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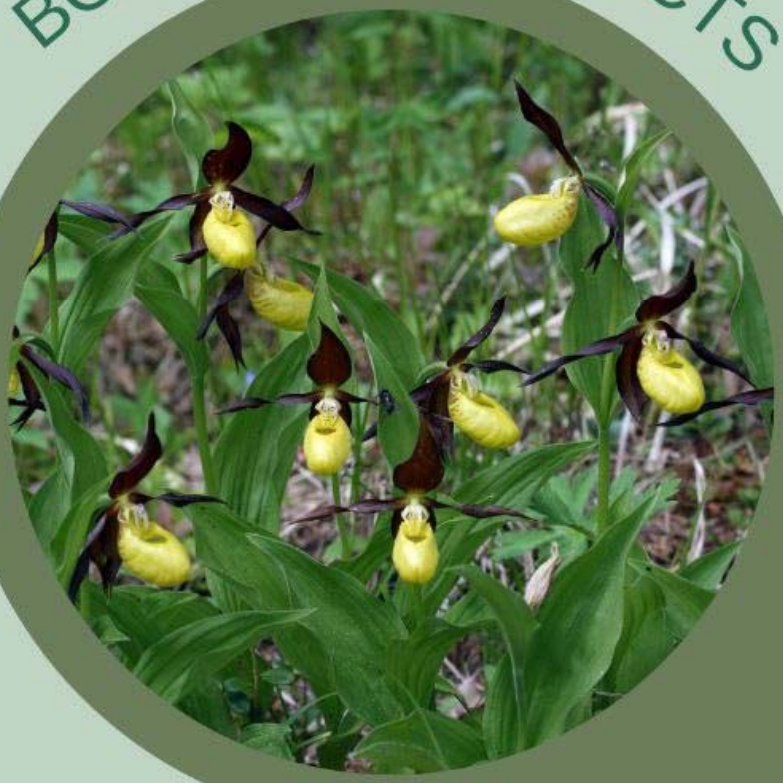
BOOK OF ABSTRACTS



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KEYNOTE SPEAKERS

Tackling challenges to escalate conservation translocations of plants globally

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Plant conservation translocations work in concert with other approaches to avert regional or global extinction, strengthen or restore ecosystems, and yield broader benefits for biodiversity and humanity. Questions abound on where and how such efforts could escalate further, especially to help achieve global conservation targets by 2030. Potential approaches may challenge established paradigms; decisions must involve improved engagement of diverse stakeholders that reflect ecological, economic, sociological, and cultural perspectives on potential benefits, risks, and associated uncertainties. While plant conservation translocation science and practice is well-established in economically advantaged countries for terrestrial and marine environments, an associated biodiversity paradox is that many regions with the richest diversity and greatest conservation need receive relatively little support. In addition to common sources of organisms from populations under human care or wild populations, potential opportunities may lie in utilizing salvaged or confiscated specimens if genetic, disease, and ecological considerations can be sufficiently addressed. The most imperiled group of species are those that are Extinct in the Wild. Such plants are rarely returned to the wild despite tremendous resources and commitments by botanical gardens and a reversal of such trends could serve as an iconic beacon of hope for conservation in general. Controversially, one aspect that may be fundamental for recovery, but is not sufficiently addressed in global policy, is increased use of assisted

colonization whereby species would be introduced to environments beyond their indigenous range. Implications abound further in the contexts of rewilding and even De-extinction. The IUCN Conservation Translocation Specialist Group aims to work with and empower others to tackle associated issues for plants and other species by escalating science, guidance, policy, training, action, and outreach by 2030.

Ecological restoration for threatened species conservation

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Threatened species are the result of the interaction of human activities rupturing the equilibria that underpin all life on earth. Thus, with more than a million species under threat of extinction, these species are key indicators of how habitats are degrading more rapidly than conservation can protect, with most threatened species unlikely to have suitable habitats within the next two decades. This dilemma of species habitat loss has resulted in the UN declaring the Decade of Ecosystem Restoration where, amongst livelihood concerns, the creation of habitats for biodiversity is a key component. In concert with the UN Decade, the Society for Ecological Restoration has derived its principles and standards for ecological restoration that provide a robust and universal means for ensuring that restoration of habitats gives the best possible outcome. Importantly, the Standards provide surety that investments in habitat creation for threatened species conservation do result in a net gain for nature and for threatened species. However the next decade is the turning point for species – only humans can use restoration to ensure a future planet has secure environments that are well managed for biodiversity and threatened species.

Adaptive management improves reintroduction outcomes with an endangered perennial legume (*Astragalus bibullatus*)

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Keywords: grassland, habitat quality, herbivory, translocation

The primary goal of reintroduction is to create genetically diverse, resilient, and self-sustaining populations, often across multiple sites in the landscape. However, meta-analyses show that many reintroductions fail to persist, primarily due to a poor understanding of species' biology and uncertainties in habitat requirements and management needs. Applying an adaptive management (AM) framework to reintroduction programs may help overcome these uncertainties and improve outcomes. Here, we use sequential experiments and demographic monitoring applied in an AM framework to improve reintroduction outcomes of the endangered *Astragalus bibullatus* (Pyne's ground-plum), a perennial herb narrowly endemic to Nashville Basin limestone glades and woodlands. In the first reintroduction experiment (2001), results supported using mixed-population sources and transplanting seedlings in autumn rather than spring. However, next generation recruitment was insufficient to compensate for mortality of the initial transplants, which led to population extinction. In subsequent experiments from 2012-2020, we used knowledge gained in previous reintroductions, and then applied the AM cycle to test the effects of caging, rhizobia inoculation, restoration technique, and habitat conditions on reintroduction success. Caging transplants to exclude mammalian herbivores dramatically increased growth, flowering,

and seed production relative to uncaged transplants, but only at sites with suitable bedrock geology and hydrological conditions. In low quality habitat, introducing large, genetically diverse populations did not promote population growth. Compared to caging, rhizobia inoculation did not consistently improve demographic performance. With caging, demographic performance is maximized in open microhabitats with well-drained soils, minimal competition, and presence of a more widespread congener. Applying knowledge gained from monitoring and sequential AM experiments resulted in improved demographic performance of reintroduced populations over time. Although no next generation seedling recruitment has occurred, some reintroductions produce greater quantities of viable seed than natural populations. Our study highlights the need to integrate AM with long-term monitoring to increase reintroduction success.

Conservation translocations as part of habitat restoration in southern Belgium

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Keywords: plant reintroduction, ex situ propagation, demographic survey, grassland restoration

Species-rich grasslands suffer from significant loss and degradation all over the world. In particular in lowland Europe, the vast majority of these habitats are in an unfavourable conservation status which requires urgent restoration measures. For most species typical of the targeted habitats, seed sowing and hay transfer are used. However, these techniques cannot be envisaged for critically endangered species as they are too scarce in the seed source sites. In the framework of the European project "LIFE Herbages" (LIFE11 NAT/BE/001060), Meise Botanic Garden, as a centre of excellence in ex situ conservation and plant propagation, has implemented conservation translocations of four critically endangered species (*Dianthus deltoides, Helichrysum arenarium, Arnica montana* and *Campanula glomerata*). Seeds have been collected on a minimum of 50 individuals per species in two to seven source populations in the closest possible similar habitats. Prior to transplantation, morphometric measures (vegetative plant size) were recorded on each plant. For each species, between 3 and 6 populations of 500 to 700 plug plants each were transplanted in 2014 and 2015. A demographic survey is performed yearly on the field. The variables recorded are:

survival and flowering rates, number of flowering stalks, number of flowers (or flower heads) and rosette diameter (or plant height). New individuals produced by the transplants are also counted in order to monitor population growth. The approach adopted for the implementation of these translocations as well as some of the results obtained after 6 years will be presented.

Assisted migration of threatened plants: looking further afield when plant reintroductions fail

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Keywords: assisted colonization, climate change, conservation translocations

When reintroductions fail, the practitioners involved are often the best people to comment on the causes of failure; competition from other plants, overgrazing from feral herbivores and lack of mutualistic fungi have all been cited as reasons for high mortality post-translocation. However, a frequently cited cause of failure is adverse weather – too hot, too dry or flooding that washed precious propagules away – and this is indicative of something that practitioners are less adept to recognise: the early signs of climate change. No-one in the conservation community doubts the existence of climate change and yet our inability to perceive incremental change and subsequent collective caution to act is hindering our progress towards addressing this global threat. Whilst we cannot directly influence global carbon emissions, we *can* think more pro-actively about how to manage threatened species with the knowledge that conditions will likely get worse in the near future and beyond. One possible tool is to apply our reintroduction expertise to conservation translocations that move plants to new habitats. Also known as assisted migration, assisted colonisation, managed relocation and under the IUCN-approved term of conservation introductions, these are techniques that invoke controversy and we have been justifiably slow to adopt. This plenary provides an overview of possible approaches to plant translocations that respond to, and plan for, current and future climate change. I hope to prompt translocation practitioners to be cognisant of climate deterioration and provide options for choosing a pragmatic path

between the risks of translocation to novel habitat and the risk that we lose plant species as a result of inaction.

Plant translocation in urban and agriculture landscapes

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Keywords: *on farm* translocation, organic farming, plant conservation, public awareness.

The human activities in the last century led to the alteration of 75% of Earth's land surface and loss of 85% of wetland areas with consequently degradation of ecosystems and associated loss of species. In order to mitigate this 'biodiversity crisis' new conservation paradigms are required. The increased demand of food produced through sustainable agriculture and the request of more nature in the cities have resulted in localised amelioration of intensive management imposed by agroecosystems and creation of micro-habitats inside urban areas. However, these newly available suitable habitats are often isolated and plant species may not be able to recolonise fragmented ecosystems from where they have been extirpated. Plant reintroduction can overcome dispersal limitation in urban areas and agroecosystems but need to be supported by farmers and local stakeholders' involvement, otherwise may generate conflicts.

I discuss practical implications referring to cases experienced in the last years in agricultural and urban areas in the Po Valley (Northern Italy), one of the most densely populated and cultivated areas in Europe.

Guidelines for the Translocation of Threatened Plants in Australia

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Keywords: translocation, guidelines, Australia, threatened plants

Developing best practice guidelines can make a positive difference in plant translocation. The Australian Network for Plant Translocation first published the Guidelines for the Translocation of Threatened Plants in Australia (Translocation Guidelines) in 1997, followed by a second edition in 2004. The third editon was pubblished in 2018, with input from over 30 experts across the country and included 23 new case studies, all new colour photographs illustrating translocation techniques, and updated references showcasing the latest research.

