‘ECOPLANTMED’

ECOLOGICAL USE OF NATIVE PLANTS FOR ENVIRONMENTAL RESTORATION AND SUSTAINABLE DEVELOPMENT IN THE MEDITERRANEAN REGION

‘GUIDE OF GOOD RESTORATION PRACTICES FOR MEDITERRANEAN HABITATS’

EcoplantMed

Project funded by the EUROPEAN UNION

ENPI CBCMED
CROSS-BORDER COOPERATION IN THE MEDITERRANEAN

Cite as: Marzo A, Herreros R & Zreik Ch (Eds.). 2015. Guide of Good Restoration Practices for Mediterranean Habitats. Ecoplantmed, ENPI, CBC-MED.

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Acknowledgements:

The authors would like to express our profound gratitude to all individuals and institutions that have kindly collaborated with us in the edition of this publication, and specially the managers and technicians of the restoration projects submitted.

Paco ALBERT, José Antonio ALLOZA, Daniel ARIZPE, Ricardo BARBERÁ, William COLOM, Jordi CORTINA, Vicent CERDÀ, Maria Antonietta DESSENA, Sela HUESCA, Miquel IBÁÑEZ, Petros KAKOUROS, Emilio LAGUNA, Eduardo MARTÍNEZ, Jesús MARTÍNEZ-LLISTÓ, Marcello MIOZZO, Martino ORRÙ, Rafael PAULO, Giorgos PETRAKIS, Silvia PINNA, Gloria ORTIZ, Carlos PEÑA, Aruca SEBASTIÁN, Sales TOMÁS, Alberto VILAGROSA, Antonio VIZCAÍNO.

The ECOPLANTMED project would like to thank the European Union and the ENPI CBC Med Programme for their support.

Cover design:

Nayla FERZLIi and Clément TANNOURI

Presentation

The creation of a Guide of Good Restoration Practices for Mediterranean habitats is an initiative that arose from the collaboration among seed banks, research institutes and institutions dealing with native plant conservation and management, who addressed the need for using native plant genetic material in restoration actions.

The Mediterranean Basin, being the third most significant plant diversity hotspot worldwide, is an area where plant species conservation and ecological habitat restoration are of major importance for sustainable development. Restoration practices using native locally adapted plant species with sufficient intraspecific genetic diversity can contribute to long-term protection and enhancement of the Mediterranean natural and cultural heritage as well as landscape protection, management and planning. Furthermore, using native plants can increase ecosystem resilience to climate change and combat the proliferation of invasive alien plants. In the case of habitats of high conservation value, appropriate restoration practices are even more crucial.

The Guide of Good restoration Practices is a compilation of bibliographical research on ecological restoration and Mediterranean habitats, and contains a selection of 15 Good restoration Practices involving native plants that have been identified for different Mediterranean habitats, as well as a description of two pilot restoration actions. It is addressed to all those involved in habitat, ecosystem and landscape restoration activities including policy makers. The Guide attempts to make the use of local plant genetic material a necessary consideration in restoration activities, thus complementing the conservation of plant diversity in the Mediterranean Basin.

The edition of the Guide and the two pilot restoration actions described within were made possible by the project **ECOPLANTMED**: 'ECOlogical use of native PLANTs for environmental restoration and sustainable development in the MEDiterranean region'. The project aims to contribute to halting the loss of biodiversity and to promote a sustainable development model in the Mediterranean region by enhancing the conservation of native plants and promoting their use in habitat restoration and the plant production sector. The Guide and the Manual for the propagation of native plants (Ballesteros *et al*., 2015) also produced by the project are expected to become useful tools for the planning and implementation of restoration action in all countries of the Mediterranean Basin.

The ECOPLANTMED project has a total budget of 1.050 million Euros and it is financed, to an amount of 0.945 million Euros (90%), by the **European Union** under **the ENPI CBC Mediterranean Sea Basin Programme 2007-2013.** ECOPLANTMED is one of 95 projects funded under this Programme, a multilateral cross-border cooperation initiative financed by the European Neighbourhood and Partnership Instrument (ENPI) which involves 14 countries (Cyprus, Egypt, France, Jordan, Greece, Israel, Italy, Lebanon, Malta, Palestine, Portugal, Spain, Syria -participation currently suspended- and Tunisia). The Programme, managed by the Autonomous Region of Sardinia on behalf of the European Commission and participating countries, aims to promote a sustainable and harmonious cooperation process at the Mediterranean basin level by addressing common challenges and enhancing the endogenous potential of the area and has a total budget of 200 million Euros (www.enpicbcmed.eu).

ECOPLANTMED project duration: January 2014 – December 2015

For more information about ECOPLANTMED, see http://www.ecoplantmed.eu/

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1

THE MEDITERRANEAN HABITATS

1.1 Introduction

The Mediterranean region extends over about 3800 kilometres from east to west, from the end of Portugal to Lebanon, and about 1000 kilometres from north to south, from Italy to Morocco and Libya (Sundseth, 2010). The concept Mediterranean region may be understood through two different points of view: The geographical approach defines it as a group of territories that surround the Mediterranean Sea, which means a coastline on the sea. Instead, the biogeographic approach also considers the climatic and geological conditions and the distribution of the plant species, defining an area whose limits are slightly different to the first ones, but define a more congruent territory. Therefore, in the context of the ECOPLANTMED project, the term 'Mediterranean region' is used in the biogeographic sense. It covers the territories of 3 continents and 24[1] states (Sfenthourakis & Svenning, 2011), in whole or in part (Figure 1).

The Mediterranean climate is characterised by a marked seasonality in the distribution of temperature and precipitation. In general, summers are hot and dry, creating a remarkable and characteristic water stress in the species in Mediterranean ecosystems, and winters are cool and wet. However, this general scheme is modified as a result of varied and contrasting topography and distance to the sea, which introduces a variable degree of continentality and climate rigor (Valladares, 2007). The high intra- and inter-annual unpredictability, with sudden torrential downpours or bouts of high winds at different times of the year, is also a characteristic of Mediterranean environments, thus exhibiting a high variety of vegetation types and landscapes: lofty mountains, rocky shores, impenetrable scrub steppe, deciduous forests, coastal wetland or sandy beaches are only a sample among the great mosaic of sceneries.

The Mediterranean climate is predominant in the Mediterranean region, but is also given in areas of South Africa, Australia, California and Chile (Figure 2). In the context of this Guide, Mediterranean habitats are those which develop in the Mediterranean climate, and which are included in the Mediterranean region. Within this concept, habitats that could be defined as 'transition habitats' could be considered, for instance those which in its most characteristic representation are already more typical of other drier or colder regions, but which nevertheless are represented in the territories of the region, showing a clear influence of the Mediterranean climate, reflected in a somewhat remote floristic composition of the typical model. Also to some extent, habitats

[1] Number of territories involved in Mediterranean region can vary depending on data source.

with the same climate in other biogeographic regions have been considered (see chapter 5): the problems derived from the climate we share -despite other common global threats- could lead us to use similar methodologies to solve these limitations; at the same time, the adaptive responses of the plants, similar to a certain degree in all Mediterranean climate regions, represent ecological keys with applications in habitat restoration.

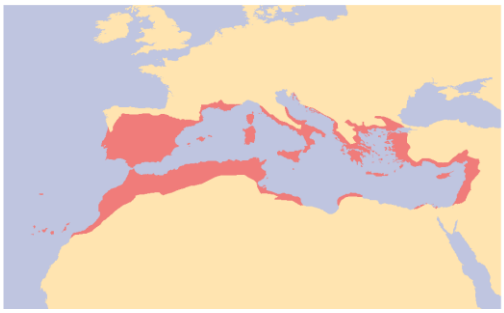

Figure 1. Biogeographic Mediterranean Region (adapted from Udvardy, 1975; Médail & Quézel, 1999; and Rivas Martínez et al., 2004).

Figure 2. Disjointed areas with Mediterranean climate (adapted from Dicastri et al., 1981).

A characteristic feature of Mediterranean region ecosystems is their high biological richness. The Mediterranean Basin is one of the most bio-diverse regions and the third most significant plant diversity hotspot worldwide with 25,000 plant species, over half of which are found nowhere else in the world (Myers *et al*., 2000). However, the Mediterranean region is also known as one of the planet's most threatened territories, being the 4th most significantly altered biodiversity hotspot of the planet (Mittermeier *et al*., 2004), and the 2nd in habitat area loss.

