Ex situ and in situ conservation activities on threatened plants in Sardinia

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In situ conservation

The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

Convention on Biological Diversity (CBD) 1992

Ex situ conservation

The conservation of components of biological diversity outside their natural habitats.

Convention on Biological Diversity (CBD) 1992

In situ (‘on site’, ‘in place’) conservation is a set of conservation techniques involving the designation, management and monitoring of biodiversity in the same area where it is encountered. The in-situ concept is best understood in contrast to ex-situ conservation.

Ex situ (‘off site’) conservation techniques are implemented away from the conservation target's natural habitat. While the identification of ex situ initiatives leaves little room for ambiguity (e.g., seed banks, captive breeding), the notion of in situ conservation covers a broad spectrum of situations ranging from the establishment of a protected area to the design of a sustainable management strategy for a particular habitat.

Key points

In situ conservation is one of two basic conservation strategies. Article 8 of the Convention on Biological Diversity (CBD) specifies in situ conservation as the primary conservation strategy, and states that ex situ measures should play a supportive role to reach conservation targets.

In situ conservation aims to enable biodiversity to maintain itself within the context of the ecosystem in which it is found.

Traditionally, protected areas have been seen as the cornerstone of in situ conservation. Conservation approaches that are more adaptable to individual situations and applicable beyond protected areas, are being increasingly applied.

In situ conservation

Purpose and use of *in situ* conservation strategies

In situ management approaches can either be targeted at populations of selected species (species-centred approaches), or whole ecosystems (ecosystem-based approaches).

Both approaches follow the same purpose:

To enable biodiversity to maintain itself within the context of the ecosystem in which it has been found, i.e. to enable a species population to self-replicate and maintain its potential for continued evolution.

- ❖ This requires conservation of the components of the natural system (populations, species, communities and biophysical systems) as well as the ecological and evolutionary processes occurring within that system.
- ❖ Conservation measures are aimed at the surroundings where a target-species developed its distinctive properties. This could be a natural habitat, or an environment heavily modified by human activity.

In situ conservation

Examples of *in situ* conservation initiatives	Protected areas are the cornerstone of in situ conservation, as is outlined in Article 8 of the CBD. There is a however growing awareness of the importance of extending in situ conservation beyond protected areas. Habitat restoration, recovery or rehabilitation
	Strategies for the sustainable use and management of biological resources
	Recovery programmes for nationally or sub-nationally threatened or endangered wild species
	On-farm agricultural biodiversity conservation targeted at traditional crop varieties and crop wild relatives
	Genetic reserve conservation, i.e. monitoring of genetic diversity in natural wild populations within a delineated area;
	Control of threats to biodiversity such as invasive alien species, living modified organisms or over exploitation;
	Preservation and maintenance of traditional knowledge and practices; and
	Implementation of the regulatory, legislation, management or other frameworks needed to deliver the protection of species or habitats

In situ conservation

The main strategy for *in situ* plant conservation and one of the core activities of conservation biology that can be particularly useful for conserving species with scattered populations is the **MONITORING** of plant populations.

Conservation of threatened species requires specific efforts dedicated to monitoring of population performance.

This activity creates challenges in terms of designing efficient strategies analysis of resulting data.

Because many species are potentially at risk, and because time and resources for population monitoring are limited, not all species can be intensively studied.

Endangered species conservation is closely interrelated to understanding the key factors determining their distribution and abundance

information on survival strategies of threatened species is a critical key to optimize and to determine the success of in situ and ex situ conservation activities.

Demographic studies and the natural history of threatened plants are crucial for both population management and conservation efforts as well as reproduction, recruitment and survival are particularly important factors when attempting to interpret plant rarity.

In situ conservation

In general, there are three basic groups of parameters which are used for monitoring threatened plant population:

the population size (number of plants or population density)	the extent of a population (i.e. area occupied)	the population viability (i.e. plant size distribution, reproductive success, age and/or stage structure of a population)

These three general categories complement each other and could/should be used together when assessing in detail the dynamics of a population; however, this approach involves a great effort in terms of cost and time.

In situ conservation

A multilevel monitoring scheme, with three levels of intensity corresponding to an increasing intensity approach, was applied

Level one

It focuses on species occurrence data by mapping its distributions and identifying the presence/absence or spatial extent of each population

Level two

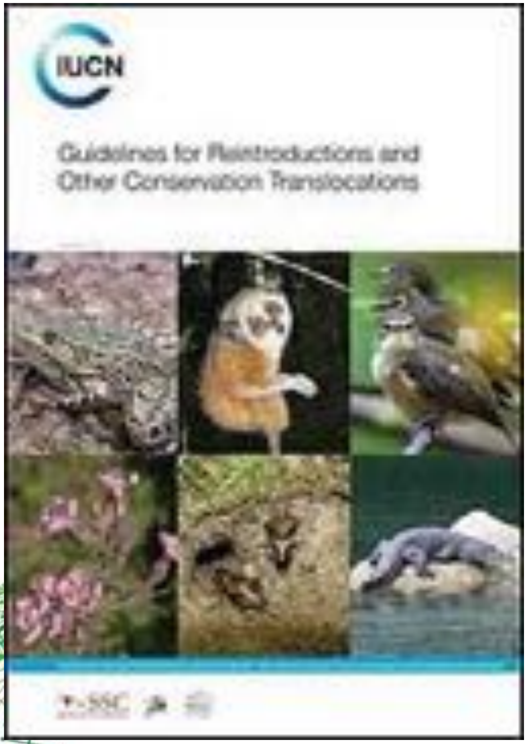
It involves a quantitative assessment of abundance or condition, often in terms of density, percent cover and frequency; this level allows the analysis of population trends and proposing hypotheses about the demographic process

Level three

It involves demographic monitoring of marked plants, thereby permitting quantitative assessment of demographic parameters, such as survivorship, growth and fecundity, that can be used for modelling and population viability analysis

Examples of in situ conservation measures

Plant conservationists have developed important strategies to counter rare plant losses, including efforts to conserve habitat, protect remaining populations, store seeds, and propagate rare plants.



