IUCN

Global Reintroduction Perspectives: 2018

Case studies from around the globe

Edited by Pritpal S. Soorae

IUCN/SSC Reintroduction Specialist Group (RSG)

RSG

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Environment Agency - ABU DHABI

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Turner Endangered Species Fund

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

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

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

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

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

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

The sixth edition of the *Global Reintroduction Perspectives* has just been published and I am happy to present you this issue. As an IUCN Global Councilor, I am glad that we are producing a publication which benefits species restoration initiatives worldwide which also includes case-studies from our West Asia region, the region I represent at the Council.

As in the past issues, the book covers examples of a wide range of projects from beetles to corals, fish to giant salamanders, lizards to pythons, macaws to oryx and orchids to lichens in 59 case studies! These range from highly successful to even some failures which further shows that species restoration can be a very challenging exercise.

I am also glad to mention that the case studies also include the spiny-tailed lizard or *dhub* translocation project from the UAE and the scimitar-horned oryx project, which though is restoring populations in Chad is an initiative funded by the Environment Agency-Abu Dhabi (EAD) and is an effort to restore this iconic species back to the savannahs of Chad.

The EAD is also working closely with SSC to develop an online database of reintroduction projects which will allow all 349 case studies to be downloaded individually and provide a valuable resource for those involved in reintroductions, policy makers, students and researchers.

Finally, I would like to thank all those who contributed their interesting projects to this issue and to Axel Moehrenschlager, the RSG Chair; Mike Phillips of the Turner Endangered Species Fund; Jon Paul Rodriguez, the SSC Chair and Simon Stuart who is now at Synchronicity Earth but is still a keen supporter of these case studies and to Pritpal Soorae for compiling these case studies.

Axel Moehrenschlager
RSG Chair
Calgary Zoo

Nature needs saving, but can it be saved? Humanity's impact is ever increasing, as our population grows from 3 billion in 1960 to 9 billion by 2040. We are straining the life-support systems that sustain nature and ourselves. Ironically the only species that can help has caused nature's greatest demise. Shall we despair?

We shall not. Perhaps more than ever before, the interconnected fate of humanity and other life is becoming apparent globally and locally. While nature can live without us, we cannot live without nature.

Conservation has made tremendous gains in the last 50 years. Just as human medicine has revolutionized, conservation tools have transformed our ability to help nature. Many species have been saved from the brink of extinction. Conservation translocations such as reintroductions are credited with many of these successes. Virtually unheard of when humans first set foot on the moon, these techniques have now been used for thousands of species.

The *Global Reintroduction Perspectives* series has brought to life ambitions, challenges, set-backs and ultimate successes. For this I once again thank my dear colleague and friend Pritpal Soorae - I continue to admire how his tireless dedication never wanes. Pritpal benefits from working for a world-leading conservation supporter, the Environment Agency-Abu Dhabi (EAD). Within EAD, Shaikha Al Dhaheri continues her visionary leadership, not only as an IUCN Councilor, but also as a passionate supporter of our Reintroduction Specialist Group - thank you once again. I must also acknowledge the colleagues, board members, and donors of the Calgary Zoological Society who make it possible for us to make such a difference regionally and globally. Finally, I am grateful for the support and guidance of our Species Survival Commission Chair, Jon Paul Rodriguez, who weaves conservation translocations into the fabric of strategies and actions that underpin the ultimate success of IUCN itself.

Tremendous accolades go to the conservation heroes whose efforts amaze on the pages to come. Across oceans and all continents, species from corals and orchids to elephants and tigers are being saved through their innovation and tenacity. These experiences not only yield knowledge and action, but something even more valuable…hope.

Can nature be saved? Yes it can. It is already being saved. And we can easily upscale our efforts to help more species, in more places, more of the time. You can help. Join us to make an even bigger difference for nature… and for all of humanity.

Mike Philips
Executive Director
Turner Endangered Species Fund

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

My teammates and I have benefitted mightily from the first several issues of the *Global Reintroduction Perspectives.* My personal copies are well used. They are dog-eared and hand-written notes are common on the margins of many pages. This issue, which is now in your hands, will be equally useful. The case studies that are presented offer wisdom and practical insights that will be useful to anyone working to restore the wondrous diversity of life that still surrounds us, to paraphrase E.O. Wilson.

In a world that increasingly is being humanized, where wild and self-willed nature is being relegated to smaller and smaller patches of opportunity, all issues of *Global Reintroduction Perspectives*, including this one, will take on added importance.

As is always the case, it is a was a high honor to work with Pritpal Soorae and others to produce this issue. Despite the increasing pressure and permanent consequences of the 6th great extinction crisis, the world is inhabited by determined restoration ecologists. I am inspired and humbled by your work as shared in the following pages.

Jon Paul Rodriguez
Chair
IUCN Species Survival Commission

The IUCN Species Survival Commission advocates evidence-based conservation interventions. Our more than 7,500 experts from virtually every country of the world, are organized into over 140 specialist groups, primarily focused on particular types of plants, fungi or animals. The knowledge that they generate informs the *IUCN Red List of Threatened Species* (Red Lists), allowing for the evaluation of species' risk of extinction, and the compilation of an extensive database on population trends, geographic distribution, natural history, and conservation interventions. The scientific output of specialist groups is fundamental for guiding society and politicians towards the actions that are more likely to have a positive conservation impact. All the activities of SSC fall along of what we call the *Assess-Plan-Act* cycle. As mentioned above, specialist groups begin with assessments for the Red List. But this is only the first step: data are then used to develop species action plans, following a systematic process spearheaded by the SSC Conservation Planning Specialist Group. Finally, prioritized actions in these plans represent the interventions that are most likely to improve the status of species, encouraging donor organizations, conservation practitioners and governments to align their financial and human resources with the best available evidence of possible success. This cycle never ends, however. Once interventions are implemented, their impact on the status of species must be evaluated, action plans adjusted, and interventions adapted to the new conditions, starting over again.

This sixth edition of *Global Reintroduction Perspectives* is a magnificent example of the Assess-Plan-Act cycle. Compiled by the SSC Reintroduction Specialist Group (RSG), experts on invertebrates, fish, amphibians, reptiles, birds, mammals, and plants, summarize the results of translocations and reintroductions for conservation purposes. The case studies presented add to a growing body of knowledge, that now reaches 349 examples from all around the world. It is clearly team work, involving numerous people and institutions. The work of Pritpal Singh Soorae and Axel Moehrenschlager has been fundamental, Program Officer and Chair of the RSG, respectively. Support from Environment Agency-Abu Dhabi, and in particular its Secretary General H.E. Razan Khalifa Al Mubarak has allowed this work to grow and develop over the years. The support of Turner Endangered Species Fund and Calgary Zoo have also been instrumental - many thanks to all! Now that this body of knowledge has been assembled in six volumes, I would like to encourage the RSG to take a broader look at translocations and reintroductions as a conservation tool. Compilations such as these are rare, and represent a unique opportunity for us to continue making cutting edge, integrated contributions to scientific knowledge.

x

Simon N. Stuart
Director of Strategic Conservation
Synchronicity Earth

It is a huge pleasure and honour to be requested, once again, to contribute a short foreword to this latest edition of *Global Reintroduction Perspectives*. As with previous issues, I must start by thanking Pritpal S. Soorae for his tireless leadership of the *Global Reintroduction Perspectives* series since its inception. The series has become a practical and indispensable resource for all those planning and implementing species' reintroductions, and would be impossible to prepare all these case studies without the contributions from members of the Reintroduction Specialist Group of the IUCN Species Survival Commission. I also thank Environment Agency-Abu Dhabi, the Turner Endangered Species Fund and Calgary Zoo for their support.

As with previous volumes, it is encouraging to see the number of reintroductions of "less charismatic" species such as invertebrates, fish, amphibians, reptiles and plants, though the numbers are still small compared with large mammals. It is also notable that fish and invertebrate reintroductions are still mainly taking place in wealthier countries. Hopefully we'll see a stronger tendency for more reintroductions of such species across the world in future editions. The number of reintroductions taking place in Sub-Saharan Africa is still very low.

It is encouraging to note how many reintroductions now appear to be successful. Clearly we are learning much more about both the science and practice of reintroductions - what tends to work, and what tends to fail. The hundreds of case studies published in *Global Reintroduction Perspectives* is now one of the most important sources of guidance for managers and scientists working on reintroduction projects.

Global conservation targets are still focused on reducing the rate of biodiversity loss. There is increasing recognition that such targets are insufficiently ambitious. We actually need to stop biodiversity loss and bring about its recovery. Reintroductions are one of the most important tools in shifting from a mind-set of slowing decline, and moving to one of fostering recovery. So we can expect the role of *Global Reintroduction Perspectives* to become increasingly significant in the years ahead.

An overview and analysis of the reintroduction project case studies

Pritpal S. Soorae, Editor

Introduction

This is the sixth issue in the *Global Reintroduction Perspectives* series and has been produced in the same standardized format as the previous five to maintain the style and quality.

The case studies are arranged in the following order:

- Introduction
- Goals
- Success Indicators
- Project Summary
- Major Difficulties Faced
- Major Lessons Learned
- Success of Project - with reasons for success or failure.

For the first issue I managed to collect 62 case studies, the second issue 72 case studies, third issue 50 case studies, fourth issue 52 case studies, fifth issue 54 case studies and this sixth issue has 59 case studies. There are now a total of 349 case studies available in this format.

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

- Invertebrates - 6
- Fish - 4
- Amphibians - 3
- Reptiles - 5
- Birds - 6
- Mammals - 24
- Plants - 11

I would also like to take this opportunity to thank the various authors for their patience and willingness to submit information on their projects and in many cases with a tight deadline. We hope the information presented in this book will provide a broad global perspective on challenges facing reintroduction projects trying to restore biodiversity.

IUCN Statutory Regions

The IUCN Statutes have established a total of eight global regions for the purposes of its representation in council. The IUCN's "statutory regions" are a list of States by Region, as per article 16 and 17 of the Statutes and Regulation 36 of the Regulations.

All eight global regions are represented within these case studies and the regions are as follows:

- North America & Caribbean - 10
- West Europe - 11
- South & East Asia - 13
- Oceania - 5
- West Asia - 4
- Africa - 9
- Meso & South America - 5
- East Europe, North & Central Asia - 2

Success/Failure of Projects

The projects presented here were ranked as Highly Successful, Successful, Partially Successful and Failure. Out of the 59 case studies, there were some cases of multiple rankings as releases were conducted at more then one site. As can be seen in figure 1, 23 projects were Highly Successful, 24 were Successful, 17 were Partially Successful and 4 were listed as Failures.

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 on the preceding page. Out of the seven major taxa only amphibians do not have a project ranked as Highly Successful. Successful projects were ranked in all 7 taxa. Only

Fig. 1. Success/Failure of reintroduction projects

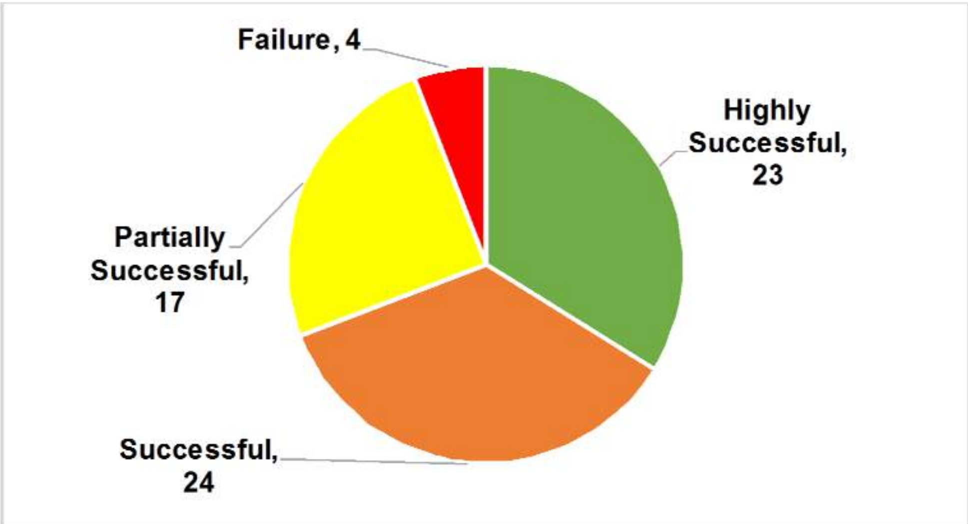
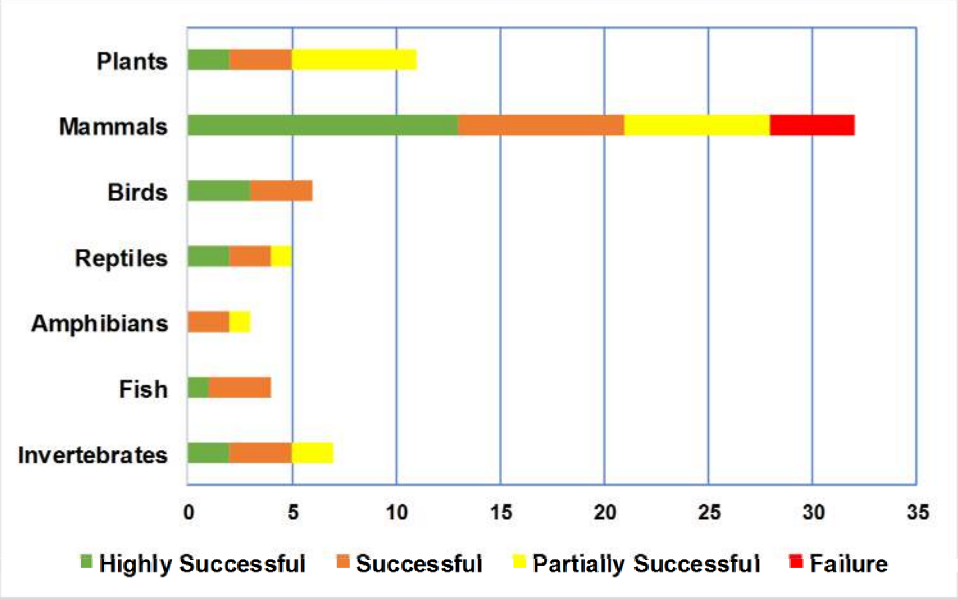


Fig. 2. Success/Failure of reintroduction projects according to major taxa



birds did not have a Partially Successful project. Only mammals had one project ranked as a Failure.

Translocation of a sand-associated blister beetle due to urban development in Uppsala, Sweden

Lina A. Widenfalk[1], Niina Sallmén[2], Åsa Hedin[3] & Åsa Berggren[4]

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Introduction

The blister beetle (*Apalus bimaculatus,* Coleoptera: Meloidae) is a beetle managed for conservation in Sweden. The species inhabits at-risk ephemeral and patchily distributed sandy habitats and are dependent on stable colonies of the bee species (*Colletes cunicularius*) on which it parasitizes. The beetle is not considered threatened at a global or European level. It has previously been categorized as Vulnerable (VU, 2000) and near threatened (NT, 2005 & 2010) in the Swedish National List, but are now considered as Least Concern (LC, 2015). The change in categorization is due to that more populations have been found, which is believed to be an effect of overlooked populations in the past. The species is still considered as declining in the country, due to a general decrease in area of suitable habitat e.g. from sandpits becoming overgrown after excavation has ceased, and when sand dunes and other sandy areas are used for human development. The beetle population in this project has until now inhabited a sandy area between pine-dominated forest and areas used for human activities. The site is in Uppsala, Sweden, and it is located in a part of the city previously little used for human development but where major building work is planned and ongoing.

Goals

- Goal 1: Translocation of *A. bimaculatus* and *C. cunicularius* from areas planned for urban development.
- Goal 2: Establishment of populations of both species in areas protected from exploitation.
- Goal 3: Increased area of sandy habitat at the translocation site.
- Goal 4: Managing the translocation site for both species to

Blister beetle © Lina Widenfalk

Bee species parasitized by the beetle
© Lina Widenfalk

increase the likelihood for sustainable populations and to know the status of the populations.

- Goal 5: Increased knowledge among the public, exploiting companies and authorities about the focal species and their requirements as well as about the on-going management work, through information signs at the site and through press releases.

Success Indicators

- Indicator 1: Individuals of both species survived the translocation (first year).
- Indicator 2: Both species are found and are reproducing within translocation areas that are saved from further urban development (second year and onwards).
- Indicator 3: The amount of sandy habitat is kept at a minimum of 10 m^2 for each patch in all of the sites (second year and onwards).
- Indicator 4: The management to create and maintain suitable habitats in the translocation sites are done routinely and the information about the populations are gathered systematically and regularly. After five years a minimum abundance of 1 bee-nesting hole/m^2 bare sand can be located within at least one newly established site and the beetles are observed each year in increasing abundance.
- Indicator 5: Information signs about the species and about the management are in place at the time of the establishment of new sites, information about the project is published in the local press during 2016. No major complaints about the new areas are made.

Project Summary

Feasibility: Focus of this project is to maintain viable populations of *A. bimaculatus* during urban development. As part of the expansion of the city of Uppsala, an area that has housed one of the largest and most stable populations of the beetle will be used for human development. The Swedish EPA has set a national program for the conservation of the species. As part of this program, restoration of sandy habitats has been carried out in several areas in Uppsala county. In other parts of Sweden, similarly created sandy habitats have been colonized by beetles within 10 years. No attempts to translocate the species have been done previously in Sweden. As the entire area that the population inhabited was going to be completely cleared within a year, translocation of the full colony with both bees and beetles was decided as the best management action.

Implementation: In December (Swedish winter) 2014 areas surrounding the targeted population were visited and habitat conditions were described. To locate possible bee-nesting-hole areas and to determine in which of these the beetle could be found, observation data of *A. bimaculatus* and *C. cunicularius* (years 2004 - 2014) in a 1 km x 1 km region around the focus populations were gathered from the open access database Artportalen (Swedish Species Observation System). The Swedish Species Information Centre, SLU, manages this database.

In spring 2016, the area was censused for number of beetles present in the population and to locate all subterranean nests of the bee. Only two individuals of the beetle were found and from Artportalen five individuals were reported. Both were low numbers compared with the highest records for the area which was 130 beetles (Artportalen, 2012). Five areas of nesting holes of the host bee species were identified during the survey, all close to the observed beetles. As preserving the species within the developmental area was determined impossible, a decision to translocate the population was made.

Suitable areas for release were searched for within a radius of 1 km of the source population. Three areas (two sites at Pollacksbacken and one at Kronparken, within 1 km from each other) were selected based on having sandy soil, a similar sun exposure as the previous nesting-hole areas and not being part of any development plans. All areas had too much grasses and herbs on the sand to be high quality habitats.

Translocation was carried out at the end of August 2016. During this period the bees and the beetles are within sand cavities, both as larvae. Areas of 5 m x 5 m within each new translocation area was dug out to a depth of 0.6 m, the soil and vegetation was removed. The sand containing the nesting holes was then excavated with a backhoe and transported carefully to fill the holes of the translocation areas, making sure that the sand layers were not shifted. A reference area was also created (3 m x 3 m, 0.6 m depth) using the same procedure but with sand from the exploited area without known bee cavities. Around each sand area larger stones were placed, to mark the area and prevent from people walking or children playing on the spot. Information signs were placed at both sites during 2016 - 2017.

Moving sand with a backhoe © Niina Sallmén

Release site © Lina Widenfalk

Post-release monitoring: The full evaluation of the project is not yet possible, as there has only been one season since the translocation and the breeding success in the new habitat is not recorded. Censuses done the year after the translocation, in spring 2017 (mid-March to mid-April) showed that both the bee and the beetle were found in one of the four areas. Several individuals of both species were found at this site on more than one occasion during the season, showing that they were able to complete their development in this site. The three other areas had no observations of either of the focal species.

The findings so far show that it is possible to move the sand, in which the bee and the beetle larvae are present as larvae, as a translocation method, but that the outcome is not certain. Information about reproduction success has not been recorded. Therefore, there are no results on the potential for establishment success for the species.

All translocation sites will be monitored in the coming 10 years during spring, to determine if and how the populations establish and expand. The areas will also be managed and work carried out to increase the area of sand cover. Although considered as a poor flyer, there have been records of *A. bimaculatus* to colonize areas situated >3 km away. There are other populations present in the city of Uppsala within that distance and thus it would be possible for individuals from these populations to colonize the managed areas.

Major difficulties faced

- The planning of the project started too close to when the area was going to be cleared for the urban development. This made it not possible to prepare for natural colonization of new established habitats and also did not make it possible to do the surveys of suitable translocation sites during the time the species are easiest to find. Sites that were known to be spared from further development for certain, was not possible to find and therefore only one of the four translocation sites used are certain to be permanent.
- Knowledge about the basic biology of the species is still scarce, making it difficult to determine best management plan for successful conservation management.
- Communication difficulties with the entrepreneurs responsible for the developmental plans of the original site lead to that some parts of the area were affected by tree felling and vehicles driving on the sand before translocation.

- Information signs put up too late or not at all, resulting in people walking on and playing in the sand. Lack of communication to the citizens before the project started lead to misunderstandings and different concerns, e.g. teachers at a pre-school close-by a translocation area was worried that the children could be stung by the bees.
- Too small areas of created sandy habitat lead to rapid overgrowth of the sand during the summer after establishment.

Major lessons learned

- It is possible for both the blister beetle and its host bee species to survive and finish their development in the sand cavities after translocation, when the sand is moved gently in late summer.
- For a successful management of habitat used by sand-dependent species it is crucial that all agencies and stakeholders working in the area are aware of the problem and are interested in working towards the same goal. Also, if the management project is initiated late in the developmental plan it is harder to take the actions that are likely to be successful.
- There has been a decline in the whole region during many years in the abundance and occurrence of the beetle species and of suitable sandy habitat. Other close by populations have disappeared after human development work. Critical thresholds when the quality of a habitat or area in a landscape has become too low to keep viable populations are missed. Therefore monitoring schemes for management of species and habitats that are dependent on a very particular successional stage would be very useful.
- To be able to draw clear and solid conclusions about the success of a translocation a scientific design of the setup, gathering of data before, during and after the translocation is crucial. Scientific analyses of the gathered data are needed to be able to draw conclusions and increase the understanding of the species and the methods used. For these steps to work well, experts of the focal species and skilled analysts should be responsible for the design.
- When working with translocations to preserve threatened species, the guidelines from IUCN should be used, as it would increase the quality of the actions including the design of the work.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Too soon in the project to draw any conclusion about whether the translocation was a success as there has not been enough time for the species to reproduce and potentially establish.
- The entrepreneur translocating the species (by moving the sand in a backhoe) was very careful and made sure to check that all steps was done as planned by the conservation consultancy. This resulted in that at least some individuals survived the translocation.
- The new sites are much closer to foot- and bikeways and primary schools than the original site. This make the sites more prone to problems with sand being

removed, but it also makes the public more aware of the species and their habitat needs.
- Success of the project will depend on the management of the sandy areas and the ability for both species to reproduce the first year.
- Scientific evaluation of the project is somewhat hindered by the lack of data of the areas before translocation, knowledge of the host species, and information about reproduction of both species during the first season.

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Taylor's checkerspot butterfly reintroduction in the Puget lowland prairies of Washington State, USA

Mary Linders

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Introduction

Taylor's checkerspot butterfly (*Euphydryas editha taylori*) is a grassland-dependent butterfly persisting on relict sites west of the Cascade Mountains from British Columbia, Canada to northwestern Oregon, USA. Once known from 80 locations, rapid habitat loss restricted the species distribution to 11 isolated sites by 2008. The last of 32 Puget lowland sites, once the heart of the species range, is on the artillery impact area of a key military installation in western Washington State; it is the largest remaining population (USFWS, 2013). Historically and at present, the drought-prone, glacial outwash soils that gave rise to the region's grasslands resist conifer invasion by fueling the human-induced fires that are fundamental to their maintenance.

Only 2 - 3% of the original grasslands now support native vegetation, but expansive restoration underway by a public/private cooperative is controlling exotic shrubs and sod-forming grasses on historical Puget lowland sites, and portends the greatest capacity for recovery rangewide. Efforts to reintroduce Taylor's checkerspot to these remote sites was initiated in 2004, and relies on annual collections from the remaining population, propagation of larvae at two captive-rearing facilities and multiple years of release. The species is listed as endangered in Canada, the USA, and Washington State.

Goals

- Goal 1: Determine habitat requirements and evaluate habitat suitability at potential reintroduction sites in conjunction with cooperative restoration.
- Goal 2: Produce larvae for release via collection of wild stock and captive propagation.
- Goal 3: Develop and refine release

Taylor's checkerspot butterfly © Mary Linders strategies and monitoring methods suitable for reintroduction of Taylor's checkerspot.

- Goal 4: Evaluate reintroduction success based on presence, distribution and abundance of larvae and/or adults.
- Goal 5: Establish at least three new Taylor's checkerspot populations on three Puget lowland prairies by 2022 to reverse population loss and move toward recovery.

Success Indicators

- Indicator 1: Release sites meet defined criteria for a reintroduction-ready condition (i.e. diverse and abundant host and nectar resources, as well as sites for roosting and basking).
- Indicator 2: An abundance (>4,000) of postdiapause larvae are produced annually via captive propagation by maximizing stage-specific survival (e.g., ≥90%).
- Indicator 3: Evidence of post-release reproduction: at least 10 prediapause larval nests within a 200 m^2 sampling area where most larvae persist to third instar.
- Indicator 4: Single day abundance estimates of at least 250 adults is achieved annually for five consecutive years based solely on natural reproduction, distributed across a 20 ha site.

Project Summary

Feasibility: Taylor's checkerspot is highly gregarious, with limited dispersal capability, and flies during peak spring wildflower bloom, laying clusters of eggs primarily on one native (*Castilleja hispida)* and one exotic (*Plantago lanceolata*) host. Larvae hatch and feed until at fifth instar they undergo a seven month diapause in response to summer drought. They resume feeding in mid-winter when they either progress to the adult stage or return to diapause for 1 - 2 more years. The sole source population for reintroductions occupies a military hazard zone where site access is highly restricted and unpredictable, which complicates butterfly monitoring, collection and study, and limits habitat management.

Project staff in field during release

Checkerspots inhabit short-stature grasslands at lower elevations, where abundant host and nectar plants are interspersed with open ground. Decades of fire suppression, exotic plant invasions and habitat destruction threaten habitat on historic sites. Restoration is costly and can be unpredictable because key actions, such as prescribed fire and

Release of larvae © Mary Linders

herbicide applications may be hampered by permitting agencies, weather or public concerns.

Invertebrate conservation is uniquely challenging due to the inability to mark/track individuals, high mortality rates, multiple life stages with varying habitat requirements, and extended periods when they are undetectable. Hundreds of butterfly reintroductions have failed (Oates & Warren, 1990), and captive rearing of a related subspecies was only partially successful. We used a multi-staged strategy to develop methods for captive rearing and release, and for assessment and monitoring of checkerspot habitat and populations. Initial habitat assessments relied on qualitative measures until we designed a mapping method that utilized the 25 m x 25 m survey grid employed in adult surveys; thresholds for host, nectar and structural suitability were derived from habitat condition at the source site.

Implementation: Following restoration of the forb-and-bunchgrass ecosystem, mapping identifies 2.5 ha “reintroduction-ready” units where release plots are sited. After testing several life stages, we targeted mature (postdiapause) larvae for release due to their limited mobility, predator resistance, and ease of handling. Rearing facilities at the Oregon Zoo in Portland, Oregon and Mission Creek Corrections Center in Belfair, Washington, use a two-pronged approach to produce sufficient larvae for release: 1) collect wild females for oviposition under a US Fish and Wildlife Service permit, and 2) captive-mate adults reared from a subset of the previous year’s wild larvae. This redundancy spreads risk and insures against loss of the source population. Rearing methods maximize stage-specific survival (e.g., >90% from hatch to adult), and all larvae from captive-mated adults are released to minimize selection in captivity.

Larvae are transported to release sites under a US Department of Agriculture permit that regulates invertebrate shipment between states. Groups of 2 - 5 larvae (741 - 3,621 per site annually) are released onto host plants where densities are

Overview of release site © Mary Linders

≥3/m^2 across plots 160 - 1,550 m^2 in size. Our objective is to release >1,500 larvae/site annually for five consecutive years to attain the critical population densities needed to found a population; we have realized this objective in 7 of 12 recent releases. Production in captivity fluctuates annually because oviposition and hatch rates are impacted by cool and cloudy spring weather, even indoors.

Post-release monitoring: To measure short- and long-term success, we evaluate reintroductions at three stages: 1) in the weeks following release, 2) during the adult stage, and 3) during the prediapause larval stage. Post-release surveys of postdiapause larvae are conducted in 4 m^2 subplots placed systematically along transects; about 10% (range 7 - 15%) of the release area is sampled on two occasions. Weighted average postdiapause survival for 2014 - 2016 was 0.50 (range 0.11 - 0.86; n=8,309 larvae), and is comparable to wild survival rates for other *E. editha* subspecies (Moore, 1989; Cushman *et al.*, 1994).

We use distance sampling to estimate daily population size and map adult distribution using standardized transects partitioned into 25 m segments. Adults are monitored in release years and annually for five years thereafter. A reintroduced population is considered established when peak single day abundance estimates (PSDAE) exceed 250 adults for five consecutive years solely through natural reproduction, and adults are widely dispersed across a 20 ha site.

Thresholds were adapted from monitoring results for the source population. One successfully established population had a PSDAE of 3,391 adults in 2016 (95% CI: 2,143 - 5,366), with a second showing a strong positive trend (PSDAE: 1,463 adults, 95% CI: 692 - 2,458) that is expected to meet establishment criteria by 2021. On three sites with only one year of release, we failed to detect butterflies by the second (n=2) or third year (n=1) following release. Based on searches at our first established site, we defined successful reproduction as ≥10 prediapause larval nests within a 200 m^2 sampling area, where most larvae persist to third instar; funding limits prevent annual monitoring. Successful reproduction was demonstrated on three sites, but only two persisted on their own for two or more years. Mapping prediapause larval distribution during habitat assessments aids prescribed fire and restoration planning.

Major difficulties faced

- Grassland habitat restoration is confounded by weather-related obstacles that are difficult to predict (e.g. prescribed fire access, herbicide effectiveness, germination rates, etc.), causing restoration to lag behind captive propagation.
- The majority of suitable and potential habitat occurs on military lands where management priorities fluctuate, affecting site access and conservation actions.
- Our ability to measure key population parameters is constrained by issues of concealment and population fragmentation (e.g. return to diapause, staggered adult emergence), which limits our understanding of factors affecting reintroduction success.
- Cool and wet spring weather in western Washington is increasingly punctuated by periods of excessive warmth (>27°C) and drought; both conditions impact checkerspot survival and reduce the likelihood of successful release.

Major lessons learned

- Even simple measures of habitat readiness are better than none at all and should be developed well in advance of captive rearing and reintroduction.
- Captive propagation proved easier than expected relative to habitat restoration, and at times exceeded the capacity of available habitat.
- Because any one release is prone to failure (Armstrong & Seddon, 2007), repeated long-term efforts are necessary to reintroduction success in Lepidoptera, which may favor an adaptive management approach over a research-based one.
- Reintroductions can stabilize populations and prevent wholesale loss while adding to knowledge of life history and habitat requirements.
- Large, collaborative efforts are fundamental to ecosystem-scale restoration however consensus-based decision-making can be cumbersome and impede project progress, especially if differences of opinion lead to delays. Identifying and implementing critical short-term actions is necessary to conserve highly imperiled species facing immediate threats.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Our success is due in no small part to ongoing funding commitments by partners including the US Fish and Wildlife Service, the Department of Defense, and others, which support needed infrastructure for captive rearing, long-term monitoring and large-scale habitat restoration.
- The ability to consistently produce abundant larvae for release permits fledgling populations to persist through the inevitable years of poor performance. Also, recent unexplained mortality not attributable to disease at one captive rearing facility has impacted project progress, but having a second rearing facility has prevented the project from stalling.
- Lengthy post-release monitoring is costly and slow, but critical to determining the outcome of reintroductions and status of these populations.
- Intensive restoration across large tracts by a cooperative group of conservation partners including public agencies, non-governmental organizations and private partners, is supporting population expansion for Taylor's checkerspot and other grassland-reliant species.

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Reintroduction of the Oregon silverspot butterfly on the Oregon Coast, Tillamook County, Oregon, USA

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Introduction

The Oregon silverspot butterfly (OSB) (*Speyeria zerene hippolyta*) was listed as a threatened species under the United States Endangered Species Act (ESA) in 1980. Originally documented from 20 locations along the Pacific coast from northern California to Washington, in 2016 the OSB had just five populations. The greatest threat to the OSB is the lack of suitable habitat. The small number, isolation, and population size are also threats to the species. Following two consecutive drought years in 2014 and 2015, all extant OSB populations experienced significant population declines, indicating the species was at great risk of extirpation. In 2015 - 2017 the US Fish and Wildlife Service (USFWS) restored 12 ha of coastal prairie habitat, planting 56,000 early blue violets (*Viola adunca*), the caterpillar host plant, and thousands of nectar plants on the Nestucca Bay National Wildlife Refuge, in Tillamook County, Oregon, USA. In August of 2017, over 900 OSB caterpillars were released into the newly created habitat. This population was established as a nonessential experimental population (USFWS, 2017). A second reintroduction is planned for 2018 within historical habitat on Oregon Parks and Recreation Department (OPRD), Saddle Mountain State Natural Area, in Clatsop County, Oregon, which currently supports suitable habitat for the butterfly.

Goals

- Goal 1: Re-establish an OSB population to minimize the species extinction risk and contribute to the 10 populations needed for recovery.
- Goal 2: Test whether habitat requirements of the species can be met with intensive habitat restoration and maintenance efforts in degraded habitat areas.

Oregon silverspot butterfly

- Goal 3: Refine reintroduction techniques to test effectiveness of caterpillar vs. pupae releases.

Success Indicators

- Indicator 1: Husbandry methods developed to augment OSB populations at risk are successful in providing captive-reared OSB to establish new populations.
- Indicator 2: Weekly butterfly index counts conducted during the butterfly flight period monitor butterfly populations. The ultimate target for success is defined as a population of 200 - 500 OSB sustained for over 10 years.
- Indicator 3: Within habitat restoration areas invasive non-native plant species abundance is significantly reduced, habitat has an abundance of native plants used by the OSB, including the caterpillar host plant, early blue violets, distributed in dense patches, greater than 10 violets/m^2, needed for foraging caterpillars and native coastal prairie species used by OSB to nectar.

Project Summary

Feasibility: In 1999 - 2000, the Oregon Zoo in Portland, Oregon, and the Woodland Park Zoo in Seattle, Washington, began a captive-rearing program to provide OSB pupae or caterpillars to augment the declining OSB populations. This effort was undertaken to prevent any further loss of OSB populations while habitat improvement could be implemented. To date, four of the five remaining OSB wild populations have been augmented with captive-reared OSB. The success of the captive-rearing program suggested OSB reintroductions were feasible. Habitat characteristics needed for the OSB include a coastal prairie or low growing native grassland which has an abundance of early blue violets (*Viola adunca*) distributed in dense patches for successful caterpillar forging (Bierzychudek *et al.*, 2009) and an abundance of nectar plants of differing species, blooming throughout the butterfly flight period (USFWS, 2001). Native seed production efforts between 2005 - 2012 provided large amounts of native seed and seedlings for OSB habitat enhancement and restoration projects.

An OSB recovery plan was completed in 2001, with an OSB recovery criteria of 10 populations across the species historical range, with 200 - 500 OSB per population for 10 years (USFWS, 2001). To meet the criteria reintroductions were found to be necessary. An OSB reintroduction plan was prepared in 2010 (VanBuskirk, 2010), which suggested that offspring from 50 mated female OSB could provide the genetic diversity needed to establish a new OSB population.

To facilitate the establishment of additional populations, the USFWS proposed two OSB reintroductions as a nonessential experimental population within the species historical range, as provided for under section 10(j) of the ESA. The designation of the non-essential experimental population allows for a threatened species to be managed as a proposed species, so neighboring landowners will not have concerns that a listed species might impose land use restrictions upon their properties. Because the OSB is not migratory and is a specialist species to coastal prairie habitat, little or no OSB are expected to leave the habitats in which they are released.

With the support of the land managers, the nonessential experimental population areas were defined surrounding the Nestucca Bay National Wildlife Refuge, in Tillamook County, Oregon, and Saddle Mt. State Natural Area, in Clatsop County, Oregon. The OSB reintroduction at Nestucca Bay National Wildlife Refuge began in 2017 and is proposed for Saddle Mountain State Natural Area in 2018 (USFWS, 2017).

Silverspot butterfly caterpillar

Implementation: The Nestucca Bay NWR has had 30 acres of coastal prairie habitat in varying stages of restoration since 2011. Since that time invasive weed abundance has been minimized, and thousands of violet and nectar plants have been planted to enhance and restore the coastal prairie ecosystem. On 28th July 2017, approximately 450 OSB caterpillars were released directly on violet plants dispersed throughout densely planted violet patches on Nestucca Bay National Wildlife Refuge. A second release on 3rd August 2017, put the total OSB released at approximately 900. The first OSB butterflies were observed flying on 21st August 2017. Weekly butterfly counts during the butterfly flight period will provide information on caterpillar survival to adulthood, OSB habitat use within habitat areas of differing quality, and overtime, fluctuations in OSB population levels each year.

A second OSB nonessential experimental population reintroduction will occur on OPRD, Saddle Mountain State Natural Area, which was historically occupied by the OSB, last documented at this site in 1973. Based on recent vegetation surveys, the proposed release site contains approximately 60 acres of high-quality butterfly habitat with sufficient densities of the essential species (*Viola adunca* and native nectar plants) to support a population. OSB caterpillars will be released into the highest quality habitat in summer of 2018.

Post-release monitoring: On the Nestucca Bay National Wildlife Refuge, the OSB populations will be annually monitored during the butterfly flight period to track year to year population levels. Habitat parameters important to the butterfly, such as violet and nectar plant survival and abundance will also be monitored. The 50 m long x 30 m wide transects will provide information on butterfly use within each area relative to the available plant resources. On Saddle Mountain State Natural Area, population monitoring will begin in summer of 2018, after OSB caterpillars are released. Monitoring at this site will include butterfly counts conducted from stationary points due to the dangerously steep slopes, but will be consistent year to year.


Nestucca Bay National Wildlife Refuge release site

Major difficulties faced

- The most challenging aspect of this project was associated with the coastal prairie habitat restoration at Nestucca Bay National Wildlife Refuge. At the onset of the project the restoration site was in a degraded condition, having been a livestock pasture for many years. Restoration activities included removing and controlling invasive plant species with herbicides, mowing, burning, and planting native seed and seedlings multiple times.
- The release of the captive-reared OSB was not particularly difficult because the captive rearing methods had been underway since 1999 and methods were well defined (Andersen *et al.*, 2010). However, the release of a large number of caterpillars in which we preferentially wanted to release the largest instar caterpillars, proved difficult to time. While the majority of OSB caterpillars released were 5^{th} or 6^{th} instar some were smaller and potentially more vulnerable to starvation and predation.

Major lessons learned

- The captive-rearing methods developed to augment OSB populations at risk can also be used to implement reintroductions into suitable habitat at other locations.
- The release of OSB caterpillars vs. the release of pupae is feasible, requires less labor than monitoring OSB pupae enclosed in protective cages. The number of butterflies observed during the transect surveys was approximately 8% of the number of caterpillars released. This is slightly lower than the 12% of OSB counted following pupae releases from cages at other locations. The results are preliminary but may reflect the trade-off of lower survival of released caterpillars verses the labor intensive pupae release method.
- OSB habitat restoration can be very challenging in degraded areas without the resources to aggressively implement site preparation treatments for reoccurring weeds. Native seed must be propagated and available to immediately plant following management activities to suppress nonnative plant invasion.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The release of OSB caterpillars was successful and three weeks after the caterpillar release, adult OSB were flying, observed mating, and females were seen laying eggs. About 8% of the number of caterpillars released were observed as adult butterflies during index counts. This information will be used to calibrate future reintroductions and releases.
- To meet the goal of establishing the new population from 50 mated females, additional releases will be needed. The new population is offspring from just 16 OSB females. Future releases will be conducted incrementally to increase genetic diversity while minimizing impacts to the donor population.

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Black nerite - an aquatic snail reintroduction in Hungary

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Introduction

Black nerite (*Theodoxus prevostianus*) (Pfeiffer, 1828), is distributed in the Pannonian bio-geographical region of Central Europe and inhabits hypothermal springs and lives attached to hard substrate. Historically, 15 - 20 populations were known, but the majority have become extinct during the past 50 years. Now only four remaining populations are known: two in Austria (Bad Vöslau, Bad Fischau), one in Slovenia (Bušeča vas) and one in Hungary (Kács). Therefore, this species is of high conservation concern; it is legally protected in Hungary, listed in Annex IV of the European Habitats Directive and categorized as endangered (EN) by IUCN. In Kács, there are two groups of springs (a cool, ~15.4 °C and a hypothermal, ~22 °C). Their water form two separate, approximately 50 - 100 m long stream sections (so called cold- and warm branches) before their confluence. Total population size is estimated to 3 - 3.2 million specimens, of which ~25% are found in the warm branch, 1 - 2% in the cold branch and the rest in the joint section.

Black nerite snail © Bálint Bajomi

Despite the legal protection, the species' conservation status and long term persistence at Kács seemed unsatisfactory, mostly because the population is located within a private property outside of the Bükk National Park.

Goals

- Goal 1: Select suitable recipient sites, which were historic locations of the black nerite and their habitat conditions seem to be adequate to support this species again.
- Goal 2: Reintroduce black nerite individuals to these sites in order to establish self-sustaining populations.
- Goal 3: Raise public awareness for the project and the species specifically, and freshwater invertebrate conservation in general.
- Goal 4: Maintain suitable hard substrate (rock/concrete surfaces free of vegetation) for the species, monitor population persistence to detect undesirable changes in population size.

Success Indicators

- Indicator 1: Survival of the translocated population at the new location was defined as the indicator of short-term success.
- Indicator 2: Presence of locally hatched offspring was defined as the indicator of mid-term success.
- Indicator 3: Permanent establishment of a self-sustaining population was defined as the indicator of long-term success.

Project Summary

Feasibility: The vulnerability of the Kács population was so obvious that the idea of creating insurance populations had long been considered prior to the alarming disturbance events of 2010 (see Fehér *et al.*, 2011 for details). The idea of reintroduction was first proposed by one of us (Gábor Majoros) in 1999. The plan took the form of a proposal during the Annual Meeting of Hungarian Malacologists in 2009.

Prior to this, we have investigated the intraspecific molecular diversity and phylogenetic relationships of this species. Three diverging intraspecific mitochondrial lineages were revealed, of which one comprised the Kács population. This was a good reason to treat the Kács population as a distinct conservation unit and it gave a final impulse to the decision of establishing one or more refuge populations at new locations.

We planned to reintroduce black nerite to such locations, where it had become extinct in past decades. Preliminarily, three sites seemed suitable to host black nerite populations again: Fényes Springs in Tata, Csónakázó-tó in Miskolctapolca and Vízfő Spring in Sály. In Tata, the springs had dried out in the 1960s due to groundwater extraction in connection with coal mining. In Miskolctapolca, the extinction of the population was connected to the reconstruction of the Cave Bath, which is fed by the same springs as the Csónakázó-tó. Vízfő Spring in Sály was captured in the 1970s and there were periods when the outflow completely dried up, causing the extinction of that population.

In March 2010, we analyzed the water quality in the three proposed sites. Regarding Calcium (Ca) and Magnesium (Mg) content, Vízfő Spring was closest to the hypothermal spring of Kács. Fényes Springs had the same Ca content but three times higher Mg content. In the outflow of Csónakázó-tó in Miskolctapolca, we measured hardly any Mg but high Ca content. The chemical oxygen demand

Donor site - Kács (left) and release site - Sály (right) © Bálint Bajomi

of the water seemed to be sufficiently low (<10 mg/L) at each site, except at Miskolctapolca where it was slightly higher than optimal. Sulphide, an indicator of anaerobic processes like rotting, could not be detected in any of the analyzed locations.

We proposed to introduce 200 specimens per year for a period of three years to each locations (1,800 specimens altogether). We applied for permission to the Hungarian National Inspectorate for Environment, Nature and Water in March 2010. After a long procedure, we got permission to reintroduce black nerites to Miskolctapolca and Sály but not to Tata, and we were allowed to collect only 200 specimens per year between 2010 and 2012 (600 specimens altogether).

Implementation: Regarding the low number of specimens we were allowed to collect, we preferred to start with one location and not to spread the permitted quantity into more than two batches (200 specimens in 2010 and 400 in 2012). We choose Vízfő Spring, which seemed to be the most promising on the basis of water quality data. Animals were hand collected and carried between wet tissue paper in a plastic cooling box. The duration of the transport was less than 30 minutes, therefore the box was neither cooled nor heated actively. The specimens were tempered gradually to the temperature of the recipient environment in a plastic bucket before releasing to the wild. The animals were released at two spots about 15 m and 30 m from the spring's outflow. The first spot was in the concrete section, the other one was in the natural section of the brook. Animals were initially sheltered by small clay pots to avoid immediate drifting of the withdrawn specimens caused by the strong water current in the stream.

Post-release monitoring: The follow up monitoring was performed somewhat irregularly, twice a year on average and neither living specimens nor empty shells were found up to August 2014, almost two years after the second translocation. At the following visit on 24th October 2015, however, numerous adult specimens were detected. One year later on 15th October 2016 the population still existed and found to occupy at least a 400 - 500 m long section down from the outlet. Living specimens were observed also upstream from the upper release spot, demonstrating the species' ability to spread upstream. Some of the specimens were found to carry the remnants of freshly freshly-hatched egg capsules attached to their shells. We have randomly set quadrates of 30 cm x 30 cm along the populated stream section to count those animals which are visible to the naked eye. Extrapolating these quadrat counts to the whole populated area, the number of adult and sub-adult specimens was estimated to be 5,000 - 20,000.

These observations let us to assume that most, if not all, of the observed individuals were born and developed *in situ*, which indicated the action was success in the mid-term. For the assessment of the long-term success of the action, of course, further population monitoring is necessary. In addition to this, active habitat management might be required to maintain suitable hard substrate for the species.

Major difficulties faced

- We were allowed to reintroduce only a small number of individuals.
- Nerites are dioecious without apparent sexual dimorphism. Therefore, it was impossible to determine the sex ratio in the donor population. In extreme situation, a skewed sex ratio combined with small number of individuals can result in the complete exclusion of one sex.

Major lessons learned

- The most noteworthy lesson of our program was the long latency of the reintroduced population. At least two years have passed after the second round of translocations and the density of the establishing population still remained below the detection threshold. The sudden increase in population size started just after that. This long latency underlines the importance of long-term follow-up monitoring in any gastropod reintroduction program.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
√			

Reason(s) for success:

- Suitable habitat conditions at the recipient site and similar physico-chemical properties of the water in the host and recipient sites.
- In order to compensate the low number of adult specimens we are allowed to collect, we selected as many specimens with unhatched egg capsules attached to their shells as possible.
- Austrian black nerite populations were known to show increased egg laying activity from August to February and to have two waves of increased mortality in September and in March, therefore we timed both translocations in late autumn.

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The Colorado Coralition: engaging landlocked youth in the restoration of staghorn coral in the Florida Keys, USA

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Introduction

Beginning in the 1970s, staghorn coral populations have declined in large abundances along the Florida Reef Tract and throughout the Caribbean. Cumulative stressors including overfishing (Jackson *et al.*, 2001), coral disease and bleaching (Williams & Miller, 2012), and the mass die-off of a keystone herbivore species, *Diadema antillarum* (Lessios, 1988), contributed to this decline. As a result, staghorn coral has been listed as “Critically Endangered” on the IUCN Red List, “Appendix II” under CITES, and “Threatened” under the ESA. Increased distance between remaining wild colonies and a macroalgae dominated state impedes success of natural recruitment from sexual reproduction (Williams *et al.*, 2008). Restoration efforts combat the decline of staghorn coral through a process called “outplanting”. After propagating corals in offshore nurseries, the Coral Restoration Foundation (CRF) relocates fragments to reefs. This approach has proven to be effective in increasing coral populations at degraded reef sites (Miller *et al.*, 2016). Additionally, training youth in restoration science techniques is an emerging strategy for increasing volunteer-based propagation, academic engagement, and introduction to scientific fields.

Staghorn coral © Jessica Levy

Goals

- Goal 1: Students successfully outplant staghorn coral fragments on reef substrate.
- Goal 2: Students engage in citizen science monitoring and data collection of existing outplants.

- Goal 3: Students participate in maintenance of offshore coral nurseries.
- Goal 4: Safe and responsible dives for all students.
- Goal 5: Students continue to engage in marine conservation efforts.

Success Indicators

- Indicator 1: Student teams outplant healthy staghorn fragments harvested from offshore nurseries on threatened reefs.
- Indicator 2: Students use citizen science training to assess status of previously outplanted staghorn fragments.
- Indicator 3: Students participate safely and effectively in ongoing efforts to maintain coral nursery structures and tag harvested coral with genetic identification tags.
- Indicator 4: Students engage in increased ocean stewardship through recycling and reuse. Students also continue participation in marine ecology offerings and potentially pursue post-secondary coursework in environmental fields.

Project Summary

Feasibility: Restoration work facilitated by CRF occurs in two standard environments: 1) the coral nursery, where corals are suspended underwater on floating structures, and 2) degraded reef sites offshore. These various locations are found upwards of 4.8 km off the coastline and are only accessible by boat. Access to restoration sites can be limited due to the impact of strong winds and inclement weather, making conditions unsafe for diving.

The Colorado Coralition project, an environmental stewardship and leadership program for middle and high school students, was developed at Polaris Expeditionary Learning School, a K-12 public school in northern Colorado's Poudre School District. Polaris uses the EL Education (formerly Expeditionary Learning) model to engage students in rigorous real-world learning experiences. To extend in-depth learning opportunities beyond the classroom, Polaris schedules three project weeks called "Intensives" throughout the school year. During Intensives, regular coursework is suspended. Students sign up for field-based projects that highlight science and technology, the arts, service learning, adventure programing, and/or career exploration. Despite this flexibility, training youth to participate in coral restoration efforts requires scuba certification from an accredited program, rigorous study and interaction with experts, and extensive fundraising for chartering commercial dive boats and travel. The Colorado Coralition therefore uses all three Intensive weeks to meet these needs: the first one involving scuba certification, the second focusing on service learning and fundraising, and the third involving the trip to Florida. Students are accepted to the Colorado Coralition based on academic performance, character, and attendance. Acceptance in the program requires students to take part in all three Colorado Coralition offerings throughout the year, in addition to scheduled meetings and fundraising events taking place after and outside of school. This program was offered to Polaris students during the 2014 - 2015 school year and the 2016 - 2017 school year.

Implementation: Work with staghorn coral and the ongoing restoration efforts are governed under CRF's operating permits for activities in both federal

(Permit # FKNMS-2011-159-A4) and state (License # SAL-17-1725A-SCRP) waters. Under the supervision of the CRF team, the assistance of volunteers and recreational divers in restoration work is also supported. Under these permits, there is no expected impediments to project implementation.

As far as engaging youth from landlocked Colorado in coral restoration work, the elements of airline travel to Florida and multiple scuba dives required a great deal of communication, risk management, and logistical planning to align with school district policies. The sponsoring teacher worked closely with administrators; parents; businesses providing travel, lodging, and food; a commercial dive operator; and CRF to ensure a safe and organized learning experience.

Colorado Coralition student entering a degraded reef area for outplanting © Matt Strand

Post-release monitoring: Coral restoration efforts in the Florida Keys have proven to be quite successful for enhancing population abundances. In 2016, Miller *et al.* showed that, in areas where restoration was taking place, *A. cervicornis* population trends were increasing, and areas where restoration was not taking place, *A. cervicornis* population trends were decreasing. Monitoring efforts by CRF take place one month, 12 months, and annually after outplanting. Observers record survival percentages of corals within the cluster and the condition of corals over time. In 2016, 81% of *A. cervicornis* observed over one year remained on the reef. The reintroduction of thousands of coral fragments back onto the degraded reef allows for an increase in coral tissue that was not previously there. After two years, nursery-reared staghorn corals have been observed spawning on restoration sites. Due to strategic outplanting of genetically diverse fragments, multiple genotypes spawn with one another, introducing new genes into the population gene pool, which may strengthen the long-term success of the entire population.

Regarding student involvement in coral restoration, no monitoring plan, evaluation, or impact study currently exists for the educational outcomes of the Colorado Coralition project. The 2015 and 2017 Coralition trips both took place during the last weeks of the school year, and students began their summer breaks at the end of each trip. However, the initial success of the 2014 - 2015 program led to the 2016 - 2017 program. Participation decreased from 20 students in 2015 to 13 students in 2017. The lead teacher determined that having an in-depth scuba certification and coral restoration program every year would likely face decreasing interest over time in a small school, particularly in an educational setting that provides a diverse offering of engaging Intensive projects for students. One solution was to invite five students from the inaugural trip in 2015 to serve as student leaders on the 2017 trip to Key Largo. In addition to increasing the number of participants to 18 students, the addition of a leadership

Students outplanting corals © Sara Abbott

component strengthened students' long-term commitment to the Colorado Coralition. Plans are in the works for a third Coralition program in the 2018 - 2019 school year. This program will also ensure returning students play a key role in leading new members of the Coralition.

Major difficulties faced

- Travel costs and logistics, including flights from Colorado to the Florida Keys, rental vehicles, and lodging and meals, required extensive group and individual fundraising throughout the school year to ensure that any student, regardless of socio-economic background, could participate in the Colorado Coralition.
- Facilitating real-world science and partnership with field biologists created demands for educational time beyond the standard class period. Restoration training prior to the 2015 and 2017 trips required creative meeting times, access to/use of technology, and ongoing communication.
- Coral restoration work is fully supported by divers in the water. Therefore, strong storm, wind events, and sea conditions can become a challenge for boats and divers. Conditions caused seasickness and uncertainty in several student divers on both trips. On the 2017 trip, the citizen science monitoring component was cancelled due to surge conditions.
- Despite careful coaching by dive-masters leading each team, some student divers had trouble clearing their ears during descent, making it impossible for them to participate in restoration work. After so much effort to participate in the Colorado Coralition, the inability to participate in restoration work took an emotional toll on these students. Fortunately, all participants completed at least one dive.
- Ongoing restoration efforts face the challenge outplanting coral in continually declining water conditions. Better management and education is needed at a large scale to promote ocean stewardship.

Major lessons learned

- Creative and ongoing fundraising helped ensure that youth from a variety of socio-economic backgrounds could participate in restoration programing. Both Colorado Coralition projects focused on individual and collective fundraising supported by the lead teacher, school administration and office staff, the parent community, participating students, grant writing efforts, and social networking. While designing a rigorous and safe educational program can dominate organizers' time, a fundraising priority from the outset helps promote equitable participation.

- Technology played an essential role in developing this youth-based restoration science program. Wireless fidelity, a webcam, and a microphone helped facilitate virtual conversations between students and experts in the field. Cloud -based programs (such as Google Classroom and Google Drive) enabled the lead teacher to collect, organize, and provide online access to relevant scientific content and initiate collaborative discussions. Digital camera/video devices (such as cell phones, camcorders, GoPros, and 360-degree cameras) and student-friendly video editing and publishing platforms (for example, WeVideo and YouTube) were essential in sharing the Colorado Coralition project with a global audience (see http://bit.ly/divingintodeeperlearning-eled). A robust technology approach helps document learning, generate public awareness, and promote fundraising while supporting 21st century skill development in students. Consequently, material and technical support from educational technology departments, teams, or specialists is invaluable.
- Unpredictable and changing weather conditions can hinder restoration efforts, particularly in marine environments. On the 2017 trip, surge conditions made outplanting very challenging for students new to scuba diving as well as their CRF instructors. A reliance on neutral buoyancy in a fixed location and proximity to other divers was a specific obstacle to a more successful outplanting endeavor. During both projects, students struggled with environmental stressors such as seasickness or problems with equalization. Training participating students (and their families) to expect and accept the possibility of a modified or cancelled restoration experience can help prepare them for this scenario. Trip leaders can also anticipate such situations by including back-up plans for individuals or the group.
- Youth engagement in restoration science is a unique approach to promoting environmental awareness, action, and positive change. Beyond post-release monitoring, measurement of students' ongoing participation in restoration programing and post-secondary studies could provide more insight into the potential long-term impacts of such experiences. Pre- and post-program surveys and interviews could provide quantitative and qualitative data on the environmental stewardship outcomes and the promotion of a new generation of scientists, policy makers, and activists.
- Ongoing, active population enhancement is key for successful restoration work in *Acropora* corals. While habitat restoration work with staghorn and elkhorn corals has evolved over the past several years, there are many emergent restoration techniques for other ESA listed corals, including boulder coral (*Orbicella spp.*) and pillar coral (*Dendrogyra cylindrus*). To best complement restoration efforts, there is much work to be done in protecting and restoring marine environments that include the reduction of those many stressors various coral species face.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- In 2015 and 2017, a total of 32 students (ages 13 - 17) participated in the Colorado Coralition project. Fundraising, academic and diving instruction, and access to experts helped ensure these Colorado students were well-prepared for coral restoration work in Florida. Academic training, diving ability, and robust risk management practices ensured that all students participated safely in dives, nursery maintenance, and outplanting efforts.
- In 2015, students outplanted 100 staghorn coral fragments on Florida reefs. In 2017, despite strong storm surge, students persevered through these conditions to outplant 40 staghorn coral fragments. Coralition students' accomplishments with outplanting complement the broader CRF mission of volunteer-based coral restoration efforts. By September 2017, with the ongoing support of volunteers, CRF outplanted over 11,000 staghorn and 1,800 elkhorn corals.
- CRF integrated the citizen science monitoring program in 2017. Participating students were highly engaged in this training as they learned how to track the health and progress of outplanted staghorn corals. Even though the formal monitoring activity was cancelled due to surge conditions, participants were still able to apply their learning during the final 2017 dive. Students and their lead teacher identified fragments they had outplanted on the reef in 2015. This was a highlight of the trip for all participants, bolstering the presence of citizen science in future programing.
- Students were also able to work with CRF staff in the maintenance of the offshore coral nursery. Students worked in teams to help clean structures, harvest fragments for outplanting, and tag fragments with genetic information. The nursery component provided participants with a more comprehensive understanding of complexities involved in restoration efforts.
- The Colorado Coralition continues to draw interest from new students, educators, and conservation programs. Many Coralition students express a high degree of interest in pursuing degrees in the marine sciences. Restoration science projects continue to be developed and refined at Polaris Expeditionary Learning School. Lastly, ongoing partnerships with CRF, regional outreach programs (Colorado Ocean Coalition), and national conservation agencies (Mission Blue/Sylvia Earle Alliance) is helping foster ocean stewardship and continued success of this youth-based program. In many ways, the growth of the Colorado Coralition project mirrors the work done by the Coral Restoration Foundation. Careful cultivation of student capacity in restoration science helps propagate more than staghorn coral on degraded reefs. Engaging youth in real-world environmental problems promotes meaningful engagement with academic knowledge, relevant skills required for fieldwork, collaborative action with experts, and a shared sense of purpose. It is the hope of the Colorado Coralition that these experiences empower students to go out into the world with the motivation and skills to improve native habitats - and to inspire others to do the same.

