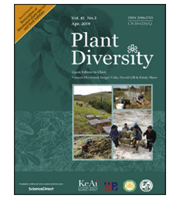
Plant Diversity 41 (2019) 94–104

Contents lists available at ScienceDirect

Plant Diversity

journal homepage: http://www.keaipublishing.com/en/journals/plant-diversity/
http://journal.kib.ac.cn



An early evaluation of translocation actions for endangered plant species on Mediterranean islands

Giuseppe Fenu [a, *], Gianluigi Bacchetta [a, b], S. Christodoulou Charalambos [c], Christini Fournaraki [d], Gian Pietro Giusso del Galdo [e], Panagiota Gotsiou [d], Angelos Kyratzis [f], Carole Piazza [g], Magdalena Vicens [h], Maria Silvia Pinna [a], Bertrand de Montmollin [i]

[a] *Centro Conservazione Biodiversità (CCB), Dipartimento di Scienze della Vita e dell'Ambiente (DISVA), Università degli Studi di Cagliari, Italy*
[b] *Hortus Botanicus Karalitanus (HBK), Università degli Studi di Cagliari, Italy*
[c] *Department of Forests, Ministry of Agriculture, Rural Development and Environment, Nicosia, Cyprus*
[d] *CIHEAM Mediterranean Agronomic Institute of Chania (MAICh), Greece*
[e] *Department of Biological, Geological and Environmental Sciences, University of Catania, Italy*
[f] *Agricultural Research Institute, Ministry of Agriculture, Rural Development and Environment, Nicosia, Cyprus*
[g] *Office de l'Environnement de la Corse (OEC), France*
[h] *Jardí Botànic de Sóller Foundation (JBS), Spain*
[i] *Mediterranean Plant Specialist Group (IUCN/SSC), Switzerland*

ARTICLE INFO

Article history:
Received 21 December 2018
Received in revised form
14 February 2019
Accepted 15 March 2019
Available online 21 March 2019

(Editor: Sergei Volis)

Keywords:
Care-Mediflora project
ex situ conservation
in situ conservation
Insular flora
Threatened plant populations

ABSTRACT

In situ conservation is widely considered a primary conservation strategy. Plant translocation, specifically, represents an important tool for reducing the extinction risk of threatened species. However, thus far, few documented translocations have been carried out in the Mediterranean islands. The Care-Mediflora project, carried out on six Mediterranean islands, tackles both short- and long-term needs for the insular endangered plants through *in situ* and *ex situ* conservation actions. The project approach is based on using *ex situ* activities as a tool to improve *in situ* conservation of threatened plant species. Fifty island plants (representing 45 taxa) were selected for translocations using common criteria. During the translocations, several approaches were used, which differed in site selection method, origin of genetic material, type of propagative material, planting method, and more. Although only preliminary data are available, some general lessons can be learned from the experience of the Care-Mediflora project. Among the factors restricting the implementation of translocations, limited financial resources appear to be the most important. Specific preliminary management actions, sometimes to be reiterated after translocation, increase the overall cost, but often are necessary for translocation success. Translocation using juvenile/reproductive plants produces better results over the short term, although seeds may provide good results over the long run (to be assessed in the future). Regardless, plant translocation success can only be detected over long periods; therefore, proper evaluation of plant translocations requires a long-term monitoring protocol. Care-Mediflora project represents the first attempt to combine the existing approaches in a common plant conservation strategy specifically focusing on the Mediterranean islands.

1. Introduction

Despite the efforts of conservationists, biological diversity faces severe threats and continues to be lost at increasing rates around the world (e.g. Pimm et al., 1995; Butchart et al., 2010; Ceballos et al., 2015). To date, plant conservation has focused on passive protection of fragmented natural habitats. This approach, however, appears inadequate to the task of reducing the accelerating losses of both species and natural habitats globally (e.g. Heywood, 2016, 2017; Fenu et al., 2017a). *In situ* conservation, which is widely accepted as the primary and most appropriate strategy for conserving biodiversity, focuses on populations in their natural

* Corresponding author. Centro Conservazione Biodiversità (CCB), Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, V.le Sant'Ignazio da Laconi 13, I-09123, Cagliari, Italy. Fax: +39 0706753509.
E-mail address: gfenu@unica.it (G. Fenu).

Peer review under responsibility of Editorial Office of Plant Diversity.

https://doi.org/10.1016/j.pld.2019.03.001

habitats (e.g. Godefroid et al., 2011; Volis, 2017; Heywood, 2019). One relatively recently developed *in situ* activity called plant translocation is a potentially important tool for reducing extinction risks for threatened species and improving the conservation status of these threatened species (e.g. Maschinski and Duquesnel, 2006; Godefroid et al., 2011; Orsenigo, 2018).

Conservation translocation (translocation, hereafter) is the controlled placement of plant material into a (semi-) natural area - managed or not - and includes population reinforcement, reintroduction, and introduction. The aim of translocation is to increase survival of a given species and has thus been encouraged as an approach to prevent the extinction of plant species (e.g. Maschinski and Duquesnel, 2006; Godefroid et al., 2011; IUCN/SSC, 2013; Volis, 2016a; Laguna et al., 2016; Commander et al., 2018). The potential of translocations to contribute to the recovery of threatened species is significant, and is enhanced when done as a part of an integrated conservation plan (Maschinski and Duquesnel, 2006; Albrecht et al., 2011; Cogoni et al., 2013; Volis, 2016b, 2017). Nevertheless, despite the strategic importance of *in situ* measures as highlighted by the most important international conventions and programmes (e.g. Article 9C of the CBD, Target 7 of the GSPC for 2020), their implementation lags far behind their full potential. The reasons for this are numerous (e.g. Godefroid et al., 2011; IUCN/SSC, 2013; Commander et al., 2018). For example, many translocation studies are not well-known by other scientists and conservation practitioners, making the lessons of translocation successes or failures difficult to learn (Meek et al., 2015; Volis, 2019). Therefore, to improve the knowledge and awareness of translocation studies within the scientific community, it is important to share all experiences from translocations, even when they are not innovative.

The Mediterranean Basin is an important centre of plant diversity. Although it only consists of 1.6% of the Earth's surface, the region hosts approx. 7% of the world's plants, and accordingly has been identified as one of the global biodiversity hotspots (Médail and Quézel, 1997; Cañadas et al., 2014). However, this plant diversity is unevenly distributed (Thompson, 2005; Cañadas et al., 2014); specifically, most plant diversity is located on the big Mediterranean islands (i.e. Sicily, Sardinia, Cyprus, Corsica and Crete) and Balearic Archipelago, which have an endemism rate of more than 40% (Fenu et al., 2017b). In fact, the peculiar Mediterranean insular features determine specific plant diversities and assemblages and, as a consequence, within the Mediterranean Basin, islands and islets constitute the main centers of plant diversity chiefly due to the narrow range of most of their flora (Médail and Quézel, 1997; Vogiatzakis et al., 2016; Fenu et al., 2017b). At the same time, it is also well known that such plant richness is severely threatened by several factors (physical and biological) and, consequently, many plants of these islands require urgent measures, including but not limited to protection.