Thousands of years of human settlement and habitat modification have distinctly altered the vegetation. The greatest impacts of human civilisation have been deforestation, usually for the purposes of expanding agricultural land or for timber harvesting, intensive grazing and fires, and infrastructure development, which has been promoted particularly in an intensive way in the coastal areas as a consequence of the global tourism. Therefore, human activities have led to habitat loss and degradation as the main threat for Mediterranean basin species, and extreme climatic events such as fires or severe droughts are expected to increase the threat further (Cuttelod *et al.*, 2008).

A general review regarding Mediterranean habitats conservation status shows that a mere 5% of the extent of the hotspot remains with relatively intact vegetation. Furthermore, it is expected that almost 19% of its species will be threatened by extinction by 2050. All of this makes clear the need, not only to conserve, but to restore habitats. Habitat restoration has become a priority in ongoing national and international programs and strategies, among which the Strategic Plan of the United Nations Convention on Biological Diversity 2011-2020 is noteworthy, which states, through target 15, that at least 15% of all degraded lands should be restored by 2020. Similarly, the Bonn Challenge, driven by the Global Partnership on Forest Landscape Restoration, has the global aspiration to restore 150 million hectares of the world's degraded and deforested lands by 2020.

1.2 General descriptions

The Mediterranean Region harbours more than half of the habitat types listed in the EU Habitats Directive. Of these, 37 occur only in this region. The large number reflects not only the region's warm climate, variable geology and complex topography with many isolated areas, but also the fact that much of the region was spared by the ravaging effects of the last Ice Age that spread across Europe.

Mediterranean forests are often open with ample light, giving room for layers of scrubs and dwarf scrubs, resulting in a complex vertical structure. Forest, scrubs and heathlands often appear in close interconnection and may merge into one another. Mediterranean forests are highly diverse in species composition. It is estimated that more than 100 tree species contribute to the various forest types. The forests are mainly broadleaved, but conifers occur at mountainous sites with shallow soils, or as plantations (*Pinus pinaster* and *Pinus halepensis*). Many of the dominant broadleaved tree species are sclerophyllous (evergreen with leathery leaves): cork oak (*Q. suber*), holm oak (*Quercus ilex* and *Q. rotundifolia*), Aleppo oak (*Q. infectoria*), kermes oak (*Q. coccifera*), and Palestine oak (*Q. calliprinos*). These forests usually have a rich layer of vines (*Clematis* sp., *Lonicera* sp., *Smilax* sp. and *Rubia* sp.), and in the more humid and mesophilous zones, they are rich in shrubs and small broadleaf tress with lauroid leaves, often entire, evergreen and leathery (*Arbutus*, *Viburnum*, *Myrtus* and *Laurus*).

Over the course of the last two – three millennia these oak forests have progressively replaced other deciduous oak trees (*Q. brachyphylla, Q. canariensis*, *Q. congesta*, *Q. faginea*, *Q. ichnusae*, *Q. pyrenaica*, *Q. virgiliana*), which are now mostly found at higher altitudes or in areas with deep soils and higher humidity.

Forests in Mediterranean mountain ranges also contain many conifer species of *Abies*, *Pinus*, *Juniperus* and *Taxus*. Some of these are endemic trees, as the cedar of Lebanon (*Cedrus libani*) which is particularly renowned for its timber, having been utilized for thousands of years and now holding pride of place on the Lebanese flag. In addition, there are few palm species native to Europe and present in the Mediterranean Basin, such as the Mediterranean dwarf palm (*Chamaerops humilis*) and the Cretan date palm (*Phoenix theophrasti*).

The forests have been much degraded by overgrazing and exploitation for firewood, but also as a result of fires. Such forest areas may become open, secondary forests with several understories, but if not properly managed they may turn into varied types of high or low dry scrubs, or in some areas to heathlands, or degrade into sparsely vegetated areas. Only very limited forest areas remain without influence from human activities. The fragments are fragile and under high pressure, and comprise areas with old oaks, pines and wild olive such as oak formations in Sardinia and Tuscan Archipelago, and Mediterranean fir formations in restricted areas in the south and southwestern part of the region. In Sicily very few individuals remain of the critically endangered and relic Sicilian fir (*Abies nebrodensis*) ca. 20 mature individuals exist and replanting have had limited success.

Mediterranean heathlands, scrubs, grasslands, and arid lands. The bush and dwarf-shrub occupy a large extension of the Mediterranean Region's landscape. The ubiquitous Mediterranean scrub comes in a variety of shapes and sizes, and is named as matorral, maquis, garrigue and phrygana depending on their geographical

location, altitude, exposure, soil, degree of degradation, human usage and species composition. But in reality these habitat types often merge into one another to form an intricate yet inherently mobile mosaic pattern across the landscape.

The height of the scrub can sometimes be used as a simple rule of thumb. Maquis, for instance, tends to form dense impenetrable thickets 1–4 meters high and is usually dominated by small trees like the strawberry tree (*Arbutus unedo*), the lentisc (*Pistacia lentiscus*), the wild olive (*Olea europaea* var. *sylvestris*) or the myrtle (*Myrtus communis*), or less frequently juniper and laurel. Garrigue on the other hand is more open and the vegetation barely reaches knee height. Here leathery-leaved plants like the rock-roses (*Cistus* sp.) and aromatic shrubs like *Lavandula* sp., *Teucrium* sp., *Thymus* sp. and *Rosmarinus* sp. are mostly in evidence, filling the air with their perfume. Phrygana, which mainly occurs in the eastern part of the Mediterranean, usually along the coast, is the lowest form of scrub of all and is composed of spiny cushion (e.g. *Sarcopoterium spinosum*, *Satureja thymbra*) forming bushes and ground-hugging shrubs. These habitats contain many types of species adapted to light and draught (e.g. *Anthyllis hermanniae*, *Genista acanthoclada*).

The complexity of the vegetation structure makes the Mediterranean scrublands exceptionally rich in wildlife. Intensively flowering scrub species are dominant, many also being highly aromatic: *Artemisia*, *Cistus*, *Genista*, *Helichrysum*, *Phlomis, Salvia*, *Teucrium*, *Thymus,* etc. Other colorful flowers typical from Mediterranean scrublands are geophytes like wild tulips, narcissus, crocuses and alliums as well as many species of bee or mirror orchids. Together they put on a brief but spectacular display of flowers every spring, but may dry out in summer. These areas are highly vulnerable to erosion and to new establishment of plants, though the deep-penetrating roots will protect the existing established vegetation for a long time. The characteristic plant genera often show a large number of species, though many may have limited geographical distribution.

Other parts of the Mediterranean are simply too dry for trees or dense vegetation and are, instead, covered in vast swathes of grasslands. At first sight, these semi-arid steppic areas may appear barren and lifeless but on closer inspection they reveal an equally rich wildlife. The wintergreen Mediterranean dry grasslands (*Lygeo-Stipetea* class) are constituted by perennial caespitose, or sometimes stoloniferous, bunchgrasses. This vegetation is widely distributed from the sea level to above 2000 m of elevation, often as a serial stage linked to the degradation of woodlands and maquis. For example, the dry grasslands dominated by *Stipa tenacissima* (known as 'espartales' in the Iberian Peninsula) constitute one of the most characteristic formations of the occidental Mediterranean semi-arid areas. *Stipa tenacissima* steppes are mostly distributed in a thin latitudinal fringe in North Africa (Libya, Tunisia, Algeria, and Morocco) and in the southeastern portion of the Iberian Peninsula. In Sardinia and Sicily, and the Iberian Peninsula, grasslands characterized by the dominance of *Brachypodium retusum*, along with other grass species (*Hyparrhenia hirta*, *Ampelodesmos mauritanicus* and *Lygeum spartum*), are quite widespread. The Mediterranean region presently only contains minor areas that are so arid as to be included in pre-desert or desert in e.g. Spain, Portugal, Sicily, Turkey, Tunisia, and other Maghreb countries.

Mediterranean freshwaters include a variety of ecosystems such as rivers, creeks, lagoons, diverse wetlands, and temporary ponds. Many Mediterranean rivers have low annual volume and irregular regimes. The predominant fluvial regime is characterised by an extended summer period of low or absent water. Because of

the water deficits in most of the region, wetlands such as mires, bogs and fens are naturally limited. However, there are some very spectacular and ecologically important wetlands in the region.