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Re-establishing salvaged coral colonies in Hawaii, USA

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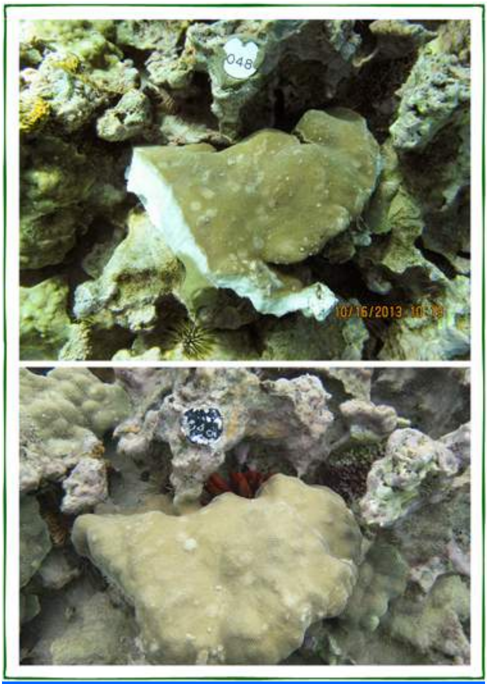
Introduction

Coral reefs offer the highest biodiversity of any ecosystem on the planet, offering home, shelter and breeding grounds to almost 25% of marine life. Anthropogenic activities are having devastating impacts on marine systems, especially coral reefs, with trophic functioning, interactions between species and a spreading loss of biodiversity. Main threats to coral reefs include: 1) increasingly potent storms with frequent run-off events which smother near-shore corals reefs and distress larvae development and settlement, 2) over-fishing of key herbivore species which disrupts the balance between coral and macro algae growth and 3) rising sea surface temperatures (SST), which lead to coral bleaching. Funds were made from multiple sources to make improvements and repairs to piers and rock groins within commercial and Small Boat Harbors on Maui, Lanai, Molokai and the Island of Hawaii. Environmental impact studies indicated a number of coral colonies living in the work zone would be jeopardized. Maui Ocean Center (MOC) was asked to participate in a first time project in Hawaii, which was to help remove the coral colonies from pier pilings and boulders within harbors and relocate them to nearby sites so they would thrive and help maintain the ocean's ecosystem.



Porita lobate **pictures taken before October 2013 (top) and after December 2014 (bottom)**

Main Goals

- Goal 1: Pre-assess at-risk coral colonies within the harbor and identify a potential receiving site.
- Goal 2: Conduct two different studies to determine best method for survivability of salvaged coral fragments.
- Goal 3: Establish transplantation methods that minimize stress to the corals.
- Goal 4: Manage and catalog coral species and develop a system for optimal reef transplant based on most dominant species in the receiving site.
- Goal 5: Perform follow up measurements and documentation for reporting purposes.

Success Indicators

Dredging taking place at the receiving site

- Indicator 1: Successful removal of coral colonies that would otherwise be destroyed during demolition.
- Indicator 2: Colonies successfully relocated and adhered using underwater epoxy to effectively bind corals to the substrate.
- Indicator 3: GPS coordinates and photographs taken to document comparisons with results of any tissue gain or loss.
- Indicator 4: Provide data for future projects that may consider coral transplanting as part of an avoidance and minimization strategy.

Project Summary

Feasibility: The five project sites were located within harbors and either removed the corals from pier posts, boulders, or boat ramps. All coral species are protected under the laws of the State of Hawaii, which is one reason why this project was important. Coral species varied depending on the location of each site but included species such as *Montipora capititata*, *Montipora patula*, *Pavona varians, Pocillopora damicornis*, *Pocillopora meandrina* and *Porites lobata*. Some encrusting corals were fragmented then transplanted near each other at the receiving site. There were also branching corals, which were more easily removed at the base of each coral head. A key focus of the operation was to transport with minimal stress.

Implementation: AECOS, Inc., Division of Natural Resources (DLNR) and MOC representatives surveyed the pier posts and boulders with coral coverage that were slated for partial demolition and removal. A plan was put into place for removal and immediate transplant of the surveyed and chosen coral colonies. Starting in 2012, over the next 1.5 years, a minimum of five MOC dive staff immediately transplanted 317 coral colonies and brought back 392 to MOC for monitoring before transplanting, resulting in a total of 709 individual coral colonies. Monitoring was implemented to compare if immediate transplant was successful versus housing the corals in a controlled environment before transplanting over a five-year timeline. The corals housed at MOC had an open system, pumps, air stones, and fluorescent lighting. Specific tools were used to minimize cross-contamination and were fed a “coral smoothie” (ingredients included *Arthrospira sp*., Selco, mysis) three times per week. Algae control by employees and herbivores (*Ctenochaetus strigosus* and *Acanthurus nigrofuscus*) was utilized. Corals were photographed and documented quarterly, requiring two employees each time.

Post-release monitoring: Several site inspections took place at each receiving site. Three divers were needed; one to locate and clean the tags, one to measure


MOC employees doing underwater documentation of corals, tag clean up and growth comparisons

and photograph each coral colony, and one to record the measurements. Former pictures and measurements were printed on waterproof paper along with an underwater map to help aid with location and comparison. Every tagged coral colony was inspected to determine any tissue loss or gain, mortality or obvious growth. A report was then submitted to DLNR and DOB.

Corals that were transplanted immediately had the following results: 317 coral colonies had a 56% success rate, meaning there were colonies with living tissue still present or significant growth documented. About 29% of corals were found dead on arrival and 29% were missing altogether. Corals that were housed and then transplanted had the following results: 392 coral colonies had a 32% success rate, 46% of corals were found dead on arrival and 36% were missing all together.At the Ma`alaea receiving site, 100% of *Pocillopora sp.,* were found dead. There was complete and unexpected consumption by bioeroding corallivores like the triggerfish (*Rhinecanthus rectangulus*). These fish were not present at the donor site but were abundant at the receiving site. For future transplantation, if it is a viable candidate, it would be recommended to put a cage over each individual colony until it is well established.

Major difficulties faced

- Natural environmental factors like worldwide bleaching events of 2014 and 2015 documented by NOAA (NOAA, 2016), sediment issues, and macro algae competition at the receiving site.
- Dredging at the receiving site in Lahaina, Maui after corals were transplanted; need for better communication and coordination with the local government.
- Some receiving sites were high surge areas, making it harder for the epoxy to adhere and resulting in the use of cable ties.
- Predation of certain coral colonies (specifically *P. damicornis*).
- New chain mooring at the Kailua-Kona, Island of Hawai`i site subsequent to transplant.

Major lessons learned

- The need to use control corals at every site to establish a base line to compare with environmental factors. Also create an underwater map for quicker locations of each groupings.

- More frequent site inspections. This will increase the opportunities for cleaning the coral tag numbers, making it easier to locate during future inspections.
- The receiving site needs to be healthy enough to receive corals and absent of any compromising characteristics such as predators or high wave action.
- Certain species were more resilient, making them more ideal for transplantation success.
- Have public relations on land to educate the public on what is happening and the importance of salvaging corals.

Success of project

Immediate transplant:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Transplant after time within facility:

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

Reason(s) for success/failure:
- Staff knowledgeable on handling/caring for corals.
- Inconsistent site inspections/monitoring.
- Each project lessons were learned which improved the success rate but also compromised the consistency.
- Need dedicated resources or programs.
- Need for an outdoor nursery at MOC before transplanting to help acclimate the corals again to more natural sunlight.

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Conservation introductions of the Running River rainbowfish into Deception and Puzzle Creeks, Australia

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Introduction

Running River rainbowfish (*Melanotaenia* sp.) (RRR) was recently identified as a unique taxon by Unmack and Hammer (2016) and is confined to a 13 km stretch of Running River between two gorges. Running River is a perennial tributary of the Burdekin River in northeastern Queensland, Australia and alternates between a broad valley with a sand based channel and deep gorges with cascades and deep pools. An introduced population of the widespread eastern rainbowfish (*Melanotaenia splendida*) was detected above the uppermost gorge and subsequent sampling confirmed they had moved downstream and were hybridizing with RRR. Thus hybridization is the key threatening process for RRR. Although it has been identified as unique, RRR is not yet taxonomically described and as a result is ineligible for Australian federal conservation listing. However, the Australian Society for Fish Biology listed the species as critically endangered in 2016, following IUCN criteria.

Puzzle and Deception creeks are tributaries of Running River with permanent water which lacked rainbowfish (two other native species were present). They were identified as key introduction sites because they are in the same catchment as RRR, large waterfalls prevent upstream colonization of introduced rainbowfish and they are on land managed by the Australian Wildlife Conservancy.

Goals

- Goal 1: Establishment of two wild, self-sustaining populations secured against introgressive hybridization with other rainbowfish.
- Goal 2: Allelic diversity of new populations represents allelic diversity of broodstock.
- Goal 3: Establish a large captive-breeding group to conserve genetic diversity.
- Goal 4: To demonstrate that conservation actions for smaller species do not require large budgets and that interest groups in the aquarium hobby can substantially contribute to successful conservation actions.

Success Indicators

- Indicator 1: Fish introduced into Deception and Puzzle Creeks survive in sufficient numbers to maintain the genetic diversity that was present within the brood stock.
- Indicator 2: Introduced fish survive to maturity and successfully spawn.

- Indicator 3: Wild spawned offspring successfully recruit within the new habitat.
- Indicator 4: Introduced populations increase in abundance.
- Indicator 5: Fish disperse to entire potentially accessible range.

Running River rainbowfish © Michael Jones

Project Summary

Feasibility: The objective of this project was to prevent extinction of RRR. Although RRR is not commercially important, it is kept by aquarium hobbyists worldwide and its decline grabbed the attention of both national and international aquarium hobbyists. Introgressive hybridization between RRR and eastern rainbowfish is the primary cause for its impending extinction. Due to the nature of the threat, wild translocated populations secured against invasion by other rainbowfish needed to be established as the removal of the exotic population of eastern rainbowfish and hybrids is not possible. Fortunately, the two creeks identified as introduction sites were located on land owned by the Australian Wildlife Conservancy; a private conservation agency which has been a critical partner in the conservation of RRR.

Implementation: In 2015, introgressive hybridization was identified between RRR and eastern rainbowfish. Researchers then took a number of RRR into captivity and transported them to the University of Canberra to be used in a captive-breeding and stocking program for conservation. A crowdfunding campaign was then set up through the University of Canberra foundation with assistance from the Australian New Guinea Fishes Association to raise money to genotype the captive fish. Eighty-four fish were genotyped to identify and remove any hybrids, then set up in spawning groups to maximize genetic diversity in the offspring. Screening identified two F1 hybrids which were removed. From the remaining fish, approximately 4,000 fish were produced and released into Deception and Puzzle Creeks. Fish were raised at the University of Canberra for 2 - 3 months before being shipped to James Cook University in Townsville where they were placed in ponds for grow out before release. Releases into Deception Creek took place between November 2016 and January 2017, while Puzzle Creek releases took place in May 2017. Before being released, fish were kept overnight in a holding net at the release site.

Post-release monitoring: Released fish were monitored using snorkel surveys in the days following release and several months after release for Deception Creek. Short-term monitoring for Deception Creek (up to ~3 weeks after release) confirmed that fish survived and began reproducing. Short-term monitoring also confirmed strong survival of wild spawned RRR in the new habitat.

Monitoring of Running River rainbowfish © Cameron Laird

Follow-up monitoring in Deception Creek in May 2017 confirmed that recruitment had been occurring continuously since their initial release, with the presence of fish less than three weeks old confirmed on the first snorkel survey. Surveys suggested that populations had established and were increasing rapidly. Surveys up and downstream from release sites suggest that fish have moved approximately 2 km in both directions beyond the release reach and should continue to expand in range. No monitoring has been conducted in Puzzle Creek yet, but surveys are scheduled for October 2017.

Some first generation individuals were retained in liquid nitrogen from Deception Creek in May for future genetic work to assess how well genetic diversity has been maintained.

Major difficulties faced

- Rapid change in genetic integrity - decline of RRR was first noticed in 2015 and by 2017 the species appeared to be quite introgressed with eastern rainbowfish.
- As RRR was only identified as a unique taxa in 2015, and was undescribed when conservation efforts were first initiated, the project was not considered eligible for any federal or state funding.
- Without federal or state support, funding for the project was limited.
- While introductions of freshwater fish for recreational and conservation are common worldwide, knowledge regarding the best practices to follow for a successful release is relatively scarce for small-bodied species.
- Remote location of the project.

Major lessons learned

- Lack of monitoring of many Australian freshwater fish species with limited ranges is likely to lead to unnoticed species declines/loss, (the decline of RRR was only noticed fortuitously).
- Declines can be rapid.
- Community support via crowd funding can provide critical resources for conservation actions.
- On ground actions are critical.
- In some instances, government responses are too slow to be effective.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The adaptability of rainbowfish as a group; broad dietary requirements, wide tolerances of environmental variables, high fecundity, young age at maturity and simple spawning requirements.
- Collaborations between the University of Canberra, James Cook University, Flinders University, Macquarie University, Australian Wildlife Conservancy and generous donations from aquarium clubs the world over provided the necessary resources and funding required for this project to be successful.
- Releases in Deception Creek took place during late spring - early summer, a period of increased growth and spawning activity for most rainbowfish species. Releases into Puzzle Creek took place in late autumn, the effect of releasing fish during this period are not yet known.
- Deception and Puzzle Creeks were in near-pristine condition, being situated on a private nature reserve.
- Quick response with financial support from aquarium clubs and individuals around the world via crowd funding provided the critical funds need to conduct the initial genetic work to choose breeders which was critical to success.

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Progress in the reintroduction program of the tequila splitfin in the springs of Teuchitlán, Jalisco, Mexico

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Introduction

The mix of geological complexity and environmental biodiversity among freshwater aquatic ecosystems provides a diverse habitat for fishes across central Mexico. Unfortunately, it is also one of the most polluted and human impacted regions in the world, where the aquatic ecosystems are disappearing, causing the extinction of several fish species. The Tequila splitfin (*Zoogoneticus tequila*) is considered as Critically Endangered in the IUCN Red List and in the Mexican Legislation (NOM-059) list. However, according to our field surveys data it is now considered extinct in its natural habitat in the Teuchitlán river (Jalisco, Mexico). This river presents characteristics that make it a perfect study model regarding research, applicability in ecological restoration and repopulation plans of extinct native fish fauna. The area, although small (<10 ha) provides a variety of different microhabitats, that may increase interest in the recovery of the native aquatic biodiversity, particularly with local communities and international organizations.

Goals

- Goal 1: Develop an educational program locally to promote and enhance environmental awareness of aquatic habitats (Teuchitlán River).
- Goal 2: Identify suitable areas for the reintroduction of native species based on biological, ecological and limnobiological analysis.
- Goal 3: Identify ecological responses of the reintroduced species Tequila splitfin through the study of biotic and abiotic interactions.
- Goal 4: Establish a viable *in situ* population of Tequila splitfin in the Teuchitlán River.
- Goal 5: Implement a long-term-monitoring program for the reintroduced population of Tequila splitfin.

Tequila splitfin © Aslam N. Parra

Success Indicators

- Indicator 1: Establish a natural and viable population of Tequila splitfin in the Teuchitlán River.
- Indicator 2: Create local awareness of aquatic habitats based on the knowledge and interest of natural resources within the local communities.
- Indicator 3: Establish a local monitoring program of water and habitat quality by local people.

Collecting fish from site © Arely Ramirez

Project Summary

Feasibility: This project followed the Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2013) developed by the Reintroduction and Invasive Species Specialist Groups' Task Force. The project has the major support of the Universidad Michoacana de San Nicolás Hidalgo (UMSNH, Mexico) and Chester Zoo (UK). It was funded by The Mohammed Bin Zayed Species Conservation Fund, Haus des Meeres - Aqua Terra Zoo, Poecilia Scandinavia, Poecilia Netherlands, The Missouri Aquarium Society, Deutsche Gesellschaft für Lebendgebärende Zahnkarpfen, British Livebearer Association, Goodeid Working Group, American Livebearers Association, The Mexican Commission for the Knowledge and Use of Biodiversity (CONABIO) and Association Beauval Nature Pour la Conservation et la Recherche.

The founding population for the reintroduction of the Tequila splitfin originates from the captive colonies maintained for the last 15 years in the laboratory of Aquatic Biology-UMSNH. In 2012, before the reintroduction program, 80 individuals (40 males & 40 females) were released into 6,000 m^2 artificial dug-out ponds. The released specimens were exposed to a completely natural environment where the water parameters follow the natural seasonality natural predation (e.g. birds and snakes), parasites, potential competitors and the fluctuation of natural resources (e.g. preys, foraging and reproduction sites). After four years in the ponds, the population was estimated to have increased up to 10,000 individuals. This new population became the source of specimens for reintroduction in to the definitive natural habitat.

During the two years of pre-release monitoring the pond provided valuable information for the evaluation of reintroduction, such as feeding ecology, reproductive biology and the prevalence of parasites.

For the second stage and prior to the reintroduction, we conducted two years of field surveys in the area in order to know limnological characteristics of the

Teuchitlán River. Diversity and population studies of zooplankton, phytoplankton, invertebrates, fish and parasite communities were conducted as well as the potential interactions with the new population of Tequila splitfin. All these results provided important information for the reintroduction process. The results showed that the entire river is rich in phytoplankton, zooplankton and invertebrates, but the benthos is dominated by non-native species. The non-native fish species are more abundant than the native species and are established mainly in the lower parts (downstream) of the river. The habitat quality is better in the upper part (upstream), the aquatic vegetation is more abundant in the middle and lower part. Regarding the above mentioned, we conclude that the upper parts of the river, as well as the springs, are the best potential places to reintroduce Tequila splitfin. Also, we identified that the non-native species, in particular the two-spot livebearer (*Pseudoxiphophorus bimaculatus*) which needs to be removed from the reintroduction area, since this species is a potential competitor for the Tequila splitfin. The parasitical analysis showed a low prevalence, so the parasitic fauna is not a risk for Tequila splitfin.

Implementation: The first stage in the reintroduction process was to remove the exotic fish from the spring where the fish were reintroduced in the first instance. When the spring was free of exotic fish, we also removed parasites from the individuals to be reintroduced using different chemicals (e.g. metronidazole and praziquantel), that were tested to have 100% of success in previous experiments, in order to prevent the introduction of exotic parasites to the habitat. When the fish were free of parasites we released them in to the spring free of exotics and into five 4 m^3 net cages that were used as a mesocosms. During this phase we continued the field surveys, focusing on limnological characteristics, diversity and population studies of zooplankton, phytoplankton, invertebrates, fish and parasite communities and their potential interactions with the new population of Tequila splitfin.

The environmental education program and workshop for local people monitoring biological communities was performed in parallel to the reintroduction. The environmental education program had the main goal of recognizing the importance of conserving and restoring the aquatic environments through conferences, environmental awareness workshops, and educational activities for different ages (e.g. spontaneous performances). Through the knowledge of the resources provided, ecosystem services and the potential use of Tequila splitfin as an umbrella species, using it as local symbol for Teuchitlán in conservation and restoration terms. These activities have been taking place in the town squares and local primary schools. Along the process, six month surveys have been conducted in order to know the impact of these activities locally. After two years of implementing the educational program we found that 75% of the people asked, had an increased awareness of the fish and the importance to conserve the aquatic resources.

The community monitoring plan created local groups with 22 volunteers, trained to monitor environmental variables related to water quality, the use of fish community to obtain the biotic integrity of the habitat such as biotic integrity. This monitoring program provides long-term data that supports the development of the strategies for the conservation management of aquatic habitat and the ultimate reintroduction success. The control of the non-native species started in other springs and upper parts of the river, but we have had only partial success, since the area was large and connected with the La Vega Dam, where non-native species are abundant. Currently we are working on an engineering plan in order to prevent the movement of non-native fish to the upper part of the river, which will be at the next reintroduction site.


Public awareness activities

Post-release monitoring: We are in the first months of reintroduction and the information available for this period is not yet conclusive. We initially reintroduced 629 specimens of Tequila splitfin in to the five net cages and 80 individuals to the spring. During the following three months about 84% of the fish died in the net cages, altogether 65 females and 49 males survived. We also found 84 offspring and 32 females were pregnant. In the spring, 45% of the specimens survived, where 24 offspring and four pregnant females were counted, concluding that the species is capable of surviving and reproducing in the area.

In two cages, some non-native species were naturally introduced, but Tequila splitfin managed to survive and even in spite of their presence reproduced. Two more years of reintroduction experiments are planned, before we have conclusive results of the reintroduction and the interactions of the biotic and abiotic components of the habitat in this newly reintroduced species. However, we consider this project a relative success since the newly reintroduced species is now surviving and reproducing in its natural habitat.

Major difficulties faced

- The existence of a high abundance of non-native species and the difficulties in implementing eradication techniques.
- Funding support for a long-term project.
- The high pressure on water resources related to social and political issues.
- The governmental policies that favor the human development without taking into consideration the natural resources, for example the use and modification of the river for recreational purposes.

Major lessons learned

- Although the genetic diversity in Tequila splitfin population is very limited, this is not a problem for reintroduction success.
- The reintroduction program needs to include an environmental education program and successful communication with local communities and authorities

and the national government for the long-term survival of the reintroduced species.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The introduced specimens can survive and reproduce in the area, but we are in the middle of the project, so more time and monitoring is needed to be sure about the overall success of the final project.

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Re-establishing the three-spined stickleback fish as part of the holistic restoration of an urban lake, California, USA

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Introduction

The three-spined stickleback (*Gasterosteus aculeatus* (stickleback)) is ubiquitous throughout coastal areas of the northern hemisphere and is not considered to be of conservation concern in North America where its west coast range stretches from Alaska to Baja California (NatureServe, 2013). Stickleback are small (3 - 5 cm) and the most common fish found in streams of San Francisco Bay Area, California, USA (Moyle, 2002). The species was the only native fish ever recorded at Mountain Lake, San Francisco's Presidio National Park. With a surface area of ~5 acres and an average depth of 2 - 3 m, the lake has undergone significant ecological changes throughout the 20th century.

Ecosystem function deteriorated and many native species were lost, including stickleback, last recorded in 1928. In the early 21st century upland restoration began and over the last four years expanded to include the aquatic system. Stickleback are essential to the holistic restoration as the species is interconnected to various ecological goals. For example, stickleback will serve as the host fish of the obligate parasitic larvae of the native freshwater California floater mussel (*Anodonta californiensis*) (Moles, 2007), a concurrent reintroduction project. Additionally, stickleback will play a role in enhancing tangible benefits to the local community such as mosquito abatement.

Goals

- Goal 1: Establish a self-sustaining population of stickleback.
- Goal 2: Eradicate invasive fishes.
- Goal 3: Sustained or reduced baseline mosquito abundance/public complaints once eradication of invasive mosquito fish (*Gambusia affinis*) occurs.
- Goal 4: Establish necessary host fish for *Anodonta* mussel life-cycle.

Three-spined stickleback with white dots on the fin edges which are parasitic larval mussels


Mountain Lake release site in 2017

- Goal 5: Bring conservation action to an urban audience.

Success Indicators

- Indicator 1: Stickleback breeding confirmed within 1 - 3 years.
- Indicator 2: No non-native fishes consistently confirmed present through time post-eradication action (i.e. rotenone application).
- Indicator 3: No significant increase in potential disease-carrying mosquito species or public complaints received regarding mosquito issues.
- Indicator 4: Stickleback confirmed naturally inoculated with larval mussels within 4 - 7 years post-mussel release.
- Indicator 5: Reach 10,000 members of the local community via “Protect Mountain Lake” pledge campaign (e.g. “I pledge to not release unwanted aquatic pets…” etc.) in five years.

Project Summary

Feasibility: As inflow/outflow connectivity to a near-by source population was lost in the 20th century due to highway construction, natural re-establishment of stickleback was not possible. Being a locally common species with high breeding rates and short generational turnaround (Moyle, 2002) stickleback exhibit ideal characteristics for rapid establishment. However, identifying and addressing the drivers of extirpation proved to be complex. Several point source runoff inputs (i.e. highway and golf course) were identified as impacting water quality and ecosystem health, which certainly had negative impacts on stickleback (e.g. low dissolved oxygen, poor water clarity, lead and other contaminants of concern associated with automobiles). While high densities of invasive fishes such as habitat degrading common carp (*Cyprinus carpio*) and predatory largemouth bass (*Micropterus salmoides*) also would have put pressure on the historic stickleback population directly and indirectly. Invasive mosquito fish (*Gambusia* sp.) were historically stocked in the lake for mosquito control. Although *Gambusia* eradication would benefit native wildlife, the public expressed concern about potential mosquito issues. Chemical eradication of the invasive fish community was identified as the only realistic management option, however, the use of a piscicide (rotenone) is controversial, especially in an urban area. The presence of the invasive red swamp crayfish (*Procambarus clarkii*) was identified as a potential threat to the reintroduction and overall restoration success, however, it was understood that rotenone would not eradicate this species at the concentration determined appropriate for the target fishes (Holdich *et al.*, 1999).

The location of the project site crosses several jurisdictional boundaries that include Federal, State, and City agencies. In addition, the identified stickleback source population, similar to the lake, was located within the Presidio National Park, however, unlike the lake that is managed by the Presidio Trust (Trust), a federal agency, the source population is managed by the National Park Service (NPS). A target collection goal of 1,000 individuals was agreed upon between the Trust and NPS in order to minimize genetic bottlenecking and improve likelihood of rapid reproductive success (Ewen, 2012). Finally, the Trust's robust environmental education and volunteering programs were identified as a means to interpret this project and provide the local community with participation opportunities in order to increase conservation awareness will bolstering public support of the larger restoration project.

Implementation: Point source runoff was addressed by a number of means, including bioswale catchment construction around golf course/storm water inputs and improving/re-directing highway drainage into the local sewer system. Meanwhile, two years of planning, involving numerous stakeholder groups and various State, Federal, and City agencies resulted in the successful application of rotenone and the complete eradication of all invasive fishes present. Six months after rotenone application, with the support of NPS, stickleback translocation began. Stickleback were opportunistically collected at the source site with seine nets and minnow traps, transported to the lake, placed in porous buckets within the shallows and allowed several hours to acclimate before release. Over the course of 10 months 1,100 individuals were ultimately released into the lake. Efforts were made to reduce handling and stress to the fish as much as possible during translocation. Local community members, school groups, and media outlets were invited to participate in the releases.

Post-release monitoring: The monitoring protocol involved a combination of standardized and opportunistic methods. Timed visual searches along the shoreline provided an index of survival and abundance, hand netting for identification occurred when necessary. Non-baited minnow traps placed at even intervals around the lake's shallow habitat supplemented visual observations and allowed for the confirmation of species identification and reproductive status. These traps also served as an early detection for non-native fishes as well as an index of crayfish abundance. Crayfish numbers underwent a drastic increase after the removal of the predatory bass, which triggered the management action of more intensive trapping. As predicted, no stickleback were visually seen or captured within the first year of release due to low detectability relative to the size and complexity of the lake (e.g. dense shoreline emergent vegetation). However, beginning in the second spring following release, several young-of-the-year were captured in traps. After the third year, stickleback were regularly seen in most of the shallow habitat and found in minnow traps throughout the lake, including various stages of development, with clear signs of high reproductive success. Within two years of rotenone application, exotic bullhead catfish (*Ameiurus* sp., not previously observed at the site), were found in the lake, which has triggered ongoing mechanical removal. In the three years following rotenone application there has been no significant increase in mosquito abundance or public complaints regarding mosquito issues.

Community stickleback release

Major difficulties faced

- Public outreach and changing perception of restoration, management actions, and the issues associated with the releasing of unwanted aquatic pets into natural water bodies.
- Getting stakeholder buy-in and obtaining the multitude of required permits for the use of rotenone in an urban area.
- Navigating and coordinating the jurisdictional complexities of the site.
- Addressing the public's concern for potential mosquito increases and articulating the ultimate vision of a healthy functioning ecosystem with natural checks and balances.
- Designing, funding, and building the infrastructure to address point-source nutrient/contaminant inputs. All the while coordinating with both highway and golf course managers.

Major lessons learned

- The release of aquatic pets is primarily driven by a general lack of public understanding regarding ecological impacts and the lack of an accessible public repository for these unwanted animals. Overcoming these barriers is key to minimizing introduced exotics. Accepting that exotic introductions may be ever-present in urban areas while having a clear plan in place to monitor and rapidly address when needed.
- Obtaining both stakeholder buy-in and the necessary permits/support for rotenone application required a tremendous amount of time and energy. Planning accordingly, well in advance, allowed for flexibility, patience, and thoroughness.
- Much of the success of this reintroduction is not immediately visible to the public without interpretative signage and other forms of outreach. Developing a strategy/plan well in advance was key in achieving Goal 5 above.
- Complete eradication of crayfish is currently functionally impossible, however, population reduction is relatively straightforward, but requires constant trapping vigilance.
- Comprehensive monitoring of the lake, including biotic and abiotic parameters, not only provides management guidance, but is also key in demonstrating restoration progress to stakeholders. Plan accordingly well in advance in order to obtain solid baselines.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- High reproductive rates and short generation times of focal species.
- Clear coordination and communication with various agencies across jurisdictional boundaries and support from the local community.
- Well-planned reintroduction methods and education/outreach programs.
- An onsite "Aquatic Pet Amnesty Drop Box," including ample interpretive signage in several languages, has successfully intercepted numerous invasive species before being released in the lake.

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Reintroduction of the trout cod in southeastern Australia: perseverance pays off

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Introduction

Trout cod (*Maccullochella macquariensis*) is a charismatic Percichythid fish of the Murray-Darling Basin (MDB) in southeastern Australia. The MDB is home to >2 million people, covers 1,055,600 km^2 and is Australia's 'food bowl'. Agricultural production in the MDB is on average 35 - 40% of the total gross value of Australia's agricultural production with irrigated agriculture using over 80% of the water resource. Trout cod is a relatively long-lived (>20 years), large bodied (max. size 16 kg and 850 mm total length) apex predator strongly associated with instream structural woody habitats, which exhibits limited movements, especially as adults. Although long suspected as a distinct taxon, it was only formally described as a species different to Murray cod (*M. peeli*) in 1972. It is now recognized as one of four cod species in *Maccullochella*, all of which are formally listed as nationally threatened. Trout cod is listed as endangered nationally, and in each State/Territory in which it still occurs (New South Wales (NSW), Victoria (Vic), Australian Capital Territory (ACT) (Lintermans *et al*., 2005). The species is also listed as Endangered (C2a) by the IUCN and by the Australian Society for Fish Biology.

Goals

- Goal 1: Develop hatchery breeding programs for trout cod to provide juvenile fish for reintroductions.
- Goal 2: Establish additional self-sustaining populations of trout cod throughout its range.

Trout cod © Gunther Schmida

- Goal 3: Conserve the two key trout cod populations in the Murray River and Seven Creeks.
- Goal 4: Rehabilitate habitat for trout cod at selected sites throughout its range.
- Goal 5: Undertake research to provide new knowledge to support conservation management.

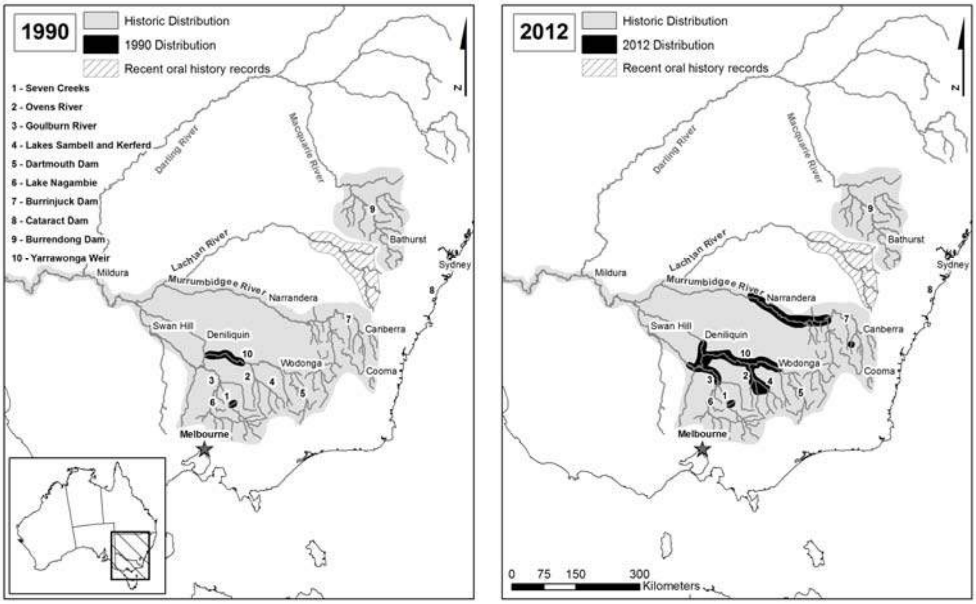
Success Indicators

- Indicator 1: Hatchery programs exist that regularly produce fingerlings for stocking.
- Indicator 2: Fish are stocked in suitable locations across the species range.
- Indicator 3: Self-sustaining populations are established in all jurisdictions within current range.
- Indicator 4: Successful habitat interventions occur that support self-sustaining and stocked individuals.
- Indicator 5: New knowledge for key ecological parameters to support for trout cod conservation.

Project Summary

Feasibility: Trout cod previously occurred across much of the southern MDB from ~200 - 900 m elevation. The species was a popular target for recreational fishing and not easily distinguished from Murray cod by anglers. The species declined dramatically over two decades post 1950 as a result of river regulation; habitat destruction and removal; introduction of alien fish species such as carp (*Cyprinus carpio*) and redfin perch (*Perca fluviatilis*); and overfishing (both commercial and recreational) (Koehn *et al.*, 2013). Rivers in the southern MDB became increasingly regulated post-WW2 with the construction of weirs and dams for irrigation. By 1990, trout cod had been reduced to a single natural population along approximately 50 km of the Murray River and two historic translocated populations: one within its natural range along 10 km of Seven Creeks; and one in a coastal drainage outside the natural range (Cataract Reservoir) - see figure 1. Trout cod was one of the first freshwater fish species formally listed as nationally endangered in 1980. However, it was not until the mid

Figure 1. Changes in trout cod distribution showing the former widespread historic distribution, the decline to just two locations by 1990, and the extent of range recovery by 2012 (from Koehn *et al.*, 2013).



Installing woody habitat © Martin Casey

-1980s that recovery efforts commenced, with two state fisheries agencies (NSW and Victoria) conducting research into hatchery breeding and commencing restocking programs.

Implementation: The first national recovery plan for trout cod was completed in 1994, with subsequent plans published in 1998 and 2008. These plans have driven and coordinated a range of management interventions across this extended timeframe. An important early action was the legislative protection from recreational harvest through fishing closures and regulations on the two remnant populations, and the provision of education materials that allowed anglers to distinguish between the morphologically similar trout cod and Murray cod. A targeted research program provided important information on breeding requirements in captivity (for hatchery production), movement ecology and habitat use. Captive-breeding programs were undertaken with regular, small-scale stocking from the late 1980s. Production increased significantly in the 1990s with an average of 109,350 fingerlings stocked annually between 1996 and 2005 across its range. Production has since declined (on average 32,450 stocked annually from 2006 - 2016) but by 2016, >1.71 million hatchery-bred fingerlings had been released. The stocking program was aided by the development and use of a population model and a structured stocking regime. Habitat rehabilitation occurred through the reinstatement of structural woody habitat at many sites in the MDB, and along with provision of environmental water, increased fish passage, improvements to river health, and education and enforcement programs funded by a variety of agencies, have all built on the early management activities.

The formation of Australia's first Freshwater Fish Recovery Team was critical to a coordinated recovery program, and contained a mix of state and federal scientists, hatchery biologists, managers and conservation organizations that shared information, discussed problems, and forged common approaches. Unfortunately, national funding for management actions and meetings of the Recovery Team ceased in the early 2000s. Since 2012 there has been a diversification of hatchery objectives to include the establishment of recreational fisheries for the species in nine NSW impoundments and two Victorian lakes. Unfortunately, hatchery production has not increased to accommodate this extra demand for fingerlings, with many hatchery-produced fingerlings now used to establish these recreational fisheries. The return of trout cod as a recreational fishing target is supported in the long-term, but hatchery production of fingerlings must be increased to establish further populations to reduce conservation risk and avoid impacts on the existing stocked populations.

Post-release monitoring: Regular monitoring of the status of the two remaining wild populations and hatchery releases commenced in the early 1990s, with the primary aim of detecting survival of stocked fish and then any wild recruitment in these populations. In the early years, relatively small numbers of stocked individuals were detected; not surprising given the initial small numbers of fish released annually, and potential movement of individuals away from the stocking sites. *Ad hoc* angler reports provided valuable indications that stocked fish were surviving and growing. There was no evidence that any of the wild populations were continuing to decline, although emergency interventions were required after bushfire threatened the population in the Seven Creeks catchment. The Murray River population appears to be more abundant than originally thought with evidence of expansion. Wild recruitment has been detected in a number of catchments (Goulburn, Ovens, Mid and Upper Murrumbidgee, Cotter) between the late 1990s and mid 2000s (Lyon *et al.*, 2012; Koehn *et al.*, 2013). Comprehensive monitoring of the lower Ovens River demonstrated the benefits of a long-term stocking program, with wide variation in the contribution of individual stocking events to the resultant population (Lyon *et al.*, 2012). Genetic analysis of upper Murrumbidgee cod larvae from 2011 - 2013 found hybridization between Trout cod and Murray cod, (Couch *et al.*, 2016) demonstrating the problem of re-establishing a threatened species into the range of an established congeneric.

Major difficulties faced

- Ensuring adequate threatened species funding for a recovery team and the application and monitoring of management actions.
- Transitioning from small-scale (temporal and spatial) stockings to large, longer -term, more successful stocking programs.
- Sustaining hatchery production in the face of resource constraints and competing demand for hatchery facilities (for other recreational species) and the diversion of hatchery fish to the recreational trout cod fisheries without additional resources to secure conservation programs.
- Obtaining angler recognition that reintroduction is a long-term process that extends beyond simply releasing hatchery-bred individuals (i.e. regular natural recruitment is required before fishing restrictions can be relaxed).
- Unforeseen climatic threats to recovery program (a millennium drought) which set back the project as harsh environmental conditions led to partial loss of some stocked populations though unexpected fish kills.

Major lessons learned

- Recovery of a large-bodied, long-lived, late-maturing species takes considerable time.
- Availability of dedicated hatchery breeding programs has been essential.
- Existence of long-term monitoring programs and development of a population model and adaptive management has allowed refinement of reintroduction approaches .
- Explicit consideration of natural (but extreme) environmental perturbations such as drought should be part of reintroduction planning.
- The acquiring of key ecological knowledge and the coordination by a national recovery team allowed for a strategic and dedicated approach to species' recovery.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- A coordinated, multi-jurisdictional approach across the species range.
- An extensive scientific research program to fill ecological knowledge-gaps for the species.
- Availability of hatchery facilities to produce fingerlings for reintroduction.
- The development of a population model to guide reintroduction strategies.
- Long-term commitment by individual scientists and conservation managers.

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Trial reintroduction of the endangered yellow spotted mountain newt in western Iran

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Introduction

The yellow-spotted mountain newt (YSMN) (*Neurergus microspilotus*) (Caudata: Salamandridae) is listed as a Critically Endangered by IUCN because of its very small area of occupancy in its breeding streams (<10 km^2), fragmented habitats, continuing decline in the extent and quality of aquatic habitats, habitat degradation, drought, and the pet trade (Sharifi *et al.*, 2009). YSMN has been recorded from 42 highland streams in the mid-Zagros Range in western Iran and eastern Iraq. Most localities inhabited by YSMN are located in the southern portion of the geographic range with 81% of localities in Iran and 19% in Iraq and over 50% of localities are located at border areas between the two countries. In aquatic habitats, the YSMN is a high predator of diverse benthic macroinvertebrate communities (Farassat & Sharifi, 2014). This newt lives long with reported a 14 years' longevity and reaches sexual maturity at about 3 - 4 years. Surveys in 32 of the 42 localities within the Iranian range have yielded in 1,379 visual counts of adult, juveniles, and larvae in 5.5 km of stream reaches. Most of the observed newts (51%) were found in just two localities, 44% in 14 streams, and the remaining 5% were scattered among 16 streams (Afroosheh *et al.*, 2016).

Goals

- Goal 1: To demonstrate that YSMN can live, grow, mate and reproduce successfully in captivity.
- Goal 2: To apply a multi-criteria decision analysis alongside with a geospatial analysis for the selection of streams which are located in general distribution area of YSMN but do not have YSMN.
- Goal 3: To demonstrate that post-metamorph juveniles of YSMN bred and raised in the breeding facility can overwinter in a selected stream with a reasonable survival rate.

Success Indicators

- Indicator 1: To have developed a successful captive husbandry and reproduction leading to high rate of hatching, low mortality of larvae and post-metamorphs and stable growth rate in the YSMN rearing in the captive-breeding facility.
- Indicator 2: Have established viable stocks of mealworms (*Tenebrio molitr*), *Artemia* sp. and earthworms (*Lumbricus terrestris*) needed for different life stages of the YSMN living in the captive-breeding facility.

Yellow-spotted mountain newt

- Indicator 3: Demonstrated by a trial reintroduction that post-metamorph captive-bred released into the wild can survive to the second growing season, and provides a choice of life-stage for a reintroduction program.

Project Summary

Feasibility: The YSMN has been in continual decline in recent decades as a result of increased human population and extensive land-use alteration. Diversion of water from highland streams to orchard and agricultural lands in conjunction with disturbing impact of climate change have caused many springs and small streams to be completely dehydrated. Various diseases including *Batrachochytrium dendrobatidis* have been reported for this newt presumably as a result of poor water quality and quantity (Sharifi *et al.*, 2014). In 2010, the Mohamed bin Zayed Species Conservation Fund helped to develop and implement a conservation management plan for YSMN. Part of this plan included the development of a captive-breeding facility at Razi University, Kermanshah, Iran. The ultimate goal of the captive-breeding program was to provide stock and increase the species' population size across different breeding streams to ensure their long-term survival and release of captive-raised YSMN to their habitat. In establishing the captive-breeding facility and performing the subsequent trial reintroduction, individuals from different breeding streams were kept separate in order to avoid genetic interaction. The reintroduction site identified by application of a multi-criteria decision analysis (MCDA) in a GIS format.

Implementation: The captive-breeding facility for reintroduction of YSMN began with allocating a 5 m long × 2.5 m wide × 3 m high room at Razi University. Additional space was available for eggs and larvae. The CBF was ventilated by an air-conditioner that recirculated the indoor air and each aquarium included terrestrial habitat in the form of small pebbles collected from the wild. The aquaria contained some aquatic plants for egg attachments and hiding opportunities. The suitability of different potential reintroduction sites was assessed against several criteria, i.e. degree of isolation from human settlements, proximity to a benthic macroinvertebrate community, submerged vegetation cover, water temperature, altitude, and land use along the stream. We examined the morphology of springs and streams, as well as their vegetative composition and structure. Among five sites investigated, the Mivan Spring was selected for a trial reintroduction of YSMN (Sharifi & Vaissi, 2014). This spring immediately joins Mivan Stream, which contains a well developed submerged periphyton vegetation. Along the stream there are also well-established emergent and marginal plant communities. For the reintroduction, the largest individuals of similar age (5 - 7 mm) newts were

Captive-breeding facility

considered to be of sufficient size to withstand predation by crabs (*Potamon bilobatum*), toads (*Bufo bufo*) and water snakes (*Natrix natrix*).

This trial reintroduction was an intentional release of captive-bred individuals inside their indigenous range. Our ultimate objective was to determine not only an optimum choice of life stage for a reintroduction program but also an optimal size and age based on a cost-effective evaluation of the reintroduction to the wild. The present trial reintroduction demonstrated that young-of-the-year captive-bred YSMN released into the wild can survive to the second growing season and may be a choice for a reintroduction plan. Observed post-overwintering visual counts gave an estimated average survival rate of 20.5% of the total number reintroduced. This preliminary result suggests that an expensive control of predator populations before large-scale releases may not be required. The experiment also demonstrates that it may be more effective to release post-metamorph rather than adult newts. The slow growth rate of YSMN means that newts would have to be maintained in captivity for a longer period. Moreover, maturation at age three or four slows down the build-up of stock available for a reintroduction and increases the expenditure per released newt. Additionally, in the case of a very long captive period, especially if individuals become mature in the captivity, adaptation to the captive life may cause negative impacts on the fitness of the reintroduced individuals.

Post-release monitoring: For identification purposes, each individual was photographed using a fixed tripod in order to use the photographic identification procedure used for this species. Post-metamorphic juveniles were released in the spring on four occasions (Sharifi & Vaissi, 2014). The newts selected for the trial reintroduction were given a visual health screening (skin slough and wound) and behavioral examination (viability and responsiveness to stimulus) to ensure they were healthy. The probability of released newts contracting an infection was considered very low because the release was planned for a site that no longer contained free-ranging newts. In 12 visits to the site before and after overwintering, a total of 31 individuals were identified. Based on an average diurnal detection probability for this newt (0.61 ±0.19 SD), the observed newts during the pre-overwintering period gave a survival rate of 20.5 of the reintroduced newts (Sharifi & Vaissi, 2014).

Monitoring of newts at release site

Major difficulties faced

- The YSMN is a poorly know species and the captive-breeding facility provided opportunities to gather information on reproductive biology of the species but there are still many important questions that should be answered.
- Sexual maturity at age 3 - 4 years, low number of eggs per female (up to a hundred), slow development and low rates of growth are major inherent difficulties encountered in a captive-breeding and reintroduction program for YSMN.
- High cost of infrastructures for a good husbandry for very long time before a captive-breeding facility begins producing adequate number of eggs, larvae, juveniles or adults. Such infrastructures are not available in zoos in developing countries and universities and other agencies are not willing to invest.
- Academic research is essential, but not adequate, to demonstrate that a proposed management action plan can work.

Major lessons learned

- We learned and published about various aspects of reproduction biology, food habits, cannibalism, effect of temperature, density, spatial diversity, water level and food quantity on growth of YSMN, spot ontogeny, disease, complete spatial randomness (CSR) in spots, life table dynamics, genetic diversity, life cycle choices for reintroduction (under investigation) and trial reintroduction in YSMN.
- Success depends on close cooperation among diverse agencies and stakeholders, who agree on common goals. Such cooperation develops slowly and depends on individuals from different agencies and groups to make sure it works.
- An efficient captive-breeding able to reintroduce significant number of offspring regularly is likely many years away because of the difficulties of dealing with many diverse factors influencing YSMN.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Completion of reproductive cycle of YSMN in the captive-breeding facility.
- Learning more about disease in this species and reporting such as *Batrachochytrium dendrobatidis* (Sharifi *et al.*, 2014).
- Applying suitability analysis for identifying potential reintroduction streams for reintroduction of YSMN using GIS-based sitting procedure.
- Witnessing how post-metamorph captive-bred YSMN when released to a selected site were able to withstand the harsh winter in the area with a good survival rate.

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Lessons learned from the reintroduction of the Chinese giant salamander

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Introduction

The Chinese giant salamander (*Andrias davidianus*) is the world's largest amphibian and is endemic to China. The species was once widely distributed in all three major river systems in central and southern China and has been found in various water bodies including streams, rivers, and underground waterways in karst caves (Wang *et al.*, 2004). Due to habitat destruction, water pollution and over-exploitation for its flesh, the species has suffered an 80% population decline since the 1950s (Liang *et al.*, 2004). In 2004, it was listed as Critically Endangered by the IUCN Red List, making it one of the most threatened amphibians in the world. In China, it was listed as a Class II Protected Species in 1989, which prohibits by law the collection of wild salamanders. However, wild populations do not appear to be rebounding due to continued threats and without restocking efforts the recovery of salamander populations might be slow, given their rarity and long generation intervals (sexual maturity occurs at 6 - 8 years or longer). Thus, captive-breeding and reintroduction are possible conservation strategies for restoration and recovery of wild populations and down-listing from its current threat level. To test this theory, our team released 31 salamanders into two head-water streams in Shaanxi Province in central China and monitored their survival and movement for one year using radio-

Chinese giant salamander

telemetry and passive integrated transponder (PIT) tags. The goals of this project are listed below.

Goals

- Goal 1: Evaluate survivorship and compare morphometric variables of post-release animals, following capture-recapture, to wild-caught conspecifics.
- Goal 2: Identify environmental variables and habitats that are selected by released giant salamanders.
- Goal 3: Assess post-release migration distances, linear home range sizes, activity, and compare seasonal movement patterns.
- Goal 4: Raise local awareness of giant salamander conservation through releasing ceremonies and local field assistant training.

Success indicators

- Indicator 1: Radio transmitters would work normally for at least one year, enabling data collection on the salamander’s reintroduction.
- Indicator 2: More than 50% of released individuals survived the first year and experienced growth similar to conspecifics.
- Indicator 3: Animals that survived had a period of settlement and chose habitat similar to wild animals.
- Indicator 4: Salamanders established territory and followed seasonal movement patterns similar to wild animals.
- Indicator 5: Increased local awareness of giant salamander conservation, such that no poaching happened during the reintroduction study.

Project summary

Feasibility: Over the past 20 years, the high market price of giant salamander meat has invoked a rapid development of a salamander farming industry. Approved by provincial fisheries bureau, these farms are expected to help generate income for rural families and support local villages. Some farms have gained sufficient experience rearing these salamanders that reproduction has become very successful in recent years (Cunningham *et al.*, 2016). Thus, salamander farms could provide a large and stable source population for reintroduction programs throughout the country if managed correctly.

In 2009, a partnership was established between Shaanxi Institute of Zoology, Memphis Zoo and Mississippi State University to conduct a reintroduction project of captive-reared Chinese giant salamanders into the wild in Shaanxi Province. This project represents a positive model for the conservation of China’s aquatic ecosystems that works with local industry, which is perhaps the only hope for biodiversity in many cases. We are hopeful that this project will serve as a positive example to inspire other conservation initiatives across China, especially those dealing with threatened aquatic species.

Implementation: The two head-water rivers selected for reintroduction were the Heihe and the Donghe rivers in the Qinling Mountains. The Heihe River, on the north slope of the mountains, belongs to the Weihe River watershed, which is the largest branch of the Yellow River. The Donghe River, on the south slope of the Mountains, belongs to the Hanjiang River watershed, which is the largest branch of the Yangtze River. Wild Chinese giant salamanders were abundant in these

Recapturing giant salamanders

two rivers in the past according to local villagers; however, they have rarely been observed in recent years.

Thirty-two juvenile giant salamanders were purchased from two farms within the Qinling Mountains for this reintroduction study. Half the animals were collected as larvae from the wild and head-started in captivity; whereas, the other half were born in captivity from stock that was collected from our release site. The Heihe group of released salamanders were about three years old with body mass that ranged from 0.36 - 1.14 kg; whereas, the Donghe group of salamanders were about five years old at release with body mass ranging from 1.10 - 2.34 kg. In March 2013, all salamanders were surgically implanted with VHF radio transmitters and PIT tags for identification and tracking (Marcec *et al.*, 2016). Half the salamanders were released six weeks post-surgery into the Heihe River, while the Donghe River group were release 16 weeks post-surgery. One salamander from the Heihe group died before release because of dehiscence of suture and several more cases were observed afterwards in the river, prompting the later release of animals into the Donghe River so they could fully recover.

Post-release monitoring: Two field assistants from local communities were trained to monitor the reintroduced salamanders at both sites. Animals were located every day through radio telemetry and presence/absence checked using an under-water inspection camera occasionally. Monitoring continued until the battery life of transmitters died (the last radio signal was collected in September 2014). Near the end of the study, recapture of all living individuals was attempted before the radio signals disappeared. We recorded body mass, snout-vent length, total body length, any abnormalities and external parasites for all recaptured salamanders to compare to their pre-release morphometric data, and compared to wild caught conspecifics. Once all measurements were completed, salamanders were released at the same location where they were caught.

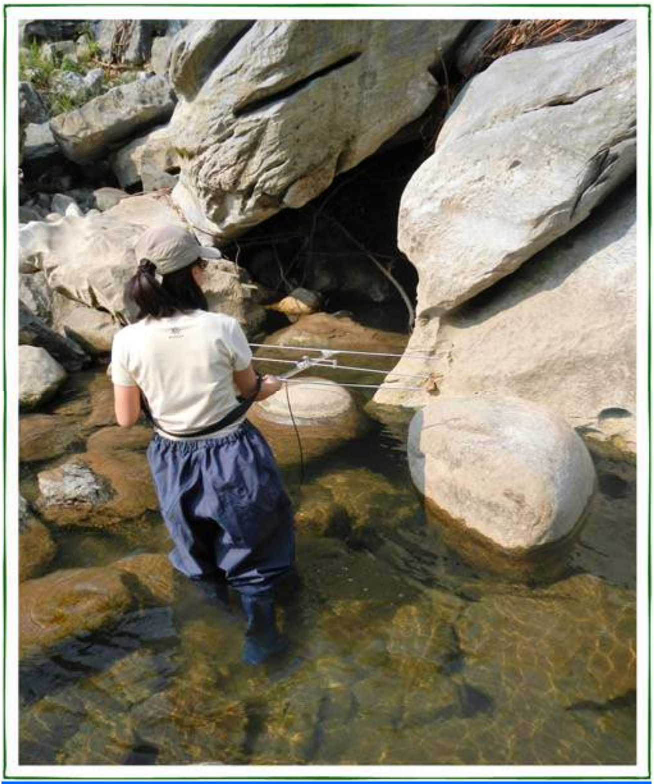
Survival rates of the two groups of salamanders were calculated and we also identified the most influential factors on their survival. The Donghe group had an annual survival rate of 0.7 in their first year in the wild, which was comparable to wild and reintroduced hellbenders (Bodinof *et al.*, 2012). However, the younger group of animals at Heihe River had a much lower survival rate of 0.4, largely because of the dehiscence of suture sites following release and several large floods that washed the animals downstream beyond detection. Salamanders would have had a higher survival rate if they had a longer recovery time from surgery. For those salamanders that survived and were recaptured, they all increased in body mass and total length after a year in the wild and they were only 7% lighter than wild animals of the same length (Zhang *et al.*, 2016). Habitat selection analyses confirmed that large boulders were the most important environmental variable to post-release settlement for reintroduced salamanders (Zhang *et al.*, 2017). Salamanders were able to move long distances, up to 880 m/in a single day; however, they usually made short-distance movements of ~10 m/day. They moved more frequently than hellbenders, with an overall sedentariness smaller than 0.3. The annual linear home range of these salamanders were about 300 m. Salamanders showed different movement patterns across seasons, such that they had a higher sedentariness, shorter daily movement, and smaller linear home range in winter than in summer (Zhang *et al.*, in prep).

Major difficulties faced

- The surgically implanted radio transmitters worked well on giant salamanders; however, it took too much time for salamanders to recover from surgery (need almost four months to fully recover). If not given enough time to recover, salamanders may experience dehiscence of suture sites after release and die soon thereafter. Furthermore, internal transmitters only last for about one year and it is difficult to replace expired transmitters with new units, thus longer monitoring plans could not be applied.
- Flooding shortly after the first release negatively impacted our smaller animals such that many of them were injured or moved beyond our ability to locate them.
- The two rivers chosen as release sites by the Provincial Fisheries Bureau were outside of any protected areas such that poaching could be a threat to our released animals now that the study has concluded.

Major lessons learned

- Captive-reared Chinese giant salamanders, even though they were raised for commercial use, could survive over a year following release with an annual



Radio-tracking giant salamanders

survival rate comparable to wild or captive-reared hellbenders reintroduced to the wild.

- For juvenile giant salamanders, older individuals may survive better than younger animals, considering their better recovery from surgery and higher resistance to floods.
- Newly released salamanders are susceptible to floods, especially younger individuals. Floods may cause injuries or long-distance movements downstream away from suitable release sites; thus, reducing salamander survivorship. It is better to release salamanders in autumn, when the rainy season is over.
- Large boulders are the most important variable selected by salamanders for settlement; thus, habitat structure providing appropriate cover should be carefully considered when selecting release sties.
- Captive-reared juvenile giant salamanders have a relatively high fidelity to release sites and are tolerant of conspecifics, which may contribute to the re-establishment of a population in the wild.
- Release sites outside of protected areas can support reintroduced giant salamander populations for short time periods; however, they remain at a high risk of poaching. It will be difficult and impractical to apply longer conservation plans outside of protected areas, considering logistics, manpower, funds, and poaching pressure. Soliciting permission to release salamanders in protected areas should be a future goal of the reintroduction program.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Chinese giant salamanders are long-lived amphibians and mature at 6 - 8 years old. To establish a self-sustaining wild population this needs to be a long-term project with continued reintroductions, monitoring, funding and support from both government and the private farming industry. Our project was the first step to show that captive-reared giant salamanders are suitable for reintroduction, but we are still far from claiming that this reintroduction was successful as viewed through the lens of a self-sustaining and reproducing wild population. We do not have any data to support this with the limited number of animals released and limited monitoring period.
- The two rivers selected as release sites had good water quality, abundant fish and invertebrates for salamanders to prey on, and plenty of large boulders for them to hide beneath. In addition, natural predators were probably extirpated from our two sites, such that there was very little threat to them outside of poaching. Hence, quality of the habitat helped with the success of the project.
- The two field assistants trained to monitor salamanders were leaders of the local communities. Villages near our release sites were fully aware that we released salamanders into the rivers and that they were being monitored by community leaders; thus, poaching was minimized during this project. Hence, community buy-in to the project helped with the success of the project.

- The final fate of released salamanders could not be determined because funding was limited to continue monitoring work past a year once the radio signal failed. Regular funding, e.g. support from related governmental agencies (Federal, Provincial and County), should be acquired for when new reintroduction projects are planned, such that more animals can be released and long-term action plans toward monitoring can be established.

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Reintroduction of the pool frog to the United Kingdom

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Introduction

The pool frog (*Pelophylax lessonae*) is found through much of central and northern continental Europe. Its global IUCN Red List category is Least Concern. However, some populations in the far north of the range have been found to be genetically and phenotypically distinct, representing a northern clade. This form was once found in the United Kingdom but was generally considered to be an introduction. It was only in the late 20th century that its status was investigated thoroughly, and in the early 2000s compelling evidence emerged to demonstrate that the species was in fact native. By this time the last known population had gone extinct. The reintroduction was planned for a confidential location in the county of Norfolk, in the east of England, the same region where the last native population occurred, using northern clade stock from Sweden. At the time of reintroduction planning, the species was listed as a national biodiversity priority and remains so. It now has a high degree of legal protection, but it was not protected at the time of reintroduction.

Goals

- Goal 1: To establish a viable population of northern pool frogs in the UK at a suitable site within their UK historical range.
- Goal 2: To assess the effectiveness of amphibian reintroduction using wild-to-wild translocation.
- Goal 3: To assess the impacts of reintroducing pool frogs on other co-existing species and habitats.

Success indicators

- Indicator 1: *Early indicators* - Survival of eggs/larvae through to metamorphosis, survival of adults, and breeding activity.
- Indicator 2: *Long-term indicators* - Adult population size of at least 50 and ideally at least 100; mixed population structure in terms of demography; progressive colonization of multiple ponds by dispersing frogs.
- Indicator 3: Co-existing species and habitats are not negatively impacted, and ideally are enhanced, by the reintroduction of pool frogs.