Plant diversity of the Mediterranean insular territories is correlated with several human activities that have recently had relevant, negative consequences on plant distributions and dynamics. Currently, insular Mediterranean plant diversity is severely threatened by both natural and anthropogenic factors and its conservation deserves particular attention. Over the last four millennia, the Mediterranean Basin has been the cradle of some of the world's greatest civilizations, a situation that has resulted in soil over-exploitation and the conversion of much of the pristine vegetation into agricultural landscapes (Vogiatzakis et al., 2016). Moreover, the Mediterranean Basin is one of the most vulnerable regions to climate changes, exposing the Mediterranean islands to unique challenges (IPCC, 2013; Vogiatzakis et al., 2016; Cramer et al., 2018).

Because of their limited area, discrete nature, and simplified food webs, islands have often been considered "natural laboratories" for ecological studies, including translocation experiments. Moreover, areas like the Mediterranean insular territories are ideal test sites because of both high rates of endemism and a large number of environmental/anthropogenic threats to plant biodiversity. These shared factors provide an opportunity to test the effectiveness of different combinations of methods and methodologies at conserving endangered plants on Mediterranean islands/islets. Despite the urgent need for translocation actions for a great number of local narrow endemics, few documented translocations have been carried out in the Mediterranean territories (e.g. Piazza et al., 2011; Cogoni et al., 2013; Rita and Cursach, 2013; Heywood, 2014; Laguna et al., 2016). Furthermore, to our knowledge, no translocation projects in this region have focused on methodological aspects.

2. Care-Mediflora approach

The Care-Mediflora project (http://www.care-mediflora.eu/), supported by the MAVA Foundation, is an initiative led by institutions of six Mediterranean islands (mostly botanical gardens and/or seedbanks) and the IUCN/SSC Mediterranean Plant Specialist Group. Participating institutions have a deep knowledge of the local flora and their conservation status, and also have extensive experience with *ex situ* conservation. All institutions jointly worked to address both short-term and long-term needs for the insular endangered plants, including: 1) *in situ* conservation through active management actions, in particular translocations, and 2) *ex situ* conservation through the seed banking of accessions representative of the overall diversity as a tool for plant multiplication for future *in situ* conservation actions (Fenu et al., 2017b).

The approach agreed upon by all partners is mainly based on the use of *ex situ* activities and knowledge as a tool to improve *in situ* conservation of threatened plant species. For example, genetic material (seeds) and know-how from previous *ex situ* activities (e.g., seed collections, germination experiments, living plant collections, etc.) was used in field work to conserve threatened plants *in situ*, particularly through translocation programs. This approach could be defined **"from *ex situ* to *in situ* conservation"** and it is consistent with the need to integrate *ex situ* and *in situ* approaches, which was recognized more than four decades ago (e.g. Falk, 1987; Heywood, 1993; Maunder et al., 2001). The Care-Mediflora project applies the experience gained from a number of conservation programs that have utilized material maintained and/or propagated in botanic gardens for *in situ* translocations (e.g. Maschinski and Duquesnel, 2006; Noël et al., 2011; Menges et al., 2016; Fenu et al., 2016). The Care-Mediflora approach can be framed in the conservation-oriented restoration concept (Volis, 2016a,b). Both are grounded on the same two major principles: (1) there are no alternative ways to actively manage populations of threatened species to prevent their extinction; (2) wide-scale plant introductions of threatened species - both within and outside of known historical ranges for the species - is essential.

3. Translocations of the care-Mediflora project

Any translocation requires an in-depth understanding of the biology and ecology of the target species (e.g. life form, reproductive biology, demographic parameters, etc.), as well as the main threats affecting the population (e.g. Maunder et al., 2004; Maschinski and Duquesnel, 2006; Noël et al., 2011; Cogoni et al., 2013; IUCN/SSC, 2013; Commander et al., 2018). The translocation process often requires relevant expert-based decisions about what- and how-to-do site selection, origin and type of the outplants (seeds, seedlings, or cuttings), planting methods, and the appropriate monitoring plan (Maunder et al., 2004; Godefroid et al., 2011; IUCN/SSC, 2013; Commander et al., 2018). Also, the expertise in *ex situ* multiplication and cultivation procedures is a crucial prerequisite (Cogoni et al., 2013; Brancaleoni et al., 2018).

In the preliminary stage, all the partners jointly established a set of common criteria for selecting target species and prioritizing their conservation actions. In particular, four main criteria were considered crucial: 1) how threatened a species is according to the global/regional IUCN Red List, 2) the regional responsibility criterion that represents the first order of priority at the local level; 3) the so-called policy plant species criterion, giving priority to the species listed in the annexes of Habitat Directive and/or in other national or regional regulations, and 4) affinity to the wetland habitat, the latter considered most sensitive to the on-going climate change/climatic instability (Fenu et al., 2017b and references therein).

Based on these common criteria, six regional lists (one per partner) and a global list of target plants in a need of conservation were compiled; then starting from the local list, each partner selected a further group of plants in an urgent need of *in situ* conservation actions. Following this procedure, a global list of 168 threatened taxa in the six Mediterranean islands was compiled, which includes mainly plants selected by the Regional Responsibility Criterion (79.07%) and plants assessed as threatened in the global and/or regional IUCN Red List (67.99%). Plants listed in the Habitat Directive, national or regional regulations and plants related to wetland areas accounted for 23.26% and 9.30%, respectively. Based on these conservation priorities, each partner worked on a set of target plants according to the available knowledge of a candidate species range, the main threats and biotic/abiotic requirements, as well as the feasibility of carrying out a translocation program. For each candidate species, all the existing data on extant and historical distribution, biology and ecology, and the main threats were examined to verify whether a translocation was the best solution to reduce the species extinction risk.

To date, 50 translocations (involving 45 taxa) have been implemented at six Mediterranean islands using a variety of protocols, which differed in type of translocation, site selection method, origin of the genetic material, type of propagated material (seeds or cuttings), and/or planting method (Tables 1 and 2).

The target species represented different life histories, mostly hemicryptophytes and chamaephytes, and a variety of habitats (ranging from sandy coasts and temporary ponds to mountain woods or rocky cliffs) (Table 1).

In the first phase, each partner collected the genetic material (mainly seeds) to be used for the production of new plants, while at the same time, each partner guaranteed the availability of the same material for future recovery or restoration programs through seedlots storage in seedbank and by implementing an "active collection" to be used for producing plants; in some cases, when it was not possible to make new seed collections, the seeds previously collected and stored in seedbanks were used. As an additional precautionary measure, accessions have been duplicated in the seedbanks of other project partners or, if necessary and appropriate, in other public institutions.

The plants were multiplied in botanical gardens and/or in public and private nurseries, depending on local needs, and the total number of the outplants produced varied depending on the type of plant (e.g. life form, seed availability, etc.), the presence/absence of biological or ecological limitations (e.g. difficulty to multiply the species, high mortality of the seedlings, etc.) or the translocation relevance (in term of number of plants; see Table 2).

Most of the translocations were planned as reinforcement for existing and threatened populations (44%), while other translocations consisted of reintroductions at sites where the plant had recently disappeared (not due to natural causes; 16%) or new populations at sites with no records of species occurrence in the past but with suitable ecological conditions (40%). In the majority of the latter two cases, selection of the microsites for planting was based on an expert-based criterion (Table 2). Our experience suggests that, although Species Distribution Modeling (SDMs) can efficiently delimit a range of potentially suitable areas, the final site selection should be made only by an expert whose decision-making takes into account many other variables, such as the real area availability, local political decisions, the acceptance by local communities, and so on.