In this presentation, both the process of updating the Translocation Guidelines will be outlined, as well the content. Thus, we will demonstrate the importance of best practice guidelines, and how they can bring people from a many sectors (government, non-government, research, commercial, and volunteer). Also, we will communicate an overview of the latest research and practice on plant translocation. This talk will be particually relevant for anyone considering writing Translocation Guidelines for their

juristiction, informing policy makers, looking for resources for students as well as those seeking a comprehensive overview of the translocation process.

The Translocation Guidelines follows the entire translocation process from preparation to implementation, monitoring and assessment. Starting with a brief history of translocations in Australia, the publication then outlines the decision making process and helps define goals and objectives. Then, a chapter on assessment of biology and ecology follows, with information on site selection. This assessment process feeds into the translocation proposal, covered in the next chapter, along with information on the approvals process. Information on pre-translocation prepartation, implementation and ongoing maintenance then follow. Guieance for monitoring and evaluation complete the translocation process. The final chapter discusses community participation and support, which can happen throughout the life of the project.

We are very grateful for the generosity of the authors of the Guidelines, and the project received funding from the National Environmental Science Program's Threatened Species Hub.

Working Together to End Plant Extinction: the CPC Plant Conservation Guidelines and Online Resources

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Keywords: plant conservation, conservation tools, reintroduction

With 36% of plant species at risk of extinction worldwide, the Center for Plant Conservation strives to prevent extinction and recover imperiled native plants. Since 1984, the Center for Plant Conservation (CPC) and its network of world-class botanical institutions has been conducting rare plant conservation. By 2022, the CPC network collectively held over one-half of the globally rare plant species of the United States, its territories, and Canada (2208 taxa of 4400) in conservation collections. In making and using our rare plant collections, CPC scientists have developed expertise and have experienced many triumphs and challenges. Our research on endangered plants has resulted in peer-reviewed publications covering fundamentals of plant conservation practice including seed storage behavior in conventional, in vitro, and cryopreservation systems, germination, propagation, genetics, and reintroduction. CPC scientists have collaborated to generate the *CPC Best Plant Conservation Practices to Support Species Survival in the Wild* that form the basis of rigorous plant conservation practice worldwide. These guidelines are available as a free online resource at the CPC Rare Plant Academy (saveplants.org/cpc-rare-plant-academy/). CPC is committed to providing technical and scientific expertise to plant conservation practitioners and advancing plant conservation science. To this end, we have expanded our conservation partners to include professional plant conservationists and students. We are currently

developing the CPC Applied Plant Conservation Course. Look for the first modules in the fall 2022! Reintroduction guidelines and course modules help practitioners plan for the best success for plant reintroductions. In addition, we are revitalizing the CPC International Reintroduction Registry, which lists reintroductions for which we have records. Contributors are welcome to contact us regarding opportunities to use the full set of database as a scientific resource. We believe that bringing together the world's plant conservation experts will make a meaningful difference in preserving plant diversity for future generations.

Translocations of threatened plants in the Mediterranean Basin: current status and future directions

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The Mediterranean Basin is at the same time one of the world's plant diversity hotspots and a region prone to several anthropic pressures besides being one of the world areas most susceptible to climate change. The combination of these features makes the Mediterranean Basin a challenging but critical focal point for the conservation of plant diversity. In this region, hosting a high percentage of threatened species, there has been a large increase in practical conservation actions to prevent the extinction of many plants or to improve their conservation status. In this framework, plant translocations have become increasingly important and, as occurred worldwide, the number of these actions has sharply increased in recent decades. However, an updated state of the art is lacking and several technical-scientific issues related to plant translocations remain unresolved.

To obtain a picture of the current status and to depict possible future directions, data on plant translocations was collected through the available databases, several national experts and the gray bibliography available online. Overall a list of about 800 translocations relating to 560 plant species, 80% of which are threatened at national or local level, were found. These actions are mainly concentrated in Spain, France and Italy (c. 90% of the total) and, except for some pioneering actions, translocations have strongly increased starting from 2010.

In a second step, it was verified how much information relating to plant translocations was documented in the scientific literature through an in-deep bibliographic search on the main scientific databases This search resulted in a list of 646 peer-reviewed papers,

which were subsequently analyzed in detail. Finally, only 22 articles provide a description of one or more translocations, reporting 79 experiences carried out on 57 plant species. Interestingly a large number of articles simply suggest the implementation of translocations as the last chance to avoid the extinction of threatened species, without any additional information.

Our research highlighted a great discrepancy between the scarce scientific documentation available compared to the large number of practical conservation actions carried out. The great experience gained in these translocations, involving different plant species and territories, constitutes an enormous heritage potentially available to implement those conservation actions necessary to preserve the plant diversity of the Mediterranean basin. A first step could be to compile a plant translocation database, highlighting the methodologies adopted and the success/failure of conservation actions, especially for threatened plants; such effort certainly requires a greater cooperation between scientists and conservationists.

ORAL PRESENTATIONS

“We’re all on a huge learning curve”. What works, what doesn’t and why do we do it? A perspective of Australian translocation practitioners.

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Keywords: practitioner experience, success, failure, unanticipated outcome, storytelling

Published translocation literature necessarily focuses on the quantified components of the project; number, survival, reproduction and recruitment. But practitioners know some of the most interesting parts of a translocation are unanticipated, unobserved, and anecdotal. Through detailed interviews with 20 mitigation and 30 conservation Australian translocation practitioners, we have explored the qualitative and quantitative aspects of translocation practice including timelines, resourcing and fundamental similarities and differences with best practice guidelines. By contrasting the experiences of mixed groups, including researchers, consultants, government and community, we have consolidated consistent learning of what works, what doesn’t and what should be improved. The results surprised us; contrary to expectations we found many practitioners felt the resources provided were adequate, even when they received little to no funding, and that there was unequivocal value attributed to the work regardless of success or budget. The key unifying features of all experiences were the inability to reliably predict timelines and outcomes, the distinctness of each translocation based on the species and it’s ecology, the value of teams (even where they differed on opinions) and an almost universal absence of quantified un-costed contributions. There was also

a broad reticence to provide details of costed budgets. Practitioners who undertook translocations, felt an intrinsic responsibility to the species, the people and conservation, regardless of their field.

The role of aftercare: increasing threatened species survival and reducing the risk of failure in challenging plant translocations

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Keywords: plant translocation, aftercare, post-translocation management, policy species

Plant translocation aims at preserving threatened species through the establishment of long-term resilient and self-sustaining plant population. Although several plant translocations have been performed, some of them have not succeeded because of failure in pre-translocation phases (e.g., erroneous recipient site selection) but especially in the post-translocation phases, that include the long-term monitoring of translocated plants and post-release site management, i.e., aftercare.

Competition, predation and drought affect negatively the success of translocated plants and their control through adaptive management (weeding, fencing, irrigation) has been demonstrated to positively impact post-translocation establishment and survival of the species. Although methodological advances have been made in pre-translocation phases thanks to several studies and guidelines, post-translocation actions require further attention.

We reviewed the literature on plant translocation to shed light on the relevance of aftercare on the success of translocated species; moreover, a meta-analysis was conducted to evaluate the effect of aftercare compared to a control (i.e., no action).

We selected 158 projects from published articles (77), books (17), grey literature (59), Citizen Science projects (2) and websites (3). Plant translocations were conducted from 1978 to 2021 in 29 countries on 285 taxa. Aftercare consisted mainy in protecting

plants, providing water, reducing competition, improving soil/topo-/hydrographic characteristics, facilitating reproduction and managing plant directly. Percentage of survivorship was 46% in 118 research projects whereas 40 projects evaluated only the effect (34 positive, 6 negative). Moreover, 19 projects out of 22 reported positive effect of aftercare compared to no action; the activities were pro-active and regarded fencing, invasive species control and water irrigation.

This work shows the link between management activities and success of translocations and demonstrates that aftercare practices increase chance of survival of threatened species, necessary for conservationist to reduce the risk of failure for challenging translocations and not wasting resources.

Reintroduction of Rare and Endangered Plants in the world and China

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Keywords: translocation, reintroduction, rare and endangered plant, climate change.

The reintroduction of species is the deliberate establishment of individuals of a species in an area and/or habitat where it has become extinct or nearly extinct. There are several procedures and guidelines for reintroductions. Reintroduction procedures for rare and endangered plant focused on “why, when, where, what, who, and how” and involves in pre-project activities, preparation and release stages, and post-release activities. About 2,044 papers on plant reintroduction were searched out in the ISI database in January, 2020. Worldwide, it has been attempted to reintroduce for about 2300 taxa around world. Most of the papers reported reintroduction cases. Nowadays, reintroduction biology has been established as an important tool for biodiversity conservation. Some papers focused on reintroduction and ecological restoration under global climate. A protocol has been established for reintroducing rare and endangered plants. There were 300 plant reintroduction projects in China by the end of 2019. These reintroductions involved 206 species, 112 of which are Chinese endemics. In addition, problems and recommendations around the reintroduction of rare and endangered plants in China are discussed.

Experimental translocations of threatened *Persoonia* in eastern Australia: an exceptional plant genus

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Keywords: cuttings, planting strategy, Proteaceae, seedlings

Persoonia (Proteaceae) is a diverse genus of 99 species, mainly of woody shrubs and small trees that are endemic to Australia. Nine species are listed as threatened, endangered or critically endangered, and eight of these occur in New South Wales (NSW). These species are threatened by habitat degradation and fragmentation, small population sizes, and lack of recruitment events, and are key inclusions for the successful restoration of mining sites. However, this exceptional genus is highly under-represented in restoration and conservation programs owing to propagation difficulties from poor seed set, complex seed dormancy mechanisms, and the inability to attain consistent strike rates from vegetative cuttings. Over the last decade at the Australian Institute of Botanical Science, NSW we have made significant advances for the successful conservation of threatened *Persoonia* in NSW having executed several population supplementations and assisted migration translocations. In my presentation, I will provide an overview of the translocation programs we have led for *Persoonia hindii*, *P. hirsuta* and *P. pauciflora*. Specifically, I will discuss the supportive research outcomes that have helped to understand the factors that limit seed set and germination success, improve the strike rate of vegetative cuttings, and detail the benefits and drawbacks of both propagation methods for short-term translocation success. Highlighting the importance of our iterative experimental translocation strategy, we have identified specific planting techniques, including the use of plant guards and local mulch that improve short-term plant survival. Our work has provided a comprehensive strategy

for including threatened *Persoonia* in translocation programs and maximise short-term plant survival.

