Using selected Habitat European Directive species as garden plants: challenges and opportunities

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Abstract

The Life+ SEEDFORCE project aims at improving the conservation status of 29 Annex II Habitat European Directive plant species, reported in bad conditions in the 2013-2018 report on the trends of habitats and species according to art. 17 of the Directive. The project objectives include identifying and removing threats to the survival of these species in their native range, assessing their genetic makeup, model their ecological niche and massively propagate them to bridge the isolation and re-establish gene flow between isolated population. Additionally, the project strives to raise awareness on a selection of the species with ornamental and/or garden value and to engage the public in their active conservation which will be furthermore tested for performance in suitable garden setting, including dry Mediterranean gardens. Selected species include *Cytisus aeolicus* Guss., *Primula palinuri* Petagna, *Valeriana amazonum* (Fridl. & A.Raynal) Christenh. & Byng, *Dracocephalum austriacum* L., *Eryngium alpinum* L.] and wet boggy gardens [*Woodwardia radicans* (L.) Sm., *Adenophora liliifolia* (L.) A.DC., *Kosteletzkya pentacarpos* (L.) Ledeb.]. The project can therefore represent an example of a bridge linking the conservation of natural biodiversity and the production sector of ornamental plants.

Keywords: Habitat European Directive, threatened plant species, ornamentals

INTRODUCTION

Humankind has relied on plants for thousands of years for food, shelter, fuel, fibre, clothing, for medicinal purposes and for their ornamental and cultural value.

The initial steps toward plant and animal domestication in the eastern Mediterranean can be pushed back to the 12th millennium cal B.P. Different species seem to have been domesticated in different parts of the Fertile Crescent, with genetic analyses detecting multiple domestic lineages for each species. Recent evidence suggests that the expansion of domesticates and agricultural economies across the Mediterranean was accomplished by several waves of seafaring colonists who established coastal farming enclaves around the Mediterranean Basin, since the Neolithic (Zeder, 2008).

The introduction of wild species into cultivation for ornament began in several civilizations not long after the first domestications of plants for agriculture. In China, for example, unimproved wild species were used for ornament in the Xia dynasty (2100-1600

BC) and possibly before then (Heywood, 2003). Unlike plants that were domesticated to secure food, the domestication and breeding of ornamental plants are driven by aesthetic values. Altman et al. (2022) examined the major elements of the extended evolutionary synthesis theory that bridges the gap between the biology of ornamental plant domestication and the sociocultural motivations behind it. They propose that it involves specific elements of cumulative cultural evolution, plant gene-human culture coevolution, and niche construction. Ornamental plant domestication represents an aesthetics-driven dimension of human niche construction that coevolved with socioeconomic changes and the adoption of new scientific technologies. Initially functioning as symbolic and aesthetic assets, ornamental plants became globally marketed material commodities as a result of the co-dependence of human and prestige-competition motivations.

The Mediterranean region hosts a flora of around 25-30,000 flowering plants and ferns and has been identified as one of the world's 34 biodiversity 'mega-hotspots' (Cañadas et al., 2014). It has been noted that in terms of plant diversity per unit area, the Mediterranean may in fact be the 'hottest' of the mega-hotspots. Furthermore, due to their isolation, some ancient plant species continue to survive on Mediterranean islands, while their relatives on the mainland have become extinct (de Montmollin and Strahn, 2005). Europe is also rich in diversity of domesticated and economically important plant resources and their wild relatives. Around 80% of the plants of the European and Mediterranean region are considered to be of current or potential socio-economic use (Kell et al., 2008). The region also hosts a rich diversity of ornamental plants such as sweet pea (*Lathyrus odoratus*), pinks (*Dianthus* spp.) and violets (*Viola* spp.) (Maxted et al., 2008). However, the genetic diversity amongst crop wild relatives in the region is being eroded at an ever-increasing rate (Maxted, 2003), and at the same time the diversity of traditional land races and old cultivated varieties are also greatly diminished due to their replacement by uniform modern cultivars.