Translocations have been implemented by using different plant material, mainly juvenile plants (64% of the total cases) and seeds (40%), followed by reproductive plants, seedlings and, in a few cases, bulbs (24, 14 and 2%, respectively); often a combination of different material type was used (40% of the total; Table 2). The effective realization of the translocations involved a wide range of protocols/options related to the target plants and the selected site for the translocation; in almost half of the cases, it was necessary to carry out preparatory actions (e.g. passive defense measures or control of invasive alien plants). Similarly, after outplanting, several actions were necessary (some of these were also repeated several times, such as supplementary watering in summer, control of alien species, etc.).

Finally, for each translocation a species-specific monitoring protocol was planned and implemented in order to ensure its sustainability; in particular, the monitoring activities were planned and implemented on a monthly basis for the 75% of the total translocations.

4. General lessons learned

All translocations were carried out recently (2017–2018), and for this reason, only preliminary data related to the first year after planting are available. It is therefore not possible to judge how successful particular programs and protocols were. However, some general lessons arise from the Care-Mediflora experience. It is widely recognized that translocations are useful tools to prevent the extinction of threatened species and to improve their conservation status (e.g. Maschinski and Duquesnel, 2006; Godefroid et al., 2011; Menges et al., 2016; Volis, 2017). However, Care-Mediflora approach confirms that severe limitations remain in the implementation of these conservation actions. In general, translocations are considered time-consuming activities, as they require several in-depth preparatory studies, a constant commitment to multiply the outplants, realize and monitor the activities, and a long-term monitoring plan to verify their effectiveness; in addition, translocation programs are considered economically expensive activities, because the pre- and post-translocation management actions required are generally high-priced. Actually, the factors that made translocation challenging, as well as stimulating, included limited human resources and availability of optimal hosting sites, bureaucratic difficulties encountered by working on both private and public properties, and the high uncertainty of success due to stochastic events.

Economic evaluation is relevant when working in territories particularly rich in threatened plant species, such as the Mediterranean islands, and when the economic resources are limited (Cogoni et al., 2013; Fenu et al., 2016). Although it is very complicated to make economic comparisons among different countries, the Care-Mediflora experience highlights that economic limitations are likely one of the most important constraints, and a detailed cost analysis is fundamental when planning a translocation. Considering all translocations carried out during the project, 80% of them required management actions that were complementary to outplanting, such as fencing, eradication of invasive alien species or weeding; these management actions are necessary both before and

Table 1
Translocations carried out within the Care-Mediflora project.

Taxon	Life form	Distribution type	Habitat type	Island	Selection Criteria	Locality	Type of translocation
Allium marathasicum Brullo, Pavone & Salmeri	G	ENE	Tree orchards	Cyprus	RL, RR	Prodromos, Platania and Amiantos (Troodos mountain)	Reinforcement
Anchusa crispa Viv.	H	IE	Coastal dunes	Corsica	RL, RR, HD	Del Sale (Aleria)	New population
Anchusa crispa Viv.	H	IE	Coastal dunes	Corsica	RL, RR, HD	Gradugine (Prunelli di Fiumorbu)	New population
Androcymbium rechingeri Greuter	G	W	Coastal sandy habitats	Crete	RL, HD	Elafonisi (Kantanou-Selinou)	Reinforcement
Anthemis tomentosa Boiss.	T	NE	Coastal sandy habitats	Cyprus	RL	Akamas and Gialia (Pafos)	New population
Arum sintenisii (Engl.) P.C.Boyce	G	NE	Olive orchards	Cyprus	RL, RR	Akamas (Pafos)	New population
Astragalus alopecurus Pall.	H	W	Shrublands	Corsica	RL, RR, HD	Punta Alta (Focicchia)	Reinforcement
Astragalus gennarii Bacch. et Brullo	Ch	ENE	Mountain shrublands	Sardinia	RR	Monte Albo (Lula)	Reinforcement
Astragalus rapahelis G. Ferro	T	NE	Badlands	Sicily	RL, RR	Vallone Piano della Corte (Enna)	New population
Astragalus suberosus Banks & Sol.	H	W	Coastal sandy habitats and phrygana	Cyprus	RL	Potamos Liopetriou and Kavo Greko (Ammochostos)	New population
Bellevalia brevipedicellata Turril.	G	NE	Phrygana	Crete	RL, RR	Elafonisi (Kantanou-Selinou)	Reinforcement
Bolanthus creutzburgi Greuter subsp. *zaffranii* Phitos, Turland & Bergmeier	Ch	ENE	Coastal screes	Crete	RL, RR	Palaiochora (Kantanou-Selinou)	Reinforcement
Centranthus trinervis (Viv.) Bég.	H	ENE	Rocky cliffs	Corsica	RL, RR, HD	Trinité (Bonifacio)	Reinforcement
Chaerophyllum creticum Boiss. & Heldr.	H	ENE	Rocky cliffs	Crete	RL, RR	Omalos, Lefka Ori (Platania)	Reinforcement
Crypsis hadjikyriakou Raus & H.Scholz	T	ENE	Peat grasslands	Cyprus	RL, RR	Almyrolivado and Passia Livadi (Limassol district)	Reinforcement and New population
Datisca cannabina L.	H	W	Stream banks	Crete	RL, WP	Nea Roumata (Platania)	Reinforcement
Dianthus morisianus Vals.	Ch	ENE	Coastal dunes	Sardinia	RL, RR	Portixeddu (Buggerru)	Reinforcement
Dianthus rupicola Biv. subsp. *rupicola*	Ch	RE	Rocky cliffs	Sicily	RR, HD	Isola Lachea e Faraglioni dei Ciclopi (Catania)	New population
Dichoropetalum kyriakae (Hadjik. & Alziar) Hand & Hadjik.	H	ENE	Open pine woodlands	Cyprus	RL, RR	Limassol District	Reinforcement
Dorycnium fulgurans (Porta) Lassen	Ch	NE	Coastal dunes	Balearic Islands	RR	Punta Prima (Santa Ponça)	Reinforcement
Dorycnium fulgurans (Porta) Lassen	Ch	NE	Coastal dunes	Balearic Islands	RR	Cap Negret (Santa Ponça)	New population
Euphorbia paralias L.	Ch	W	Coastal dunes	Cyprus	RL	Gialia (Pafos)	Reintroduction
Gentiana lutea L. subsp. *lutea*	G	W	Mountain grasslands	Sardinia	RR, HD	Monte Genziana (Talana)	Reintroduction
Horstrissea dolinicola Greuter, Gerstberger & Egli	G	ENE	Dolines	Crete	RL, RR	Skinakas (Anogion)	Reinforcement
Isoetes histrix Bory & Durieu	G	W	Temporary ponds	Balearic Islands	RR, WP	Clot d'Albarca, (Escorca)	New population
Kosteletzkya pentacarpos (L.) Ledeb.	H	W	Salt marshes	Corsica	RL, RR, HD, WP	Pinia (Ghisonaccia)	Reinforcement
Limonium creticum Artelari	Ch	RE	Coastal habitats	Crete	RL, RR	Matala (Faistos)	Reinforcement
Limonium elaphonisicum A.Mayer	Ch	NE	Coastal habitats	Crete	RL, RR	Elafonisi (Kantanou-Selinou)	Reinforcement
Limonium mucronulatum (H.Lindb.) Greuter & Burdet	H	ENE	Salt marshes	Cyprus	RL, RR	Alyki Larnakas (Larnaka)	Reinforcement
Linum maritimum L.	H	W	Coastal dunes/Salt marshes	Balearic Islands	RR	Pont dels Anglesos (Albufera d'Alcúdia)	Reintroduction
Linum maritimum L.	H	W	Coastal dunes/Salt marshes	Balearic Islands	RR	Es Comú (Albufera d'Alcúdia)	New population
Maresia nana (DC.) Batt var. *glabra* (Meikle) Christodoulou & Hand	T	ENE	Coastal dunes	Cyprus	RL, RR	Gialia (Pafos district)	Reinforcement
Muscari gussonei (Parl.) Nyman (=*Leopoldia gussonei* Parl.)	G	ENE	Coastal dunes	Sicily	RL, RR, HD	Biviere di Gela (Gela)	New population
Myosurus minimus L.	T	W	Temporary ponds	Balearic Islands	RL, RR, WP	Son Mut Nou (Llucmajor)	New population
Ononis crispa L.	Ch	IE	Coastal habitats	Balearic Islands	RR	Cabrera National Park	Reinforcement
Ononis zschackei F. Herm.	NP	ENE	Rocky stands	Balearic Islands	RR	Cúber (Escorca)	Reinforcement
Origanum onites L.	Ch	W	Rocky stands	Sicily	RR	Grotta Palombara (Syracuse)	New population
Peganum harmala L.	H	W	Roadsides	Cyprus	RL	Pyli Ammochostou (Nicosia)	Reintroduction

