ESTABLISHMENT OF A PLANT MICRO-RESERVE NETWORK IN CYPRUS FOR THE CONSERVATION OF PRIORITY SPECIES AND HABITATS.

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ABSTRACT

The project titled “Establishment of a Plant Micro-Reserve Network in Cyprus for the Conservation of Priority Species and Habitats” (PLANT-NET CY) is implemented under the EU LIFE+ programme. Its main objective is to improve the conservation status of four priority plant species and two priority habitat types of the EU Habitats Directive that are found exclusively in Cyprus, through the establishment, monitoring and management of a network of five Plant Micro-Reserves (PMRs). The PMRs approach was initially developed about 15 years ago in Valencia (Spain) and since then it has been successfully implemented in several other parts of Europe. This concept is now widely accepted as one of the most effective practices towards the conservation of plant diversity in small land plots that are of peak value in terms of plant richness, endemism or rarity. The project introduces an integrated approach for the conservation of the targeted species and habitats through monitoring of all environmental parameters affecting them, implementing specific *in situ* conservation actions, complementary *ex situ* conservation actions and promoting public awareness and controlled public involvement in the conservation activities. The project is expected to secure the protection and sound management of the targeted species and habitats and increase the participation of local people/stakeholders in the design and implementation of conservation initiatives. Moreover, PLANT-NET CY project brings together scientists who have been involved in the implementation of the PMRs approach over the last 15 years, to facilitate networking and exchange of scientific information and best practices.

INTRODUCTION

The existing distribution of Mediterranean plant species has been shaped by a combination of geological and climatic changes during the Oligocene (Hewitt, 1996). These factors have led to nearly 25.000 plant taxa nowadays observed to be native to the Mediterranean basin (Montmollin and Strahm, 2005). A significant number of these taxa

(60%) is found solely in the Mediterranean basin (Montmollin and Strahm, 2005). This extreme richness consist the Mediterranean region one of the word's biodiversity "hotspots" (Myers N., Cowling R. 1999). In recent centuries and especially during the second half of the 20th century, plant species extinction rate has reached an almost unprecedented level, usually because of anthropogenic processes, (Merlo and Croitoru, 2005). These pressures are very intensive for Mediterranean taxa, which are threatened by direct or indirect human activities (e.g. urbanization, tourism/recreation, fire change in agricultural practices, habitat fragmentation, collecting pressure) (Montmollin and Strahm, 2005). Climate change is definitely an additional threat (Thuiller *et al.*, 2005). .

The progressive loss and degradation of European natural habitats has led to the adoption of the Directive 92/43/EEC (Habitats Directive) as the main legislation tool for the conservation of biodiversity through the conservation of natural habitats in a protected site network.

The Plant Micro-Reserve approach

The conservation and sustainable management of plants should primarily be achieved by specific actions that can be enforced on the area that a plant species occurs. *In situ* conservation activities secure that recovering populations are maintained in the surrounding where they have developed their distinctive properties, thus ensuring the ongoing processes of evolution and adaptation within their environments (Geburek and Turok, 2005). The Plant Micro-Reserve (PMR) approach is one of the widely accepted practices for the *in situ* conservation and management of plant diversity. The PMRs approach was developed around 1990 and originally put into practice in 1994 (Laguna *et al.*, 2004; Laguna, 2004). This approach focuses on the conservation and management of plant populations of rare and threatened species. The PMRs aim to protect a selected

sample of each of the main populations of the rarest, endemic or most threatened species and at the same time to establish a continuously monitored network in order to: (i) achieve a representation of plant biodiversity richness, (ii) facilitate understanding of the long-term changes of endemic richness or relict plant communities, (iii) provide germplasm to the regional, wild plant seedbanks, and (iv) support ongoing, plant conservation activities (re-introductions, reinforcements, translocations, *in situ* management etc.) (Laguna *et al.*, 2004; Laguna, 2004). PMRs are defined as areas of small size (usually less than 20 ha and average of 5 ha), ideally in the form of a network, which in the long-term should be considered as a complementary tool to the generally adopted "large site" strategy that has recently materialised into the European Network of nature conservation, NATURA 2000.