Project Summary

Female pool frog © Jim Foster/ARC

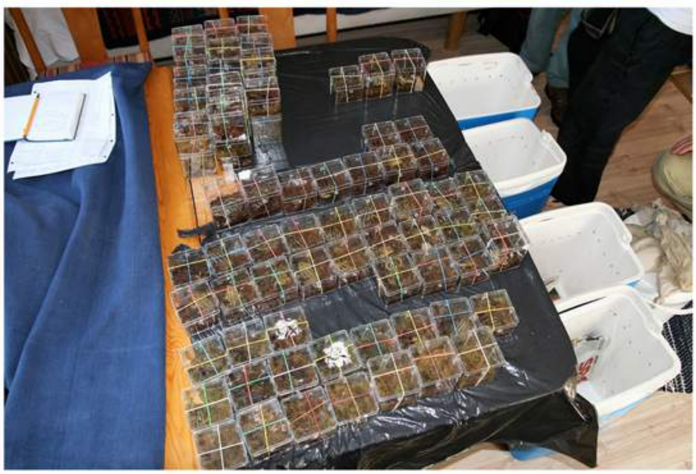
Feasibility: The northern pool frog was only recognized as a UK native species in 2005 after its national extinction, having been generally regarded an introduction from other parts of Europe. Research in the 1990s and 2000s confirmed its native status, reversing its position from an unwelcome alien species to one of high conservation concern. An investigation into the desirability and feasibility of reintroduction concluded that establishing a population in the UK would represent a significant gain for national biodiversity, as well as a contribution to its European status, given that the northern populations are scarce and often imperiled. The main reasons for decline and extinction were thought to be a reduction in water levels due to abstraction, and substantial deterioration in habitat condition. The species was listed as a biodiversity priority, though it was not yet legally protected because of the earlier confusion over its status. All of these issues were thoroughly investigated and a reintroduction strategy was produced following consultation with experts in amphibians and reintroduction methods (Buckley & Foster, 2005). Goals and indicators of success were set out in that document, and further developed in documentation supporting the releases, in particular to ensure compliance with IUCN reintroduction guidance. Much effort was put into early liaison with site managers and regulatory authorities to ensure that the more complex challenges were considered and addressed well before the releases were due to occur. Efforts to restore habitat for a receptor site involved examination of habitat characteristics at historic pool frog sites in the UK and existing sites in Sweden. It was decided to keep the precise location of the receptor site confidential to reduce the chance of collection of frogs, for what would be the rarest UK amphibian after reintroduction.

Implementation: The reintroduction was achieved by wild-to-wild translocation, using founders from Sweden (a close genetic match and where populations were robust enough to tolerate some removals). Early discussions with the Swedish authorities were important, because of the need to carefully assess potential impacts, and legal issues relating to capture, export from Sweden and import to the UK. Frogs were caught during four annual visits from 2005 to 2008, flown to the UK and released at a specially prepared receptor site. Following a population viability analysis, a mix of adults, juveniles, spawn and larvae was imported. Mortality during import was minimal, with a loss of <5 larvae per year, and no mortality of post-metamorphic animals. Head-starting was used in addition to hard release in some years, with mixed success. Early discussions with veterinary experts (the Institute of Zoology) were important, to ensure that we implemented a full disease risk assessment, disease risk management, and post-release health surveillance (Sainsbury *et al.*, 2016). An advisory group, comprising species experts, landowners and regulatory authorities, assessed progress by reviewing monitoring reports, undertaking site visits and providing additional advice on methods.

Post-release monitoring: Monitoring comprised three main strands: 1) monitoring of released pool frogs via individual identification and counts of all detectable life stages; 2) monitoring of co-existing amphibians, reptiles and habitat condition; 3) monitoring of health status of pool frogs and other amphibians. In summary, we found: a) a breeding population of pool frogs has been established, with an estimated adult population size of 67 (95% CI = 64-76) [as at end of 2016]; there is a good demographic profile, with regular breeding, though in some years counts of metamorphs or juveniles have been low; pool frogs have colonized and breed in multiple ponds; b) common frogs (*Rana temporaria*) appear to have increased substantially, while the status of newts has not noticeably changed (there are issues with detectability, but no decline is evident); habitats appear to be providing excellent conditions for a range of other wildlife, including aquatic beetles, reptiles and mammals; c) pool frogs and other amphibians appear to be in good health condition and there is no evidence of co-introduction of serious infectious disease. Ecological monitoring has been undertaken by a contractor working to a specification provided by the project leaders, and health monitoring has been undertaken by the Institute of Zoology. Annual reviews ensure that monitoring goals and methods remain appropriate and take account of changing constraints.

Major difficulties faced

- Given that population establishment takes many years and there is a background of fluctuating reproductive success, establishing meaningful short-term indicators is difficult.
- Understanding patterns and causes of mortality in reintroduced frogs and, especially, their progeny.
- Uncertainty over interpreting the significance of potential threats such as shifting habitat condition or increase in predator abundance.
- Deciding how to balance resources available for pool frog conservation between: 1) ensuring activity at the first reintroduction site progressed adequately, and 2)



Frogs prepared for export in boxes © Jim Foster/ARC

establishing additional populations to ensure a more resilient national population of pool frogs (releases for the second reintroduction site started in 2015).
- Securing continuity of funding for implementing reintroduction activity.

Pool frog habitat © Jim Foster/ARC

Major lessons learned

- Given the inherent uncertainty in the outcomes of reintroduction activity, flexibility in implementation was crucial, based on monitoring and adaptive management of the reintroduction program.
- Detailed ecological knowledge of the target species was key to planning the reintroduction.
- Setting a clear objective and indicators of success helped to plan monitoring.
- Planning the reintroduction required substantial lead-in time and consultation with a range of authorities, and this effort required significant co-ordination and funding.
- Project management takes time and needs clear governance, especially where there are risks relating to legal and procedural issues, and where implementation requires flexibility to deviate from agreed plans.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Careful planning, implementation, documentation and resourcing of the reintroduction.
- Selection of an appropriate receptor site with resources reasonably guaranteed for long-term management.
- Development of a thorough evidence base on which to plan the reintroduction, notably on pool frog status, monitoring methods, ecological requirements and decline factors.
- Advice from an inclusive partnership of researchers, practitioners, site managers and government agencies.

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Translocation trial of spiny-tailed lizard or *dhub* in Dubai, United Arab Emirates

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Introduction

The spiny-tailed lizard or *dhub (Uromastyx aegyptia leptieni*) is one of three subspecies of *Uromastyx aegyptia* and is found from Oman's Hajar al-Gharbi Mountains through to the northeastern United Arab Emirates (UAE). The species is listed on CITES Appendix II and categorised as vulnerable by the IUCN. Within the UAE, where this project is taking place, it is protected specifically under Federal Decree Law Number 9 of 1983. An estimated 1.5 million people are moving to cities globally each week. It is estimated that almost 90% of the UAE population will be urbanised by 2020, a trend obvious in Dubai in particular. Road infrastructure, services and megaproject construction are seriously impacting on available habitat for many local species of biota. Habitat conversion for development and agricultural use are identified as key threats to threatened reptile species of the Arabian Peninsula (Cox *et al.*, 2012).

A translocation attempt moved dhubs from the Abu Dhabi Airport expansion (Barcello & Tourenq, 2005), with the subsequent recovery of animals at one of the release sites (Soorae *et al.*, 2008). There is no other official documentation of translocating dhubs within the UAE, although there have been attempts within the Emirate of Dubai during the Al Maktoum Airport development and development of other coastal projects.

Goals

- Goal 1: Evaluate burrow usage and animal movements.
- Goal 2: Determine the feasibility and protocol for translocating *U. a. leptieni*.
- Goal 3: Monitor the release site fidelity in preparation for future translocations.

Success Indicators

- Indicator 1: Released animals remain within the release area over one brumation period.

Spiny-tailed lizard or *dhub*

Holding pens placed on top of burrows for seven days

- Indicator 2: Released animals follow a similar activity pattern to animals that were not translocated but monitored in a similar fashion.
- Indicator 3: Capture of animals with no mortality or injury.

Project Summary:

Feasibility: Throughout their range, *dhubs* can be found on loose to hard gravel plains, avoiding soft sands. This is also prime construction land, as well as being a favoured surface for off road vehicles and weekend campers. There is some debate as to whether *dhub* are completely vegetarian or, as suggested by some authors (Castilla *et al.*, 2011) whether they are selective scavengers. The authors (O'Donovan and O'Riordan, in prep.) suggest that those in the UAE are more likely to be incidental scavengers and consume non-vegetative items as they forage and therefore have specific dietary requirements. Preferred forage species from the study sites include, *Heliotropium kotschyi, Tribulus* sp., *Fagonia bruguieri, Stipagrostis plumosa, Panicum turgidum, Helianthemum lippii, Pennisetum divisum* and *Leptadenia pyrotechnica* seed pods when they were available. During the initial survey period, a total of 1,653 individual burrows (both active and abandoned) were identified. Of these the orientation of 784 were recorded with more than 50% orientated in a westerly direction, which was different to the primary orientation previously recorded for *Uromastyx aegyptia* (Cuningham, 2001).

Implementation: The initial phase of the present study saw 13 animals captured and fitted with radio transmitters (Model # R1860 ATS, Isanti, MN, USA) and Hygrochron Temperature & Humidity iButton (DS1923-F5# Embedded Data Systems) during 2014 and 2015. These 13 animals were monitored throughout subsequent phases allowing the collection of important movement data (O'Donovan and O'Riordan, in prep.). A localised trial translocation was attempted with three of these animals (AQ01, WAS 002 and WAS 004). Subsequently, in September 2014, two animals, NAK 003 and NAK 004, were moved from a proposed construction site to a new area approximately 1 km from their capture burrow. These two animals were each released into a holding pen placed on top of the release burrow, which was left in place for the first seven days after translocation.

In early October 2015, 10 more animals were caught on the same day, subjected to veterinary checks and fitted with the same transmitter and iButton combinations. Five were returned to their capture burrows and five translocated to a new site approximately 31 km away. For these five translocated animals, abandoned burrows, where there was adequate and suitable vegetation, which had been identified in earlier surveys (O'Donovan and O'Riordan, in prep.) were excavated and the animals released into these.

Post-release monitoring: Of the first three early localised translocations, AQ01 was successful, WAS 002 survived for 25 days before being predated and WAS 004 lost its transmitter. The other two dhubs, NAK 003 and NAK 004, who had been kept within holding pens for the first seven days after release, remained in their release area and were observed there in early 2017. All ten of the October 2015 tagged animals were monitored on a daily basis for the first 14 days and every alternate second day thereafter for four months. Of the five translocated animals, three died, two from predation as they did not settle in any specific burrow and one was presumed dead in a burrow where it took up residence in. All the deaths were within 90 days of release. The other two were considered to have established in the release area.

Of the five dhubs that had been tagged in October 2015 but were not translocated, four were found alive at the end of the monitoring, while one, WAS 059, was presumed predated as it disappeared with no radio signal detected. Of the remaining monitored but not translocated animals throughout the study, there was only one other mortality, MUG 005 which died of natural causes. The monitored animals showed a lot of movement between burrows and while there was certain burrow fidelity, animals were often recorded (using bespoke RFID traps - RFIDRW-E-232, Priority 1 Design, Melbourne, Australia) in burrows up to several hundred metres apart (O'Donovan and O'Riordan, in prep.). Also two of the translocated animals were recorded in RFID traps during January 2018.

Major difficulties faced

- Released animals establishing in release burrows.
- Predation from feral cats, foxes or raptors.
- Ability to identify release animals after removal of transmitter either after battery depletion or loss of transmitter. Follow up monitoring would be difficult without further captures.

Overview of habitat at release site (yellow arrow shows dhub)

Major lessons learned

- Release animals need to be retained in a

temporary holding pen for several days at the release location and allowed to excavate their own way out.
- Old abandoned burrows can be utilised in translocation projects.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- There were too many mortalities which could be attributed to the homing instincts of dhub exposing them to increased risk of predation or chilling/ heating extremes.
- The chance of success was much greater when animals were held in release pens or caught and returned to the release burrow until it had established in the release area.
- Capture and monitoring protocols have now been established and can be implemented rapidly in the case of urgent translocation from construction projects.
- As this was a short-term pilot project the measurement of success was the ability to complete one brumation cycle effectively. Whether any of the translocated animals have contributed to the increase of the local population would be difficult to determine.

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Reintroduction of the Telfair's skink to Gunner's Quoin, Mauritius

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Introduction

The Vulnerable (IUCN) Telfair's skink (*Leiolopisma telfairii*) is the sole surviving member of a unique Mascarene genus of large, terrestrial and omnivorous lizards. Once widespread throughout Mauritius and offshore islands, Telfair's skinks became restricted to Round Island (219 ha, 20 km northeast of Mauritius) from the mid-1800s, representing the only suitable location not colonised by invasive mammalian predators, particularly rats (*Rattus norvegicus* and/or *R. rattus*). However, from the early 1800s introduced goats (*Capra hircus*) and rabbits (*Oryctolagus cuniculus*) decimated Round Island's hardwood and palm-rich habitat, threatening the survival of Telfair's skinks and other endemic reptiles (Cheke & Hume, 2008). To mitigate extinction risk, a captive assurance population was established from 1976 at Jersey Zoo, Round Island's introduced herbivores were eradicated by 1986 and invasive mammals (predators and herbivores) were eradicated from neighboring islands by 1998, opening them for reptile reintroductions (Cheke & Hume, 2008). The islands were reviewed as possible reintroduction sites and Gunner's Quoin (70 ha, five km north of Mauritius) was selected. Gunner's Quoin was one of the last locations outside of Round Island to maintain Telfair's skinks;

Telfair's skink © Nik Cole

the cause of their loss had been removed in the 1990s and supported a suitable prey base and structural habitat required by the skinks.

Goals

- Goal 1: Re-establish a self-sustaining population of Telfair's skinks on Gunner's Quoin.
- Goal 2: The reintroduction does not compromise the health condition of the Telfair's skinks.
- Goal 3: The reintroduced Telfair's skink population shares the same genetic diversity as Round Island.
- Goal 4: Gunner's Quoin's native resident reptile populations remain robust following the reintroduction of the Telfair's skink.
- Goal 5: Following the successful reintroduction of Telfair's skinks, continue to rebuild Gunner's Quoin's reptile community with the reintroduction of the skink's predator, the Endangered (IUCN) Round Island keel-scaled boa (*Casarea dussumieri*).

Success Indicators

- Indicator 1: Telfair's skinks reach their predicted carrying capacity on Gunner's Quoin within 10 years.
- Indicator 2: Reintroduced Telfair's skinks maintain healthy body-condition scores and remain free from novel parasites and disease.
- Indicator 3: Allelic diversity and heterozygosity within the reintroduced skink population is the same as the source population, with no evidence of bottlenecks or inbreeding.
- Indicator 4: The relative abundances of the four native lizard species on Gunner's Quoin does not decline below pre-Telfair's skink release abundances.
- Indicator 5: Round Island keel-scaled boas are reintroduced to Gunner's Quoin.

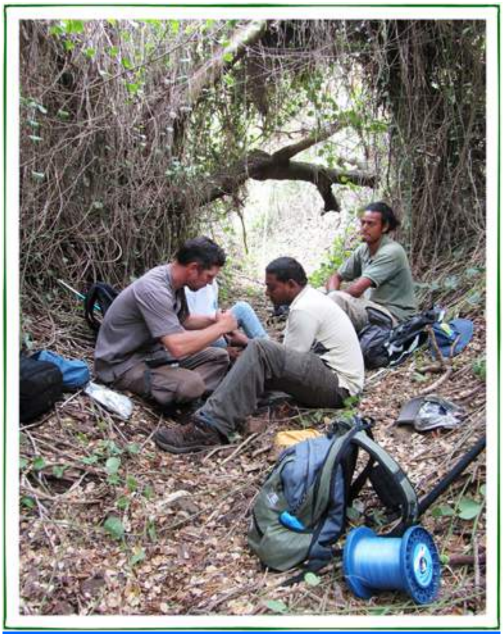
Project Summary

Feasibility: The overall objective of the reintroduction project was to rebuild the reptile community on the closed Island Nature Reserve, Gunner's Quoin, and reduce extinction risks for Round Island's reptiles. Between 2002 and 2006, Gunner's Quoin's suitability was assessed and Telfair's skinks identified as the priority species for reintroduction (Bloxam, 1982; Jones, 1993; Cole *et al.*, 2009). By 2006, Gunner's Quoin was free from invasive predators, relatively safe from anthropogenic disturbances, offered suitable structural habitat and food resources. Robust populations of small endemic reptile species had survived and recovered from previous disturbances on Gunner's Quoin and were predicted to withstand the Telfair's skink reintroduction (Cole *et al.*, 2009). The capacity of relevant stakeholders to undertake the reintroduction and monitoring was assessed, training needs and required external expertise were identified and project partners selected. The feasibility of translocation from Round Island was assessed; determining age, gender, health and disease risk assessment, distribution and planning selection for translocation, skink abundance and release size, timing and method of translocation and release, modes of transport, biosecurity, permissions, ethical review, funding requirements and post translocation survey and monitoring methods and protocols. Population viability models were developed from wild and captive Telfair's skink data to predict the impact of removing skinks from Round Island for translocation and probabilities of survival and population growth post release on Gunner's Quoin.


Gunner's Quoin © Nik Cole

Implementation: In 2005, the Government of Mauritius granted permission to start rebuilding Gunner's Quoin's reptile community, with the initial reintroduction of Telfair's skinks. The translocation, monitoring and survey protocols were established. In 2006, the Durrell Wildlife Conservation Trust, Mauritian Wildlife Foundation and the National Parks and Conservation Service, with support from the University of Bristol and International Zoo Veterinary Group were granted Darwin Initiative funding (Ref:15038), with additional funding from the Government of Mauritius for the translocation and monitoring over three years (Cole *et al.*, 2009). This coincided with training of Mauritian staff to conduct the translocations and monitoring, with the establishment of 72 permanent survey transects and 8 km of access paths on Gunner's Quoin to monitor the resident fauna and flora, the translocated reptiles and to conduct frequent biosecurity checks. In February 2007, 250 (83 male, 153 female & 14 sub-adult) Telfair's skinks were selected from Round Island and translocated by helicopter for hard release in pre-selected locations of suitable habitat across Gunner's Quoin. Each released skink was fitted with a Passive Integrated Transponder (PIT) tag for individual recognition, permitting post-release monitoring of abundance, apparent survival, recruitment and dispersal. The national media (newspapers, radio and televised news broadcasts) were utilized and workshops with the Police and National Coast Guard were conducted to sensitize island users and enforcement agencies of the project and the protected status of Gunner's Quoin to try to reduce trespassing and resultant human induced impacts. From 2008, with agreement and support of the Government of Mauritius, the project partners started to seek additional funding to continue the project long-term and develop additional research support through academic partners.

Post-release monitoring: For the first three years, seasonal (summer and winter) post-release monitoring consisted of capture mark recapture (CMR) methods to determine Telfair's skink abundance, apparent survival, recruitment and dispersal (with all newly discovered skink being PIT tagged). Monitoring also involved habitat and dietary utilization to determine impact upon the resident species; health and disease comparisons to Round Island; relative abundance estimates of invertebrates, vertebrates and key plant species; and biosecurity



PIT tagging skinks © Nik Cole

checks to detect and remove invasive species incursions. Since then CMR, relative abundance estimates of vertebrates and health surveys have been conducted annually (Summer), but biosecurity checks have continued biannually. Post release survival, recruitment and dispersal has been high. No novel diseases or parasites have been found in the source or translocated reptile populations and the reintroduced skinks have remained healthy with higher than average body condition scores. In 2013, no evidence of genetic bottlenecking or inbreeding was found in the Gunner's Quoin population and allelic diversity and heterozygosity was no different to Round Island (Cox, 2013). Dietary work demonstrated that Telfair's skinks were consuming native and introduced species as predicted, but there have been no significant declines in native resident species to date. However, some introduced species consumed by the skink have declined, such as the wasp (*Polistes hebraeus*), once abundant it has not been detected on the island since 2014. With a readjustment of the skinks' predicted carrying capacity following habitat specific abundance estimates on Round Island the observed growth in skink abundance on Gunner's Quoin has been similar to what was predicted. The skinks reached their carrying capacity in 2014, and their abundance is currently estimated at 14,297 individuals (±95%CI: 10,272 - 20,514), a 31.2% increase on the global population. Given the growth of the skink population, its native predator, the Round Island keel-scaled boa was successfully reintroduced between 2012 and 2014 and the boa population is growing.

Major difficulties faced

- Access to Gunner's Quoin and poor survey conditions in winter meant that only thorough summer surveys could be continued.
- A high changeover in staff meant that capacity building has been ongoing limiting core surveys to just a couple of staff.
- Despite being an Island Nature Reserve with prohibited access to the public, Gunner's Quoin continues to be frequently trespassed, leading to littering, burning, trampling, poaching and species introduction, such as the Australian redback spider (*Latrodectus hasseltii*) that took two years to eradicate. The risks of invasive predator incursion remains an issue.
- Lack of capacity within Mauritius for reptile disease screening, requiring the lengthy and costly process of sending samples overseas.
- Public support for reptile conservation and widespread opinions for reptiles remains low, despite extensive sensitization of their importance to the Mauritian ecosystems and regional biodiversity.

Major lessons learned

- Ensuring partners are made up of government agencies, non-government organizations and academic institutes to facilitate permission and support, with organizational flexibility and cutting edge expertise.
- Understanding the critical needs of the species and using expert opinion where there are gaps in the scientific literature to make, then test and adapt management decisions.
- Using, testing and adapting population viability models to predict and test outcomes and plan further actions.
- Although the project was conceptualized externally, what has made this project successful has been the ongoing building of host country capacity to lead this project with external support.
- Ensuring long-term financial support to learn, develop, manage and generate buy-in from all partners.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Good understanding of the species ecology and behavior.
- Ensuring that the threats to the survival of the species were no longer present.
- Having a vision that focuses on species to rebuild ecosystems.
- Long-term commitment of partners and high level of monitoring.
- Developing partnerships between Government agencies, NGOs and academic institutes to meet the skill sets required to ensure success.

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Rescue, rehabilitation and release of reticulated pythons in Singapore

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Introduction

The reticulated python (*Malayopython reticulatus*) (Schneider, 1801) belongs to the family Pythonidae. The species holds the record for being the longest snake species, with reliable measurements exceeding 9 m. It has a wide geographic range extending from India through Southeast Asia to Sulawesi and is generally locally abundant. Despite being Not Evaluated on the IUCN Red List, it is currently listed on CITES Appendix II. An estimated 300,000 individuals are harvested from the wild annually from Malaysia and Indonesia for the commercial leather trade. A two decades-long study showed that the harvest from the wild in Indonesia appears to be sustainable, while the sustainability of farming for skins in other range countries is still up for debate. Reticulated pythons are also opportunistically hunted for bush meat and killed out of fear or retaliation of livestock loss. In Singapore, reticulated pythons are the largest extant terrestrial predators in the highly modified urban landscape. It appears they have adapted to urbanization and are frequently encountered in residential and commercial built-up areas. Approximately 70% of their diet consists of rats, including the invasive Norway rat (*Rattus norvegicus*). They are also definite hosts of the parasite *Sarcosystis* sp., which further helps control rodent populations.

Goals

- Goal 1: To conduct an effective and sustainable translocation program for urban “conflict” reticulated pythons.
- Goal 2: To monitor movements and study urban ecology of translocated snakes.
- Goal 3: To reduce and eventually eliminate incidences of members of the public injuring and killing pythons.
- Goal 4: To foster an attitude of co-existence and tolerance amongst members of the public through education on the role pythons play in the ecosystem.

Reticulated python on lamp post

Success Indicators

- Indicator 1: Continue to receive python rescues each year.
- Indicator 2: Continued survival of translocated pythons as indicated by recaptured snakes in good body condition.
- Indicator 3: Presence of neonate sightings each year in urban areas.
- Indicator 4: Obtain home range sizes and movement patterns of translocated pythons.

Python in a drainage gutter

Project Summary

Feasibility: Singapore is the world's third most densely populated country, placing the reticulated python population in a unique situation. Annually, approximately 300 individual pythons are found each year in urban areas, including residential and commercial buildings; gardens; in vehicles and under construction debris. They are locally perceived to be dangerous as well as a pest species because they occasionally prey on domestic animals (e.g. chickens, stray cats and dogs). The aim of this translocation project was to ensure the long-term survival of the urban reticulated pythons in Singapore. While snakes in the forest are able to camouflage well and are not detected by recreational park users, snakes encountered in the urban areas usually attract large crowds that are occasionally hostile towards the animal. These situations at times necessitate the need for authorities to intervene capture and translocate the snake for its own safety.

Implementation: Since 2010, the Singapore Python Working Group was established and hosted by Wildlife Reserves Singapore (WRS), in partnership with governmental and non-government organizations, to consolidate efforts of rescue, rehabilitation and release of these conflict pythons. Captured snakes are transported to the Wildlife Healthcare and Rescue Centre at Wildlife Reserves Singapore by Agri-Food Veterinary Authority (AVA) contractors as well as the rescue team from the Animal Concerns Research and Education Society (ACRES). Snakes assessed by the WRS veterinary team and if deemed to be fit for release, are translocated to forested areas around Singapore. Snakes that are severely injured or in emaciated body condition (e.g. due to high parasite load) are euthanized. All released snakes are tagged with a PIT (passive integrated transponder) tag prior to release.

Monitoring released pythons

Post-release monitoring: Snakes that were marked seven years prior have been recaptured up to 20 km away from release locations respectively, indicating that these snakes can thrive in an urban environment and have found ways to navigate through the human-modified landscape. We investigated their post-release movement from April 2014 to January 2016. Twenty-eight individuals were tracked using radio-telemetry with three relocations a week. Approximately 76% of all relocations (each time a tagged individual's location was pinpointed) were at the forest edge and/or in urban areas.

Major difficulties faced

- Changing public perception from uncertainty and fear to understanding the role of snakes in the ecosystem and subsequently human treatment of snakes in encounters.
- The need for transparency, clear communication and cooperation between multiple agencies, both from government and non-governmental sectors.

Major lessons learned

- Our findings are evidence that the reticulated python population in Singapore has adapted to the human modified landscape despite translocation activities. The animals are also breeding in urban environments as neonates are found each year.
- Continued and persistent education and outreach messaging is vital in changing public perceptions towards the role snakes play in the ecosystem and their subsequent treatment of these animals during an encounter.
- Continued cooperation and communication through the platform of the working group is imperative in managing and monitoring the urban python population.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Formation and effective delegation of the Singapore python working group (consisting of government agencies, non-governmental agencies, private stakeholders) to consolidate rescue, rehabilitation and release efforts of pythons.
- While the working group is now at the front line for public calls when they encounter a python, outreach through social and print media needs to be increased as cases of pythons found injured or dead due to intentional human actions still occur.
- Radio-telemetry study provided evidence of snakes actively returning to the forest edge and urban matrix for shelter and food.

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Reinforcement of gharial in the Gandak River, India for population restoration

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Introduction

The gharial (*Gavialis gangeticus*) (Gmelin, 1789) is Critically Endangered and is endemic to the Indian sub-continent. It is the most aquatic of all extant crocodilians, and a resident of flowing rivers with deep pools, high sand banks and good fish stocks (Whitaker & Basu, 1983). Historically distributed across several major river systems in Pakistan, India, Nepal, Bhutan, Bangladesh and Myanmar (Whitaker & Basu, 1983; Whitaker, 1987, 2007; Hussain 1999, 2009), the gharial is now restricted to a few scattered locations in India and Nepal (Whitaker, 2007). The reasons for an estimated 96 - 98% decline from an estimated population that ranged between 5,000 and 10,000 between 1946 and 2006 are known to be over-hunting for skins and trophies, egg collection for consumption, killing for indigenous medicine and excessive and irreversible loss of the species habitat (Biswas, 1970; Whitaker, 1975; Choudhury *et al.*, 2007). Presence of three breeding populations (Chambal, Katerniaghat and Son Rivers) and two non-breeding populations (Ken and Mahanadi Rivers) in the Indian rivers have been described by Choudhury *et al.* (2007).

River Gandak (Narayani in Nepal, is an important trans-boundary river that supports a gharial population within the geographical limits of both the countries. Despite available knowledge about gharial population in this river system (Shahi, 1976), little effort was made to document and implement conservation measures in this river system until the survey supported by Wildlife Trust of India (WTI) and other conservation organizations documented presence of about 15 gharials in the Indian stretch of the river and proposed conservation measures including strengthening of the remnant population (Choudhary, 2010).

Establishment of protected areas and their restocking with captive-born individuals are the key conservation programs undertaken in India and Nepal for conservation of the species. Restocking success rates have averaged from 3 - 10% in the species range over the last 30 years (Choudhury *et al.*, 2007).

Released gharial basking in the Gandak River © Subrat Kumar Behera

Though, restocking did not achieve significant success, but it is argued that total extirpation was averted due to such intervention.

In 2014, WTI and Bihar Forest Department jointly started the gharial reinforcement project in the Gandak River. Captive -born and reared gharials at Patna Zoo were released in the Gandak followed by post-release monitoring. This paper is a summation of these efforts.

Gharials kept in wooden crates for transportation
© Samir Kumar Sinha

Goals

- Goal 1: Strengthen the remnant population of Critically Endangered gharial in the trans-boundary Gandak River through release of captive-born and reared gharials in the Gandak River as a reinforcement strategy.
- Goal 2: Monitor the released and wild gharials to ascertain the success of this intervention.

Success Indicators

- Indicator 1: Gharial population increases in the Gandak River.
- Indicator 2: Released gharials survive in the river.
- Indicator 3: Released gharials disperse and occupy suitable habitats.

Project Summary

Feasibility: The reintroduction project aimed not only at successfully conducting the restocking of gharials in the Gandak River, but also initiated an integrated *ex situ* and *in situ* conservation project in the river that was a known distribution range of the species. Small population size of the species in the river was one of the major threats to the gharial population, apart from incidental and accidental catches in fishing nets, trade and construction of a barrage on the River (Rao *et al.*, 1995). However, after declaration of Valmiki Tiger Reserve as a protected area in 1994, the 60 km stretch on the left bank of the river downstream of the barrage in India got legal protection thus safeguarding the gharial habitat. Following an assessment of the suitability of habitat, WTI and Bihar Forest Department jointly started the gharial reinforcement program for which the release stock was already available at Patna Zoo where a captive-breeding program had started as early as in 2002 - 2003.

Implementation: WTI surveyed the River Gandak in 2014 to assess the suitability of habitat for the release of gharials. Simultaneously, a translocation protocol was prepared to implement the project scientifically. At Patna Zoo, the


Radio tracking of released gharials © Rajkumar

release stock comprising of sub-adult individuals was examined for health condition and acclimatized by providing live fish as food for six weeks to allow for inculcation of hunting skills in them. Prior to transportation, each individual was sexed and marked by tail scute mutilation marking technique (Bustard & Choudhury, 1981). Two individuals were fitted with satellite transmitters, while VHF tags were implanted on four individuals for remote monitoring. Morphometric measurements of all release individuals were taken. Altogether, 30 sub-adult (length <3m) gharials (3 males & 27 females), were released in three batches between April 2014 and February 2015. The individuals identified for release were physically restrained and put in specially made jute bags with their snouts exposed. The animals were transferred in customized wooden crates of 1.5 m x 0.3 m x 0.3 m. dimension and transported by road in the evening hours from the source site at Patna (India) to the release site at Valmikinagar near India - Nepal border with approximately 300 km being covered in 9 - 10 hours. The jute bags were moistened at regular interval during the transportation. The animals were released in the afternoon hours after they were stabilized for 8 - 9 hours.

Post-release monitoring: A team conducted field based monitoring following two protocols - point observation at gharial basking sites, and boat survey in the rivers for direct sighting of gharials. Gharials were observed using binoculars (8 x 40) and photographed to identify the uniquely marked and released individuals based on the tail-scute cut pattern. In the bank and river based surveys location of VHF tagged individuals was assessed through the radio signals received using antenna and receiver. Location of gharials and other details of the habitat which the satellite tagged gharials were using was also received at regular intervals.

Monitoring results found 60% of the released gharials surviving in the wild, six months after their release. Maskey and Percival (1994) concluded low survival rate (7%) of captive reared gharials released in the Narayani River. Ballouard *et al.* (2010) also had similar findings that highlighted disappearance of 50% of the released gharials each year in the Narayani River. However, while monitoring the released gharials in the Gandak River, several Nepal released gharials (identity was confirmed based on the individual marking pattern) were sighted by the monitoring team in the Gadank River almost 75 - 100 km downstream of their release site in Nepal. These studies must have considered such gharials lost after their release and inferred low survival rate. Long distance dispersal of captive

VHF tagged and released gharial in the Gandak River © Subrat Kumar Behera

reared and released gharial could be one of the key reasons of such low sighting records post-release in the wild.

Major difficulties faced

- Long distance movement by the released animals after a week or so, made radio-tracking and visual observation based post-release monitoring difficult.
- Tracking the location of the released individuals became difficult after seasonal floods in the river as also their transboundary movement into Nepal. Without transboundary collaboration monitoring of such gharial movements was difficult.

Major lessons learned

- Released gharials may move over large distances than earlier documented, even as far as over 1,000 km.
- Use of inflatable boat is a must for post-release monitoring of gharials.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success

- The first milestone of the project has been reached with evidence that 18 out of 30 released gharials were re-sighted in the river six months after release suggesting their survival in the wild.
- The captive-born and released gharial have started sharing the habitat with wild individuals. This shows that the habitat selection instinct is present in the captive-born and reared gharials.
- Released gharials dispersed up to a maximum distance of 1,000 km from the release site, thus populating other habitats as well.

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Introduction to Ile aux Aigrettes, Mauritius, of the Aldabra giant tortoise as an ecological replacement for the extinct Mauritian tortoise

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Introduction

The Mascarene Islands (Mauritius, Rodrigues and Réunion) supported five species of *Cylindraspis* tortoises that became extinct by the mid-1800s, as a result of human exploitation, predation by invasive animals and habitat destruction/modification (Cheke & Hume, 2008). Giant tortoises were the principal herbivore and maintained open savannah habitats, where they played key roles in seed dispersal and maintaining a grazing climax plant community. A suite of native plants co-evolved with tortoises and have developed traits such as large fleshy fruits with hard seeds, to encourage the tortoises to feed on them and for the seeds to survive gut passage, following which the seeds show enhanced germination, leaf heterophylly where the juvenile leaves are highly patterned which discourages browsing, high silica in grasses to discourage grazing, and an ability to cope with trampling. Effective seed dispersal of some plant species may have been reduced following the extinction of the native tortoises, contributing to their decline. We aimed to reinstate these ecosystem functions through the introduction of an exotic tortoise, the Aldabra giant tortoise (*Aldabrachelys gigantea*), as an

Aldabra giant tortoise © Vikash Tatayah

ecological replacement for the dome shelled grazing Mauritian tortoise (*Cylindraspis inepta*). Although *A. gigantea* is Vulnerable (IUCN) and CITES Appendix II, it is common in captivity on Mauritius derived from animals imported in the 1870s and later. Ile aux Aigrettes (26 ha) was selected as a suitable site to conduct a trial translocation as it supports a restored native forest, is free of mammalian predators and is permanently staffed permitting close monitoring.

Goals

- Goal 1: Introduce tortoises to restore a grazing climax plant community with the tortoises performing the grazing, trampling and seed dispersal functions once performed by the endemic tortoise *Cylindraspis inepta.*
- Goal 2: Study plant-tortoise interactions and their effectiveness at native seed dispersal.
- Goal 3: Study the effect of tortoises on the control of invasive alien plants.
- Goal 4: Establish self-sustaining breeding population of Aldabra tortoises on Ile aux Aigrettes.

Success Indicators

- Indicator 1: Native seeds are consumed, dispersed, germinate, and grow into seedlings.
- Indicator 2: Invasive plants are controlled by tortoise herbivory.
- Indicator 3: Tortoises remain healthy with low rates of mortality, free from diseases, and maintain or improve body condition.
- Indicator 4: The tortoise establish a successful reproducing population.

Project Summary

Feasibility: Ile aux Aigrettes has the last area of coastal forest, once well distributed in Mauritius, where tortoises were common. Sub-fossil bones of the endemic dome shelled grazing tortoise *Cylindraspis inepta* have been found on the island. This low-lying coralline island, situated 600 m of the south-east coast of Mauritius, is managed by the Mauritian Wildlife Foundation that has been conducting ecological restoration since 1984. The island offers opportunities for restoration using tortoise ecological replacements as it has relatively intact native flora, albeit mainly higher order plants; no large introduced vertebrates or predators of hatchlings; a well-equipped field station and permanent occupation by field staff that conduct long-term ecological monitoring.

Tortoise hatchling © Vikash Tatayah

Ile aux Aigrettes - release site
© Vikash Tatayah

Four Aldabra tortoises were introduced to a small enclosure on Ile aux Aigrettes in the 1990s where they remained for several years for preliminary studies on food preference and for education purposes. The animals were fed and provided with water daily and maintained good body condition. Animals from other captive collections were loaned or donated. Newly arriving animals were tested for herpes virus and endoparasites, and dewormed. Some animals arrived in poor health due to inadequate diets and lack of exercise; they were supplemented with leaves and vegetables, and most improved. All new tortoises were quarantined on the island for a minimum of one month, and integrated into the herd once they reached a satisfactory health status.

In November 2002, the four tortoises were moved to a 1 ha fenced enclosure, and were joined by others to eventually form a herd of 20 animals (Griffiths, 2008; Griffiths *et al.*, 2010, 2011). The impact the tortoises had upon the vegetation was monitored. Copulations were observed and eggs and hatchlings were found within the first year, which has since continued annually. An attempt was made to incubate eggs artificially, but has proved to be unnecessary due to the high hatch rate under natural conditions.

Implementation: Monitoring showed that the tortoises were not having a profound negative impact on the native vegetation within the enclosure, and since late 2004 the tortoises have been allowed to roam freely on the island (Griffiths, 2008; Griffiths *et al.*, 2010, 2011). Monitoring has continued researching the movement of the animals, their health status, impacts upon the vegetation, the spread and germination of seeds in their droppings. Animals continued to be weighed and measured regularly to assess their health and growth rates. Water is provided to the animals, although there is no need to feed them since they forage naturally. Almost all animals put on weight and grew, even in the older (60 - 80 years old) animals, as shown by the growth of carapace scutes. However, some geriatric health problems could not be resolved despite medication and supplementary diets, and two animals had to be taken off the island and two euthanized. Two animals were lost or stolen from the island, including the smallest of the cohort, but other adults were donated and by 2017 there were 25 free-roaming individuals breeding on the island. Reproductive output on the island averages 60 - 100 hatchlings found per year. Poaching of hatchlings for sale as pets on the local and international market is a problem and hence were head-started in secure facilities at the captive-breeding centre in Black River or on Ile

Transferring tortoises to the island
© Vikash Tatayah

aux Aigrettes. The head-started animals are disease screened and translocated to Round Island, to establish a second free-living population.

Post-release monitoring: The 25 tortoises on the island are monitored monthly for survival, movement, health, and bi-annually weighed and measured. Hatchlings are harvested and after head-starting in captivity for 2 - 3 years, are translocated to Round Island. The impact on vegetation continues to be monitored with tortoise exclosure studies and dietary and behavioral research projects. To identify all the species consumed by the tortoises a PhD student from the Cardiff University, UK, is conducting meta-barcoding research on tortoise droppings in relation to a DNA barcode library of all plant species.

Major difficulties faced

- Some of the animals were in poor condition when we received them. Despite veterinary care and supplementary food, some animals had chronic health issues, two were euthanized, and two were removed from Ile aux Aigrettes.
- Two animals disappeared and were suspected to have been stolen.
- Hatchling tortoises have been stolen from the island by visitors and staff, causing a loss in terms of stocking Round Island (current) and other islands in the future (e.g. Gunner's Quoin, Flat Island), in addition to Nature Reserves in Rodrigues.
- Whilst tortoises are controlling some weeds (e.g. *Leucaena leucocephala* seedlings), access to certain areas are limited due to the rugged terrain. Some invasive alien plants (e.g. *Stachytarpheta jamaciensis*) are not eaten by tortoises. Hence manual weeding remains an important management tool for some species.

Major lessons learned

- Ecological replacements can help restore missing ecosystems functions.
- Monitoring and detailed studies are essential to document the impact of ecological replacement projects and to overcome resistance to their use.
- This project has produced a surplus of baby tortoises that have been used to support other translocations to Round Island where a second population has been established.
- The successful experiences from Ile aux Aigrettes (and Round Island) has provided information for the proposed introduction of Aldabra tortoises as an

ecological replacement for *Cylindraspis peltastes* into the Grande Montagne Nature Reserve in Rodrigues.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Detailed research into the ecological history of the native tortoises, allowed us to pose hypotheses about the impacts tortoises had upon the plant community. These could be tested by releasing Aldabra giant tortoises and measuring their effects.
- The careful choice of ecological replacement species is essential for the success of a rewilding project. The Aldabra giant tortoise was chosen because of its taxonomic closeness to the extinct *Cylindraspis* tortoises, it is in a sister clade, and due to its presumed ecological similarity to *C. inepta* based on morphological similarities between the species.
- Tortoises were chosen to test the idea of ecological replacement since if there were deleterious impacts, they could easily be removed, as well as the tortoises being key-stone species.
- Continuous research and monitoring has allowed the benefits of ecological replacement to be documented.
- Clear leadership and drive to bring the project forward, and well as close collaboration between the private sector, universities and the Mauritian Wildlife Foundation allowed this project to be implemented.

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Reintroducing the osprey to Switzerland, one century after its disappearance as a breeding species

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Introduction

The osprey (*Pandion haliaetus*) was last recorded as breeding in Switzerland in 1911, with the last territorial pair observed in 1914 (Stemmler, 1932). Since then ospreys continue to migrate through Switzerland each year to more northerly breeding grounds, but the species is listed as Regionally Extinct in the Swiss Red Data Book. While listed as globally Least Concern by IUCN, it has largely disappeared as a breeding species throughout western, central and southern Europe, a large area of its former range. It is listed in Annex 1 of the European Birds Directive, Annex II of the Convention on Migratory Species, and Appendix II of CITES. This reintroduction project is taking place in the "Trois-Lacs" region of Switzerland in the Canton of Fribourg, an area with ample habitat (lakes, rivers and forests), and the political will to see the return of this emblematic species. The project was started in 2015, just a century after the species disappeared. It is the flagship project of "*Nos Oiseaux*" (the Swiss Romande Society for the Study and Protection of Birds), which was created in 1913, around the time when the last pairs of ospreys were disappearing from the country (Strahm & Landenbergue, 2013).

Goals

- Goal 1: A viable osprey breeding population is restored in Switzerland.
- Goal 2: The osprey serves as a flagship species to promote wetland and forest conservation.

Success Indicators

- Indicator 1: A minimum of 60 osprey chicks are successfully translocated and released in Switzerland (from 2015 - 2020).
- Indicator 2: The first pair of ospreys nest in Switzerland (anticipated within 5 - 7 years from project start).
- Indicator 3: The first reproduction of a wild pair (meaning that both breeding birds were not translocated) takes place in Switzerland (anticipated within 10 - 15 years from project start).
- Indicator 4: A core breeding population of at least 10 pairs will have been reinstalled in Switzerland (anticipated within at least 15 - 20 years from project start).
- Indicator 5: The general public will have forgotten that ospreys had disappeared for over a century as a breeding species in Switzerland, and will expect to see them fishing each year on Swiss lakes and rivers (possibly within 30 years or more from project start).

Project Summary

Osprey chick just after translocation
© Strahm Landenbergue

Feasibility: Ospreys are a migratory and extremely philopatric species that do not readily colonise new areas (Poole, 1989). They are the only diurnal raptor to feed exclusively on fish caught in the upper surface (maximum 20 cm depth) of both freshwater and marine bodies. With their spectacular dives, they are a highly visible and much admired species throughout their range. In the past widely persecuted in Europe for taxidermy and egg collection, they are now strictly protected and are increasing in numbers, but very slowly in range (Schmidt *et al*., 2014). The only conflicts osprey may have are with fish farms raising valuable ornamental species such as koi carp, and at times ospreys have been entangled and drowned in nets protecting farmed fish. Otherwise ospreys never become so numerous as to compete with professional and amateur fishers. Meetings with fishing associations were undertaken prior to the project to avoid potential conflict, but they had no objection to the reintroduction. The other constraint is to find suitable trees where the birds can breed, which are usually dominant Scot pines or oaks. In northeast Germany the species breeds mostly on high tension electricity pylons which have served as a substitute for emergent forest trees. Ospreys readily nest on artificial nesting platforms, widely used in the USA where ospreys were successfully reintroduced in the 1980s following decimation by DDT. They also breed on artificial nest platforms in Europe. Our project aims to encourage them to breed on forest trees, which will serve to protect old trees and the surrounding habitat.

This project is based on other successful osprey reintroduction projects that have been undertaken in the USA and then in Europe, with the first project started in Rutland Water (England) from 1996 - 2001. Since then birds were reintroduced in Andalucía (Spain, with two reintroduction sites, from 2003 - 2012); Maremma (Italy: 2006 - 2011); Alqueva (Portugal: 2011 - 2015); Urdaibai (Spain: 2013 - 2017) and now Bellechasse (Switzerland: starting 2015). A second English reintroduction project has started in Poole Harbour (England) in 2017.

Implementation: Techniques for osprey translocation and hacking have been well developed. Since ospreys on average have 2 - 3 chicks per nest, but not all survive to fledging, the collection of 12 chicks per year in healthy populations will have no effect on population dynamics as a whole. Ospreys are not bred in captivity, thus chicks must be collected from the wild. We are fortunate to work with Roy Dennis, who undertook the first osprey reintroduction project in Europe (Dennis & Dixon, 2001). He made the initial feasibility studies in

Veterinary check prior to transport in Germany
© D. Landenbergue

Switzerland and collected the first six chicks in Scotland for the "test phase" of our project in 2015. After that we developed agreements with the State of Sachsen-Anhalt in Germany to collect 6 chicks/year for a period of five years, working with Daniel Schmidt (who has led an osprey ringing study in Germany since 1990) and ringers Holger Gabriel and Mario Firla. In Norway we work with osprey researcher Rune Aae from Østfold where we have permission to collect up to 12 chicks/year for a similar period of five years. This provides an excellent safety net in case we do not manage to collect six chicks each year from Germany. For Germany, the birds are then transported by car to the release site, and for Norway the chicks flown from Oslo to Zurich and then transported by car, with all the necessary CITES and veterinary authorisations. Having two collection sites is essential in case there are problems (perhaps a bad breeding season due to climate issues) in one or the other site. Translocating chicks from Scotland, Germany and Norway will also help increase genetic diversity of the founding population in Switzerland. The release site is located within the State Prison of Bellechasse (Fribourg), which guarantees maximum security for our released birds plus the prison has provided much in-kind help including accommodation and construction of our release aviaries.

Post-release monitoring: By 2017 the reintroduction phase of the project was half-way finished, with 30 chicks released, and releases for an additional three years are planned. The birds are all ringed with metal Sempach (Swiss Ornithological Station) rings on their left leg and with blue plastic rings on their right leg, permitting identification by telescope or camera. Just prior to release the birds are fitted with 3 g tail-mounted transmitters so that they can be monitored within the release area up to when the birds migrate. However, they are not fitted with backpack-mounted satellite transmitters as it has been suggested that these may increase chick mortality, which is already naturally high (about 33% of ospreys do not survive their first year). The first returns of released birds are hoped for in 2018, and they will be monitored by the reintroduction team (composed of three full-time staff as well as many volunteers).

Major difficulties faced

- Convincing some ornithologists, who thought that the birds would recolonise "naturally" if given enough time, that the project was necessary.
- Identifying donor countries and partners to collect chicks for translocation.
- Obtaining the necessary authorisations in Switzerland and in the donor countries.

- Identifying a number of dangerous electricity pylons in the release area and working with the electricity company to neutralise potentially lethal installations.
- Dealing with the unexpected, as there are many ways in which osprey chicks can accidentally die.

Major lessons learned

- The need to engage with all stakeholders, including conservationists, to achieve common understanding about the issue.
- Ensure that electricity lines in the vicinity of the release site are not dangerous (either not fully insulated, or having dangerous and unnecessary “bird spikes”).
- A highly motivated team of professionals and volunteers to guarantee around-the-clock observation and care of the young birds is central to the success of the project.
- Working with foresters to protect suitable nesting trees, and to prepare strategies for when the birds return to nest, is essential.
- In the longer term there is a great need to improve regulation along the entire migration route (particularly in countries bordering the Mediterranean) to stop current illegal hunting of migratory birds.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Out of 30 birds released so far from 2015 - 2017, 27 have migrated, which when compared to what would happen in the wild is highly successful.
- While it is too early to report on success of this project at this stage, it should be noted that similar osprey reintroduction projects undertaken in Europe have all been successful, with released birds returning to breed in England, Spain, Italy and Portugal.
- The project has raised much awareness about ospreys in the press and other media, and periodic updates on the project can be found at www.ospreys.ch.

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Reintroduction of scarlet macaws to Los Tuxtlas, Veracruz, México

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Introduction

The scarlet macaw (*Ara macao*), is a widely distributed species in tropical rain forests of the Americas, from Mexico south to Brazil and Bolivia. It is considered of Least Concern in IUCN (BirdLife Red List), and is listed in Appendix I of CITES, because the pet trade has threatened their persistence as wild populations. Other problems for them are habitat loss, and invasive species such as African bees. The northern part of its range is occupied by *Ara macao cyanoptera*. In southern Mexico and northern Central America, a greater human population density has strongly affected wild populations, displacing them from a wide part of its historical distribution (Monterrubio *et al.*, 2016). Hence, the conservation situation of *cyanopterus* is very different from *A. m. macao* (Schmidt, 2013). In Mexico, the remaining wild population is decreasing in the Lacandon forest (Iñigo, 1996), so the species is considered as Endangered at the national level. Two reintroduction projects were started from captive-bred specimens: one in Palenque (2013) and one in Los Tuxtlas, Veracruz (2014). The Los Tuxtlas project is carried out west of the Isthmus of Tehuantepec, that is, in places where they ceased to exist about 40 years ago (Aguilar, F. pers. comm., 2015).

Goals

- Goal 1: To establish a viable new population in southern Veracruz, Mexico, in the Reserva de la Biosfera Los Tuxtlas and if possible reach a total of 500 individuals.
- Goal 2: To use the scarlet macaw as an ambassador species for the protection of other forest species, and for habitat restoration.
- Goal 3: To make rural communities take interest and ownership in the species care so that our effort endures in this Reserve.
- Goal 4: To assist rural communities in improving their ecotourism projects through the presence of macaws.

Scarlet macaw

- Goal 5: To be able to replicate this project in other areas of Mexico.

Feeding station © Fatma Escalante

Success Indicator

- Indicator 1: Survival rate at the first year of being released greater than 50%. Successful nesting in 2 - 7 years of release.
- Indicator 2: The existence of reforestation/ agroforestry programs for farmers and ranchers that also benefit potential habitat for macaws.
- Indicator 3: Local collaboration in the care and recovery of macaws for rehabilitation, and future release.
- Indicator 4: Better attitudes towards conservation of wildlife.
- Indicator 5: Cultural integration of the scarlet macaw in the region.

Project Summary

Feasibility: The rain forests of Los Tuxtlas are currently reduced to 16% of its original distribution (Dirzo & Garcia, 1992), and they have now a protected area decree. The scarlet macaw does not occupy closed forest; therefore they can cross open lands as long as there are enough trees to feed on, with cavities for nesting. So for the project to succeed it is necessary in the mid-term, to improve the vegetation cover so that the habitat will be sufficient for the macaws to establish. The region's wildlife has traditionally been exploited, but the presence of groups of researchers for 40 years or more, has permeated into the local population. There is better awareness of the biodiversity loss problems that we are experiencing, and that are accelerating. There is a land use administration by the Reserva de la Biosfera Los Tuxtlas. Peasants themselves appreciate that the fauna has greatly diminished, having being very abundant before, and have even appreciate the change in the rain regime due to the deforestation. They are currently experiencing at least two months of drought, which was not the case previously. This has facilitated a positive attitude of the rural communities towards the Project.

Implementation: We have established an alliance among several institutions/ stakeholders to carry out the project in the medium and long-term. The Xcaret aviary maintains a breeding colony and provides groups of macaws prepared in their facilities for reintroduction. The Reserva Ecológica Nanciyaga provides the operational site and habitat for the recently released main group of macaws. Nanciyaga has an area of 18 ha, but along with other neighbors form a continuous patch of forest of about 40 ha. The Instituto de Biología de la UNAM in partnership with Bosque Antiguo AC operates the project *in situ.* We established

Reintroduction UNAM-Nanciyaga team
© Fatma Escalante

a pre-release aviary 12 m wide x 18 m long and 6 m high. In it, the macaws are received; they fulfill their quarantine, and receive trainings and stimuli to recover survival skills. They need abilities in recognizing naturally available food, and awareness about dangerous predators in the forest, including humans. A mixed work team has been formed which combines biology and veterinary graduates, with peasants, and other community members to carry out the project. Other organizations have provided financial support to make the project possible. These are: Wildlife Without Borders - Mexico (US Fish and Wildlife Service), Defenders of Wildlife Mexico, World Parrot Trust, PROCER (Program for Conservation of Endangered Species) of CONANP (Comisión Nacional de Áreas Naturales Protegidas) and the Fondo Ambiental Veracruzano (Veracruz State Environmental Ministry).

Post-release monitoring: To date we have established three release sites within Los Tuxtlas Reserve: Nanciyaga, La Otra Opción, and Reserva Ejidal Benito Juárez, and we have had five release events. We try to have a soft release each time, so that the macaws slowly explore the habitat and recognize the territory. With this, they should not disperse from the site, their partner or group, and that makes it easier for them to slowly locate natural food, and a safe territory. Supplementary food is provided on tall tree feeding stations (10 - 15 m high) for 6 - 9 months after the group has been released. The marks on their peaks last 2 - 3 months, and with them each macaw is identified when they visit the feeding stations and are counted. That is our best chance to see if any one of them is away or lost. If missing macaws are not around, they are sought after in communities and nearby habitats, and if possible they get returned to the site of release. Community monitors perform counts and distribution maps. Eleven nest boxes have been mounted; some pairs are occupying them since the first year. A few eggs have been found, but chicks or juveniles have not yet being detected. African bees occupied two nest boxes instead.

Major difficulties faced

- One of the main difficulties has been fund raising. There are currently many needs, much competition, good conservation projects, and few resources. This project requires maintenance of infrastructure and operational funds to be able to attend the essential activities of the field team.

Major lessons learned

- To use only soft releases with a preparation time for each group of at least six months together. This helps when they go out of the aviary for the first time (the most critical time). Macaws are usually very cautious and they explore the new habitat little by little. This way they can locate their new food while they still have access to the feeding temporary stations.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Scarlet macaws are very charismatic and the human population easily adopts them, feels proud of their return, and collaborates with their care.

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Translocations of Laysan and black-footed albatrosses in Hawaii, USA, to create new protected breeding colonies safe from climate change

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Introduction

Over 95% of the global populations of Laysan albatross (*Phoebastria immutabilis*) and black-footed albatross (*P. nigripes*) nest on low-lying atolls in the Northwestern Hawaiian Islands, USA. These atolls and the animal and plant populations they support are threatened by sea level rise and increasing storm surge associated with global climate change. Both species are regarded as Near Threatened by the IUCN. Protection of suitable nesting habitat and creation of new colonies on the higher main Hawaiian Islands are among the highest priority conservation actions for these species. Many seabird species have been extirpated from the main Hawaiian Islands by human activities and non-native predators introduced by humans. Restoration of seabirds to these islands requires management of habitat and non-native predators.

James Campbell National Wildlife Refuge (JCNWR) on the northern coast of Oahu, Hawaii, USA, contains an area of coastal strand that provides excellent nesting habitat for seabirds including albatross, and it is managed for seabirds, but none currently nest there. JCNWR is high enough to be safe from inundation based on current projected climate change scenarios. This project takes a proactive approach by attempting to mitigate the effects of climate change before they become urgent.

Black-footed albatross with chick, Midway Atoll National Wildlife Refuge © Eric VanderWerf

Goals

- Goal 1: Create new Laysan and black-footed albatross breeding colonies at JCNWR that are safer from effects of climate change.
- Goal 2: Construct a predator-proof fence at JCNWR to protect the new colonies against non-native predators.

- Goal 3: Attract albatrosses to JCNWR that have been displaced from existing colonies on other islands that are washing away.
- Goal 4: Establish and improve upon techniques for translocating and raising seabird eggs and chicks.
- Goal 5: Provide educational opportunities about albatross and other seabirds and the effects of climate change.

Albatross release site JCNWR
© Eric VanderWerf

Success Indicators

- Indicator 1: Completion of a predator-proof fence at JCNWR and removal of all non-native mammalian predators from inside the fence.
- Indicator 2: Successful translocation of Laysan and black-footed albatross chicks to JCNWR.
- Indicator 3: Hand-raising of healthy Laysan and black-footed albatross chicks to fledging with fledging rates greater than or equal to fledging rates of wild chicks.
- Indicator 4: Return of the translocated albatross as adults to the release site at JCNWR (and not their natal sites).
- Indicator 5: Breeding by translocated and socially-attracted albatrosses at the release site at JCNWR.

Project Summary

Feasibility: Translocation and social attraction have been used to create new seabird colonies and augment existing colonies. Social attraction is more likely to be successful if source colonies exist nearby. Seabirds exhibit high natal site fidelity, meaning they usually return to breed as adults at the same location where they were raised. For albatrosses, the critical period at which they imprint on their natal location is about one month of age. A small Laysan Albatross colony exists at the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai. These birds nest near an active runway, however, where they pose a collision hazard to aircraft. The Navy has implemented a collision abatement program in which all albatross eggs are removed and adults are hazed from the area. The simultaneous availability of Laysan albatross eggs from PMRF and suitable but unoccupied albatross nesting habitat at JCNWR represented an opportunity to accomplish an important conservation action (establish a new colony on a high island), prevent destruction of viable eggs, and help solve a human-wildlife conflict.

LAAL translocated egg pipping Kaena Point
© Eric VanderWerf

Black-footed albatrosses are especially vulnerable to climate change because they often nest on open sandy beaches on the perimeter of atolls. The largest and most accessible black-footed albatross breeding colony is at Midway Atoll National Wildlife Refuge.

Implementation: Laysan Albatross eggs were translocated by airplane from PMRF on Kauai to Oahu, held in an incubator until a foster nest was located at two existing colonies on Oahu, then placed temporarily in foster nests. The eggs hatched in the foster nests, allowing chicks to imprint on the correct parental species and acquire the appropriate gut fauna through regurgitated food from their foster parents. The chicks were moved to JCNWR at about three weeks of age. Three cohorts of Laysan albatross eggs have been moved, in 2015, 2016, and 2017, which resulted in 50 chicks that were raised at JCNWR. Hatching rate was low in the first year, but changes in methodology caused the hatching rate to increase to 76% in 2017. The first cohort of 15 black-footed albatross chicks was moved from Midway Atoll to JCNWR in February 2017 when they were three weeks old. Birds from Midway were held in quarantine for one week before release at JCNWR. At least two more cohorts of 25 chicks will be moved in 2018 and 2019.