(*continued on next page*)

Table 1 (*continued*)

Taxon	Life form	Distribution type	Habitat type	Island	Selection Criteria	Locality	Type of translocation
Ranunculus bullatus L.	G	W	Shrublands	Balearic Islands	RL, RR	S'Aranjassa (Palma, Mallorca)	New population
Ranunculus sylviae Gamisans	H	ENE	Mountain shrublands	Corsica	RL, RR, WP	Bucchinera-Cuscionu (Serra-di-Scopamene)	New population
Reseda minoica Martín-Bravo & Jiménez-Mejías	T/H	W	Coastal cliffs	Crete	RL	Matala (Faistou)	Reinforcement
Rhamnus persicifolia Moris	P	NE	Riparian forests/ shrublands	Sardinia	RR, WP	Monte Genziana (Talana)	Reinforcement
Ribes sardoum Martelli	NP	ENE	Mountain shrublands	Sardinia	RL, RR, HD	Monte Corrasi (Oliena)	New population
Senecio morisii J.Calvo & Bacch.	H	NE	Wetlands	Sardinia	RR, WP	Funtanamela (Laconi)	New population
Silene velutina Loisel.	Ch	IE	Coastal habitats	Corsica	RL, RR, HD	Cornuta Islet (Zonza)	Reintroduction
Tripolium pannonicum (Jacq.) Dobrocz.	H	W	Salt marshes	Sicily	RR, WP	Saline di Priolo (Syracuse)	New population
Urtica rupestris Guss.	H	ENE	Shady outcrops	Sicily	RL, RR	Villasmundo-S.Alfio (Syracuse)	Two new populations
Viola scorpiuroides Coss.	Ch	W	Phrygana	Crete	RL	Elafonisi (Kantanou-Selinou)	Reinforcement

Life form abbreviations: T = Therophytes; H = Hemicryptophytes; Ch = Chamaephytes; G = Geophytes; NP = Nanophanerophytes; P = Phanerophytes. Distribution type categories are abbreviated according to the following scale: ENE = Extremely Narrow Endemic (only one population); NE = Narrow Endemic (≤five populations); RE = Regional Endemic (plants growing in only one Island); IE = Insular Endemic (plant growing in more than one island) and W = plants distributed in a wider area. Selection Criterion according to: inclusion in global/regional IUCN Red List (RL), regional responsibility criterion (RR), species listed in the annexes of Habitat Directive and/or in other national or regional regulations (HD) and the plants linked to wetland habitats (WP). The acronym "SDM" reported in the column "Site selection" indicate that the expert-based selection was supported by Species Distribution Model.

after translocation. Animal exclusion was the most frequent action, although this is not surprising given high grazing intensity throughout the Mediterranean. Even in other regions this is a common management practice when restoring rare and threatened plant species (Guerrant, 2012), greatly improving the demography of the introduced population over the short term (Godefroid et al., 2011; Fenu et al., 2016). In some cases, it was necessary to repeat or continue the post-translocation management actions such as eradication of alien species or control of the growth of surrounding vegetation. Clearly, the overall cost of a project will increase with the number and frequency of the after-care actions.

The costs of outplant production, on the other hand, are rather small compared to the total cost of a project, if efficient plant production protocols are available. Only in a few cases was outplant production expensive due to the involvement of specific treatments and fully controlled conditions during seedlings' growth in a greenhouse, as was the case with some relict plants represented by a single remnant population with limited sexual reproduction (e.g. *Ribes sardoum* Martelli, *Urtica rupestris* Guss., etc.). Thus, development of an efficient outplant production protocol, if the latter does not exist, is a way to reduce the cost of a translocation project. Significant cost reductions can also be achieved for the translocation program by the inclusion of researchers, public authorities, volunteers, and local stakeholders.

The Care-Mediflora experience also highlights the relevance of unexpected natural stochastic events that may affect the success of a translocation. In our project, such events mainly related to extreme weather conditions or the presence of feral animals, especially where no fences had been planned, which occurred in 40% of cases (Table 2). Extreme weather events are difficult to predict, but potential animal disturbance can be expected in the majority of the cases and, for this reason, fences (especially in the first years after transplanting) and/or protective fine chain-link fences should be used whenever possible.

Our experience confirms that, although there is a large number of endangered plants growing on private lands (and outside of the protected areas), translocations were more feasible on legally protected sites managed by public administration (76% of the total) rather than on private land (12% of the total; Table 2), as previously reported (e.g. Godefroid et al., 2011; Fenu et al., 2016); this should have clear implications for the choice of the optimal site, suitable habitat, and then the most suitable microsites.

In general, reinforcement of existing populations is considered a preferred option, while reintroductions and the creation of new populations are usually associated with greater uncertainty in terms of feasibility and success. To reduce this uncertainty, we used a precautionary approach in reintroduction projects by choosing only the sites where local extinction was due to human-mediated factors and not due to natural causes. Regarding the creation of new populations outside the known species range, several Care-Mediflora actions adopted a more positive perspective to assisted migration (colonization) than previous experiments. This perspective aligned with previous work that considered "facilitating species redistribution" (Bonebrake et al., 2018) as the only means to mitigate climate change-induced shifts in species range and to halt biodiversity loss (e.g. Hewitt et al., 2011; Thomas, 2011; Volis, 2016a, 2019).