According to Article 6 of the Habitats Directive, Member States are required to undertake conservation measures in order to maintain species and habitats at a "favourable conservation status". If necessary, these measures may involve appropriate management plans. The guidelines set by Article 6 led to the conceiving of the PMR approach, which is considered as a very important approach by international resolutions and strategies (national and European) (IUCN, 2004; Smart *et al.*, 2002; Laguna and Pérez-Rocher, 2003); over the last two decades it has been successfully adopted in Spain (Valencia and Minorca) (Laguna, 2004; Laguna *et al.*, 2007a, Laguna *et al.*, 2007b), Slovenia (Karst Edge) (Laguna *et al.*, 2007a; Laguna *et al.*, 2007b) and Greece (Crete) (Thanos *et al.*, 2005; Laguna *et al.*, 2007a; Laguna *et al.*, 2007b).

The most recent PMRs projects are the projects entitled: (i) A pilot network of small protected sites for plant species in Bulgaria using the Plant Micro-Reserve model (LIFE+08 NAT/BG/279 – BulPlantNet) and (ii) Establishment of a Plant Micro-reserve Network in Cyprus for the Conservation of Priority Species and Habitats'' (LIFE+08 NAT/CY/000453 – "PLANT-NET CY), which started in January 2010 and are funded by the European LIFE+ Programme.

This paper describes the most important aspects of the PMR project of Cyprus. The project is implemented by a consortium consisting of: (i) the competent authorities of Cyprus on nature conservation [Department of Environment and Department of Forests; both of the Ministry of Agriculture, Natural Resources and Environment], (ii) two Universities [Nature Conservation Unit of Frederick University and Department of Botany, Faculty of Biology of University of Athens] and two NGOs [Federation of Environmental Organisations of Cyprus and the United Nations Development Programme]. The main objective of the project is to improve the conservation status of four priority plant species and two priority habitat types of the EU Habitats' Directive that are found exclusively in Cyprus. This objective is expected to be achieved through the establishment, monitoring and management of a network of five PMRs.

IMPLEMENTATION OF THE PMRs APPROACH IN CYPRUS

The island of Cyprus

Cyprus is characterised by a rich biodiversity, which is expressed at both the habitats and species levels (Meikle, 1977; Biocyprus, 2009). The varied geology and geomorphology of Cyprus, as well as the intense fluctuations of temperature and rainfall in small-scale areas (Tsintides *et al.*, 2002; Delipetrou *et al.*, 2008) resulted in the creation of many different habitat types over a relatively short distance. Moreover, the location of the island in the eastern Mediterranean Sea, at the crossroads of three continents, makes the island an important migration route not only for humans, but also for flora and fauna species. These factors, along with the long history of the island, resulted in the formation of a rich and unique biodiversity, which is comparable to the richest areas of Europe, in biodiversity terms (Cyprus Forestry Department, 2005). Indicatively, a number of 48 different habitat types of the Annex I of the European Habitats Directive (92/43/EEC) have been identified

in Cyprus, out of which four exist exclusively on the island. It is noted that Annex I refers to natural habitat types of community interest whose conservation requires the designation of special areas of conservation. The great variation of habitat types meets the specific needs of a large number of plant species. To date, approximately 2000 taxa have been identified in Cyprus, out of which 145 are endemic to the island (Tsintides and Kourtellarides, 1998; Tsintides *et al.*, 2007). A considerably high number of plant species of Cyprus, mainly the endemics, are considered rare since their populations are small and few in number. According to the "Red Data Book of the Flora of Cyprus" (Tsintides *et al.*, 2007), which evaluates the conservation status of the Cyprus flora based on the criteria set by the International Union for Conservation of Nature (IUCN), 23 taxa are characterised as Regionally Extinct, 46 as Critically Endangered, 64 as Endangered, 128 as Vulnerable, 45 as Data Deficient and 15 as Near Threatened. Moreover, 20 taxa of the Cyprus flora are included in Annex II (animal and plant species of community interest whose conservation requires the designation of special areas of conservation) of the European Habitat Directive (92/43/EEC), out of which eight (**Arabis kennedyae,* **Astragalus macrocarpus* subsp. *lefkarensis,* **Centaurea akamantis,* **Chionodoxa lochiae,* **Delphinium caseyi,* **Ophrys kotschyi,* **Pinguicula crystallina,* **Scilla morrisii*) are characterised as priority species.

Nowadays the nature of Cyprus and specially the ability of plants and their habitats are under the negative impact of climatic change and the human impact (anthropogenic processes).