In alpine regions, geographic isolation, glaciation, and a varied history of species migration and/or evolution, all together lead to high degrees of taxonomic richness of genetic complexity and speciation (including endemism). Even on a micro-scale alpine plant diversity is high, and 200 to 300 species can be found in areas of less than 10 km^2, suggesting that additional characteristics of the alpine environment favour species richness. After checking several floras and trying various ways of compilation, it appears plausible to assume a total alpine flora of the world in the order of 8,000 to 10,000 species (Körner, 1995). The size of the total European alpine flora to be at about 2,500 species and subspecies. This estimate is based on a 20% sample of the European alpine flora (species predominantly occurring above the treeline) and excludes the Caucasus (Nagy et al., 2003). Climate change, especially global warming, may lead to the extinction of Alpine plants, at least locally and the loss of alpine species might be important. Famous ornamentals (*Leontopodium, Rhododendron, Gentiana, Anemone* species) do not grow at critical high elevations and could disappear locally from mountains which are too low in elevation (Grabherr, 2009). The conservation of threatened taxa has become a major issue. However, protection of all the taxa or ecosystems is not an achievable goal owing to wildlife's extreme diversity and finite allocated budgets. Thus, setting up a hierarchisation of patrimonial taxa is needed in order to determine the main conservation concerns of flora. Le Berre et al. (2018) carried out the classification of 913 patrimonial taxa of south-western Alps into four concern categories, which aims to improve the available financial and human resources allocation for conservation measures.

Within the ornamental plants a great number of bulbous tuberous plants, woody and herbaceous perennials, biennials and annuals are found in alpine, montane and mediterranean flora. The rate of endemism is also high within this plant group. Most of the relatives of the ornamental species are found in wild habitats. Examples of plants used as ornamental are *Allium, Anemone, Arum, Centaurea, Chonodoxa, Colchicum, Crocus, Cyclamen, Delphinium, Dianthus, Eranthis, Fritillaria, Galanthus, Gladiolus, Gypsophila, Helleborus, Hyacinthus, Iris, Leucojum, Lilium, Muscari, Narcissus, Nectaroscordum, Ornithogalum, Paeonia, Pancratium, Rosa, Scilla, Silene, Sternbergia, Tulipa,* and *Viola*. Many of these are in danger of extinction and are protected by international conventions, including the European Habitat Directive and National/Regional laws.

Non-traditional ornamentals are under-utilized and/or un-explored plant species or relatives of commercially important crops having attractive ornamental plant characteristics. However, their potential ornamental value is not fully realized and are therefore not primarily recognized or treated as an ornamental/floriculture crop. In recent years many of the novel ornamental types from the wild have been recognized and domesticated for ornamental gardening, after improving their vegetative and reproductive traits (Janakiram et al., 2021).

Several projects have been dedicated to selecting wild species for possible cultivation for ornamental purposes. Some of these projects have involved rare, endemic or threatened species. An example of particular interest is the one illustrated by Dragovic (2015) in relation to five endemic species of Madeira. The experimental work started with the species that were more easily accessible in nature, to allow adequate in situ observations, seed harvesting and, in some cases, collection of material for vegetative propagation.

Almost all the domestication projects of plants for ornamental use have been developed starting from an industrial, agricultural and market point of interest. The LIFE SEEDFORCE project, on the other hand, also includes an activity aimed at developing the possibility of domesticating threatened species, protected by international laws and of considerable aesthetic value as part of a conservation strategy, exploiting the possible trade – on limited areas – of new ornamental plants, and hypothesizing that this could contribute to a greater awareness of the need to respect nature.

In the 1980s the mounting scientific evidence pointed out to the current plant extinction crisis, that was put at the centre of botanic gardens activities and eventually led to the formulation of a Global Strategy for Plant Conservation which arose from a resolution of the International Botanic Congress, held at St. Louis, Missouri in 1999. The global botanical community joined forces via BGCI (Botanic Gardens Conservation International), promoting red-listing, seedbanking, threatened plants cultivation, translocation actions and habitat restoration.

The LIFE SEEDFORCE project idea originates from the network of Italian seedbank (RIBES) with the main objectives being: i) to carry out a national flagship project to demonstrate seedbank contribution to plant conservation with well targeted conservation actions where most needed; ii) express the full potential of seedbanks and demonstrate their role for plant conservation in a skeptical national context.