All chicks of both species were fed 15 - 25% of their body weight daily on a diet of blended fish, squid, fish oil, pedialyte and vitamins, with black-foot chicks requiring a higher proportion of their body weight than Laysans. The frequency and quantity of feedings were gradually decreased during the final two months to allow chicks to reach an appropriate fledging weight. The chicks grew faster and more consistently than wild reference chicks in a Laysan albatross colony at Kaena Point, Oahu, attained larger body size, and fledged at younger ages on average. The fledging rate of chicks was high; 46 of 50 (92%) in Laysan albatross and 14 of 15 (93%) in black-footed albatross, which are higher than the fledging rate in wild chicks (78%).

A predator fence 1,125 m long, enclosing an area of 6.56 ha, and capable of excluding all non-native mammalian predators at JCNWR was completed in October 2016. All feral cats, mongooses, and rats have been removed from the fence. A few house mice remain but should be gone soon.

A social attraction program consisting of 10 decoys and a solar-powered sound system broadcasting courtship calls was deployed for each species. Many wild adult Laysan albatrosses visited the site, and the number of visits increased each year, with 354 separate visits by up to 11 adults in 2017. Visiting adults courted with each other, the decoys and speakers, and also visited the chicks and sometimes attempted to feed them. The chicks sometimes begged from or attempted to court with the visiting adults. No black-footed albatrosses visited the release site, but the black-foot chicks often rested next to the decoys and speakers.

Post-release monitoring: All albatross chicks raised at JCNWR were banded to allow individual identification. Each bird received a metal band on one leg, and a plastic auxiliary band on the other leg with larger characters that can be read from a distance. Albatrosses are long-lived and have delayed reproduction; they spend their first few years at sea and begin returning to land 3 - 5 years after fledging and begin breeding after 7 - 9 years. Albatrosses will be monitored at JCNWR (and at other sites on Oahu) during continuing restoration work with other seabird species, and with automated remote cameras. The decoys and sound systems will be deployed indefinitely to continue to attract albatrosses to the release site. Birds from the first cohort of Laysan albatrosses that fledged in 2015 should begin returning to JCNWR in 2018.

Major difficulties faced

- All previous seabird translocations have involved chicks, this was the first project in which eggs were moved and had to be hatched. Methods for moving and hatching albatross eggs had to be worked out.
- The ultimate success of the project will not be known for several more years, when the translocated albatross are expected to begin returning as adults. It was important from the outset to explain the long-term nature of the project to permitting agencies and funding organizations.
- Moving eggs and chicks among islands and locations required numerous permits from a variety of State and Federal management agencies, particularly from Midway Atoll, which is not part of the State of Hawaii. All permits were granted, but required substantial coordination time.
- Moving large seabirds to an island like Oahu that has a relatively large human population has the potential to cause concern about human-wildlife conflicts, whether real or perceived. It was frequently necessary to explain the biology of the species and the need for the project in order to generate support.

Major lessons learned

- Higher egg hatching rate was achieved by placing eggs in foster nests than by keeping them in an incubator for an extended period.

Translocated chicks JCNWR © Eric VanderWerf

- Chicks required constant and individualized attention during five months of care to ensure their health and proper development. Some birds required more food than others during different stages of development to maintain growth. Daily visual monitoring and measurements allowed illnesses and other problems to be detected quickly and treated in most cases.
- The fledging period was a crucial time during which some chicks required assistance. Some chicks that fledged during periods of strong wind were blown back onto land and needed to be returned to a suitable location to fledge again.
- The chicks served as a powerful social attractant. In addition to the decoys and sound system, many visiting adult Laysan Albatross also interacted with the chicks, sometimes resting next to them overnight and even attempting to feed them. The chicks sometimes begged from or attempted to court with visiting adults.
- Social attraction was not effective for black-footed albatross because the nearest existing colony is over 161 km away. No adults visited the release site at JCNWR, and few visited Kaena Point, Oahu, during six years of attempted social attraction.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The release at JCNWR site is protected with a predator fence and all predators have been removed. There was no predation on translocated chicks or visiting adults.
- Translocation of eggs and chicks was successful, and improved techniques were developed for hatching eggs and raising chicks.
- Translocated chicks were healthy, grew steadily and attained larger body size than wild reference chicks, and fledged at a younger age.
- The fledging rate of chicks was high; 92% in Laysan albatross and 93% in black-footed albatross, both of which are higher than the fledging rate in wild chicks.
- The ultimate success of the project will not be known for several more years, until the translocated birds are old enough to begin returning, and eventually breeding, at JCNWR.

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Reintroduction of the critically endangered Mauritius fody to Ile Aux Aigrettes, Mauritius

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Introduction

The Mauritius fody (*Foudia rubra*) is a small passerine bird, endemic to Mauritius and classified as Critically Endangered by the IUCN in 2002 before conservation efforts started. The species were once found all over Mauritius but now only persists in upland and intermediate forest. The area where they are found in relative abundance consists of an upland forest which contains patches of degraded and invaded endemic forest as well as a *Cryptomeria japonica* plantation. Surveys done every 10 years showed an important decline (Safford, 1997) in the population of Mauritius fody which prompted the need for action before it became too late. The population of fodies was studied and the main threat identified: nest predation by mammalian predators (introduced black rats (*Rattus rattus*), feral cats (*Felis catus*) and crab-eating macaques (*Macaca fascicularis*). Different options were considered but the one chosen which could mitigate this threat was to create a new subpopulation in a predator free area (island or mainland island). For this, different sites were identified but Ile aux Aigrettes (IAA) was chosen as the most suitable as it had a restored native forest and was free of mammalian predators.

Mauritius fody
© Vikash Tatayah

Goals

- Goal 1: Reduce the risk of extinction.
- Goal 2: Set up a second self-sustaining subpopulations (that breed on their own and require minimal management).
- Goal 3: Downlist the Mauritius fody from Critically Endangered to Endangered then vulnerable in the IUCN Red List.
- Goal 4: Learn more about the species.
- Goal 5: Design and refine management methods adapted to the Mauritius fody.

Release site - Ile aux Aigrettes © Vikash Tatayah

Success Indicators

- Indicator 1: Increase in the number of Mauritius fody in Mauritius.
- Indicator 2: Mauritius fody downlisted.
- Indicator 3: The creation of at least one additional self-sustaining subpopulation.
- Indicator 4: Improved knowledge on biology and ecology of the species.
- Indicator 5: Adapted management methods for the Mauritius fody.

Project Summary

Implementation: The focus of this project was the reintroduction of the Mauritius fody in suitable areas to create new subpopulations which would lead to a reduced risk of extinction (Safford & *et al.*, 1998). To achieve that, potential areas for reintroduction were investigated. The main threat identified was predation by introduced mammalian predators, the site had to either have extensive predator control or no predators at all. IAA was identified as the most suitable site since rats and cats were eradicated from this islet. IAA is a small islet of 25 ha, 660 m away from the mainland, where continuous efforts have been made to restore the forest since 1985. IAA has a lowland coastal endemic forest which stands at around 10 m high and due to shallow soils might never exceed this height greatly. IAA, being close to the mainland, has been naturally invaded by introduced birds such as the Madagascar fody (*Foudia madagascariensis*), red-whiskered bulbul (*Pycnonotus jocosus*) and Indian mynah birds (*Acridotheres tristis*). As the Mauritius fody has natural predators which are endemic birds therefore know how to defend against other birds, and that nest predation by introduced birds on the mainland was not frequently witnessed, the risk of failure because of the presence of introduced birds on IAA was predicted to be minimal. However, to avoid bringing new pathogens to IAA, all the birds reintroduced were screened for disease prior to translocation and were de-wormed.

Since 2001, Mauritius fody pairs were monitored to understand the species better and facilitate the decision making process. A first trial was made in 2002 to try harvesting chicks from wild nests then hand-rearing them. The trial being a success, chicks were harvested from nests in Pigeon Wood, Black River Gorges National Park and brought to the Gerald Durrell Endemic Wildlife Sanctuary for hand-rearing in bigger numbers. To maximize the number of Mauritius fody harvested as not many nests reached chick stage, eggs were also harvested on the third day. In parallel, four pairs of hand reared birds were used for captive-breeding. In total, 52 chicks and 21 eggs were harvested from the wild population and captive-breeding produced 32 fledglings. The 93 resulting juveniles and adults (captive-breeding pairs) were released on IAA over a period of three years. The hand rearing and captive-breeding programs were stopped in 2006 after the Mauritius fodies on IAA bred successfully for two consecutive seasons (Cristinacce & *et al.*, 2009).

The Mauritius fodies were released on the island using a soft-release technique. The birds were brought to the island and kept in an aviary for habituation between 7 - 12 days before release. This helped them to get used to their new environment and to be calmer and less stressed when released afterwards. It also encouraged them to come back to the aviaries for supplemental feeding once released.

Post-release monitoring: Since release on the island, the survival, breeding activity, territoriality, and feeding ecology of the fody population has been monitored closely and is ongoing (Ferrière *et al.*, 2016). The results of this monitoring shows that the Mauritius fody population is continuously growing and has now reached 258 birds with an extra 87 birds which have been seen in the last year but not the last month (and therefore are not assumed dead yet), adding to a total of 345 Mauritius fodies (MWF, 2017). The Mauritius fodies occupy the whole island and territories have become smaller in recent years to make space for the recruitment of new breeding pairs to the population. All individuals are ringed as chicks in their nest or as fledglings when they come to get supplemental food at the aviary. On the mainland sites, Mauritius fodies were believed to be monogamous but data from breeding monitoring on IAA shows that the Mauritius fodies can be polygamous. Mauritius fody males were observed building nests with more than one female sometimes simultaneously but females seem to only have one male at a time. This could be due to the strong bias between male and female numbers (there are a lot more females than males on IAA). Opportunistic feeding observations data has shown that they are a very adaptable species, eating mainly invertebrates but also nectar and fruits from a wide range of plant species when available. Monitoring health and survival has also proven its worth after pox outbreaks on IAA which resolved themselves naturally but could have been fatal to the population if its spread was not mitigated quickly. As a result of the creation of this self sustaining subpopulation, the Mauritius fody was downlisted to Endangered in 2009.

Major difficulties faced

- Finding a suitable site to create a new subpopulation proved challenging and IAA was the only choice available at the time.
- Bringing Mauritius fodies to a new habitat and had to use a soft release technique to make sure it would not be a problem.
- This was the first time passerines were hand-reared in Mauritius and the techniques had to be designed and tested, thankfully experts from zoos made it possible with minimal difficulties.
- Nest predation by introduced bird species were documented on IAA but even with that pressure, the number of birds on the island is growing.

- There was a risk of hybridization with the Madagascar fody but thankfully only one case of hybridization was found and it did not happen again.

Major lessons learned

- A population of birds can increase very quickly even when only one limiting factor is addressed.
- It is possible to sustain a population of birds with only minimal management, the Mauritius fodies are only fed twice a week and the population is still increasing.
- Having a (relatively) closed system (an island) facilitates research and makes it easier to learn about a species and its breeding.
- Monitoring at least survival and breeding is important to detect and resolve problems quickly for example in case of disease outbreak.
- It is important to look at the whole system and risks before translocating birds.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The project has had a clear vision and goal which did not change over time.
- Research was done on the species before any action was taken which permitted the correct identification then removal of the limiting factor.
- The relatively high number of released birds through captive-breeding and hand rearing gave the population a good head start to overcome predation and competition with introduced birds.
- The Mauritius fody is a very adaptable species which reproduces quickly and productively.
- The dedication and motivation of the staff and volunteers were fundamental to the success of the project.

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Translocation and re-establishment of the Rimatara lorikeet from Rimatara Island, Austral Islands, French Polynesia to Atiu Island, Cook Islands

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Introduction

The Rimatara lorikeet (*Vini kuhlii*) (also Kuhl's, ruby, scarlet-breasted lorikeet, *'Ura, Kura*, *Vini kuhlii*) appears on CITES Appendix II and is listed on Birdlife International/IUCN Red List as "endangered" due to its small population, limited distribution, and risk of ship rats becoming established on its home islands. The species is restricted to three islands: Rimatara in western French Polynesia and Tabuaran and Teraina in remote northeastern Kiribati. The former natural range for the species was the southern Cook Islands and Rimatara while the inclusion of the Kiribati Islands is due to birds introduced by Polynesians before the discovery of the group in 1798. The native Atiu population valued the lorikeet's brilliant red plumage which was hunted to extinction before Captain Cook's arrival in the 1777. The overall goal of this conservation effort was to reintroduce a founder population from Rimatara and to establish a reserve population on a ship rat-free island within its former range. The project is organized by the Cook Islands Natural Heritage Trust, the Ornithological Society of French Polynesia (MANU) and San Diego Zoo Global with the support of the communities of Rimatara and Atiu, and the approval of the governments of French Polynesia and the Cook Islands.

Rimatara lorikeet © Gerald McCormack

Goals

- Goal 1: Capture and translocate a founder population of Rimatara lorikeets from Rimatara, French Polynesia with subsequent release of the birds on Atiu Island, Cook Islands, with a minimum loss of birds to re-establish a thriving population on Atiu.

Release site on Atiu Island © Alan Lieberman

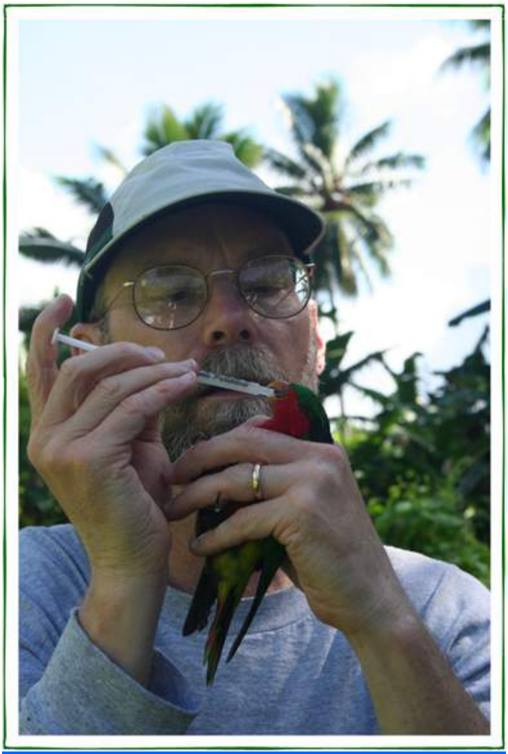
- Goal 2: Perform a health evaluation of all the captured birds on Rimatara before translocation with a follow-up of the released population on Atiu in subsequent years.
- Goal 3: Reduce or eliminate the introduced common myna (*Acridotheres tristis*) on Atiu that would jeopardize the successful establishment of a new founder lorikeet population on Atiu.
- Goal 4: Support a public education campaign that would prevent the potential introduction of the ship rat (*Rattus rattus*) on Atiu Island.
- Goal 5: Gain the support of the local communities to the concept of capture and removal of the Rimatara lorikeet (Rimatara Island) and likewise, the concept of release of the lorikeet on Atiu Island.

Success Indicators

- Indicator 1: Capture (mist net) of up to 27 Rimatara lorikeets on Rimatara, transfer to Atiu, release birds, and make subsequent observations to document breeding and population growth.
- Indicator 2: Diagnostic samples and parasites are taken from a subset of captured birds as well as examinations conducted for overall health using weight, plumage condition, morphometrics, and body condition as indicators.
- Indicator 3: The local community is engaged in a common myna eradication program using a reward system for bodies and documenting the declining population over time.
- Indicator 4: Public information materials are produced and distributed in multiple languages in Cook Islands Maori and English to inform the local community about the dangers of the accidental introduction of the ship rat.
- Indicator 5: Public meetings are organized to discuss the goals of the program on both Rimatara and Atiu, leading to a democratic vote of support of the project (or not).

Project Summary

Feasibility: In 1992, the Cook Islands Natural Heritage Trust (Trust) undertook the first extensive research of the lorikeet and its habitat on Rimatara. The estimate was approximately 900 birds, with the greatest density in the man-modified horticultural belt (2.2 birds/ha). A preliminary survey showed that while


Lory receives pre-release nectar feeding © Marshall Humphries

the Pacific rat (*Rattus exulans*) and the Norway rat (*Rattus norvegicus*) were present, there was no evidence of the ship rat (*Rattus rattus*). At the 1993 Ornithological Society of Polynesia (MANU) conference in Papeete, Tahiti, the Trust proposed three conservation actions for the lorikeet on Rimatara: 1) confirm absence of the ship rat and intensify the rat surveillance and control procedures; 2) survey the lorikeet population every 2 - 3 years, and 3) establish a reserve population of lorikeets on an island free of ship rats. Aitutaki (Cook Islands) was free of ship rats but was unsuitable for a reintroduction program because it already supported a population of the introduced blue lorikeet (*Vini peruviana*), which would compete for food and nest sites, leaving Atiu as the only populated island within the lorikeet's former natural range suitable to support a reintroduced reserve population. Of some concern was the common myna (*Acridotheres tristis*), which was introduced to Atiu in 1916. Although the blue lorikeet has thrived on Aitutaki in the presence of the common myna since 1915, observations of the first nesting attempt on Atiu showed aggressive interactions between emerging lorikeet fledglings and resident common mynas which led to the conclusion that the common myna was a potential threat to the success of the reintroduction program. The proposed capture, holding and transport of the birds followed the same protocols used to successfully translocate 29 ultramarine lories (1992 - 1994) from Ua Huka to Fatu Hiva (Marquesas Islands, Fr. Polynesia).

Implementation: In April 2007, the field team of 13 began the capture effort. Additionally, Immigration, Customs, and Quarantine officers were flown from Papeete to Rimatara to expedite the inspections and authorizations to remove birds from one country (French Polynesia) to another (Cook Islands). These officials were required to process passengers and birds for the direct international flights between Rimatara and Atiu. The Cook Islands counterparts also had to be flown from Rarotonga to Atiu, which similarly is not a port-of-entry. The field teams were composed of two bird-catching teams and one "Bird House" team. Each field site had nine to 11 nets open from dawn to dusk. Nets were monitored continuously and birds were removed within minutes of capture and transported immediately to the Bird House. Upon arriving at the Bird House the birds were weighed, banded, measured, examined and treated for external parasites, swabbed (choanal) for later disease surveillance, and placed in a holding cage. The cages were based on those used previously for translocating the ultramarine lorikeet. Choanal, fecal, and blood samples, as well as feather mites, were collected for diagnostic evaluation. A total of 28 birds were captured and held for as few as six days and as long as 11 days. Twenty-seven birds (one bird was released on Rimatara) were transported via aircraft and released on Atiu immediately upon arrival. In the entire process of capture, holding, and transport there were no health issues and no mortalities.

Post-release monitoring: The census team of eight biologists and volunteers assembled on Atiu in September 2016 and worked in pairs and trios to increase the chance of hearing or seeing kura within 50 m of the eight road-transects, which totaled a transect area of 292 ha (29 km in length x 100 m width = 292 ha). The counting on each transect started at approximately 06:00 hrs and lasted for up to two hours; the team completed 40 hours of searching over a period of 10 days. The daily average number of birds detected within 50 m of the eight road-transects was 0.35 kura/ha. The area sampled on the transects was 292 ha or 26.5% of the habitable 1,100 ha on the island. We multiplied 0.35 kura/ha x 1,100 ha to arrive at an estimated total of 385 kura on Atiu. Four kura were captured and were inspected, bled and swabbed by the San Diego Zoo Global veterinarian and were considered to be in excellent health with no diseases or parasites. The common myna eradication program was completed at the same time as the 2016 census with the elimination of the last four common mynas known on the island. It is estimated that approximately 26,000 common mynas were eliminated during the seven years eradication campaign. And finally, as a result of the public information campaign against the accidental introduction of the ship rat, the public inspects all off-loaded cargo arriving on the weekly barge as well as watching for the tell-tale signs typical of ship rat activity on gnawed coconuts.

Major difficulties faced

- Public campaign on Rimatara was required to convince the local community to allow the capture and removal of up to 27 lorikeets; a species that was protected by royal decree from Queen Tamaeva in the early 1900s.
- There was a logistical challenge of exporting and importing a protected species from French Polynesia to the Cook Islands with proper and legal authorization of the respective agencies responsible for Customs, Immigration, and Animal/Plant Sanitation.
- Finding and assembling a field team in 2007 and 2016 that had the experience and expertise in bird capture, care, health evaluation, transport, release and follow-up census.
- Designing a census protocol on Atiu that utilized available access (roads and trails) that would provide an accurate, reliable and replicable estimate of the lorikeet population.
- Raising the funds from several sources to undertake the translocation and to carry out the census nine years later.

Major lessons learned

- How to best manage wild birds in a “catch and release” effort, even when faced with a long (10 days) holding period, long plane flights, and “hard releases”.

- By involving the local community in managing the limiting factors, even the daunting challenge of eliminating an entire population of an invasive-introduced species (common myna) is possible.
- The importance of a thorough, transparent, and well-supported disease risk analysis that involves all stakeholders.
- Public education is key to protecting a fragile insular environment, i.e. both Rimatara and Atiu continue to be ship rat free.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Having dedicated groups in the two countries, the Cook Islands Natural Heritage Trust and Ornithological Society of French Polynesia, with the patience and persistence to undertake the six years of negotiations between the two governments and two communities.
- Having excellent primary funding from BirdLife International combined with additional funding from Air Rarotonga, San Diego Zoo Global, the governments of French Polynesia and the Cook Islands and several bird clubs, foundations and private donors.
- Having a diverse and experienced field team (especially for the capture and captive management and veterinary evaluation) is key to ensuring the health of the birds during the process of a successful translocation.
- Knowing that a similar vegetation habitat to that occupied by the lorikeet on Rimatara was more extensive on Atiu and, in particular, that the ship rat was absent.
- The strong support of the Atiu community to remove the common myna after it was seen to seriously harass nesting lorikeets in 2008.

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Reintroduction of North Island kākā to Wellington, New Zealand's capital city

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Introduction

Kākā (*Nestor meridionalis septentrionalis*) are medium-sized, forest-dwelling parrots endemic to New Zealand. Once common, their distribution has reduced due to habitat destruction and predation by invasive mammals; the population is estimated at fewer than 10,000 birds. They are listed as Endangered by the IUCN and At Risk-Recovering by New Zealand's Department of Conservation (Birdlife International, 2016; Robertson *et.al.,* 2017).

As kākā evolved without mammalian predators, they are vulnerable to predation by introduced stoats, cats and rats, particularly due to their habits of nesting in tree cavities and spending time on the ground after fledging. Kākā are rare on New Zealand's three main islands, but numerous on offshore islands (Moorhouse, 2013). The creation of mainland sanctuaries free from mammalian predators provides an opportunity to establish strongholds on mainland New Zealand. Reintroduction of native wildlife like kākā into ZEALANDIA sanctuary (a 225 ha area surrounded by a 9 km fence that excludes all pest mammals except mice) was an important part of the goal to restore the valley as close as possible to pre-human arrival (Campbell-Hunt, 2002). It also offered the opportunity to discover whether the species would establish in a highly human-populated landscape due to the sanctuary location within 2 km west of Wellington City CBD.

Goals

- Goal 1: To restore a population of kākā in ZEALANDIA sanctuary.
- Goal 2: To restore the indigenous character of the sanctuary valley.

Kākā with Wellington city in background
© Judi Lapsley Miller

- Goal 3: To restore key natural processes in the sanctuary.
- Goal 4: To provide an opportunity for people to encounter and learn about the species.
- Goal 5: To provide a back-up for mainland kākā populations in less secure environments.

Success Indicators

- Indicator 1: Self-sustaining population of kākā established at ZEALANDIA sanctuary.
- Indicator 2: Community members and stakeholders involved and committed to the successful establishment of kākā.
- Indicator 3: Kākā population at ZEALANDIA used as source to supplement or create other kākā populations.

Project Summary

Feasibility: The design and establishment of the first effective mammal exclusion fence, and the removal of introduced pest mammals from 225 ha of regenerating diverse lowland forest, was essential before the endangered kākā and other missing species could be re-established. This required fence trials, fund -raising and considerable engagement with neighbours and the community given the location of the sanctuary in Wellington City. Kākā had been effectively extinct from the area, primarily due to predation, since the early 1900s. Experience elsewhere indicated that release of young captive-bred birds was the most likely successful translocation technique and this project was supported by the kākā captive-breeding program. Furthermore, the support of the local community was essential to the success of the restoration program, and the introduction of a large, charismatic species would allow the Wellington community to learn about and become engaged with conservation occurring at the recently-opened ZEALANDIA.

Implementation: Once ZEALANDIA had been confirmed safe from introduced mammals, four separate releases of 14 individually banded juvenile kākā were undertaken between 2002 and 2007. This followed extensive consultation with the New Zealand Department of Conservation, local government, Māori (indigenous peoples of New Zealand) and other sanctuary supporters. The birds originated from five different locations, primarily zoos, and were all parent-raised in captivity. The founder population consisted of 8 males, 5 females and 1 bird of unknown sex. All birds were held in quarantine for 30 days before transfer and screened for various diseases, particularly Psittacine Beak and Feather Disease (PBFD). After arriving at ZEALANDIA, the kākā were kept in an aviary within the sanctuary to site-fix the birds, ensure they were well prepared for release and that the transmitters fitted for post-release monitoring had no attachment issues. In the first translocation birds were kept in captivity for up to 104 days. Kākā in later releases were kept for less time as confidence in the transmitter attachment had grown and it was assumed that the conspecifics would help new birds settle into their surroundings. Supplementary feeders were built where visitors could see the birds, building community support for the project. Year round *ad lib* supplementary food was used to support and encourage kākā to remain and breed within the safety of the sanctuary. Nest boxes were also installed throughout the valley.

Kākā chick being banded © Judi Lapsley Miller

Post-release monitoring: All kākā from the first three releases were fitted with transmitters and radio-tracked. Between 2003 and 2016, the ZEALANDIA kākā population was intensively monitored for survival, dispersal, recruitment, and productivity to determine the population status and trends. All chicks hatched in nest boxes were individually color banded. Survival of founders to breeding age was high averaging 88% for the four releases. Eleven of the 14 founders (79%) paired and bred within the sanctuary. Site fidelity was high with 11 birds still regularly recorded within the sanctuary three years after release (average seven years). One individual is still regularly sighted 15 years post release.

Breeding occurred in the first year of transfer and has occurred every year since then, with breeding success and productivity exceeding that of wild populations elsewhere (Powlesland *et. al.*, 2009).The 800th chick was banded during the 2016 - 2017 breeding season, and monitoring has now changed focus to support academic research projects. Significant social support has emerged through engagement of many volunteers in post-release monitoring and ongoing management.

Kākā are now breeding outside the sanctuary, and are heard and seen throughout the Wellington suburbs. Due to the success of the kākā translocation, there have been three transfers (2013, 2016 and 2017) of birds from ZEALANDIA to other sanctuaries, with more planned in the future.

Major difficulties faced

The success of the reintroduction and increasing presence of this large parrot within and now beyond New Zealand's capital city has caused management challenges for the species, as listed below:

- Dangers such as window strikes, birds in flight hit by vehicles, and predation by cats and dogs must be managed or mitigated, and injured birds cared for where required.
- While interactions between people and kākā have been overwhelmingly positive, some activities such as feeding birds outside ZEALANDIA can cause problems. For example, inappropriate food can cause disease (e.g. nuts that can cause metabolic bone disease in chicks); kākā flocking to backyard feeding sites can distress neighbours; kākā can be exposed to lead poisoning from chewing on roof fixtures; people can be bitten by kākā that have been hand-fed.

- Kākā can cause damage to trees and property, and they also make noise. In an urban landscape the perception of these behaviors can become negative; these perceptions sometimes need to be managed and consideration given to changes to people's activities or the built environment that might discourage such behaviors.

Major lessons learned

- Fenced sanctuaries free from introduced predators can provide a successful and important site for restoration of threatened species where predation is an issue.
- Reintroductions to urban areas are complex, and human-interactions must be considered. Public involvement is critical for long-term reintroduction success, to create a positive public profile, and to minimize any human-wildlife conflicts . In the case of kākā, there have been active campaigns by city conservation organizations to ensure the public is aware of issues and risks associated with feeding the birds and encouraging responsible pet ownership (to reduce the chance of predation).
- Urban translocations are a valuable tool for public engagement and education on conservation issues, providing opportunities for citizens to encounter wildlife that usually can only be seen in remote locations.
- Long-term monitoring of translocated populations is important for evidence-based management of the species. For example, different types of nest boxes were trialed over several years to determine the best design requiring minimal management and high fledging success. In addition, any sick, injured or dead birds found continue to be examined to determine the cause of illness or death; this helps with quickly recognizing and mitigating problems the population may be facing.
- A volunteer workforce provides a useful way to achieve intensive long-term monitoring, and also provides volunteers with a chance to encounter the species of interest.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The site has suitable habitat with a diversity of native vegetation, much having been regenerating for over 100 years, as well as natural springs & streams; exotic trees attractive to kākā (mainly *Pinus radiata*) are also present. The successful removal and ongoing exclusion of introduced mammalian predators and competitors has created a site that is safe for an endangered species such as kākā.
- Earlier trials with transfers of kākā elsewhere provided key information on translocation design to ensure the best chance of success in reintroducing kākā into ZEALANDIA (by using captive-reared juveniles); the transfers have also been supported by occasional natural immigration that began even before any releases occurred.

- Specially designed kākā feeders and nest boxes, as well as local natural and supplementary food were placed in the aviary to help the birds become familiar with them before release; release occurred beside the familiar kākā feeders, and *ad lib* provision of the attractive supplementary food and widely distributed nest boxes encouraged the juveniles to forage and later nest within the safety of the sanctuary.
- A highly social species, minimal dispersal after release, some immigration from wild sites (that increased genetic diversity), high productivity, and good survival of fledglings ensured the small founder population increased rapidly and a kākā population successfully established at ZEALANDIA.
- The highly public and urban nature of the sanctuary has allowed the achievement of key goals around community engagement and education, and the success of the translocation itself now allows people to experience this species in their local green spaces.

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Reintroduction of addax to Djebil National Park, Tunisia

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Introduction

The addax (*Addax nasomaculatus*) was once widespread and abundant across the dunes and gravel plains of the Sahara, but suffered catastrophic declines due to unsustainable hunting, habitat degradation, competition with domestic livestock, regional insecurity, and impacts of oil exploration. As a result the addax is Critically Endangered (IUCN/SSC Antelope Specialist Group, 2016) and is thought to be on the verge of extinction in the wild (Stabach *et al*., 2016). The addax is listed in Appendix I of the Convention on Migratory Species (CMS) and Appendix I of Convention on the International Trade of Endangered Species (CITES). It is specifically protected under national legislation across some of its range including Tunisia (IUCN/SSC Antelope Specialist Group, 2016). Historically, addax occurred within the Grand Erg Oriental in Tunisia. Whilst it has persisted south of the Sahara, albeit in very small numbers, it disappeared in Tunisia in 1932. However, in the last 25 years addax have been introduced to one National Park and returned to an additional two National Parks in Tunisia, including this latest project in Djebil National Park (NP). Designated in 1994, the park is located 40 km south of Douz on the edge of the Grand Erg Oriental.

Goals

- Goal 1: *Short-medium term* - Create a founder population of addax in Djebil National Park, as part of a protected Tunisian meta-population.
- Goal 2: *Medium-term* - Enhance capacity for antelope reintroductions and monitoring through provision of training.
- Goal 3: *Long-term* - Create a free-ranging population of addax in the Grand Erg Oriental from dual release sites in Djebil National Park and Senghar National Park.
- Goal 4: Establish long-term monitoring of reintroduced addax populations.

Success Indicators

- Indicator 1: Addax population established and growing in Djebil National Park.
- Indicator 2: Addax maintained in good health.
- Indicator 3: Locally collected biological data informing management decisions.
- Indicator 4: Increase in the number of trained protected area personnel and wildlife veterinarians.
- Indicator 5: Addax free-ranging in the Grand Erg Oriental.


Addax in its natural habitat

Project Summary

Feasibility: The addax is on the brink of extinction in the wild with the last remaining population distributed unevenly along a narrow 600 km band between Termit /Tin Toumma in Niger and the Djourab sand sea in Chad (Newby, 2013). A survey in April 2017 in core addax habitat in the Termit and Tin Toumma National Nature Reserve area found just six individuals (Rabeil, 2017), and there are probably fewer than 100 addax remaining in the wild (Stabach *et al*., 2017).

Despite the precarious position of addax in nature, there is an abundant *ex situ* population, with available animals in the Species Survival Plan (SSP) under the auspices of the Association of Zoos and Aquariums (AZA), and the European *Ex situ* Program (EEP) under the auspices of the European Association of Zoos and Aquaria (EAZA). A conservation introduction of addax to the fenced Bou Hedma NP in Tunisia had previously been undertaken. Hence the project to re-establish the species in Djebil NP was able to utilize addax born within the country, genetically augmented with animals selected from the SSP and EEP populations. Tunisia has long established legal, strategic and institutional frameworks to support the reintroduction and protection of addax. 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 Direction Générale des Forêts (DGF), the statutory authority responsible for the management of protected areas. Djebil NP comprises major dune systems and gravel plains and is situated 40 km south of the Oasis town of Douz on the margins of the Grand Erg Oriental, and within the species' indigenous range. Previously utilized opportunistically by nomads, a 7,700 ha section of the park has been fenced to exclude domestic livestock from the addax release site and to enable habitat regeneration. There are two permanent ranger posts on the northern and southern edge of the park boundary and one at the main entrance in the North.

Implementation: Two operations took place to bring Addax to Djebil NP. In February 2007, 15 addax were translocated from Bou Hedma NP by DGF assisted by the Fondation Internationale pour la Sauvegarde de la Faune and supported by Fond Français pour l'Environnement Mondial, and the Convention on Migratory Species. A second group of 13 animals arrived from the USA and Europe in December 2007 in a joint international operation by EEP and SSP representatives. Animal selection was based on genetic contributions through pedigree analysis using data from the International Studbook and aimed to create

Habitat at the Djerbil release site

a more genetically diverse population. Veterinary health screening was undertaken in accordance with Tunisia's statutory requirements, guidelines for best practice, and informed by previous experience. Holding enclosures were already present within the park to enable quarantine and acclimatization of addax prior to their release. Husbandry of the animals during this phase followed established guidelines (Engel & Brunsing, 1999).

Post-release monitoring: The addax were released from the acclimatization enclosures in February 2008. Following training, local NP personnel monitored the addax, including recording behavior, body condition and significant life history events. This process was supported by visiting ecologists and veterinarians providing ongoing staff training and undertaking supplementary surveys of addax numbers, distribution and health.

The first calves were born in the acclimatization enclosures, with further births recorded steadily thereafter. Body condition of the addax improved post-release with increased grazing in the park, although heavy tick burdens were also observed before and after release. Provision of supplementary feed as a management intervention during periods of drought had mixed results with cases of competitive aggression, and both acute and chronic acidosis necessitated changes in protocols. Behaviorally, the addax formed stable social systems, were observed exploiting a wide range of food plants, and sought artificially provided water during the dry hot seasons. Body scores indicated that animals generally remained in good health with expected seasonal variations in their condition. Addax mortalities have been recorded throughout the decade since their release but without timely post-mortem examination, specific causes of death were difficult to determine. NP personnel reported some losses of young calves to apparent predation, but no direct evidence was available to ascertain whether these animals were directly preyed upon or opportunistically scavenged.

By 2011, the minimum observed population size peaked at around 60 animals, representing a net doubling of the founder population within five years. However, lack of fence maintenance and accumulation of sand allowed animals to disperse beyond the perimeter of the park confounding the ability to monitor them, although a core population still remains and reproduction continues.

In 2017, a joint project was initiated by DGF, Marwell Wildlife and partners to undertake a comprehensive assessment of the addax population in Djebil NP, including acquisition of tissue samples for genetic analyses. Further work will be undertaken to survey the Grand Erg Oriental to determine the outcome of the unplanned dispersal of addax into this area.

Researchers monitoring addax in the field

Major difficulties faced

- Unforeseen economic constraints and political reform in Tunisia, and regional insecurity inevitably affected the continuity of the project and ability to meet the original goals within the expected timeframes.
- Transporting addax from the USA and Europe proved to be administratively and logistically complex, and expensive.
- Although eventually overcome, international restrictions on livestock movements due to outbreaks of foot & mouth disease and bluetongue threatened the export of addax from the USA and Europe.
- The challenging environment, lack of infrastructure and ability to acquire essential resources hampered husbandry of addax during the acclimatization phase.
- Poor retention of trained national park personnel led to inconsistent monitoring and management.

Major lessons learned

- Given the shifting socio-economic and political backdrop in Tunisia over the last decade, persistence, flexibility and adaptive management were critical factors in sustaining the project.
- Captive-bred and translocated addax integrated seamlessly on release and proved equally adaptable to their new environment with similar survivorship recorded between groups.
- Management intervention need to be considered carefully because of the risk of unintended consequences on the behavior and health of animals.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- International cooperation along with national & local commitment to the project was critical for fund raising and ensuring the requisite breadth of expertise was available.
- Lengthy period of protecting and allowing vegetation to re-establish within the park provided adequate grazing resources to sustain the addax post-release.
- A genetically diverse founder population of addax was established and stable population growth occurred during the first five years.
- Dispersal of addax outside of the fenced protected area resulted in the species returning to the Grand Erg Oriental, albeit in an unplanned way and efforts are now needed to assess this outcome.

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Experimental reintroduction of South Andean huemul and Guanaco in the Huilo Huilo Chilean Private Reserve, Chile

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Introduction

The largest hervibores of Chile, the South Andean huemul (*Hippocamelus bisulcus*) and the guanaco (*Lama guanicoe*) used to occur in most of central south Andean region in close proximity. Both species present local extinctions processes and fragmented populations all through their distribution range. The South Andean huemul is an endemic deer of Chile and Argentina patagonia. With an historical distribution range from 34°S to 54°S, total number of the binational population have been estimated to about 1,500 individuals. The species is included on the IUCN Red List as Endangered and on CITES Appendix I. It went extinct in the reintroduction area in the late 1980s.The Guanaco, present from 8°S to 55°S, is considered a Least Concern species by the IUCN. Even though there is not strong evidence of historical presence of guanacos in the "reintroduction/ introduction" area, the species is an important target prey for the top carnivore, the puma (*Puma concolor*) under the working group perception.

Huilo Huilo (S 39º 57' 17'' W 071º 53' 54'') at the central south Andean region has an extension of 100,000 ha with an elevation that stretches from 600 - 2,400 m, the reserve and their associated ecosystems of woodlands and grasslands offers an important habitat to both species which includes the "Mocho-Choshuenco" public reserve at 7,537 ha.

South Andean huemul

Goals

- Goal 1: Initiate a breeding center for both species in Huilo Huilo Reserve, with the huemul as the main target.
- Goal 2: Generate an umbrella for the effective protection of several other species present in the area.
- Goal 3: Incorporate local communities as real actors in the reintroduction project and global conservation.
- Goal 4: Reintroduce and introduce both species into the reserve which is a unique Andean ecosystem.

Success Indicators

- Indicator 1: Successful breeding has occurred for a decade and breeders were born at the center.
- Indicator 2: Logging activities decreased dramatically during the 10 years breeding process and finally stopped in the 65,000 ha before releasing the first group of South Andean huemuls into the wild. Areas with South Andean huemul presence are declared an exclusion spot for every anthropogenic activity except the working group and government inspectors - Servicio Agrícola y Ganadero (SAG). Several other species are under protection in the present since the reintroduction process began.
- Indicator 3: At least 90% of the rangers that protect the reserve and the animals are local residents. School children in several schools have incorporated the emblematic species as part of their lives and interest.
- Indicator 4: Individuals of both species have been released into the wild and we will establish the species over the long-term.

Project Summary

Feasibility: The project aims to return the South Andean huemul to Huilo Huilo reserve and Region de Los Rios, where the species became extinct in the late 1980s due to unknown reasons. The species which is included in the Shield of Arms of Chile, has never recovered in any population neither Chile or Argentina regardless all binational efforts. Numbers tends to decrease, even though "the Chilean National Plan of Conservation" for the species considered *ex situ* projects with a reintroduction purpose and has been on-going for more than three decades. All the attempts to stablish a long-term breeding center failed in the past. Since the Guanaco, a highly charismatic ungulate, is observed in most of the places where the highest huemul populations occur. The

Rangers with a guanaco

species was incorporated into the reintroduction process, primarily, as an attempt to decrease puma predation impact over the few huemuls available for the reintroduction process.

Author and rangers working on a female huemul

Implementation: On 21st April 2005, after one year of presenting the Project to the Chilean authorities, the first two huemuls (out of six allowed) were captured in Aysen, Chilean Patagonia región. Both animals were transported by air using two helicopters and one military transport airplane of Ejército de Chile. Upon the successful arrival of the first male and female into Huilo Huilo reserve, resident people at the extraction region made a formal complain to local authorities. Even though the project demonstrated the legal right to capture the remaining four individuals, since there was an official government permit, the captures were stopped. Thus the Project had to attempt captive-breeding with just two individuals, the only ones in captivity on the whole planet!

The first fawn was born on October 2006, later the pregnant female was shot inside the fenced area and the project was left with just one adult male and one juvenile female. The Chilean wildlife authorities, "SAG", provided one adult female as a breeder to the project. The animal came from a different/distant population than those captured at the beginning. Since then the project reached a number of 18 individuals after 10 years of hard work, but all animals are the product of just three individuals. The project attempted to improve the genetic pool for 10 years, and also trying to convince the authorities about the importance of the project. The decision to initiate an experimental reintroduction came defying the belief that Huilo Huilo private reserve, would never release animals into the wild. Obtaining a reintroduction permit took almost one more year and as agreement with SAG to demonstrate that huemuls and guanacos would not be a sanitary threat for livestock. The animals were blood sampled for 1-Bovine leukosis virus, 2-Paratuberculosis, 3-Brucellosis and 4-Diarrea viral bovina (BVD) including an anti-helminthic treatment.

After analyzing the possible threats and the requirements to improve the survival of the animals to be released in conjunction with wildlife officers (SAG), the team decided that guanacos would be released one year earlier. The first release would have 20 adult Guanacos (males and females) and five adult huemuls (only males, a consideration for the first process to protect breeding females in the experimental stage). Both groups of animals would be soft-released from the breeding centers where they were born and at a distance of 5 km from each


Guanacos in their native habitat

other. Two years before, 3 (out of 6 adults) pumas were monitored by radio-telemetry in the area to learn more about their ecology.

Post-release monitoring: During late November 2016, the reintroduction of South Andean huemul began with five adult males, all under radio-telemetry surveillance. Using ATS VHF radio collars, animals are evaluated twice a day, including guanacos which are monitored under the same protocol. Upon visual contact with the animals, the GPS position is registered plus a general evaluation of every individual and composition of the group is recorded. As an additional effort, camera traps were installed as a fixed device, sometimes additional cameras are used for specific purposes. Every site with a positive presence of huemuls is considered “an exclusion area” for every anthropogenic activity and the rangers take positive control of the area, where logistically possible. Every dead animal carcass (huemul or guanaco) is inspected to determine the cause of death. Since the reintroduction began, six adult guanacos, plus two new born in the wild were predated upon in one year by pumas. Additionally, three guanacos were killed by domestic dogs (*Canis lupus familiaris*) in one day! After eight months, one huemul radio-collar was found in a river (animal missing) in the most southern border of the reserve with the local police starting an investigation. A new release process is being planned for both species, with 20 more guanacos (males and females) and five more huemuls (males and females).

Major difficulties faced

- The co-ordination and dialog with government organizations to reach an agreement for obtaining the permits for working with the species.
- Changing the perception that government organizations are not the only ones to work with this species.
- Convincing the government organizations that the project needs new genetic stock urgently.

Major lessons learned

- Even though huemuls were bred in a semi-captive program (70 ha), and they remained in captivity for 10 years, they have shown abilities to avoid pumas predation and live in the wild without any support.
- Guanaco as an alternative prey species, seems to be an important key for the conservation of the huemul.

- No matter about the preventive actions taken, poaching and domestic dogs are a real threat.
- Without the “real approval” of the Chilean authorities, it will always be at a serious risk of collapsing.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Ten years of previous experience on captive-breeding and management of similar Chilean native deer, the pudu (*Pudu puda*).
- Team experience on wildlife capture, transport, rehabilitation and rearing.
- Habitat quality of Huilo Huilo reserve.
- Logistic support of Huilo Huilo foundation and Ejército de Chile.

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Evaluation of a 10 year guanaco reintroduction in the upper belt of central Argentina

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Introduction

The guanaco (*Lama guanicoe*) reintroduction project in the upper belt of the mountains in central Argentina was developed to recover a large native herbivore that historically inhabited the region. Since the Spanish colonization, cattle overgrazing and frequent use of fire to induce grass regrowth had triggered a widespread process of soil erosion, and the plant cover was replaced with exposed bedrock. In 1996, Quebrada del Condorito National Park (QCNP)(31° 34'S, 64°50', 320 km^2; 1,700 - 2,800 m a.s.l.) was created, and even though domestic livestock were removed from a large area of the Park, their exclusion caused a disproportionate expansion of a thick-leaved tussock grass at the expense of grazing lawns, reducing local diversity and spatial heterogeneity. In an attempt to control landscape homogenization and at the same time avoid soil erosion processes induced by livestock, in 2007 the guanaco (Least Concern in the IUCN Red List of Threatened Species, but locally extinct early in the 19th century), a low-impact grazer, was reintroduced. The reintroduction project involved a continuous monitoring program and was a milestone in the history of reintroduction of wild species in the national system of protected areas in Argentina.

Goals

- Goal 1: Successful release of individuals and monitoring of the reintroduced population throughout the project to evaluate their success and make proper management decisions.
- Goal 2: Adaptation of reintroduced guanacos to the new habitat and environmental conditions.
- Goal 3: Long-term establishment of a self-sustaining population.

Guanaco in its natural habitat

Success Indicators

- Indicator 1: Survival rate during the first three months after release and during the following years, as well as recruitment rate and other demographic parameters that determine population persistence probabilities.

- Indicator 2: Settled reproductive groups showing behavioral response, habitat selection and feeding habits typical of wild guanaco populations.
- Indicator 3: An established core group of more than 50 guanacos 10 years after the start of the project, and a self-sustaining guanaco population not requiring new reinforcements after 20 years.

Monitoring released guanaco

Project Summary

Feasibility: The project was conducted by an interdisciplinary group of professionals (biologists, veterinarians and park rangers). Before the start of the guanaco reintroduction project in the Park, the methods, resources and steps necessary to meet the set objectives were defined. Workshops and consultations were conducted with specialists, a monitoring protocol was developed, and guidelines were drawn up to determine the success of the different actions taken during the reintroduction process. Guanacos were reintroduced into the Park following IUCN guidelines, based on a pre-feasibility study. Each reintroduced guanaco was marked with a colored and numbered plastic ear tag and a neck-band (red in males and blue in females), and nearly 30% of all released individuals were also radio-collared to facilitate monitoring. Two groups of guanacos were reintroduced. In 2007, 113 individuals from a wild northern Patagonia population (40° 47'S, 66° 45'W) were released without being subject to a pre-adaptation period. In 2011, 25 individuals from a captive population from the province of Buenos Aires (38°01'S, 61°40'W) were released. Given the lessons learned from the experience in 2007, the latter group was subjected to a 40 day pre-adaptation period in a barnyard constructed in the Park for that purpose.

Implementation: For the implementation of the first stage of the project, human, material and financial resources were provided by the National Park Administration and the Global Environment Facility of the International Bank for Reconstruction and Development. Guanacos that would be moved to the Park were acquired (either purchased or received from donations), and all relevant steps were taken to ensure the permits and requirements for reintroduction, as well as the necessary logistics (sanitary control & proper conditions for movement) and inputs for the guanaco establishment and their subsequent monitoring in Quebrada del Condorito National Park.

Released guanacos in Quebrada del Condorito National Park

The original draft project included successive guanaco releases over the years after the first one in 2007; however, no reinforcement was made until 2011, and since then no new reinforcements have still been made, although currently the management plan of the Park includes the need for reinforcement of the reintroduced guanaco population. Of all individuals released in 2007, which had not been subjected to pre-adaptation period, only about 20% survived the first three months of the critical post-release period, with starvation, predation by puma (*Puma concolor*) and individuals caught in wire fences being the most frequent causes of death. Due to these earliest results, a 2 ha pre-adaptation barnyard was constructed in the Park where individuals were maintained for at least a 40 day period before being released. That management measure produced more than 80% critical post-release survival of individuals released after a pre-adaptation period in 2011.

Post-release monitoring: The post-release monitoring and different studies conducted on the guanaco population reintroduced in the Park indicate that the individuals that survived the critical post-release stage were adapted in terms of behavior, habitat selection and diet. Preliminary evidence also showed that guanacos contributed to the ecological restoration of the area. The information obtained during the earliest releases in 2007 was used to improve the release methodology; thus, a shift was made from a hard to a soft release, which yielded positive results in the 2011 reinforcements.

To evaluate the extinction rate, a population viability analysis was conducted in 2016, based on demographic parameters and on three different possible scenarios (without supplementation of individuals and with a realistic and optimistic supplementation) and two possible catastrophic events (fire and food shortage). The analysis predicted that the current reintroduced population could become extinct in the next few decades if no reinforcements occur, and that only a continuous supplementation can reach the probability that the population survives over the next 100 years. Even though individuals settled in the Park show adult survival and reproductive rates similar to those of wild guanaco populations, the recruitment rate was low because most of the offspring were predated by pumas. Therefore, the high extinction probability of the current reintroduced guanaco population would not be related to reproductive success or population structure, but to the small number of individuals, increasing their vulnerability to suffer negative effects of stochastic dynamics. So far, even though the guanaco reintroduction project can be considered to have been partially successful since the beginning, given the establishment of some reproductive groups in the Park and their good response in terms of behavior, habitat use and diet, the current population is at risk of extinction if further supplementation of individuals is discontinued.

Major difficulties faced

- Given that the guanaco is a social species, the first hard release without a pre-adaptation period resulted in a high initial mortality.
- Fences and other probable mortality factors should have been removed before individuals were released.
- The logistic and structural constraints in the National Park Administration of Argentina reduced the frequency of the release schedule and of the project success.
- Coordination among the authorities of the National Parks Administration, the staff of the Quebrada del Condorito National Park and researchers should have been improved.

Major lessons learned

- The goals set for the pilot phase were mostly achieved. However, the objective of establishing a core group of more than 50 guanacos after 10 years from the start of the project has still not been met, since the projected successive reinforcement releases were not accomplished.
- The pre-adaptation period should be extended and fences should be removed to reduce mortality of individuals.
- The continuous reinforcement of the guanaco population in the next years must be guaranteed by the National Park Administration of Argentina in order to achieve project success.
- A minimum of 130 guanacos settled in the Park would be necessary to achieve a 99% probability of population persistence during the next 100 years.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Specialists’ recommendations were little taken into account at the start of the project.
- The first release of individuals did not include a pre-adaptation period.
- Unlike proposed in the original project, releases of new individuals were not made every year.
- Management mistakes were not corrected immediately and work protocols were improved later than necessary.

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Goral supplementation in Thailand

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Introduction

Goral (*Naemorhedus griseus*) is listed as one of Thailand's endangered animals; Vulnerable by the International Union for Conservation of Nature (IUCN) (IUCN, 2017); and is also listed in Appendix I of the Convention of International Trade on Endangered Species of Wild Fauna and Flora; CITES (IUCN, 2017). Gorals prefer living in mountain area with high elevation. In Thailand, they can only be found in the Northern part of the country.

Their populations have been dramatically reduced due to habitat loss because of human activities such as housing development or over hunting for food and horns. In 1993, there was an effort to reestablish a healthy population of goral outside of their natural habitats (*ex situ*) at Om Koi Wildlife Breeding Station in Chiang Mai province, Thailand. The captive-breeding program has been very successful (Kongprempoon, 2016), considering that were more than 100 gorals have been born in captivity.

The next important step for goral conservation is to re-establish healthy populations in their natural habitats (*in situ* conservation). Studies to increase the number of gorals and reintroduction of captive-bred gorals back into their natural habitat are needed for effective and long-term conservation of gorals in Thailand. To successfully reintroduce gorals back into their natural habitats thorough and careful planning is needed (Department of National Park, Wildlife and Plant Conservation, 2005) .


Goral in its natural habitat

Goals

- Goal 1: Increase number of gorals in captivity.

- Goal 2: Supplementation of goral from captivity to a sustainable population in the wild.
- Goal 3: Increase genetic diversity of gorals in the natural situation.

Success Indicators

- Indicator 1: At least 100 gorals present in captive-breeding.
- Indicator 2: Increasing number of goral in the wild.
- Indicator 3: Births recorded in the wild from reintroduced goral.

Project Summary

Feasibility: The Mae Lao-Mae Sae Wildlife Sanctuary was used for reintroducing gorals in Chiang Mai Province. The topography of the site was dominated by rolling hills of low to medium elevation. The topography of the site was dominated by rolling hills of low to medium elevation. There are several peaks above 1,000 m a.s.l., and the site includes the headwaters of several tributaries of the Mae Teang and Mae Sa rivers. The site supported a range of forest types, including evergreen forest, evergreen forest on slopes above ~800 m a.s.l.. Deciduous forest was found at lower elevations, with coniferous forest and evergreen forest along the drier ridges.

Implementation: Nine healthy gorals (3 adult males, 3 adult females & 3 juveniles) which were genetically fit were selected from the Om Koi Wildlife Breeding Centre. The average value of inbreeding coefficient of all gorals was 0.084. The gorals selected were checked for infectious diseases such as tuberculosis, brucellosis, melioidosis, foot and mouth disease, to prevent the spreading of any diseases from the reintroduced gorals to the wild populations. Each individual was then marked using an ear-tag and a radio-collar was put on the six adults.

Post-release monitoring: Gorals were directly sighted from vantage points through binoculars. Indirect observation was done by checking their droppings and footprints. Photographs of their habitat, fecal material, footprints and watering spots were taken using a digital camera. Moreover, the observed behavior included feeding (forage), feeding (concentrate), ruminating, drinking, defecation, urination, standing, walking, running, jumping, climbing, sleeping, resting, sleep while standing, grooming, scratching, aggressive, guarding, mating, social behavior, collar scratching, soil lick, horn rubbing and milking. A routine health check, which included body condition score, hair

Goral release site - habitat overview

Close-up of goral in rocky habitat

feature, posture, locomotion, feeding and feces content analysis were also performed. This could be established using the radio collar and at least two radio receivers to track them down. Gorals usually stay in the soft release cage for at least 12 months. Radio telemetry was applied to determine location and survival rate of gorals by triangulation from three separate points marked along the study trails or the road for estimating position using the LOAS software. The data were then analyzed the position in Arcview 9.0 for estimating home ranges. Moreover, the density in turn was estimated according to the observed home range of each animal and the overlap among home ranges. The gorals food was record based upon direct field observations.

Gorals health status was determined by using the Body Condition Score (BCS), described by Villaquiran *et al.* (2007). Furthermore, the forest utilization and feeding types were recorded in every times that each goral was found.
Out of the nine released and tracked gorals, six survived, putting the survival rate at 66.67% and death rate at 33.33%. Three dead gorals were autopsied to determine the cause of death, which was pneumonia.

Major difficulties faced

- The survival rate, in the period with high rainfall, the gorals are more prone to infection, which is the cause of death for many of them. When they were infected, the disease affected their life tremendously.
- Behavioral observations in soft release conditions was difficult, because of the difficulty of observing areas of the study site with high slopes, and thus this lack of information made it difficult to predict certain behaviors.

Major lessons learned

- Hence, for further study we recommend that the gorals should be released in spring because the gorals were treated and adapted for that environmental condition.
- The proportion for release of goral in soft release conditions should be male-female with 1:2 or 1:3 ratio to increase their breeding probability which will lead to an increase in the goral population.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- The reintroduction process was suitable for this species.
- The suitable weather in the area helped in the success.
- Sex ratio of gorals was adequate for this release.

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Roe deer reintroduction in central Portugal: a tool for Iberian wolf conservation

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Introduction

The Iberian wolf (*Canis lupus signatus*), a subspecies of gray wolf, is endemic to the Iberian Peninsula. According to the IUCN, and the Portuguese Vertebrates Red Data Book, the Iberian wolf in Portugal is considered Endangered (EN), having suffered a significant decrease in its distribution and abundance throughout the 20th century, partly due to direct human persecution. Wolves have progressively disappeared from littoral, south and central regions of the country (Álvares, 2011). This top predator is considered a priority subspecies for conservation and is included in the Bern Convention, CITES and Habitats Directive. In central Portugal, south of the Douro River, in the Arada, Freita and Montemuro (AFM) mountains, there is an isolated and fragmented population of Iberian wolf particularly vulnerable to local extinction (Pimenta *et al.*, 2005). Wild prey, such as roe deer (*Capreolus capreolus*), is virtually extinct in central Portugal in areas inhabited by wolf, namely in the AFM mountain range (Cruz *et al.*, 2014; Torres *et al.*, 2014). The reintroduction of roe deer in selected areas of wolf range would once again allow the wolf a choice of natural prey, reducing livestock attacks and decreasing human-wolf conflicts (Torres *et al.*, 2015). Also politically, such measures would show that wolf conservation can be a dynamic process and not merely a passive protection. For this purpose, the reintroduction of roe deer in central Portugal would improve the productivity of the region by providing, in due course, a surplus of wolf wild prey.

Goals

- Goal 1: Reintroduce a viable and breeding population of roe deer in AFM Mountains.
- Goal 2: Increase the density and diversity of wild prey for the Iberian wolf, decreasing wolf livestock predation, thus reducing conflicts with humans.
- Goal 3: To contribute for the protection and conservation management of the Iberian wolf in Portugal.

Roe deer in its natural habitat

- Goal 4: To serve as a model for future reintroductions.

Success Indicators

- Indicator 1: Successful adaptation to AFM mountains - individuals have survived for one or more years.
- Indicator 2: Successful reproduction has been monitored.
- Indicator 3: Successful contribution to Iberian wolf diet.
- Indicator 4: Stakeholders positive feedback.

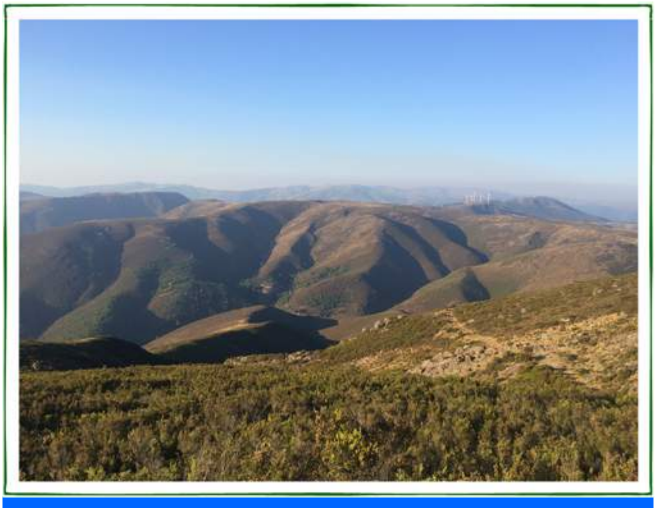
Project Summary

Feasibility:

Feasibility and background research - We established roe deer habitat requirements and life history parameters by summarizing relevant information from literature.