Research and information management are also vital tools in the practice of conserving rare plants.

One further technique is the **translocation** of native plants back into their wild habitat.

What is the translocation?

Translocation is a general term that describes the controlled placement of plant material into a natural or managed ecological area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ELSEVIER

Review

How successful are plant species reintroductions?

Sandrine Godefroid[a,b,c,*], Carole Piazza[d], Graziano
Ruth Aguraiuja[h], Carly Cowell[i], Carl W. Weekley
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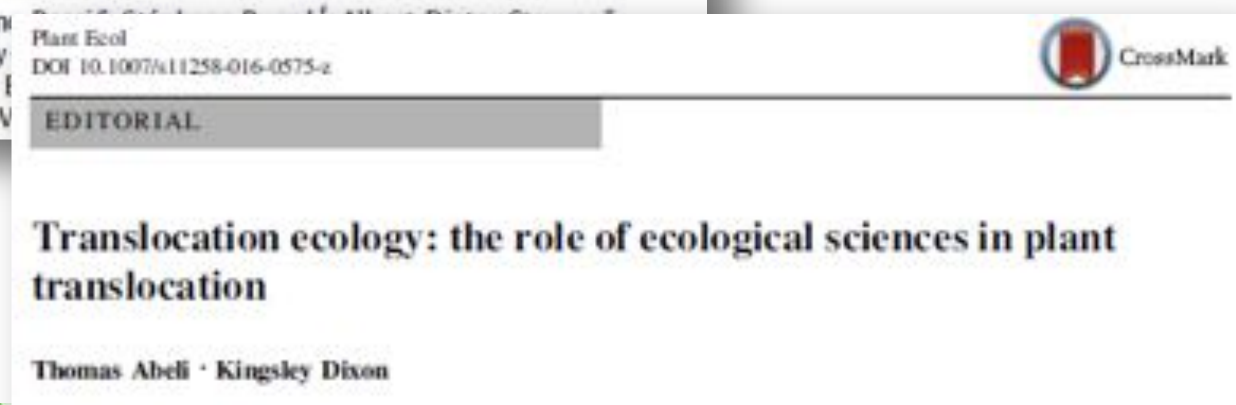

Plant Ecol
DOI 10.1007/s11258-016-0575-z

CrossMark

EDITORIAL

Translocation ecology: the role of ecological sciences in plant translocation

Thomas Abeli · Kingsley Dixon

Translocation

Translocation

Reintroduction: indicates the issuance of a plant species in an area in which it there was previously, but in which it is now extinguished.

Reinforcement: is an effort to increase population size or diversity by adding individuals to an existing population (also called supplementation, enhancement, augmentation or restocking).

Introduction: action carried out on recently species extinct in their historic habitat which is no longer able to support them for various anthropogenic or natural factors. Therefore, in order to avoid the extinction of the species, as an extreme act of preservation in situ, it can be expected to include such species in a territory which does not coincide with the historic habitat, but currently presents suitable ecological conditions.

Why it is important to realize a translocation?

Conservation-oriented reintroductions:

The goal of translocation conducted in response to a conservation imperative is two-fold:

- to ensure the long-term survival of a threatened plant species
- to restore elements of biological diversity.

Besides reintroducing plants to formerly occupied habitat, reintroductions within the conservation context can include augmenting (supplementing) existing plant populations as well as introducing plants to suitable habitat that may not have necessarily supported the species in the past.

Translocation

The rationale for translocation is the establishment or augmentation of new or existing populations, to increase the survival prospects of a species by increasing population size and genetic diversity, or by representing specific demographic groups or stages.

Translocation

Translocation of endemic and endangered plant species to their natural habitat is one of the emerging tools of biodiversity management.

Consequently, to prevent the extinction risk of threatened plant species and to improve their conservation status, translocations have become increasingly important in plant management worldwide

Translocation

Which steps? The basic principles for the translocation are divided according to the following operating steps

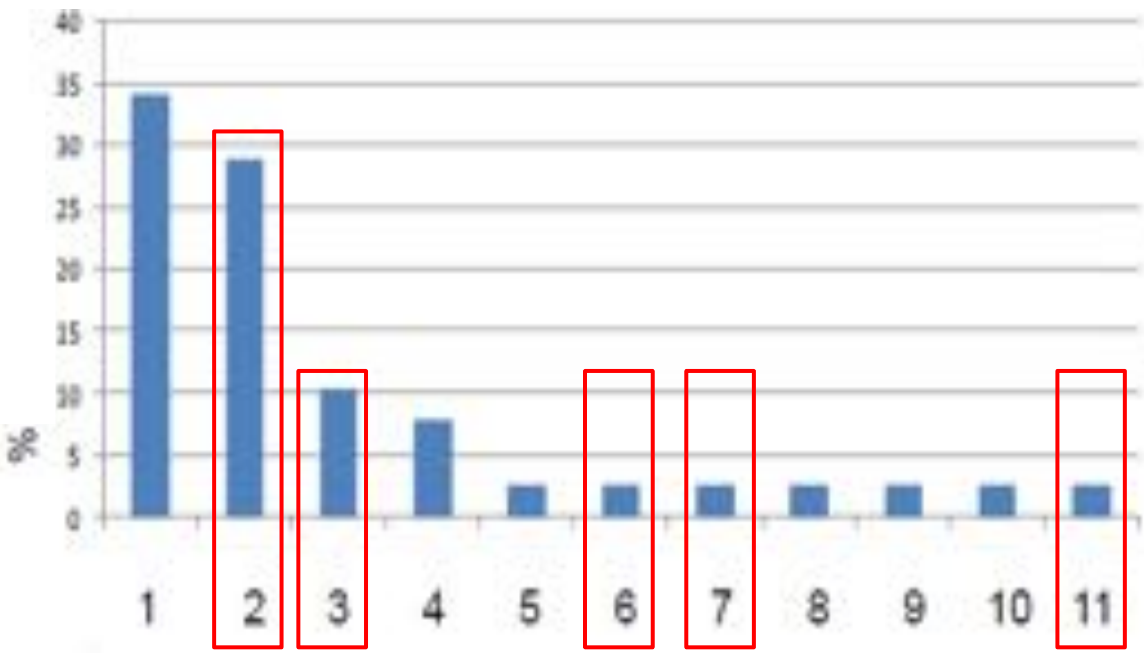
1. Preliminary study phase and feasibility assessment
2. Preparation phase and testing
3. Implementation phase
4. Assessment phase and monitoring of the project