Monitoring and conserving habitats and species listed in the Annexes of the EU Habitats Directive (92/43/EEC) is a mandatory action for each Member State of the European Union. Italy is home to a high number of vascular plants of Union interest (currently 104 taxa included in Annexes II, IV & V), making Italy the third Member State as per richness after Spain and Portugal. Annex II currently lists 84 species for Italy, mainly present in the Alpine and the Mediterranean biogeographical regions, with a high rate of endemism (over 60%). However, the last ex art. 17 Report (EEA, 2020) showed a negative trend for 58 Annex II species (69%) that have been reported with 'unfavourable' conservation status, confirming the results of the latest IUCN assessments. The efforts undertaken in Italy over the last 20 years proved insufficient to grant to these taxa a 'favourable' conservation status. Extinction risks for endemic plants include human-induced habitat modifications, especially the abandonment of traditional agricultural/land-use practices (e.g., discontinued coppicing and haymaking) and overgrazing, and also the spread of invasive alien species and high-impact recreational activities and tourism. Intrinsic factors also have a significant role to play for species that are naturally scarce and distributed in a limited number of small, fragmented populations. Significant efforts are still necessary to achieve the EU Habitats Directive targets in terms of long-term plant conservation.

The main goal of the LIFE SEEDFORCE project is to improve the conservation status of 29 EU Habitats Directive Annex II species with an 'unfavourable-inadequate' (U1) (19 taxa) or 'unfavourable-bad' (U2) (10 taxa) conservation status, according to the art. 17 reporting (EEA, 2020). An integrated ex situ/in situ approach will be undertaken to remove the threats that these 29 species are facing, aiming at improving the quality of both habitats and populations in 76 Natura 2000 network sites (SCI/SACs) where these species grow or have recently disappeared.

The 29 project target species are listed in Table 1.

Table 1. Target species of the LIFE SEEDFORCE projects.

Species[a]	Family	Conservation status[b]	Endemism type[c]
Acis nicaeensis (Ardoino) Lledó, A.P.Davis & M.B.Crespo (= *Leucojum nicaeensis* Ardoino)	*Amaryllidaceae*	IT MED U2(-)	E
Adenophora liliifolia (L.) A.DC.	*Campanulaceae*	IT ALP U1(x); SL ALP FV CON U1(x)	W
Astragalus verrucosus Moris *	*Fabaceae*	IT MED U1(-)	S
Botrychium simplex E.Hitchc.	*Ophioglossaceae*	ALP U2(x)	W
Campanula sabatia De Not. *	*Campanulaceae*	IT MED U1(-)	E
Crepis pusilla (Sommier) Merxm.	*Asteraceae*	MT MED U2(=)	W
Cytisus aeolicus Guss. *	*Fabaceae*	IT MED U1(-)	S
Dracocephalum austriacum L.	*Lamiaceae*	ALP U1(x)	W
Elatine gussonei (Sommier) Brullo, Lanfr., Pavone & Ronsisv.	*Elatinaceae*	IT MED U1(x)	E
Eleocharis carniolica W.D.J.Koch	*Cyperaceae*	IT ALP CON U1(-), SL CON U1(-)	W
Eokochia saxicola (Guss.) Freitag & G.Kadereit [= *Bassia saxicola* (Guss.) A.J.Scott] *	*Amaranthaceae*	IT MED U1(=)	E
Eryngium alpinum L.	*Apiaceae*	IT ALP U1(+), SL ALP U1(x)	W
Galium litorale Guss. *	*Rubiaceae*	IT MED U2(-)	S
Gentiana ligustica R.Vilm. & Chopinet	*Gentianaceae*	IT ALP FV; MED U1(x)	E
Gladiolus palustris Gaudin	*Iridaceae*	IT ALP CON MED U1(X), SI ALP CON U1(-)	W
Himantoglossum adriaticum H.Baumann	*Orchidaceae*	IT ALP U1(-) CON MED FV	W
Kosteletzkya pentacarpos (L.) Ledeb.	*Malvaceae*	IT CON U2(-) MED U2(=)	W
Limonium strictissimum (Salzm.) Arrigoni *	*Plumbaginaceae*	IT U2(-)	E
Linaria flava (Poir.) Desv.	*Plantaginaceae*	IT MED U1(-)	E
Linaria pseudolaxiflora Lojac.	*Plantaginaceae*	IT MED U1(=)	E
Linum muelleri Moris (? = *Linum maritimum* L. subsp. *maritimum*) *	*Linaceae*	IT U1 (=)	E
Liparis loeselii (L.) Rich.	*Orchidaceae*	IT ALP CON U2(-)	W
Marsilea quadrifolia L.	*marsileaceae*	IT ALP U1(x) CON MED U2(-), SL CON U2(-)	W
Primula palinuri Petagna	*Primulaceae*	IT MED U1(-)	E
Ribes sardoum Martelli *	*Grossulariaceae*	IT MED U2(-)	S
Saxifraga tombeanensis Boiss. Ex Engl.	*Saxifragaceae*	IT ALP U1(=)	E
Silene hicesiae Brullo et Signor. *	*Caryophyllaceae*	IT MED U1(=)	S
Valeriana amazonum (Fridl. & A.Raynal) Christenh. & Byng (= *Centranthus amazonum* Fridl. & A.Raynal)	*Caprifoliaceae*	IT MED U2(-)	S
Woodwardia radicans (L.) Sm.	*Blechnaceae*	IT MED U1(-)	W

[a]Species of priority interest for the European Union are highlighted with an asterisk.