Selection of the release sites - We investigated the habitat conditions needed for persistence of the reintroduced population but also the size and composition of the release groups. For that, we have identified the areas potentially suitable for roe deer, trough habitat suitability modeling, and evaluated whether this areas were sufficiently well connected to guarantee the establishment, the survival and the spread of a viable population.

Selection of the roe deer source populations - Since the 1990s, there have been reintroduced roe deer populations in central Portugal mainly for hunting purposes using stocks from Spain and specially France. It was unknown whether present day populations descend from local ancestors, from reintroduced animals or both, as the genetic structure of roe deer in Portugal is almost unknown. Therefore, we have analyzed the patterns of genetic variability and differentiation of the roe deer in Portugal and some areas of Spain, using both mitochondrial DNA sequences and microsatellite data. We have identified an adequate source population in Spain. We also established protocols for veterinary screening of release stock, handling and transport procedures.



Overview of release site

Socio-economic and legal preparations - Although the wolf conservation is a priority for Portuguese Authorities, the focus is set on passive protection. Throughout six years there were several scientific, technical and bureaucratic issues that had to be clarified. The attitudes of local people towards wolf conservation and roe deer reintroduction were assessed and contact was established with several local stakeholders. The long-term financial support was assured by a private conservation fund - the Wolf Fund.

Researcher radio-tracking released deer

Implementation: One month before each reintroduction, the animals to be reintroduced were captured from the source population and subjected to a rigorous veterinary screening: all animals were tagged and blood samples were taken (for biochemical, haematological and genetic analysis); biometric measurements were also collected. These animals were placed in a quarantine enclosure and tuberculin skin tested. On the reintroduction day, members of the team, including veterinaries, would capture the animals from the quarantine enclosure (Spain) and transport them to the release nuclei (Portugal). The animals were placed in individual transport boxes and at the bottom of each box, straw and a diaper was placed to make it possible to check the urine colour of the animals, indicative of some stress problem. During the transport, as well at the reintroduction nucleus, the veterinary team regularly checked the condition of the animals.

The first reintroduction took place during November 2013 and 12 animals (5 males & 7 females) were released, with half of them being equipped with GPS collars. The second reintroduction was during November 2014 and 24 animals (9 males & 15 females) were released in a different reintroduction nucleus (4 km from the first nucleus). Again, half of the released animals had GPS collars. The third reintroduction was during November 2015 and 22 animals (11 males & 11 females) were released in a different reintroduction nucleus (1 km from the second nucleus), with half of the released animals having GPS collars. The whole reintroduction process has been supervised by the Institute for the Conservation of Nature and Forests (*Instituto da Conservação da Natureza e das Florestas*) and the stakeholders and general coordination of the project is assured by the Iberian Wolf Habitat Conservation Association (*ACHLI*), with the support of several partners (technical, scientific, logistic and institutional).

Post-release monitoring: Half of the reintroduced animals were fitted with GPS collars (a novel approach in Portugal for roe deer). We are now focused on examining post-release movements and space use patterns of the reintroduced roe deer population in the AFM Mountains. For the first two months after release, the animal's position was recorded every 30 minutes, after that it was every two hours and 55 minutes, which is a good trade-off between collars battery and results. We are now quantifying habitat selection, spatial use, activity patterns, intraspecific interactions, and parameters for the populations such as reproductive success, productivity and survival and dispersal behavior. Therefore, this is also a unique opportunity to improve scientific information about roe deer habitat adaptation, selection and population dynamics, which is completely unknown in Portugal. Additionally, after releasing the animals, several 1 km transects were systematically placed throughout the study area, providing equal coverage of different habitats that occur in the surveyed area. Transects were surveyed using pellet group counting (indirect method), a method that is frequently used to assess habitat use of large ungulates. This method also allowed confirming the presence, distribution and expansion of the released species. Additionally, vantage points and camera trapping were also used in order to sight the animals (direct method).

Major difficulties faced

- Bureaucracy regarding project implementation and animal translocation (Spain to Portugal).
- Mortality from poaching, which was high in the first year.
- Summer fires, which degraded part of the suitable habitat and enhanced mortality.
- Failure of some GPS collars - this lead to the loss of monitoring of some animals.

Major lessons learned

- AFM Mountains are highly suitable for sustaining roe deer populations.
- Reproduction and population growth is evident in the AFM Mountains.
- Intensive preparation of the pre-release phase and release strategies are vital to ensure high post-release survival rates.
- Through the development of a thorough reintroduction protocol, based on IUCN Reintroduction Guidelines, roe deer individuals can be successfully reintroduced in the wild and establish home ranges and reproduce.
- Roe deer reintroduction was highly accepted by the general community, and that could be used to raise awareness of Iberian wolf conservation.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- A reproductive and widespread roe deer population was successfully established in AFM Mountains.
- The use of large release groups, that includes a natural sex ratio (1 male per 1.5 females) and different age classes, but also several reintroduction nuclei, promoted a favorable social environment and rapid initial population growth.
- Long-term financial support.
- Political support and stakeholders coordination.
- The project is now recognized as an important Iberian wolf conservation project.

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Adaptation, survival and challenges of released endemic Farasan mountain gazelles on Farasan Islands, Southern Red Sea, Saudi Arabia

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Introduction

Gazelles from the Farasan Islands have been known to scientists since at least 1825, when the first specimens were collected by the explorers Hemprich and Ehrenberg (Groves, 1983), and are now recognized as the Farasan mountain gazelle (*Gazella gazella farasani*) (Thouless & Al Bassri 1991). Until 1988, when the first official survey was conducted on the Islands (Thouless *et al.*, 1988), nothing was known regarding the status of this species. The 2017 survey not only estimated a population of ~800 but also noted that this is the largest free-ranging population of Arabian mountain gazelle or *idmi* in Saudi Arabia (Islam *et al.*, 2017). This high density of Farasan gazelle is astonishing, as all species of gazelles have been drastically affected by hunting, habitat degradation and competition for food with domestic livestock in unfenced protected areas. It is categorized as Vulnerable on the IUCN Red List (IUCN 2017).

Farasan mountain gazelles © O. Couppey

It is speculated that the gazelles were either released or separated from mainland to Farasan Islands in southern Red Sea of the Saudi Arabia a long-time before. They have been investigated genetically to see the difference between mountain gazelles on the mainland and Farasan Islands. Studies by Saudi Wildlife Authority states that the taxonomy of the genus *Gazella* is exceedingly complicated but there is considerable morphological variation within species. The Farasan Island gazelles resembled mainland *Gazella arabica*, and their shape was slender and graceful, and their gait was also characteristically bounding, gazelline face markings and flank stripe resembles the mainland gazelle, while the animals appeared greyer and smaller than those of the mainland (Thouless & Al Bassri, 1991). Lerp *et al*. (2014) states that the gazelles show reduced body size on the Farasan archipelago through the study of morphometric analyses of skulls and they found genetic differentiation between Farasan and mainland populations using 11 nuclear microsatellite loci and detected a distinct genetic cluster exclusively present on the archipelago.

It became imperative to restore this possibly endemic subspecies of Arabian mountain gazelle on Farasan Island, where the species has largest density in the Arabian Peninsula. We have been studying and monitoring the population and conservation issues related to gazelles and its adaptability and survival in harsh conditions on the island, with tremendous pressure from humans. Gazelles in Farasan represents the largest natural population in Saudi Arabia that remained stable at approximately ~700+ individuals since 1988 (Islam *et al.*, 2017).

Goals

- Goal 1: Restore and re-establish a Farasan gazelle population on the islands, being isolated from the next indigenous population.
- Goal 2: Capture and reintroduce Farasan gazelles to other islands, where they were hunted out.
- Goal 3: Initiate captive-breeding program using stocks from the Farasan Islands and subject to research and planning to improve health and genetic status of gazelles for future reintroductions.
- Goal 4: Establish post-release monitoring to provide information on habitat choice, food preferences, dispersal distances and mortality rates in a reintroduction area with marginal habitat and severe environmental conditions (extreme temperature, low precipitation and low food availability).
- Goal 5: Compare those data with other reintroduction attempts (e.g. in the Mahazat as-Sayd and Ibex Reserve; see RSG volume 2011) and with indigenous mountain gazelle populations in the Asir and Hejaz Mountains and on the Tihama coastal plains.

Success Indicators

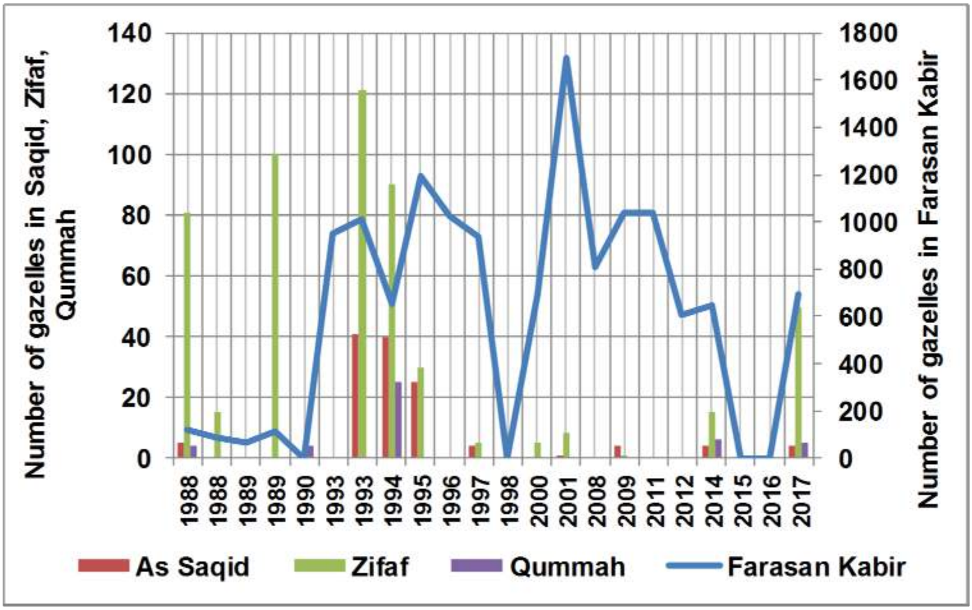
- Indicator 1: A healthy and self-sustaining breeding Farasan gazelle population on the Farasan Island.
- Indicator 2: Well adaptive to local climatic conditions and long-term survival even with a large human population presence.
- Indicator 3: Productivity of wild Farasan gazelles is high.
- Indicator 4: Dispersal and free movement of gazelles on Farasan Kabir Island.
- Indicator 5: A significant reduction of illegal hunting on Zifaf Island, where the population is increasing.
- Indicator 6: Increased acceptance and public awareness by the local communities around the protected area, and the recognition of the potential of Farasan Islands as a destination for national and international tourism.

Project Summary

Feasibility: The Farasan Islands (16.7058° N, 41.9833° E, with an area of 5,408 km^2) are group of islands formed of raised fossil coral reefs at elevation of 0 - 30 m in the southern Red Sea in Jazan province and about 40 km from the coast of mainland of Saudi Arabia. The gazelle have persisted on Farasan Island since a couple of centuries. More than 170 islets and shoals have been mapped in Farasan, and four of them, i.e., Farasan Kebir 400 km^2 (gazelles present here), As Saqid 160 km^2 (gazelles present), Zifaf Island 33.2 km^2 (gazlles present) and Qummah 25 km^2 (gazelles present) are permanently occupied by people, except Zifaf Island, where only coastguards have a camp. Large parts of the islands are flat gravel plains notched by well-vegetated *wadis* and other fragmented terrain formed when the fossil reef was raised by underlying salt domes (Cunningham & Wronski, 2009). The climate is arid with a highly variable annual rainfall of 50 - 100 mm and there is no permanent surface water. Inland vegetation comprises *Acacia-Commiphora* bushland with *Ziziphus* and *Salvadora*, as well as *Euphorbia* thickets and dense, 3 m high *Asparagus* bushland. There are several dense stands of mangrove (mostly *Avicennia* but also *Rhizophora*). Some islands are fringed with salt-tolerant bushes. These thickets provide shade, protection and food for gazelles.

Implementation: Since 1800s when the local population of gazelles was documented, they were thought to have been released on the island captured from the mainland. The origin of Farasani gazelle is not clear, while it became important to protect it and possibly use it for captive-breeding purpose and reintroduce them to other islands, where the gazelle used to occur before. The Saudi Wildlife Authority has declared Farasan Islands as a protected area due to

Figure 1. The number of Farasan gazelles in Farasan Kabir, As Saqid, Zifaf and Qummah (drop in population in some years as no census was conducted)



the presence of the largest population of gazelles and high concentrations of nesting sea and coastal birds including threatened species white-eyed gull, sooty falcon and ospreys. Farasan also qualifies for Ramsar criteria and there are turtle nesting beaches along with outstanding coral reef habitats and wildlife, and representative examples of unusual vegetation types, including important mangrove communities.

Monitoring: Farasan gazelles have been monitored since 1988 and the method used including actual sightings and extrapolations. Monitoring data of gazelles collected using foot, vehicle and/or aerial surveys, following predetermined or random transects, and covering the entire area. The field researcher's involved and monitoring techniques applied varied between years and methods were not standardized, and standardized monitoring protocols have been drafted in 2015 (Islam, 2014a). For gazelle monitoring some important methods as proposed in protocols have been followed including a) drive counts (ground-based detection), b) aerial counts c) line transect counts, d) spot-light counts, e) remote sensing, f) mark recapture methods, g) change-in ratio and related methods, h) track and trail count, i) pellet-group counts, j) footprint counts, k) camera trapping and l) road strip counts. Among these the most suitable methods were road strip counts, footprint counts & camera trapping.

The Road Strip count technique was used by applying a predetermined strip width and the total length of the transects to determine the area surveyed. The following formula was used to calculate gazelle numbers: $N = nH/h$. Whereby n is the number of animals actually seen during the count, H is the size of the total survey area (Farasan Kabir) and h is the size of surface area covered during count. All gazelles observed along transect were counted irrespective of the strip width. Other than Farasan Kabir, other methods were followed e.g. track and trail count, pellet-group count and footprint count, especially in Zifaf, Qummah and As Saqid. The survey was carried out by a team of six observers and one driver/ranger, during the early morning from 06:00 hrs - 10:30 hrs and vehicles were driven at 10 - 30 km/h, depending on the area and terrain. The length of the various road strips varied according to the area and terrain surveyed with a total length of 163.2 km travelled in the six sectors, while a fixed strip width of 600 m (*i.e.*, 300 m on each side of the vehicle) was used for extrapolation purposes. Strip width was based on the average visibility as determined in the field prior to the survey (Islam, 2014b). The last survey results population estimate for Farasan Kabir using traditional analysis and the original six tracks is 695 with a 95% CI. This corresponds to a density of 1.75 gazelles/km² respectively. Tracks and middens were also recorded in Farasan al Kabir, Saqid and Zifaf islands. The mean group size was 1.34 ± 1.19 gazelles/group based on only six tracks (Islam *et al*., 2017).

Major difficulties faced

- Human population is increasing and houses are built in areas, where gazelles persisted.
- Constant disturbances and hurdles in the movement of gazelles.
- In the absence of a rangers camp on As Saqid animals are extirpated and similarly gazelles disappeared from Dumsak, Saso and other islands of Farasan.
- Gazelles have competition with livestock and feral animals especially donkeys.


The survey team on the Islands

- Network of roads in remote areas increased disturbance and made it easy for gazelles to be hunted.
- Due to the presence of a human population, it is difficult to control intrusion by illegal hunters from big cities and sometime local people capture gazelles.
- Unregulated tourism making the species' survival at par.
- No permanent researcher based on site to monitor and study the gazelles, except annual or bi-annual censuses.
- No species management plan.

Major lessons learned

- Observation of reproductive rates are comparatively higher, and range use parameters are relatively higher too than in areas with more ecologically favorable conditions, are in keeping with the expectation that marginal areas became unsuitable for gazelles due to houses. Habitat condition are still better but in shrinking to small pockets such as Wadi Matar and Sier in Farasan Kabir.
- Farasan gazelles 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 program.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure

- Gazelle population in the mainland had been observed extirpated, while in Farasan, it is stable at ~700+ individuals.
- Despite the islands being overpopulated by humans, experiencing low rainfall and naturally low food availability for extended periods, Farasan gazelle survival and reproduction has resulted in net population growth over last 10 years or more.
- Due to human development projects, gazelles confined to pockets and sometimes dispersed to other areas, where they found suitable habitat and food.

- Gazelles are planned to be captured from Farasan Kabir and to reintroduce them in As Saqid, Dumsuk and other islands where they used to occur.
- Through planned captive-breeding of Farasan gazelles at King Khalid Wildlife Research Center, it would be released and managed in areas where they were extirpated or number became very low.

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Reintroduction of black rhinoceros in the Sera Community Rhino Sanctuary, Kenya

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Introduction

The Eastern black rhinoceros (*Diceros bicornis michaeli*), commonly referred to as the hooked-lipped rhinoceros, is a subspecies of the black rhinoceros. It is listed by CITES on Appendix I and categorized as ‘Critically Endangered on IUCN Red list with a confirmed 886 individuals (as at 2015) left in the wild in continental Africa (Emslie *et al*, 2015). Kenya hosts approximately 75% of this subspecies with the remainder in Tanzania and South Africa. In May 2015, a founding population was reintroduced into Sera - a community based conservancy under the umbrella of the Northern Rangeland Trust (NRT) that is located in Samburu County - some 100 km North of Isiolo town, in Northern Kenya.

This is the first black rhino breeding sanctuary in East Africa that is community owned and managed. The reintroduction followed after more than 20 years of absence and was carried out in response to the Kenyan National for Conservation and Management Strategy 2012 to 2016, that encourages community participation. Sharp decline of black rhinos from an estimated 20,000 in 1970 to less than 400 in 1990 mainly due to poaching necessitated the government of Kenya to capture and put all free-ranging rhinos in enclosed sanctuaries where protection was provided.

Eastern black rhinoceros

Goals

- <u>Goal 1</u>:To establish the first community owned and managed black rhino breeding sanctuary in Kenya as per the Kenyan National Strategy for Black Rhino Conservation and management before 2016.

- Goal 2: To contribute to rapid breeding of the Kenyan black rhino meta-population to attain a 5% annual growth rate.
- Goal 3:To raise awareness on rhino conservation through community participation locally and internationally.
- Goal 4: To use the established rhino sanctuary as a sustainable tourism product for income generation for Sera Conservancy.
- Goal 5: To restock black rhino in its former ranging areas in Kenya.

Success Indicators

- Indicator 1: Successful translocation of 20 individuals to Sera as per IUCN African Rhino Specialist Group (AfRSG) guidelines.
- Indicator 2: An annual growth rate of 5% or above.
- Indicator 3: Income generated from tourism activities in relation to the Sera rhino sanctuary.
- Indicator 4: Improved security on rhinos to stop poaching and illegal trade on its product through community policing.
- Indicator 5: Establishment of the first community owned black rhino sanctuary in Kenya by 2016.

Project Summary

Feasibility: Feasibility studies were conducted based on the request by Sera conservancy to KWS to establish a breeding black rhino founding population. These studies included a habitat suitability assessment that estimated the Ecological Carrying Capacity (ECC) for black rhinos in 2010. The study was done through visual assessment of woody plant canopy cover and depth that considers Browse Availability (BA) and Suitability. The results for Sera Conservancy with an area of 355 km² was a projection of 0.244 (87 individuals) rhinos per km² or 72 rhinos taking the lower 95% confidence interval of the estimate and 104 taking the upper 95% confidence interval. The Maximum Productivity Carrying Capacity (MPCC) for Sera Conservancy was calculated as 65 black rhinos however a ring fence with an approximate area of 107 km² was constructed that is able to hold 27 rhinos.

Other studies included in the feasibility included assessments and appraisals covering Environmental Impact Assessment (EIA), disease risk analysis (prevalence of tsetse flies), community attitudes and perceptions, security and management capability. A holistic conservancy management plan was developed through a participatory approach together with a separate rhino sanctuary management plan. To ensure that the project can succeed in the long-term. a sustainability strategy was also developed with a view of exploring several potential revenue streams.

Implementation: Several community engagements were conducted and this included formal and informal meetings that raised the awareness and profile of the project. This was done through the Sera conservancy governance structure with several meetings held at village level that targeted various groups i.e. elders, women, youth, traditional warriors (moran), herders and opinion leaders. A smaller area for the construction of the ring fenced rhino sanctuary was selected and endorsed by the conservancy board. NRT provided technical support and fund raised through partners for the construction and most of the capital

Rhino being released © Ami Vitale

expenditure. This included a solar powered electric fence, a rhino boma/ stockade, staff houses, water wells with solar pumps, access roads, monitoring and security vehicles and airfield; all taking approximately five years to put in place. Translocation was done with candidates identified from government owned parks and private rhino sanctuaries. These were Nairobi and Lake Nakuru National Parks and Lewa Wildlife Conservancy. Sex ratio was one male to one female with various individuals groups of different age to mimic a healthy age structure.

Capture and immobilization was done by KWS veterinary and capture department with a combination of equipment and vehicles from KWS, NRT and Lewa. Darting was done from the helicopter and physical restraint and crating done by a specialized ground team. Rhinos were loaded into individual crates and transported via road using 4 WD vehicles. Thirteen rhinos were captured and moved (7 from Lewa and 6 from Lake Nakuru) to Sera with hard release between 16:00 hrs - 04:00 hrs. This was done in a period of seven days until it was halted to evaluate three unfortunate deaths that were experienced. Chemical immobilization and transportation is a delicate exercise with previous good success unfortunately the post-translocation complications was majorly due to the dry nature of Sera compared to the wetter conditions from the recipient area.

Post-release monitoring: Release sites for the rhinos at Sera were pre-selected several weeks before the translocation and surface water was provided at several points. A team from Sera conservancy staff were identified and trained at Lewa in 2014 on rhino monitoring following the standardized IUCN AfRSG black rhino monitoring protocol. This team was supported by experienced rhino monitoring instructors from Lewa who followed up each individual rhino upon release. The rhinos were all fitted with tracking devices (radio telemetry on the front horn) and each individual was ear notched according to a particular Kenyan pattern formula to enable individual identification. All the rhinos dispersed naturally in different directions and it took them between 3 - 6 months for them to explore most of the fenced area. After approximately one year, several individuals had shown a more definite pattern of preferred area/territory. Pairing and mating were observed after 12 months with some individuals forming social groupings of 3 - 4 individuals. The average body condition for the first year was good at a score of 3.5 and 4 during the wet season. In 2016, Sera got its first calf - a female from a young adult that was translocated when it was already pregnant. A second calf - a male, was born in 2017 and believed to have been conceived and born in

Sera. The total population is currently 12 individuals with a sex ratio of one male to one female, a growth rate of 20%.

Released black rhinos in the release site

Major difficulties faced

- Loss of three individual rhinos from post-translocation related complications especially conducting translocation in the late dry/early wet season.
- Fund raising challenges due to high cost involved especially on the capital expenditure required to establish a breeding rhino sanctuary.
- Building consensus and goodwill by community to accept and set aside their land for rhino conservation due to varied perceptions and attitudes.
- Long distance travelled from site of origin to destination compromising the general welfare and care of animal while on transportation.
- Convincing the government to accept and allowing a local community to host and manage highly protected wildlife (black rhinos) outside national parks and private sanctuaries as this was considered a big risk.

Major lessons learned

- Profile of individual candidates from monitoring data need to be thoroughly examined with a view to understanding their previous histories on interventions and behavior.
- Hard release conditions need to carefully considered in regards to provision and access of adequate surface water.
- Soft release is highly recommended with rhinos to be held in boma/stockades for between 24 - 48 hours where individuals are being moved from a wet area to a dry area. This will ensure that the rhinos are well hydrated and are able to feed/ forage immediate after release from the holding/ transporting crate. Defecation will be the obvious sign that the candidate being held is not constipated.
- Hard release is best done at dawn to allow immediate follow up and maximize monitoring during the day light. There should also be several release sites in consideration with sex and age structure.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Good will and support by the Kenyan government through the Kenya Wildlife Service in supporting government (public), private, community partnership.
- Significant good will, participation and improved attitude towards black rhino conservation by community members.
- Improved security through the establishment of community conservancies and community policing in Northern Kenya.
- Experienced personnel (vet, capture, security, logistics and donor liaison) ensured that all plans were successfully implemented.
- Adequate funding from willing partners in supporting Sera Conservancy.

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Reintroduction based recovery of tiger population in Panna Tiger Reserve, Central India

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Introduction

The tiger (*Panthera tigris tigris*) is an iconic large carnivore, with credible flagship value and umbrella species context. It has been listed as Endangered (A2abcd;C1) in IUCN Red Data list, is protected under the Schedule I, Part I of Indian Wildlife Protection Act, 1972 and is placed under Appendix I of CITES. The dwindling population of tigers in India, despite showing an upward trend as reflected by tiger population estimates (from 1,411 in 2006 to 2,226 in 2014), continues to remain threatened by poaching and habitat fragmentation. Panna Tiger Reserve (PTR), with core area of 576 km^2 and 1,002 km^2 of buffer area is located in the Vindhyan Range, in the Indian state of Madhya Pradesh. It once had a sizable population of tigers that diminished to local extinction in 2008 - 2009 due to poaching. In order to restore the tiger population in PTR, a reintroduction-based recovery project was launched in 2009 collaboratively the Madhya Pradesh Forest Department (MPFD), Wildlife Institute of India (WII) and National Tiger Conservation Authority (NTCA). Beginning with release of three animals and subsequent releases of four animals, PTR's population grew rapidly to >40 individuals and is considered as the model tiger reintroduction program with significant scientific and management insights.

Goals

- Goal 1: To establish a viable, free-ranging tiger population in Panna Tiger Reserve by the end of 2019 (i.e. in 10 years time) based on founder individuals sourced from other similar areas in the state of Madhya Pradesh.
- Goal 2: To institutionalize adaptive management strategies for long-term viability of the reintroduced

Reintroduced tiger female with first litter of two cubs © Subhoranjan Sen

Female tiger with collar © K. Ramesh

population based on the scientific and management insights gained from intensive monitoring of the founder and next generation individuals.

Success Indicators

- Indicator 1: Successfully establishing the founder population, and ensuring reproductive success.
- Indicator 2: Understanding their population dynamics, prey -predator relationship and response to disturbance, as these have implication for long-term management strategy.
- Indicator 3: Estimating the population size, turn over, and movement pattern within the reserve and in the landscape.
- Indicator 4: Achieving the carrying capacity of tigers in PTR, and maintaining the demographic and genetic viabilities.
- Indicator 5: Securing the threat free environment and well-trained management team for safeguarding of the tigers in particular and PTR in general.

Project Summary

Feasibility Analyses: The habitat in PTR is configured by a step-like topography consisting of upper Talgaon plateau, middle Hinota plateau and lower Ken river valley, separated by steep and rocky escarpments of varying height up to ~80 m. The forest type in PTR is tropical dry deciduous, formed by a mosaic of woodlands and grasslands, and a riparian community along the water sources. Tiger population in PTR dwindled rapidly due to combination of socio-political issues and management lapses, giving rise to a major conservation crisis. Wildlife Institute of India was commissioned to assess the status of tiger population and feasibility analyses for tiger recovery efforts. Accordingly, an investigation was carried out during 2008 - 2009 and the study concluded functional extinction of tiger in PTR due to anthropogenic causes including aggressive poaching, but found that the area is suitable for reintroduction on account of suitable habitat and optimal prey availability (WII, 2009). People in the region are generally poor and major source of livelihood comes from husbandry practices, small-scale farming and labor work. However, anthropogenic disturbances were controlled by village relocation program that enabled inviolate core area and enhanced protection measures by the Forest Department. Subsequently, a reintroduction and species recovery plan was developed for implementation from 2009, in five-year phases.

Implementation: Founder population of six individuals (2 males & 4 females) was initially determined to be released based on population viability analyses

(PVA) to achieve a target population of 25 adult tigers, which was estimated to be the carrying capacity, given the prey density availability at that point in time. Various scenarios were considered so as to ensure that the population growth is achieved to the desired target level. Three animals (1 male & 2 females) from different source populations were translocated in 2009. These animals began breeding quickly and registered successive litters in 2010. Due to combination of limitations in the availability of founder individuals and the reintroduced population with large number of cubs dominated by males, subsequent releases were preferred to be of females. Accordingly, two females (reared in captivity and trained in semi-wild conditions) were released in 2011, followed by another female in 2014. One male was accidentally captured when it ventured into the city of Bhopal and was translocated as an additional male to the founder population in 2015. The entire process was implemented in a structured framework with clear institutional mechanism, state ownership, effective leadership at various levels, scientific and technical support, veterinary support at local level, capacity building and resource commitments. The key players were the State Forest Department of Madhya Pradesh, Wildlife Institute of India and National Tiger Conservation Authority. Necessary infrastructure, logistics and scientific instruments for chemical immobilization and post-release monitoring were always kept in ready, and every step was visualized well in advance and implemented accordingly.

Post-release monitoring: The tigers were released through soft-release process initially, but subsequently adopted both soft-release and hard-release process depending on the conditions of the animal. Each individual tiger was attached with VHF/GPS collar and was monitored intensively since release in the PTR. Post-release monitoring was devised with two specific strategies; one involving security-based 24/7 monitoring by dedicated team of PTR's forest staff on a shift basis for each tiger and the other involving scientific monitoring by dedicated team of WII's biologists. The radio-collar was designed to have activity sensors and thus the movement of the animal could be understood clearly. The monitoring method involved home-in as well as triangulation strategies and domestic elephants were extensively used for close observation of the animals when veterinary intervention were required. Information on the animal movement was closely monitored based on pre-designed data format with information recorded at every hour and there was systematic reporting mechanism, both from security and scientific monitoring perspectives. The reintroduced tiger population bred successfully in the past six years and produced over 50 individuals and it has already reached the carrying capacity of 25

Radio-tracking of tigers © K. Ramesh

adult tigers, with current population size is known to be >35 tigers (including sub-adults and cubs). Dispersal events have also started taking place (Ramesh *et al.*, 2016) and individuals from PTR have also been released in other reserves. It was found that male tigers in PTR had the largest home range when compared to other Indian reserves. It was also found that the release site had no influence on home range or mate selection (Sarkar *et al.*, 2016), but they tend to avoid mating with genetically close conspecifics (Reddy *et al.*, 2016). The successful tiger reintroduction in PTR has provided scientific and management lessons for planning and up-scaling such recovery efforts in other parts of tiger range countries as well (Gray *et al.*, 2017).

Major difficulties faced

- There was a general mistrust and lack of popular support for the reintroduction program since the tiger population extinction took place at the backdrop of continued warning by certain section of scientific and management communities.
- There was initial challenge to source founder individuals due to administrative constraints and opposition by tourism lobby, although the state of Madhya Pradesh had many source populations.
- After two weeks of release in PTR, the male tiger traversed out of the reserve, potentially affecting the reintroduction success. It took considerable efforts and resources to capture and return the animal to release site.
- The reintroduction effort required regular veterinary interventions and it required series of trails & errors to execute capturing, radio-collaring and medical treatment of the animals on regular basis.
- Post-release monitoring required involvement of large number of dedicated team and the local manpower needed intensive capacity building, specifically since the monitoring involved telemetry technology, which is new frontier for the staff.

Major lessons learned

- Proper monitoring mechanism needs to be in place in all the source populations so that right candidate animals could be identified quickly for such translocation purposes. Captive animals, appropriately trained in semi-wild conditions may be an option if wild founders are not available.
- Soft-release facilities needs to be large enough to provide enclosure enrichment and to avoid stress to animals, and the shape of such enclosure are required to aligned to the topography of the area. Release site does not influence the habitat occupancy of released animals.
- Dedicated team of professionals such as veterinarian, biologists and trained field staff should be prepared well in advance and deploy them along with necessary logistics and infrastructure.
- It is important to consider mate-selection opportunity for females as well, and therefore, founder composition need to accommodate sufficient number of males and females, and should not be significantly biased towards males.
- Carrying capacity analysis needs to factor in habitat suitability (not total area available), prey density distribution (not cumulative density) and minimum home range size of tiger to provide realistic expectation of population growth and upper limit of the population size.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success

- Institutional Framework with clear objectives and specified roles along with review mechanisms enable effective execution of such tiger reintroduction project.
- Unconstrained resource availability (both fiscal and human resources) and quick administrative approvals are required to effectively implement all the activities as outlined in the Species Recovery Plan or Detailed Project Report.
- Efficient leadership and dedicated team of field staff are critical for post-release monitoring and adaptive management, supported by scientific leadership and team of wildlife professionals.
- Technological integration such as telemetry, camera trapping tools and use of GPS and compass by field staff enable effective monitoring of the reintroduced populations.
- It is important to streamline the communication mechanism so that all the stakeholders including political leadership and media are kept updated of the progress of the project so that there is no communication gap or miscommunication to all concerned.

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Success in reintroducing orphaned and hand-raised greater one-horned rhinoceros into Manas National Park, India as part of a conservation translocation strategy

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Introduction

Until the early 1990s, Manas National Park (26°30'N to 27°00N and 90°50'E to 92°00E), a UNESCO World Heritage Site (WHS) in India, had a healthy population of greater one-horned rhinoceros (*Rhinoceros unicornis*), This population was ,however, completely extirpated due to civil unrest during the late 1990s. The civil unrest ended in 2004 following political agreements that led to the formation of the Bodoland Territorial Council (BTC). Several conservation initiatives by multiple conservation actors have revived the fortunes of this park after UNESCO had put it as a WHS site in danger in 1992. One of these was the restocking of Manas with large mammalian fauna especially greater one-horned rhinos, eastern swamp deer, Asiatic elephants, Himalayan black bears and clouded leopards by the BTC, the Assam Forest Department (AFD) and the Wildlife Trust of India (WTI). The other key conservation success was the political will shown as early as in 2008 to increase the area of Manas from 500 km^2 to 1,500 km^2 across a landscape that has come to be known as "Greater Manas" (Menon & Kaul, 2008 in Menon *et al.* Ed. (2008)). This overt show of political will, along with other measures, led to the UNESCO taking the site of the endangered list in 2011. Of this 350 km^2 has been legally added to Manas NP as of August 2016. It has been surmised that this was made possible in part by the pride raised in local governments and communities due to the reintroduction and restocking of large mammalian fauna. This paper summarizes the success of reintroducing orphaned and hand-raised rhinos as a population and landscape management strategy for Manas.

Released rhino "Ganga" with her calf

Kaziranga National Park (26°33'N-26°45' and 93°9'E-93°36'), another UNESCO World Heritage Site in Assam, has a population of about 2,400 greater one-horned rhinos, which is more than twothirds of the global population. Situated in the bank of river Brahmaputra, flooding is a natural phenomenon in Kaziranga, inundating about 90% of the park during peak floods. Animals that move out of the park in search of highlands come into frequent conflict with humans living in the periphery of the park. To attend to wildlife emergencies and rehabilitate wildlife orphans that get displaced, a Centre for Wildlife Rehabilitation and Conservation (CWRC) was established in 2002 by the Assam Forest Department in collaboration with Wildlife Trust of India (WTI) and in partnership with the International Fund for Animal Welfare (IFAW) and Animal Welfare Division, Government of India. This center has been playing a major role in the rescue and hand-raising of rhino calves since its establishment. The Assam Forest Department as part of Rhino Vision 2020 decided to bring back rhinos to Manas National Park using a two-pronged strategy i.e. wild to wild translocations and reinforcement of the population using the rehabilitated rhinos. Rehabilitated animals are now seen as a useful scientific resources and not limited to the classical theories of individual animal welfare or endangered species conservation (Robinson, 2005). When a population is threatened, either globally or locally, release of rehabilitated individuals using a sound conservation translocation protocol can make a positive contribution to conservation.

Goals

- Goal 1: To reintroduce the greater one-horned rhinoceros in Manas National Park as a species conservation strategy.
- Goal 2: To restore a key UNESCO World Heritage Site that had been placed in danger due to local habitat destruction and species exterminations through a restocking program of select flagship species.

Success Indicators

- Indicator 1: At least 80% of the released individuals survive the first three years.
- Indicator 2: All released individuals that survive establish their own home ranges.
- Indicator 3: Birth of calves to released female rhinos indicating breeding success.

Project Summary

Feasibility: Wildlife rehabilitation is still in its infancy (Holcomb, 1995), and professional and scientific wildlife rescue and rehabilitation program as a key component of wildlife conservation scenario is lacking in India (Ashraf & Menon, 2005). Reintroducing hand-raised rhinos being the first attempt in India, a wildlife rehabilitation consultative workshop was organized in 2005 to formulate a protocol for reintroducing these rescues rhino calves at CWRC. Between 2002 and 2016, 33 rhino calves, displaced largely due to raising water levels in the park, were admitted to CWRC. Aged between 1 - 4 months at the time of admission, these were hand-raised with the objective of rehabilitating them back to the wild. All rescued rhino calves were hand-raised at CWRC, Kaziranga following the protocol developed through a consultative workshop. Of the 33, 12 rhinos died within a few months of rescue (64% survival rate). Once the survivors attained about three years of age, 11 of them were translocated to a pre-release boma at Manas National Park. The rhinos were lured into a crate, loaded onto a truck and then transported 400 km to Manas by road. All translocated rhinos were held at a pre-fabricated boma for about one and half years with minimum human interference. No food supplementation was deemed necessary when rhinos were inside the boma. All rhinos were radio collared with VHF transmitters (Telonics Inc.) before they were released from the boma.

The first hand-raised female rhino “Mainao” was translocated to Manas in 2006. In 2007, two more females were moved to Manas. These three were released to the wild from the boma in October 2008. At the same time, two adult males were reintroduced at Manas through a separate wild-to-wild rhino translocation program by the Assam Forest Department. One young male rhino died following the entry of a translocated wild rhino into the rehabilitation boma. Between 2006 and 2013, 10 hand-raised greater one-horned rhinoceros were released after temporary accommodation of 1 - 3 years in the boma. Out of the 10 released rhinos, five were females.

Post-release monitoring: All of the released rhinos were monitored using VHF radio collars. All of them were seen to establish their own home ranges after release. The first three rhinos after one year had shown home ranges between 15 - 20 km^2. (Barman *et al.*, 2014) On 5th April 2013, the second female released (name: Ganga) was detected with a new born calf. On 2nd June 2013, the first female (name: Mainano) reintroduced at Manas was detected with her new born calf. On 31st July 2013, the third released female (name: Jamuna) was detected with her new born calf. Thus the first female batch of rhinos reintroduced in Manas all gave birth. Very interestingly on 19th June, 2015, the rhino Ganga was seen with her second calf. On 30th July, the rhino Mainao was also detected with her second calf. The inter-calving interval of these two rhinos was as follows - two years one month 15 days and two years one month 28 days. Inter-calving intervals for the species has been variously pegged at between 2.8 and five years (Laurie, 1985; Dinerstein & Price, 1991; Molur *et al.*, 1995; Rothley *et al.*, 2004). The current observations could be the first indicating the possibility of rhinos calving intervals to be as short as 2.1 year i.e. 25 months. In September 2017, the rhino Jamuna was also seen with her second calf. Thus, all three female rhino reintroduced in Manas in 2006 and 2007 have given birth twice post release in Manas National Park.

There have been three mortalities post release of the rehabilitated orphans. One male rhino which was released in Manas on 29th October 2014 was found dead on 7th September 2015. Postmortem findings however could not reveal any definite cause of death. Another reintroduced male sub-adult rhino was found dead after one year of release. Postmortem findings found injury marks most likely due to the attack of another male rhino in the park. On 29th July 2016, the first reintroduced female rhino Mainao was found dead after 10 years of release in Manas National Park. She has given birth to two calves in Manas. The post mortem findings however could not find any definite cause of death in this case too, other than attributing natural causes.

No rhino rehabilitated from Kaziranga under this project or its progeny have been victims of poaching. In sharp contrast, 10 out of 18 wild to wild translocated rhinos have been poached as of date. We hypothesize that this is due to extreme site fidelity of the rehabilitated rhinos allowing them to be in close proximity to heavily secure areas as opposed to others that strayed to less secure regions of the park and even outside the park. As of today seven out of the 10 rhinos rehabilitated have survived in Manas National Park with six additional calves born during the period. The rehabilitated rhinos and their progeny today comprise 43% of all rhinos in Manas NP.

Rhino being released into the boma

Major difficulties faced

- Difficulty in post release monitoring after the radio-collar drop-off due to thick tall grasslands in Manas National Park.
- Minor opposition from the local people around Kaziranga against translocation of rhinos from Kaziranga to Manas, following the poaching of some of the wild-to-wild translocated rhinos and local pride and sentiment.
- Though habituation to human presence persisted for 2 - 3 years in some cases, one of the released young males became aggressive much like a wild rhino within two years of release. Opportunistic crop-raiding by the reintroduced rhinos in the paddy fields outside the park led to conflict with farmers at times.

Major lesson learned

- Move the rhinos from the rescue centre (CWRC) to the release site in Manas at an early stage of two years in order to avoid habituation.
- Boma could be bigger in size to hold a self-sustaining number of three rhinos for two years.
- Solar power fencing in the southern park boundary so that released rhinos cannot come out of the park or go for crop raiding in the nearby paddy fields.

Success of the project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success / failure:

- Reinforcement of rescued and hand-raised rhino in Manas National Park was a great success due to meticulous planning and cooperation from key stakeholders, especially Assam Forest Department and Bodoland Territorial Council.
- The site fidelity established by the adopting a soft-release protocol (unlike the wild-to-wild translocated rhinos that were hard-released), curtailed the

movement of animals far away from the boma, which in turn eluded them from the hands of poachers.

- Rhinos are ideal candidates for rehabilitation, as they are large-bodied to deter predation, not social animals that do not require integration into wild herds and a species that can live with overlapping home ranges.

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Reintroduction of the scimitar–horned oryx in to the Ouadi Rime-Ouadi Achim Game Reserve, Chad

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Introduction

With a distribution that once extended unbroken across the sub-desert belt of Africa, from Mauritania and Morocco in the west to Egypt and Sudan in the east, the scimitar-horned oryx (*Oryx dammah*), a large herding antelope, is now extinct in the wild due to a lethal combination of overhunting, drought and habitat loss. The species was officially classified 'Extinct in the wild' over 15 years ago (one of only two mammal species in this Red List category) and is a Convention on the International Trade of Endangered Species (CITES) Appendix I species (IUCN/SSC Antelope Specialist Group, 2016). Fortunately, the species was not entirely lost due to the large herds held by a number of zoos and private institutions worldwide. The founding father of the United Arab Emirates (UAE), H.H. Sheikh Zayed bin Zayed al Nahyan was passionate about the conservation of this species and this has created an extraordinary opportunity to honor his legacy by reintroducing scimitar-horned oryx, once held in his private collections, back to their native grasslands in the central African nation of Chad.

After a remote sensing analysis (Freemantle *et al.*, 2013), wildlife surveys and habitat studies, the Ouadi Rimé-Ouadi Achim Game Reserve (OROAGR) in Chad - one of the last places wild oryx were observed - was selected as a suitable site. With a goal of restoring a viable population of scimitar-horned oryx to its historical range in the unfenced, 77,950 km^2 Ouadi Rimé-Ouadi Achim Game Reserve in central Chad, the Environment Agency Abu Dhabi (EAD),

Scimitar-horned oryx

in collaboration with the government of Chad and the Sahara Conservation Fund (SCF) and partners, began implementing this project in 2014 with the first animals reintroduced in 2016.

Goals

- Goal 1: Establish secure, viable, free-living herds of scimitar-horned oryx in Ouadi Rimé-Ouadi Achim Game Reserve (OROAGR) and ultimately, have the scimitar-horned oryx removed from the IUCN Extinct-in-the-Wild category.
- Goal 2: Share knowledge and technical expertise relevant to improving the management and protection of the OROAGR thereby increasing conservation of all species in the reserve.
- Goal 3: Facilitate capacity-building of government staff and professionals.
- Goal 4: Develop public education and awareness programs highlighting the importance of wildlife and habitat preservation.
- Goal 5: Establish a healthy, genetically diverse, resilient source population of scimitar-horned oryx in Abu Dhabi, UAE to support this project and future conservation/reintroduction efforts.

Success Indicators

- Indicator 1: Between releases and wild newborns, achieve the foundation of a self-sustaining population ~500 individuals in the OROAGR over the first five years of the project.
- Indicator 2: Increase genetic diversity of the “world herd” source population in Abu Dhabi, UAE before translocation to Chad by expanding founder lineages, improving herd health and reproduction.
- Indicator 3: Successful translocation of selected groups of animals to the pre-release pens in the reserve.
- Indicator 4: Released individuals adapt to their new environment and give birth to wild-born calves.
- Indicator 5: Post release survivorship of the majority of adult oryx through the first dry season.

Monitoring team in August 2017 © Xavier Eichaker

Project Summary

Feasibility: Historical data and multiple recent wildlife and habitat surveys indicated the enormous potential of the OROAGR to support a reintroduced population of scimitar-horned oryx (Wacher *et al.*, 2011a & b). The reserve contains abundant space and suitable habitat to meet the oryx’s seasonal and annual requirements for feeding, shelter, migration and dispersal (Wacher, 2012). The suitability of the site, along with strong commitments from the governments of the UAE and Chad, and technical support from EAD, SCF, the Zoological Society of London (ZSL) and the Smithsonian Conservation Biology Institute (SCBI), created a strong foundation for this groundbreaking conservation initiative. In the years leading up to the project, an international symposia of oryx and arid-lands experts developed a global strategy for the species' restoration, including a suite of tools for the selection of suitable conservation sites and establishing specific criteria for success. In 2012, a workshop was held in Chad to engage stakeholders from government agencies and civil society organizations.


Released herd with wild-born calves

Implementation: From its inception, the project has utilized best practice standards for species reintroductions (IUCN/SSC, 2013). The project remains in a fairly early stage: the first group of oryx were transported from Abu Dhabi, UAE to Chad in March 2016 and released in August of that year. Two more groups were transported in November 2016 and January 2017, and released in December 2016 and August 2017. There are currently 89 oryx in OAORGR, Chad (71 from the UAE and 18 surviving calves). Oryx translocation from the UAE to Chad, and releases of animals into the wild, were primarily timed with the onset of the rainy season to maximize the survival of the reintroduced population. Oryx were selected, crated and transported during the cooler months in the UAE (November - February), which aligns with the cool, dry season in Chad. Animals were flown from Abu Dhabi, UAE to Abéché, Chad and transported approximately 200 km by truck to the release site. Oryx undergo an acclimation period of 1 - 6 months depending on: a) their arrival date, and b) the abundance of foraging resources as a result of the wet season in the reserve (generally June - September). The majority of oryx have been released during the peak of the wet season, when high -quality food resources are available.

Post-release monitoring: *In situ* activities are essential to evaluate project progress, demonstrate results, and meet internationally recognized guidelines (IUCN/SSC, 2013). Three components - community relations, protection of reintroduced individuals, and monitoring - are critical for adaptive management of release strategies and maximizing the likelihood of project success. In particular, field monitoring activities enhance the security of the reintroduced population, and help develop relationships with local communities, a key stakeholder in any reintroduction program.

The main objectives in our post-release monitoring program are:

- Answering critical questions about the movement, ecology and behaviour of reintroduced oryx.
- Building capacity for the people of Chad to assume responsibility for the long-term future of scimitar-horned oryx and its habitat.
- Delivering detailed project evaluations and reports to project partners, Chadian government officials, and the international conservation community.
- Creating acceptance and support for the restoration of oryx in local communities.

Monitoring of reintroduced scimitar-horned oryx is facilitated by GPS satellite collars, VHF beacons, and visual observations by a local field team. Nearly all released oryx carry Vectronic GPS collars, which enable project partners to remotely investigate oryx movements and locate individual oryx as they disperse across the landscape. The main goals of post-release monitoring are to evaluate animal health (e.g. reproduction, body condition), survival, space use, habitat selection, long-term movement strategies, social dynamics; as well as regional threats. At the time of writing, GPS collars have collected over 300,000 data points, and reintroduced oryx have moved across an area of approximately 7,500 km^2.

Major difficulties faced

- Human-caused bush fires were widespread throughout the first dry season destroying large areas of natural grazing areas.
- One animal was shot by a poacher a year and a half after the first oryx release, indicating that hunting remains a critical threat to this species.
- Providing water to released oryx during the first dry season attracted jackals, resulting in an atypically high concentration of jackals around the release site, and the predation of at least one calf.
- On the ground monitoring of all individuals is more challenging as the number of oryx in the reserve increases and animals disperse more widely across the vast landscape.
- It is essential that long-term access to vital grazing areas and shade remain available by ensuring cooperation between stakeholders to develop livestock and water management regimens.

Major lessons learned

- Careful planning of transportation between Abu Dhabi, UAE and the release site is essential. We used a protocol based upon temperature conditions at the origin and destination, to minimize stress and the risk of over-heating in the crates.
- The project’s two large (500 m x 500 m) pre-release pens have provided ample space for acclimation, grazing, calving and natural herd behavior prior to release.
- The design of the catch pen and accompanying chute with a specially designed alleyway for separation with a Tamer Jr. (Fauna Research) allowed for the safe and efficient collaring of oryx at the release site.

- MOU with the Ministry of Environment and Fisheries providing financial support to enable the purchase of vehicles, supplies and salaries for the rangers providing protection and community outreach in the reserve.
- Investment in capacity building/involving local staff in the reserve has been successfully initiated but requires further development.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Clearly defining objectives, partners, roles/responsibility and securing financial resources.
- Selection of release site and pre-release pens based upon years of wildlife and habitat surveys.
- Involvement of the local community in monitoring, protection and community engagement.
- Strong commitment and comprehensive MOUs among the governments of the UAE and Chad, reinforced by technical support from EAD, SCF, ZSL and SCBI.
- The use of cutting edge remote monitoring technology paired with on the ground ecological and behavior monitoring.

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Back to the wild - rehabilitation of orphan Asian elephant calves in Sri Lanka

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Introduction

The Asian elephant (*Elephas maximus*) has been listed as endangered in the IUCN Red List and in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. There are 40,000 - 50,000 Asian elephants in the world. More than 13% of them (6,000) live in Sri Lanka, which has a unique subspecies (*Elephas maximus maximus*). Sri Lanka is an island in the Indian Ocean with 65,610 km^2 land area and has the highest density (per land mass) of elephants in the world. These elephants ranged throughout the island at one time, but are currently confined largely into low country dry zone. Today, habitat loss and fragmentation and the resultant human elephant conflict (HEC) is the major threat to elephant existence and conservation in Sri Lanka. The HEC causes an average death toll of 200 elephants and 60 humans per year and 14 elephant are orphaned as a result. The Department of Wildlife Conservation (DWC), the authorized government institute for implementation of the Fauna and Flora Protection Ordinance, established the Elephant Transit Home (ETH), Udawalawe in 1995 to rehabilitate orphan elephant calves. During the last 22 years the ETH has released 117 elephants back to wild.

Goals

- Goal 1: Rescuing of orphan Asian elephants.
- Goal 2: Rehabilitation of orphan Asian elephants.
- Goal 3: Releasing of orphan Asian elephants back to wild.
- Goal 4: Ethical treatment of Asian elephants those are orphaned due to anthropogenic reasons.
- Goal 5: Successful breeding in the wild that demonstrate conservation and welfare of rehabilitated Asian elephants.

Success Indicators

- Indicator 1: Being able to rescue, transport, treat any injuries and diseases and start rehabilitation.
- Indicator 2: Initiate feeding and living regime, successfully integrate to the existing group and ensure normal behavior.
- Indicator 3: Release the calves when they are over five years old.

Released elephants drinking water

- Indicator 4: Tracking released Asian elephants to ensure survival and integration of with wild Asian elephants.
- Indicator 5: Monitoring breeding of females in the wild.

Project summary

Feasibility: The Asian elephants is a keynote species of Sri Lanka and up to the present day there is a close association between Asian elephants and the people. Increasing human population in Sri Lanka has led to human-elephant conflict and the occurrence of orphaned calves. The mothers of these orphaned elephants are either killed or have been driven away. Traditional methods of rearing, orphaned calves by private individuals or by temple authorities have not been successful. If many of those orphans did not survive to adulthood and those that did survive were often maintained as captive elephants in poor conditions. Because of the declining elephant population in Sri Lanka as well as the welfare of orphaned elephant calves, in 1995 the DWC decided to establish the ETH with the aim of rehabilitating calves and releasing them back into the wild. The establishment of the ETH attracted criticism from some environmentalists and members of the general public. Their major concern was the feasibility of reintroducing hand-reared elephant calves back into the wild. They questioned whether traumatised calves that had been cared for and fed by humans for an extended period of time would be able to survive and thrive when returned to a wild environment and reintegrate with existing elephant herds. At that time there were no rehabilitation facilities for Asian elephants anywhere in the world. The only successful rehabilitation of African elephants in Kenya, was not well documented at that time.

Implementation: The ETH as the first facility established anywhere in the world with the purpose of rehabilitating Asian elephants started in a very primitive manner with limited resources. By a process of trial and error the ETH has had to investigate and develop methods and guidelines for elephant rehabilitation, release and post-release monitoring. On arrival calves are examined for physiological and psychological problems. The height and weight are measured and the age is estimated. On average they have ranged in age from few hours to several years. The veterinary team manages any injuries or diseases in the specialised hospital for the care of newly arrived calves, which has indoor and outdoor elephant pens to hold and acclimatize them. The calves are then introduced to the feeding and living regime with three hourly milk feeds, seven times/day and independent foraging in-between in the nearby forest. The single

Visitors only see rehabilitated elephants during feeding time

herd of very young animals and juveniles up to about six years old are managed and monitored by a workforce of up to 50 elephant keepers. The decision to release an elephant is taken based on their age, size and behavioural indicators that show friendly and cooperative behavior to each other. Usually the calves are released when they are between 4 - 7 years old. The first group of elephants were released from the ETH in 1998 and 85 of the elephants were released to adjacent Udawalawe National Park and rest of them to the Maduruoya National Park about 250 km away from the ETH. A 'hard releasing methodology is followed which means that the elephant calves undergo routine management at the ETH until the day of the release. For post-release monitoring, the calves are fitted with a fitted with a radio-collar (VHF and GPS) about two months before release.

Post-release monitoring: The released elephants are tracked and monitored daily from the date of release up to two weeks and thereafter once or twice a week. After three months the elephants are routinely monitored. Based on post-release monitoring data, it is clear that a 6 - 12 month period is necessary to establish the home ranges for released elephants. The released elephants are similar in behaviour to wild elephants but usually roam as a group for a short period after which some members join with wild herds. Data from long-term monitoring of released elephants indicate that females permanently live together but males leave the group when they get old. One female member have established her own herd with own offspring and a group of other females with their own calves. Although the area that the elephants are released is known for human elephant conflict, the released elephants are indicated in any incidents. A few complaints have been received from villagers about crop raiding by released elephants, but most of these incidents happened in the places where electric fences that separate elephants from cultivated land had collapsed. It is probable that rehabilitated calves had simply followed the common behaviour of their wild counterparts in raiding crops when given the opportunity.

Major difficulties faced

- Complex health and injury problems of calves on arrival.
- Failure of veterinary intervention on health complications of elephant calves leading to calf mortality.
- Introducing milk feeding to orphan calves which sometimes causes gastrointestinal issues.

- Shortage of staff and infrastructure facilities.
- Financial support for medical interventions and purchasing of good collars for post-release monitoring.

Major lessons learned

- Establishing a milk-feeding regime that is interspersed with browsing in the nearby forest to become independent in foraging.
- Minimum contact with orphan calves, so that calves are not dependent on human care, as this is essential for rehabilitation.
- Regular veterinary inspection for health, internal and external parasites and monitoring of growth.
- Observational studies to ensure that behaviors are similar to those in the wild and to enable decisions for which elephants to be released in groups.
- As the calves are adapted to living in the forest and other wildlife, integration with wild elephants and breeding in the wild is facilitated.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- This program has helped the survival of more than 200 orphaned elephant calves.
- Successful growth of calves with display of normal play, social and sleep behaviors at the ETH.
- The project has already released 117 elephants back to wild.
- Released elephants successfully integrate with the wild counterparts.
- Effective breeding in the wild and survival of second generation.

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Reintroduction of Asian elephants to restore forest ecology in Thailand

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Introduction

The number of Asian elephants (*Elephas maximus*) in the world has decreased at an alarming rate. The wild population with a currently estimated size of 30,000 - 50,000 animals in 13 countries of South and Southeast Asia has declined over recent decades, primarily due to habitat destruction. Asian elephants have been listed in the Appendix I category of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1973, and in the Endangered species Red List of the International Union for Conservation of Nature (IUCN) since 1986. This species has been listed under the Wildlife Preservation and Protection Act of 1962 (BE 2505) and of 1992 (BE 2535) of Thailand. Since 1957, the total number of elephants (wild and captive) in Thailand has declined dramatically from an estimated 100,000 to around 6,000. Raised awareness of public and private organizations on the plight of elephants in Thailand has resulted in the initiation of a reintroduction program to preserve and increase elephant population numbers in the wild, and thereby to maintain and restore the important role elephants play in forest ecology.

Goals

- Goal 1: Restoration and conservation of the natural habitat by released elephants.
- Goal 2: Creation of self-sustaining populations of elephants in suitable protected areas.
- Goal 3: Better understanding and a more caring approach to elephant conservation.

Success Indicators

- Indicator 1: Ecological enhancement post-release.
- Indicator 2: Ability of released elephants to survive in the natural habitat, social interaction and group forming of released elephants.
- Indicator 3: Natural mating and birth of elephant calves from released elephants.
- Indicator 4: Community engagement in elephant conservation.

Project Summary

Feasibility: Elephants play an important role in Thailand's history and remain as an enduring symbol today. The elephant also has special spiritual significance through association with Buddhist and Hindu beliefs. Thai society loves and respects elephants, (and particularly so with the reintroduced elephants because they belong to the beloved Queen of Thailand). In Thai society, people make merit by releasing animals; therefore, few threats were anticipated to these elephants released by Her Majesty Queen Sirikit.


Released elephants with a new born calf

The project was officially initiated in January 1997 when H.R.H. Queen Sirikit of Thailand released three adult female elephants into the Doi Phamuang Wildlife Sanctuary. The release location was selected based on the criteria of 1) previous existence of wild elephants, 2) abundance of elephant food, 3) availability of natural fences or barrier e.g. cliffs, and 4) non-existence of human elephant conflict (Somgird, 2013).

To date, 108 elephants have been released into three protected areas: a) the Sublungka Wildlife Sanctuary (latitude 15° 44' – 15° 20' north and longitude 101° 16' – 101° 22' east, 155 km^2) in Lopburi province (central Thailand); Doi Phamuang Wildlife Sanctuary (latitude 18° 7' – 18° 27' north and longitude 98° 58' – 99 ° 15' east, 580 km^2) in Lampang-Lamphun province (Northern Thailand), and Phu Phan National Park (16° 49' – 17° 15' north and longitude 103° 15' – 103° 56' east, 664.7 km^2) in Sakon Nakorn province (Northeastern Thailand).

Implementation: Elephants in the reintroduction project were recruited by donation or were purchased for release by the Elephant Reintroduction Foundation. All elephants obligatorily had an official identification card, and a microchip number with background information to ensure their legal status as captive-elephants, such as tourist elephants, logging elephants, etc. Before entering the project, elephants were examined for health, transmissible diseases and parasites, as recommended by IUCN/SSC Reintroduction Specialist Group, and were quarantined for 30 - 60 days before commencing the rehabilitation and release process.