Reintroduction of Rare and Endangered Plants in Korea: Current Status and Challenges

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Keywords: Reintroduction project, Rare and endangered plants, Korea, Botanic garden

Reintroduction of rare and endangered plants is recognized as one of the important strategies for biodiversity recovery. However, most of plant reintroduction projects in Korea are unsuccessful due to poor understanding of process and lack of practice guidelines. Here, we analyze and present an overview of plant reintroduction project in Korea using all documented project including grey literature. Starting with the reintroduction of *Asplenium antiquum* in 1971, a total of 254 projects were carried out, and most of the projects were carried out after 2000. Taxonomically, the information of reintroduction projects comprises about 107 taxa representing 84 genera, 49 families. Orchidaceae (16%) is most exclusive taxonomic group followed by Asteraceae (11%), Liliaceae (6%), Rosaceae (6%). 74 taxa are listed as national Red List, of which 4 taxa are designated as legal protected species by two acts. Reintroduction projects are most commonly carried out by botanic garden (91 projects), followed by local government, NGOs and National park. 58% of reintroduction projects were done within protected area and the larges number of projects were carried out in Jeju Island where is biodiversity hotspot in Korea. The range of founding population sizes for which we have information varies greatly, from a low of three individuals to a high of more than ten thousand individuals. Although many plant reintroduction projects have been carried out

by various institutions in Korea, it is difficult to understand whether it's successful or not due to severe lack of documentation about post monitoring of project. Although many efforts to reintroduce plants to the wild often failure in Korea, continuous attempts of reintroduction project for biodiversity conservation will contribute to the development of plant reintroduction activities in Korea. In particular, it is urgent to make efforts to support the conservation community such as dissemination of guidelines and professional workshop.

Italian Database of Plant Translocation IDPlanT: best practices, errors and perspectives of half a century of plant translocation in Italy

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Keywords: translocation candidates, best practices, success in translocation, failure in translocation

IDPlanT is the Italian Database of Plant Translocation. The Italian translocation activities were carried out in Italy since the first recorded case in 1958, but a national repository was still lacking. In fact, most translocation cases are not published in the scientific literature or data are limited to the grey literature or not reported at all. The development and analysis of IDPlanT allowed to establish the first complete account of plant translocation performed in Italy. Based on the 185 cases currently included in IDPlanT, methods that were used in plant translocation are described and analysed, with a focus on material type used, propagation method, introduction method, demography of the population of origin, habitat suitability assessment, pre- and post-release practices, monitoring and costs of translocation activities. These variables are related to the final survival of translocated plants, with vegetative propagation and the demographic stability of source populations, showing a positive relationship with survival and seeds as material type and sowing as introduction method, showing a negative relationship with the final survival. Comparing these relationships with the translocation techniques used, allowed to identify the best practices, errors made and future directions in plant translocation in the specific Italian and Mediterranean contexts,

increasing the conservation relevance of these actions, and in turn improving the chances of success in restoring threatened species.

Quality assessment of mitigation translocation protocols for protected plants in France

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Keywords: Mitigation translocation, Protocol quality,Mitigation hierarchy, Environmental impact assessment

Construction and other landscape modifications by human activities cause significant pressures on plants and may lead to mitigation translocations under legal procedures. Mitigation translocations are much less studied than other conservation translocations, although they are increasingly used. We assessed the quality of the protocols for mitigation translocations proposed in France (2018-2020) in derogation requests from nature protection laws, which are mandatory for translocating a protected plant species. Determining the quality of these protocols is crucial to improving the success of the operation. We assessed each translocation proposal according to an evaluation grid, which covered the quantity and quality of information on plant species and translocation sites in the files and the quality of translocation protocols. According to this evaluation grid, we have shown that translocation protocols are of low quality, with much missing information. The biology and ecology of the species proposed for translocation are not sufficiently known, nor are the ecological characteristics of the host sites. The derogation requests that have received a favourable opinion from the assessment body are more likely to propose a protected host site and post-translocation monitoring. We believe that to optimise their outcome, mitigation translocations need to be improved

upstream, with more detailed protocols and better knowledge of the species. We strongly recommend following the same guidelines for mitigation translocations as for other conservation translocations.

Early results in reintroduction of *Sophora toromiro* (Phil.) Skottsb. in Rapa Nui: Species Extinct in the Wild (EW)

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Keywords: Threatened, Plant, Rhizobia, Pacific, Island, Rapa Nui

In this work, background information is presented for the reintroduction of *Sophora toromiro* (Phil.) Skottsb. emblematic extint species of Rapa Nui culture. The last specimen of the species found inside the Rano Kao volcano was cut at the end of the 1950s and progeny of this individual prospered in private collections and Botanical Gardens thanks to previous collections.

The reintroduction of *S. toromiro* in its current ecosystem in recent decades was unsuccessful, mainly because the first plantings did not considered that the species, of the Fabaceae family, is intrinsically associated with rhizobia, hence the basis of its success in the field.

Pilot trials established between 2018 and 2019 with previous inoculations with rhizobia, delivered survival results of 49% from selection of 12 strains with good performance in both growth and survival. Most of the strains correspond to the *Mezorhizobium* genus.

The strategy to follow in this species is discussed based on the current ecosystem present on the island and the interactions and associations of academy, local community, government organizations and private companies for the success of re-

population an extinct species in its original habitat and that serves as a model to other species in this condition.

Conservation of Boswellia species in the Socotra Archipelago (Yemen)

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Keywords: ecological restoration, IUCN RED List, regeneration, seed germination,

Frankincense trees (Boswellia spp.) are economically important species that are intimately intertwined with human history since millennia and currently endangered in Socotra Island (Yemen). Commerce with olibanum and other kinds of resin has been a common practice on Socotra since antiquity. Eleven endemic taxa have been described from the island, making Socotra the area with the largest radiation of Boswellia species globally. Despite being a UNESCO Natural World Heritage Site known for its unique ecosystems harboring a high proportion of endemic species, the biodiversity on Socotra is increasingly affected by human-induced and climatic impacts. Recent changes in traditional land management practices causing overgrazing, resulted in the lack of tree regeneration and ultimately lead to decline, even extinction of local populations. Moreover, cyclones and prolonged droughts caused by global climate change, have recently destroyed mature frankincense trees across the island. Our Boswellia conservation project, founded by the Franklinia foundation, includes several integrated activities such as a comprehensive inventory also supported by unmanned aerial vehicles, re-assessment of their conservation status according to the IUCN Red List

criteria, seed germination trials, protection of in situ seed germination and seedlings and woodland ecological restoration with fences and individual protection system. Activities also include training and awareness campaign for local communities and technical staff to ensure a long-term conservation of trees with high ecological and cultural importance.

Translocation case of *Dianthus superbus* L.: from designing to monitoring

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Keywords: translocation, *Dianthus superbus*, methodology

Dianthus superbus L. is in Estonia scarcely distributed and locally protected (II category) plant species. According to the local Red List evaluation, *D*. *superbus* is classified as vulnerable (*VU*). The need for translocation of *D*. *superbus* plants was raised due to the landowner´s request to build a modular buildings factory on the property. Previous inventories and monitoring's evaluated the abundance of the species approximately to a few hundred flowering individuals. In Estonia plant translocation decisions are made by the Estonian Environmental Board and they proceed on expert opinion. The expert opinion concluded that the *D. superbus* population on the property was declining, the estimated abundance was a few hundred flowering individuals and the population can be translocated to nearby species protection site. Historically, these two sites were united but due to real estate development, the area became fragmented and part of the population isolated. Translocation took place in autumn 2018 and a total of 1874 *D. superbus* clumps were dug out and planted in a new location. Ten sites of 25 m x 25 m were established for planting, precondition was, that on the site there are previously no *D. superbus* plants. To monitor the success of the translocation, all planted clumps were numbered and gathered different characteristics like the number of juveniles and generative shoots. After planting, all clumps were mapped based on spatial location to simplify the monitoring. According to three years of monitoring, the

survival rate of the planted clumps varied from 65% to 75%, the mortality rate was highest on the first and third year. Of all planted clumps that had *D. superbus* individuals, 699 clumps had plants flowering and 413 clumps had only vegetative plants.

In situ conservation of at-risk plants in the Southeast United States

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Keywords: *in situ* conservation, translocation, Gulf of Mexico, restoration

Atlanta Botanical Garden leads innovative strategies and leverages partnerships to conserve imperiled plants and natural communities across the Southeast United States. Acting as an arm of the Conservation and Research Department, the Gulf Coast Field Team helps bridge the gap between *in situ* conservation via large-scale restoration and species-focused conservation action. This Field Team, with *ex situ* support from the Atlanta-based Conservation Greenhouse, Safeguarding Nursery, Seed Bank, and Micropropagation and Genetics Laboratories, allows important *in situ* conservation work to be accomplished along the Gulf of Mexico, including the Apalachicola River watershed, a hotspot for biodiversity and endemism.

The Gulf Coast Field Team leads direct *in situ* conservation for a number of at-risk plant species along the Gulf of Mexico including Chapman's rhododendron (*Rhododendron minus* var. *chapmanii*), white fringed orchid (*Platanthera blephariglottis* var. *conspicua*), whitetop pitcher plant (*Sarracenia leucophylla*), yellow butterwort (*Pinguicula lutea*), Florida torreya (*Torreya taxifolia*), black-bracted pipewort (*Eriocaulon nigrobracteatum*), and telephus spurge (*Euphorbia telephioides*). A locally-based field team allows for the implementation of statistically sound experimental design for seeding and translocation experiments of these species. It also provides increased engagement with local land managers, Universities, and other NGOs, as well as the ability to conduct follow-up monitoring and data collection of *in situ* experiments. Additionally, species distribution

models have been created and utilized by the Gulf Coast Field Team with success in locating new populations of rare plant species. This increases the capacity for successful *ex situ* conservation action by providing additional sources of germplasm and genetic diversity. Approaches to *in situ* conservation along the Gulf of Mexico will be presented in addition to successes and failures of specific translocation experiments, seed trials, demography studies, and large-scale restoration projects.

Where do plants for translocation come from? Utilising *ex situ* collections in the translocation of *Grevillea calliantha* (Proteaceae) in Western Australia.

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Keywords: germplasm, conservation, ex situ, planning.