[b]Conservation status in Europe: FV 'favourable', U1 'unfavourable – unsatisfactory', U2 'unfavourable – bad'. Trends of Conservation Status in Europe: (+) 'improving', (=) 'stable', (-) 'deteriorating', (x) 'unknown'. European biogeographical regions: ALP 'Alpine', CON 'Continental', MED 'Mediterranean'. Countries: IT 'Italy', FR 'France', MT 'Malte', SL 'Slovenie'.

[c]S 'Stenoendemic species, with narrow distribution limited to 3-5 sites occurring within few km'; E 'Euriendemic species with wider distribution with approx. 10 sites occurring within a 200 km radius'; W 'widely distributed species with several sites occurring across thousands of km'.

The project involves 76 SAC/SCI, mainly in Italy (59) and in cross borders areas of Slovenia (12), France (4) and Malta (1), a total of 450,250 ha, and 153 translocation sites.

Regarding habitat-related impacts, LIFE SEEDFORCE aims to mitigate and/or remove

threats by: i) controlling re-vegetation, removing shrubs and trees, and cutting grass; ii) protecting the sites from overgrazing and trampling with relevant fencing; iii) eradicating invasive alien species according to the currently accepted best practices.

For intrinsic threats related to small and fragmented populations, the project team will increase population size with a carefully selected genotype mix that will mimic natural gene flow (usually blocked by isolation), reducing plant isolation and habitat fragmentation. The project team will also manage each site to sustain a viable population of the target species, increasing the number of individuals and removing threats. This will give each target species better resilience to future challenges, ultimately improving their conservation status.

The project's objectives are in line with the EU Habitats Directive, the 2030 Biodiversity Strategy, EU Regulation 1143/2014 on Invasive Alien Species, Farm to Fork Strategy, the new Common Agricultural Policy (CAP), and the EU Pollinators initiative.

Expected results are:

1. Improved conservation status of habitats in the 76 Natura 2000 sites (SCI/SACs) selected, covering 450,250 ha, ensuring that each site can support a viable population of the target species, by means of fencing, cutting grass, removing shrubs and trees, eradicating alien invasive species, as appropriate, adopting international standards;
2. Collection of target species germplasm, without affecting the natural reproductive potential of the donor population, and its storage for long-term conservation;
3. Propagation of target species, producing at least 50,000 individuals, making use of the facilities at each partner's site, including seed germination labs and nurseries;
4. (Re)introduce/reinforce 139 populations of the 29 target species, in the target 76 Natura 2000 sites;
5. Monitor and maintain in each Natura 2000 site optimal conditions for the survival of the translocated materials in partnership with the managing authorities;
6. Deliver, in partnership with ISPRA (technical services of the Ministry of the Ecological Transition), guidelines and training for the management of each Natura 2000 site, to grant favourable conditions for the long-term survival of each target species;
7. Develop long-term agreements with the managing authorities of the 76 SCI/SACs, to guarantee the long-term survival of each target species.

MATERIAL AND METHODS

LIFE SEEDFORCE will reach out to the general public and raise its awareness on plant conservation appealing to the unique value of endemic plants as flagship species, showcased in dedicated flower beds and put in the horticultural trade. It will engage at least 100,000 persons and 10,000 students in education. This is one of the expected results and impacts.

The target species of the project were subjected to an evaluation based on the judgments of experts who considered several important parameters for the production and commercial chain of the species and important characters for their conservation: a) aesthetic appearance (shape, colour, duration of flowering, etc.); b) life cycle; c) ease in collecting seeds and, in some cases, material for vegetative propagation; d) difficulty or ease of reproduction and propagation; e) method of cultivation; f) diseases and parasites; g) geographical distribution, the habitat; h) threats; i) conservation status (EEA, 2020); j) IUCN status (2013, updated here to IUCN, 2023 version); k) suitability of becoming a flag species to raise awareness of the importance of conserving threatened flora.