The "soft-release" process was started by recruiting these elephants into a rehabilitation program for adaptation to the forest environment, and group formation. Initially elephants were released while dragging free-ended chains (the idea being that they could more easily be tracked and brought under control again if it was required to do so in this period). Elephants destined for rehabilitation


Community outreach in schools

were assessed in terms of health monitoring, individual and group interaction behavioral observations, and emerging social structure, as well as human-elephant interactions. Intensive observation for health and behavioral adaptation in the rehabilitation area was conducted for six months for each elephant. Genetic data (DNA fingerprint and mitochondrial DNA) were collected from every elephant before release for parentage analysis, individual identification, and future research work. (Thitaram *et al.*, 2015).

Post-release monitoring: During the first three years of the reintroduction project, GPS Radio collars and satellite collars were placed on the matriarch of each group, and their movements were accurately tracked. (Angkawanish & Thitaram, 2012). The “hard-release” process was completed in time frames of between 3 months - 2 years depending on the individual elephants. Behavioral observations and social interactions were conducted by mahout-rangers at least once a week to track them in the deep forest. Health status was checked from the behavior, body condition score, and dung quality. Roaming area was recorded from the GPS data. Most of the released elephants developed a wariness of humans, and will hide, run away or keep a distance when people are approaching, while very few of them still appeared tame to human presence. However, all the calves born from released elephants behave like wild elephants , not allowing people to touch or even get close to them .

Presently the legal status of release elephants and elephants born in the wild from released parents is unclear. The Elephant Reintroduction Foundation is pushing for clarification - either through the Wildlife Preservation and Protection Act law (which is presently being updated), and/or through the brand new Elephant Act which is presently being developed.

Major difficulties faced

- Human-elephant-livestock interface in the forest.
- Elephant-elephant interface, when the elephants from different places came to stay together in the forest of limited size, particular with the mature bulls.
- Human-elephant conflict post-release when the elephants raided the crops of farmers.
- Crop raiding by reintroduced elephants occurred quite often during cultivation time and compensation has to be paid to the farmers.

- Limitation of the available natural habitats and food and water resources when the number of the elephants continues to increase in the future.

Major lessons learned.

- Public relations and community engagement around the forest are important.
- Strong regulations and laws such as for protected area management and zoning the forest for human and livestock use are equally important.
- Elephant-elephant conflict (male-male, female-female, male-female) can occur, and result in deaths of elephants.
- Releasing of female elephants with calves can stimulate group formation from other previously released cows (Angkavanish & Thitaram, 2012).
- Numbers of released elephants should be restricted according to the size of the area, otherwise, the conflict between elephants could occur.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The restoration of forest ecology has been ongoing since the beginning of the project because of the ecological role played by elephants, and because human threats to the forest have reduced due to the presence of elephants.
- Most released elephants have survived in the natural habitat.
- As of May 2017, 19 calves have been born from natural mating of released elephants.
- Aggressive bulls were placed in a restricted area, and could not be freely released.
- The project was initiated by the Queen of Thailand, and supported by Thai society.

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Problem lion translocations in Botswana, Southern Africa

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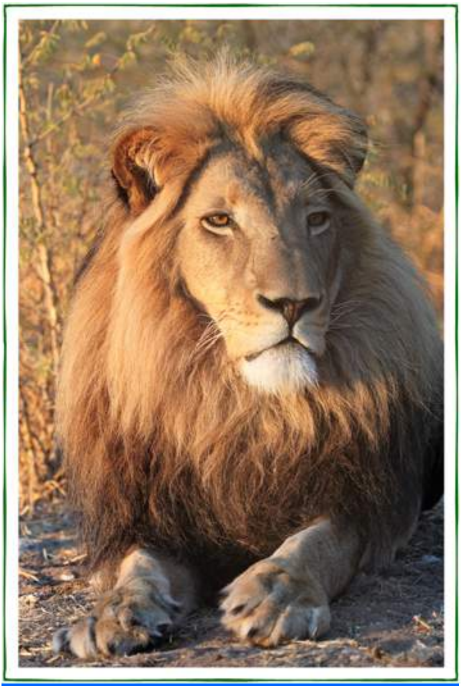
Introduction

Addressing human-carnivore conflicts presents a major challenge to effective management and conservation. African lions (*Panthera leo*) have suffered major declines in recent decades resulting a Vulnerable status by the IUCN and a listing on Appendix II of CITES. As a collaborative project between the Botswana Department of Wildlife and National Parks (DWNP) and Kalahari Research and Conservation (KRC) we collected data on translocations of "problem" lions (i.e., lions that preyed on livestock) into protected areas in Botswana from surrounding communal areas. Since killing lions is illegal in Botswana, our goal was to examine the effectiveness of translocating problem lions as a non-lethal tool to mitigate human-lion conflict. We were concerned that translocating lions into areas with established lion populations would not succeed. As such, our research strove to answer the following questions: a) Do translocated lions return to the area from which they were captured? b) If lions do not return, how do they adapt to their new area? c) In either case, what is the fate of translocated lions?



Male African lion

Goals

- Goal 1: Reduce human-lion conflicts.
- Goal 2: Preserve lions.
- Goal 3: Determine the fate of translocated lions in Botswana.
- Goal 4: Evaluate the movement patterns of translocated lions in Botswana, particularly with respect to homing behavior.
- Goal 5: Develop recommendations towards policy that may increase the number of successful outcomes for translocated lions in Botswana.

Success Indicators

- Indicator 1: Fates of all translocated lions documented.
- Indicator 2: Translocated lions no longer engage in livestock depredations.
- Indicator 3: Movements of all translocated lions and any homing behavior documented.
- Indicator 4: Recommendations from the results of the study provided to the government in a report and published in the scientific literature.

Lioness in natural habitat

Project Summary

Feasibility: When lions frequently kill livestock as prey, in particular far from protected areas, it becomes increasingly difficult to find solutions to help the farmer and keep the lions alive. In Botswana farmers are encouraged not to shoot lions in retaliation for livestock depredation. The Problem Animal Control (PAC) Unit of the Botswana Department of Wildlife and National Parks (DWNP) does not shoot lions in their attempts to reduce human wildlife conflict. The tool of last resort used to help the farmer and the lions is capturing and translocating livestock depredating lions into a protected area.

Implementation: The Botswana DWNP, whenever possible, captures and translocates lions known to frequently kill livestock in areas when farming is the main land use. We assisted in placing satellite capable GPS collars (Vectronic Aerospace GmbH) onto 13 of these translocated lions (7 males & 6 females) that were moved into protected areas (either the Kgalagadi Transfrontier Park (KTP), or the Central Kalahari Game Reserve (CKGR) from April 2013 to June 2016 with the assistance of a DWNP veterinarian. Prior to release, the lions were fitted with satellite/GPS collars than enabled us to track and monitor their movements after release. Most of these lions (n = 9) came from the area around KTP, with the rest (n = 4) coming from the area around the CKGR. The DWNP selected release sites based on their policy of moving problem lions approximately 120 km in a straight line from the point of capture to the point of release. We set the collars to record four GPS locations per day, but increased the number of fixes to 13 locations per day to prepare for re-capture if the animal moved close to a settlement.

Post-release monitoring: The translocated lions were moved a mean of 156 ±12 km from capture to release site and a mean distance of 26 ±6 km from the nearest park boundary. Four lions required a second capture and release and one lion needed a third translocation. Eleven of the 13 translocated lions died after

Research team working on darted lion

living a mean of 272 ±63 days post-release, one lost its collar (i.e. it may or may not have died) after just 15 days, and one remains active (released in June 2016). Farmers killed four lions after they left the protected area and five lions died of "natural" causes. Of the remaining four animals, one lion's collar stopped transmitting after 10 months, we found two collars from animals we presume died, but might have slipped their collars and one lion remains alive with an active collar. None of the variables we analyzed significantly influenced lion survivorship, including gender, distance from capture to release point, or the amount of time the animals spend in and out of protected areas in the wet and dry season. The high rate of mortality of translocated lions suggests the need to explore other methods of resolving human-lion conflicts.

Translocated lions spent most of their time inside of protected areas, but the proportion of time varied greatly by individual lion. Lion movement patterns differed significantly ($t = 1.94$, $df = 16$, $P = 0.07$) by season, with translocated lions spending more time outside of protected areas in the dry season than the wet season. Prey availability likely influenced seasonal movements among translocated lions, something that deserves additional research. However, lion populations at the release sites probably also affected the behavior of new arrivals. Resident lions may have forced some lions (especially females) to return to their ranges. We need further research to answer these assumptions.

We conclude that translocation was not an effective method for dealing with lions that depredate livestock in our study, especially females. Females usually returned close to the point of their capture and so risked retaliation killing by livestock farmers. Males often moved into new areas to predate livestock.

Major difficulties faced

- Lions, especially females, often quickly returned to their original home ranges.
- Botswana lacks areas suitable for lions that do not already contain healthy lion populations.
- Wildlife fences in Botswana do not inhibit the movement of lions.
- Only single lions were captured and translocated even if they were part of a group.

Major lessons learned

- Moving lions that are known to have predated livestock frequently into habitats that already contain established lion populations results in failure and the ultimately the death of the translocated lions.
- Translocating lions into established population likely disrupts the population in the target site.
- Other methods of mitigating lions that prey on livestock must be explored.
- Partnerships between government agencies and non-government research teams can result in valuable insights and improvements to wildlife management.
- It is vitally important to monitor translocated animals to determine their fates and understand their behaviors.

Success of project

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

Reason(s) for success/failure:

- Female lions displayed homing behavior.
- None of the translocated lions survived more than two years following translocation.
- Translocated lions continued to predate on livestock as they moved into new areas that contained livestock.
- Translocation occurred into areas that already contained resident lions.

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Reintroduction of African lions to Akagera National Park, Rwanda

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Introduction

African lion (*Panthera leo*) populations, like those of other large carnivores, have undergone precipitous declines in the last half century due to habitat loss and human persecution. Lions are listed as "Vulnerable" by the IUCN and are estimated to occupy less than a quarter of their historic range (Ripple *et al.*, 2014). At least 23,000 - 39,000 lions remain across the continent (Bauer *et al.*, 2016). Akagera National Park, Rwanda has for years faced the same pressures as other parks and reserves across Africa. Akagera's lion population may have once been as high as 300 when the park was triple its current size, but political unrest in the 1990s, habitat encroachment from pastoralists, and retaliatory killings ultimately led to their extirpation before 2001. Creation of the Akagera Management Company, through partnership between African Parks and the Rwandan Development Board, has led to improved infrastructure and strengthened law enforcement, allowing the ecosystem to recover to the point that lion reintroduction is a viable option. In July of 2015, seven lions were translocated from South Africa and released at Akagera.

Goals

- Goal 1: Return lions to Akagera, from which they were extirpated in the early 2000s, to establish a new population stronghold for a species with a declining population.

Male African lion in Akagera National Park

- Goal 2: Re-establish a complete ecosystem with the full complement of large carnivores.
- Goal 3: Ensure that all lions remain in the park and that there is zero lion-human conflict in the communities adjacent to the park, while also fostering a feeling of pride for the park and lions amongst community members.
- Goal 4: Further improve security of the

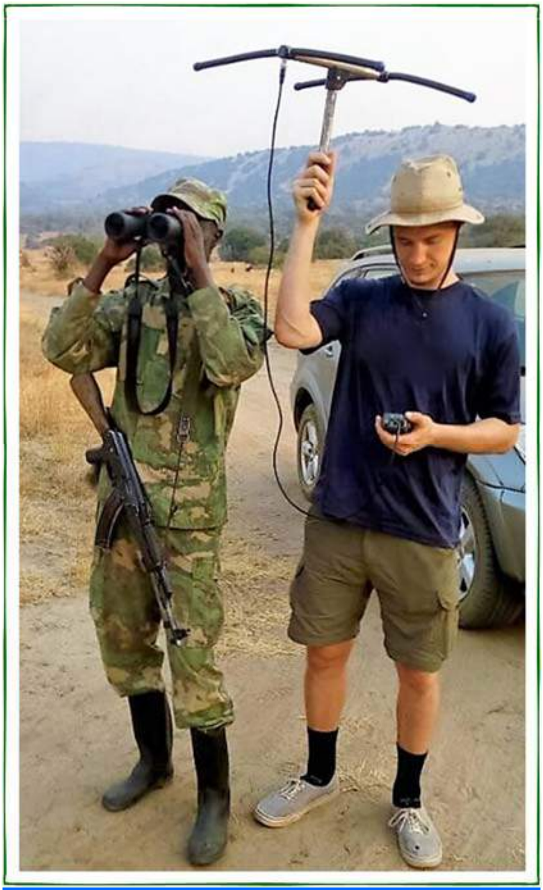
Overview of lion release site

park to ensure the lion population is safe from poaching and human persecution.
- Goal 5: Increase tourism and revenue by reintroducing a species that will bring Akagera one step closer to "Big Five" certification.

Success Indicators
- Indicator 1: Lions exhibit "normal" social, hunting, and reproductive behaviors.
- Indicator 2: The lion population increases.
- Indicator 3: No lions leave the park and there is zero lion-human conflict; support in the communities continues to increase.
- Indicator 4: Poaching is prevented and no lions suffer human-related death or injury.
- Indicator 5: Revenue increases and tourism levels grow sustainably as the lions provide a new attraction to visitors.

Project Summary
Feasibility: The future of lions in Africa is tied to protected areas and lions will likely one day be confined to these areas if current trends continue. Protecting these areas and current populations is the highest priority. Re-establishing populations within historic ranges ("population restoration") may also prove to be a valuable conservation tool. Akagera National Park is a perfect chance for reintroduction. Lion numbers were as high as 300 before extirpation in the early 2000s. The direct cause of extirpation was human-wildlife conflict as returning refugees from the civil war of the 1990s poured into Akagera along with almost 25,000 head of cattle in the current park area (McPhearson, 2013). Improved infrastructure and strengthened law enforcement has greatly reduced the threat from poaching and the park has excluded all human presence not essential to park management and tourism. A 120 km carnivore-proof fence was erected in 2013 to prevent future lions from leaving the park and to increase support for the reintroduction by local communities. Akagera's habitat is well-suited for lions and is like the ecosystem and climate from which the individuals will be sourced.

Open plains, dry forests, and wetlands support a large prey base that resembles those in South Africa, including cape buffalo (*Syncerus caffer*), impala (*Aepyceros melampus*), warthog (*Phacochoerus africanus*), and zebra (*Equus quagga*). Increases in population of key prey species that approach or exceed ecological


Post-release monitoring

carrying capacity estimates for the park indicate the ecosystem could provide enough food for lions, and that lions will serve as regulatory element to prey numbers. Akagera is large enough to support movements as male cubs disperse from their natal groups and seek new territory. Akagera may one day support a lion population of 30 - 50 individuals given prey numbers, water availability, park security, and land area. Of the seven founders, two females are sisters and another two are a mother-daughter pair. All others are genetically unrelated, providing adequate genetic diversity.

The Rwandan Development Board pledged support logistically and assisted in sorting out the proper documentation for moving the lions. Funds from donors have covered all costs associated with the translocation. Akagera's community liaison team has worked tirelessly to gain the support of the surrounding communities through sensitization programs, outreach, and community events like the Lion Cup football tournament and drama performances.

Implementation: Five females were selected from Phinda Private Game Reserve and two males from Tembe Elephant Park in South Africa, and donated to Akagera by the source parks. All seven lions were kept in a boma in South Africa for approximately one month prior to translocation. All lions were vaccinated and have the proper import/export and CITES permits for moving animals internationally. Upon arrival at Akagera, lions were released into a single 50 m x 50 m boma. Lions were held in the boma for one month for condition observation, acclimation to the new environment, and bonding between un-related individuals, per recommended practices (Miller *et al.*, 2013). The boma was constructed near a ranger post in the north of the park for easy access by managers and secluded from tourist roads to reduce stress on the animals. The boma was located near two lakes and two areas of high prey density to make acclimation easier on the lions following release. Lions were released directly from the boma on 27th July 2015. All lions were fully mature and the ratio of males to females roughly simulated what may be seen in established prides. Although the lions have origins in South Africa, Akagera is a closed system so the risk of interbreeding with lions of the East African genetic line is minimal.

Post-release monitoring: All released lions are fitted with satellite/VHF collars for monitoring that send positional fixtures to a database. This is to continue to build confidence and trust in the project within the communities and for monitoring by management. Fixtures were recorded every two hours initially, with the number of fixtures per day being reduced to three over time. Park rangers make weekly trips to visually assess each animal and all sightings along normal patrol routes are recorded. Eleven cubs have been born to four females. The seven male and four female cubs have thrived through sub-adulthood. One female, who did not bear cubs, died of injuries sustained hunting. All surviving lions have shown normal social behaviors and interact with one another intermittently, despite not forming a single cohesive pride. All have been observed hunting successfully, both individually and in groups. The initial release was such a success that managers elected to release two new male lions in July 2017. Observational monitoring will be increased to examine pride formation, territory partitioning, and interactions between the original lions and the new males. Attitudes in the community towards lions and the reintroduction are continually monitored by Akagera's community liaison team and outreach programs to sensitize the communities continue.

Major difficulties faced

- Sourcing lions for translocation to Akagera.
- Securing funding to capture lions, build bomas in South Africa and Rwanda, and pay for translocation fees.
- Ensuring the lions remain in the park and that there is zero human-lion conflict while gaining support from adjacent communities for the reintroduction.
- Securing the park to prevent poaching.
- Maintaining a large enough prey base to support the initial seven lions, as well as future lions as the population begins to grow.

Major lessons learned

- Investing in practices to mitigate human-wildlife conflict is critical. Erection of the boundary fence has kept all lions in the park and has led to major support from the communities who have taken immense pride in the reintroduction project. Sensitization programs and community engagement has also increased support.
- Support from government partners and donors is critical to assist with logistics, sourcing, funding, and gaining community support.
- Security is crucial to minimize poaching and persecution so that the lions can adopt normal behaviors and movements within the park.
- Ensuring the prey base is healthy enough to support the proposed number of lions is essential. It is important to monitor the lions to ensure they are feeding enough and to monitor prey to identify major effects of lion reintroduction to preserve those species. Management decisions must be made to support the reintroduction while also considering other species in the park.
- Lions are a charismatic species and tourist will travel to see them. It is important to monitor lion locations to aid guides in providing good sightings for clients and to market the lions' return to Akagera to promote tourism and support for local communities.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:
- Lions are hunting successfully and interacting socially with one another.
- Lions are reproducing successfully and 11 cubs have been born.
- No lions have left the park and there has been no lion-human conflict in the adjacent communities, including zero lion depredations. Community support for the reintroduction is wide-spread.
- No lions have been lost to poaching and the only lion death was due to natural causes.
- Tourism has increased in the past two years, up from around 12,000 from January through June 2015 to over 15,000 in 2017 for the same months.

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Reintroduction of captive-raised Amazonian manatees in Brazil

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Introduction

The Amazonian manatee (*Trichechus inunguis*) is an exclusively freshwater sirenian endemic to the Amazon basin. It is widely distributed from the main Amazonian rivers of Colombia, Ecuador and Peru to the estuary of the Amazon River in Brazil (Best, 1984). The species is classified as "Vulnerable" by IUCN (Marmontel *et al*., 2016) and the Brazilian Red Book, and it is listed in Appendix I of CITES. Historical commercial exploitation during recent centuries for oil, hide and meat was the main cause of its dramatic population reduction. Although protected by national laws in all countries of its distribution, *T. inunguis* hunting still persists for the subsistence of riverine communities and to maintain the illegal trade of its meat. To increase the ecological information available for this species and promote its conservation, since 1974, the Aquatic Mammals Laboratory of the National Institute of Amazonian Research, LMA/INPA, has rescued and rehabilitated orphan Amazonian manatee calves. The success of this rehabilitation program and research resulted in the establishment of a group of animals that could potentially be returned to the wild, promoting a new step toward the conservation of this species.

Amazonian manatee

Goals

- Goal 1: To assess the re-adaptation of the captive-raised Amazonian manatees after release in the wild.
- Goal 2: To monitor the daily and seasonal movements of the released manatees.

- Goal 3: To assess the home range and habitat use of the released manatees.
- Goal 4: To promote environmental education programs in the communities of the project area to increase the engagement of local people in Amazonian manatee conservation activities.

Success Indicators

- Indicator 1: Survival of the individuals over at least one complete flood pulse of the river.
- Indicator 2: Movements and exploration of the area by the released manatees and selection of suitable habitats for the species.
- Indicator 3: Absence or low contact of the released individuals with humans.
- Indicator 4: Participation and engagement of the local people in the protection and monitoring of the released manatees.
- Indicator 5: Interaction of the released animals with wild Amazonian manatees.

Project Summary

Feasibility: The Amazonian manatee reintroduction program was established in 2008. Release sites were chosen based on the following requirements - appropriate habitats, presence of wild manatees, food availability, an absence or decline in hunting, location within Protected Areas and support of local communities for the protection and post-release monitoring of the animals. Initially, the Cuieiras River (02º41’29.5”S/60º20’51.8”W) in the Puranga-Conquista Sustainable Development Reserve (SDR), Amazonas state, Brazil, was selected as a release site. In this phase, the animals were released directly from captivity into the wild. The individuals showed difficulty adapting, and the translocations were suspended after two releases. A second phase began in 2016 at a new site (Piagaçu-Purus SDR), located in the lower Purus River (04º12’05.7”S, 61º55’48.5”W). To improve the success of the animals after release, we adopted new strategies before the release process, with the animals spending 1 - 4 years in a semi-natural lake for adaptation. In both areas, an education program was also established to create awareness of the project and promote human engagement.

Releasing manatees in the Cuieiras River

Implementation: Due to illegal hunting and entanglement in fishing nets, orphaned manatee calves from the Amazon rivers in Brazil are rescued by partner organizations, governmental agencies or riverine residents and taken to INPA’s facility. During the rehabilitation process, the animals are kept in fiberglass pools and are fed with an artificial milk formula for approximately two years. After weaning, they are transferred to bigger pools and fed with several natural plants and cultivated vegetables. Animals with the potential to be reintroduced were selected based on their time in captivity, their health conditions and behavior assessments. *T. inunguis* has high genetic diversity and a panmictic population (Cantanhede *et al*., 2005); therefore, genetic issues are not exclusionary criteria. The selected animals were transported mostly at night, to avoid the heat, using a covered truck and a regional boat, keeping the animals' skin wet. Before release, the animals were kept in a floating tank for 1 - 7 days to reduce transportation stress and to test the telemetry equipment. Two release protocols were used: direct release (2008 - 2009) and soft release (2016 - 2017). During the first reintroduction, in the Cuieiras River, four sub-adult manatees were released directly from the pools to the river. We conclude that *T. inunguis* raised in captivity have very low perception of the seasonal variation in the hydrological cycle and in the search for food. Two animals died approximately 130 days after release. The third individual lost its belt after 165 days, likely due to weight loss. The fourth animal was recaptured after 120 days with a weight loss of 30% body mass and was returned to captivity for rehabilitation. Thus, the reintroduction protocol was revised, introducing an adaptation phase in a semi-natural area before release.

Since 2011, the selected manatees have been moved to a 13 ha semi-natural facility for the minimum of one year for the gradual adaptation to the environmental conditions (Souza *et al*., 2012). From 2016 - 2017, nine manatees (5 males & 4 females) were released in the Piagaçu-Purus SDR. One male manatee was released twice, one time in each area. All release processes had the support of the local people helping with the releasing and monitoring procedures.

Post-release monitoring: All reintroduced animals (n=12) were monitored using a radio-telemetry system. A VHF transmitter is attached to a belt and fixed to the caudal peduncle, totaling 900 g in weight. The monitoring was conducted using an aluminum boat and canoe with the manatee's positions determined directly or by triangulation. Additionally, animal-borne digital recorders with an automatic release mechanism were used to record the swimming behavioral and feeding events of the manatees over a short period after release (maximum 14 days) (Kikuchi *et al*., 2011). The manatees were monitored daily for 75 to 550 days. During the first days after release, the animals remained relatively close to the floating tank, gradually moving greater distances from the release site. Individual differences in movement and space use have been observed. The average displacement of the animals was 3 km/day (min. 0.3 km and max. 37 km per day). The farthest distance recorded from the release site was 100 km. Usually, the manatees were observed in calm water areas with abundant food. Although the animals were raised and kept together for approximately 10 years in captivity, after release, they spent most of their time separately, supporting the information on the solitary behavior of the species.

However, interactions with wild manatees were recorded. Although the signals of transmitters can be lost in some areas, such as flooded forest, radio-telemetry showed a high efficacy rate, totaling more than 2,200 records. Post-release survivorship showed a significant increase after the adoption of the semi-natural captivity stage in the protocol, with a current 100% success rate. One of the monitored manatees was recaptured eight months after release, showing increased body size and weight as expected.

Major difficulties faced

- The high costs of the long-term program to monitor the released animals, including gaining the permits to import the equipment.
- The long period required for the rehabilitation of the orphan rescued manatees in captivity (5 - 7 years) to achieve the ideal body conditions for release and the cost of maintenance.
- Logistical difficulties in implementing the semi-captivity facility. Currently, we are using a private area with natural and safe conditions.
- The inexistence of a standard protocol for the release of Amazonian manatees. We had to learn based on our own actions, defining the best season for release, age of individuals, time in semi-captivity, and how to improve the belt design to avoid injuries.
- Determining how to evaluate the manatee health conditions and adjust the belts of the released animals; due to the complexity of the habitats plus the cryptic behavior of the species, the observation and recapture of the animals are challenging.

Major lessons learned

- As the Amazonian manatee is still hunted, one important requirement for the selection of a release site is that the area should be located inside a Protected Area to minimize the risks for the animals.

Local school children greeting the manatees

- Inclusion of former manatee hunters in the monitoring team and involvement of the local people are extremely important for the success of the release program. Environmental education programs are necessary for the protection of the released manatees, highlighting the importance of this species and its habitat in the region.
- Time spent in the semi-natural captivity area for at least one year is necessary in order to promote the gradual re-adaptation of the manatees and to increase the success of the reintroduction.
- Reintroduction during the beginning of the rising water of the rivers is recommended to offer greater food availability as well as more time for the adaptation to the seasonal variation in the water level.
- The VHF belt design for the Amazonian manatee has been widely used in marine sirenians. Until now, there has been no information on the durability of this belt in the Amazon freshwater environment. After examining the conditions of two belts one year after deployment, the need for modifications to minimize injuries to the animals and to improve the monitoring system signals became clear.
- *Antenna* - The intensity of the transmitter's signals decreased considerably after six months for 75% of the tracked animals. We noticed that the antenna of the transmitter was broken at its base, and now a modification of the supporting base of the antenna was applied to allow more flexibility and durability.
- *Belts* - The metal screws that hold the belt are expected to corrode over time to allow the belt to fall off, preventing injury with the growth of the animal. We found that in freshwater, the corrosion of the belt screws occurs more slowly. To accelerate the corrosion rate, we soaked the steel bolts in vinegar to remove the zinc plating. Our expectation is that the belt can break faster, in less than 18 months. Leather belts are not designed to corrode away but to rip when entangled. For the same reason, we also reduced the leather thickness from 0.4 mm to 0.3 mm.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Contrary to our early expectations, the inability of the captive-raised Amazonian manatees to understand the seasonal variation in the water level of the rivers suggests a very strong learning component in the species. Therefore, the direct reintroduction of animals from captivity to the wild is not recommended.
- Constant review of the reintroduction protocol for the species. The inclusion of the semi-natural captivity step shows a 100% success rate for manatee survival in a new environment.
- Involving former Amazonian manatee hunters with the team considerably improves the monitoring quality due to their great experience in terms of the species ecology and by promoting the empowerment of local people.

- The success of the manatee release program in the Piagaçu-Purus SDR indicates that the environmental characteristics of the region (floodplain and ria lakes) have contributed to the survivorship of the reintroduced animals.
- The experience and results accumulated up to now are crucial to improve our management techniques (transport, semi-captivity and release) and to propose guidelines for the conservation of this species over the long-term.

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First reintroduction of the western barred bandicoot to inland Australia

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Introduction

The western barred bandicoot (*Perameles bougainville*) is the smallest bandicoot species in Australia (200 g) and was once widespread (Richards, 2012). Since European settlement it has become extinct on the mainland and is now found naturally on only two offshore islands in Western Australia where the population is estimated at between 2,200 - 4,400 bandicoots, depending on rainfall (Short *et al.*, 1997). The species was reintroduced to a fenced reserve (Heirisson Prong) on the mainland in 1995 (Richards & Short, 2003) but the population has since become extinct due to feral cat incursions (Short, 2017). Subsequent more successful reintroductions have occurred at Arid Recovery and Faure Island (Richards, 2012). The cause of original decline and reintroduction failures is thought to be predation by introduced cats and foxes. The western barred bandicoot is listed as Vulnerable in the IUCN Red List and is nationally listed as endangered under the Australian *Environment Protection and Biodiversity Conservation Act 1999*. Arid Recovery is a private conservation organization supported by BHP Billiton, University of Adelaide, South Australian Department of Environment and the local community. Arid Recovery manage a 123 km^2 fenced Reserve near Roxby Downs in arid South Australia. Threatened species have been reintroduced to 60 km^2 of the Reserve from which feral cats and foxes are excluded.

Goals

- Goal 1: Re-establish an insurance population of western barred bandicoots on the mainland in an arid environment.
- Goal 2: Create a self-sustaining population that could survive without management intervention.
- Goal 3: Understand the role that bandicoots played in arid environments and their ecology.

Western barred bandicoot © Ryan Francis

- Goal 4: Improve or maintain genetic diversity.

Success Indicators

- Indicator 1: Long-term population trajectory is stable or increasing.
- Indicator 2: Persistence of population during drought conditions.
- Indicator 3: Population of more than 500 individuals.
- Indicator 4: Population spread throughout the 6,000 ha protected from cats and foxes.
- Indicator 5: No significant decline in genetic diversity.

Project Summary

Feasibility: Western barred bandicoots formerly occurred throughout semi-arid Australia with the range extending in a broad band from the north-west coast of Western Australia through the Nullarbor Plain and southern S.A. to Victoria and Liverpool Plains in New South Wales (Short *et al.*, 1998). The Arid Recovery Reserve is within the known range of the bandicoot, as evidenced by specimen records from the eastern Nullarbor Plain and supported by sub-fossil remains located near Arid Recovery (Owens & Read, 1999). However, as the remaining extant wild population is located on islands with significantly higher rainfall and vegetation cover, there were some concerns about how the species would survive in a much more arid environment with low, sparse plant cover. The Arid Recovery Reserve experiences highly erratic rainfall around a long-term mean of 165 mm of rain each year. The Reserve is dominated by longitudinal sand dunes separated by up to 1 km of inter-dunal clay swales. Vegetation is dominated by *Acacia* shrubs in the dunes and chenopod shrubland in the swales. Free water is rarely available in the environment. After significant rainfall events there can be a large increase in cover of ephemeral forbs and grasses but droughts are also common and can lead to a stark reduction in cover and food.

Logistical constraints were also present as western barred bandicoots are only present on two adjacent islands in remote Western Australia and had to be captured and moved more than 2,400 km to the release site in remote South Australia. Arid Recovery worked closely with the WA Department of Conservation and Land Management (now Department of Biodiversity Conservation and Attractions) to develop a translocation proposal and obtain approval permits including ethics, take from the wild and export and import permits.

Dune vegetation at release site where bandicoots build nests under shrubs © Arid Recovery

Releasing a bandicoot © Arid Recovery

Implementation: Twelve western barred bandicoots were captured on Bernier Island in September 2000 and then transferred and released into an 8 ha release pen at Arid Recovery. Bandicoots were captured in hand nets using spotlights and transported individually in wooden nest boxes, first by boat to the mainland and then via light aircraft to Arid Recovery. They were radio-collared and monitored daily after release. After one month, concerns regarding an unknown papilloma virus affecting Bernier Island bandicoots prompted the capture and quarantine of the released bandicoots at the Adelaide Zoo for observation. After seven months no conclusive evidence of the virus was recorded in these animals and they were re-released at Arid Recovery.

Post-release monitoring: Bandicoots were monitored daily using radio-telemetry for the first few weeks until the discovery that multiple bandicoots were entangling their feet in the collars. Collars were then removed and bandicoots monitored through spoor counts and spotlighting. Annual cage trapping was implemented but was unsuccessful due to trap saturation by reintroduced burrowing bettongs. Bandicoots are now monitored using biennial spoor counts conducted over 10 km of transects. Bandicoots bred successfully immediately after release and the population has increased gradually over the last 17 years. Recent monitoring suggested the bandicoot population has now exceeded 500 individuals and is still increasing. Five additional bandicoots were added from a reintroduced population of bandicoots on Faure Island to Arid Recovery in 2009 to increase the genetic diversity. Genetic samples were taken from founder individuals and compared with captured bandicoots 17 years after release. Genetic sampling conducted by the University of Adelaide confirmed no major loss of genetic diversity since release.

Major difficulties faced

- Issues with the discovery of a papilloma virus in the source bandicoot population led to extended quarantine of reintroduced individuals which delayed release and potentially caused additional stress to the animals.
- Two incidents of bandicoots trapping their feet in their radio-collars led to the death of one individual and all collars were then removed which hampered post-release monitoring. The low capture rate in traps due to high trap saturation and disturbance by sympatric bettongs also made monitoring difficult.

- High costs involved with the capture, transport and release of bandicoots from a remote source and release location had to be covered by extended fundraising.
- Capture myopathy and death in some individuals reduced the founder size and was exacerbated by veterinary intervention and handling by inexperienced staff.

Major lessons learned

- Western barred bandicoots are well adapted to arid conditions and can cope with droughts.
- Disease risks should be reviewed prior to translocation to minimize stress to animals.
- Fitting radio-collars and over-handling bandicoots can lead to death of individuals and experienced staff and other monitoring methods need to be used.
- Despite the Reserve fence being permeable to young bandicoots, failure to naturally establish outside suggests fox and cat predation remains a key limiting factor.
- Intentionally reintroducing animals from two separate source populations maximized the genetic diversity of the resulting population (White, 2017).

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Successful exclusion of foxes and cats from the Arid Recovery Reserve.
- Dedication and perseverance of Arid Recovery staff, partners and volunteers to deal with unplanned events and issues.
- Generous support from Roxby Downs community and NGOs who helped raise necessary funds.
- The large area and good condition of the Arid Recovery Reserve vegetation enabled persistence during dry periods.

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Reintroducing fishers to forest ecosystems in Washington State, USA

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Introduction

The fisher (*Pekania pennanti*) is a mid-sized carnivore of the Mustelidae family that occurs only in the temperate and boreal forests of North America. Unregulated harvest, loss and fragmentation of habitat, and predator control campaigns collectively resulted in the extirpation of fishers from much of the southern portion of their historical range (southern Canada and the northern United States, including Washington State) by the mid-1900s. The fisher is currently listed as an endangered species in Washington and is included on IUCN Red List. Because of the success of fisher reintroductions in the southern portion of their range, reintroductions are currently being used to restore fishers in Washington.

In Washington, fisher conservation efforts are focused in two recovery areas that include national park and national forest lands within the historical range of the fisher. The Olympic Recovery Area includes most of the interior of the Olympic Peninsula in northwestern Washington, whereas the Cascades Recovery Area coincides with much of the Cascade Mountain Range in Washington. To provide sufficient habitat for a self-sustaining fisher population, recovery areas include large areas of low-

Fisher being released © Paul Bannick

and mid-elevation forest mosaics that are dominated by mature or old-growth coniferous-forest habitat.

Goals

- Goal 1: Restore a self-sustaining population of fishers to the Olympic Recovery Area by reintroducing 90 fishers to Olympic National Park (2008 - 2010) and monitoring reintroduction success by tracking the post-release movements, home range establishment, survival and reproduction of released fishers (2008 - 2011).
- Goal 2: Evaluate the success of the Olympic fisher reintroduction by conducting occupancy surveys for fishers throughout the Olympic Peninsula (2013 - 2016) to assess the distribution, occupancy patterns, genetic characteristics, and reproductive success of reintroduced fishers.
- Goal 3: Restore a self-sustaining population of fishers to the southern portion of the Cascade Recovery Area by reintroducing 80 fishers to the Gifford Pinchot National Forest and Mount Rainier National Park and monitoring as described in Goal 1 above (ongoing; December 2015 to December 2018).
- Goal 4: Restore a self-sustaining population of fishers to the northern portion of the Cascade Recovery Area by reintroducing 80 fishers to the Mount Baker-Snoqualmie National Forest and North Cascades National Park and monitoring as described in Goal 1 above (December 2017 to December 2020).

Success Indicators

- Indicator 1: *Olympic and Cascades Reintroductions* - Greater than 50% of released fishers of each sex establish a home range in the year following release.
- Indicator 2: *Olympic and Cascades Reintroductions* - Annual survival of >50% of released fishers in the year following release.
- Indicator 3: *Olympic and Cascades Reintroductions* - Evidence of successful reproduction by ≥ 1 female fisher in each reintroduction area.
- Indicator 4: *Cascades Reintroductions* - Home range establishment in closer proximity to release sites and sooner after release events as compared to the Olympic reintroduction project. Because we are using far fewer release sites (2 vs. 21), our expectation is that the greater presence of previously released fishers near Cascade release sites prompts newly released fishers to establish home ranges closer to the release site and sooner after the release event.
- Indicator 5: *Olympic Occupancy Surveys* - Evidence of successful reproduction as indicated by the presence of second and third generation fishers (via DNA analysis) within the Olympic Recovery Area.

Project Summary

Feasibility: A feasibility assessment for fisher reintroductions was completed in 2004 that included an assessment of habitat suitability and carrying capacity, and an evaluation of potential source populations. National Environmental Policy Act (1972) analyses were also conducted for the Olympic and Cascade reintroductions that disclosed and evaluated the potential environmental and social impacts of considered reintroduction options. The habitat assessment identified large, connected landscapes at low- or mid-elevations that were dominated by mature or old-growth coniferous-forests. The carrying capacity assessment indicated that three areas were expected to provide habitat that


Release site of fishers © Jeff Lewis

would support reproductive success by female fishers and a total population of ≥50 fishers: the Olympic Peninsula, the southwestern portion of the Cascade Range, and the northwestern portion of the Cascade Range.

The assessment also identified three possible source populations: northern Alberta (Canada), central British Columbia (Canada) and northwestern California (USA). We chose the source population from central British Columbia because it was closest geographically, most similar genetically to historical Washington fishers, and we were able to obtain permits to capture and translocate fishers from this source population. Fisher reintroductions in Washington and elsewhere are not socially or economically controversial, and many are supported by the public because 1) the fisher is not a threat to people, 2) fishers are not seen as a significant threat to pets, livestock, or business interests and 3) the public is interested in the restoration of wildlife.

Implementation: Reintroductions in Washington involve the capture of wild fishers in central British Columbia by licensed British Columbia trappers, with the use of box traps. Captured fishers are transported to a local wildlife facility and housed temporarily until they can be examined by a veterinarian, vaccinated against potential diseases, and equipped with a VHF radio-collar (Olympic reintroduction) or a VHF abdominal-implant transmitter (Cascade reintroduction). Fishers deemed healthy and suitable for reintroduction are then transported to Washington and released at specific release sites within recovery areas. These activities require a capture and transport permit from the British Columbia Provincial Government, and adherence to capture quotas established to protect the source population. The capture and transport permit, a health certificate from a licensed British Columbia veterinarian, and an approved Importation Declaration form (3-177) from the U.S. Fish and Wildlife Service (USFWS) are required to transport fishers from British Columbia to Washington (USA). Officials with the USFWS and U.S. Border Patrol may also inspect fishers and their transport boxes when border crossings occur. After crossing into Washington, fishers are transported to a release site, where they are released the following morning by project biologists, agency staff, and interested members of the public. To date, we have released 90 fishers in the Olympic Recovery Area and 69 fishers in the Cascade Recovery Area.

Post-release monitoring: Each released fisher is equipped with a VHF radio-transmitter, which enables us to monitor their post-release movements, home range establishment, survival, and reproduction. The large majority of monitoring is accomplished via aerial telemetry surveys (using a fixed-wing airplane) to locate and determine the survival status of released fishers. Telemetry data are used to inform implementation activities (e.g., avoiding release locations where fisher mortality was more prevalent, releasing individuals of one sex to facilitate mate acquisition where one sex is much less abundant or absent) and to identify potential den sites of females for monitoring post-release reproductive status.

During the Olympic reintroduction, we found that after being released, many males and females moved extensively before establishing a home range or dying (Lewis, 2014). Mean distance from a release site to a home range was greater for males (44.5 ±6.4 km) than for females (30.1 ±3.6 km). A greater percentage of females (67%; 18 of 27) established home ranges with the Olympic Recovery Area than males (38%; 8 of 21). In contrast to resident fisher populations, the survival rates of fishers released on the Olympic Peninsula were greatest for juveniles, lower for adult males, and lowest for adult females. Survival rates also varied among the release-year cohorts (2008 [high], 2009 [low], 2010 [intermediate]). We documented seven reproduction events by seven females (ages 2 - 4 years) and litter sizes of one to four kits; other females were suspected of having kits.

A fisher occupancy study was conducted from 2013 to 2016 on the Olympic Peninsula to evaluate the success of the reintroduction of 90 fishers from 2008 to 2010. The objectives of the study were to determine the current fisher distribution, the proportion of the recovery area currently occupied, and the genetic characteristics and reproductive success of the fisher population, via DNA analyses. The initial findings indicate that fishers are widely distributed across the Olympic Peninsula both inside and outside the recovery area, and the presence of second and third fishers indicates substantial reproductive success by founder individuals and their descendants (Happe *et al.*, 2016).

Major difficulties faced

- Conducting radio-telemetry to track released animals was extremely challenging due to combined effects of multiple factors; extensive wilderness (i.e., roadless areas), rugged terrain, and wide-ranging dispersal of released fishers forced us to gather almost all of the post-release data via aerial telemetry.
- Data acquisition via aerial telemetry was further limited by

Fisher in the wild © National Park Service weather conditions that were unsuitable for flying and the limited signal strength of our radio-transmitters. Antenna breakage on a number of radio-collars was an additional problem during the Olympic reintroduction because it greatly diminished signal transmission distance and made locating individuals more difficult.

- Determining cause of death for dead fishers and finding den sites were limited by terrain inaccessible to foot traffic for all or part of the year due to deep snows, difficult river crossings, and steep terrain.
- High cost of aerial telemetry surveys.

Major lessons learned

- Extensive post-release movements and extensive breeding-season movements by adult females suggested that fewer release sites (2 to 4 vs. the 21 used during the Olympic reintroduction) may facilitate greater mate acquisition and reproduction (by increasing proximity to potential mates). Selecting release sites to facilitate proximity to potential mates is a higher priority than distributing release sites broadly to facilitate occupancy over a large spatial extent within the recovery area.
- Release as many individuals before 1st January as possible to facilitate the reproductive success of pregnant females by disassociating the stress of a reintroduction process from the period of active gestation (late February to April; see Facka *et al.*, 2016, Ecosphere 7(1):e01223).
- Because duration in captivity may negatively influence survival, minimize time in captivity to the extent feasible (Lewis, 2014).
- Release a founder population over two or more years that is female biased (55:45 to 60:40) to better accommodate the polygynous mating system of fishers and the possibility of poor female survival in one or more years.
- Use implant transmitters instead of radio-collars to prevent loss of signal transmission distance and loss of data acquisition that results from broken radio-collar antennas or shed collars.

Success of project

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

*** positive indications, but still being evaluated**

Reason(s) for success/failure:

- The factors that caused the decline and extirpation of fishers are greatly diminished or no longer exist; i.e. furbearer trapping is regulated, fur trappers in Washington are limited to the use of box (cage) traps, regulatory protection of fishers is provided via state endangered status, and widespread and indiscriminant predator-control campaigns no longer exist.
- Large areas of habitat remain within the recovery areas to support reproductive populations and there is protection of a large proportion of the remaining suitable habitat.
- Sufficient founder population size and suitable sex-ratio was available due to a robust source population within feasible proximity to recovery areas.

- There is a great deal of support for fisher reintroduction and recovery efforts, including support from State, Federal and Tribal government agencies, non-profit organizations, commercial timber companies, private landowners and the public.
- Coordination with private landowners and involvement of Tribal and First Nations co-managers ensured project support.

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Reintroduction of Arabian hares in Mahazat as-Sayd Protected Area, Central Saudi Arabia

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Introduction

The cape hare (*Lepus capensis*) has a wide geographic range, from South Africa up to and across North Africa and Southwest Europe in to the Middle East and central Asia to East China (Flux & Angermann, 1990). There are six sub-species of cape hares living on the mainland of Arabian Peninsula and two sub-species living on offshore Islands (Harrison & Bates, 1991). According to Harrison and Bates (1991) in Saudi Arabia there are two confirmed sub-species of cape hare recorded, they are *L. c. arabicus* (Arabian hare) and *L. c. cheesmani.* The sub-species *L. c. jefferyi* could also be recorded in parts of Saudi Arabia but needs more clarification.

As per the IUCN Red List, the cape hare is a widespread species, with a large population, whose decline does not qualify it for listing as a threatened species (IUCN, 2008), but it has been described as a less than 10% decline since 1904 and expected to continue at this rate until 2104 (Kryger *et al*., 2004). The geographic range includes isolated populations scattered across the entire Arabian Peninsula**.** In Saudi Arabia, the Arabian hares population in general has declined dramatically in many areas mainly due to hunting and in some areas are locally extinct (Khalid & Moayyed, pers. comm.). Hunting of Arabian hares is permitted in Saudi Arabia (IUCN, 2008), while species exist in many protected areas in the country, where they are not allowed to be hunted. Based on our work, in central west Saudi Arabia, the Arabian hare is near to extinction in the wild, only small numbers are remaining near Al-Mahd area, in some private farms and government fenced areas. Historically, the Arabian hares used to occur in Mahazat as Sayd and surrounding areas but disappeared due to severe hunting pressure in early 1980s before the protected area was established. After confirmation of the historical records of this species by interviews from the locals, the

Arabian hare © Moayyed Sher Shah

reintroduction of the Arabian hare in Mahazat as-Sayd Protected Area was proposed by Prince Saud Al-Faisal Wildlife Research Center, Taif (PSFWRC). The reintroduction of Arabian hares was always a part of the Mahazat Master Management Plan. This reintroduction is an attempt by the Saudi Wildlife Authority (SWA) to restore Arabian hares and would make a significant contribution to the conservation of the species, which is known to be under severe pressure outside of formal conservation areas.

Goals

- Goal 1: To re-establish a wild and optimum population of Arabian hares in Mahazat as-Sayd Protected Area in central Saudi Arabia.
- Goal 2: To restore back the Arabian hare to its native habitat in central Saudi Arabia.
- Goal 3: Establish a post-release monitoring program that will provide important information (e.g. habitat preference, food preferences, dispersal rate, seasonal and annual home ranges, mortality causes and rate), which will help in the reintroduction of Arabian hares in other suitable sites in Saudi Arabia.
- Goal 4: Manage the reintroduced populations in the protected areas.

Success Indicators

- Indicator 1: The captive-bred Arabian hares provided for release from both the private hare collections were healthy.
- Indicator 2: Founders of the Arabian hares for release in Mahazat as-Sayd were captured from around the protected area before they went locally extinct.
- Indicator 3: Productivity of Arabian hares was high and in future Mahazat as-Sayd Hares population can be used as source for reintroduction in other suitable areas of central Saudi Arabia.
- Indicator 4: Local public and government supports the reintroduction of Arabian hares and Mahazat is a feature national and international tourism site.

Project Summary

Feasibility: Arabian hares previously occurred in Mahazat as-Sayd Protected Area (22°15'N-41° 40'E) and surrounding areas, it is an area of open desert steppe habitat with temperate and arid climate. Mahazat is located in southwest of Saudi Arabia and 150 km northeast of Taif, it was established 1988 and was completely fenced and protected from livestock grazing. With the rapid recovery of vegetation till date, five species are successfully reintroduced in Mahazat. The local community was taken in confidence for the reintroduction programs and the Saudi Wildlife Authority got full support from local community and the government. Arabian hares went extinct locally in Mahazat due to excessive hunting in the 1980s. The reintroduction of Arabian hares in Mahazat is highly supported by the local peoples and they have worked together with SWA for the restoration of this species by providing hares for release.

Implementation:

Source of Arabian hares for the reintroduction program - One of the main challenges to start the Arabian hares reintroduction program was to have Arabian hares from the local area. Attempts were made to capture hares from the wild for two years from which only few individuals could be captured. There were two main source of Arabian hares, private collections available from nearby areas of

Mahazat. One collection belongs to Mr. Khalid Nashi and other to Mr. Faleh Al-Subai. Mr. Khalid Nashi private hares collection is 8 - 9 years old and is located mainly in Al-Muwyah Area 2 km from Mahazat. Founders hares of his collection are from Hafr Kashab area, which is just 70 km north of Mahazat. Mr. Khalid provided a total of 25 Arabian Hares to PSFWRC from his collection during 2014 - 2015. Mr. Faleh Al-Subai hares private collection is located in Al-Khurmah just 20 km south of Mahazat. The founders of Mr. Faleh hare collection is from Harrat Subai, which is 60 - 70 km south of Mahazat and he provided 13 (6 males & 7 females) Arabian hares to PSFWRC from his collection in 2016 for the second release. Arabian hares provided by both hare collection owners were in good health and disease free. Both the hare collections are from the reliable sources of Arabian hares which were managed properly. Age of the Arabian hares provided for the release from both collections were between one to eight months old.

Release Sites in Mahazat - Two sites for release of Arabian hares in Mahazat were selected and release pens were built within both locations of the reserve. The main release location was selected near the mammal camp, west of Mahazat which is a 500 m x 500 m fenced enclosure and hares were released here in May 2015. But the vegetation condition was not favorable and was very dry for the 2016 release. Second release location was selected in central south in Mahazat near the Romromiya area camp, where vegetation conditions was good. Both locations were selected on the basis of preferred habitat for Arabian hares, vegetation condition and historical records of the species in the Reserve. Both locations were selected in fenced area where meso-carnivore trapping was carried out and were predator free before the release of hares. Between May 2015 and March, 2016 a total of 24 Arabian hares were released in Mahazat in two groups.

First Release - In 2015 the first group of 13 (6 males & 7 females) Arabian hares were transferred from PSFWRC to Mahazat on 25th May 2015 and were kept in the holding pen in the Mammal Camp for two days. All the Arabian hares were vaccinated before transferring to Mahazat and were secured with radio-collars attached with reflecting tags for monitoring purposes. Two Arabian hares died before the release in the holding pen and 11 (5 males & 6 females) were released in a 500 m x 500 m enclosure in west of Mahazat as-Sayd Protected Area on 27th May 2015. Three Arabian hares (2 males & 1 female) were released directly from boxes by H.H. Prince Bandar bin Saud (former SWA President) and the remaining eight hares were also released softly by opening the gate of the hares holding enclosure.

Second Release - In 2016, the second group of 13 (6 males & 7 females) hares were transferred on 1st March 2016 from Mr. Faleh collection to Mahazat in the 2 km x 2 km enclosure in west Mahazat. In addition to the 13 hares, three other females were also transferred from the Mammal camp holding enclosure which had survived from the first release. Two males and three female hares were secured with radio-collars and it was decided that the remaining animals will be released without radio-collars. All animals were in good health condition and vaccinated, and 16 (6 males & 10 females) hares were released on 3rd March 2016 by Mr. Faleh Al-Sharrakh. Three females were released directly from boxes and remaining 13 hares were also released softly by opening the gate of the hares holding enclosure into the enclosure. Next morning all Arabian hares had left the holding enclosure.

Release of Arabian hares © Hajid Subai

After release, food and water was provided at three locations in each release enclosures till the last Arabian hare had left the release site. All animals were monitored on a daily basis after release and date, time, location, behavior, habitat used and group composition were recorded for each observation.

Post-release monitoring: Monitoring of the Arabian hares in Mahazat after release was conducted by a combination of three methods to have better understanding of their ecological requirements. These methods are monitoring of Arabian hares by radio-tracking, by conducting random surveys and camera trapping in the release sites. After the first release in May 2015, about eight (5 males & 3 females) hares were recorded dead within one month of release from 11 released. The main causes of mortalities were due to poor condition as these hares were captive-bred and the design of the radio-collar was not good and got stuck in the mouths of some individuals. The late timing of release was an important factor for mortalities of hares and three female hares have survived from the first release in 2015 and were monitored to be in good health. These three females were attracted back to the holding enclosure by providing alfalfa and were kept their due to the bad vegetation condition of the 500 m x 500 m fenced enclosure in the Mammal camp. When releasing the second group of 13 hares in Romromiyah (2 km x 2 km) during March, 2016 these three female were also released back.

After the second release in March 2016, three radio-collared hares (2 males & 1 female) were recorded dead between March and June 2016 from the 16 released individuals in west of Mahazat in the Romromiyah fenced enclosure (2 km x 2 km). The main cause of these three mortalities were due to predation by carnivores. With the selection of good vegetation conditions at the release site and re-designing the straps of radio-collars and early release timing in early spring have controlled the mortalities of hares during the second release. After the heavy rain in Mahazat during May 2016, large holes were made in the fence of the Romromiyah enclosure and most of the Arabian Hares left the enclosure from the holes and some predators entered the fence. The last individual was recorded in June, 2016 in the Romromiyah fenced enclosure. After leaving the Romromiyah fenced enclosure hares were recorded in different parts of the


Overview of habitat at release site

protected area. Only one sub-adult female was recorded near the fence and left Mahazat from small hole near the gate. The first breeding of the reintroduced Arabian hares in Mahazat is recorded on 23rd September 2017 in Al-Raha area. Two leverets were recorded during the night surveys near the fence, it is quite possible that other released individuals in Mahazat may have given birth but not recorded as from the second release. Eleven hares were released without radio-collars and it difficult to locate and monitor them. Currently hares are located in two *wadis* in Mahazat, in Al-Raha and Kharama. With the present drought condition in Mahazat still a small numbers of the released hares have survived and the first breeding recorded. The present population of Arabian hares in Mahazat is between six to 13 individuals and monitoring is been carried out. Comparing the initial results of Mahazat Arabian hares reintroduction program with other hares the reintroduction projects even with better vegetation conditions are acceptable as the survival rate in hares reintroduction programs are relatively low in the initial stages. The survival rate of brown hares released in central Poland, was 37% with 22 individuals surviving after one year of release and highest mortality rate was 40% (Misiorowska & Wasileswski, 2012). It is planned to release another group of 40 hares in Mahazat this year in December if the vegetation conditions are favorable for release.

Major difficulties faced

- Studies of the genetic diversity for the Arabian hares species in Saudi Arabia has not been done in detail and also limited analysis were done for the released hares.
- Lack of skills for capturing Arabian hares in the wild to have a source population for a reintroduction and breeding program.
- Detection of Arabian hares during monitoring after release in Mahazat, especially individuals without radio-collars.
- Lack of source population of hares in captivity of the research centers for reintroduction programs.

Major lessons learned

- Effective management plan is needed before the reintroduction start to manage the Arabian hare population in the fenced area of Mahazat where food availability is restricted. As in the future over population of such species can be problem for the existing species.

- Participation and involvement of the members of local community together with SWA in such reintroduction programs by providing animals and their support in the main success for such programs.
- Vegetation condition should be favorable at the time of release and the release timing is also very important for the success of such reintroduction programs.
- Keeping the animals in pre-release enclosures in the reintroduction site to get them acclimatized to the natural environment and provide required food and water before and after release.
- Releasing captive-bred Arabian hares in the fenced predator-free enclosures increase the survival chances during the first weeks of release.
- Survival and breeding of Arabian hares in drought conditions.
- Public awareness program to educate and highlight citizens about the importance of such reintroductions programs and other initiatives of SWA is very important. Also citizens should be informed about the biological and historical significance of cape hares in the society.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The Arabian hare species is near to extinction in south-western Saudi Arabia and now we have a small numbers with the first breeding recorded through the reintroduction program.
- With drought conditions in Mahazat still a small number of Arabian hares are surviving without any additional food and water provided.
- Low number of Arabian hares released and late release timing.

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Reintroduction of the riparian brush rabbit in the San Joaquin Valley, California, USA

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Introduction

Brush rabbits (*Sylvilagus bachmani*) are found along the Pacific coast of North America from the Columbia River in the north to the southern tip of Baja California and 14 sub-species are recognized. Although the species is classified by the IUCN as a species of Least Concern, one sub-species, the riparian brush rabbit (*S. b. riparius*), is listed as Endangered by the state of California and the U.S. government. The riparian brush rabbit occupies riparian habitat in the northern San Joaquin Valley of central California, habitat that has been reduced to less than 1% of its historical extent, primarily due to irrigated cultivation, impoundment of rivers, and stream channelization. The only known population occurred within Caswell Memorial State Park, a small park dominated by riparian oak forest on the Stanislaus River. In 1998, a second population was confirmed in the southern Sacramento/San Joaquin River Delta, in non-forested and early successional riparian forest habitat. Subsequent research showed that the rabbits prefer habitat composed of willow thickets, blackberry, wild rose, and other successional shrubs and trees, even though they also use riparian-oak forests. In 2001, a captive-breeding and reintroduction program was initiated to recover the riparian brush rabbit.

Goals

- Goal 1: Establish and protect continuous habitat along the Stanislaus and San Joaquin rivers from Caswell Memorial State Park (MSP) to the south end of the San Joaquin River National Wildlife Refuge (NWR), a stretch of about 40 river-km that potentially could support several thousand brush rabbits.

Riparian brush rabbit © Moose Peterson

- Goal 2: Establish a self -sustaining population on the west side of the San Joaquin River on the San Joaquin River NWR.
- Goal 3: Protect and expand the population in Caswell MSP by acquisition of contiguous

cultivated ground, restoring and enhancing habitat to double or more the current carrying capacity of the park to around 300 or more rabbits, and greatly reduce the threat of population extinction by fire or flood.

- Goal 4: Enhance, protect, and manage the South Delta population, which is on private land, so that it has permanent habitat as well as refugia during flooding.
- Goal 5: If one or more of the preceding goals are not achieved, establish self-sustaining populations elsewhere on public land, such as the San Luis NWR, in the northern San Joaquin Valley to achieve the goal of at least three protected, self-sustaining populations outside of Caswell MSP.

Success Indicators

- Indicator 1: Establish that rabbits will breed in captivity.
- Indicator 2: Produce enough captive-born young to initiate and sustain a multi-year reintroduction program on the San Joaquin River NWR and adjacent lands.
- Indicator 3: Post-release survivorship is high enough to ensure breeding of rabbits in the wild, which is further verified through the capture of wild-born rabbits.
- Indicator 4: The San Joaquin River NWR population is resilient to extreme flooding.
- Indicator 5: Ultimately, the riparian brush rabbit can be down-listed and delisted.