Seeds, cuttings and other forms of germplasm in *ex situ* collections are utilised for a variety of purposes, often many years after collection. Conservation translocation relies on seeds and nursery-grown plants from *ex situ* collections to augment small and declining populations. This is usually part of a broader recovery plan to prevent extinction of species and loss of biodiversity. It is important to consider the end use of collections entering *ex situ* storage when planning and undertaking the germplasm collection. These considerations are presented as part of a case study on *Grevillea calliantha* (Proteaceae), a species listed as Critically Endangered in Western Australia and Endangered in the Australian Environment Protection and Biodiversity Conservation Act.

A variety of other end uses are also possible for germplasm stored *ex situ* including research, restoration, plant breeding and horticultural display. The importance of partnerships, such as the Australian Seed Bank Partnership, for achieving conservation

goals is outlined. We also highlight resources developed by the Australian Network for Plant Conservation to assist those involved in translocation, ecological restoration and *ex situ* conservation in Australia and gratefully acknowledge the contribution of hundreds of collaborators in preparing this suite of best-practice guidelines.

This presentation has been prepared as a 9 minute video as part of Plant Treasures video series associated with the third edition of *'Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising ex situ collections in Australia*'.

An effective and broadly applicable genomic workflow to support plant translocation practices

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Keywords: Future Proofing, Multispecies Workflow, Landscape Genomics, Population Resilience, Resource Efficiencies

Carefully planned translocation strategies can improve the fitness and viability of populations, increase their resilience to change, as well as reduce the overall risk of extinction. Ideally a translocated population should be genetically diverse and consist of fit founding individuals, but without the necessary genetic information designing such a population can be challenging, especially when responding to a range of objectives, constraints and trade-offs. Owing to decreasing costs and increased efficiencies, it is now conceivable that landscape and conservation genomic information should be regularly used to improve the effectiveness of most plant translocation programs (for either threatened or common taxa). In most cases including a simple genomic study as an initial decision-making step of translocation-based projects, will inform long-term recovery and restoration efforts in multiple ways. Using examples, we present a simple, standardized, and cost-effective workflow for genomic research that can guide efficient collection, analysis and application of genomic information in a time- and resource-effective manner across disparate settings. Interpretations do not require prior genetic knowledge about the target taxa, and directly support on-ground, applied activities while allowing for flexible inputs, the imposition of realistic constraints, and the examination of conflicting goals. Conservation and management outcomes range from lineage

delineation, to genetic rescue, the establishment of ‘climate-ready’ seed production areas, and more.

Seed technology for multispecies seeding in degraded agricultural landscapes

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Keywords: seed pelleting, processing, seed-based restoration

In the South-Western region of Western Australia (a global biodiversity hotspot) native vegetation has been systematically cleared for over a century to make room for extensive crop production, urban development, and resource extraction. As a result, less than 10% of the original vegetation cover is left, with most remnants, being of small size, fragmented and isolated. This situation is concerning for biodiversity conservation, with species and communities becoming endangered, and for farming. Loss of ecosystem services has resulted in increased salinity and soil erosion turning agricultural landscapes in unproductive wastelands and biological deserts. Recently tree planting initiatives, mostly for carbon sequestration, have initiated the process of re-establishing native vegetation, however most of these projects are limited to a handful of tree and shrubs species, and current planting and seeding practices are highly inefficient. Our research team has been developing technologies aimed at maximizing the use multispecies native seed mix to degraded landscape. A key impediment is the high variability in seed size that often results in wastage, especially for small-seeded species. By combining seed processing techniques with seed pelleting, we can standardize the size of small seeded species (from less than 1mm to 2mm) allowing for

the delivery of multispecies native seeds mixes with large scale agricultural equipment. We tested seed pelleting on a wide range of small seeded species and assess seedling emergence in laboratory and field condition. In general pelleting performed similarly to untreated seed, suggesting that this approach is ready to be tested at scale in the field. In a separate experiment we tested the effects of Salicylic acid delivered via seed pelleting on plant establishment and survival and obtained a 5 to 10% increase in plant survival one year after seeding. Such techniques, so far tested on common species, could improve translocation effectiveness for rare and endangered small seeded species.

Combining genetic rescue and conservation translocations

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Key words: Plant fitness, pollination, Scotland, *Cicerbita alpina*

We present a study that uses genetic rescue to help maximise the success of conservation translocations. Species in need of translocations often remain as small, scattered and isolated populations. This makes them vulnerable to genetic problems, such as genetic erosion, inbreeding depression and a lowered evolutionary potential. These genetic problems often decrease plant fitness and consequently make recovery work more difficult. Genetic rescue can help to overcome fitness declines in small populations and can consequently be a strong tool for creating more suitable plant material for conservation translocations. Here, we put genetic rescue to practice, including all associated steps, such as gathering genetic background information on the study species, cross-pollinations in a nursery, fitness measurements, and translocations. We're using the alpine blue-sowthistle (*Cicerbita alpina*) as an example, which is only left in four very small populations in Scotland, UK, where it fails to reproduce. Like so many other species, *C. alpina* is unlikely to recover naturally and could be lost without human interventions. We demonstrate that genetic diversity is low and inbreeding high in Scotland, compared to larger, more continuous Norwegian populations. Cross-pollinations do improve plant fitness in the nursery, outbreeding depression is unlikely, and plants can establish at new sites (when micros-siting is correct) but grazing has strong negative impacts on plant growth. We demonstrate that genetic rescue and conservation translocations can indeed help plant conservation but

will only succeed in conjunction with wider habitat conservation, and considerable expertise on the study species.

Genetic tools for designing and monitoring plant translocations

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Keywords: admixture, contemporary pollen flow, effective population size, inbreeding depression

Genetic tools can significantly contribute to optimize plant translocation success, (1) by identifying target populations to restore and selecting the adequate source populations for translocation, and (2) by evaluating the effectiveness of plant translocations to restore or (re)create demographically viable and genetically resilient populations. Genetic methods, especially when they combine neutral and adaptive makers, allow inferring many key factors in translocation success (or failure), which cannot be assessed by a demographic approach: mating processes, contemporary gene flow, clonal extent, genetic quality of seed sources (sibship, parentage), inbreeding and outbreeding depression, contribution of sexual reproduction to recruitment, and admixture level (crosses between sources) in post-translocation established generations. A genetic approach can be particularly important when the remaining potential sources only consist of small census-sized populations or when there may be suspicion of clonal extent, small effective population size (N_e) or disrupted pollination.

We exemplify the different analyses combining molecular markers and fitness-related quantitative traits which are relevant for genetic assessment in designing plant translocations and for genetic monitoring of translocated populations, for the self-

incompatible *Arnica montana* (Asteraceae) and *Campanula glomerata* (Campanulaceae) and the self-compatible *Dianthus deltoides* (Caryophyllaceae) in southern Belgium. The strategy to use several seed sources in a mixed planting design and to translocate a high number of founders in beforehand ecologically managed areas was successful in founding highly genetically diverse populations and in facilitating contemporary pollen flow, leading to admixed recruits (resulting from crosses between transplants from different seed sources) in the newly established generation, and to higher plant fitness due to heterosis in outcrossed progeny in *Dianthus*. However, source and translocated populations of the clonal *Dianthus* showed small contemporary N_e due to substantial selfing levels despite high flowering population sizes, emphasizing the importance of assessing the genetic quality of the transplants.

Translocation of *Arenaria grandiflora* L.: chronicle of an extinction foretold

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Keywords: mixing populations, monitoring, genetics, demography, projections

After the drastic decrease of population sizes in the late 20st century of *Arenaria grandiflora*'s population in the Parisian region, a translocation program was implemented in 1999. A preliminary study revealed that the main cause of the population's extinction was the low genetic diversity and the associated low fitness of the last individuals due to inbreeding depression. To save this species from extinction in this region, non-local and local plants were multiplied by *in vitro* culture and introduced in three sites of their natural area. Our hope was that this species would be saved by the phenomenon of heterosis between two gene pools that had evolved in different regions, 250 km apart, but in similar ecological conditions. On a genetic point of view, the three translocated populations were funded with the same mixture of 450 individuals, 2/3 being clones of local plants and 1/3 of clones from non-local ones. Since 2000, to evaluate the evolution of the project and the population status, we monitored them yearly, individual by individual, and performed dynamic and genetic analyses with capture recapture methods and 13 microsatellite markers.

In this talk, we will present the benefits and the drawbacks of having mixed individuals of two origins to reinforce the metapopulation of the Parisian region. By now, two of three translocated populations persist, while the third became extinct in 2004. Analyses of the ecological parameters indicated that differences in soil pH and moisture in the

sites should have contributed to the differences in population dynamics. Our genetic analysis shows how the progressive declines in effective sizes of the populations have affected genetic diversity. Our dynamic models display different demographic parameters among sites but the simulations of the translocated populations predict their inevitable end, probably in line with climate change.

At the intersection between scientists, practitioners and the public - the role of Botanical Gardens in the conservation of threatened plant species

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Keywords: plant translocations, gardens, conservation network

Ex-situ cultures and translocations are important conservation tools. However, they are costly, laborious, challenging and often unsuccessful. To improve their efficiency and success, scientists need to base their studies on long-term data of successful and unsuccessful *ex-situ* cultures and translocations, conservation practitioners need to be informed about the newest scientific findings and public awareness needs to be raised to ensure the availability of resources for conservation measures. At the intersection of scientists, practitioners and the public, Botanical Gardens have the enormous potential to facilitate communication and information exchange on plant conservation between these stakeholders and push the field of plant translocation and *ex-situ* conservation to meet national commitments to biodiversity.

At the Botanical Garden of the University of Bern, we develop a strong conservation-oriented vision and a research environment to put forward our cultural and scientific mission. Our scientists study different aspects of plant translocations, such as their population and evolutionary ecology, and then combine scientific knowledge to improve future translocation success. Our gardeners propagate threatened plant species for translocations carried out by conservation practitioners and by sharing the expertise of gardeners, practitioners and scientists we give guidelines on best practices and write cultivation manuals. With two partners, we organize workshops for conservation

practitioners and scientists to promote a national network and facilitate the much-needed exchange of scientific findings, practical experiences and legal requirements. In turn, we receive feedback on issues faced by practitioners not yet studied scientifically and information on long-term successful and unsuccessful translocation projects, which otherwise remain unknown to science. Through guided tours, exhibitions and other outreach events we raise public awareness on biodiversity loss and nature-conservation necessity. This virtuous network creates a win-win situation for all stakeholders and benefits the conservation of threatened plant species by improving *ex-situ* cultivation and plant translocation success.