The network of PMRs in Cyprus - Targeted species and habitat types

The PLANT-NET CY project focuses on the conservation of priority species and habitat types, which are endemic to Cyprus. The targeted species and habitat types are presented below:

- **Ophrys kotschyi* is described as one of the most impressive wild orchids across Europe. It is a perennial, erect herb, 10-30 cm high, and is found in a variety of habitats at 30 locations throughout Cyprus (Tsintides *et al.*, 2007). It is a strictly protected species according to the Bern Convention and is included in the Red Data Book of the Flora of Cyprus (characterised as Vulnerable), in Annex II of the Directive 92/43/EEC and in the CITES Convention. This species is threatened by urban development in lowland areas, unsustainable agricultural practices, grazing, reduced reproductive ability, and decrease in genetic variability of the population due to low ability for sexual reproduction. Periochi Mitserou site (SCI - CY2000003) (**PMR 1** - Fig. 1; Table 1) has been selected for the establishment of a PMR focusing on this species. This site hosts one of the largest subpopulations of the species.
- **Arabis kennedyae* is an erect herb, 5-30 cm high growing only in three locations (southwest of Chionistra, Kryos Potamos and Cedar Valley) (Tsintides *et al.*, 2007). This species is included in the Red Data Book of the Flora of Cyprus (described as Endangered), in Appendix I of the Bern Convention, in Annex II of Directive 92/43/EEC and in the IUCN booklet titled “Top 50 Mediterranean Island Plants” (Montmollin and Strahm, 2005). This species is mainly threatened by biotic factors (e.g. insect consumption), fires, genetic erosion as a result of isolation and its small number of subpopulations and climate change (Kadis, 1995; Andreou, 2010; Andreou *et al*, 2011). The PMR for this species has been established within the Koilada Kedron - Kampos site (SPA - CY2000006 and SCI - CY2000008) (**PMR 3** - Fig. 1; Table 1).
- **Centaurea akamantis* is a composite subshrub with pendulous stems that grows on rocky areas. It is restricted in only two neighbouring locations at the Akamas peninsula, one of which is the Avakas gorge (Tsintides *et al.*, 2007), where PMR4 has been established. The species is included in the Red Data Book of the Flora of Cyprus (described as Endangered), in Appendix I of the Bern Convention, in Annex II of

Directive 92/43/EEC and in the IUCN booklet with the “Top 50 Mediterranean Island Plants” (Montmollin and Strahm, 2005). The species is threatened by overgrazing and genetic erosion as a result of isolation and of the small size of its subpopulations. This project targets the largest and most important subpopulation of this taxon, which is situated at Avakas Gorge, at the Chersonisos Akama site (SPA - CY4000023 and pSCI - CY4000010) (**PMR 4** - Fig. 1; Table 1).

- **Astragalus macrocarpus* subsp. *lefkarensis* is an erect, perennial, hairy herb, 30-100 cm high, found in 6 locations (Tsintides *et al.*, 2007). One of these locations is situated close to Asgata village, where PMR5 has been established. The subspecies is included in the Red Data Book of the Flora of Cyprus (described as Vulnerable), in Appendix I of the Bern Convention, in Annex II of Directive 92/43/EEC and in the IUCN Booklet with the “Top 50 Mediterranean Island Plants”. The species is threatened by disturbance of its natural habitats for urban development, reduced reproductive ability and genetic erosion as a result of the isolation and the small size of its subpopulations. The project targets the largest and most important subpopulation of this taxon, in the Periochi Asgatas site (SCI - CY5000007) (**PMR 5 -** Fig. 1; Table 1).
- 9390 “*Scrub and low forest vegetation with *Quercus alnifolia*” is found exclusively on the Troodos mountain range. The key species of the habitat, *Quercus alnifolia* (Golden oak), is the National Tree of Cyprus. The species has great ecological value as it grows on rocky slopes preventing soil erosion, while its fruits are excellent nutriment for the local fauna (Tsintides *et al.*, 2002). The habitat type *9390 is included in Annex I of the Directive 92/43/EEC as a priority habitat type. Although it has a large distribution area, climatic change could possibly affect it negatively. During the last decade, prolonged periods of draught combined with high temperatures, have already affected several *Quercus alnifolia* stands which dried out. Additionally, the habitat type is threatened by from human intervention (e.g. recreational activities, road development) and biological

processes (e.g. consumption of its fruits by insects). The PMR focusing on this habitat type has been established within the site of Koilada Kedron-Kampos (SPA - CY2000006 and SCI - CY200008) (**PMR 2** - Fig. 1; Table 1), which hosts a representative stand of habitat type *9390.