Many species of submerged plants are types of pondweeds, such as *Potamogeton pectinatus*, which covers one third of the area of lake Ichkeul in Tunisia, and is the main species consumed by wintering duck populations. When the water is saltier, the pondweeds are replaced by tassel-weeds (*Ruppia* sp.), whereas in areas that remain dry for more than one month, there are shallow water communities such as stoneworts (*Chara* sp.), which can withstand summer drought.

The reed *Phragmites australis* is clearly a dominant species among the large emergent macrophytes of freshwater marshes. This species grows where conditions remain wet through most of the year. In areas that are permanently flooded it can form floating masses. When there is intensive grazing, the reeds can be replaced by prostrate grasses such as *Aeluropus littoralis*, or by sea club-rush *Scirpus maritimus*, which tolerate salt better, and flourish in lightly grazed areas, often on the banks of deep lakes. The most extensive beds are found in the Daimiel wetland in the centre of Spain and in the marshes of the Crau in the Camargue.

Most river forests (riparian forests and alluvial woods) have disappeared from the European floodplains, although in certain deltas, some fragments remain, as is the case at the Nestos, in Greece, in which there remain sixty hectares of seasonally-flooded deciduous forest, or in the Ebro delta where there are stands of poplars (*Populus* sp.), alders (*Alnus* sp.), and white willows (*Salix alba)*. Due to the torrential character of most Mediterranean rivers, Mediterranean riparian vegetation fits a seasonally water-stressed environment. Plant communities in these ecosystems are structurally similar, with a developed shrub layer, few dominant trees, and a patchy mosaic of herbaceous, shrub-dominated, and closed-canopy ecotypes that are associated with distinct geomorphic landforms and/or soil moisture regimes. Common plant genera along the Mediterranean riparian forests include *Celtis, Fraxinus, Nerium, Populus, Salix, Tamarix, Ulmus* and *Vitex*. The composition of the diverse plant communities varies along geographical location, altitude, exposure, soil-composition and river flow. These habitats contain many types of species adapted to light and draught. Some differences exist within the Mediterranean Basin, for example there is a greater presence of *Platanus, Eleagnus, Pterocarya,* and *Cercis* in the eastern part of the Basin. Examples of relict *taxa* within riparian communities include *Rhododendron ponticum* in the western Basin (Portugal, Spain) and *Liquidambar orientalis* in the eastern Basin.

The temporary ponds form some of the most distinctive plant communities. A great number of these very diverse plants, and in particular several species of quillworts (*Isoetes* sp.) and other pteridophytes (e.g. *Marsilea* sp., *Pilularia minuta*), can only be found in this region.

Mediterranean coastal habitats are very diverse, even within short distances, with rocky stretches and sandy and gravely beaches or coves, including habitats such as rocks and sea cliffs, sandy dunes, caves, lagoons and deltas. Vast areas of dunes and wetlands have totally disappeared.

Posidonia oceanica is a marine plant endemic to the Mediterranean Sea. It forms dense underwater meadows at a depth of up to 40 meters. Much like the grasslands on land, these *Posidonia* beds are exceptionally rich in wildlife and play a key role in protecting the coastline. However, *Posidonia* beds are under strict protection, as over a half of them have regressed or disappeared in the Mediterranean in the last 30 years or so.

Dunes play a major role in preserving beaches and protecting the forests, biological communities and amenities situated behind them. However, only few areas remain untouched. Dunes are the exclusive habitat of many endemic plant and animal species. One third of the dune flora is endemic to the Mediterranean. Many dune species are useful pioneer plant species, which help to colonize or to repair sandy substrata, such as *Eryngium maritimum*, *Pancratium maritimum, Cakile maritima, Silene* sp., *Malcolmia* sp., *Matthiola* sp. Diverse coastal dune grassland communities include species as *Ammophila australis, Elymus farctus*, and *Euphorbia terracina*. Coastal dunes are often colonized by Mediterranean thermophilous pines (*Pinus halepensis* and *P. pinea*), or are the habitats of diverse *Juniperus* sp. microforests (e.g. *J. macrocarpa* and *J. phoenicea* subsp. *turbinata*), leading to unique habitats where diverse species are found. Indigenous dune vegetation is also in this region endangered by the invasion of exotic species, which have escaped from private gardens, such as *Carpobrotus* sp. or *Acacia* sp. The decline in Mediterranean dunes has been severe: more than 70% are estimated to be lost since 1900. Most of the former dune area has been used for urbanization, for tourism purposes, or they have been planted to stabilize moving sands and have gradually been turned into dry forests, often with pines and/or *Acacia* sp.

Sea-grasses are found on the seaward edges of lagoons, where the two types of environments blend together. In the intertidal zones, the vegetation is generally dominated by eelgrasses *Zostera* sp., which is generally replaced by *Ruppia* sp. in the calmer, more enclosed, and warmer waters of saline ponds. On the banks, in marshy zones that are seasonally flooded, there are annual and perennial halophyte species that germinate in the dry season, when the water recedes below the surface of the ground; in particular, *Salicornia*, *Arthrocnemum*, and the grasses of brackish marshes that are resistant to both winter flooding and intensive grazing. *Salicornia* (glassworts) occupy wide areas of brackish marshland in the Mediterranean Basin), in particular in the deltas, on the edges of lagoons, and around salt lakes in Northern Africa. They help maintain these structures by capturing sediments, which leads to the emergence of a characteristic land form dotted with mounds. Other communities of halophyte plants proliferate on the edges of marshes, such as rushes (*Juncus* sp.), which can form a belt just a few metres wide around ponds, at the upper limit of the zones that are flooded in winter, just before the tamarisks (*Tamarix* spp.), which give way to wet grassland as you move away from the shore.

Along the coasts, rocky landscapes with cliffs, gorges, crevices and caves are frequent. They present extreme living conditions for plants as well as for animals and vegetation is sparse. Cliffs and gorges harbour cliff-dwelling plants and a number of tree and shrub species with dwarf forms because of water and nutrient limitations as Phoenician juniper (*J. phoenicea* subsp. *turbinata*), *Genista* gr. *acanthoclada*, *Anthyllis barba-jovis*, or *Astragalus* gr. *massiliensis*. Narrow crevices serve as micro-habitats for a large number of endemic species (*Bellium* sp., *Silene* gr. *mollissima*, *Limonium* sp.).

2
ECOLOGICAL RESTORATION

2.1 Concept

Ecological restoration represents a holistic process aimed at fully repairing ecosystem structure, function, and the provision of goods and services. It provides a conceptual framework where the link between nature and culture is especially inspiring. It is an important management approach that can contribute to broad societal objectives for sustaining a healthy planet and delivering essential benefits to people (SCBD, 2010), by renewing economic opportunities, rejuvenating traditional cultural practices and enhancing ecological and social resilience to environmental change (Keenleyside *et al*., 2012).

According to the International Primer on Ecological Restoration (SER, 2004), ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. An ecosystem has recovered -and is restored- when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy, it sustains itself structurally and functionally, demonstrates resilience to normal ranges of environmental stress and disturbance and interacts with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions.

Various terms have been used in the literature to define activities that can be performed to manage degraded ecosystems, such as rehabilitation, reclamation, mitigation, reallocation, remediation, revegetation, and also forestation, reforestation, and others. These concepts have been employed to refer to activities that differ from restoration, but they have also been used to describe different levels of recovery from a degraded to a restored state (van Andel & Aronson, 2012). Moreover, they have been favoured in different regions of the world (Clewell & Aronson, 2007). Accordingly with SER (2004), restoration encompasses part of the work under this terminology: the actions may be qualified as ecological restoration if they satisfy the attributes of the restored ecosystems. Since ecological restoration has gained the acceptance of the scientific and technical community, much of the work previously defined as rehabilitation, reforestation, etc., is now being identified as restoration.

Ecological restoration is an intentional activity aimed at returning an ecosystem to its historic trajectory. The historic trajectory of a severely impacted ecosystem may be difficult or impossible to determine with accuracy. Nevertheless, the general direction and boundaries of that trajectory may be established by combining knowledge on past ecosystem structure, composition and functioning, comparisons with less degraded ecosystems, and reference information on the ecological, cultural and historical context. These combined sources of information allow the historic trajectory or reference conditions to be charted from baseline ecological

data and predictive models, and its emulation in the restoration process should aid in piloting the ecosystem towards improved health, integrity and sustainability (SER, 2004).