Creation of seed producing orchards of the endangered species *Taxus baccata* in the Valencian Region (East of Spain) as a strategy to improve natural dispersal.

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Keywords: Taxus baccata, yew, climate change, seed production, recruitment, dispersal

The Mediterranean *Taxus baccata* (Yew) woods are a relict plant community, included as priority habitat in the EU Habitats Directive. The European Environment Agency considers that its current conservation status, "structures and functions" and "future prospect" in the Mediterranean biogeographical region is U2 (Unfavourable-bad). This communication presents the efforts under development by the environmental administration in the Region of Valencia, Spain, to improve its conservation status in the context of the recently approved LIFE Teixeres project (LIFE20/NAT/ES/001128). The main identified conservation threats in the Valencian region are habitat fragmentation, small population sizes, low seed productivity and recruitment, herbivory and trampling by wild fauna, climate change and wildfires. The project proposes several conservation measures to correct its fragility. Among one of them is the installation of seed producing orchards under controlled conditions, in order to improve natural seed dispersal and recruitment. This action is a *quasi in situ* conservation measure, in order to complement the effectiveness of *in situ* translocations on close natural habitats. These orchards consist of plantations of yews accompanied by a set of native, fleshyfruit producing species-mainly from the family *Rosaceae* (*Prunus, Crataegus,* etc.)-, that should attract seed dispersing fauna and increase ecological interactions. These new sites are being

placed in agricultural terraces or other artificial sites close to the natural populations. The yew plants used for the orchards are being obtained from cuttings coming from the natural close populations in order to have quicker seed production by shortening tree maturity, avoiding sex ratio problems and increasing genetic diversity. Farmed orchards will also allow bigger seed yields than natural populations, reducing seed collection pressure for conservation purposes. The project includes other conservation measures such as forestry treatments to reduce competition and wildfire risk, germplasm collections for plant production and ex-situ conservation, plant production and population reinforcements.

Ex situ evolution of *Digitalis lutea* at Meise Botanic Garden and its implications for reintroduction success

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Keywords: ex situ conservation, genetic differentiation, unconscious selection, seed dormancy loss

Ex situ collections of living plants in botanic gardens are considered to be an important resource for species conservation measures such as translocations or population reinforcements. At the same time, evidence is mounting that cultivation of plants outside their natural habitat for longer periods results in adaptive evolutionary changes in important life-history traits, such as in seed germination, flowering phenology and plant architecture. Although this calls into question the suitability of ex situ derived material for translocations, no study has yet tested experimentally whether those changes have negative impacts when these plants are brought back into the wild. We explore this topic using the short-lived perennial *Digitalis lutea*, cultivated for 30 years at Meise Botanic Garden and, at the same time, kept stored as seed frozen in the seed bank of the garden. By a genetic comparison with the resampled original wild population (ISSR markers), germination and flower visitation experiments, as well as artificial self- and cross-pollinations, we uncover the evolutionary changes due to cultivation in this species and the processes involved in it. Moreover, we show the impact of those changes on establishment success in a translocation experiment with seeds of the three

seed sources (garden collection, seed bank stored and wild re-collected seeds). Finally, we outline the implications for the production of plants for conservation and restoration.

Using banked seeds for plant translocation: the practicalities and challenges

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Keywords: banked seeds, plant translocation, conservation

Billions of seeds are currently stored in more than 1,750 seed banks around the world. Plant translocation from these stored seeds is a key conservation priority and one of the targets of the UN's Global Strategy for Plant Conservation. However, there is little information available on the use of banked seeds for plant translocation; the skill level and knowledge seed banks have for successful translocation; and the difficulties seed banks encounter. To bridge this gap, we circulated a questionnaire across the major networks of seed banks around the world. We received responses from over 80 seed banks based in 25 countries representing 650,000 accessions of 50,000 taxa. Just over 70% of respondents had previously used their collections for plant translocation, and more than 75% of seed banks had incubators, greenhouses and outdoor space for plant propagation from seed. Two thirds had staff to facilitate plant propagation. The main limiting factor for seed banks that had not performed any translocations were the limited number of seeds available and that plant translocation was not in the remit of the seed bank. Even for seed banks that have performed translocations, they still faced challenges, with half identifying funding and one third saying resources (e.g. time, staff) were constraints. Fewer than 10% of seed banks felt they had no constraints on their ability to carry out plant translocation. Over 95% of respondents would like to carry out plant translocations from their collections in the future, indicating there is an appetite for seed banks to use their collections but there is a lack of funding and resource available, limiting the full potential of seedbanks for conservation translocation. Our results

suggest funding and personnel resource should be prioritised to promote the practical use of banked seeds.

The role of herbaria on plant de-extinction: evaluation, prioritization, and germination protocol development

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Keywords: De-extinction, herbaria, seed, candidate

De-extinction, the new frontier of conservation aiming at resurrecting or creating proxies of extinct species, is currently only theoretical. Nonetheless, de-extinction in plants may be achieved by germinating viable diaspores or culturing tissues preserved in herbarium specimens. To try the first de-extinction ever using seeds collected from herbarium specimens of extinct plant species, we developed the following research project: i) we assessed the role of plant natural historical collections (especially herbaria) in conservation biology through a review of the published literature (Albani Rocchetti et al., 2021a). It resulted that collected specimens have been used to fill gaps in systematics, range extent, and past genetic diversity. Moreover, they offer material to foster species recovery, ecosystem restoration, and de-extinction, and these elements should be used in conjunction with machine learning and citizen science initiatives to mobilize a force as large as possible to counter current extinction trends.

ii) We developed an internet-based survey to assess (a) whether the scientific community would consent to use of herbarium specimens of extinct species to attempt de-extinction, and (b) the limitations of removing diaspores from specimens (Albani Rocchetti et al., 2021b). From this survey, a consensus for using specimens of extinct plant species emerged.

These results help to formalize a pragmatic approach to resurrecting extinct plant species from herbarium specimens.

iii) We developed a methodology for selecting candidates for plant de-extinction from diaspores occurring in herbaria, based on seed characteristics and specimen age, and identified the first list of candidates for plant de-extinction. We made a worldwide assessment of the herbarium specimens of extinct, finding more than 500 specimens belonging to 364 extinct taxa bearing seeds (Albani Rocchetti et al., in prep.).

iv) We are developing a germination protocol for old seeds collected from herbarium specimens, testing several pre-treatments and treatments (i.e., priming techniques and hormones). For now, we obtained 50 germinations of 6 to more than 100 years old seeds.

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The role of population reintroduction and augmentation in sustainable use of over-exploited species

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Keywords: CITES, forest-grown, plant conservation, non-timber forest product

Over-exploitation is among the greatest threats to species survival (Maxwell *et al*. 2016). The cultivation of wild over-harvested species is a common strategy to meet continued demand and achieve species conservation at the same time (Abensperg-Traun 2009; Anderies 2015; Challender et al. 2015). It is often assumed that cultivation can alleviate wild harvesting pressure and benefit species conservation. However, a recent review found that there is limited evidence and information to validate this assumption (Liu et al. 2019). Cultivation operations structured to meet market demand only are not likely generate conservation benefit, regardless how large the operations are and how long a species has been under cultivation. One reason is that for many species, such as traditional medicinal plants, products cultivated under complete artificial conditions are not perfect replacement for wild collected counterparts, and therefore demand for wild-harvest product persists despite existence of mature artificial cultivation. Nevertheless, there are cases in which cultivation has generated or is likely to generate conservation benefits, including the implementation of restoration friendly cultivation approaches, in which populations planted in native wooded areas can be harvested (Liu et al. 2019). These cultivation operations can be seen as a hybrid between commercial cultivation and population restoration because farmers can adopt harvesting regimes that enable the population to persist and reproduce. In this

presentation I will share a few examples of this practice on species regulated by the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES).

Environmental characterization of a lake for hosting the endangered species *Isoëtes cangae* in the Amazon rainforest

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Keywords: Conservation, ecophysiology, photosynthetically active radiation, chlorophyll a fluorescence

The Amazon endemic quillwort *Isoëtes cangae* (IC) is a critically endangered submerged plant found exclusively at the Amendoim Lake (AL), at iron rock fields in Serra dos Carajás, Eastern Amazon. The AL is an oligotrophic lake with distinctive features such as a high iron content and organic-clay sediment. Other aquatic ecosystems in the nearby region were scanned to further translocate IC in order to preserve it. So, the goal of this study was to investigate the limnological features and ecophysiological markers of IC at natural conditions in AL and in três Irmãs Lake (TIL), in order to evaluate if this last ecosystem is a good candidate for IC translocation and conservation. Light spectra, water physicochemical characteristics, and both water and sediment nutrients were measured in both locations at 3-month intervals along two years. Also, PAM fluorometry was used to determine the chlorophyll *a* fluorescence of IC. Both water and sediment physical-chemical characteristics and mineral nutrients were determined by either laboratory analysis or *in situ*, using the Aqua Troll 600 multiparameter sonde. Our results showed that limnological dynamics of both lakes are very similar throughout the year, except for the flood season. As a result, *IC* can maintain its photosynthetic performance in the TIL. Also, the effective quantum yields of

photosystem II, as well as the electron transport rate of IC, were similar in both lakes. Despite the minor limnological differences between the two sites, our findings suggest that, concerning ecophysiological aspects, the TIL is a suitable candidate ecosystem for IC conservation.

Improving plant translocation success in the Southwest Australian biodiversity hotspot.

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Keywords: Translocation success, adaptive management, Mediterranean climate, Biodiversity Hotspot.

The ultimate goal of threatened plant translocations is to establish self-sustaining populations. If translocations are to be effective in conserving and recovering species, then lessons learnt from previous plant translocations need careful consideration and used to inform future management practices and increase the likelihood of success. The Mediterranean-type climate of the Southwest Australian Floristic Region is home to >8300 plant species. More than 400 species are listed as threatened in the region, a key factor contributing to its listing as a biodiversity hotspot. Western Australia's Department of Biodiversity, Conservation and Attractions has used translocations as an integral part of its recovery program for threatened plants over the past 25 years, establishing translocations for 65 threatened plant species at 110 sites. The Department has used an adaptive management approach, where the knowledge and experiences

gained in early translocations have been used to improve the success of later attempts. Techniques such as watering and the use of fences to protect plants from herbivory have been implemented when translocations have been established. The influence of these techniques on survival, growth, and reproduction for a subset of 76 translocations has been assessed using Generalized Linear Mixed Models, along with the interaction with rainfall. This talk will describe the results of the models developed for this analysis and highlight how information gained during the 25 years of translocation implementation has been used to inform management practice.