RESULTS AND DISCUSSION

Based on the evaluation criteria listed above, eight species with ornamental and/or garden value were selected: *Cytisus aeolicus*, *Primula palinuri*, *Valeriana amazonum*, *Dracocephalum austriacum*, *Eryngium alpinum*, *Woodwardia radicans*, *Adenophora liliifolia*, *Kosteletzkya pentacarpos*.

Cytisus aeolicus (Figure 1) is a shrub 2-4 (8) m high, endemic to the islands of Vulcano, Stromboli and Alicudi (Aeolian Archipelago, Sicily, Italy). It is a pioneer species, colonising environments that are subjected to intense and frequent disturbance (landslides, volcanic fires, agricultural soils). It grows on sandy soils and piroclastic deposits, in garrigues and

scrublands in the thermo-Mediterranean zone. The overall species population amounts to more than 3,000 individuals. At least 3,000 of them are known for the SAC 'Isola di Stromboli e Strombolicchio' (Zaia et al., 2020), about 150 between adults and sub-adults are present at Vulcano (although only a few tens in natural habitats), and finally 'Isola di Alicudi' hosts less than 30 plants (Troìa and Pasta, 2002). In the past, people used its wood to build vine supports and sledges for timber transportation. Existing data indicate low levels of genetic variability in the present Aeolian population, even largely partitioned within rather than among subpopulations (Conte et al., 1998). Moreover, according to Troía and Domina (2016) the species has both low fecundity and low seed germinability, and scarce seedling recruitment. Intrinsic threats are due to low genetic diversity, small natural subpopulation size (only few tens of individuals in natural habitats within the SAC boundary), and low fecundity. Current major extrinsic threats are summer fires and sheep/goat/cattle grazing. According to the Italian Red List (Rossi et al., 2013) *C. aeolicus* is classed as EN [B2ab(ii, iv)], although in the European Red List of Vascular Plants (Bilz et al., 2011) the species is classed as CR [B1ab(ii, iv) + B2ab(ii, iv)]. The last global assessment (2017) confirmed a EN status [B1ab(iv, v) + 2ab(iv, v); C2a(i)]. According to the data included in the last Report under art. 17 (EEA, 2020), it scores inadequate (U1=) in IT(MED). All actions aimed to the conservation and enhancement of *C. aeolicus* are planned and carried out by the University of Catania (Department of Biological, Geological and Environmental Sciences). The species is very well suitable for the creation of gardens in hot and arid climate areas (xeroscaping).

Figure 1. From left to right, 1st line: *Cytisus aeolicus* (photo A. Cristaudo), *Primula palinuri* (photo G. Chenais, CC0), *Valeriana amazonum* (photo G. Bacchetta), *Dracocephalum austriacum* (photo C. Bonomi); 2nd line: *Eryngium alpinum* (photo V. Casolo), *Woodwardia radicans* (photo G. Bacchetta), *Adenophora liliifolia* (photo G. Propetto), *Kosteletzkya pentacarpos* (photo M. Villani).

Primula palinuri (Figure 1) is a suffruticose plant with a robust rhizome and a thick rosette of fleshy and viscous leaves, a 15-20 cm tall scape with numerous golden-yellow flowers and a powdery white calyx. It is a stenoendemism, paleoendemic of some sites of the Lucanian Tyrrhenian (southern Campania and Basilicata) and Calabrian limestone coast. Six populations of *P. palinuri* are currently known, which are highly fragmented and have significantly declined in number; in total there are an estimated 18,500 mature individuals left (Uzunov et al., 2008). It is partially affected by pasture, tourism, fires and illegal collection. *P. palinuri* is included in the National Red List as VU B1ab(iii, v)+ B2ab(iii, v), (Rossi et al., 2013), and EN in EU (Gangale et al., 2011). Its conservation status according to art. 17 report

(EEA, 2020) is inadequate (U1-) in IT (MED). The species has embryonic dormancy (interrupted by low temperatures, chilling) and its germination process is significantly influenced by the thermal parameter, which affects the percentages of germination, the speed of the process and the state of secondary dormancy or vitality of the seeds. With temperatures around 6°C, germination occurs with high percentages and rather quickly, with an average time between approximately eight and nine days. Conversely, at higher temperatures there is a strong reduction in the percentage of germination, which becomes zero at 30°C. At a temperature of 24°C the seeds remain alive but do not germinate, unless subsequently placed at lower temperatures (Barbi, 2008). All actions aimed to the conservation and enhancement of *P. palinuri* are planned and carried out by the University of Rome "La Sapienza" (Botanical Garden and Department of Environmental Biology) with the authorization of the competent authorities, the Cilento, Vallo di Diano and Alburni National Park. The species may be suitable for the production of potted plants to be traded as the flagship species of this National Park.