Frequently, the ecosystem that requires restoration has been degraded, damaged, transformed or entirely destroyed as the direct or indirect result of human activities. Examples of such results are pollution, overgrazing, soil erosion or compaction, drainage, structural damage, high-grade logging and alien species invasion. In some cases, the impacts to ecosystems have been caused or aggravated by natural factors such as wildfire, floods, storms, or volcanic eruption. An ecosystem may reach a point at which it cannot recover its pre-disturbance state or its historic developmental trajectory. Therefore, 'ecological restoration' as defined above is not always possible to achieve. Indeed, in the field of restoration ecology, it is generally accepted that a return to the past is not possible. This implies that the notion of a historic reference system, representing pre-disturbance conditions should not be conceived in a narrow fashion or restricted to an idealised situation of the past. A reference system may change over time and may in fact be developed as a series of successive reference states or systems (van Andel & Aronson, 2012).

2.2 The importance of native species in ecological restoration

A restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure (SER 2004).

Since ecological restoration of natural ecosystems attempts to recover a historic state, the use of native species and the reduction or elimination of exotic species at restoration project sites is highly desirable.

Increasing the use of native species in restoration activities provides real environmental and livelihood benefits. Four important benefits are as follows (Bozzano *et al*., 2014):

(1) It contributes to conservation of the species themselves and their genetic diversity.

(2) If planting material represents not only a native species but originates from seed sources local to the planting site, it will have evolved together with other native flora and fauna of the area. It should therefore be well adapted to cope with the local environment and should support native biodiversity and ecosystem resilience to a greater extent than would introduced (exotic) planting material.

(3) Native species may be less likely either to become invasive or to succumb to introduced or native pests than exotic species.

(4) Native species may correspond better to the preferences of local people, and chances are higher that local people hold ethnobotanical and ethno-ecological knowledge of these species, which may facilitate their successful use in restoration projects.

Successful establishment and survival of the native species in ecological restoration projects depend on where and how seeds are collected. It is important to use locally adapted seeds, not only because local populations often show home-site advantages, but also because non-local genotypes may be maladapted to local environmental conditions (Vander Mijnsbrugge *et al.,* 2010) or even cause genetic contamination of local populations. Furthermore, to attain a functional and resilient ecosystem, it is important that the genetically adapted planting material used for establishing a plant community represents a minimum level of intraspecific

diversity to ensure that its progeny will in turn be viable and able to produce viable offspring. Aside from the initial quality and genetic diversity of germplasm, and its suitability for the planting site, the extent of gene flow across landscapes over subsequent generations is also of central importance for successful long-term restoration. This ensemble of genetic qualities is necessary to provide the desired functions, goods and services (Bozzano *et al*., 2014).

Ecological restoration projects need an effective supply of seeds of native species. Obtaining seeds of wild species is a significant challenge for local or regional scale restoration, and even more for landscape scale restoration. Factors such as the availability of seeds, the technical knowledge, training and licensing of the seed collectors, the cost of seeds, and the biological and technical knowledge necessary to correctly process, store, break dormancy and deliver seeds to restoration sites contribute to seed-supply shortfalls (Bozzano *et al*., 2014). Therefore, seed banking of native species is a crucial link in the restoration chain.

The unification of science-based seed knowledge with the infrastructure to support large-scale seed management and the development of effective working relationships between seed scientists, restoration practitioners, the commercial seed industry and the local community will ensure that seeds are used to their full potential for ecological restoration purposes (Bozzano *et al*., 2014).

3

USE OF NATIVE FLORA: REGULATORY FRAMEWORK OVERVIEW

At present, there are numerous references in relation to the importance of biodiversity conservation, and therefore genetic diversity within species (inter-populations and intra-population), in policies and treaties at an international, national and local level. Among these, the Convention on Biological Diversity[2], signed by all Mediterranean countries, and the Resolutions of the Ministerial Conference on the Protection of Forests (Forest Europe[3]) related to forest genetic resource use and conservation are noteworthy.

Genetic diversity plays a critical role in the ability of resources to adapt to environmental changes and in their resistance to pests, diseases and other stresses, etc.

However, on a practical level, these principles are not always applied, and instead of using locally adapted native species in natural habitat restoration actions, exotic species or inappropriate provenances are sometimes used. This occurs, in part, due to insufficient awareness of the importance of conserving genetic diversity or by lack of knowledge, but also because there are not always adequate regulations governing these issues.

From the point of view of the genetic resources management and the restoration practice, suitable use[4] would mean: 1) Use native, avoid exotic; 2) Use quality materials: certified origin, adequate phenotypic quality and wide genetic basis; and 3) Use local provenance materials (or locally adapted materials).

3.1 Avoiding exotic species

An autochtonous (or native, or indigenous) species can be defined as a species existing within its natural distribution and dispersion range. Conversely, an exotic (or alien) species is not native to the region in which it occurs; it has been introduced by humans to a region either intentionally or unintentionally.

In partner countries, the current regulations to avoid the use of exotic species in the wild do not go to the whole extension of the meaning of exotic species: usually, only those exotic species that are invasive or potentially

[2] https://www.cbd.int/

[3] http://www.foresteurope.org/

[4] Specific regulations for protected species/areas or those aimed to control pests and diseases are out of the scope of this chapter.

invasive are specifically regulated, except for certain protected specific areas, such as Natura 2000 sites, nature reserves, etc., which usually helps to avoid the use of any exotic species.

General regulations have been made to stop the importation of certain exotic species from territory in Tunisia[5], as well as to avoid hybridisation, such as Palmaceae and Rutaceae (especially Citrus genus) families, etc., although that law aims to mainly control pests and diseases.

Very limited measures are taken in Lebanon to enhance the use of native species. It has prohibited the introduction of alien seeds, seedling and plants of Cedrus genus[6] to avoid genetic pollution, but there have been no specific regulations for the issue of invasive species developed. However, the Ministry of Environment executed, in 2002, the National Reforestation Plan, aimed at rehabilitating and restoring Lebanese degraded forest areas, and in this framework, only the use of native forest trees in the reforestation activities was allowed with a specific ban on the use of introduced species (MoE, 2009).

In Spain, the national regulation for invasive (or potentially invasive) species[7] specifies, for each species in the catalogue, its avoidance (for import, trade, transport, tenancy and use in wild) in the whole territory or only in part of it. Local (Valencian region) regulation[8] also exists, containing more species than those provided by the Spanish Catalogue and different kinds of limitations for them, more or less depending on the case.

In Italy, the 'exotic and invasive vascular flora of Italy' was published in 2010; however, there are no specific laws that regulate the use of exotic plant species in habitat restoration. Conversely, they are often considered elements of economic value for the forest, as in the current law in force for forests[9]. Some recommendations to avoid the use of alien invasive species are made through new plans and strategies at the national and regional level, such as the 'Regional Plan for Forest and Environment' (PFAR) of Sardinia, but no specific restrictions are made. Exotic species are only indirectly regulated in Italy by application of the Decreto Legislativo 19 Agosto 2005, n. 214[10], which is the implementation of Directive 2002/89/EC[11] on protective measures against the introduction and spread within the Community of organisms that are harmful to plants or plant products.

In Greece, the most recent revisions of related law for the conservation of biodiversity[12] and forests[13] state the obligation to restore natural habitats with approved restoration plans, and taking action to restore the impacts of invasive alien species on biodiversity, but do not include specific regulations for the plant species used. There

[5] Journal officiel de la république Tunisienne N°45, 8 Juin 2012, p1403- 1404

[6] قرار 1/108، الصادر بتاريخ 1995/9/12، منع إستيراد أو إدخال كل بذور و شتول الأرز، وزارة الزراعة

[7] Real Decreto 630/2013, de 2 de agosto, por el que se regula el Catálogo español de especies exóticas invasoras

[8] Decreto 213/2009, de 20 de noviembre, del Consell, por el que se aprueban medidas para el control de especies exóticas invasoras en la Comunitat Valenciana

[9] Regio decreto-legge 30 Dicembre 1923, n. 3267. Riordinamento e riforma della legislazione in materia di boschi e di terreni montani

[10] Decreto Legislativo 19 Agosto 2005, n. 214. Attuazione della direttiva 2002/89/CE concernente le misure di protezione contro l'introduzione e la diffusione nella Comunità di organismi nocivi ai vegetali o ai prodotti vegetali

[11] Directive 2002/89/EC, of 28 November 2002, on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community

[12] Νόμος 3937/2011 (ΦΕΚ 60 Α/31.03.2011), Διατήρηση της βιοποικιλότητας και άλλες διατάξεις

[13] Νόμος 4280/2014 (ΦΕΚ 159 Α/08.08.2014), Περιβαλλοντική αναβάθμιση και ιδιωτική πολεοδόμηση – Βιώσιμη ανάπτυξη οικισμών Ρυθμίσεις δασικής νομοθεσίας και άλλες διατάξεις

are only specific regulations for the restoration of mines[14], which state that the plants used for restoration must belong to the surrounding ecosystem and the introduction of alien species must be avoided, and for the management of public green areas[15], which state that plant species used must predominantly be native or species of Mediterranean climate. However, there is no specific regulation prohibiting the planting of certain exotic species.