Translocation

Which are the main risks of translocations?

- *Genetic contamination*
- *Maladaptation of plants to particular microsites*
- *Taxa acting as exotic invasive species*
- *Loss of reproductive output due to absence of pollinators or dispersal agents*
- *Impacts on donor populations*
- *Spread of pathogens*
- Loss of community or ecological integrity

Translocation



1. Unknown
2. Unsuitable habitat
3. Predation
4. Environmental changes
5. Unknown biology
6. Seed germination
7. Michorizzas
8. Lack of reproduction
9. Release young plantlets
10. Few plants released
11. Phenology

Reasons of failure

In a high percentage of cases (ca. 50 %), perceived reasons for failure are due to **ecological issues**

Role of ecological studies in plant translocation formally recognized
TRANSLOCATION ECOLOGY is the ecological research applied to translocation

Translocation

Translocation is commonly recognized as a relatively high-risk and high-cost activity and thus, it is necessary to properly evaluate the risks and costs before starting such projects.

Many restrictions remain in the implementation of these conservation actions, such as the high economic and time costs, the availability of the optimal site, the difficulties in the implementation of these actions in private areas and the high uncertainty of success principally connected to natural stochastic events.

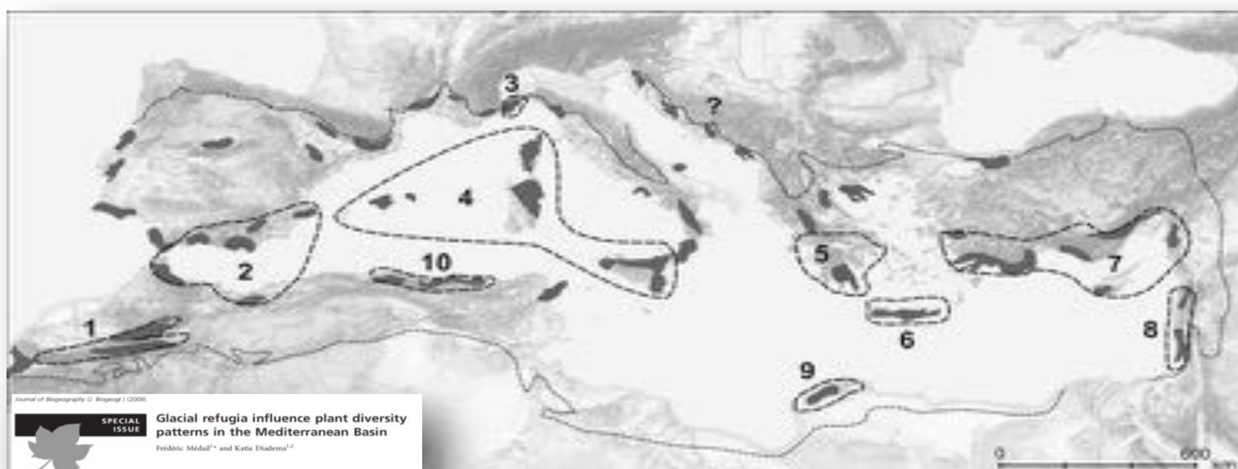
From this perspective, disseminating the results of previous experiences (successful and unsuccessful) is important to provide examples and case studies that will allow the development of common standards and methodologies.

The Sardinian example

In the Mediterranean Basin, conservation studies represent a crucial issue because this area, which represents only 2% of the world's surface, houses 10% of the world's total floristic richness.

The Mediterranean Basin hosts a flora of around 25–35,000 flowering plants and ferns and has been identified as 1 of 34 biodiversity hotspots of the world.

The high rate of regional endemism is, perhaps, the major characteristic of the Mediterranean flora, with close to 60% of all native taxa being Mediterranean endemics, half of which corresponds to narrow endemic species



The Sardinian example

Sardinia is the second largest island in the Mediterranean Sea, where geographical isolation and high geological diversity have created a wide range of habitats with high levels of endemism.

The vascular flora of Sardinia consists of 2494 taxa with a high percentage of exclusive and narrow Sardinian endemics (184 taxa). Therefore, considering the high qualitative value of the Sardinian endemics, the island has been identified as a hotspot within the Mediterranean Basin.