Valeriana amazonum (Figure 1) is a perennial herb up to 90 cm high, with pinkish-white flowers, clustered in dense inflorescences. It is a narrow endemic plant of central-eastern Sardinia (Italy) where it occurs only in two localities, Monte Corrasi near Oliena and Codula di Luna near Urzulei (Bacchetta et al., 2008). The population of Monte Corrasi consists only of ca. 50-60 reproductive plants.

The main threat is the scarce number of plants; other threats are grazing by goats, and collectors. The species is assessed as Critically Endangered (CR) [B1ab(i, ii, iii, iv, v) + B2ab(i, ii, iii, iv, v) + D1] (Rossi et al., 2013). Its conservation status according to art. 17 report (EEA, 2020) is bad (U2-) in IT (MED).

According to the best protocol (Mattana et al., 2010), multiplication is achieved by incubating the seeds at 10-15°C (8 h light/16 h dark). The seedlings must be cultivated under controlled conditions before planting them in the ground in order to increase the chance of future survival. All actions aimed to the conservation and enhancement of *V. amazonum* are planned and carried out by the University of Cagliari (Center for Conservation of Biodiversity and Sardinian Germplasm Bank, structure of the Department of Life and Environment Sciences). Also, this species may be suitable for the production of potted plants to be traded as the flagship species.

Dracocephalum austriacum (Figure 1) is a long-lived perennial plant up to 60 cm high with blue-violet flowers grouped in cylindrical and dense inflorescences. It is widely distributed in stony dry secondary grassland from the Pyrenees to Ukraine and in the Caucasus, but with scarce and fragmented populations all across its range. In Italy *D. austriacum* is distributed over an EOO of 20,384 km^2 and an AOO of 28 km^2 for approximately. Six sites and 1,200 individuals, 3 sites occur in Trentino (Mangili et al., 2015). The main Italian population with approximately 1,000 plants is located on the top cliffs of Monte Malachin. North of the Alps the population is estimated in the range of hundred thousand. The main threat is an intrinsic one, related to small population size and habitat fragmentation. Shading related to woodland expansion is also a local significant threat.

D. austriacum category for Italy is EN [B2ab(iii)] and DD in the European list. The conservation status according to art. 17 is inadequate (U1=) in IT(ALP) (EEA, 2020).

According to Ceriani et al. (2022, unpublished) the species shows a germination rate up to 40%, but also a high mortality of the seedlings in the acclimatization phases. Once acclimatised, adult individuals go through periodic phases of good growth and crisis with sometimes total loss of the aerial part. Water stagnation is not tolerated even for short periods; on the other hand, the species tolerates summer temperatures and the relative periods of aridity. During growth in an external environment, a marked attractiveness of the species by snails was noted, which caused the loss of numerous individuals. All actions aimed to the conservation and enhancement of *D. austriacum* are planned and carried out by the Museo delle Scienze (Trento Science museum). The species has an interesting garden value.

Eryngium alpinum (Figure 1) is a perennial herb up to 70(100) cm high, with showy inflorescences with an involucre of flower heads made up of 10-20 erect bracts of amethyst-blue colour. It is an alpine endemism that occurs from the montane to high-montane belt from France to Slovenia. It is widely distributed in western Alps, with large populations in

Piedmont, Switzerland and France, where occurs in both natural environments such as meadows, pastures, cleared prairies, snow valleys, grassy edges of woods, megaphorbs, pine woods, shrubs, and anthropogenic environments, such as rural paths and roads, abandoned areas, embankments, ski slopes and artificial grasslands. In the eastern Alps is rare: in the Carnic Alps the population is approx. less than 8,000 individuals, almost completely in the site of Casera Lodin. However, the species has become extremely rare in almost all of its range and even at risk of extinction in some localities, in the past also due to its beauty and consequent indiscriminate collection (Barisani, 2020; Gygax et al., 2011). Other main threats are the encroachment due by temperature elevation and leave up of management, and lower snow protection during winter (Oriolo and Strazzaboschi, 2016). The Italian and European Red Lists include *E. alpinum* as EN B2ab(i, ii, iv, v) and NT respectively. Its conservation status according to the art. 17 (EEA, 2020) report is inadequate (U1+) in IT(ALP), (U1=) in SI(ALP).