An important regulation that could currently be applied to all members of the EU is the new regulation on invasive alien species[16] that was published in November 2014. This regulation establishes rules designed to prevent, minimise and mitigate the negative effects of the introduction and spread, deliberate and accidental, of invasive alien species on biodiversity and related ecosystem services, as well as on other areas of economic and social importance. To this end, the European Commission has opened a growing list of invasive alien species of concern, which is periodically updated and revised. The species mentioned in the list may not be intentionally introduced into the EU, nor can they be kept, bred, transported to, from or within the Union, marketed, cultivated or released into the environment.

3.2 Use quality materials: ensuring identity, phenotypic quality, wide genetic basis

The European Directive 1999/105/EC[17] is aimed to enhance transparency in the market of the plant reproductive materials (seeds, fruits, parts of plants, plants) of the main species used in forestation and restoration, and to ensure that they are of adequate genetic and phenotypic quality. Control mechanisms in the production and marketing processes will ensure the identity, as well as the establishment of certain requirements that should be met by the materials (in terms of age, height, root system and others) to be marketed will ensure its adequate phenotypic quality. Requirements for regions having Mediterranean climate are provided specifically. The obligation to use only approved basic material for the production of forest reproductive materials to be marketed will ensure the genetic quality, by setting up conditions within these basic materials, among them, only for certain basic materials, enough number of individuals to ensure adequate inter-pollination and to avoid the unfavourable effects of inbreeding.

It introduces the concept of 'region of provenance', which is defined as an 'area or group of areas subject to sufficiently uniform ecological conditions in which stands or seed sources showing similar phenotypic or genetic characters are found'. The Member States should establish lists, and draw up maps, of regions of provenance. This concept is particularly interesting because represents a basic aspect for a rational-ecologically

[14] Κοινή Υπουργική Απόφαση Δ10/Φ68/οικ. 4437/01.03.2001 (ΦΕΚ 244 Β/08.03.2001), Προδιαγραφές και χρονοδιάγραμμα ειδικής μελέτης αποκατάστασης (άρθρο 7 παρ. 1 εδαφ. β Ν.2837/2000)

[15] Υπουργική Απόφαση 125837/726/03.06.2013 (ΦΕΚ 1528 Β/21.06.2013), Προδιαγραφές Σύνταξης των Μελετών Διαχείρισης Κοινόχρηστων χώρων πρασίνου

[16] Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species

[17] Council Directive 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material

management, allowing to reach adaptation (including genetic adaptation) of the materials to the sites in which them would be implemented.

Spain, Italy and Greece have involved the full incorporation of this Directive through different state-Directives[18,19,20], thus ensuring the identity of the material forest reproduction and the adequate genetic and phenotypic quality of a number of forest species widely used in restorations, for production and marketing. Regions of provenance are also defined for the species listed in each case. These regulations, however, do not consider regulation of the use of these materials in a plain sense (i.e. they do not condition the decision to use one or the other at a particular site), which constitutes their main limitation. The materials are certified, i.e. origin and quality are guaranteed, but a suitable use is therefore not ensured.

In Tunisia, law N° 99-42 of 10 May 1999[21] on seeds, seedlings and new plant varieties established the conditions for the control, production, propagation as well as the general standards of storage, packaging and labelling for marketing in order to guarantee the quality of seeds and seedlings.

In Lebanon no similar regulation exists.

3.3 Use local provenance materials

In Spain, this kind of regulation is not at a national level. In the Valencia region, Decree 15/2006[22] contains guidelines regarding the origin and characteristics of forest reproductive material, expanding the number of species already established by national Royal Decree by 40. For these species, the same control system and requirements are applicable, within their regional range, than the ones established by state law[18], except by basic materials issue; then, the materials of the new species listed can in fact be collected from areas without specific requirements being in risk to lose the genetic quality. Particularly interesting is Article 19, which explicitly states that forest reproductive material to be used in reforestation or restorations should come from the same region where reforestation/restoration is going to be implemented, i.e. ensuring the adaptation of the reproductive forestry material to ecological conditions where reforestation/repopulation is going to be implemented through the obligation to use local sources. To implement these tasks, specific subdivisions of the national provenances are made within this regional legislation, and, in addition, different and specific provenances for certain riparian species are provided.

In Tunisia, Greece and Lebanon there is no specific regulation indicating any obligation to the use of local sources where ecological restoration will be conducted. However, in Tunisia, a specific Atlas exists that defines

[18] Real Decreto 289/2003 (modificado por el Real Decreto 1220/2011), de 7 de marzo, sobre comercialización de los materiales forestales de reproducción

[19] Decreto Legislativo 10 Novembre 2003, n. 386. Attuazione della direttiva 1999/105/CE relativa alla commercializzazione dei materiali forestali di moltiplicazione

[20] Προεδρικό Διάταγμα 17/2003 (ΦΕΚ 14 Α/27.01.2003), Δασικό πολλαπλασιαστικό υλικό, σε συμμόρφωση προς την οδηγία 1999/105/Ε.Κ.

[21] Law N° 99-42 of 10 May 1999 on seed, seedlings and new plant varieties

[22] Decreto 15/2006, de 20 de enero, del Consell de la Generalitat, por el que se regula la producción, comercialización y utilización de los materiales forestales de reproducción

for each forest and ecotype the location of seed provenance, the period of harvesting, etc. Practically, harvested seeds can be re-used in the same region.

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In Italy, they do not have this kind of regulation, although some efforts have been made to address this issue: the PFAR of Sardinia aims to use local sources of forest reproductive material through reorganisation of the regional nursery, but the PFAR does not have a complete legal regulation approved yet.

Also, Italy is elaborating a 'national plan on biodiversity', which has not yet been approved, but aims to regulate the production, storage, trade, distribution, and (importantly) the use of any kind of material for propagation and conservation of the genetic diversity of wild and domesticated life in Italy.

4

TECHNIQUES ON HABITAT RESTORATION

Although Mediterranean ecosystems generally show high resilience to natural disturbances that have been affecting them periodically over time, and its species have developed adaptive responses to them, they are very vulnerable to anthropogenic factors and their self-recovery capacity may be limited or even become depleted.

Restoration projects must be planned to restore the structure and function of ecosystems; one of the biggest challenges is deciding which interventions are needed to achieve this goal.

Depending on the level of degradation, interventions may be more or less complex: in slightly degraded ecosystems, management practices aimed at removing the stressors may be enough to recover the functionality of the system and prevent degradation going forward. In other cases, besides the removal of existing degradation factors, it may be necessary to realise a biological modification or to restore physic and/or chemical environment conditions, or both. In the most extreme cases, vegetation cover, soil and the original morphology may have been destroyed completely or in part, therefore working towards the recovery of previously existing morphology and the restitution of the soil must be undertaken.

The types of intervention required will depend on the initial conditions of degraded areas: those concerning the biocenosis status (state of the soil seed bank, seedling proportion surviving after the last disturbance, number of breeding individuals, presence of dispersive wildlife, etc.), as well as those referred to abiotic parameters (rainfall and temperatures regime, soil status and characteristics, erosion levels, etc.), and also the current threats, the potential risk factors and even the surrounding environmental conditions (the isolation degree of the disturbed habitat will influence the migration phenomena of both plant diasporas and fauna disseminators and/or predators).

Technical difficulties will also condition the restoration process. These difficulties may arise from adverse topographical conditions, accessibility, nature of the substrate, lack of availability of suitable plants and seeds (absence or little diversity of species in the market and lack of local sources), and the absence of knowledge about the seedlings establishment ability of species to be introduced and nursery cultivation techniques that favour it.