Project Summary

Feasibility: The prospects for recovering the riparian brush rabbit did not look very promising when the only known population was thought to be confined to Caswell MSP. Not only is the park small (250 acres) and largely surrounded by private farmland, but we knew that only some of the habitat in the park was used by the rabbits, that the population was affected by camping and day use activities, and also by a feral cat problem. However, in late 1998, a second riparian brush rabbit population was confirmed along a network of linear habitat remnants along waterways and railroad rights-of-way in the South Delta, in effect a network of small populations and habitat patches (totaling about 430 acres), a spatial arrangement that is thought to be more resilient to flooding and wildfires, and better configured to support genetic diversity. Consequently, the discovery of the South Delta population accelerated the collaborative effort between federal and state agencies to formally initiate a recovery program for the brush rabbit, something that could not have been done without the active cooperation of the land owners.

Implementation: In 2001, a captive-breeding and reintroduction program (CBRP) was initiated (Williams *et al.*, 2002). Centered on the San Joaquin River NWR, the program included breeding small numbers of rabbits that were temporarily removed from the South Delta population in three large outdoor pens (each about 1 acre). Following veterinary inspection, healthy young rabbits (weighing 400 - 500 g or more) from the breeding pens were released into suitable habitat on the NWR. The first captive bred brush rabbits were released in July 2002. Initially, rabbits were soft-released into fenced enclosures that were opened after a few days to a week to allow the rabbits to move out into remnant riparian and newly-restored riparian habitat. However, in spring 2007 hard-releases of collared rabbits were shown to be equally effective (in terms of survivorship of released rabbits) and soft-release pens were no longer used. For the first five years of the program, many of the rabbits were fitted with radio-collars. This was done to get detailed information on survivorship, dispersal, and habitat use (Williams *et al.*, 2008; Hamilton *et al.*, 2010; Kelt *et al.*, 2014). However, this research was interrupted by manmade and natural events. A major wildfire swept across the NWR in 2004 and it was nearly completely inundated by flooding of the San Joaquin River in 2006, the latter resulting in the mortality of nearly all brush rabbits on the NWR, and pushing adaptive management into high gear. The extent and magnitude of flooding on the refuge was mapped so that locations could be chosen for the placement of large mounds of dirt that would be vegetated with brushy species and serve as temporary refuges during floods. The ideal locations for mounds were areas that did not experience deep water flooding or experience significant currents and scouring during floods. The U.S. Fish and Wildlife Service also fast-tracked a program to vegetate miles of river levees on the NWR.

The paired habitat management/restoration measures, construction of the 'bunny mounds' and vegetation of the levees, were fully implemented, with mature vegetation in both cases, by the time the next major flood arrived in spring 2011. As a result, when the flood waters receded and the habitat recovered, the brush rabbit population quickly rebounded, by the end of 2011 in fact, and without augmentation, whereas following the 2006 flood it took the population two to three years to recover, and that was with ongoing augmentation from the captive-breeding program.

Implementation of the CBRP expanded in late 2005 and early 2006, with the release of rabbits on the privately-owned Faith Ranch. The ranch, which is under conservation easement, has about 7.2 river-km of oak-riparian habitat connecting the NWR northwards towards Caswell MSP. Further, in August 2006, the U.S. Fish and Wildlife Service acquired the 371 acre Buffington tract and added it to the San Joaquin River NWR. This tract brought an additional 3.2 river-km of oak-riparian habitat under conservation management. More importantly, it linked the Faith Ranch to Caswell MSP, thereby creating more than 32 continuous river-km of riparian habitat for the brush rabbit and many other species, including the also endangered riparian woodrat (*Neotoma fuscipes riparia*). Starting in 2006, and following some extensive habitat restoration work, captive-bred brush rabbits were released on the Buffington Tract through the end of 2012, as well as on the Faith Ranch. By the time the CBRP was suspended in December 2013, a total of 1,496 riparian brush rabbits had been released on the NWR, including the Buffington Tract and the Faith Ranch.

Post-release monitoring: Post-release monitoring was done through a combination of radio-telemetry, although this was reduced over time, and biannual censuses: 18 transects; 15 traps, 15 m spacing; trapped spring/fall for one week.

Major difficulties faced

- One of the major ongoing challenges in recovering the riparian brush rabbit is the small amount of suitable habitat that remains in the region. A related challenge is that most of the federal, state, and private land available for conservation purposes in the region is already involved in the brush rabbit recovery effort at some level. An important population, South Delta, exists nearly entirely on private land that is not dedicated to conservation. Further, it is separated from protected habitat by 24 river-km (13.7 air-km) of variable-quality habitat that is all on private land.

Author with rabbit during fall census in 2010
© Tristan Edgarian

- Given their preference for riparian habitat, riparian brush rabbits are very vulnerable to flooding. The CBRP has already experienced major flooding three times, in 2006, 2011 and 2017. This threat was identified from the outset, but measures to counteract it were not implemented until after the 2006 flood. Those measures included: 1) the construction and vegetation of 34 flood refugia, large mounds (32) or berms (two, each 400 m long) of dirt that were vegetated with brushy species ('bunny mounds' and 'bunny berms'), and 2) the vegetation of 19.3 km. of river levees that formerly were kept free of vegetation other than grasses and forbs. These paired habitat management and restoration measures proved to be very beneficial during the 2011 and 2017 floods.
- Wildfire is also a significant threat to riparian brush rabbit populations. There have been a number of wildfires on the San Joaquin River NWR and adjacent lands since the CBRP was initiated. The most significant wildfire took place in July 2004. The Pelican Fire swept southwards across the NWR from Highway 132 burning approximately 58% of the NWR, affecting a significant amount of habitat for riparian brush rabbits and riparian woodrats: 53% (300 acres) of high quality dense riparian and willow/shrub mix habitat and 44% (60 acres) of moderately suitable oak woodland habitat burned (Phillips *et al.*, 2005). Fire breaks are used by NWR personnel, but it is generally recognized that these can be of limited use under severe fire conditions.
- Urbanization is an ongoing challenge in the region, especially in the South Delta. Along with it come urban edge effects that can penetrate deeply into riparian conservation areas. They include but are not limited to trespass, habitat degradation, and depredation by household pets, especially domestic cats. There seems to be a problem with the release of cats in some riparian areas, especially Caswell MSP, but feral cats are also a problem at the San Joaquin River NWR.
- Another less common but still significant challenge for the CBRP was illegal marijuana gardens. From time to time, these small grow sites would appear in dense riparian habitat and thus curtail recovery efforts until the situation was stabilized by law enforcement.

Major lessons learned

- By creating semi-natural conditions in large outdoor enclosures, we learned that it was relatively easy to breed riparian brush rabbits in large numbers for reintroduction elsewhere. It would seem from this experience, that this model could be implemented with other cottontail species and perhaps with other non -cottontail lagomorphs.
- A quantitative habitat suitability assessment is warranted prior to initiating reintroduction. The habitat must meet the basic ecological needs of the species so that reasonable survivorship rates are achieved. We learned this lesson on the Buffington Tract with elevated mortality rates following the initial reintroductions, but ultimately rectified the situation through extensive habitat restoration.
- In reintroduction programs it is important to plan for the unexpected, so an adaptive management approach should be adopted from the outset. Nature or manmade factors will surely intervene to upset the best laid plans and they did in our case (e.g., flooding, wildfires). We learn from setbacks, modify our management, and move forward.
- We also need to plan for the long-term. Reintroduction is rarely simple or straightforward, or something that can be achieved over a few breeding seasons. In our case, it formally got under way in 2002, and appears to be successful but there is still work to be done and goals to achieve to recover the riparian brush rabbit.
- We must involve all stakeholders to the extent necessary and to the extent that we can, and be open to their viewpoints. This recovery effort was guided by a Riparian Mammals Technical Group that had representation from state and federal agencies, non-profits and academia. We also engaged with private landowners where possible.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The first reason for the success of the CBRP was the availability of a second population of riparian brush rabbits, albeit on private lands, a population that could be sourced for a captive-breeding program.
- A second reason is that it was a truly cooperative effort. The process was guided and supported by a Riparian Mammals Technical Group that met regularly. It included representatives from the U.S. Fish & Wildlife Service, U.S. Bureau of Reclamation, California Department of Fish & Wildlife, California Department of Water Resources, California Department of Parks & Recreation, UC Davis Wildlife Health Center and Veterinary Medical Teaching Hospital, Sacramento Zoo, Center for Natural Lands Management, River Partners, and California State University, Stanislaus - Endangered Species Recovery Program. Other important partners included the California Bay-Delta Authority and River Islands LLC, the owner of the South Delta property that was the primary source of the breeding program rabbits.

- A third reason was the availability of public land, the San Joaquin River NWR, to anchor the reintroduction program.
- A fourth was major funding from supportive programs and agencies: Central Valley Project Conservation Program; CVPIA Habitat Restoration Program; California Bay-Delta Authority; U.S. Bureau of Reclamation; U.S. Fish & Wildlife Service; California Department of Fish & Wildlife.

Rescuing rabbits from a flooding event

- A fifth is the hard work and dedication of the many past and present members of the riparian brush rabbit team and other staff members of the CSU Stanislaus - Endangered Species Recovery Program that have supported this project since 2000.

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Sea otter reintroductions into previously occupied habitat, Northeast Pacific, USA and Canada

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Introduction

Once numbering about 300,000, sea otters (*Enhydra lutris*) historically occupied all nearshore habitats around the north Pacific Rim from central Baja California, Mexico to the northern Islands of Japan. Beginning in 1741 they were exploited in a 170-year commercial fur harvest resulting in catastrophic population declines to approximately 1,000 animals until international protections were put in place in 1911. Between 1937 and 1989, nine sea otter reintroductions into previously occupied habitat, resulted in six successful and self-sustaining populations. Today, those reintroduced populations comprise approximately 30% of the nearly 125,000 extant sea otters and occupy more than 50% of the sea otters historic range. Three sub-species are presently recognized based on skull morphology: *E.l. lutris* (Russia), *E.l. kenyoni* (Alaska to Washington) and *E.l. nereis* (California). Two stocks of sea otters are listed as threatened under the Endangered Species Act (ESA): California and the Southwest Alaska (from Kodiak Island in the east to the end of the Aleutian chain in the west). The sea otter is listed as Endangered by the IUCN due to past population declines, the California subspecies is listed as an Appendix I species, and all other populations are listed as Appendix II species by CITES.

Goals

- Goal 1: Augment the natural recolonization of sea otter habitat vacated as a consequence of the maritime fur harvest that ended in 1911.
- Goal 2: Establish self-sustaining populations of sea otters to pre-exploitation abundance in previously occupied habitat.
- Goal 3: Reduce the threat of a catastrophic event that may eradicate a geographically isolated population and result in sub-species or population extinction(s).
- Goal 4: Restore the historical ecological structure and function of nearshore marine habitats and communities that were dramatically changed with the widespread removal of sea otters.
- Goal 5: Re-establish historical connectivity and gene flow of sea otter populations throughout the north Pacific rim.

Success Indicators

- Indicator 1: Establishment and persistence of self-sustaining and growing sea otter populations in previously occupied habitat.
- Indicator 2: An increased rate of sea otter range expansion into previously occupied habitat resulting from reintroductions.


Female sea otter and pup

- Indicator 3: Reduction of threats to remnant populations by increasing connectivity between populations.
- Indicator 4: The transition from a less complex and herbivore (sea urchin) dominated coastal ecosystem to one dominated by benthic primary producers (the alga such as kelps) with more ecological complexity and diversity due to the presence of an apex predator (sea otter).
- Indicator 5: The increase of genetic diversity across sea otter populations due to enhanced geneflow between adjacent populations that had previously been genetically isolated for over 100 years.

Project Summary

Feasibility: The commercial maritime fur harvest from 1741 - 1911, while driving sea otters to near extinction, resulted in little impairment of sea otter habitat, which consists of marine waters and benthos between the supratidal zone and the 100 m bathymetric contour. Until recently, with the effects of global climate change on the nearshore ecosystem unknown, industrialization and human developments have not widely altered sea otter habitats and most sea otter habitat remains suitable for complete recolonization and restoration. The removal of sea otters via the maritime fur trade harvest provides a seminal example of the effect of removing an apex predator from a food web. The removal of the sea otter from nearshore marine habitats resulted in many sea otter prey populations, including various species of clam, crab, mussel and urchin, to dramatically increase in abundance. These benthic invertebrate increases eventually formed the basis for commercial and recreational fisheries on species such as Pismo and razor clams, several species of abalones, sea urchins and Dungeness crab. As sea otters naturally recolonize and are reintroduced into vacant habitat, competition and conflict often arises between humans and sea otters over these valuable invertebrate resources. Alternatively, the abundant prey populations available to reintroduced sea otters have contributed to sea otter population growth rates that are found to be significantly greater within the reintroduced populations (often near maximum for the species) than rates demonstrated within recovering populations.

As sea otters reclaim previously occupied habitat, they initiate a cascade of ecological effects that include reduction in the abundance and grazing effects of the herbivorous (primarily kelp eating) sea urchins, resulting in the re-establishment of understory and canopy forming kelp forests, and an increase in nearshore biodiversity largely through kelp dependent species of invertebrates,


Sea otters in their natural habitat

fishes and seabirds. Where sea otter populations persist, there tends to be a more complex nearshore marine ecosystem illustrating the value of a critical keystone species.

Implementation: Numerous sea otter reintroductions have occurred. The first experimental translocation of sea otters was conducted by the Russians in 1937, when nine sea otters were captured in the Commander Islands, for transport to the Murman coast in the southern Barents Sea, well outside the species historic range. Two males survived for five years demonstrating the potential for reintroducing this species into previously occupied habitat. The first efforts to reintroduce sea otter populations within their historic range began between 1951 and 1959 when sea otters were moved from Amchitka Island in the central Aleutians to the Pribilof Islands in the Bering Sea and Attu Island in the western Aleutians. These two reintroductions failed, most likely due to poor husbandry and inadequate numbers transferred. In 1965, multiple successful reintroductions followed from Amchitka and Prince William Sound to the Pribilof Islands, southeast Alaska (two efforts), British Columbia, and Washington and included one unsuccessful reintroduction to Oregon. The latest effort was in 1987, when 139 animals were taken from the central California coast to San Nicolas Island, off the coast of Southern California. Despite several successful reintroductions, currently there remains a large portion of unoccupied sea otter habitat between San Francisco, California and southern Washington that is not likely to be re-colonized by natural sea otter range expansion in the near future. Thus, further reintroduction is recommended to recover the sea otter and its habitat in this area.

Post-release monitoring: Little systematic effort was allocated toward monitoring early reintroductions and the status of those sea otter populations was determined primarily through anecdotal observations and infrequent surveys and reports. Following the sea otter reintroductions in the 1960s to 1970s, state and federal agencies conducted infrequent surveys of distribution and abundance to evaluate success and the status of those populations. Recently, over the past two decades, more frequent surveys have improved documentation of change and trend in both remnant and reintroduced sea otter populations. Across all reintroductions, initial declines of the number of individuals moved generally were high, about 90% in most cases, presumably resulting from emigration and mortality. However, following initial declines, population growth rates, in most cases, approached the maximum possible for the species of about 20% annually. The notable exception was San Nicolas Island off the coast of southern California;

of the 139 animals moved after the initial decline there remained a population of less than 20 animals which remained unchanged for nearly two decades despite normal reproduction. Only recently has the population increased its growth rate, reaching 100 animals in 2016. Incidental mortality associated with fisheries around San Nicolas Island in California likely contributed to the initial slow growth of this population. In addition legal harvest for otter pelts by First Nations in Alaska have reduced growth rates of some reintroduced sea otter populations.

Major difficulties faced

- Rates of loss of individuals following translocation approach 90% due to mortality and emigration.
- Limited understanding of the basic physiology related to thermoregulation and adverse effects of long distance transportation to reintroduction sites resulted in high post reintroduction mortality.
- Limited understanding of species specific social structure and affinity to relatively small home ranges resulted in a large loss of individuals from the reintroduction site due to emigration.
- The abundance of commercial and recreational fisheries species in the nearshore coastal areas was inflated due to the removal of sea otters from the system during the fur trade thus the adverse impact of sea otters on these fisheries caused conflict and controversy.
- Conveying to management and the public the ecological consequences (e.g. trophic cascades) of reintroducing a key-stone predator back into its historic range.

Major lessons learned

- Successful reintroductions contributed significantly to the conservation and recovery of sea otters with 30% of current sea otter abundance resulting from reintroduced stocks and the return of this keystone species restored ecological structure and function of nearshore marine communities.
- Biology of the species is important. The selection of healthy animals that sustain minimal injuries or stress from reintroductions should be released in healthy habitats.
- Behavior of the species is important and should be taken into account. The sea otters fidelity to small home ranges and affiliations with conspecifics likely contributed to initial losses where reintroduced individuals tended to try to return to where they were originally taken.
- Mixing of individuals from geographically/genetically distinct populations contributed to increased genetic diversity in reintroduced populations.
- Unanticipated fisheries conflicts and related mortality along with legal human harvests likely led to delayed success in at least two reintroductions.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√1, 2, 3, 4, 5, 6			√7, 8, 9

1. Pribilof Islands
2. Southeast Alaska-northern section
3. Southeast Alaska-southern section
4. Vancouver Island
5. Washington State
6. San Nicolas Island California
7. Pribilof Islands (early 20th century)
8. Attu island (early 20th century)
9. Oregon state (late 20th century)

Reason(s) for success/failure:

- Initial failures resulted from high mortality related to poor husbandry practices including but not limited to the soiling of pelage during transport and the resulting negative effect on thermoregulatory processes.
- Insufficient numbers of individuals translocated likely contributed to failures.
- Larger numbers of individuals translocated likely contributed to successful reintroductions.
- The lack of human caused degradation of previously occupied habitat and abundance of prey likely contributed to success.
- The mixing of individuals from different locations has resulted in increased genetic diversity in the reintroduced population and has resulted in the recovery of genetic diversity lost due to the extensive fur trade extirpations.

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Rescue, rehabilitation and release of Sunda pangolins in Singapore

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Introduction

The Sunda pangolin (*Manis javanica*) Desmarest, 1822, is a Critically Endangered (IUCN Red List) member of the Pholidota order and is considered one of the most trafficked mammals in the world (Wilson & Reeder, 2005). They are illegally harvested for meat and their scales are highly valued as traditional Chinese medicine. All pangolin species were up-listed to CITES Appendix I in September 2016. There are four Asian species and *M. javanica* occurs throughout Southeast Asia, from Southern China to Java and Borneo as well as adjacent islands. It generally occurs in lowland forests and has been found from sea level up to 1,400 m a.s.l.

In Singapore, the species is found in forest edges and urban areas. They have been observed to use burrows and they exhibit arboreality as well (Lim & Ng, 2008). In Singapore the species has been listed as Critically Endangered since 2008. Road-related mortality remains the biggest threat in Singapore, with 59 carcass records since 1995. This threat is compounded by a decline in forest habitat in Singapore. Regional- and National-Level Species Action Plans are currently being drafted for the species, a result of strategy meetings that took place in June 2017.

Goals

- Goal 1: To monitor survival rates and movements of translocated pangolins.
- Goal 2: To develop guidelines for rehabilitation and hand-rearing of rescued pangolins.
- Goal 3: To create an adequate diet that is accessible and ingestible for hand-reared pangolins.

Sunda pangolin © Nathanael Maury

- Goal 4: To improve our understanding of pangolin urban ecology.
- Goal 5: To improve our understanding of pangolin ontogenesis.

Success Indicators

- Indicator 1: Obtain home range sizes and movement patterns of translocated pangolins.
- Indicator 2: Publication of guidelines for rehabilitation and hand-rearing rescued pangolins, including a nutrition guide for captive pangolins.
- Indicator 3: Adequate and palatable diet readily accepted by pangolins that are either hand-reared or in rehabilitation.
- Indicator 4: Ability to predict where pangolins are most likely to occur in urban areas.
- Indicator 5: Understand differences in pangolin needs at different life stages and for different sexes.

Project Summary

Feasibility: In August 2014, the Singapore Pangolin Working Group (SPWG) was established to better coordinate local conservation, research and outreach efforts for pangolins in Singapore. SPWG includes varied stakeholders such as Animal Concerns Research and Education Society (ACRES), Agri-food and Veterinary Authority (AVA), Conservation International (CI), Lee Kong Chian Natural History Museum (LKCNHM), National Parks Board (NParks), Singapore Nature Society (NSS), The Pangolin Story, Wildlife Conservation Society (WCS) and Wildlife Reserves Singapore (WRS). Stakeholders discuss pangolin conservation needs and in 2014 it was decided that pangolin rescue, rehabilitation and release would be a priority action for Singapore. Approximately 11,000 ha of Singapore's nature reserves and other greens spaces are managed by NParks, with less than 0.3 ha consisting of remaining primary rainforest. Pangolins have adapted to live in secondary forest and other semi-urban habitats.

Implementation: A 24 hour wildlife rescue hotline operated by ACRES allows us to respond to calls within an hour. The number of calls for pangolins ranges from 1 - 6 calls/month. If ACRES judges that a pangolin is safe for immediate release, the pangolin will be translocated to a safe area. However, if the pangolin is unfit for release, e.g. suffering from severe dog bites, infected wounds, broken limbs, general weakness, or is too young for release, then the animal is transported to WRS Wildlife Healthcare and Research Centre for veterinary treatment and rehabilitation. The veterinarians at WRS aim to minimize any time that a pangolin spends in captivity. Typically rescued pangolins are initially fed with ant eggs and most rescued pangolins usually recover within 1 - 2 days. However, some individuals require extra care, especially if they are young and still require to be hand fed, and are thus only released after several months of care and soft release procedures.

Post-release monitoring: Post-release monitoring began in March 2016 and to date nine pangolins have been tagged and monitored. Eligibility for tagging is determined by age and size, as most juvenile pangolins have hind scales that are too small to accommodate the tag attachment. In 2016 to 2017, we were still very limited by tracking technology. Conventional tagging methods such as collars, backpacks, or adhesives, are less successful for the Sunda pangolin, which has

Releasing pangolin in the forest
© David Tan, WRS

both subterranean and arboreal habits. Two holes are drilled into a pangolin hind scale and the tag is attached using fishing wire or metal bolts. In Singapore the majority of pangolin rescues are small juveniles (<3 kg). Our initial trials with VHF tags (Biotrack 20 g with activity sensing) snapped the juvenile pangolin scale and tags were dislodged within 1 - 2 weeks. Tags were also easily dislodged by adult pangolins (average female 4.5 kg, average male 8 kg). We requested smaller VHF tags 15 g from Biotrack with the cost of reduction in battery life, and tagged only larger pangolins with larger, thicker scales, which effectively means only sub-adult to adults. Of the five larger rescues (3.5 kg - 10.4 kg), the most successful has been the largest male (10.4 kg) that was tracked over two weeks until he moved out of range of our receiver. Its tag was later dislodged and found in dense undergrowth of a roadside verge. He was re-rescued four months afterwards in the same urban area. His weight was stable (9.8 kg) and the veterinarians confirmed that he was healthy. This time he was translocated further into the nature reserve but was still found to live alongside roads and other urban structures within the reserve. He moved out of range within three weeks. For future post-release monitoring efforts, we hope to deploy solar powered GPS tags which weigh only 2 g. We hope this reduction in tag size and the use of GPS will allow us to make further progress with post-release monitoring of pangolins.

Major difficulties faced

- Post-release monitoring was often hindered by problems with device attachment. The transmitters either break or get dislodged.
- The transmission range of radio tags can be very limited (<100 m) when pangolins are underground or when the signal is blocked by rocks or dense vegetation.
- Difficulty in feeding of hand-reared young during the transition from milk-to-solids stage as they are unable to feed and ingest independently. In some cases, care-takers have had to resort to force-feeding and those individuals continue to remain in captivity.
- Pangolins are strictly nocturnal animals; and thus through-the-night volunteer manpower for surveys and focal observations is scarce.

Major lessons learned

- Rescue, rehabilitation and release requires the input of many varied stakeholders, both governmental and non-governmental, setting up an

Pangolin project team © David Tan, WRS

inclusive local working group who meet throughout the year will help to facilitate the full process.

- Pangolin rescues can happen at any time. As such, a dedicated support team is necessary to facilitate rescue and release any day of the year, 24 hours a day.
- Animals that are not eating well in captivity appear to have a lower chance of survival post-release; thus in some cases it may be better to release the animal before their full recovery from injuries so that they can forage and have a higher chance of survival.
- Collaboration with external partners is essential to make use of cutting-edge technology, such as the development of custom-made tracking devices. Expect to modify your post-release monitoring tools with technological advancement and innovation.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Lack of knowledge about pangolin ecology, nutrition and pathology explains the slow progress in developing a comprehensive rehabilitation and release plan.
- The rehabilitation and release program is still in its nascent stages, with young (abandoned) individuals successfully surviving in captivity but not necessarily equipped and ready for reintroduction.
- Few recaptures: only two out of nine translocated pangolins. This could be either a sign of success - perhaps a pangolin once captured might never venture out to hazardous areas again - or failure - high mortality rate after capture and reintroduction.
- The lack of suitable tracking tags for post-release monitoring. They should ideally have GPS and VHF functions to maximize our understanding about pangolin behavior and ecology.
- The reliance on the continued support of volunteers and members of the working group, in terms of time and funds.

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Reintroduction of the Eurasian red squirrel into two urban parks in Portugal

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Introduction

The Eurasian red squirrel (ERS) (*Sciurus vulgaris*) (Rodentia, Sciuridae) is widely distributed in the Eurasia. As a forest-living species it occurs mostly in coniferous and mixed-deciduous forests. Although abundant throughout most of its range, there have been well-documented population declines and range contractions in several countries (Bosch & Lurz, 2012). During the 16th century, the combination of intense farming and tree logging for the naval industry resulted in habitat destruction and fragmentation, leading to the decline and extinction of ERS in Portugal (Mathias & Gurnell, 1998). Following an absence of almost four centuries, the ERS has recolonized and expanded its distribution in northern and central parts of the country, since the 1980s (Mathias & Gurnell, 1998). Despite apparent good dispersal capabilities of the ERS, human activities such as tree logging, roads expansion, hunting, and wildfires might reduce habitat availability and suitability for this species. The ERS is classified as Least Concern by IUCN (Shar *et al.*, 2016). However, due to population declines, conservation status varies according to regional and national laws, being under protection in countries such as Germany, Switzerland, France, Belgium, Italy and Great Britain (Bosch & Lurz, 2012). In Portugal, the ERS was previously classified as Rare but recent range expansion in the country supported its current classification as Least Concern (Cabral *et al.*, 2005).

Eurasian red squirrel © Bianca Vieira

Goals

- Goal 1: Reintroduction of ERS to urban parks inside the species' distribution.
- Goal 2: Improvement of parks' aesthetic appeal and environmental

education, facilitating the opportunity of people observing and sharing the urban area with the ERS.

- Goal 3: Persistence of population at the parks where the ERS was introduced.
- Goal 4: Identification of main resources used by the reintroduced ERS at the urban parks.

Success Indicators

- Indicator 1: Abundance of individuals at each park similar or higher to the number of reintroduced individuals 20 years after the first reintroduction.
- Indicator 2: Awareness about the conservation of ERS and associated forests.
- Indicator 3: Enjoyment of people with the presence of ERS in the urban parks.
- Indicator 4: List of resources used and key procedures that make ERS' population viable at the urban parks.

Project Summary

Feasibility: Isolated reintroductions of ERS took place at two urban parks in Portugal: The Botanic Garden of the University of Coimbra (JBUC) and *Parque Biológico de Gaia* (PBG). These reintroductions occurred in the 1990s, but monitoring to understand population dynamics and abundance occurred only 20 years later (Vieira *et al.*, 2015). Interactions of humans and wildlife in urban parks are common in Europe, being considered an important tool of environmental education by urban park managers and other stakeholders. The managers of JBUC and PBG believed the presence of native squirrels enhances the aesthetic appeal of the urban parks and attracts visitors to observe and interact with fauna. Indeed, the ERS is a charismatic and attractive species, being well accepted and highly appreciated by humans. Although absent from Portugal during almost four centuries, reforestation programs in the 1980s favor ERS recolonization of the country (Mathias & Gurnell, 1998). Additionally, ERS do occur in isolated urban parks and its populations thrive in fragmented habitats if resources are available and some degree of connectivity exists (Bosch & Lurz, 2012).

Implementation: In the 1990s, there were two isolated initiatives to reintroduce the ERS at the JBUC and the PBG. Although there was an ancient record of ERS in Portugal, its previous distribution and genetic connectivity between populations were not fully understood. The JBUC released 12 squirrels from Madrid in Spain in 1994. Supplementary feeding was provided only during the first year. The perception of the explosion of ERS population at the park by managers was considered an indicator of success, and population support was terminated. In 1997, the PBG released 12 squirrels from Azé in France. This reintroduction was followed by three reinforcements with a total of 40 pairs not only from Azé but also from Epe in Netherlands, which occurred between 1998 and 2001. Supplementary feeding was continuously provided through bird feeders, and this population had full-term veterinary support, through a wildlife rehabilitation center located therein. Both initiatives acquired the ERS individuals from commercial creators with proper licenses and veterinary support controlling for diseases and parasites.

Post-release monitoring: Both reintroductions lacked continuous monitoring. In 2013, around 15 to 20 years later, a post-release evaluation was conducted using transects to count individuals, parcels to assess food sources,

Overview of release site © Bianca Vieira

and surveys with people to evaluate people's general feelings about the ERS. After the mentioned perception of explosion in population at JBUC, there was a decrease of ERS individuals, with an estimated abundance of two remaining individuals 20 years after the reintroduction. On the hand, the PBG has a stable population counting around 47 individuals 15 years after the initiative. While in the JBUC the main available food sources were 70% of mushrooms and fruits of *Pinus pinea*, *Quercus robur*, and *Celtis australis*; in the PBG main food sources were only 16% of mushroom and fruits of *Q. robur*, *C. sativa*, and *P. pinaster*. The estimated energetic content of food sources at the JBUC was twice higher than at the PBG however the PBG counted with continuous supplementary feeding (Vieira *et al.*, 2015). In both parks, the ERS selected mostly forest patches dominated by *Quercus robur* to place dreys. Awareness and enjoyment of people with the ERS at the urban parks could not be directly measured due to limitation in time however managers were both satisfied with the presence and numbers of ERS at the sites. Squirrels were found in other localities nearby and road kill was reported in both places. These results indicate reintroductions for aesthetic and leisure purposes have significant effects on wildlife management and conservation. Although guidelines exist for reintroductions focusing on conservation and management, other initiatives concerning reallocation and settlement of wildlife populations should also follow standardized international guidelines, regulations and monitoring.

Major difficulties faced

- The high costs of keeping long-term monitoring and supplementary food.
- Lack of genetic comparison between donor populations from Spain, France and Netherlands, and naturally expanding populations in Portugal
- Mitigating and preventing road kill in the nearby areas.
- Lack of systematic monitoring and proper data collection instead of manager's general impressions.
- Costs and logistics monitoring dispersion of reintroduced individuals.

Major lessons learned

- Reintroductions focusing on aesthetic and environmental education purposes help awareness and conservation of species.
- Reintroductions focusing on aesthetic and environmental education purposes also need proper regulation following basic principles from reintroductions focusing on conservation.

- Need to account for road kill and uncontrolled dispersion of populations before reintroduction.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- ERS's populations are still present in both urban parks 15 to 20 years after the reintroductions.
- However, these local populations seem to be decreasing.
- Active adaptive management is necessary to improve the current deficiencies in post-release actions such as monitoring health and abundance.

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Water vole reintroduction on the Gwent Levels, Wales, UK

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Introduction

The European water vole (*Arvicola amphibius*) is a semi-aquatic member of the Rodent family. They are vegetarian and inhabit watercourses ranging from rivers and lakes to ditches and ponds. They build complex burrow systems within the banks of watercourses and act as ecosystem engineers, creating niche habitats for other species to live. In Britain, water voles are protected under the Wildlife and Countryside Act 1981 (as amended). They are in decline in the UK and are classed as a Priority Species in the UK Biodiversity Action Plan. The Gwent Levels is a south Wales estuarine landscape, rich in both historical and natural heritage. It sits in the southeast corner of Wales on the north side of the Severn estuary between Cardiff in the west and Chepstow in the east. Gwent Wildlife Trust's nature reserve Magor Marsh is where the water voles were released, and is the last relatively natural area of fenland on the Gwent Levels.

Goals

- Goal 1: The establishment of a successful American mink control network on the Gwent Levels.
- Goal 2: The restoration of a viable water vole meta-population on the Gwent Levels.

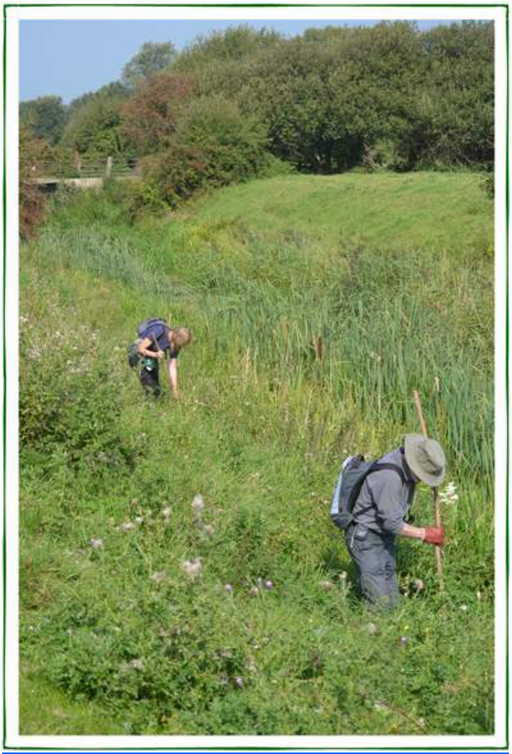
Success Indicators

- Indicator 1: Water voles spread from release site into wider landscape.
- Indicator 2: The resident American mink population is reduced or removed.

European water vole © Andy Karran

Project Summary

Feasibility: Water voles were once an intrinsic part of the Gwent Levels. The introduction of the invasive non-native American mink (*Neovison vison*) in the 1950s onwards meant the population crashed, as reflected across the UK. In 2011, Gwent Wildlife Trust conducted a pilot project to assess feasibility for a water vole reintroduction at Magor Marsh Nature Reserve. We ascertained that the most recent record of a water vole in the area was 2003 and despite yearly surveys, no other records were found since. Desk studies also revealed no likely nearby populations. Since 2006 American mink control had been happening on our Magor Marsh Nature Reserve on the Gwent Levels. With large areas of suitable habitat available, American mink were certainly the cause of the decline in water voles in the area. Magor Marsh is a Site of Special Scientific Interest and we have been managing it in favor of wildlife for over 55 years. We have approximately 4.5 km of suitable ditches at Magor Marsh with more suitable habitat in the area around the reserve. We also made sure there were sufficient animals available for us to release from the breeding facility. All of these points gave us confidence that Magor Marsh was an extremely suitable reintroduction site for water voles.



Water vole survey © David Lucas

Implementation: Gwent Wildlife Trust already had an established American mink trapping program at Magor Marsh Nature Reserve. In 2011 - 2012, we extended the trapping to a wider area around the reserve. This not only caught animals in a wider area but also served as an early warning or surveillance system so we could quickly detect any new mink who entered the zone before they reached Magor Marsh. This proved successful and so in 2013 we released over 200 water voles on to Magor Marsh Reserve. These were captive-bred animals who had been properly health screened before release. We were also certain that the animals were of genetic stock suitable to lowland conditions (as opposed to water voles from the highlands). We used a soft release method to gently introduce them to their new surroundings. We released water voles in several stages, to mimic the natural colonization of the area.

Post-release monitoring: Gwent Wildlife Trust survey the same 10 ditches twice a year on Magor Marsh Reserve to monitor the population. We follow the standard methodology found in The Water Vole Handbook (Strachan *et al.*, 2011) and survey 200 m of each ditch to search for water vole field signs including burrows, droppings, feeding remains such as chewed grass, and the animals themselves. Our monitoring shows the water voles are thriving. Surveys completed in areas around Magor Marsh in the wider landscape show the water voles have spread over 10 km away. We continue to trap and monitor for mink, and these show that the mink have remained at low density. It is likely we have eradicated the resident population and are now only seeing migrating individuals coming in from other areas.

Major difficulties faced

- Demonstrating the importance of American mink control to counter the negative perception some members of the public have.

Major lessons learned

- Success depends on high input from volunteers to monitor for mink and help us complete water vole surveys.
- Success depends on setting up an American mink control program well before water voles are released, with proven evidence that mink numbers are low.
- American mink control is an on-going commitment, anyone undertaking a water vole release will need to commit to long-term mink control.
- Success depends on having enough suitable habitat available with good connectivity to other good habitat elsewhere. This enables the establishment of a large robust meta-population which is better able to withstand localized extinction events (such as flooding).

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The water voles have established a thriving population within Magor Marsh and also throughout the wider landscape around the reserve leading to a resilient meta-population.
- We have engaged with several different partners which has led to a larger Landscape Scale partnership looking at diverse ecological issues across the Gwent Levels.
- We have successfully engaged with and educated lots of different people in wildlife and water voles helping protect wildlife for the future.
- We prepared for the reintroduction for several years, establishing a good mink control program well in advance.

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Pilot pine marten reinforcement in mid-Wales, UK

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Introduction

The pine marten (*Martes martes*), occurs throughout most of continental Europe, Asia Minor, northern Iraq and Iran, the Caucasus and in westernmost parts of Asian Russia. It is classified by the IUCN as Least Concern but is listed as a protected species in Appendix III of the 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats. The pine marten is also included in Annex V of the European Community's Habitat and Species Directive of 1992, so that taking in the wild and exploitation of the species may be subject to management measures. In the UK, the pine marten is protected under Schedule 5 of the Wildlife and Countryside Act and listed as a UK Biodiversity Action Plan Priority Species. Pine martens were formerly widespread in Britain; however, in the 19th century, persecution resulted in their eradication from most of southern Britain. Remnant populations were restricted to north-west Scotland and isolated parts of northern England and Wales. Since the mid-20th century, the population in Scotland has expanded south and eastwards, but in England and Wales numbers were so low that recovery is unlikely without intervention. This intervention has started in Wales with a closely monitored, pilot reinforcement.

Goals

- Goal 1: Increase numbers and genetic diversity to prevent extinction and restore a viable population of pine martens to Wales.
- Goal 2: Establish a community-wide level of support for the project and a sense of community ownership of the Welsh pine marten population.
- Goal 3: Long-term persistence and expansion of the pine marten population in Wales.
- Goal 4: To develop a robust, transferable protocol for pine marten translocations.

Success Indicators

- Indicator 1: *Initial success (1 - 2 years)*- Translocation and release of a minimum of 30 - 40 adult pine martens over two years with no loss or injury. Stable home ranges established and overall annual survival rates of at least 70%.

Pine marten with radio-collar © Nick Upton

Pine marten release site © Henry Schofield

- Indicator 2: *Initial success (1 - 2 years)* - Evidence of successful breeding by some translocated females in the first year following release, and survival of site-native young.
- Indicator 3: *(Short-term)* - Establishment of site-native population and production of second generation animals.
- Indicator 4: *(Long-term)* - Increase in pine marten population size in release area over 10 years, subsequent colonisation of surrounding suitable habitat and population spread.
- Indicator 5: Wide scale involvement of local community in helping to monitor the pine marten population.

Project Summary

Feasibility: Although recovering in Scotland, there is consensus that in England and Wales pine marten numbers are so low that the species is almost extinct. So, in 2014, The Vincent Wildlife Trust's Pine Marten Recovery Project began. Habitat modelling identified potential reinforcement regions, where reports of recent sightings and other evidence suggested pine martens were still present albeit in extremely low numbers. Analyses were carried out of variables likely to impact on establishment and spread, such as woodland patch size, connectivity and prey availability. The results of the feasibility study suggested that the large expanse of well-connected woodland throughout the Cambrian Mountains in central Wales provides a suitable habitat network with the potential to support a viable pine marten population. Whilst a public opinion survey suggested that the majority of people would be in favour of action to prevent the pine marten from becoming extinct in Wales, detailed consultations with stakeholders and other land users in the area were also carried out in order to gauge local levels of support for the project and identify any specific issues.

Implementation: As part of the feasibility study and associated translocation plan, an assessment was made of the number, age class and sex ratio of individuals required to maximise the chances of the translocation achieving its goals. Capture methods, holding, transportation and release protocols were all designed to minimise stress to the animals and maintain the highest standards of animal welfare. A detailed disease risk analysis was also undertaken. In early September 2015, trapping began in a number of areas in Scotland selected as suitable donor sites. By this time, young of the year are independent and adults have mated. Post-translocation releases were carried out in autumn when food availability is high.

Captured animals were initially evaluated in the trap and suitable candidates for translocation were taken to a nearby mobile veterinary unit. Here the pine martens were anaesthetised by a wildlife veterinarian, given a full health check and samples were taken for further screening and surveillance. Animals not suitable for translocation (not of breeding age or a surplus of either sex) were released at their capture site after recovery. Pine martens selected for translocation were microchipped, the throat patch photographed for subsequent visual identification and a hair sample taken for genotyping. All animals were fitted with a radio-collar incorporating a mortality sensor to monitor post-release survival. Larger animals were also fitted with a GPS logger to gather more detailed movement data. Combined collar/transmitter weights did not exceed 5% of the weight of the animal. Once the animals had fully recovered, they were transported to the release area overnight by road in a modified vehicle.

Pine martens were soft-released, as it is suggested that this can minimise the distances travelled following release. Large (3.6 m x 2.3 m x 2 m), temporary, pre-release pens were constructed at release sites by staff from Chester Zoo, one of the project partners. Animals were held for a maximum of seven nights, during which time they were monitored remotely by camera for any visible signs of stress, Each pen held only one animal, and pens were located so that each male's pen was within 500 m of a female but at least 2 km from the nearest male. Following release, supplementary food was provided at each site for between 2 - 6 weeks, as long as it continued to be taken.

Twenty pine martens (10 males & 10 females) were translocated from Scotland to mid-Wales and released in autumn 2015, with a further 10 males and 9 females in autumn 2016 and a final 8 males and 4 females in autumn 2017.

Post-release monitoring: Following release, all of the animals were intensively radio-tracked until they had established home ranges, after which they were located daily and then weekly. From the following March onwards, there is a further period of intensive radio-tracking to locate denning sites of breeding females. Hair tubes and camera traps are also used to monitor breeding success. In the first year, we were able to confirm that at least four females successfully reared kits. At least three females from the second year of releases have also been confirmed as having bred so far. Pine martens are re-captured approximately 10 - 12 months after release to remove radio collars and check the animals. So far, all have been in good condition at re-capture. Mortality is monitored and carcasses are retrieved immediately and sent for post-mortem examination as part of an ongoing health surveillance program. Research is key to improving the science of reintroductions and translocations. The VWT, in partnership with the University of Exeter, has a rigorous program of research associated with the Pine Marten Recovery Project. This is focussed not only on the ecology of the translocated animals, but also on other species at the release sites as well as the socio-economic impacts of the project.

Major difficulties faced

- The terrain in the release area, coupled with the distances travelled by some animals made radio-tracking challenging, and the GPS equipment often failed to get fixes in the dense forest habitat and deep valleys that pine martens utilise.

Pine marten project team

- Pine martens have a low reproductive rate: females do not breed until their third year and then will only have a maximum of one litter per year, usually of 1 - 3 kits. Therefore, population growth is slow and increase and expansion will take many years. This requires a long-term commitment to monitoring and management to ensure success.
- Some land managers were apprehensive about having another UK protected species present and the possible restrictions that will impose on what they can do on their land. By providing information about pine marten ecology, and supporting land managers with practical help and advice, we have been able to allay many of their concerns.
- Changing the negative perception of predators among some sectors remains challenging.

Major lessons learned

- Establishing support for the project from a wide spread of sectors across the community at the earliest stages was key.
- Thorough research and meticulous planning are vital, but adaptive management is also necessary.
- GPS technology for relatively small, forest-dwelling mammals is still in its infancy.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Short-term success criteria have all been met, however it will be at least another 15 years before the long-term goals are achieved and it can be judged a complete success.
- Extensive, ongoing community and local volunteer involvement in the project from the pre-planning stage was key to the initial success of the project. This began very locally with face-to-face contact with adjoining landowners and residents in the release area, and was expanded out from there. Communication and open dialogue with other land users in the area,

particularly those with conflicting views, in order to address and resolve any areas of real or perceived conflict before they arise. Continued dialogue with all sectors of the community is likely to be important to the project's long-term success.

- Allowing sufficient time and resources for detailed preparation and planning. However, it is also essential not to stick rigidly to those plans but continually review the process and have the flexibility to adapt and improve or refine protocols as the project proceeds.
- Ensuring sufficient funding, personnel and number of donor animals as well as a long-term commitment to the success of the project.
- Partnership working with a multidisciplinary team of scientists, wildlife veterinarians and land managers. Having a long-term research and monitoring program and a staged exit strategy with the goal of local "ownership" of the project.

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Conservation, propagation and reintroduction of two-colored cymbidium orchid in Singapore

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Introduction

Cymbidium bicolor subsp. *pubescens* (Lindl.) Du Puy & P.J.Cribb, this species has long leathery leaves, up to 45 cm long and 1.5 cm wide. Each pendulous inflorescence is not more than 25 cm long with several flowers, each measuring 2.5 to 3 cm in diameter. All floral parts are dark purple brown with a cream yellow margins. The lip has some hairs especially near the base of the mid-lobe. The species is also found in Borneo, Java, Peninsular Malaysia, the Philippines, Sumatra and Sulawesi. In 2000, *Cymbidium bicolor* spp. *pubescens* was rediscovered in Sungei Buloh Wetland Reserve. Before that, it was presumed nationally extinct. It was last collected in Sungei Buloh in 1891 by Mr. H. N. Ridley. The survival of the species over the past 100 years in its natural habitat shows that wild orchid species can still be found in spite of habitat loss. Before our reintroduction effort, there was only one plant left in Singapore. Fortunately, plants have been raised successfully from seeds collected from this plant. Many reintroduced seedlings have flowered.

A flowering two-colored cymbidium orchid

Goals

- Goal 1: To conserve the species by raising seedlings from seeds.
- Goal 2: To reintroduce the seedlings to its natural habitat, parks and roadside trees.
- Goal 3: To monitor the growth of reintroduced plants.

Success Indicators

- Indicator 1: To propagate the species from seeds effectively.
- Indicator 2: To ensure the species are reintroduced successfully into the natural habitats, parks and roadside trees.
- Indicator 3: To ensure the reintroduced plants continue to survive after the reintroduction.
- Indicator 4: To find out the best conditions for reintroduction.

Project Summary

Propagation

Seedlings culture - Propagation of seeds is the most effective way to conserve orchid species. In nature, most orchids are pollinated by insects, which results in the production of genetically-diverse seeds suitable for conservation. In cultivation, genetic diversity can be achieved through manual propagation. A modified KC medium (Arditti, 1977) is used for the germination of seeds; once germinated, seedlings are transferred to a second medium which is essentially the same KC medium except for the addition of 100 g of banana homogenate. Chemical components and organic additives of the medium are added to water. The mixture is heated while stirring to dissolve the agar and 50 ml of medium is dispensed into 250 ml culture flasks. All media are sterilized by heating in an autoclave to 121°C at 1.06 kg cm^{-2} for 20 minutes. Water which will be needed in subsequent steps can also be sterilized by autoclaving, or in a pressure cooker. Flasks which contain seeds are maintained at 25 ±1°C, and placed approximately 30 - 50 cm below two plant growth fluorescent tubes. Seedlings are transplanted twice in a second medium, until they grow to about six cm tall, which takes about 12 months. They are then ready to be transferred to the nursery.

Natural fruits on two-colored cymbidium orchid

Propagation of seedlings in nursery - When the seedlings reach about 6 cm, they are ready for transplanting into community pots. The seedlings should then be soaked or washed with lukewarm water until the agar has been removed, and then rinsed with a good fungicide. Seedlings should generally be planted in groups of about 30 into community pots, using small charcoal pieces and brick chips as a potting medium. Individual seedling of *Cymbidium bicolor* subsp. *pubescens* were planted on separate slabs of wood and grown in the nursery for 12 to 18 months; plants are ready for reintroduction when each seedling has 3 - 4 new shoots and a healthy root system.

Implementation:

Reintroduction - Cymbidium bicolor spp. *pubescens* is an epiphyte, the seedlings should be planted on trees.

Time of planting - The best time for planting tropical orchid seedlings is before or during the rainy season. In Singapore, the rainy season starts around October and lasts until January. Most of our plantings have been carried out from late September through November. Seedlings planted during these periods have established themselves quickly, producing new shoots and roots. Once the roots

Orchid growing on a rain tree

of epiphytic species have attached themselves to the bark of the host tree, they can absorb water and nutrients directly from the environment.

Host trees - Trees that support more epiphytes tend to be better hosts than those with fewer epiphytic plants, as their presence indicates that conditions are suitable for epiphytic species. Of all roadside trees that are suitable for epiphytes, the rain tree fosters the most luxuriant growth of epiphytic plants. The most common epiphyte found on rain trees is *Asplenium nidus* (bird's nest fern) and *Dendrobium crumenatum* is the most common orchid.

The seedlings were planted under the proper environmental conditions, for this species, they were planted on mature host trees with other epiphytes and with 30 - 50% shade. When a suitable tree has been selected as a host, slabs of wood with established seedlings were secured on tree trunks and/or branches with horticultural wires and/or nails. Seedlings were reintroduced first to Sungei Buloh in 2007. Other plants were subsequently planted at the Singapore Botanic Gardens, Telok Blangah Hill Park, Dairy Farm Nature Park, Sungei Buloh, MacRitchie Reservoir,Pulau Ubin, Holland Road and Napier Road.

Post-planting monitoring:
Growth of seedlings after reintroduction - More than 80% of the seedlings have done well in most areas. An exception is those planted on exposed areas of young mangrove trees at Sungei Buloh. More than 90% of the seedlings dehydrated and died. On the other hand 90% of the seedlings planted on trees near the Dairy Farm Nature Park Visitor Centre (less direct sunlight, the trees had more epiphytes) survived. Many reintroduced plants have flowered. Seed capsules form naturally have been collected, the seeds can be germinated successfully in the laboratory. Seedlings planted in locations with high relative humidity tend to survive better than those in dry areas. For example, among all of the selected planting locations, seedlings that have been planted at Kent Ridge Park, the location with the highest elevation and greatest exposure (to both sunlight and wind), have had the lowest survival rates. In contrast, orchids planted in humid forested areas, such as Central Catchment Nature Reserve, have grown well without any supplemental watering, even during drought periods. Seedlings are planted in partially-shaded areas, with at least 50% shade to prevent the plants from being scorched by the sun. The results can be seen in Table 1.

Table 1. Survival rate of reintroduced seedlings of *Cymbidium bicolor spp. pubescens* to various parts of Singapore		
Location	**Percentage of shade (%)**	**Level of Survival[2]**
Bukit Batok Nature Park	20 80	+ ++++
Central Catchment Nature Reserve	80	+++++
Dairy Farm Nature Reserve	80	+++++
Kent Ridge Park	20	-
Pasir Ris Park	20 80	- ++++
Sungei Buloh	20 70	+ ++++
[2] - Level of survival was represented by ranking: 0% survival (-), Up to 20% survival (+), 21-40% survival (++), 41-60% survival (+++), 61-80% survival (++++), 81-100% survival (+++++)		

Some of the reintroduced plants have grown for more than 10 years in various nature reserves, parks and on roadside trees. More than 80% of the plants planted under the optimal environmental conditions have survived, and many of them have flowered and fruited. Our hope is that these plants will be able to self-propagate by seed; in this way, our reintroductions can help to enrich the development of the ecosystems in which they have been planted. Their flowers may attract and support viable populations of pollinators, which may in turn allow the development of viable seeds. These seeds may be dispersed to nearby locations, and if mycorrhizal fungi are present, germination will be possible, allowing the recruitment of new native orchids into these habitats.

Major difficulties faced

- Seedlings planted at exposed areas did not survive.
- Some of the seedlings were removed by monkeys.

Major lessons learned

- The species prefers to grow in areas with at least 70% shade with high relative humidity.
- Trees that support more epiphytes tend to be better hosts than those with fewer epiphytic plants.
- The best time for planting is during the rainy season.

Orchid flowering at Sungei Buloh Wetland Reserve

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Seedlings were grown to a mature size in the nursery before reintroduction.
- Reintroduced plants were planted on the right host trees.
- Reintroduction were carried out just before or during the rainy reason to ensure the seedlings establish well after planting.
- More than 80% of the plants planted under the optimal environmental conditions have survived, and many of them have flowered and fruited.

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The reintroduction of *Primulina tabacum* Hance, a critically endangered endemic plant, in southern China

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Introduction

Primulina tabacum Hance is a calciphilous perennial herb belonging to the family Gesneriaceae. Its distribution is restricted to the entrances of karst cave drainages along the border between northern Guangdong and southern Hunan, China. *P. tabacum* is on the list of the 'First Class Protected Key Wild Plants of China', a legally binding national plant protection list issued in 1999. It is also on the funding priority list of 'Wild plants with extremely small populations in China' developed in 2012. *P. tabacum* relies on alkaline calciferous groundwater and grows in poor soils. Because of climate change and increasing anthropogenic disturbances, the population size of *P. tabacum* has drastically decreased during the past century. It is estimated that there are less than 10,000 individuals at the entrances to only eight karst caves in South China.

Goals

- Goal 1: Restore the populations of *P. tabacum* to a healthy state.
- Goal 2: Secure habitat protection.
- Goal 3: Facilitate propagation for commercial use.

Success Indicators

- Indicator 1: Establishment of reintroduced *P. tabacum* individuals to the cave entrances where the species were historically present.
- Indicator 2: The reintroduced plants can produce offspring.

Primulina tabacum **Hance**


Surveying the reintroduced plants

- Indicator 3: Establishment of *in vitro* propagation and plant regeneration system using biotechnology.

Project Summary

Feasibility: Successful reintroduction requires knowledge about the distribution, taxonomy, reproductive biology, demography, horticulture, and ecology of the reintroduced species. We have studied the distribution, conservation status, ecological and biological characteristics, genetic diversity, and pollination biology including pollen morphology of *P. tabacum* since 2002. We established our intent to reintroduce *P. tabacum* to appropriate sites in 2002. We began by performing seed germination tests at the South China Botanical Garden during 2003 - 2006 to determine whether seeds could be used effectively for reintroduction, but no seeds germinated. However, we were successful in tissue culture and obtaining plantlets in 2007, which led to the reintroduction of *in vitro* propagated *P. tabacum* plantlets to the plant's historical and extant habitats.

Implementation: We used leaf explants from the *P. tabacum* population for tissue culture in January 2007 and obtained about 4,000 plantlets *in vitro* in July. We acclimatized these plantlets at the South China Botanical Garden on 25th September 2007. During the acclimation period, 7.2% of the plantlets died from desiccation. One thousand of the remaining plantlets were then transplanted into the caves at Dixiahe (25°1' N, 112°21'E), Lianzhou City, Guangdong, southern China, on 26th October 2007. At the time of transplanting, the plantlets were 1.5 ±0.1 cm in height and 3.0 ±1.0 cm × 3.5 ±1.0 cm in crown size. The transplants were watered on day one and day three. The planting quadrats were not fenced, fertilized, or mulched. In addition, we proposed successfully to the local government to establish a small natural reserve to conserve the remaining wild individuals in 2007. We also successfully established an *ex situ* collection in the experimental area of the nature reserve in 2010. We recommend continuing promotion of these propagation techniques in commercial horticultural use to alleviate wild collecting pressure.

Post-planting monitoring: After transplantation, we monitored the survival, height, and crown of all transplants, and examined the causes of death (i.e., insect defoliation, fungal decay, nutrient deficiency, lack of water, or strong radiation) from 2007 to 2012. The monitoring was carried out once per month during the first year and once per year thereafter. Micro-habitats and soils were also monitored every year. About 10% of the transplanted seedlings survived by 2012. Our field observations indicate that transplanted *P. tabacum* grew slower than wild *P. tabacum*. The transplanted *P. tabacum* performed especially well under the cover of the nursing moss, *Gymnostomiella longinervis* Broth. Positive interactions between species, i.e., nurse plant effects, are important for the reintroduction success.

Next generation of individuals

Major difficulties faced

- The local farmers and domestic animals unintentionally disturbed or sometimes destroyed the reintroduction sites.
- It will take a long time and large effort to survey the entire potential distribution range to locate any remaining populations in remote mountain areas

Major lessons learned

- Success depends on the close cooperation among all stake holders including farmers, scientists and the local government.
- It is essential to have an integrated species-recovery plan that includes patrolling to prevent plant removal, establishing an *ex situ* living collection that contains the entire wild genetic diversity, facilitating propagation for commercial use, and implementing reintroduction and augmentation to increase population number and size.
- The best way for the conservation of rare and endangered plant is *in situ* preservation, and reintroduction can be used to achieve this goal and function as a helpful tool to conserve biodiversity.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Moss is a key nurse plant for the reintroduction of *P. tabacum.*
- The use of innovative propagation methods and nurse plants can facilitate the reintroduction of rare and endangered herbs.

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Reintroduction and assisted colonization of Spicer's paphiopedilum in South China

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Introduction

Spicer's paphiopedilum (*Paphioepdilum spicerianum*) is found in Northeast India and Myanmar, and has been heavily harvested for its horticultural value. In China, only a single population of Spicer's paphiopedilum with 38 mature individuals was found in 2006 in the Pu'er Prefecture of Yunnan Province (Ye & Luo, 2006). These were sub-terrestrial plants that grow on steep river banks and their habitat is seriously threatened due to the surrounding monoculture of coffee plantations. This beautiful orchid flowers from the middle of October to the end of November and fruits mature in November in the following year. The natural fruit sets and seedlings were observed at the site. Spicer's Paphiopedilum is treated as a species of Wild Plants with Extremely Small Populations in China (PSESP; State Forestry Administration of China, 2012).

Based on the studies of pollination ecology, mycorrhizal fungi diversity (Jessie *et al.*, 2016), and *in vitro* seed germination (Chen *et al.*, 2015), 30 seedlings were reintroduced into original habitat in June 2015. As a comparison, another 30 seedlings were transplanted into TianZi Reserve at Bulangshan, which is near the border between China and Myanmar with an elevation of ~400 m higher than the original habitat.


Spicer's paphiopedilum

Goals

- Goal 1: Enhancement of the only existing population.
- Goal 2: Assisted colonization of a new population in higher elevation area.
- Goal 3: To assess the facts that may affect establishment of new populations.
- Goal 4: To assess the effects of pollinators and mycorrhizal fungi on assisted colonization population.

- Goal 5: To determine the key facts that affect long-term survival of the population.

Success Indicators

- Indicator 1: Spicer's paphiopedilum can associate with a wide range of orchid mycorrhizal fungal genera and is capable of utilizing different genera simultaneously.
- Indicator 2: The low specificity to mycorrhizal fungi in adult Spicer's paphiopedilum suggests that the choice of locations for new populations might be broader than initially anticipated.
- Indicator 3: Some co-flowering plants may have great impacts on reproductive success of Spicer's paphiopedilum
- Indicator 4: As one of PSESP species, conservation of Spicer's paphiopedilum attracted great attention both from local government and scientists.