From a practical point of view, two preliminary indications emerge after a year of monitoring. Generally, the initial survival rate seems related to the biological form: in the very short term, woody and shrub plant species reach the best performance with average survival rates of ca. 50% and therefore they seem to better tolerate the transplant shock. Secondly, after one year, the best results on average were obtained for translocations carried out using juvenile and reproductive plants; although exceptions have been observed, this preliminary indication is consistent with previous studies that have highlighted the advantages of using juvenile and reproductive plants rather than seeds or seedlings because they have usually higher survival rates than seedlings or seeds (Godefroid et al., 2011; Albrecht and Maschinski, 2012; Liu et al., 2015; Menges et al., 2016). More specifically, although it is not reasonable to draw conclusions after a few months of observation, the preliminary data indicate a lack of significant differences between translocations carried out using/planting juvenile or reproductive plants. This finding, if confirmed in the future, suggests that the use of juvenile plants would be preferable because they reduce the costs of production/maintenance/cultivation of plants in nursery, specifically, as in our case, when working with forbs, geophytes and (half)shrubs that

Table 2
Translocations carried out within the Care-Mediflora project. The acronym "SDM" reported in the column "Site selection" indicates that the expert-based selection was supported by the Species Distribution Model.

Taxon (and type of translocation)	Locality	Protection status	Land property	Site selection	Type of Material (and quantity)	Provenance/ source of material	Plant production/ Cultivation	Preliminary actions	Post-release measures	Causes of initial failures	Overall costs
Allium marathasicum (Reinforcement)	Prodromos, Platania and Amiantos (Troodos mountain)	Natura 2000 and National Forest Park	Public & Private	Site where the plant has become recently extinct	Juvenile and reproductive plants (139)	Same population	Greenhouse of ARI	None	None		7500 €
Anchusa crispa (New population)	Del Sale (Aleria)	Natura 2000 site; "Conservatoire du littoral" land	Public	Expert-based selection	Seeds (100) and juvenile plants (45)	Two different populations	Public nursery	None	None	Feral animals (e.g. boars, ants, etc.) Unexpected Storm	10,000 €
Anchusa crispa (New population)	Gradugine (Prunelli di Fiumorbu)	"Conservatoire du littoral" land	Public	Expert-based selection	Juvenile plants (127)	Two different populations	Public nursery	None	None	Storm	10,000 €
Androcymbium rechingeri (Reinforcement)	Elafonisi (Kantanou-Selinou)	Natura 2000 site	Public & Private	Expert-based selection and SDMs	Seeds (440) and seedlings (240)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		8000 €
Anthemis tomentosa (New population)	Akamas and Gialia (Pafos)	Natura 2000 and National Forest Park	Public	Expert-based selection	Reproductive plants (111)	More different populations	Greenhouse of ARI	None	None		16,500 €
Arum sintenisii (New population)	Akamas (Pafos)	Natura 2000 and National Forest Park	Public	Expert-based selection	Juvenile (63) and reproductive plants (63)	One different population	Greenhouse of ARI	None	None		7000 €
Astragalus alopecurus (Reinforcement)	Punta Alta (Focicchia)	Natura 2000 site	Public	Expert-based selection	Seeds (300)	One different population	None	Fence erection	Fence maintenance		20,000 €
Astragalus gennarii (Reinforcement)	Monte Albo (Lula)	None	Public	Expert-based selection and SDMs	Juvenile plants (250)	Same population	Public nursery	Control/removal of natural vegetation	Fence erection		12,000 €
Astragalus rapahelis (New population)	Vallone Piano della Corte (Enna)	Natura 2000 site and Nature Reserve.	Public & Private	Expert-based selection	Seeds (660)	Two different populations	None	Control/removal of natural vegetation	None		15,000 €
Astragalus suberosus (New population)	Potamos Liopetriou and Kavo Greko (Ammochostos)	Natura 2000 and National Forest Park	Public	Site where the plant has become recently extinct	Seeds (1080) and reproductive plants (18)	More different populations	Greenhouse of ARI	Removal of invasive species	Control of invasive species	Tourist activities in late spring (human trampling). Feral animals (i.e. hares)	17,000 €
Bellevalia brevipedicellata (Reinforcement)	Elafonisi (Kantanou-Selinou)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (350) and seedlings (350)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		8000 €
Bolanthus creutzburgi subsp. *zaffranii* (Reinforcement)	Palaiochora (Kantanou-Selinou)	None	Public & Private	Expert-based selection and SDMs	Seeds (180) and seedlings (151)	Same population	Nursery and Greenhouse of MAICh	None	Protective cages erection		8000 €
Centranthus trinervis (Reinforcement)	Trinité (Bonifacio)	Natura 2000 site; "Conservatoire du littoral" land	Public	Expert-based selection	Seeds (50) and juvenile plants (40)	Same population	Public nursery	None	None		20,000 €
Chaerophyllum creticum (Reinforcement)	Omalos, Lefka Ori (Platania)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (180) and seedlings (180)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		14,000 €
Crypsis hadjikyriakou (Reinforcement and New population)	Almyrolivado and Passia Livadi (Limassol)	Natura 2000 and National Forest Park	Public	Expert-based selection	Seeds (100) and reproductive plants (92)	Same population	Greenhouse of ARI	Removal of competing vegetation and invasive species	Control of competing vegetation and invasive species		7000 €
Datisca cannabina (Reinforcement)	Nea Roumata (Platania)	None	Public	Expert-based selection and SDMs	Seedlings (75)	Same population	Nursery and Greenhouse of MAICh	Removal of invasive (ornamental) species	None		10,000 €

(*continued on next page*)

Table 2 (*continued*)

Taxon (and type of translocation)	Locality	Protection status	Land property	Site selection	Type of Material (and quantity)	Provenance/ source of material	Plant production/ Cultivation	Preliminary actions	Post-release measures	Causes of initial failures	Overall costs
Dianthus morisianus (Reinforcement)	Portixeddu (Buggerru)	Natura 2000 site	Public	Expert-based selection	Reproductive plants (38)	Same population	Botanic Garden of Cagliari University (HBK)	Fence erection	None		18,000 €
Dianthus rupicola subsp. *rupicola* (New population)	Isola Lachea e Faraglioni dei Ciclopi (Catania)	Natura 2000 site and Nature Reserve.	Public	Expert-based selection	Juvenile plants (48)	Same population	Specialized nursery and Botanic Garden	Removal/ eradication of alien species	Natural vegetation restoration, control of alien species, Fence erection and Water support	Feral animals (i.e. rats)	25,000 €
Dichoropetalum kyriakae (Reinforcement)	Limassol	Natura 2000 and State Forest Land	Public	Expert-based selection	Seeds (448) and juvenile plants (64)	Same population	Greenhouse of ARI	None	Water support		7000 €
Dorycnium fulgurans (Reinforcement)	Punta Prima (Santa Ponça)	None	Public	Expert-based selection	Juvenile plants (150)	Same population	Soller Botanic Garden	None	Water support	Competition by other species, salt spray during marine storms	12,000 €
Dorycnium fulgurans (New population)	Cap Negret, (Santa Ponça)	None	Public	Expert-based selection - close to the natural population	Juvenile plants (50)	One different population	Soller Botanic Garden	None	None	Natural events (destruction by marine storms)	10,000 €
Euphorbia paralias (Reintroduction)	Gialia (Pafos)	Natura 2000 and State Forest Land	Public	Site where the plant has become recently extinct	Seeds (196) and juvenile plants (113)	More different populations	Greenhouse of ARI	None	None	Summer drought	6000 €
Gentiana lutea subsp. *lutea* (Reintroduction)	Monte Genziana (Talana)	None	Public	Sites where the plant has become recently extinct	Juvenile plants (200)	One different population	Public nursery	Fence erection and control/ removal of natural vegetation	Control/ removal of natural vegetation		30,000 €
Horstrissea dolinicola (Reinforcement)	Skinakas (Anogion)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (180) and seedlings (192)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		14,000 €
Isoetes histrix (New population)	Clot d'Albarca (Escorca)	Natural Park	Private	Close to the actual population	Adult plants (3)	Same population	Soller Botanic Garden	Temporal pond restoration	Control of natural vegetation		15,000 €
Kosteletzkya pentacarpos (Reinforcement)	Pinia (Ghisonaccia)	Natura 2000 site; "Conservatoire du littoral" land	Public	Expert-based selection	Juvenile plants (226)	Two different populations	Public nursery	None	None	Summer drought	20,000 €
Limonium creticum (Reinforcement)	Matala (Faistos)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (300) and juvenile plants (100)	Same population	Nursery and Greenhouse of MAICh	Removal of invasive species	Protective cages erection and control of invasive species		12,000 €
Limonium elaphonisicum (Reinforcement)	Elafonisi (Kantanou-Selinou)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (300) and juvenile plants (300)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		8000 €
Limonium mucronulatum (Reinforcement)	Alyki Larnakas (Larnaka)	Natura 2000 site	Public	Expert-based selection	Seeds (250) and reproductive plants (202)	Same population	Greenhouse of ARI	None	Fence erection, control of invasive species and competing vegetation		12,000 €
Linum maritimum (Reintroduction)	Pont dels Anglesos (Albufera d'Alcúdia)	Natural Park	Public	Site where the plant has become recently extinct	Juvenile plants (57)	Same population	Soller Botanic Garden	Removal of natural species	Water support during the first summer		14,000 €