In turn, the socio-economic context in which the project will operate can influence the planning, implementation and monitoring of the project, and therefore the ultimate success of it, so the expectations of the community around the project and the financial means available must be taken into account.

A restoration project is also a good opportunity to promote feedback between practice and ecological science. For instance, local scale projects could be used to compare different approaches to solve specific constraints,

new techniques could be tested in a real context and research on ecological issues overlapping the project could be implemented.

The ecological restoration projects should be adaptive, that is, they must have the ability to allow variations in implementation according the evolution of the system in which the actions are being conducted. Early monitoring systems are required, supported on specific indicators that report on possible deviations from the expected results.

Restoration projects may cover a wide variety of objectives. It is advisable that restoration projects are complemented with other *ex situ* or *in situ* activities aimed at ensuring (or at least promoting) the long-term sustainability of the restored habitat. Communication activities, environmental education or awareness can help people to determine values, motivation and responsibility regarding the improvement of the quality and sustainability of the ecosystems. Passive or active habitat management, by developing, for instance, management plans to be carried out after restoration actions, or by promoting regulations to prevent detrimental activities or to protect the area, will contribute to prevent the return to a degraded state. The storage in seedbanks of threatened, rare or endemic species, or the development of germination and cultivation protocols, are tasks recognised as an essential complement for restoration purposes. Lastly, strengthening relationships with other parallel initiatives related with ecosystem protection and restoration, such as green infrastructure, is also recommended.

In any case, restoration projects should consider both the available knowledge on the habitats present in the degraded area and the previous restorative experience and its efficiency. Taking into account that heterogeneous states and contexts are the rule, requirements for success are not clear and absolute, and, in that sense, restoration projects should not be 'copied and pasted', but projects already implemented –including successes but also failures– could be useful to move in the right direction.

Many techniques for habitat restoration have been developed empirically or on the basis of research initiatives. In this chapter, a compilation of some suitable techniques that have been used with success in restoration projects developed in the habitat types selected in ECOPLANTMED project is provided.

Special emphasis is placed on issues related to revegetation, as it is the main topic of ECOPLANTMED, but also because revegetation is an important part of most restoration projects. Some protective structures that are necessary or complementary to the reintroduction of plants have been included, such as the defence of structures from erosion or protective structures to create adequate site for plants to survive and grow; proposed construction methods are environmental friendly and aesthetically attractive.

4.1 Forests

Main human pressures	Consequences	Strategies	Techniques
• Changes in forest fire regimes • Land use conversion (agriculture, urbanisation) • Resource overexploitation (overgrazing, firewood, timber, etc.) • Mining • Transport infrastructure • Pests and diseases (mainly no native species) • Forestation with no native species or provenances	• Forest surface reduction • Soil loss and desertification • Biodiversity loss • Habitat fragmentation • Genetic introgression	• Restoration of natural fire regime • Management plans design • Pest and disease control • Stabilise slopes to prevent soil erosion • Protection from grazing • Recover fields to increase forest area and connectivity • Revegetation	• Fire prevention • Reforestation and afforestation with native plants • Stabilisation of slopes with natural material structures • Fencing or other measures to prevent overgrazing • Adequate sylvicultural practices implementation

An increase in forest fire occurrence may be the most dramatic anthropogenic pressure in Circum-Mediterranean forests, followed in some countries by overgrazing and overcutting. Besides fire management strategies and measures to control overexploitation, policies facing habitat restoration almost always include forestation, both reforestation and afforestation, plans.

Forestation: Native species from local provenance should be selected for planting. Monospecific forests of Pines in Mediterranean countries have been largely planted because of their high survival rates and relatively fast growth. At present, it is also recommended to use other woody trees and shrubs (for instance, species that are able to re-sprout, such as *Quercus* spp., or which produce fleshy fruits, for example *Juniper*). In this way, resilience to disturbances, mainly fire, and species interaction are promoted. Exotic species or genetically selected material must be restricted to plantations for production purposes.

Bare root plants have been used widely in the past because of their relatively low cost of production. However, there is evidence that container-grown plants perform better than bare-root stocks, due in a large part to the protection of root systems in soil media up to the time of planting; besides, planting time is longer for plants in containers. Anyway, bare roots could be use in areas without water limitation. In both cases, high quality plant stocks from local provenances should be use. Concerning direct seeding, this technique has shown low efficiency in many experiences in Mediterranean conditions.

When growing plants, care must be taken in nursery management to produce suitable seedlings able to face drought as a critical factor (type of container, type of nutrients, watering and fertilisation regime, among other). One year old material is generally planted in the field. Two year old plants could be used for some low growing species.

Site preparation also plays a relevant role in improving water supply and the physicochemical properties of the soil. The appropriate technique should be selected taking into account soil characteristics and slope degree, impact on landscape, size of the area to be forested, but also economic constraints. Site preparation could be limited to outplanting places by digging manually or mechanically using a drill or an excavator. For linear site preparation on slopes with less than 35% incline, a ripper could be used working down linearly to 35-60 cm. Lines should follow level curves to prevent soil erosion. This method allows the preparation of a large area, reducing costs compared to manual digging. Besides, it improves soil physical properties for plant survival and does not have a negative impact on landscape. Other methods exist for linear site preparation with different types of machines and results, such as for instance the creation of terraces or berms. Mechanical whole surface preparation is also possible but is not recommended if the is risk of erosion or when standing natural plant cover exists).

In Mediterranean climate when planting manually in container, pits at least 40-45 cm in depth should be prepared. The adequate time of plantation is during the dormant period. Late autumn and late winter to early spring is recommended to take advantage of the Mediterranean regime rainfall. Roots should not be bound or bent upwards in the holes in bare root plants when planting. Care must be taken to bury the plant straight and slightly above the root collar and to sufficiently compact the soil when filling it back to ensure good root to soil contact. Small ditches or berms could be created around plants after planting to retain after planting irrigation and rainfall. Plants could also be surrounded by mulch to prevent water loss and weed competition.

Properly designed individual tree shelters are useful for reducing mortality by drought and grazing. However, they could produce abnormally elongated stems in some species. If economically possible, boundary fences could be established in small forested areas when there is a danger of trespassing and damage by grazing animals. Individual plant protectors to prevent wild animal grazing are also used. Protection should be removed when plants reach a certain height.

Forestation should be monitored in the autumn of the first years after plantation to assess restoration success. Replanting to replace dead plants is recommended.

Protection form erosion: in sites with erosion in advanced stages where gullies have been excavated by runoff water, forestation could be complemented by mitigating structures, such as wattle fences, fascine, retaining dry walls or geotextiles in small areas. These techniques could also be used early after forest fire to prevent soil loss.

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4.2 Freshwater Habitat

Main human pressures	Consequences	Strategies	Techniques
• Flood control (dams, weirs) • Channelisation (levees and bank stabilisation) • Land use conversion (agriculture, urbanisation) • Water diversions and ground water pumping • Pollution • Transport infrastructure (roads, bridges) • Gravel mining • Livestock trampling	• Channel incision and bank destabilisation • Water quality deterioration (physical, chemical and biological) • Biodiversity loss • Habitat fragmentation • Invasive species	• Implementation of the environmental flow regime • Improve riparian connectivity and continuity • Diffuse pollution control • Revegetation	• Recovery of land to enlarge floodplain • Transversal infrastructures removal (or substitution or complemented by fish passes in riparian) • Channelisation removal • Invasive species control • Stabilisation of banks with natural material • Native plant species reintroduction • Bank fencing

The primary impact on Mediterranean riparian and wetland habitats is the modification of flow regimes or water availability. In the context of policies and management plans, the relevance of these factors on the biota forces to take measurements in relation to the quality and dynamics of water. To conciliate both aspects, water for human use and habitat conservation, an environmental flow regime should be adopted. Apart from water management, hydrological restoration may include establishing structures to prevent soil erosion and recovering bank vegetation in the short-term. A number of bioengineering methods for achieving river or lake banks stabilisation and revegetation and visual landscape integration at the same time could be used in many circumstances. When live vegetation as an engineering material is not enough to stabilise banks, then other low impact techniques must be use, combining them with vegetation if possible (as for instance riprap with live staking). Some of the bioengineering methods that are currently used are concisely described.