E. alpinum is already cultivated in orchards and gardens in many varieties and for various uses, as a tall herbaceous border plant or as a mixed flower bed. It is also harvested before the flowers open and dried properly, as an element of dry floral compositions. it is sought after for its particular colour, purplish blue with metallic reflections, very uncommon among garden plants. The plant has no particular needs with respect to the substrate; it grows indiscriminately on limestone, dolomite, calc schist, siliceous schist, sandstone, but the ideal soil has a pH tending towards basic, moderately fertile, well drained (it fears water stagnation especially in the cold season), moderately humid, especially in the growth phase. Being an alpine species, its cultivation in mountain gardens is recommended. It loves full sun and in winter it resists temperatures down to -15°C. All project's actions aimed to the conservation and enhancement are planned and carried out by the University of Udine (Department of Agricultural, Food, Environmental and Animal Sciences). Boosting the production and trade of this species, whose plants can live for 20-25 years, could discourage illegal harvesting.

Woodwardia radicans (Figure 1) is a boreal-subtropical giant fern (the leaves can reach a length of 3 m), whose origin dates back to the Tertiary period. Main distributional centre are the Atlantic Islands of the Azores, Madeira and Canaries, but it grows also in south-western Europe, with a fragmented distribution in the northern of Portugal and Spain, Corsica, southern Italy, Sicily and Crete, with usually only several remnant populations in individual countries; it occurs also in northern Africa, Asia, and as naturalized in Florida and California. *Woodwardia radicans* is a hygrophilic, sciaphilous, thermophilous species, and occurs in ravines between 200 and 700 m of altitude in particular microclimatic conditions characterized by high humidity, low light intensity, and limited daily and annual temperature variations. It settles on acid soils constantly soaked with water, often in the condition of leaking water. The macroclimate, referable to the humid or hyperhumid mesomediterranean type, has a marked oceanicity. *Woodwardia radicans* frequently is found on dripping walls near waterfalls and water jumps, otherwise, it is found in the undergrowth of riparian or gorge woods. In Italy *W. radicans* occupies an area of 1,846 ha, with ca. 5,400 individuals in 36 populations, mainly in Calabria with 4,872 individuals, 464 in three populations in Sicily and only 72 individuals in two populations in Campania.

The main threats are isolation, fragmentation and small diminishing population size; other threats are habitat loss/degradation, invasive alien species (*Robinia pseudoacacia*), and natural disaster (erosion and landslide). All the Italian populations are particularly important for the conservation of the species at the Mediterranean scale, representing 50.21% of the whole Mediterranean population. In the last 50 years, the Italian population suffered a decline of about 40% with the local extinction of 24 populations. According to the Italian Red List (Rossi et al., 2013): EN B2ab(i, ii, iii, iv). In the European Red List of Lycopods and Ferns (García Criado et al., 2017): VU A2c. Conservation status is unfavourable inadequate-declining (U1-) in IT (MED), according to the 4th report ex art. 17 (EEA, 2020).

For plant propagation, spores are set to germinate in vitro and incubated in a climatic chamber until the development of mature gametophytes. Then, these are transferred into Steri vent containers for in vitro reproduction and weekly nebulized to stimulate the fecundation and the development of the sporophytes. Sporophytes with adult leaves are transferred into pots with sterilized soil in a controlled environment firstly in the growth

chamber and then in the greenhouse. Adult plantlets in pots will be cultivated in greenhouse/nursery until their use. The project's actions aimed to the conservation and enhancement of *W. radicans* are planned and carried out by the Tuscia University (Germplasm Bank). *W. radicans* is an already cultivated species: great plants are used for the shady garden border, woodland planting, creating a fernery or as pot plants for a shady spot. In pot the plant reaches smaller dimensions without however losing vigor and charm.

Adenophora liliifolia (Figure 1) is a perennial herb growing to 0.5 (1.5) m, with large pyramidal panicles with patent branches and a dozen of flowers, with a blue or white corolla. It occurs in warm bright woodland clearings on limestone at medium altitude and needs full or half sun. Its range extends from Italy and Switzerland to western Siberia and Mongolia. In Italy it can only be found at the southern margin of the Alps, occurring in 40 sites ranging between 1,500 and 5,800 individuals. Its populations are declining not only in the number of localities, but also in the number of plants representing a single population. A first intrinsic threat is related to small population size and habitat fragmentation; a second one is shading and is related to woodland expansion after the traditional wood clearing is being progressively discontinued. Illegal collection and climate change can also be considered as minor threats.