Project Summary

Feasibility: The initial aim of this project was to enhance the only population of Spicer's paphiopedilum found in China, and to re-establish a new population at a higher elevation site. The species is of great importance to horticulture and ornamental plant breeders. The flowering plants could be occasionally found in local flower markets, but we did not know where the plants come from. It was said that there are several wild populations in different places on China side near Myanmar, but all had not been confirmed by field surveys or specimen collection records. This only clear population was found in the bank of a seasonally flooded small river which is near a newly established village. The habitat, a small remnant, is surrounded by coffee plantations and also seriously threatened by household garbage. The remaining plants might disappear due to flood or river-bank erosion. *In situ* conservation seems meaningless, but reintroduction near the original habitat and assisted colonization of a new population in higher elevation areas could be possible to protect this species.

Transplanting seedlings of Spicer's paphiopedilum at Tian Zi Reserve

Implementation: From 2010, we started to conduct the integrative conservation of Spicer's paphiopedilum, including *ex situ* conservation of living plants in Xishuangbanna Tropical Botanical Garden, seeds storage, developing a propagation system via *in vitro* seed germination, monitoring on population dynamic, studies on pollination ecology and mycorrhizal fungi diversity. Thousands of seedlings have been produced successfully and were ready for reintroduction in the beginning of 2015. Based on the studies of pollination ecology and mycorrhizal fungi diversity, we thought that the choice of locations for new populations might be broader than initially anticipated, but for the long-term maintenance of new populations, lack of pollinators might be a great limitation. Translocation of some co-flowering plants at the same time should be considered for the successful establishment of new populations of Spicer's paphiopedilum, especially for assisted colonization.

Transplanted plants two years later in June 2017

Post-planting monitoring: For the reintroduced plants in the original habitat, plants were monitored every three months by counting the living plants and assessing the plant growth status. The survival ratio was 40% (12 plants remained) after two years at June 2017, and many plants disappeared after the rainy season of 2016. For the transplanted plants in Tian Zi Reserve, plants have been managed regularly after planting, and were also monitored every three months by counting the living plants and assessing the plant growth status. The survival ratio was 80% (24 plants remained) after two years in June 2017. It is important to choose appropriate and safe sites for reintroduction and assisted colonization, and it is necessary to conduct regular management after seedlings are planted.

Major difficulties faced

- The original habitat is seriously threatened by many factors, and it is hard to establish a reintroduced population in original habitat.
- As a PSESP species, all seedlings come from just several mother plants, which may result in low genetic diversity of reintroduced and transplanted populations.
- For the assisted colonization out of original habitat, reproductive success may limited by lack of effective pollinators, and could be the major factor that limits potential for full recovery of a self-sustaining population.
- It is uncertain now if seeds could successfully germinate with compatible fungi for transplanted populations.
- Flowering, plants may also be collected by local people.

Major lessons learned

- Basic research such as seed storage, *in vitro* seed germination, monitoring on population dynamics, studies on pollination ecology and mycorrhizal fungi diversity are essential to conduct reintroduction or assisted colonization of endangered orchids.
- Sites selection is very important for future success of new population establishment.
- Regular management is necessary after seedlings are planted.
- Close cooperation with local natural reserves is important for success in the long-term.
- To establish a self-sustaining population, seedlings should be planted many times in different seasons.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- As a PSESP species, the integrative conservation of Spicer's paphiopedilum attracted great attention from government, conservation agencies and the general public.
- Spicer's paphiopedilum can adapt a broader range of mycorrhizal fungi environment.
- It may take many years to demonstrate, if the reintroduction or assisted colonization was fully successful, and the effective pollinators and compatible fungi for seeds germination would be key factors to establishment of a self-sustaining population.

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Reintroduction of *Delissea kauaiensis*, a critically endangered lobeliad, on Kauai, Hawaii, USA

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Introduction

Delissea kauaiensis Lammers is a small tree species in the Campanulaceae family. It is endemic to the island of Kauai in the Hawaiian Islands. In Hawaii, the Campanulaceae represents one of the largest adaptive radiations of species with over 159 endemic taxa recognized in this family. The Hawaiian Campanulaceae is becoming a case study in rare plant management, as over 60% of the taxa in the family are either extinct, endangered or threatened. *D. kauaiensis* was listed as endangered by the United States Fish and Wildlife Service and the State of Hawaii in 1996. It is Red Listed as Critically Endangered by the IUCN. *D. kauaiensis* is restricted to mesic forests in the north-west facing valleys of the island of Kauai. There are currently only seven mature, wild plants known of this species, scattered in four different locations. This project has attempted to establish new populations within the species' original geographic range. The project sites are within the Kuia Natural Area Reserve which is owned and managed by the state government for multiple uses, some of which conflict with conservation of the species. Several fenced exclosures that have been built provide protected areas against feral ungulates for reintroducing this species.

Goals

- Goal 1: Make seed collections of every mature, wild individual of *Delissea kauaiensis*.
- Goal 2: Secure *ex situ* collections of seeds in long-term storage at Lyon Arboretum and the National Tropical Botanical Garden.
- Goal 3: Establish new populations by reintroducing plants into five protected exclosures within the species' natural range.
- Goal 4: Include the maximum genetic diversity possible in each new population.

***Delissea kauaiensis* Lammers**

- Goal 5: Monitor reintroduction sites for threats, population structure, and project success.

Success Indicators

- Indicator 1: Every wild individual is represented in nurseries or seed banks.
- Indicator 2: Reintroduced populations will include a minimum of 50 individuals that are mature and reproductive at each of five sites.
- Indicator 3: Progeny from every wild individual is equally represented within each new population.
- Indicator 4: Seedling recruitment is observed at each of five sites.
- Indicator 5: Minimum of 25 mature, reproductive recruits are established at each of five sites.

Project Summary

Feasibility: *D. kauaiensis* has always been considered rare. Through habitat degradation by feral goats, deer and pigs, this species has been reduced to the seven mature individuals that are currently known. The largest wild site has only four mature individuals and each of the four sites occurs in a different valley making cross-pollination between sites highly unlikely. The state government mandate to manage the area as a multiuse space promotes the continuance of feral game for local hunters at the expense of protecting the wild plants. To address their responsibility to protect the native species, they have built five fenced exclosures around what is considered the best examples of native mesic forest in the reserve. The exclosures vary in size from 1.2 - 80 acres. The first was completed in 2009 and the last one was completed in 2013, but has not had all of its deer eradicated yet. Management of the exclosures includes removing all deer, pigs, and goats and performing invasive plant control. This project intends to establish a single population of the endangered *D. kauaiensis* in each of the five exclosures available. All mature wild individuals, or founders, will be represented in each of the new populations to maintain the maximum potential genetic diversity of the species. Very little research has been done with this species, so much of this project, such as site selection, was based on observations of the habitat where the current wild individuals are found. These sites may not be the ideal locations for the species, but rather are remnants where threats like goats cannot reach them.

Implementation: For the past nine years, the Hawaiian Plant Extinction Prevention Program has been monitoring, collecting from, and managing threats to the wild individuals of this species as well as surveying for more individuals. Two new sites were found during those surveys with single individuals at each site. Eight founders have been collected from, although not all of those founders are still alive today. Seed was both stored and propagated for every individual from which collections were made. In 2010, 124 individuals of *D. kauaiensis* representing a single founder were introduced into a fence exclosure. As propagules representing new founders were collected and grown, they were added to the sites and new sites were established in other exclosures. At present, there are three sites in three different exclosures. Over 500 plants have been planted out in total and seven founders are represented. Not all of the reintroduction sites have all of the founders represented yet, but as propagules of underrepresented founders become available for planting out, they are distributed

Steve Perlman collecting founder stock

between the sites to add genetic diversity. This project is on-going and two of the exclosures slated for reintroduction have not been planted in yet. One has not had all the animals removed yet and another is just awaiting the next batch of plants to be ready for planting.

Post-planting monitoring: Survival of *D. kauaiensis* has been greater than expected, but not all sites fared the same. Within one year of planting, we began to see mature *D. kauaiensis* flowering and fruiting abundantly at our first site. Within two years, we began to see seedlings recruiting into the site. So far these recruited individuals are not mature. At our second site, we had greater mortality, but still saw maturity in the planted individuals by the first year. So far no seedlings have recruited at that site. Our third site was just started in 2016, so it is too early to draw any conclusions about how it will fare. From our first two reintroduction sites, we have learned a few things that have influenced us in choosing our third site. While the wild plants occur in areas with thick canopy, in our reintroduction sites, the plants had better survival in areas that had less canopy cover. In our second site, we had much less survival than our first site and we believe that it was because we introduced those plants before all of the invasive plants had been removed. Removal of strawberry guava (*Psidium cattelianum*) was occurring simultaneously to the reintroduction rather than being completed before the reintroduction.

Major difficulties faced

- This project has been very slow to implement as we have been dependent on the timeline of exclosure construction by conservation partners, and the removal of feral animals and invasive plants before any reintroductions could take place.
- There is very little research that has been done on this species regarding environmental growing requirements, pollination ecology, or genetic diversity, so our decisions have been made with whatever information was available and have had to change as new information became apparent.
- As new individuals become mature or are found, additional collections have been required to have all mature wild individuals represented. We are continually adding more plants to our reintroduction sites to try to equalize under-represented founders.

Major lessons learned

- Using the current habitat of extremely rare species as a guide to choosing reintroduction sites can be misleading. We learned areas within our reintroduction site that had a dense canopy (>75% cover) like that of the wild plants' sites, actually experienced more mortality than the areas with a thinner canopy (25 - 75% cover).
- It is important that the invasive plant species *Psidium cattelianum* be removed prior to any reintroductions. Planting into an area where it was being removed at the same time as the introduction resulted in 19% greater mortality compared to an area where it had been removed prior to planting.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Seeds from every mature, wild individual have been collected and are represented in seed storage facilities.
- Only three of the five introduction sites have been planted into at the time of this article.
- Most, but not all, founders are represented at each site.
- One site has documented recruitment of seedlings, but these individuals are not reproductive yet. Some of the sites are still too new to expect recruitment at this time.

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Rescue and reintroduction of the endemic lily-flowered hibiscus in the Grande Montage Nature Reserve, Rodrigues, Mauritius

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Introduction

The lily-flowered hibiscus, locally known as 'mandrinette' (*Hibiscus liliiflorus*) (Cavanilles, 1787), is a small heterophyllous tree endemic to two Mascarenes islands namely Rodrigues, a 108 km^2 semi-autonomous state of the Republic of Mauritius, and La Réunion, a French overseas territory, where it is presumed extinct. In 1981, this species was feared to be extinct in Rodrigues too, when the last known individual died, in what is now the Grande Montagne Nature Reserve (GMNR). Fortunately, two more founder individuals were found in the wild in the Mourouk valley in 1983, and a third was discovered near Montagne Ursule in the 1990s. This species is currently listed as endangered by the IUCN (though this may warrant a review) and most individuals can be found on the plateau of the 13.8 ha GMNR. This protected area is located in a cool and humid zone and has been under active restoration by staff of the Rodrigues Regional Assembly (RRA) Forestry Service and of the Mauritian Wildlife Foundation (MWF) since it was declared a Nature Reserve in 1983 (Kirsakye, 2015).

Goals

- Goal 1: Save *H. liliiflorus* from extinction.
- Goal 2: Improve propagation success from cuttings and seeds in nurseries.
- Goal 3: Increase *H. liliiflorus* numbers reaching maturity in the GMNR.
- Goal 4: Understand the interactions of *H. liliiflorus* with other endemic and native plants.

Lily-flowered hibiscus locally known as 'mandrinette' © Vikash Tatayah

Success indicators

- Indicator 1: Number of wild found and wild reintroduced *H. liliiflorus.*
- Indicator 2: *H. liliiflorus* seedlings successfully propagated in the nursery.
- Indicator 3: Number of *H. liliiflorus* in the GMNR that exceed 10 years of age.
- Indicator 4: Better knowledge on the conditions preferred by *H. liliiflorus* to ensure maximum survival.

Project Summary

Feasibility: Founder *H. liliiflorus* plants were known to inhabit steep rocky hillsides in the valleys of Mourouk, Baie aux Huîtres and at Grande Montagne (Strahm, 1989); however, the cutting of trees for firewood, grazing by herbivores, wildfires and out-competition by invasive alien species has left Rodrigues as one of the most degraded islands in recorded history (Gade, 1985). Few relics of ancient forest remained in unfenced areas in Rodrigues, so saving *H. liliiflorus* required conservation actions in fenced areas, with the necessary environmental characteristics. The GMNR was considered an ideal location for a reintroduction given its protected status and since it contained several endemic species including one of the last known *H. liliiflorus* plants.

Implementation: Cuttings were taken from the last three remaining *H. liliiflorus* in Mourouk and Mount Ursule, and were used to produce clones planted by MWF and Forestry Service staff in 1996 - 1997, in a fenced gene bank, in Solitude. When these trees reached sufficient maturity, they were used as an additional source of cuttings. Once sexually mature, they were used as a source of seeds. In 2017, nine of these are still alive and in good health (average height 4.7 m, minimum 2.0 m, maximum 6.0 m). They continue to produce seed and provide cuttings. Throughout this time, cuttings and seeds were collected from the founder plants. One of the two founders located in the Mourouk Valley died in the late 1990s, but the other two are still alive and productive.

In 1999 and 2000, more individuals were propagated from cuttings and seeds from the three founders and planted on the plateau of the GMNR by the Forestry Service. In 2017, 18 of these remain (average height 2.6 m, minimum 1.6 m, maximum 4.0 m). Several additional individuals were planted in the same area by MWF between 1998 and 2003. Today, six are still alive (average height 2.2 m, minimum 1.0 m, maximum 3.0 m).

Reintroduction team in the field
© Vikash Tatayah

From this population of 36 individuals, seeds and cuttings were collected


Habitat restoration before out-planting
© Vikash Tatayah

and propagated by both MWF and Forestry Services staff since the mid-1990s and planted in the GMNR. Between 2008 and 2016, some 1,573 *H. liliiflorus* plants were propagated by MWF staff and planted in the GMNR. MWF only collects seeds from the nine founder clones in the gene bank, for fear of collecting hybrid seeds from *H. liliiflorus* pollinated by *H. rosa-sinensis*, an introduced ornamental species, present in the vicinity of the GMNR. The Forestry Service has propagated *H. liliiflorus* from the clones as well as from offspring in the GMNR.

Prior to planting in the GMNR, 80% of the exotic plant cover is cut or uprooted, stacked and left to decompose, contributing towards soil rehabilitation. The remaining 20% is left standing to shelter the young plants and prevent erosion during heavy rainfall. No less than 10 years after planting, when the endemic and native plants have grown sufficiently, the remaining 20% are cut. *H. liliiflorus* was planted in combination with another 44 native and endemic species, also propagated by the MWF and Forestry Service. Planting density has varied over the years, but has stabilised around 1 individual/m^2 for MWF plantations, and lower density and diversity for the Forestry Service. For MWF plantations, species selection within restoration plots is based on knowledge of species survival and growth during the first three years in different conditions.

Post-planting monitoring: The MWF has run a monitoring program for endemic and native species planted in the GMNR since the mid-1990s. This is carried out in 5 m^2 or 10 m^2 quadrats, assessing species survival, height, long and short-axis growth for three years after planting. Following this period, plants are revisited during maintenance where exotic plant regrowths are controlled, and when the remaining 20% of non-native species are removed. During the first three years of early growth of plants propagated by seedlings and cuttings, *H. liliiflorus* monitoring showed extremely low success rates; this has continued to be the case in plots restored more recently. We believe *H. liliiflorus* individuals planted together with other endemic and native species in high density have been outcompeted, leading to their death.

Considering that in the mid-1990s there were only four known *H. liliiflorus* individuals in Rodrigues, and that there are now at least 54 recorded mature flower and fruit-bearing *H. liliiflorus* individuals, we consider *H. liliiflorus* is no longer in immediate danger of extinction in the wild; however, continued restoration efforts are necessary.*H. liliiflorus* is planted as an ornamental in private yards and public grounds (these trees were not included in this account, especially as they may be in contact with introduced hibiscuses). *H. liliiflorus* is also conserved *ex situ*, e.g. in the Pamplemousses Botanical Garden in Mauritius and in the Waimea Botanical Garden in Hawaii.

Major difficulties faced

- The death of the GMNR founder plant was an unfortunate setback that may have led to the loss of its genetic diversity. Only a genetic study of the remaining clones can confirm if the genes of this individual have been saved, since we do not have comprehensive records on the clones still alive nor whether the Forestry Services may have cloned from this founder.
- Whilst concentrating on a few critically endangered species, it was possible to monitor these closely and achieve higher levels of success; however, when expanding the Rodrigues threatened endemic plant conservation program, less attention was devoted to certain species e.g. *H. liliiflorus.* As such, due to a long list of threatened species to conserve (>40), monitoring of *H. liliiflorus* lost central focus.
- The potential risk of hybridization of the endemic *H. liliiflorus* and the introduced Chinese hibiscus (*H. rosa-sinensis*), has prevented MWF from collecting seeds from the several individuals planted in the GMNR and other sites around Rodrigues.

Major lessons learned

- Planting in higher density has advantages for restoring habitats, however for a relatively slower-growing species such as *H. liliiflorus*, this led to high mortality rates which could have been avoided if monitoring had continued for longer than three years.
- Future planting of *H. liliiflorus* will include: 1) planting in more open spaces with fewer other endemic and native species in close proximity, 2) Controlling overgrowth from other endemic and native plant species currently growing in close proximity to live young *H. liliiflorus* individuals and 3) Monitoring *H. liliiflorus* more closely and beyond the usual three years.
- The importance of maintaining detailed records so that conservation efforts can be adequately evaluated decades down the line. In addition, a genetic study is underway to investigate if hybridization has occurred to plants growing in the wild and to what extent.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
The main reasons behind the success that resulted in a one order of magnitude increase in the population of *H. liliiflorus* present in the wild are:

- The collaborative effort between the RRA Forestry Services (Local Government) and the MWF (Non-Government Organisation).
- Full protection and supervision of the first *H. liliiflorus* clones in a fenced gene bank annexed to the MWF and Forestry Services endemic plant nurseries.

- The choice of a legally declared fenced Nature Reserve, affording the necessary protection to the second population of *H. liliiflorus* clones and offspring.
- Propagating *H. liliiflorus* from seeds originating from clones planted in close proximity to each other in the gene bank, to reduce the risk of hybridisation whilst increasing genetic diversity.

The main reasons that limited the increase in *H. liliiflorus* population currently present in the wild, to only one order of magnitude are:

- Reducing efforts and resources available specific to *H. liliiflorus* conservation, to conserve over 40 other endangered endemic species.
- Planting the slow growing *H. liliiflorus* within a high density of other faster growing endemic and native species.

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One year after the first reintroduction of the Malinverni's quillwort in the Ticino River Natural Park, Italy

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Introduction

The Malinverni's quillwort (*Isoëtes malinverniana* Ces. & De Not.), is an endemic aquatic pteridophyte occupying a very restricted range in the western Po Valley (Piedmont and Lombardy, Northern Italy). It occurs in lowland streams, channels and small river branches originally characterized by oligotrophic waters and the presence of *Fontinalis antipyretica* Hedw., an indicator of clean waters. Nowadays, most populations are found in a highly impacted area, well known for the production of rice. Major reasons for decline are the agricultural practices connected with rice cultivation, in particular, the use of fertilizers and herbicides that changed the water chemistry of the area from oligotrophic to meso- or eutrophic and the mechanized channel reshaping and cleaning (Abeli *et al.*, 2012; Barni *et al.*, 2013). *I. malinverniana* is included in annex II of the European Directive 92/43/EEC among the species requiring special areas of conservation and in annex I of the Bern Convention. Moreover, this species is listed as Critically Endangered in the Red List of the European Union and in the Red List of Italy for the strong range decline observed in the last 15 - 20 years (Minuzzo *et al.*, 2016). The project described represents the first reintroduction attempt for this species.

Reintroduced Malinverni's quillwort
© P. Cauzzi

Main Goals

- Goal 1: Investigate and define the threats affecting the species.
- Goal 2: Create an *ex situ* population to be used as a nursery for the final translocation in the wild.
- Goal 3: Establish some viable (self-sustaining) populations of the species in suitable areas within its native range.

Success Indicators

- Indicator 1: Threats affecting the species understood.

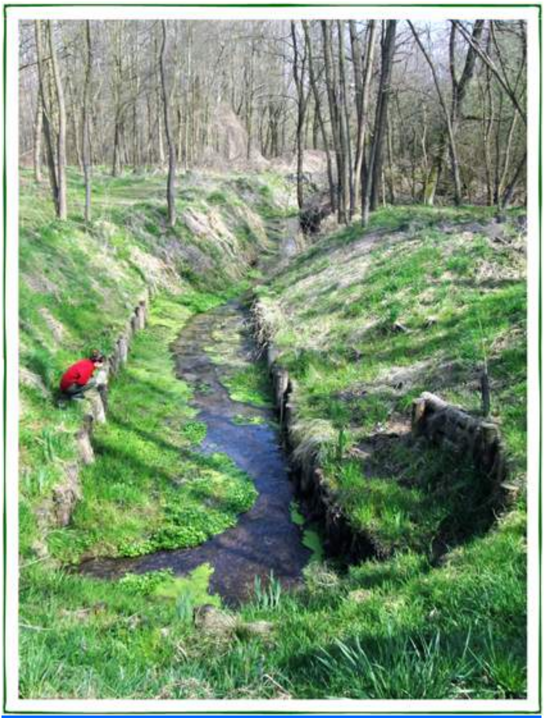
- Indicator 2: Establishment of a safety *ex situ* population of at least 300 plants from sexual reproduction.
- Indicator 3: Creation of at least two new populations of the species in suitable sites.

Project summary

Feasibility: Given the rapid decline in extent of occurrence recorded at the end of 2000s, conservationists realized that urgent conservation measures were needed for this species. The past species distribution was quite well known from 1960s and 1970s field survey. Recent (2007 - 2009) surveys revealed that the species was still growing only in nine sites (88% of its original range). However, knowledge on the species ecology and reproductive biology were scarce or lacking, preventing the realization of proper conservation actions. For this reason, since 2008, the species was the subject of several studies aimed at investigating the population genetics (Gentili *et al.*, 2010), the ecological requirements (Abeli *et al.*, 2012; Barni *et al.*, 2013) and the reproductive phenology (Abeli & Mucciarelli, 2010) of the target species. These studies made it possible to understand the reasons for the species decline. In particular, the ecological studies highlighted the negative effect of water eutrophication and channel management on the species survival. Moreover, data obtained during these studies were of key importance for the reintroduction project described here, and for future reintroductions. In particular, knowledge gained were useful to identify suitable release sites for the species and to develop a spore cultivation protocol for the *ex situ* propagation of the species.

Implementation: Genetic analyses performed on nine known populations revealed a moderate within-population genetic variation and a low between-population genetic differentiation, so *ex situ* propagation of the species was aimed at increasing the genetic variation by crossing male and female spores form different wild populations. A spring-fed artificial channel within a protected area (Parco Naturale della Valle del Ticino) was chosen as reintroduction site. This site was prepared for the reintroduction. In particular, the channel was reshaped and the spring (partially covered by soil and rotten vegetation) was restored, increasing the water flow. The water chemistry was not as good as in other pristine-like wild populations of the species, but the general conditions of the habitat were excellent (the channel crosses one of the few relict pristine *Alnus glutinosa* woodlands). Moreover, constant monitoring from the Park staff could be guaranteed. In spring 2016, 20 individuals of *I. malinverniana* were placed in the middle of the channel as a first trial. Further 20 individuals were transplanted in spring 2017.

Post-planting monitoring: The post-release monitoring is still active and consists of monthly visits to the reintroduction site. Variable collected are the mortality (18% after one year and including the 20 plants planted in 2017) and the length of the longest sporophyll in each plant as a measure of performance. Mortality was mainly due to anomalous sediment deposition on the plants. In autumn 2016, we checked for mature spores and we found that they were mature (grey) and ready for dispersal. A complete survey of the downstream sector of the channel in spring 2017 did not reveal any sporelings. So, one year after reintroduction we did not observe the second generation. For this reason, we can conclude that our translocation has been partially successful. It should be


Reintroduction site © T. Abeli

considered that the number of released plants was low and this likely affected the reproductive potential of the overall population (low probability of establishment). The monitoring activity will continue in the next years.

Major difficulties faced

- *Low number of individuals*: The low number of wild individuals prevented the identification of lethal thresholds for nutrients and pesticides through experimental manipulation. This also limited spore for *in vitro* fecundation and reproduction
- *Low growing rates*: Plants reproduced *in vitro* grew very slowly (about 8 - 9 months from spores to individuals of 8 - 10 cm). However, one year old plants can potentially reproduce.
- *Scarcity of suitable release sites*: based on the model developed by Abeli *et al.* (2012), an analysis of nine apparently pristine channels and streams revealed the none were suitable for the species.
- *Hydrological modification of the selected channel*: Changes in water speed and sediment accumulation threaten the reintroduced population. Constant monitoring and management are required. Further 20 individuals were released in early 2018 after sediment accumulation was halted.

Major lessons learned

- Although the success of a translocation is linked to the next generation establishment, the outcome of our project is encouraging and a key aspect of our success is the deep knowledge of the species developed with *ad hoc* studies.
- Constant monitoring is essential after transplanting to ensure rapid corrections should problem arise.
- Small-scale trials and gradual transplanting allow to highlight unforeseen problem and correct the project before the massive release of individuals.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- The reintroduced population is still alive and healthy one here after its release, yet sporelings were not observed.
- The reintroduced population require constant management and monitoring.
- A suitable site for a second reintroduction has not been found yet.

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Density as an important parameter for the success of the summer snowflake reintroduction in northern Italy

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Introduction

The summer snowflake (*Leucojum aestivum* L. subsp. *aestivum*), is a C-S-European/W-Asiatic wetland dependent plant, occurring in several lowland riparian plant communities, including *Alnus glutinosa* and *Salix alba* woodlands, reed and sedge communities (Parolo *et al.*, 2011). *L. aestivum* can be locally rare, especially in highly-impacted lowland areas (Parolo *et al.*, 2011). In these areas, the species is threatened, as other wetland species, by habitat fragmentation and destruction. Additionally, extreme climatic events, like extreme drought, negatively affect the species that require a minimum amount of water in the soil to grow (Parolo *et al.*, 2011). In Italy, *L. aestivum* subsp. *aestivum* is mainly distributed in the Po Valley, a highly populated and impacted area, due to agricultural and industrial activities. Here, *L. aestivum* occurs in several fragmented populations and threatened by the change in land use. *L. aestivum* is of conservation importance because it is a characteristic species of healthy *Alnus glutinosa* woodlands that represent a habitat of conservation priority for the European Union (Habitat 91E0 - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*).

Wild population of summer snowflake © T. Abeli

The project described here was part of a larger wetland restoration project involving the mid-course of Po River, near Parma (LIFE Pianura Parmense - LIFE07 NAT/ IT/000499) ended in 2012.

Main Goals

- Goal 1: Create two new self-sustaining populations of the species in a restored area.

- Goal 2: Investigate the role of pollination attraction on the reproductive performance of the new populations.

Success Indicators

- Indicator 1: Survival of planted individuals, in the short– and medium-term.
- Indicator 2: Observe new plants developed from seeds, in the long -term.

Reintroduction of summer snowflake
© T. Abeli

Project Summary

Feasibility: *L. aestivum* was well known from an ecological point of view, thanks to a study performed on 26 wild populations in the Po Valley (Parolo *et al.*, 2011). This study produced key information on the species general ecology, characteristics of microsite where it grows, germination requirements and pollination biology. On this last issue, Parolo *et al.* (2011) revealed some density dependent dynamics in the reproduction of the target species. In particular, the fruit set and the seed set increased with increasing population size and density.

Further analyses highlighted that pollinator attraction in this self-incompatible species is mainly visual as the flowers do not produce any volatile organic compound (Abeli *et al.*, 2016). For this reason, having the opportunity to create two new populations we decided to experimentally test the effect of density on the reproductive performance of two reintroduced populations.

Implementation: In order to reach the aforementioned goals, in 2011 we planted two populations of *L. aestivum* within the hunting reserve ''Fienile Vecchio''(Busseto) near Parma, differing in density (low and high). The two populations were structured as follow: 1) high-density population composed of 48 plants/m^2 (16 adults & 32 sub-adults). This density equaled the density of wild populations of in the same habitat as the release site (an ecotone between a *Salix alba* stand and a wet meadow); 2) low-density population composed of 24 plants/ m^2 (8 adults & 16 sub-adults). Only adult and sub-adult plants were used to maximize the survival rate. In fact, the use of young plants, often leads to high mortality rates after the translocation (Godefroid *et al.*, 2011).

Post-planting monitoring: The post-release monitoring lasted five years. During this period, we annually monitored the two populations. At each visit, we counted the total number of plants from which we derived the percentage mortality, the number of sub-adult plants that become adult flowering plants, the number of new developed seedlings, the number of fruiting plants and the number of fruits produced by each mature individual. The seed set (%) was computed only in 2015 to reduce the impact on the reproduction of the new populations just after the reintroduction. Seed set was estimated on two collected fruits per plot as the number of developed seeds divided by the total number of ovules. In the last monitoring year mortality was very low (2.8% and 3.5% in the high-density and low-density population, respectively) and seedlings were observed only in the high-density population. Because in the high-density population the number of fruiting plants and percentage fruit set were significantly higher than in the low-density population, we concluded that high-density stands attracted more pollinators, which in turn increased the chance of successful reproduction.

Major difficulties faced

- We did not face any specific problem. The species can be easily propagated *ex situ* from seeds and it is easy to grow and handle. On the other side, it is a slow-growing species requiring 4 - 5 years to grow from the seedling to the adult stage. Planting is facilitated by the fact the *L. aestivum* is a geophyte, so the bulbs can be buried at the beginning of the growing season (March) reducing the transportation and planting stress. From other experiences, we know that one of the major risks that may occur during the translocation of *L. aestivum* is a period of drought just after the release. In such cases abundant watering should be provided.

Major lessons learned

- Density other than population size should be taken into account when creating a new population.
- Facilitating the pollinator attraction increases the seed set and in turn the chance of a second generation.
- *Ad hoc* preliminary studies (ecology, pollination biology, etc.) on the target species increase the success of a translocation.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- *L. aestivum* is easy to reproduce and to grow *ex situ*.
- The microsite for reintroduction was carefully selected based on the ecological requirement of the species.
- Density-dependent population dynamics were properly considered, at least in one population.
- Monitoring and initial site management (mowing of the grassland) likely reduced the competition with other species.

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Supplementation of juniper on the Lizard Peninsula, Cornwall, UK

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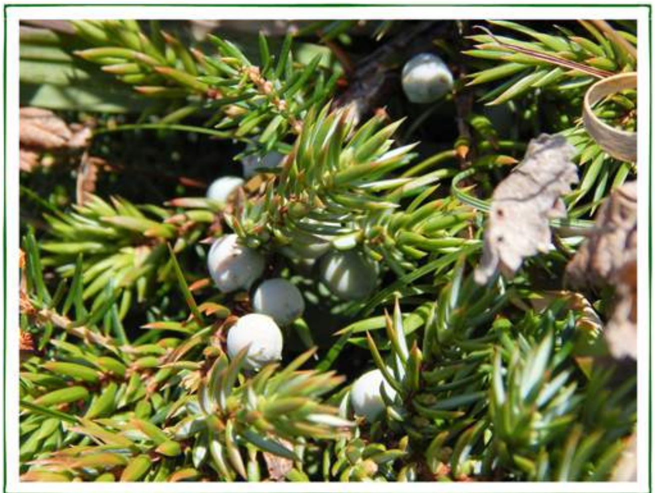
Introduction

Thirteen existing plants of *Juniperus communis* subsp. *hemisphaerica* remain on the Gew Graze Valley on the Lizard Peninsular in Cornwall in the south west of England. The sub species *hemisphaerica* is found in two locations on low maritime cliffs in the UK. The population in Cornwall was first recorded in 1871 where it grew in abundance; the status of the second population in Wales is unknown and unlocatable. The Cornish coastal habitat is identified as NVC: *Erica vagans - Ulex europaeus* Coastal Heath and *Erica vagans - Schoenus nigricans* Coastal Heath. The population in Cornwall has been greatly reduced and is now classified as critically endangered according to the IUCN Red Listing handbook and is also a BAP priority species. Four individuals of the Gew Graze population have been identified as female with six males and three plants unknown sex with no noted evidence of seed regeneration and seedling production on the studied sites.

Goals

- Goal 1: Maintain and monitor the 13 individual *Juniperus communis* subsp. *hemisphaerica* at Gew Graze Valley, Cornwall.
- Goal 2: Ascertain the fate of the previously introduced individuals of *Juniperus communis* subsp. *hemisphaerica* at Mullion Cliffs NNR.
- Goal 3: Establish an *ex situ* representative of each of the 13 surviving wild plants through propagation by cuttings.
- Goal 4: Produce a vegetative propagation protocol for *Juniperus communis* subsp. *hemisphaerica*.



Juniperus communis* subsp. *hemisphaerica

- Goal 5: Assess the feasibility of supplementing the existing population of *Juniperus communis* subsp. *hemisphaerica* on the Lizard Peninsula.


Monitoring juniper in the wild

Success Indicators

- Indicator 1: Presence of 13 individual *Juniperus communis* subsp. *hemisphaerica* at Gew Graze, annual reports on the health and growth of the plants.
- Indicator 2: Interview staff from the Lizard NNR and report findings.
- Indicator 3: Hold and maintain a representative *ex situ* population of the 13 plants from Gew Graze.
- Indicator 4: Produce and report propagation protocols for *Juniperus communis* subsp. *hemisphaerica.*
- Indicator 5: Identify a suitable planting site and propagate new plants from cuttings.

Project Summary

Feasibility: In 1874, the sub species of *Juniperus* was reported as widespread, but the population has been in severe decline. This is thought to have been due to wide spread fire and possible damage by grazing. The subsequent fragmentation of the male and female plants may have prevented natural regeneration, as well as an unfavorable habitat for regeneration. As the population ages the seed generation and viability reduces.

Implementation: Issues linked to supplementing the natural population include spread of plant diseases; *Phytophthora* is present in other wild populations of native species of *Juniperus* in Cornwall. Transplanting shock could be possible due to the change in growing medium from the peat free growing medium on the nursery to the acid heath land soil on the Lizard. Soils on the Lizards Peninsula are based on serpentine rock with low calcium and high magnesium levels. Grazing of newly planted small plants could be fatal; clearing of scrub may be needed to allow the *Juniperus* to establish. Management of accidental wild fires on the site will be needed, in the form of fire breaks. Maintaining an *ex situ* population of *Juniperus communis* subsp. *hemisphaerica* will also be needed to safeguard the taxon.

Post-planting monitoring: Mapping of the existing individual plants with GPS co-ordinates has taken place, these plants also have physical tags in the plants with accession numbers allocated to them and their position and health

Overview of juniper habitat

recorded on BG Base, the Eden Project's plant database. All the young 195 plants which were planted in to a new enclosure have also been accessioned and their parent plant information recorded.

The *in situ* population will be inspected twice a year, and the general health and size of the plants will be recorded. The general management of the heathland around the junipers will be discussed with the NNR staff and adjusted where needed. The newly planted young plants are fenced off to protect them from grazing, this will be removed once the plants have established.

The fruit production of the *in situ* and *ex situ* plants is recorded on an annual basis and a record of the number of seeds per fruit is also being kept. Germination tests are also being carried out on seeds that are collected, although as previously mentioned the germination time of this genus is known to be long. Once a sufficient number of seeds has been collected a representative sample of the population will be sent to the Millennium Seed Bank as part of the UK National Tree Seed Project.

Major difficulties faced

- Access to the *in situ* plants is difficult and not possible by vehicle.
- The small population has led to a genetic bottleneck.
- Germination time of the seeds of this genus is known to be two years.
- The seed viability appears to be very low, and has complex dormancy requirements.
- The limited resources of the project make locating any possible additional population on the Lizard Peninsula very difficult.

Major lessons learned

- Protection against fire is needed.
- Identification of genetically different plants is difficult in the field; propagation by cuttings alone has not increased genetic diversity.
- The number of seeds produced within each fruit is low, the complex dormancy and long germination periods mean seed regeneration is slow and has not yet been successful.
- Staff turnover has made detailed record keeping essential.
- Propagation by cuttings, following the propagation protocol, has been successful.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Propagation protocols have been produced.
- The existing population has been maintained.
- The existing population have been supplemented with younger potentially more fertile plants.
- The fencing around the *in situ* population has helped to maintain the population and the newly planted areas.
- The genetically diversity of the population has not been increased so far due to the reliance on vegetative propagation.

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First conservation translocation project of the East Asian trixspermum on Jeju Island, South Korea

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Introduction

East Asian thrixspermum (*Thrixspermum japonicum*) (Miq.) Rchb.f., is an evergreen epiphytic orchid, having stems pendulous with many nodes and dense leaves on branches and major habitats are located at forest margins along rivers or valleys (Chen *et al*., 1999). This epiphytic orchid is distributed in East Asia including Japan, China and Korea. In Korea, it is documented only on Jeju island, where its habitats are in an evergreen forest in the Donnaeko Valley in South region of Jeju Island at an altitude of 250 - 350 m a.s.l. (KNA, 2008; National Institute of Biological Resources, 2012; Lee, 2011). The wild populations of this species have a limited area of occupancy and extent of occurrence in Korea. The main threat to most of orchid in Korea is over-collection due to its ornamental value (Kim, 2016).

Although the remnant habitats of this species are located within the boundaries of the national park, the high demand for this species as an ornamental materials will remain as an ongoing potential threat. Because of this, it is under major pressure considering its extremely small area of occupancy. The estimated population size is less than 50 individuals in its habitats (National Institute of Biological Resources, 2012) and this was categorized as Critically Endangered in the national level of Korea (KNA, 2008) and has not yet been evaluated for the IUCN Red List of Threatened Species at a global level. All orchid species, including the *Thrixspermum japonicum*,

East Asian thrixspermum orchid

are listed on the Appendix II of the Convention on International Trade in Endangered Species (CITES).

Monitoring orchid in the wild

Main Goals

- Goal 1: To prepare *in* and *ex situ* conservation strategies of *T. japonicum*.
- Goal 2: To implement a regular monitoring to the translocated site over 10 years.
- Goal 3: To establish a self- sustaining population of *T. japonicum* in the wild.
- Goal 4: To enhance recognition on public awareness on the conservation values of threatened plant taxa.

Success Indicators

- Indicator 1: Alleviating of population decrease due to illegal and over collection in the wild.
- Indicator 2: Obtaining the progeny from translocated population to apply for *ex situ* conservation.
- Indicator 3: Securing long-term survival of more than 10 years of the translocated population.
- Indicator 4: Improve flowering and fruiting rates in the translocated population.

Project Summary

Feasibility: The information on natural habitat of *T. japonicum* is very limited and there is only one herbarium specimen documented in the wild in Korea. According to reference, natural habitats of *T. japonicum* in Korea involve only one location; unique remaining of habitats for this orchid is located near the Donnako Valley of Jeju Island. The estimated population size in this site is less than 50 individuals (National Institute of Biological Resources, 2012). It is very difficult to find the mature individuals in the wild due to restricted population size and epiphytic characteristics of loading on branches. Some mature individuals were documented in 2011 by a staff of the Halla Arboretum, Jeju Island, during the field survey and then mature fruit was collected in the wild. Using this fruit, artificial propagation has been executed in the Korea National Arboretum since 2012 and now all seedlings are in Korea National Arboretum and Halla Arboretum for *ex situ* conservation.

Implementation: The main purpose of this project is to prepare appropriate *in* and *ex situ* conservation strategies for *T. japonicum*. Thus it is very important to secure a population for *in situ* conservation because of its restricted distribution range.

Post-planting monitoring: All of translocated individuals have been marked, monitored and recorded annually to secure data on surviving individuals, flowering and fruiting rates, human interferences and seedlings. There was no human interferences and 73% of the founder individuals survived the first year after translocation. But, the survival rate was dramatically decreased to 63% in the second year after translocation. Although some individuals failed to survive in the translocated site, a few individuals successfully flowered and fruited after translocation. About 10.1% and 26.3% of the founder individuals became reproductive in the first and second years, respectively. Nearly all individuals matured in the first and second years. Mean number of fruits *per* individual was 1.75 and 2.83 in the first and second years, respectively. There was no emerged seedling so far.

Table 1. Survival, flowering, and fruiting rates

Period	2015	2016	2017
No. of surviving individuals (Survival rates, %)	216	158 (73%)	137 (63%)
No. of flowering individuals (Flowering rates, %)	-	16 (10.1%)	36 (26.3%)
No. of fruiting individuals (Fruiting rates, %)	-	16 (10.1%)	35 (25.5%)

Major difficulties faced

- There are limited reference and knowledge on the species such as distribution range, ecological environment of natural habitats to select the appropriate translocation site.
- It is difficult to secure parental individuals to conduct the mass propagation for translocation.
- Due to the number of limited parental individuals used for mass propagation, it is expected that neo-population has very low genetic diversity.
- Due to the epiphytic growth characteristics of this species, it takes a lot of time to get settled in the beginning.
- The maintenance of the original site, whose habitats are unique remaining ones in Korea, is uncertain and unpredictable.

Major lessons learned

- Selecting an appropriate site is the key factor to success of translocation project of *T. japonicum* because this target species has very limited distribution range in Korea.
- Establishment of a monitoring collaboration system with local residents and stakeholders is effective to prevent human interference for ornamental orchid translocation project.
- Before starting the translocation project, securing sufficient biological understanding such as life cycle must be established.
- The long-term monitoring and adequate documentation are essential factors for successful translocation project.

- As for translocation of epiphytic orchid transplanting should be made in a way that roots can effectively grow on branches of the host plant.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- High rates of flowering and fruiting and high number of seeds per plant in two years.
- Establishment collaboration system with local stakeholders.
- Short-term monitoring.
- Decreased survival rate in two years.

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Translocation of bryocaulon and lung lichens in the north of Sakhalin Region, Russia

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Introduction

The bryocaulon lichen (*Bryocaulon pseudosatoanum*) (Asahina) Kärnefelt fruticose epiphloeodus East Asian and west North American species that are prevalent mainly in the temperate zone and in the mountains of the oceanic regions of East Asia and the west of North America. In Russia it is found in the Sakhalin Region (Nogliki and Poronaisk districts of Sakhalin Island and Kunashir Island), in the Khabarovsk Territory (The Red Book, 2005). The species is listed in the Red Data Books of the Russian Federation with category “3g” (2008) and Sakhalin Region with category 3 (2005), this taxon has not yet been assessed for the IUCN Red List. The lung lichen (*Lobaria pulmonaria*) (L.) Hoffm. is a large-leafed epixylus, epiphloeodus species, found in the oceanic and mountainous regions of Europe, Macronesia, Africa, Asia and North America. It is known nearly on all the territory of Russia (The Red Book, 2008). The species is listed in the Red Data Books of the Russian Federation (2008) with category “2b” and Sakhalin Region with category 3 (2005), this taxon has not yet been assessed for the IUCN Red List.

The limiting factors for these species are the destruction of old-growth forests, fires, anthropogenic transformation of natural habitats, air pollution and collection for medicinal purposes (lung lichen). In accordance with phyto-geographical zoning, the studied area relates to the North-Sakhalin area of the Amgun-Sakhalin floristic district of the Circumboreal floristic region and occupies the territory of the North-Sakhalin plain. The studied species of lichens are confined to forest habitats only, which are represented by larch (*Larix cajanderi*) forests with green mosses and short grasses and by larch fir (*Picea ajanensis*) and silver fir (*Abies sachalinensis*) forests with green mosses. The existing experience in the realisation of such projects is not numerous. For example, in the Kichertsky district of the Perm Territory there was a project, to create artificial populations of lichen species (*Lobaria pulmonaria, Flavoparmelia caperata, Heterodermia speciosa, Cetrelia cetrarioides* & *Flavopunctilia soredica*). The transplantation was used as a main method. The survival rate of thallome was 85.3% (Shayakhmetova, 2015).

Goals

- Goal 1: The assessment of possible alternatives to the preservation of viable individuals of *Bryocaulon pseudosatoanum* and *Lobaria pulmonaria*.
- Goal 2: The preservation of the target species *in situ* by translocation outside the zone of negative impact from the construction of the compressor station of the ‘Sakhalin-2’ project.

Translocated species of lichens: *Bryocaulon pseudosatoanum* on the branches of *Abies sachalinensis* (left) and *Lobaria pulmonaria* on the trunk of *Salix hultenii* (right)

- Goal 3: Understand the threats affecting the target species and assess the impact of the planned economic activity.
- Goal 4: Define suitable methods and elaboration of the technologies of lichens translocation.
- Goal 5: The search for indicators for monitoring, according to the peculiarities of lichen biology.

Success Indicators

- Indicator 1: The survival of the subpopulations of lichens undergoing the translocation.
- Indicator 2: For *Lobaria pulmonaria* - a change in the area and perimeter of the projection of thallomes, the proportion of necrosis, the functional-age states of the subpopulations.
- Indicator 3: For the assessment of the growth of model thallomes, *Lobaria pulmonaria* - a change in the length of the thallomes (the distance between the monitored marker points).
- Indicator 4: For *Bryocaulon pseudosatoanum* - the presence of necrosis and the desiccation, the functional-age states of the subpopulations.
- Indicator 5: For the assessment of the growth of model thallomes *Bryocaulon pseudosatoanum* - a change in the length of the branches of thallomes of the first order and the maximum size of apothecium.

Project Summary

Feasibility: The compact habitat of protected species with the area of 0.04 ha is a piece of forest after a clear-cut designed to prepare a site for the construction of an industrial facility. The population of *Bryocaulon pseudosatoanum* was quite numerous on this site. There were also thallomes both with and without apothecia. In the subpopulations of *Lobaria pulmonaria*,

Monitoring translocated lichen

small sterile and sorediоus thallomes predominated, and apothecia were not found. In the period 2013 - 2016 several signs of damage of thallomes were observed: colour change, necrosis, drying, damages caused by changes in microclimate parameters (humidity and insolation) due to deforestation and blowdown. The Performance Standard: Biodiversity Conservation and Sustainable Management of Living Natural Resources (2012) acknowledges that protection and conservation of biological diversity and careful use of ecosystems, taking into account future needs, form the basis of sustainable development. Special requirements are set for critical habitats. In case critical habitats are negatively affected, an impact assessment should be provided to minimize the consequences for biological diversity and to integrate the monitoring of such habitats into the company's project management system (2012).

At the initiative of Sakhalin Energy Co Ltd. the assessment of the risks of alternatives for the protection of rare lichen species and their habitats was realized in the given territory: 1) conservation of *in situ* populations within the restricted area with a 10 m technological buffer zone; 2) preservation of coenopopulations *in situ* by translocation into similar biotopes. Both options do not contradict the standards of the International Finance Corporation (the requirement to prevent total losses), as they are accompanied by reduced environmental risks for rare species and provide long-term monitoring of dynamic indicators. Based on the results of the integrated assessment, a variant of translocation of lichens into similar biotopes was considered appropriate. At the same time, the negative impact factor from the planned industrial facility (emission of pollutants into the atmosphere) will not have a damaging effect on the usage of the compressor station (Efremov *et al.*, 2013).

Implementation: In 2013, complex research was carried out to assess the status of the population of the target species (the nature of the synusia, substrate affinity, abundance, etc.) of their habitats (microclimate parameters, atmospheric gas composition, exposure, localization on the trunk of the phorophyte, etc.). The search for recipient territories meeting the criteria for optimal habitat has been performed: the presence of *Lobaria pulmonaria* and *Bryocaulon pseudosatoanum* in lichenosynusia; similarity of phytocoenosis and microclimatic conditions; substrates suitable for settlement by diasporas; location outside the impact zone; with a bigger ecological capacity. In 2016, 26 *Lobaria pulmonaria* subpopulations and 76 *Bryocaulon pseudosatoanum* subpopulations, were translocated *in situ,* each individual with an ID. The primary controlled indicators were identified, as well. Based on the analysis of alternatives, the main recipient territory, which corresponds to the criteria of the optimal habitat (95 subpopulations) was selected. To take into account the evaluation of the success of implemented initiatives, seven subpopulations were transferred to the additional recipient territory in the zone of negative impact.

The procedure includes the following basic phases:

- The selection and marking of trees with protected rare species of lichens.
- The marking-out fragments of phorophytes exceeding the diameter of the lichen thallomes in size by 2 - 3 times.
- The transportation of fragments of phorophytes with thallomes of lichens to the recipient sites.
- The attaching of fragments of phorophytes to the recipient territory.

The project was carried out in accordance with the requirements of the current legislation on the basis of permit No. 58 dated 01.08.2016, issued by the Federal Service of Supervision in the Sphere of Nature Management.

Post-planting monitoring: In 2017, the first stage of monitoring of the translocation results for the construction phase was performed, including the determination of the main and additional (for model thallomes) controlled indices in 100 translocated subpopulations and three native subpopulations. Two subpopulations of all the *Bryocaulon pseudosatoanum* populations exposed in 2016, they were lost during the wind on an additional site. After the first year of translocation, the survival rate of *Lobaria pulmonaria* in translocated subpopulations (the number of thallomes) was 100%, the survival rate of *Bryocaulon pseudosatoanum* was about 74%. It should be noted that the autochthonous populations of *Lobaria pulmonaria* exhibit signs of drying (yellowish lobes), red spots and thallomes exfoliation with the substrate. In autochthonous populations of *Bryocaulon pseudosatoanum*, large accumulations of thallomes with parts of phorophytes fell off, mechanical fragmentation of thallomes during snowmelt and windfall. This may indicate that, along with stress translocation factors, natural processes in ecotopes can also influence the efficiency of the process (e.g. the duration of the dry period, the low humidity of the air, etc.).

Major difficulties faced

- *The lack of actual data* - lack of experience in this sphere does not allow prediction of results with a higher probability.
- *The efficiency indicators* - it is extremely difficult to observe the change in the size of thallomes, to asses the renewal due to the slow growth of lichens and the complexity of identifying propagules in nature.
- *The peculiarities of reproduction biology* - in *Lobaria pulmonaria*, apothecia are rare in nature, that does not allow the use of this parameter for the evaluation of efficacy. *Bryocaulon pseudosatoanum* has no organs of vegetative reproduction.
- *The dimensional characteristics* - the area of the projection and the dimensions of the thallomes vary greatly depending on the humidity. The use of this indicator as a controlled one requires further study.

Overview of translocation site

- *The peculiarities of biomorph* - in *Bryocaulon pseudosatoanum* it is difficult to determine the size due to bushy-branched thallomes. Thallomes are fragile enough, often mechanically damaged, they fall off with parts of phorophytes.

Major lessons learned

- *The choice of habitats* - the most important factor in the choice of recipient territories is the presence of the target species in the association.
- *Unit of translocation* - the use of the thallomes of lichens with fragments of phorophytes as a unit of translocation is more effective for the preservation of individuals in comparison with thallomes and their fragments without a substrate.
- *The efficiency of translocation* - due to the peculiarity of the biomorph *Bryocaulon pseudosatoanum* it attaches to the substrate only by the base and the survival of individuals of this species is significantly lower than in *Lobaria pulmonaria*.
- *The fixing methods* - the use of inert materials reliably fixes fragments of phorophytes with lichens to trees and does not have a toxic effect.
- *The processing of primary data* - the use of the image processing programs by overlaying photos of different periods with a marker point makes it possible to improve the accuracy of primary quantitative indicators.
- *Controlled indicators* - probably the most optimal and representative indicators for monitoring are: the proportion of necrosis, functional-age conditions of lichen subpopulations.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- *The optimal receptor site* - the selection of the receptor site was made considering the ecology of the species.
- *The conditions for microhabitats* - the transfer to the recipient sites was carried out on a suitable substrate, taking into account the exposure of the trunk and humidity.

- *The translocation with substrate* - the transfer of lichens was performed together with the substrate.
- *The biomorphological features* - the *Bryocaulon pseudosatoanum* thallomes are very brittle and damaged by mechanical action (including in nature), probably this species is poorly suited for translocation.
- *The duration of monitoring* - reliable results could be obtained after a longer monitoring of at least during 3 - 5 years.

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The reintroduction of Yellow gentian on Mount Genziana, CE Sardinia

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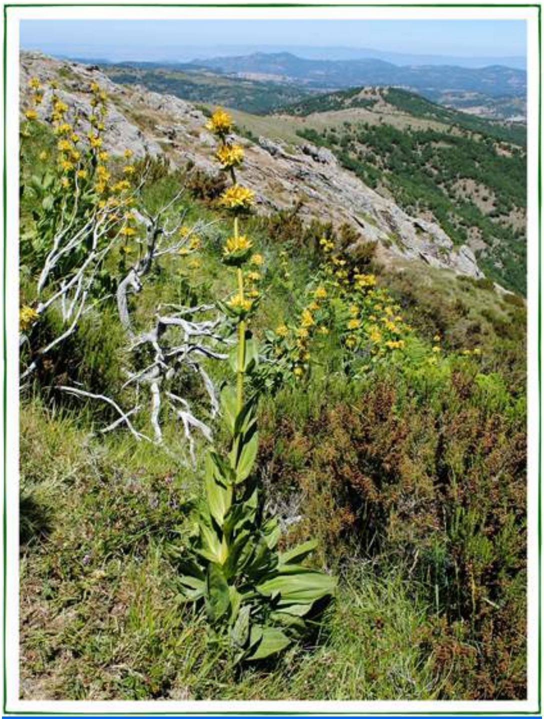
Introduction

Yellow gentian (*Gentiana lutea* L. Gentianaceae) is a long-lived, rhizomatous geophyte which develops fertile stems that generally produces new shoots in early summer, and blooms with several tens of yellow flowers; its fruits are capsules which ripen in late summer. The distribution range of *G. lutea* includes mountainous grasslands and pastures of central and southern Europe: Sardinia, Corsica, Iberian, Italian, Balcan Peninsulas and, rarely on W. Caucasus and Anatolia. *Gentiana lutea* subsp. *lutea*, the only subspecies present in Sardinia, is restricted to the Gennargentu Massif (Central-Eastern part of the island). This massif represents an independent phytogeographical sector and consists of a system of summits with four peaks at more than 1,800 m.



***Gentiana lutea* L. subsp. *lutea* in its natural habitat in Sardinia © G. Bacchetta**

The Sardinian population, that represents a southern edge of its overall distribution range, is characterized by small groups or scattered individuals. *Gentiana lutea* is listed in the Habitats Directive 92/43/EEC and, considering its restricted distribution range and its threats, mainly related to the negative effects of global warming and root harvesting, it was categorized as Near Threatened (NT) at Italian level (Rossi *et al.*, 2016). In Sardinia, where various extinction events were recorded in the last century, this taxon was considered as Endangered (EN; Fois *et al.*, 2016).

Goals

- Goal 1: To reintroduce plants in a locality where the taxon was recently extinct due to unnatural causes.
- Goal 2: To determine the conditions required for this plant reintroduction to be successful.
- Goal 3: To make the results of this project available for future plant reintroduction trials in Sardinia and, more in general, in the Mediterranean context.
- Goal 4: To examine how successful plant reintroduction has been in establishing viable, self-sustaining population in Sardinia and, more in general, in the Mediterranean context.

Translocation site © G. Bacchetta

Success Indicators

- Indicator 1: Long-term plant survival.
- Indicator 2: Plant growth and plant development patterns.
- Indicator 3: Flowering and reproduction rate of the established plants (in the mid-term).
- Indicator 4: Number of established seedlings (in the mid-term).
- Indicator 5: Number of recruited seedlings becoming reproductive (in the mid and long-term).

Project Summary

Feasibility: *G. lutea* subsp. *lutea* grows in grasslands, meadows, and clearings of beech, alders, heathers and brooms in the upper montane and (sub-) alpine pastures. The translocation has been performed after conducting an exhaustive ecological study and analysis of historical and current natural distribution ranges of this plant in Sardinia. Studies based on a presence-only distribution model and optimal geomorphological, present and future climatic conditions, identified a suitable area for a translocation in Monte Genziana (Talana), where *G. lutea* subsp. *lutea* recently disappeared due to an intensive root harvesting (Fois *et al.*, 2015). The locality chosen for this action is named "Serra Siccorruli", located in the Monte Genziana (Talana) at an altitude of 1,425 m a.s.l. and with a slope of approximately 20%. The suitability of this area was also confirmed in field by the presence of soil, moisture and vegetation characteristics that *G. lutea* generally prefers in Sardinia. Simultaneously, the conditions for seed germination were tested in the field and in the laboratory to understand the germination behaviour and to apply the enhanced knowledge at larger scales (Cuena-Lombraña *et al.*, 2016).

Implementation: Seeds of *G. lutea* subsp. *lutea* were collected from the largest locality actually present in Sardinia in order to maximize the genetic diversity of the material. Successively, plants obtained from seeds were cultivated for 1 - 3 years in the greenhouses of the Agenzia FoReSTAS (Agenzia Forestale Regionale per lo Sviluppo del Territorio e l'Ambiente della Sardegna, Autonomous Region of Sardinia), located in the municipality of Talana, close to the selected area. Before performing the translocation, the selected area was fenced following the previous experiences in Sardinia (Fenu *et al.*, 2016). The translocation has been carried out in two periods: the first in autumn (December 2014) and the second in spring (March 2015) by using plants of different ages (100 plant of 1 year old and 100 plants of 3 years old). The translocation was firstly supported by a specific project of the Autonomous Region of Sardinia and, then, by the international project Care-Mediflora (founded by the MAVA Fundation).

Post-planting monitoring: All transplanted plants were monthly monitored from April to September recording plant growth and survival rate; flowering and reproduction of the established plants and number of new established seedlings are planned to be monitored after five years from the transplanting action. Management actions aimed to reduce the natural vegetation evolution has been periodically carried out by removing the fast-growing species in the site (e.g. *Erica arborea* L., *Rubus ulmifolius* Schott., etc.).

Preliminary results indicated a similar survival rates both for ages of plants and seasons of translocation. The higher mortality rate was observed during the first year, while this rate diminished up to zero in the next years. After three years, the survival rate was sufficiently high, with 94 plants alive (47%).

Major difficulties faced

- *Site* - the remoteness and travelling distance to get to the translocation site made the monitoring difficult and expensive.
- *Summer drought* - the Sardinian population occurs at the edge of their ecological range; the hot and dry summers desiccated plants in their first year before roots were able to grow deep enough to tap into subsoil moisture.
- *Plants* - the slow growth rate requires a very long times to correctly evaluate the outcome of reintroduction.
- *Root harvesting* - a possible risk that the transplanted plants will be destroyed for the root exploitation.
- *Management actions* - the natural evolution of the vegetation in the selected area could promote a loss of suitable habitat for the species; periodic management actions will be required to promote the effectiveness of this translocation.

Major lessons learned

- Select an appropriate area and microhabitat, something unique to each taxa, is a key feature for successful plant reintroduction.
- Choice of an area managed by a public administration: the conservation of threatened plants is more practicable than on private lands.
- To realize reintroduction with plants of different ages in order to better select and choose the individuals to carry out the future reintroduction.

- To realize reintroduction in different season in order to select and choose the appropriate season to carry out the future reintroduction.
- To realize a long-term plan monitoring to verify the effectiveness of the reintroduction and, if necessary, to adopt improved solutions.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- High number of survived transplants (after the first critical summer).
- Positive impact of the fence to promote plant growth and exclude grazing.
- High rate of flowering and fruiting rate (to be evaluated in the mid-term).
- High number of viable seeds produced per plant (to be evaluated in the mid-term).
- High number of new recruited seedlings (to be evaluated in the mid and long-term).

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