Live fascines: cylindrical bundles (of diameter 30-50 cm and 3-4 m length) of branches (of minimum diameter 3 cm and minimum length 2m) of woody easy-to-root species (*Salix* spp. or *Tamarix* spp.), tied together with galvanised wire are constructed. They are immediately placed along the toe of embankments by means of wood stakes or steel rods of minimum length 60 cm.

Living wattle fence: wooden stakes (0.50 to 1 m length) are driven vertically into the ground at a distance of approximately 50 cm. Flexible living branches of easy-to-root species are then braided around the stakes, first

burying its end in the ground. The fences are filled with soil at the back to prevent vegetative material from drying out.

Living brush mattress: a levelled bank is covered by poles or ramified branches of woody easy-to-root species, whose bottom ends extend into the water. They are held in place by wires stretching between steel pegs or alive or dead stakes. The mattress is covered slightly with soil.

Vegetated log cribwall: An excavation with a slightly reverse slope is made. A single or double-walled cribwall are built of logs (of minimum diameter 20 cm). While filling the cribwall with soil, living branches, cuttings or rooted plants of woody species are inserted rising towards the outside.

Live staking: on gentle slope banks, cuttings of woody easy-to-root species (diameter of 1-5 cm and length of 30 cm to 1.5 cm) are driven vertically or, more frequently, in a certain angle into the ground.

Textiles: A wide variety of geo-fabrics and organic textiles can be used to provide a temporary layer until a natural vegetation cover is established.

Invasive plant control: invasive species should be removed manually or mechanically as much as possible before planting. Chemical control is used if other methods are not possible or if there is risk of bank destabilisation; allowed herbicides, with a low negative impact on environment must be used. *Arundo donax*, like other shade-intolerant species, could be controlled to some extent by creating a tree cover. Alien species development should also be controlled in maintenance to avoid post-planting competition with native species.

Revegetation: Native species from local provenance should be selected for planting. Plant materials commonly include cuttings of easy-to-root riparian native species, such as Poplars, Willows or Tamarisk. They could be collected from a nearby donor site or obtained from a plant supplier. The former option is the best way if no control of provenance is guaranteed by the nursery. In any case, care must be taken in collection to get material from both sexes and to prevent the propagation of only few genotypes. Live cuttings or stem sections at least 40 cm long and 1.5 cm wide from dormant vigorous young wood are driven approximately three-quarters of their length into the soil in the late winter, during dormancy but when frost risks are lower. Long branch cuttings of 1-3 m in length and 4-15 cm in diameter could be use when the water table under the plantation is deep, for instance in high steep banks. For these easy-to-root species, it should not be difficult to produce plants from seeds to promote genetic diversity in the new populations.

Other shrubby or woody riparian species plants are also commonly installed in the second row vegetation along the banks and in floodplains (as for instance ash, alder or elms in riparian habitat). These species are cultivated in containers and planted as 1-2 year old seedlings; however, larger sizes have also been used. Holes proportional to plant container size are dig manually. In the Mediterranean climate, the best time for planting is the end of winter to early spring, when plants are already dormant and the soil is wet enough; it is also possible to plant in late autumn. Plants must be watered immediately after planting to improve soil adherence to the roots.

For some aquatic vegetation, such as species from the genus *Chenopodium*, *Typha, Phragmites* or *Iris,* rhizome sections could be used. Rhizomes are cut into pieces, spread out on the bank surface near the water and covered slightly with soil immediately. It is advisable to do this at the beginning of the vegetative period. Outplanting hydrophytes that root in aquatic environment require special containers to prevent culture substrate from crumbling away or the container floating upon contact with water. Biodegradable containers, such as

wooden boxes, pallets or containers of pressed peat to which a gravel layer is added could be used. Aquatic species with no attachment to the mud could be cultivated in a nursery and be released on the water surface.

Plant distribution in the area should take into account that vegetation in wetlands and streams usually occupies different positions in relation to the water. It is advisable to take into account a well-preserved stand close to the area to be revegetated as a reference. A planting pattern designed on a modular basis could lead to a floristically and structurally diverse vegetation: each module or stand includes one or two tree species and some shrubs, different from other modules. These small stands are repeated randomly all along the banks, adjusted to the topography and soil characteristics.

Seeding by hand or mechanically with native wetland herbaceous species is also a common practice for stabilising the floodplain and bank soils, mainly to reduce soil loss immediately after revegetation, as trees and shrubs take time to develop; it could be done in association with the placement of textiles. Care must be taken to avoid commercial batches of herbaceous seeds, as they are prepared normally with non-autochtonous species.

Plants should be watered regularly during dry periods throughout the first year after plantation. Temporary bank fencing or individual plant protectors must be use if there is threat of livestock or native animal grazing or high recreational pressure.

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4.3 Coastal / Dune Habitat

Main human pressures	Consequences	Strategies	Techniques
• Urbanisation • Coastal infrastructure • Agriculture • Pollution • Overgrazing • Arid extraction • Outdoor recreation • Afforestation in some cases	• Changes in dune dynamics • Increase coastal erosion • Changes in natural sediment flux • Biodiversity loss • Habitat fragmentation • Invasive species	• Infrastructure elimination • Barrier dune reconstruction and/or protection • Revegetation • Invasive species elimination • Reduce recreational pressure	• Sand fencing • Native plant species reintroduction • Invasive species control • Mulching • Enclosure fencing and footbridge • Gradual elimination of inadequate artificial forests

Influence of humans on coastal dunes in the Mediterranean is large, mainly due to urbanisation and coastal recreation activities. Reconversion of already constructed areas seems to be unrealistic. At this point, recovery and conservation of less or minimally disturbed coastal dunes should be a major consideration in regional environmental policies. Among other strategies to be adopted, reconstruction of dune systems by placing artificial barriers to reduce wind velocity and to trap blowing sand is a common practice. It is frequently complemented by the reintroduction of native plant communities in order to recover natural dynamics and biodiversity. Specific barriers to give protection to recently planted areas and developing vegetation could also be set up.

Permeable sand fencing: They should be constructed with natural material and placed perpendicular to prevailing wind. They could be made of branches and twigs from shrubs, such as *Tamarix* spp., straw from leafy vegetation, for example *Spartina versicolor* used in Spain, or wooden slats. For dune system restoration in the Mediterranean coast, a void to solid ratio of 40-60% is adequate for fences to be effective.

Over time, they are covered by sand, rot, and disappear, reaching an all-natural dune aspect in the 6-7th year. In the leeward, the palisades take longer to disappear. Regular monitoring and maintenance should be undertaken to repair fencing and remove debris that may be caught along the fencing.

When designing foredune location, it is necessary to establish limits of wave run-up (dry beach) to prevent failure of the project. In practice, such distances could be estimated in reference systems near to the area to be restored. When designing dune geomorphology reconstruction, it is also of major importance the windward and leeward slopes (30% and 40%, respectively). If sand replenishment from outside sources is required, sand with a minimum grain size of 0.2 mm must be used.

Enclosure fencing and footbridges: fences to mitigate threatening processes like livestock grazing or recreation activities pressure, mainly on recently planted areas, could be installed. It is preferable to use fences made of natural material (wood, ropes) and remove them as soon as threats disappear. Installing footbridges in wood as paths for recreational visitors is good practice to prevent trampling on the dunes.

Geotextile containers: large sand-filler containers have been used as structural elements instead of concrete or rip-rap to protect coastal areas where shore erosion control is necessary.

Invasive species control: alien species control should be included as part of site preparation and be carried out by hand at small scale or mechanically over large areas if there is no danger of losing dune structure; the application of herbicides could be needed in some instances. Control is also necessary in maintenance to avoid post-planting competence.

Revegetation: A selection of the native species from local provenances based on existing reference systems that are less degraded and taking into account the different sectors of the dune (windward, leeward, crest and embryonic dune) is the best option.

High quality nursery-raised plants of known origin should be used, but seeding instead of planting could not be avoided for some species; project cost could be dramatically reduced. Direct seeding is advisable for fast growing species (for instance those belonging to the Leguminosae or Cruciferae families), particularly if good quality plants are not available. Planting at high densities to promote rapid plant cover and to reduce open spaces for invasive species could also be a good strategy.

For species that tend to produce a developed root, such as Gramineae species, it is advisable to bury plants almost entirely, exposing only the last 10 cm of the aerial part, which means that the root collar of the plants will be at a depth of 15-25 cm, and not at the surface level, as is normal in other plantation types. This practice often entails phytosanitary problems to plants of other habitats but not in those adapted to dunes. Although this practice entails a greater physical effort during planting, roots will take benefit from soil moisture and plant unearth by wind is prevented.