Linum maritimum (New population)	Es Comú (Albufera d'Alcúdia)	Natural Park	Public	Expert-based selection - close to the natural population	Juvenile plants (71)	One different population	Soller Botanic Garden	None	Water support during the first summer	Summer drought	16,000 €
Maresia nana var. *glabra* (Reinforcement)	Gialia (Pafos)	Natura 2000 and State Forest Land	Public	Expert-based selection	Seeds (200) and reproductive plants (21)	Same population	Greenhouse of ARI	Removal of invasive species	Control of invasive species		11,500 €
Muscari gussonei (=*Leopoldia gussonei*) (New population)	Biviere di Gela (Gela)	Natura 2000 site and Nature Reserve.	Public	Expert-based selection	Bulbs (50)	One different population	None	None	None	Feral animals (i.e. grazing by wild goats and sheep)	15,000 €
Myosurus minimus (New population)	Son Mut Nou (Llucmajor)	None	Private	Expert-based selection - close to the natural population	Juvenile plants (129)	One different population	Soller Botanic Garden	None	Small fence erection	Feral animals (i.e. grazing by wild rabbits)	14,000 €
Ononis crispa (Reinforcement)	Cabrera National Park	Natural Park	Public	Expert-based selection	Juvenile plants (270)	Same population	Soller Botanic Garden	None	Water support for the first summer	Summer drought	17,000 €
Ononis zschackei (Reinforcement)	Cúber (Escorca)	Natura 2000 site and Natural Park	Public	Expert-based selection	Juvenile plants (82)	Same population	Soller Botanic Garden	None	Fence erection and water support the first summer	Summer drought Grazing by goats	15,000 €
Origanum onites (New population)	Grotta Palombara (Syracuse)	Nature Reserve.	Private	Expert-based selection	Juvenile plants (12)	One different population	Specialized nursery	None	Water support		10,000 €
Peganum harmala (Reintroduction)	Pyli Ammochostou (Nicosia)	None	Public	Site where the plant has become recently extinct	Juvenile plants (53)	One different population	Greenhouse of ARI	Removal of competing vegetation and ground preparation	Control of competing vegetation and water support		9500 €
Ranunculus bullatus (New population)	S'Aranjassa (Palma, Mallorca)	None	Private	Close to naturals population where only 2 plants where found	Adult plants (100)	Same population	Soller Botanic Garden	none	Watering only the first month		14,000 €
Ranunculus sylviae (New population)	Bucchinera-Cuscionu (Serra-di-Scopamene)	Natura 2000 site	Public	Expert-based selection - close to the natural population	Juvenile plants (48)	One different population	Public nursery	None	None	Trampling by livestock and summer visitors	20,000 €
Reseda minoica (Reinforcement)	Matala (Faistou)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (300)	Same population	None	None	Protective cages erection and control of invasive species		8000 €
Rhamnus persicifolia (Reinforcement)	Monte Genziana (Talana)	None	Public	Expert-based selection	Juvenile plants (154)	Two different populations	Public nursery	Control of natural vegetation and eradication of alien species	Water support		25,000 €
Ribes sardoum (New population)	Monte Corrasi (Oliena)	Natura 2000 site	Public	Expert-based selection	Juvenile plants (23)	Same population	Botanic Garden of Cagliari University (HBK)	None	Fence erection	Feral animals (i.e. grazing by wild goats and mouflons)	12,000 €
Senecio morisii (New population)	Funtanamela (Laconi)	None	Public	Expert-based selection	Juvenile plants (120)	Three different populations	Botanic Garden of Cagliari University (HBK)	Control of natural vegetation and eradication of alien species; fence erection	Control of natural vegetation and eradication of alien species	Unexpected storm (flood)	25,000 €

(*continued on next page*)

Table 2 (*continued*)

Taxon (and type of translocation)	Locality	Protection status	Land property	Site selection	Type of Material (and quantity)	Provenance/ source of material	Plant production/ Cultivation	Preliminary actions	Post-release measures	Causes of initial failures	Overall costs
Silene velutina (Reintroduction)	Cornuta Islet (Zonza)	Natura 2000 site.	Private	Site where the plant has become recently extinct	Seeds (150) and juvenile plants (316)	Three different populations	Public nursery	None	Fence erection and control of natural vegetation	Summer drought; plant competition; impacts of seabirds	25,000 €
Tripolium pannonicum (New population)	Saline di Priolo (Syracuse)	Natura 2000 site and Nature Reserve.	Public	Expert-based selection	Juvenile plants (42)	One different population	Specialized nursery	Removal/ eradication of alien species	Natural vegetation restoration and control of alien species; Water support	Unexpected storm (flood)	25,000 €
Urtica rupestris (Two new populations)	Villasmundo-S.Alfio (Syracuse)	Natura 2000 site and Nature Reserve.	Private	Expert-based selection	Juvenile plants (110)	One different population	Botanic Garden	Control of natural vegetation	Fence erection and Water support		25,000 €
Viola scorpiuroides (Reinforcement)	Elafonisi (Kantanou-Selinou)	Natura 2000 site	Public	Expert-based selection and SDMs	Seeds (300) and seedlings (300)	Same population	Nursery and Greenhouse of MAICh	None	Fence erection		8000 €

reach maturity within a few years and that the use of plants older than one-year old has no advantage. On the other hand, it is difficult to assess success in projects performed on annual plants or with direct sowing of seeds. The success of such projects can rarely be evaluated in the short-term, because seeds may enter the soil seed bank and persist there for years. As noted by Albrecht et al. (2018), little is understood about translocating annuals, for which there is no alternative to sowing. This, however, requires long-term monitoring. Additionally, the true success of translocation - regardless of life history - is only evident in successful recruitment of new generations (e.g. Bell et al., 2003; Godefroid et al., 2011; Fenu et al., 2016). Prolonged monitoring increases the probability that rare events with population effects will be detected (e.g. Monks et al., 2012; Duquesnel et al., 2017). In addition, when results of a translocation are evaluated through sufficiently long monitoring, poorly performing methods can be discarded and replaced with more effective ones (Kaye, 2008). The initial monitoring frequency during the Care-Mediflora project (monthly in majority of the cases, 75%), was found to be too costly for the Mediterranean islands (as earlier suggested by Cogoni et al., 2013 and Fenu et al., 2016). For this reason and the reasons described above, each partner committed to a less intensive but long-term monitoring protocol including at least five years after completion of the project.