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ELSEVIER

Hotspots within hotspots: Endemic plant richness, environmental drivers, and implications for conservation

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Systematics and Biodiversity (2014), **12(2)**: 181–193

Taylor & Francis

Research Article

Using endemic-plant distribution, geology and geomorphology in biogeography: the case of Sardinia (Mediterranean Basin)

GIUSEPPE FENU, MAURO FOIS, EVA M. CAÑADAS & GIANLUIGI BACCHETTA

The Sardinian example

Despite this rich plant diversity, until a few years ago not many biological conservation studies had been carried out on threatened species of Sardinia; however, the increasing number of papers detected in the last years represents a good signal that more attention will be devoted to threatened endemic species in the near future.

In Sardinia, the CCB (Centro Conservazione Biodiversità, University of Cagliari) in the last 10 years has carried out in situ conservation activities through monitoring population on endemic and threatened Sardinian vascular flora.

Species selection was made following two main criteria: the policy species listed in Habitat Directive and the priority list of the exclusive taxa of Sardinia.

Plant Biosystems, 2015
Vol. 149, No. 3, 473–482, http://dx.doi.org/10.1080/11263504.2014.1000424

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ORIGINAL ARTICLE

Threatened Sardinian vascular flora: A synthesis of 10 years of monitoring activities*

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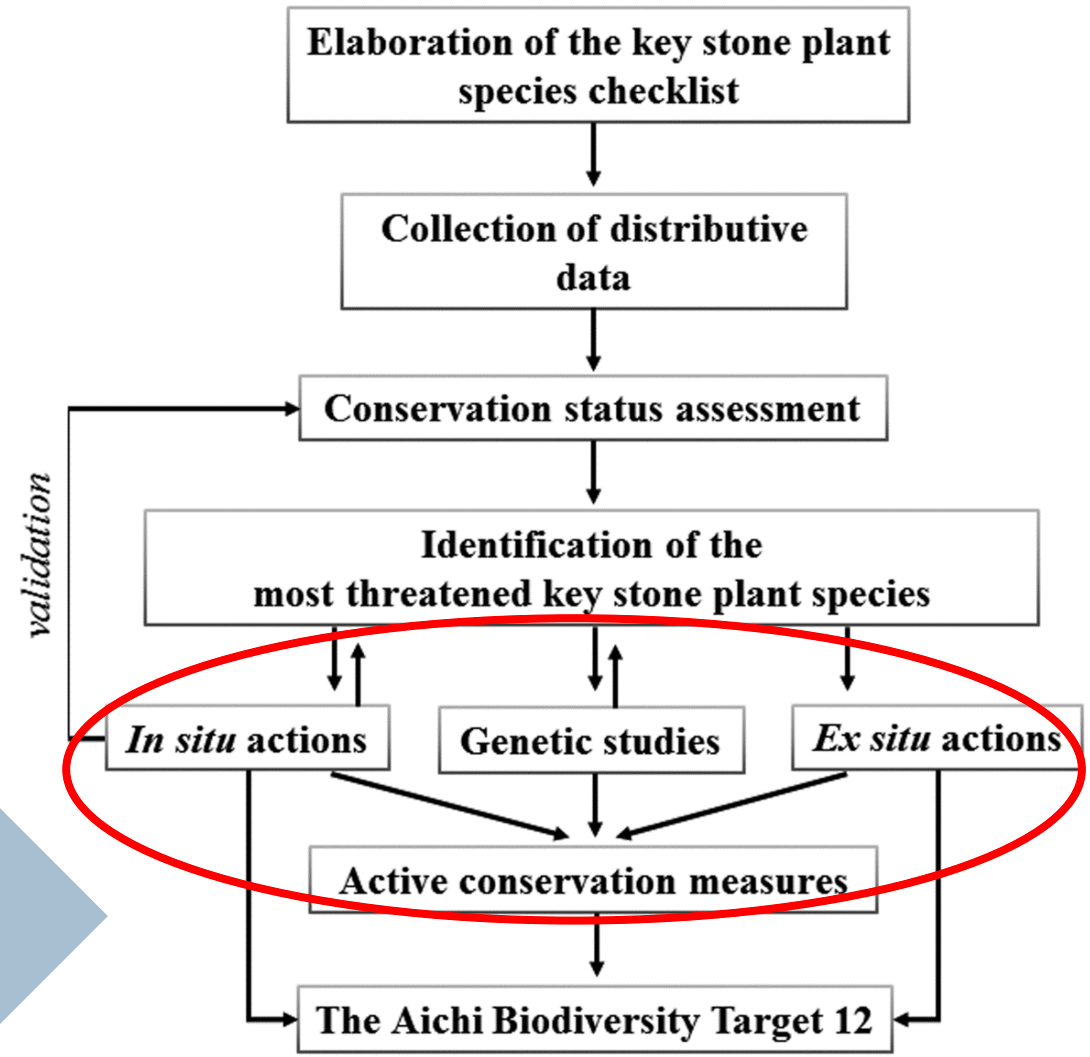
The Sardinian example

Flow chart summarising the steps in implementing a methodological approach to conservation for target species.
Through singular and/or simultaneous processes of *in situ*, and *ex situ* actions
(plus additional genetic studies), the active conservation measures are planned.