Plant translocations in Europe and the Mediterranean: geographic and climatic directions and distances from source to host sites.

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Keywords: plant translocations, climate change mitigation, climate distance, biodiversity conservation

Although the number of plant translocations has been rapidly increasing for two decades, no study is available to date that examines the directions and distances of plant displacements, which is essential (though not sufficient) information for considering translocations as a management tool to enable species to cope with the consequences of climate change. In this article, by using plant data from the TRANSLOC database, which contains data on translocated species (animals, plants and lichens) in Europe and the Mediterranean from 1980 to 2020, we study the geographic and climatic directions and distances from source to host sites in 638 source-and-host site pairs of plant translocations that aimed to achieve viable populations. Translocation distances ranged from 0 to 661 km, with a majority (82%) being at less than 25 km without any preferential geographic direction or altitude relative to the source sites. In contrast, on a climate compass constructed from a principal component analysis of seven bioclimatic variables, the host sites were slightly, but significantly, under colder climatic conditions than the source sites. This observation

appears to be more the consequence of an effort to counteract already felt effects of climate change than to anticipate future changes.

Synthesis. This study is the first to compare, geographically and climatically, the source sites of biological material and the host sites in translocations of wild plant species to obtain viable populations. Past translocations are in line with mitigating the consequences of global warming on plant species, because the host sites were in slightly cooler conditions than the source sites. Despite this, climate considerations seem to have been little taken into account in plant translocation projects and will certainly have to be much more so in a future with rapid anthropogenic climate change.

Quantifying the potential niches of endangered plant species for improving reintroduction success

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Keywords: conservation, endangered plants, potential and realized niche, species distribution modeling (SDM)

One of the most severe threats to global biodiversity is land-use changes. Reintroduction is a major conservation tool, but its success relies on accurate estimation of the species niche. While niche modeling has been used to predict distribution of a plant, it has been rarely used as a tool for predicting reintroduction success. We aim to examine the possible use of niche modeling for improving endangered species reintroduction success.

In Israel, >400 plant species are included in the Israeli Red List of endangered plants. As Israel is one of the most populated countries in the word, very few natural areas remained, challenging the identification of appropriate sites for reintroduction. Attempts of reintroduction were done for over 50 endangered species in Israel, but only a handful were quantitatively monitored for long term, not sufficient for understanding the factors that affect reintroduction success or failure.

We used niche models to estimate the suitable habitat for rare species, based on known sites of occurrences. Complimentary reintroduction field experiments are currently performed for four endangered endemic plants, representing two endangered habitats in Israel. Each species was reintroduced at least in three sites that differ in predicted habitat suitability. Reintroduction success rate will be compared with the niche model predictions and will be used to improve the model.

The results of this study may be used later on as a conservation tool when considering an endangered species reintroduction.

Translocation of species for conservation: the case of *Abies nebrodensis* in Sicily

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Keywords: Plant Conservation, Population reinforcement, Plant reintroduction, Habitat Directive.

Translocation of species for conservation has sharply increased in recent decades. In Italy, the reinforcement of *Pinus heldreichii* subsp. *leucodermis* (Antoine) E.Murray in the Pollino Mount (Calabria) is the first documented translocation, carried out in 1958. In Sicily, in the Madonie mountains, *Abies nebrodensis* (Lojac.) Mattei has been object of attention for conservation purposes since 1941 when prof. Domenico Lanza fenced off the few surviving individuals to protect them from animals and human activities, and preserved *ex situ* some individuals by reproducing them by seed and grafting. Its natural population consists of 30 individuals scattered across a small area in the Polizzi Generosa municipality in the Madonie Natural Park (Sicily). This is a priority species of Annex II and IV to the Habitats Directive 92/43/EEC. The first reforestation interventions date back to 1975 when plots were established in the localities Marrabilice and Case Prato and Vallone Prato, not far from the surviving nucleus in nature. Conservation efforts have been combined between the Sicilian Region, the Madonie Regional Park and the University of Palermo. The species has been the subject of two Life projects: "Conservation *in situ* and *ex situ* of *Abies nebrodensis* (Lojac.) Mattei" (2000-2005) and NAT/IT/000164-LIFE4FIR (2019-2023), carrying out concrete conservation actions. A total of 5 population reinforcements and 21 reforestation plots were built between 1975

and 2004 in the Madonie area at altitudes between 800 and 1600 meters with very variable percentages of engraftment due to the characteristics of the different sites and their management. With the LIFE4FIR project interventions are planned in other ten areas of the Madonie with use of 4000 seedlings obtained by manual pollination. Today, thanks to the interventions carried out, the future of *A. nebrodensis* is brighter, but we must not forget to continue active research and vigilance on this species.

Restoring the lung lichen *Lobaria pulmonaria* in Mediterranean oak forests

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Keywords: Conservation, Epiphytic lichens, Reintroduction, Translocation

During the last years, the Working Group for Ecology of the Italian Lichen Society has focused its activities on the development of a protocol for the relocation of *Lobaria pulmonaria* L. (Hoffm.), a tripartite foliose epiphytic lichen, in which the fungus is associated with both a green alga and a nitrogen-fixing cyanobacterium. This species has declined throughout Europe as a consequence of air pollution, and it is currently threatened by intensive forest management and climate change. This research began in 2016 with a legal logging in a mixed oak forest in Tuscany, C-Italy, that heavily impacted a large population of *L. pulmonaria*. Whole thalli and thallus fragments fallen to the ground or remained on the cut trunks, have been collected and used for a long-term monitoring on the effectiveness of transplantation in Mediterranean logged and unlogged oak forests. The effectiveness of transplants was also tested in areas with different levels of air pollution comparing the results of transplants located in Italian areas already hosting the species and in the Western Carpathians, where *L*. *pulmonaria* occurred in the past, but is currently extinct. Chlorophyll a fluorescence emission and total chlorophylls are used as a proxy for the overall vitality of the transplants, while their growth is considered as an indicator of long-term effects. Our results outline the

potential for meristematic fragments under suitable growth conditions in oaks forest (remote areas, unlogged stands, north side of the trunk, at about 100 cm from the ground) for maintaining vital thalli and a 4-year survival rate of 50 percent after translocation. The most interesting aspect is that surviving thalli have developed new regenerative lobules and rhizines, appearing overall healthy, performing and without obvious signs of alteration even at an ultrastructural level. In a few cases, newly formed individuals were also observed after four years.

Reinforcement of quillworts – *Isoetes spp.*, and other keystone species of Mediterranean temporary ponds (EU habitat type 3170*) in restored standing freshwater habitats.

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Keywords: Natura 2000, LIFE programme, restoration ecology, Mediterranean habitats

Transitional wetlands and coastal forests are among the most degraded and threatened ecosystems in the European Union. This has resulted in many habitats and species in Mediterranean coastal areas having 'unfavourable', 'vulnerable' or 'near threatened' conservation status according to the EU Habitats Directive (92/43/EEC). Actions to improve habitats' conservation status are particularly needed in two such areas along the Greek and Italian coasts, the 'Delta Nestou' and 'Palo Laziale'. Both sites have standing freshwater habitat types particularly rich in biodiversity, such as the 'Mediterranean temporary ponds' (3170*). They are usually heterogeneous, shallow (few centimetres deep), and small water bodies, which dries entirely in summer. The length of the flooding period has a strong influence on the floristic composition, mainly belonging to the *Isoeto-Nanojuncetea* class. The associated plant and animal species face several threats, including bush encroachment, climate change and inappropriate forest and water management.

LIFE PRIMED (LIFE17 NAT/GR/000511) implemented a set of traditional and innovative ecological restoration practices in both sites to improve the conservation status of this habitat, including the creation of new ponds and *ex-situ* and *in-situ* reinforcement of keystone plants. The reproduction strategies of these species have been tested in the germplasm bank of the Botanical Garden of Rome. First monitoring

findings show successfully colonisation trends of all the introduced species in the recreated ponds. One pond resulted in a more effective conservation of plant communities whereas another pond resulted had more appealing to rare amphibians.

The monitoring activities are still ongoing, but the colonisation by temporary ponds' species confirms the pioneering aspect of the habitat, and restoration actions must consider successional stages that may exclude these communities. The outcomes of these practices will enable the development of sexual and asexual reproduction protocols and field operation guidelines that will support similar activities elsewhere in the Mediterranean area.

POSTERS

Utilizing assisted translocation to enhance forest growth and carbon stocks in European forests.

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Keywords: Adaptation, Assited-migration, Climate-change, Carbon-sequestration, Emission-reduction

The role of European forests as carbon sinks is increasingly endangered by climate change induced droughts and disturbance events. On the policy level European Union has an ambitious plan increasing the terrestrial carbon sink and achieving net zero emissions by 2050. Adaptive management strategies such as choice of species and planting materials is therefore crucial for maintaining forest carbon sinks and increasing forest resilience. Assisted translocation (ATL) of forest tree species and populations were suggested to avoid maladaptation and to maintain forest growth under future climate. We identified ATL schemes for seven major European tree species on basis of 587 range-wide provenance trials, evaluating more than 4000 provenances. Using models that account for environmental and genetic factors of phenotypic traits variations, we, estimated above ground carbon stocks of 40 year old trees under current and projected future climate by adapting species composition and seed sources.

When species adapted to current climate are planted utilizing seeds suitable for projected future, total carbon stock was estimated to be 2678 million tones, which is 54% higher higher compared to a scenario where local seed sources are planted. The same trend is also observed in the future whereby substantially higher carbon

stocks can be achieved by planting adapted species combined with appropriate seed sources. By adopting ATL today, EU's forests are expected to sequester enough CO2 to offset 6% of EU's baseline (1991-2010) yearly emissions. Although CO2 sequestration is likely to decline during the period 2061-2080, but ATL can still enable EU's forests to sequester enough CO2 to offset around 4% of EU's baseline emission.

Based on a broad empirical basis, our analysis provides strong evidence for fostering an active transnational forest genetic resource management if Europe’s future forest shall maintain their precious ecosystem services.