A. liliifolia scores NT and LC in the Italian and European list respectively (Rossi et al., 2013; Bilz et al., 2011). The conservation status according to art. 17 is inadequate with trend unknown (U1x) in IT(ALP) and SL (CON), and favourable stable in SL (ALP) (EEA, 2020).

For the plant propagation, seeds germinate in vitro in a controlled environment; young plants are transplanted in soil in greenhouses after about six months from germination. The species is suitable for light (sandy) and medium (loamy) soils, mildly acid, neutral and basic (mildly alkaline) soils. It cannot grow in the shade and prefers moist soil. It has garden value, is quite fast growing and is often used as background plant in flower beds.

The project's actions aimed to the conservation and enhancement of *A. liifolia* are planned and carried out by the Botanic Garden of the University of Padova.

Kosteletzkya pentacarpos (Figure 1) is a perennial halophyte, growing up to approximately 1 m, with large pink flowers. The native range of this species is east USA to Texas, Bermuda, Cuba, south Europe to north Iran (amphi-Atlantic). In Europe the species shows a distribution very fragmented by agricultural and urban development, and over the past few decades it has been lost from many localities where it was previously known. It can be found in marshes and seaside bogs of Caspian and Black Sea rivers, and in Mediterranean area. In Italy it is very rare and grows only in two regions: Emilia Romagna and Veneto, with populations subject to considerable fluctuations in the number of plants, from few hundreds to 4,000. The species is threatened mostly by land reclamation and drying out, management of vegetation and invasion of alien species. Agricultural intensification, abstractions from groundwater and pollution of surface waters are also regarded as threat. Locally the species also suffers the massive growing of competitor as *Phragmites australis* and *Rubus ulmifolius*.

In Europe, *K. pentacarpos* is assessed as CR A2ac (EW in Lazio, Puglia, Campania e Toscana) for the Italian Red List (Rossi et al., 2013) and VU (B2ab (i, ii, iii, iv, v)) for IUCN European Red Lists (Bilz et al., 2011). The conservation status is considered unfavourable-inadequate (U1-) and deteriorating (EEA, 2020).

Plants are easily propagated by seed. Mature seeds are physically dormant and require scarification, can be achieved by submersion hot water (almost boiling for a few minutes) or by vigorously rubbing between pieces of sandpaper, among other techniques. Seeds quickly (1-2 days) germinate after imbibition when placed on top or lightly covered with peat based potting mix. Plants are easily produced using standard greenhouse and nursery procedures. Studies indicate that *K. pentacarpos* is also a potentially useful species for phytoremediation of saline soils polluted by metalloids (Zhou et al., 2021).

The project's actions aimed to the conservation and enhancement of *K. pentacarpos* are planned and carried out by the Botanic Garden of the University of Padova.

The eight above cited species are a selection of policy species, that are protected by EU Habitats Directive (92/43/EEC), assessed as potential ornamental plants. Three of these are suitable for Mediterranean gardens (*C. aeolicus*, *P. palinuri*, *V. amazonum*), two for

montane/alpine gardens (*D. austriacum*, *E. alpinum*) and three for wet boggy gardens (*W. radicans, A. liliifolia*, and *K. pentacarpos*). *E. alpinum* is suitable also for production of dry cut flower.

Some of these species are already being grown and traded for ornamental or other purposes, but in limited quantities. An increase in their production and greater commercial diffusion could help promote the conservation of wild populations, reducing illegal collection, increasing awareness of the importance of the survival of endangered species and economically supporting small and medium rural communities in a framework of sustainable development of protected areas of international interest.

CONCLUSIONS

The LIFE SEEDFORCE Project is clearly dedicated to the conservation of policy endangered species of native flora, already subject to protection rules provided by the EU Habitats Directive (92/43/EEC), through translocation actions, however, it broadens its vision towards attention to the productive world of floriculture starting from the conservation point of view, but also developing ideas that highlight a possible role of floriculture itself for the protection of species that are struggling to survive. This role can help limit genetic erosion and increase awareness of the patrimonial value of spontaneous flora, both on a global scale and in small communities, strengthening their sense of identity. The evaluation of the 29 species of the Italian flora and the choice of eight of them for their potential interest as ornamentals is just one example that could be extended to other floras, deepening the studies also from a socio-economic point of view and evaluating in greater detail any risks regarding possible reproductive contacts between cultivated plants and wild plants and a possible reduction in the genetic variability of the populations of the target species.

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