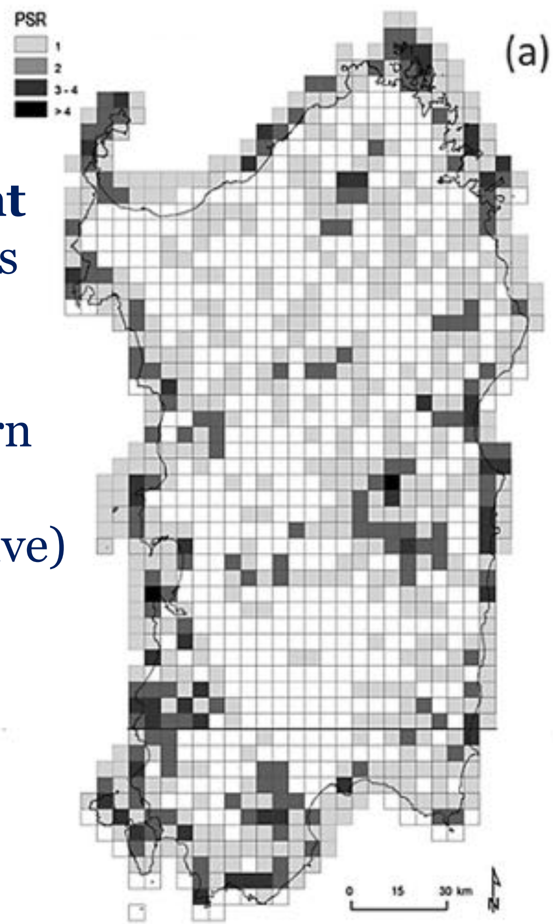
From ex situ to in situ conservation



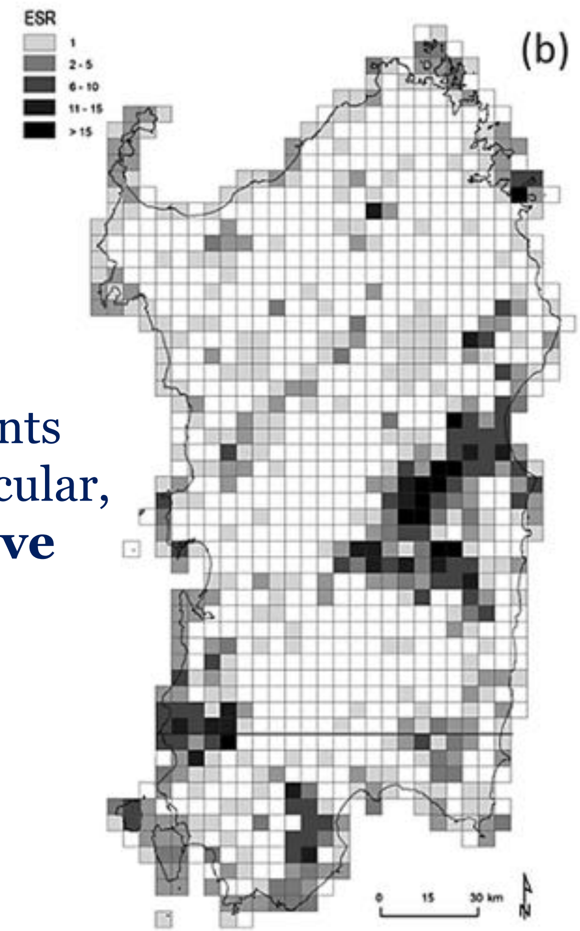
The Sardinian example

In species-rich areas effective conservation needs the establishment of priorities at finer-scales: the **Regional Responsibility criterion**

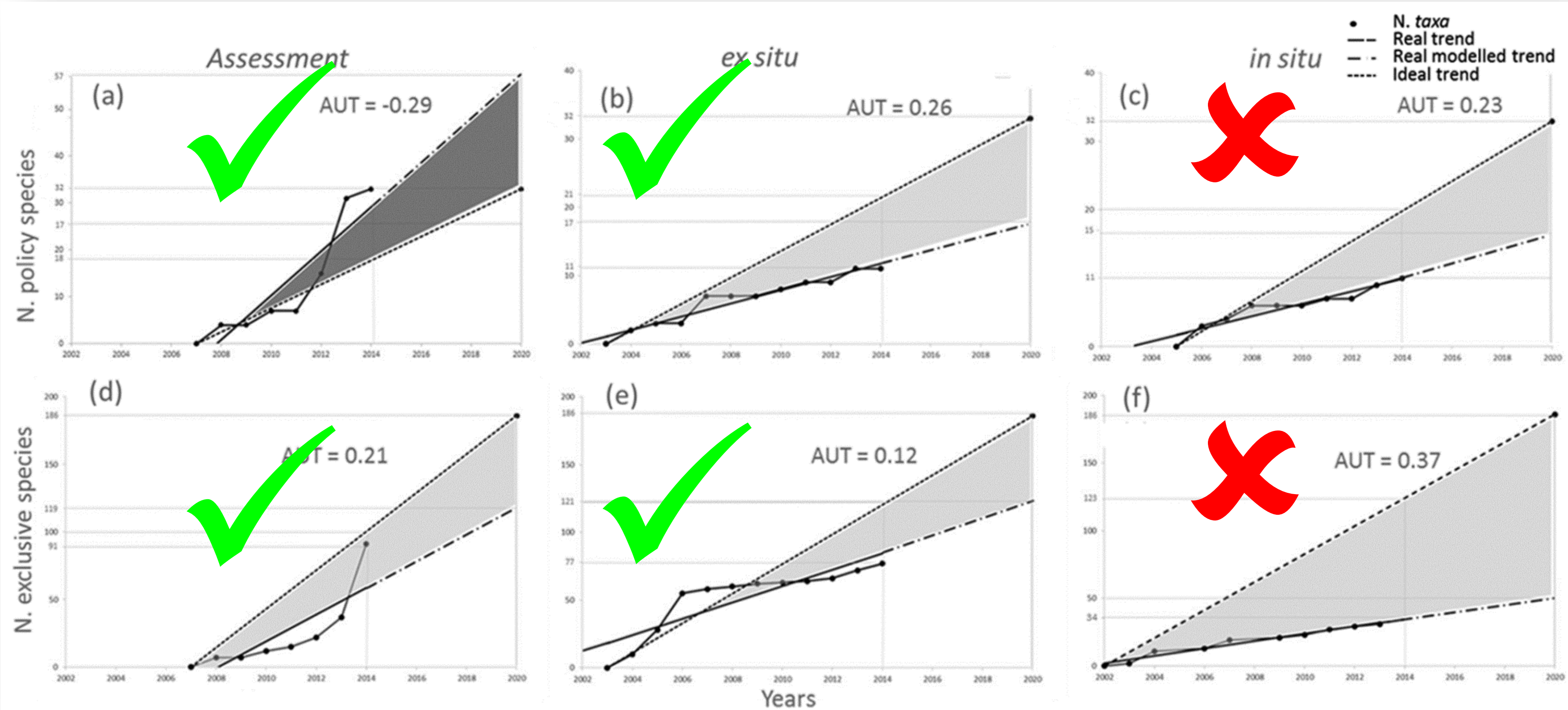
32 Policy plant species: species listed in the international regulations (Bern Convention and Habitats Directive)