Conservation of *Jacobaea paludosa* in peripheral populations: reintroduction experiments and analysis of reproductive biology in the Po valley (northern Italy)

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Keywords: river corridor plants, helophytes, wetlands, range marginality

Jacobaea paludosa (L.) Gaertn., Mey. & Scherb. is a perennial helophyte typical of oligotrophic marshes and river and canal sides. On a national scale, it is not listed among the threatened species, but is declining in many parts of its range, because of habitat destruction and widespread water pollution and eutrophication. To contrast this phenomenon, four reintroduction experiments were performed from 1998 to 2018, always in protected areas and using both juvenile and adult plants obtained from seeds collected from the closest populations. Plantation sites were chosen by expert assessment. These experiments gave uncertain results: in three cases all individuals died after a time variable from few months in one site to 15 years in another (with flowering and fruiting declining over time), in one case plants are still alive and 100% flowering, fruiting and recruiting. We therefore studied the principal reproductive parameters to understand the reasons for such a result, both on natural and reintroduced populations (the natural ones were of variable dimensions to verify the effect of population size on reproduction fitness). Pollen viability was generally high

(50% minimum, on average); seed viability was extremely low (9% maximum), with many seeds malformed or without embryo. There was no correlation between population size and seed viability. Pollination experiments revealed a possible autogamy, but generally with production of non-viable seeds; viable seeds were produced only when insects could visit the flowers (natural cross pollination), but with scarce germination (11-21%), which was even lower in case of manual inter-population pollination (10% maximum). In the control test, germination varied from 1-2% in a large natural population to 75% in a small one. Thus, despite the persistence of some large populations, *J. paludosa* is in danger of disappearing for its reproductive problems: an inclusion in the national red list would be desirable.

Ex situ conservation of imperiled plant species in the Southeastern United States

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Key Words: Augmentation, *Ex situ* conservation, Safeguarding, Conservation Collections

Atlanta Botanical Garden (ABG) works to advance the science of plant conservation through research collaborations and native species recovery programs. ABG pairs field research with conservation collections by focusing on propagation, restoration, and habitat management of under-represented endangered plant groups. In addition to the *in situ* work, the conservation horticulture team at ABG specializes in *ex situ* collections management and propagation techniques from field to lab to nursery production of imperiled species. The Garden has more than 30 years of experience in the conservation and recovery of rare and threatened species through propagation, collaborative restoration, and habitat management.

ABG works to address the urgent need to protect imperiled species across the southeastern states in the US and the Neotropics through *in situ* and *ex situ* conservation, conservation horticulture, restoration and augmentation, and seed banking. One of the primary tools utilized by ABG is diversification of *ex situ* conservation collections, with extensive living collections tracked by maternal line, seed bank (conventional and cryo bank), micropropagation, and tissue and DNA banks. The Conservation Collection objectives for ABG include:

- Create and maintain genetically diverse *ex situ* collections of the highest conservation value possible within the resources available

- Develop and implement best practices in plant conservation for botanical garden collections

- In collaboration with local and international partners, increase knowledge and collections of southeastern United States plant diversity through exploration and inventory of targeted geographic areas

- To provide long term planning and continuity for the Conservation Collections

- Further develop and exchange *ex situ* conservation collections and plant diversity data with institutions located and/or working in the southeastern United States.

- Identify and fill living plant conservation collections' gaps in *ex-situ*, *inter-situ* and *in-situ* settings

- Discover, via collaborations and partnerships, new ways to effectively preserve plant germplasm over the long term or in perpetuity.

Inter-individual variability in germination and seedling establishment in *Campanula thyrsoides* subsp. *carniolica* for translocation

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Keywords: *Campanula thyrsoides*, reinforcement, germination, monocarpic perennial.

Campanula thyrsoides subsp. *carniolica* (Sünd.) Podlech is a monocarpic perennial species endemic of Eastern Alps that reach its westernmost distribution in Monte Serva in Dolomiti Bellunesi National Park. Here, the population suffered of major decline due to heavy grazing pressure by sheep and wild animals (like mouflons). Around 200 individuals are reported in the area, but only few individuals bloom and disperse seeds every year. In order to reinforce the population of Monte Serva, seeds of the closest population (Alpago, around 20 km) were collected. During collection, seeds from 8 different individuals (1 from Serva and 7 from Alpago) were kept separated and tested to verify differences in seed germination and seedling establishment. Experiments were conducted in temperature- and light controlled incubators. All seeds were sown on 1% agar in distilled water, with four replicates of 30 seeds each per individual. Fresh seeds were exposed to 0°C for 4 weeks and after moved to 15°C at 12 h daily photoperiods. Differences in seed germination and seedling establishment were detected between individuals (P-value < 0.001), with final percentage of germination ranging from 7 to 95%, and seedling establishment ranging from 72 to 96.2%, The results of this preliminary experiment show that individuals of the same population can differ significantly in their seeds germination success, with unexpected consequences on

genetic variability of populations and translocated individuals, that need to be further investigated. These data suggest that the inter-individual variability should be considered in the selection of individuals in order to develop an effective translocation plan.

Translocation actions for threatened plant species in Apulia region (Southern Italy)

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Keywords: *in situ* conservation, *taxa* of conservation concern, Apulia

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, acting directly on populations in their natural habitat.

Over the last 20 years, the Botanical Garden Museum of the University of Bari has carried out several translocation interventions in the Apulian territory, focusing on *taxa* of conservation concern, i.e., policy species, Red List species, locally rare ones, endemics or, in any case, species of biogeographic importance. In order to disseminate past pilot translocation experiences so that a wider audience can benefit from both their strengths and weaknesses, as recently restated for the Italian context by Abeli et al. (IDPlanT: the Italian database of plant translocation. Plant Biosystems, 2021), these interventions are presented in this contribution, starting with the first realized in 2001 and concerning *Cistus clusii* Dunal at Bosco Isola di Lesina (FG), up to the latest ones carried out in 2021 at Monte Sant'Elia (Massafra - TA), in the Regional Natural Park "Terra delle Gravine", and having, as target *taxa*, *Arum apulum* (Carano) P.C. Boyce

and *Salvia fruticosa* Mill. subsp. *thomasii* (Lacaita) Brullo, Guglielmo, Pavone & Terrasi. An analysis of a total of 25 translocation actions has been carried out, evaluating several different key elements concerning target *taxa*, main threats affecting the local populations, sites and methodologies: e.g., the species' biology, chorology and habitat; the translocation sites' peculiarities; the origin and type of propagation material; the translocation type and techniques; not least, the success or failure of the interventions.

Effect of self and cross- pollination on the seed quality of 15 orchid species from Northwest Italy

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Keywords: seed viability; seed germination; orchids; hand-pollination

Ex-situ conservation is an important part of many plant translocation plans and studies on reproductive biology of the species to be reintroduced/reinforced are crucial to maximise their reproductive fitness. Some studies on pollination and self-compatibility of terrestrial orchids are available, but information on seed micro-morphology correlated with viability and germination ability is generally lacking for European orchids. With this work, we pointed at corroborating information about auto-compatibility for 15 orchid species from Liguria, comparing the quality and germination ability between seeds deriving from autogamous, geitonogamous and allogamous pollination. For each species, three pods were obtained for each pollination treatment. Information concerning pre- and post-zygotic barriers was obtained for all the selected species. Data relating to seed and embryo length/width (SL, EL, SW, EW) and percentage of embryonate seeds were collected; seed volume, embryo volume, SL/SW, and EL/EW were calculated, while seed viability was checked via Tetrazolium test; seed germination trials were conducted. Results showed that most of the analyzed species are self-compatible, but in general outcrossing allows the production of bigger embryos/seeds and significantly improves seed viability; overall, a positive correlation

was found between bigger embryos/seeds and viability, although we observed some exceptions (i.e in *Ophrys apifera* and *Anacamptis coriophora*). According to the complex of data from the sowing experiments, seeds from cross-pollination germinated faster and in higher percentages. Results confirm that cross-pollination enhances seed quality and germination rates in most of the selected orchid species; our findings suggest that hand-pollination programs aimed at the genetic reinforcement of the offspring, along with controlling seed viability, should therefore be recommended in conservation projects where plant translocation is envisaged.

From planning to practice: translocation of *Calendula maritima* Guss., an extremely rare and endangered plant from western Sicily

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Keywords: genetic pollution, habitat loss, in-vitro propagation, narrow endemic

Calendula maritima Guss. (Asteraceae) is a rare herbaceous plant endemic to western Sicily (Italy). It is restricted to some small coastal stretches and micro-insular environments, where only 16 small and scattered populations still survive. The major threats to its conservation issue from heavy human pressure that affected the coastal environments and the habitats where it lives (e.g. habitat destruction/degradation, seasonal disturbances associated with beach tourism), and genetic pollution caused by hybridization with the congeneric species *C. fulgida* Raf.. According to that, translocation in more suitable and safer sites could represent the last chance to ensure the survival for such a vulnerable species.

Translocation practices were supported by propaedeutic genetic investigation aimed at detecting and selecting the purest and most diverse lineages to propagate through *in-vitro* techniques. The most suitable sites for translocation were chosen based on environmental proxies (e.g., vegetation patterns, soil characteristics), protection regime (e.g., protected areas, Natura 2000 sites) and property type (public properties were preferred).

Since 2020, within the historical range of the species 1177 plants were used for translocation in three new sites. Their survival rate varied according to technical issues and the occurrence of extreme weather events. The main hurdles faced were summer drought stress and post-transplanting crisis, the latter usually overcome by irrigating once just after planting. Additional criticalities consisted of exceptional storm surges involving salt spraying and/or a huge deposition of *Posidonia oceanica* (L.) Delile residues that covered to death the plants closest to the coastline. Three years after the first plantations more than 61% of the plants is alive and healthy. Moreover, almost all plants, including those that did not survive beyond the first summer season, lived long enough to complete dispersal and start recruitment, which is the best indicator of the action success.

The translocation actions of the Life Floranet project

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Keywords: Restocking, habitat directive, new population

The LIFE15 NAT / IT / 000946 project, called FLORANET, was promoted by the Maiella National Park (MNP), as coordinating beneficiary, and by the University of Camerino, Sirente-Velino Regional Park (SVRP), Abruzzo, Lazio and Molise National Park (ALMNP), Legambiente onlus as associated beneficiaries.

The 7 plant taxa covered by the project are extremely important because they are present in the annexes II and IV of Directive 92/43/EEC.