- 9590 "**Cedrus brevifolia* forests (*Cedrocetum brevifoliae*)" is restricted to only one population in the Pafos forest. Habitat type 9590* is an endemic habitat type of Cyprus and is included in Annex I of Directive 92/43/EEC as a priority habitat type. Moreover, its main distribution area (Tripylos) has been declared as a Nature Reserve for flora and fauna protection (Tsintides *et al.*, 2002). The Cyprus cedar forests are threatened by climate change, as well as from biotic (e.g. insect attacks) and abiotic (e.g. forest fires) factors. **PMR 3** was established within the Koilada Kedron – Kampos site (SPA - CY2000006 and SCI - CY200008), which hosts the entire Cyprus cedar forest. (Fig. 1; Table 1).

Main actions – conservation and management measures

The development and implementation of the project's conservation measures utilized previous knowledge on the targeted species and their habitats. In general, the project adopts a multidisciplinary approach through the implementation of both *in situ* and *ex situ* conservation actions.

In situ activities that have indirect impact on the targeted species and their habitats include:

- ***Establishment of the PMRs in the field***: the boundaries of the PMRs were defined by placing signs at their borderline, while the accessibility within the PMRs was achieved by constructing pathways. Information boards were also installed within each PMR and in the neighbouring inhabited places.

- ***Installation of permanent monitoring plots***: The monitoring plots are essential for the monitoring of the targeted species/habitats and the assessment of the results of the conservation activities. The number of plots in each PMR varies according to the size and distribution of the targeted species or habitat types.
- ***Monitoring of the PMRs***: It is a vital element that must be integrated in the development of concrete conservation measures. A system of digital, environmental sensors and data loggers were installed in each PMR. The outcome from this measure is to ensure that the external factors adversely affecting the targeted species and habitats will be monitored and controlled.

Central to this project is the application of *in situ* conservation measures, which were developed to address the specific requirements of each targeted species and habitat type. These measures include mild interventions within the PMRs aiming at enhancing the structure and composition of the habitat and improving the conservation status of the targeted species. Some examples of these measures include:

- Protection of an effective number of seedlings from each targeted species (except **Ophrys kotschyi*) by artificial covering of selected individuals.
- Selective fencing / covering (in cases of external threats) of adult individuals to reduce or eliminate seed/fruit predation.
- Sustainable control of seed/fruit predators in an effective number of **Astragalus macrocarpus* subsp. *lefkarensis* individuals and possibly other targeted species, to increase seed output.
- Increase of sexual reproduction in **Ophrys kotschyi* by hand pollination.
- Protection of individual plants from erosion through small-scale relief modifications.
- Decrease of competition through mild pruning, weeding and removal of seeds, seedlings and saplings of the main competitors.
- Reduction of the risk of wildfires through removal of dried, flammable biomass.

- Increase of the survival rate and the reproductive output of an effective number of individuals through moderate provision of water in extreme drought conditions.
- Increase of the seed output of **Astragalus macrocarpus* subsp. *lefkarensis* through moderate provision of fertilizer/manure.
- Enrichment of the populations of the targeted species by increasing their sexual reproduction through artificial seed dispersal and/or planting of seedlings. The number of seeds that will be dispersed in each PMR will depend on the reproductive output of each species.

The project also includes a series of complementary *ex situ* conservation measures, which ensure the long-term survival of the targeted species. Such measures include:

- Utilisation of the three Botanical Gardens of the Department of Forests which are situated in different altitudes and can meet the requirements of all targeted species. Adequate numbers of individuals from each targeted species will be planted to ensure a sustainable, genetically representative living collection. The Botanical Gardens could also promote public awareness, by familiarizing visitors with plant conservation initiatives and practices.
- Collection and storage of seeds of the targeted species at the seed bank of the Cyprus Agricultural Research Institute. Seeds are collected from the natural populations of the targeted species following the international protocols (Royal Botanic Gardens and Universidad Politécnica de Madrid 2008). International standards and recommendations will be also followed for further processing and manipulation (drying, cleaning, storage and general management) of the seed lots will be followed as well.

CONCLUSION

The project introduces integrated methods for the conservation of the targeted species and habitats through adopting the PMR approach. Hence, monitoring of all environmental parameters affecting the targeted species and their habitats, implementing specific *in situ*

conservation actions, implementing complementary *ex situ* conservation actions and promoting public awareness and controlled public involvement in the conservation activities, will achieve the project goals. The project is expected to secure the protection and sound management of the targeted species and habitats, as well as to increase the participation of local people/stakeholders in the design and implementation of conservation initiatives. Moreover, the project aims to provide a platform for networking of all previous projects with a focus on the establishment of PMRss in Europe. This platform will serve as an exchange mechanism of scientific information and best practices and will facilitate the networking of researchers who have adopted the PMR approach over the last 15 years.