Endemic plants and, in particular, **186 exclusive plants** of Sardinia



The Sardinian example: Aichi Biodiversity Target 12



BIODIVERSITY, 2015
Vol. 16, Nos. 2–3, 120–135, http://dx.doi.org/10.1080/14888386.2015.1062423

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The Aichi Biodiversity Target 12 at regional level: an achievable goal?

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Dianthus morisianus: a study case

Dianthus morisianus Vals., the only psammophilous species of the genus in the Mediterranean basin and with only one population, on the Portixeddu coastal dune system in Buggerru, south-west Sardinia, is one of the most threatened plants on the island.

D. morisianus is a perennial herb characterized by numerous woody stocks, erect stems and a basal rosette with thin and linear leaves. The stems bear terminal multiflowered heads; the calyx is characterized by lanceolate teeth and the colour of the corolla is pink. The flowering season is from early May to late June, and ripe fruits can be found during June–July.

Dianthus morisianus: a study case

This plant grows on stabilized dunes at the edge of *Juniperus* spp. Micro-forests and scrub dominated by *Cistus* spp.

The natural habitat of *D. morisianus* has been strongly modified by human activities, causing habitat loss and fragmentation: there are several settlements in the species' habitat and since 1950 much of the dune system has been afforested to stabilize the dunes and halt the movement of sand inland.

Dianthus morisianus: a study case

Preliminary researches (taxonomic studies, distributive studies etc.)

Seed germination	Seeds germinate easily	No limitations
Reproductive biology (*ex situ* research)	No inbreeding depression	No limitations
Seedling recruitment	Extremely low recruitment	Severe limitations
Ecological requirements	Sand substrate	Specific requirements
Plant community (habitat)	Plants grows preferentially in open area	Specific requirements
Ecologica context	Nurse effect	Specific requirements
Main threats	Grazing/Trampling	protective measures

Dianthus morisianus: a study case

Project plan

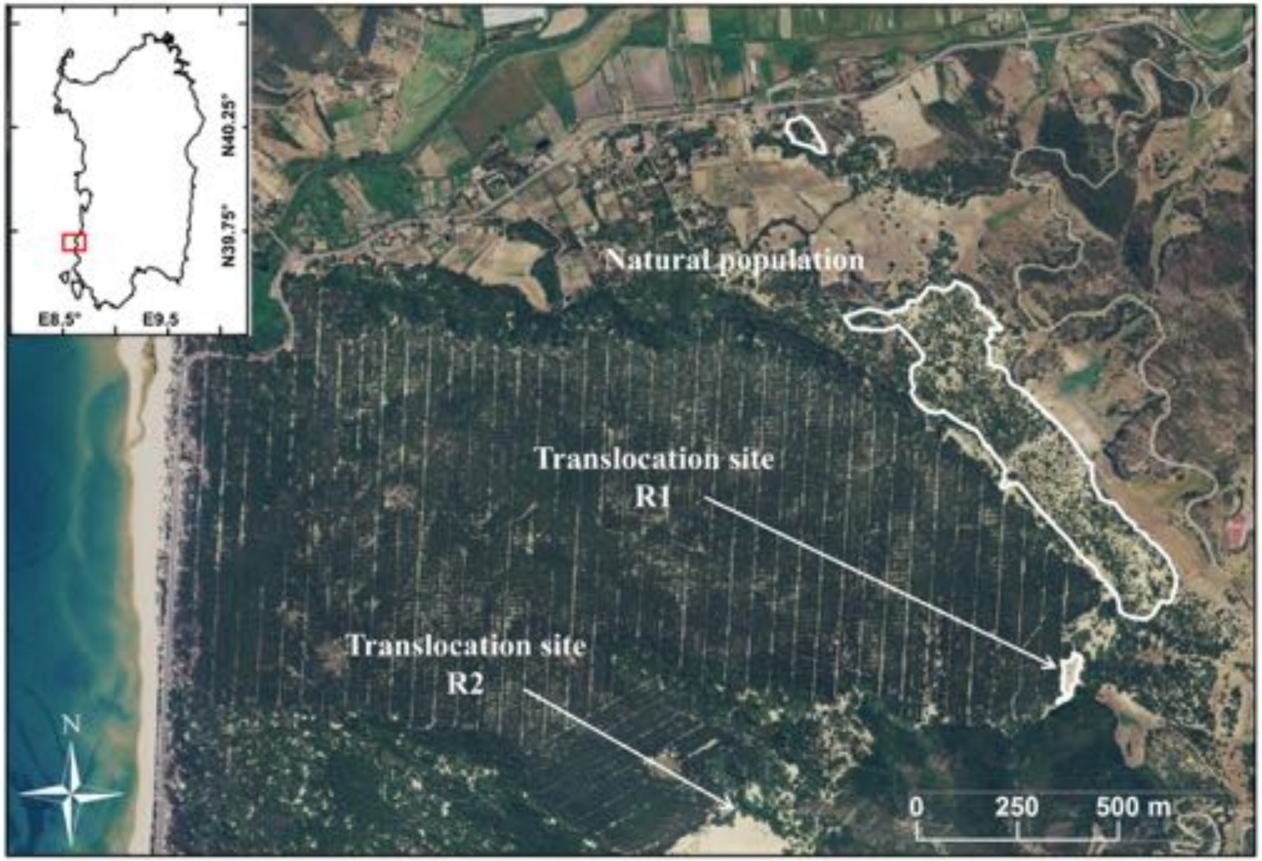
- Juvenile plants were used for the reintroduction
- No horticultural treatments were adopted
- Selection of suitable microhabitat
- Selection of a suitable season
- Management activities (i.e. erection of fences)