The taxa involved in the project are: *Cypripedium calceolus* L., *Adonis distorta* Ten. (endemic to the central Apennines), *Androsace mathildae* Levier (endemic to the central Apennines), *Iris marsica* I.Ricci & Colas. (endemic to the central Apennines), *Astragalus aquilanus* Anzal. (currently endemic to the central Apennines), *Klasea lycopifolia* (Vill.) Á.Löve & D.Löve and *Jacobaea vulgaris* Gaertn. subsp. *gotlandica* (Neuman) B.Nord.

A part of the plant material reproduced, as part of the Life Floranet project, through the activities of the Germplasm Bank and the nursery was used for the restocking of small and threatened populations of *Iris marsica*, *Jacobaea vulgaris* subsp. *gotlandica*, and *Klasea lycopifolia* as well as for the creation of two new populations of *Astragalus*

*aquilanu*s. Both of these operations have the objective of increasing the survival chances of the species by reducing the risk of imbreeding, the decline due to even accidental alterations of the environment, and overgrazing.

Androsace mathildae: 10 new individuals were planted in October 2019 and 25 in October 2020 in a small existing population at Mt. Pesco Falcone in MNP. In 2021, only 2 individuals had survived.

Klasea lycopifolia: 140 individuals were planted in September 2020 inside the fence installed at Campo Felice in Lucoli municipality (SVRP). In 2021, 135 individuals had survived of which 8 flowered.

Jacobaea vulgaris subsp. *gotlandica*: 105 individuals were planted in September 2020 inside one of the fences installed at Piani di Pezza in Rocca di Mezzo municipality (SVRP). In 2021, 102 individuals had survived of which 32 flowered.

Iris marsica: In total 100 plants were bedded out in ALMNP at Camosciara, 50 in 2019 and 50 in 2021. In 2021, 74 individuals had survived.

Astragalus aquilanus: In Abruzzo, Lazio and Molise National Park at Salcone (Ortona dei Marsi municipality) 100 plants have been planted in 2021 to create a new population. In Maiella National Park 100 new individuals in 2019-2020 were planted in the existing population at Cansano while 100 individuals in 2019-2020 were planted in order to create a new population at Pacentro where the species was historically recorded. In 2021 at Cansano and Pacentro, 94 and 91 individuals had survived, respectively.

Eco-evolutionary restoration of sustainably viable populations in practice

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Keywords: genetic rescue, reintroduction, population restoration, ex situ, breeding program, endangered species, population viability

There is an ongoing debate about the best procedure to restore plant populations. Should we use plants or seeds? From an evolutionary viewpoint, population viability results from an interaction between genetic variation and the habitat through selection of the best adapted genotypes. Planted adult plants may produce seeds in their first year, but adult transplants maladapted to a restoration site may spread 'bad' genes into the environment. To create genetically enriched seed mixtures for population translocation, we first rescue the genetic diversity of the remaining populations with *ex situ* breeding programs. We hypothesize that using seeds from different populations, but from a similar habitat as the target site, will be more beneficial, especially if source populations are first outcrossed in an *ex situ* breeding program. Especially in genetically depauperate populations, this approach increases genetic diversity. Sowing these genetically enriched seed populations into new environments will result in selection of the best-adapted genotypes. Introduction by sowing also tests the suitability of the environment for establishment from seeds, which is an important requirement for establishment of a long-term viable population.

Here we present results of ongoing restoration projects following the above approach, on three endangered species in the Netherlands: *Antennaria dioica*, *Scorzonera humilis*

and *Primula vulgaris*. Learning from both successes and failures, we aim to convince you that our eco-evolutionary approach ultimately is the key to viable translocation.

Reintroduction strategy and reproductive success of *Malcolmia littorea* (L.) W.T.Aiton (Brassicaceae), an endangered plant of the Mediterranean coast

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Keywords: coastal dunes, seed germination, threatened species, translocation

Malcolmia littorea is characterised by a disjointed distribution across the Mediterranean, with declining populations due to human-derived threats. The Italian subpopulation has unique genetic attributes and is a priority for conservation. The reintroduction study was aimed at 1) developing a reintroduction protocol through field trials and an experimental approach; 2) evaluating the reintroduction success through yearly censuses and by testing the germination ability. Three sites were selected for the experimental reintroductions based on biological, logistical and historical criteria. Torre Olevola (TOL; Latina): in 2010, about 4,800 seeds randomly selected were sown in groups of 100 in 48 paired plots to test the microsite effect through gap creation. Torre Astura (TAS; Rome): in 2013, 200 non-hardened adults (13-month-old) and 200 juveniles (6-month-old) were transplanted in plots of 10 using a two-level factorial design with three factors: life stage; cultivation/planting practice; reintroduction microsite. Rio Martino (RIO; Latina): in 2014-2015, 50 hardened adults (12-month-old) and 50 juveniles (7-month-old) were planted in plots of five in the interdune.

Seedling emergence and plant survival were recorded monthly during the first year and after on an annual basis to record the number of reproductive individuals. In 2019, seeds were collected from the reintroduced populations and tested for germination.

In TOL, the results demonstrated that gap creation facilitated seed germination and seedling emergence. This sub-population showed the same reproductive fitness found in 2012 and continued to grow up from 101 to ~5,000 reproductive individuals in 2019.

In TAS and RIO, only a few juveniles survived after the first year. In 2019, 112 adults were recorded in RIO; in TAS the plants on the sea-facing slope established and reproduced reaching ~3,000 adults against 30 on the inland-facing slope.

Finally, the number of Italian sub-populations doubled with the total number of reproductive individuals increasing from ~260 to more than 8,400.

Utilizing translocation with symbiotic relationships in restoration to cope with multiple stressors, and the afterlife of invasive an species

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Keywords: translocation, assisted migration, mycorrhiza, invasive species

During the UN Decade on Ecosystem Restoration, the need for regeneration, replanting, and restoration is expected to grow, while planting material shortages constrain efforts and climate change presents new challenges. We tested two strategies to address these challenges: translocation of tree ecotypes and of native mycorrhizal communities symbiotic with plant roots. In some studies, intraspecies translocations from warmer climates still show reduced survival compared to local provenances. Additionally, mycorrhizal inoculation, effective if well-matched to plants and site conditions, can have neutral to negative results with poor pairings, so methods for its use with translocation are not obvious. Few studies examine the interaction between these two strategies. We evaluated these two factors and their interaction with the soil

legacies left by an invasive plant, under the worst drought conditions since 800 ce. We compared *Populus fremontii* (Fremont cottonwoods) from two ecoregions / adaptive trait syndromes (a confluence of traits adapted to either frost or heat). Trees were planted at a field site in soils with or without legacies of invasion by exotic *Tamarix* spp. (tamarisk). For half of the trees, we concurrently translocated native mycorrhizal fungi. Four main lessons emerged. 1) Tamarisk soil legacies reduced native cottonwood survival by 85%. 2) Active translocation of a diverse, native community of mycorrhizal fungi after tamarisk invasion doubled and then tripled cottonwood survival during the first and second field seasons. 3) By the second field season, translocated trees survived at twice the rate of trees from the local ecoregion, if inoculated. 4) However, inoculation sometimes had neutral to negative effects, interacting with timing, pairing between tree and inoculum sources, and soil conditions. Results emphasize the efficacy of utilizing symbiotic relationships in translocation, the need to thoughtfully optimize mycorrhizal pairings and inoculation timing, and the detrimental effects of an invasive plant's soil afterlife.

Conservation of vulnerable orchids: pollinator and habitat requirements of deceptive *Thelymitra variegata* species complex

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Keywords: deception, ecological networks, habitat, *in situ* conservation; orchids; pollination success, vulnerable species

Effective conservation of orchids requires an all-inclusive approach based on knowledge of ecological features that determine their survival. Among these, pollinators and specific habitat requirements are of critical importance when vulnerable orchid species have low pollination rates. The *Thelymitra variegata* complex is a group of iconic Australian food deceptive species threatened by poaching, loss of habitat and infrequent pollination. Our project will define the ecological traits determining the reproductive success of *T. variegata* species, by studying their pollination ecology to inform *in situ* conservation practices. Specifically, our aim is to test whether pollination of *Thelymitra* orchids occurs via generalised food deception or Batesian mimicry to the tinsel lily (*Calectasia* sp.), a co-blooming species with superficial similarity to orchids. Confirmation that pollination occurs via food deception is accomplished by examining the pollinators of the putative model plants and the orchid species. Spectral reflectance coupled with false colour photography of flowers according to bee visual perception, morphological and scent analysis of mimic and co-flowering plants will compare orchids

to putative model flowers. Quantification of fruit set and pollen removal, relative to co-flowering plants' abundance will test which components of the floral community impact the orchids' pollination success. In addition, we will identify habitat requirements of the species by ranking biotic and abiotic threats to orchid fitness. Our findings will lead to effective conservation strategies that mitigate impacts of ecological factors limiting orchid recruitment and survival, by identifying fundamental relationships with animal and plant species. This project will also help to define conservation units and reassess the rarity of these iconic orchids based on internationally recognised IUCN criteria. Overall, our study may provide a model system for successful *in situ* conservation practices for other endangered orchids with deceptive pollination syndrome.

Retranslocation of three endangered and protected aquatic plant species in Mediterranean wetlands

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Keywords: aquatic plants, Mediterranean, drought, restoration, endangered

Actions for conservation of plants of the Mediterranean basin is a keypoint for the preservation of the living beings of this biodiversity hotspot. After more than 10 years monitoring the conservation status of some Mediterranean endangered and protected plant species, we have start to act in front of all the threats that Mediterranean wetlands endangered plants have. This endangered situation of wetlands in the Iberian peninsula has been increasing the last decades with the acceleration of the climate change. Concretely, we are doing a series of ex-situ and in-situ conservation actions to promote the recovery of three protected and threatened flora taxa of the Montgrí Natural Park, the Medes Islands and the Baix Ter (PNMBT), in North-estern Iberian peninsula: the hydrophytes *Butomus umbellatus* and *Hydrocotyle vulgaris* and the halophyte *Sarcocornia perennis* subsp *alpini.* Their populations have been declining in recent years in the PNMBT and the whole eastern Iberian pensinsula and the aim of this action is to create new localities with individuals of these three taxa in areas without obvious threats in order to increase their area of distribution and number of individuals and thus improving its state of conservation. Ex-situ conservation actions have been positive for the three taxa, and, in this presentation, we show our first successful retranslocation monitoring results. Moreover, we present a methodology based on the importance of an

interdisciplinary human team to achieve successfully ex-situ and in-situ actions of retranslocations in Mediterranean wetlands.