5. Concluding remarks

The Mediterranean insular territories, which share an extraordinary rate of endemism coupled with a remarkable degree of environmental and human-related threats, provide an opportunity to combine different methods and methodologies within a common conservation strategy focusing on endangered plants. In addition, due to their limited area, discrete nature, and simplified food webs, islands can represent “natural laboratories” for ecological studies, including translocation experiments. The Care-Mediflora project represents the first attempt to develop common strategies and an opportunity to join and integrate methods and methodologies focused on threatened plant conservation in the Mediterranean islands. The project's actions represent a step forward for the conservation of the Mediterranean flora, and perhaps a basis for planning conservation measures for the other species threatened with extinction if our experiences are replicated in partner countries (at a larger scale), as well as in other Mediterranean countries with similar environmental conditions. Furthermore, translocations have a relevant social-cultural impact and strengthen fruitful collaborations among national and regional administrations, as well as NGOs and local stakeholders (Maschinski and Duquesnel, 2006). For this reason, an important activity of Care-Mediflora project was dedicated to sharing knowledge and experiences among partners and adopting common protocols. Care-Mediflora project participants from all islands shared differences in translocation protocols at meetings to develop the technical aspects, refine methodologies, and plan successful *in situ* conservation actions. At the same time, each partner has actively involved the local and regional authorities and local stakeholders (in particular in the monitoring activities) to make the translocations more effective.

Finally, the translocations carried out during the Care-Mediflora project represent an important contribution to the achievement of the EU Biodiversity Strategy to 2020 (i.e. target 6) and several Aichi Targets (e.g. 11, 12 and 19) but in particular to the implementation of the *in situ* conservation measures advocated by Aichi Target 12.

Conflicts of interest

None declared.

Acknowledgements

MAVA Foundation is gratefully acknowledged for financially supporting (80%) the CARE-MEDIFLORA project. The authors wish to thank all those people who gave their contribution to the Care-Mediflora project. The authors are also grateful to the Editor and the anonymous reviewer for helpful comments.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pld.2019.03.001.

References

Albrecht, M.A., Maschinski, J., 2012. Influence of founder population size, propagule stages, and life history on the survival of reintroduced populations. In: Maschinski, J., Haskins, K.E. (Eds.), Plant Reintroduction in a Changing Climate. Island Press, Washington, pp. 171–188.

Albrecht, M.A., Guerrant, E.O., Maschinsky, J.M., Kennedy, K.L., 2011. A long-term view of rare plant reintroduction. Biol. Conserv. 144, 2557–2558.

Albrecht, M.A., Osazuwa-Peters, O.L., Maschinski, J., Bell, T.J., Bowles, M.L., Brumback, W.E., Duquesnel, J., Kunz, M., Lange, J., McCue, K.A., McEachern, A.K., Murray, S., Olwell, P., Pavlovic, N.B., Peterson, C.L., Possley, J., Randall, J.L., Wright, S.J., 2018. Effects of life history and reproduction on recruitment time lags in reintroductions of rare plants. Conserv. Biol. (in press) https://doi.org/10.1111/cobi.13255.

Bell, T.J., Bowles, M.L., McEachern, A.K., 2003. Projecting the success of plant population restoration with viability analysis. In: Brigham, C.A., Schwartz, M.W. (Eds.), Population Viability in Plants. Springer, Berlin, Heidelberg, pp. 313–348.

Bonebrake, T.C., Brown, C.J., Bell, J.D., Blanchard, J.L., Chauvenet, A., Champion, C., Chen, I.-C., Clark, T.D., Colwell, R.K., Danielsen, F., Dell, A.I., Donelson, J.M., Evengard, B., Ferrier, S., Frusher, S., Garcia, R.A., Griffis, R.B., Hobday, A.J., Jarzyna, M.A., Lee, E., Lenoir, J., Linnetved, H., Martin, V.Y., McCormack, P.C., McDonald, J., McDonald-Madden, E., Mitchell, N., Mustonen, T., Pandolfi, J.M., Pettorelli, N., Possingham, H., Pulsifer, P., Reynolds, M., Scheffers, B.R., Sorte, C.J.B., Strugnell, J.M., Tuanmu, M.-N., Twiname, S., Verǵes, A., Villanueva, C., Wapstra, E., Wernberg, T., Pecl, G.T., 2018. Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science. Biol. Rev. 93, 284–305.

Brancaleoni, L., Gerdol, R., Abeli, T., Corli, A., Rossi, G., Orsenigo, S., 2018. Nursery pre-treatments positively affects reintroduced plant performance via plant preconditioning, but not maternal effects. Aquat. Conserv. 28, 641–650.

Butchart, S.H.M., et al., 2010. Global biodiversity: indicators of recent declines. Science 328 (5982), 1164–1168.

Cañadas, E.M., Fenu, G., Peñas, J., Lorite, J., Mattana, E., Bacchetta, G., 2014. Hotspots within hotspots: endemic plant richness, environmental drivers, and implications for conservation. Biol. Conserv. 170, 282–291.

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M., Palmer, T.M., 2015. Accelerated modern human–induced species losses: entering the sixth mass extinction. Sci. Adv. 1, e1400253.

Cogoni, D., Fenu, G., Concas, E., Bacchetta, G., 2013. The effectiveness of plant conservation measures: the *Dianthus morisianus* reintroduction. Oryx 47 (2), 203–206.

Commander, L.E., Coates, D., Broadhurst, L., Offord, C.A., Makinson, R.O., Matthes, M., 2018. Guidelines for the Translocation of Threatened Plants in Australia, third ed. Australian Network for Plant Conservation, Canberra.

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J.-P., Iglesias, A., Lange, M.A., Lionello, P., Llasat, M.C., Paz, S., Peñuelas, J., Snoussi, M., Toreti, A., Tsimplis, M.N., Xoplaki, E., 2018. Climate change and interconnected risks to sustainable development in the Mediterranean. Nat. Clim. Change 8, 972–980.

Duquesnel, J.A., Maschinski, J., McElderry, R., Gann, G.D., Bradley, K., Cowan, E., 2017. Sequential augmentation reveals life history and suitable conditions for colonization of the rare mahogany mistletoe in South Florida. Restor. Ecol. 25 (4), 516–523.

Falk, D.A., 1987. Integrated conservation strategies for endangered plants. Nat. Area J. 7, 118e123.

Fenu, G., Cogoni, D., Bacchetta, G., 2016. The role of fencing in the success of threatened plant species translocation. Plant Ecol. 217 (2), 207–217.