Post-plantation monitoring: The transplanted plants were marked and monitored monthly

(In) Success indicators

- Indicator 1: Survival rates.
- Indicator 2: Number of established seedlings.
- Indicator 3: Number of seedlings becoming reproductive.
- Indicator 4: Flowering and fruiting rates per plant.
- Indicator 5: Mean number of fruits/seeds per plant.

Dianthus morisianus: a study case



 doi:10.1017/S003060531200169X
CAMBRIDGE JOURNALS

The effectiveness of plant conservation measures: the *Dianthus morisianus* reintroduction

DONATELLA COGONI, GIUSEPPE FENU, ERICA CONCAS and GIANLUIGI BACCHETTA




Group	No. plant reintroduced	First year						Second year					
		No. dead plant	Mortality rate	Flowered plant (%)	Fruited plant (%)	Mean fruits per plant	NS	No. dead plant	Mortality rate	Flowered plant (%)	Fruited plant (%)	Mean fruits per plant	ES
1	12	1	0.083	33.33	25.00	2.33±2.31	3	0	0	63.64	63.64	7.43±3.26	0
2	10	0	0	40.00	40.00	4.00±2.45	7	0	0	40.00	40.00	4.75±4.35	8
3	9	0	0	66.66	66.66	4.50±1.52	9	0	0	88.88	88.88	15.25±13.17	12
4	15	0	0	46.66	46.66	3.14±1.95	25	0	0	86.66	73.33	10.18±6.15	22
5	15	0	0	40.00	33.33	3.60±2.07	1	0	0	80.00	66.66	7.60±6.33	0
6	6	0	0	33.33	33.33	1.50±0.71	0	0	0	83.33	66.66	4.00±3.46	3
7	20	2	0.100	25.00	25.00	3.20±2.77	0	0	0	55.55	50.00	4.44±3.09	1
8	16	0	0	56.25	56.25	5.78±3.27	47	0	0	56.25	62.50	7.80±6.09	41
9	10	1	0.100	40.00	30.00	2.67±1.15	0	0	0	70.00	33.33	3.67±2.52	0
Total	113	4	0.035	41.59	38.94	3.84±2.48	92	0	0	68.80	60.55	7.97±7.11	87




Dianthus morisianus: a study case

Log-term monitoring of the entire new population

	2012	2013	2014	2015
Seedlings	92	236	349	516
Established plants		27	82	473
Reproductive plants			16	137

The number of seedlings produced by the reintroduced plants increased every year, and after 5 years, the total number of reproductive plants had doubled.

The size population increased over time, indicating that it is self-sustaining through the development of successive generations.