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Table 1: The Plant Micro-Reserve network in Cyprus.

PMR	Species – Habitat types	Area (ha)	Population size
PMR1	**Ophrys kotschyi*	2.8	647 (2011 count)
PMR2	9390 *Scrub and low forest vegetation of *Quercus alnifolia*	22.9	-
PMR3	**Arabis kennedyae* and 9590 **Cedrus brevifolia* forests	15.8	1202 (2010 count)
			-
PMR4	**Centaurea akamantis*	17.3	532 (2010 count)
PMR5	**Astragalus macrocarpus* subsp. *lefkarensis*	2.7	172 (2011 count)

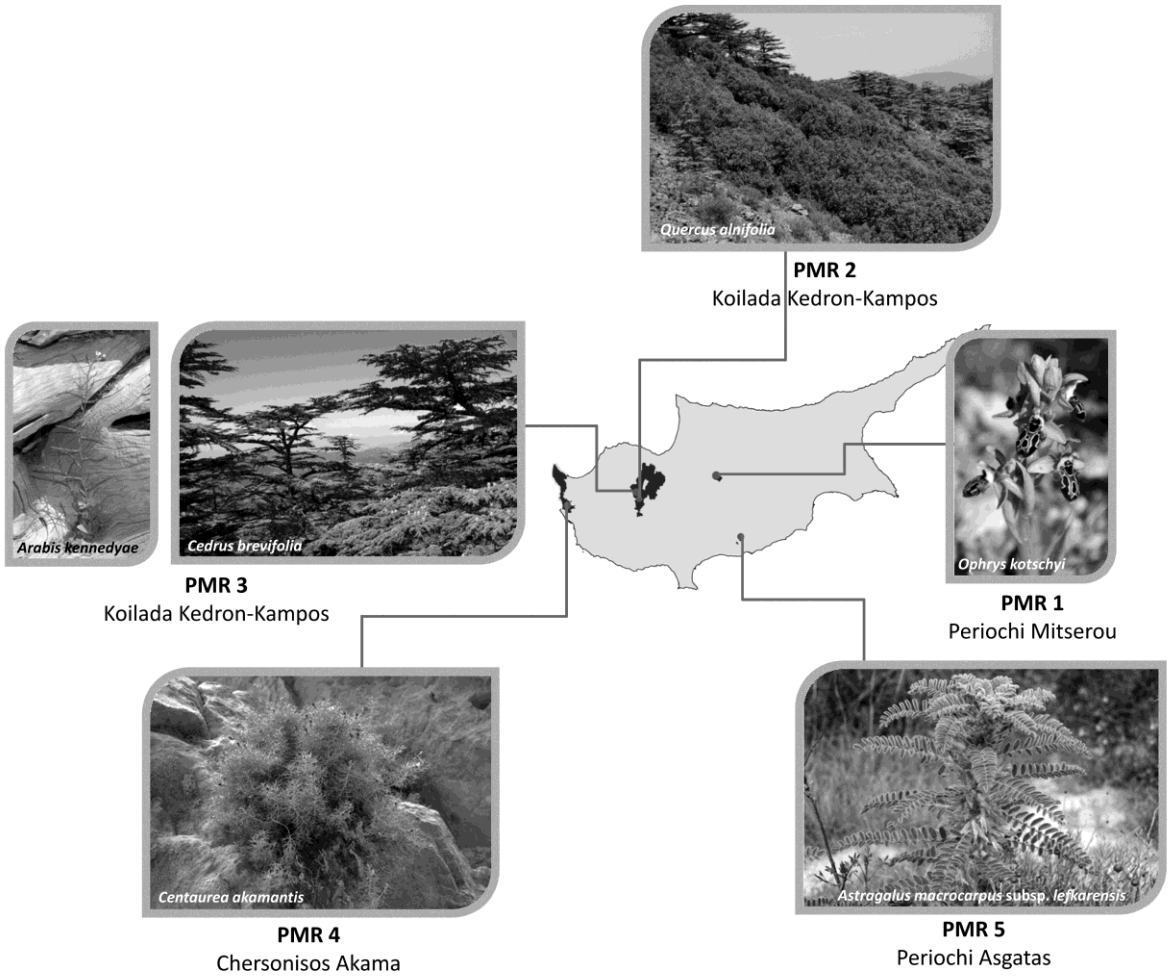

Figure 1: Map of the Plant Micro-Reserve Network in Cyprus.