Fenu, G., Bacchetta, G., Giacanelli, V., Gargano, D., Montagnani, C., Orsenigo, S., Cogoni, D., Rossi, G., Conti, F., Santangelo, A., Pinna, M.S., Bartolucci, F., Domina, G., Oriolo, G., Blasi, C., Genovesi, P., Abeli, T., Ercole, S., 2017a. Conserving plant diversity in Europe: outcomes, criticisms and perspectives of the Habitats Directive application in Italy. Biodivers. Conserv. 26, 309–328.

Fenu, G., Giusso del Galdo, G.P., Montmollin, B. de, Gotsiou, P., Cogoni, D., Piazza, C., Fournaraki, C., Kyratzis, A., Vicens, M., Christodoulou, C.S., Bacchetta, G., 2017b. Active management actions for the conservation of the endangered Mediterranean island flora: the CARE-MEDIFLORA project. Plant Sociol. 54 (2 Suppl. 1), 101–110.

Godefroid, S., Piazza, C., Rossi, G., Buord, S., Stevens, A.-D., Aguraiuja, R., Cowell, C., Weekley, C.W., Vogg, G., Iriondo, J.M., Johnson, I., Dixon, B., Gordon, D., Magnanon, S., Valentin, B., Bjureke, K., Koopman, R., 2011. How successful are plant species reintroductions? Biol. Conserv. 144, 672–682.

Guerrant Jr., E.O., 2012. Characterizing two decades of rare plant reintroductions. In: Maschinski, J., Haskins, K.E. (Eds.), Plant Reintroduction in a Changing Climate: Promises and Perils. Island Press, Washington, DC, pp. 9–29.

Hewitt, N., Klenk, N., Smith, A.L., Bazely, D.R., Yan, N., Wood, S., MacLellan, J.I., Lipsig-Mumme, C., Henriques, I., 2011. Taking stock of the assisted migration debate. Biol. Conserv. 144, 2560–2572.

Heywood, V.H., 1993. The role of botanic gardens and arboreta in the *ex-situ* conservation of wild plants. Opera Bot. 121, 309–312.

Heywood, V.H., 2014. An overview of *in situ* conservation of plant species in the Mediterranean. Flora Mediterr. 24, 5–24.

Heywood, V.H., 2016. *In situ* conservation of plant species e an unattainable goal? Isr. J. Plant Sci. 63, 211–231.

Heywood, V.H., 2017. Plant conservation in the Anthropocene – challenges and future prospects. Plant Divers. 39, 314–330.

Heywood, V.H., 2019. Conserving plants within and beyond protected areas – still problematic and future uncertain. Plant Divers. 41, 36–49.

IPCC, W.G.I., 2013. Climate change 2013: the physical science basis. In: Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

IUCN/SSC, 2013. Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. IUCN Species Survival Commission, Gland, Switzerland.

Kaye, T.N., 2008. Vital steps toward success of endangered plant reintroductions. Native Plants J. 9 (3), 313–322.

Laguna, E., Navarro, A., Pérez-Rovira, P., Ferrando, I., Ferrer-Gallego, P., 2016. Translocation of *Limonium perplexum* (Plumbaginaceae), a threatened coastal endemic. Plant Ecol. 217, 1183–1194.

Liu, H., Ren, H., Liu, Q., Wen, X., Maunder, M., Gao, J., 2015. Translocation of threatened plants as a conservation measure in China. Conserv. Biol. 29, 1537–1551.

Maschinski, J., Duquesnel, J., 2006. Successful reintroductions of the endangered long-lived Sargent's cherry palm, *Pseudophoenix sargentii*, in the Florida Keys. Biol. Conserv. 134, 122–129.

Maunder, M., Higgens, S., Culham, A., 2001. The effectiveness of botanic garden collections in supporting plant conservation: a European case study. Biodivers. Conserv. 10, 383–401.

Maunder, M., Havens, K., Guerrant, E.O., Falk, D.A., 2004. *Ex situ* methods: a vital but underused set of conservation resources. In: Guerrant, E.O., Havens, K., Maunder, M. (Eds.), *Ex situ* Plant Conservation. Supporting Species Survival in the Wild. Island Press, Washington, DC, USA, pp. 3–20.

Médail, F., Quézel, P., 1997. Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Ann. Missouri Bot. Gard. 84, 112–127.

Meek, M.H., Wells, C., Tomalty, K.M., Ashander, J., Cole, E.M., Gille, D.A., Putman, B.J., Rose, J.P., Savoca, M.S., Yamane, L., Hull, J.M., 2015. Fear of failure in conservation: the problem and potential solutions to aid conservation of extremely small populations. Biol. Conserv. 184, 209–217.

Menges, E.S., Smith, S.A., Weekley, C.W., 2016. Adaptive introductions: how multiple experiments and comparisons to wild populations provide insights into requirements for long-term introduction success of an endangered shrub. Plant Divers. 38, 238–246.

Monks, L., Coates, D., Bell, T., Bowles, M.L., 2012. Determining success criteria for reintroductions of threatened long-lived plants. In: Maschinski, J., Haskins, K.E. (Eds.), Plant Reintroduction in a Changing Climate. Island Press, Washington, DC, pp. 189–208.

Noël, F., Prati, D., Kleunen, M., Gygax, A., Moser, D., Fischer, M., 2011. Establishment success of 25 rare wetland species introduced into restored habitats is best predicted by ecological distance to source habitats. Biol. Conserv. 144, 602–609.

Orsenigo, S., 2018. How to halt the extinction of wetland-dependent plant species? The role of translocations and restoration ecology. Aquat. Conserv. 28, 772–775.

Piazza, C., Hugot, L., Richard, F., Schatz, B., 2011. Bilan des opérations de conservation *in situ* réalisées entre 1987 et 2004 en Corse: quelles leçons pour demain? Ecol. Mediterr. 37 (2), 7–16.

Pimm, S.L., Russel, G.J., Gittleman, J.L., Brooks, T.M., 1995. The future of Biodiversity. Science 269 (5222), 347–350.

Rita, J., Cursach, J., 2013. Creating new populations of Apium bermejoi (Apiaceae), a critically endangered endemic plant on Menorca (Balearic Islands). Anales J. Bot. Madrid 70, 27–38.

Thomas, C.D., 2011. Translocation of species, climate change, and the end of trying to recreate past ecological communities. Trends Ecol. Evol. 26, 216–221.

Thompson, J.D., 2005. Plant Evolution in the Mediterranean. Oxford University Press, Oxford, UK.

Vogiatzakis, I.N., Mannion, A.M., Sarris, D., 2016. Mediterranean island biodiversity and climate change: the last 10,000 years and the future. Biodivers. Conserv. 25 (13), 2597–2627.

Volis, S., 2016a. Conservation meets restoration – rescuing threatened plant species by restoring their environments and restoring environments using threatened plant species. Isr. J. Plant Sci. 63, 262–275.
Volis, S., 2016b. Species-targeted plant conservation: time for conceptual integration. Isr. J. Plant Sci. 63, 232–249.
Volis, S., 2017. Complementarities of two existing intermediate conservation approaches. Plant Divers. 39, 379–382.
Volis, S., 2019. Killing two birds with one stone: conservation-oriented restoration as a way to restore threatened species and their habitats. Plant Divers. 41, 50–58.