Dianthus morisianus: a study case

Importance of the post-intervention management

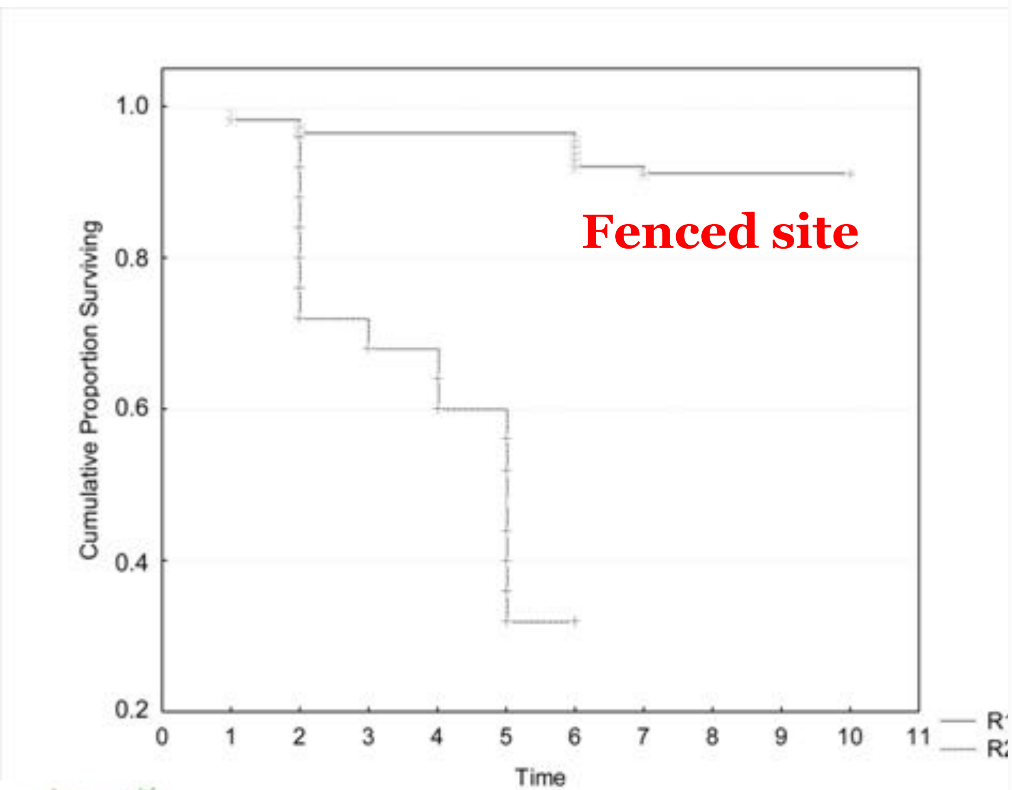
Fenced site

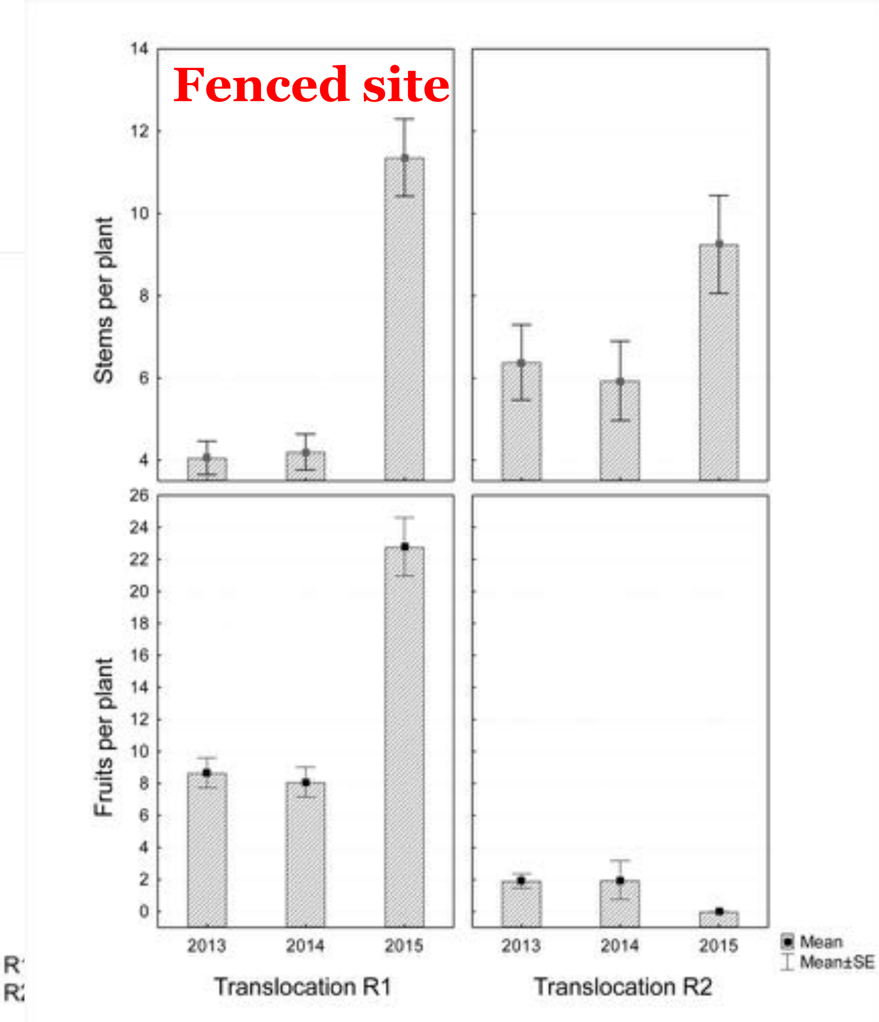
	2012	2013	2014	2015
Seedlings	92	236	349	516
Established plants		27	82	473
Reproductive plants			16	137
Seedlings		0	6	6
Established plants			0	0
Reproductive plants				0

Unprotected site

Dianthus morisianus: a study case

plants survival





Reproductive output

Dianthus morisianus: a study case

Addressing a correct post-release management……

In the case of *Dianthus morisianus* in Sardinia, simple fences allowed the long-term success of the population reinforcement

Activity	Standard costs (€)	Transplantation 1 Costs (€)	Transplantation 1 %	Transplantation 2 Costs (€)	Transplantation 2 %
Transport of plants from Cagliari, including the driver (centner)	115.10	390.19	1.31	86.32	4.51
Workman costs/day	115.00	1725.00	5.78	575.00	30.06
Pit opening (deep 30 cm; each one)	4.85	548.05	1.84	121.25	6.34
Plant placement (each one)	7.40	836.20	2.80	185.00	9.67
Metal fence with chestnut poles (meter)	98.50	23640.00	79.16	0.00	0.00
Monitoring activities	460.00	2300.00	7.70	690.00	36.08
Travels costs per year (mean value)	85.00	425.00	1.42	255.00	13.33
Total		29864.44	100.00	1912.57	100.00

The role of fencing in the success of threatened plant species translocation

Giuseppe Fenu · Donatella Cogoni · Gianluigi Bacchetta

Conclusions

How to measure the reintroduction success?

Success is defined here as the ability of the population to persist and reproduce.

A key measure of the success of a plant reintroduction is the **<u>survival rate, the transplants' ability to flower and set fruit and the recruitment of new individuals.</u>**

Conclusions

Many translocation studies reveal that survival, flowering and fruiting rates are generally low and sometimes show a downward trend with time.

In a few studies (e.g. *Dianthus morisianus*), the survival and fruiting rate remain high over time and the mean number of fruits per plant was high

Few studies have included data on seedling recruitment, which would allow more direct assessment of population viability.

Recruitment is considered the highest measure of success because it indicates that the population is self-sustaining through the development of successive generations, which is the primary goal of a translocation project.

Thanks for your attentions!