Cuttings should be about 20-30 cm, planted as vertically as possible, and exposing only the upper 5 cm.

When palisades are built, seeds may be buried to a depth equal to twice their diameter. If there are strong winds, they can be dug up and dragged to the edge of the fence, which is not a problem: at first, there will be a non-natural distribution, but this effect will disappear over time.

Plantation should be performed manually; the terrain advises against any other technique. Small machines with rubber tracks may be used for the distribution of plants and tools inside the dune field.

Ideally, planting would be performed from the first rains of autumn to the end of winter, but can be extended to mid spring without much inconvenience. A layer of bark chips, coco shell or other natural materials such as mulch could help to maintain soil moisture and weed control around plants.

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4.4 Arid / Semi-arid Systems

Main human pressures	Consequences	Strategies	Techniques
• Livestock at high densities • Overcutting for firewood • Land use conversion (agriculture, urbanisation) • Mining • Recreational activities • Changes in fire regime	• Soil degradation and desertification • Biodiversity loss • Habitat fragmentation	• Pastoral land management • Revegetation • Improvement of soil characteristics • Increase local water availability • Promote sustainability of native plant use	• Soil stabilisation and amendments • Native plant species reintroduction • Water redistribution • Livestock management implementation or exclusion • Biomass management as energy resource • Fire prevention

These fragile habitats have been largely influenced by human activities or overexploitation, leading to vegetation loss and the degradation of soil physicochemical properties and structure. Besides removing causes (for instance, managing livestock and the provision of alternative energy sources, especially in some rural Mediterranean areas), in areas where the threshold for a natural recovery has been crossed, the main sustainable method to improve soil conditions is to re-establish plant cover. Actions in this direction are hard to achieve as abiotic constraints hamper reversing desertification. At present, some low-technology techniques related to redistributing and concentrating water availability in microsites have been developed and could be used to promote planting success in revegetation actions.

Revegetation: A mixture of native plant species, from local provenances, selected by their relevant and complementary ecological role to promote natural interactions and biodiversity, should be use in reintroduction actions. For instance, planting fleshy fruit species would enhance the plant-animal mutualistic relationship, and thus contribute to seed dispersion and speed-up natural plant cover recovery. Other species may improve conditions for seedling establishment, such as *Leguminosae* species, which tends to increase nitrogen concentration and organic matter in the soil.

Revegetation with plants in a container is common practice, as they cope more easily with harsh conditions compared to bare-root or direct seeding. Seedling quality becomes a key factor in these habitats, so care must be taken in the nursery to select plant growth conditions and management (type of container, irrigation and fertilization regimes, etc.).

Although large scale features, such as bedrock and slope angle and orientation, is commonly considered when planning revegetation actions, small-scale spatial heterogeneity plays a major role in plantation success in arid conditions. Physical environment, mainly due to soil characteristics (micro-scale topography, soil texture and structure, soil depth, etc.), must be taken into account. In the same way, facilitation by already established

plants that create suitable environmental conditions for outplanting is a relevant issue, as seen between *Stipa tenacissima* and outplanted shrubby Mediterranean species.

Site preparation for plantation also dramatically affects plant survival. Pits larger than the container volume at least 30 cm in depth should be prepared, as soil depth is relevant to root growth and survival. Mechanical preparation by lineal subsoiling at 50-60 cm depth could also be used in plains and gentle slopes, mainly in compacted soils formerly used for agriculture and pasture. It is highly advisable to retain existing natural vegetation whenever possible, so whole surface preparation is not recommended. Soil characteristics could be improved by adding fertilisers, as they enhance the growth of plants.

Besides after planting watering (if possible), implementing suitable techniques to improve water availability could help plants to overcome environmental constraints. Traditional micro-catchments altering the topography of the site around plants are adequate for harvesting and redirecting rainfall water. They could also be considered a resource sink, because they can retain seeds and organic matter. In addition, other techniques, such as placing a more or less impermeable cover (stones, organic mulch, geo-textiles) around plants or creating small holes filled with stones (dry wells) near the roots, could help to retain moisture into the soil profile. Drip irrigation is more expensive but it could be used for small surfaces if there is no budgetary constraint. However, this method tends to increase salt content in the soil. In areas of extremely low rainfall but frequent fog, catcher nets have been used to condense water for irrigation.

In areas where grazing pressure by livestock or wildlife is high, protection of new plantations must be installed. Appropriate protection system is selected on the basis of risk source and economic constraints (individual shelters vs. perimeter fencing, type of shelter or fences, etc.).

Fascines: In steep slopes, and especially in loose soils, where rainfall erosion tends to produce gullies, it is recommended to construct fascines with organic material (rolled biodegradable textiles, logs, bundles of branches). This technique suits also in rocky slopes for trapping and holding soil, creating a suitable place for natural plant establishment as well as for outplanting.

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5
THE GOOD PRACTICES

5.1 Methodology used to identify and select Good Practices

A Good Practice is defined as an initiative (e.g. methodologies, projects, processes and techniques) which has already been proven successful and which has the potential to be transferred to a different geographic area. In the context of this Guide, Good Practices are restoration projects which have provided tangible and measurable results in achieving a specific objective, as a consequence of the suitable methodologies used for its development. The practices will have the potential to be transferred to other regions on the basis that the actions take place in territories that have similar problems and share similar vegetation, so the optimal solutions found in one case may guide the actions to take in another.

Within this framework, during the ECOPLANTMED project 31 Good Practices were initially identified, reaching a final selection of 15, through a series of criteria commonly agreed among the project partners, as follows:

Criteria used to identify Good Practices:

The criteria used were exclusive, which means that in order to identify a restoration project as a Good Practice, the project had to meet all five criteria. Failure to meet one criterion meant that the project could not be accepted.

1) Restoration projects concerning Mediterranean habitats

Restoration projects were identified only in Mediterranean habitats according to the following:

i) 'Mediterranean habitats' considered were habitats of Mediterranean-type climate (see chapter 1), mainly included in the Mediterranean region (minimum 25 cases), but also in other biogeographical regions with the same type of climate (maximum 5 cases).

ii) The search for identification of Good Practices covered all territories with Mediterranean climate type. These territories were divided into the 6 following groups, from each of which a minimum number of 5 cases of restoration of Mediterranean habitats was identified.

a. Greece, Turkey, Balkans, Middle East
b. Italy, Malta, France
c. Lebanon, Cyprus, Syria
d. Spain, Portugal
e. Tunisia, Egypt, Morocco, Algeria
f. Non-Mediterranean regions with Mediterranean-type climate (in Australia, California, Chile and South Africa)

2) Restoration projects concerning different habitat types

Restoration projects identified from each geographic group covered different habitat types (see chapter 1) with at least one Good Practice chosen from each of the following:

a. Forests

b. Freshwater habitats (wetlands, riparian systems, etc.)

c. Coastal/dune habitats

d. Arid and semi-arid systems (grasslands, phrygana, maquis, steppes, etc.)

It was possible for a project to cover a wider area including more than one habitat type.

3) Restoration projects using native species

Restoration projects identified included an action or actions with the use of native species.

4) Implemented projects representing 'restoration in practice'

All projects identified included restoration action put into practice.

5) Restoration projects with available information

All projects identified should contain the maximum possible information regarding the criteria used to evaluate them, to allow the final selection of practices.

Criteria used to evaluate Good Practices:

Six criteria concerning the design, implementation and monitoring of the restoration project, with special focus on the management of plant genetic resources, were identified through exchange of experiences among ECOPLANTMED partners. These criteria represent the technical basis upon which the restoration projects should be developed, and should be taken into account independent of the ecosystem degradation status and the scale of the restoration project. Thus, these criteria are able to cover the wide and heterogeneous case diversity that can be found in the framework of the restoration practice.

Projects were evaluated in terms of suitability according to the general guidelines described in each of the criteria listed below. Considering the general framework of the ECOPLANTMED project, relatively more weight was given to criterion number 4.

1) Characterisation of the site to be restored

Once the need for restoration has been identified at a particular area, the characterisation of the site to be restored should be conducted, aimed to provide essential information without which there will not be a successful project implementation.

Projects should collect information on a number of site characteristics. This includes general parameters (boundaries, area, historical usages and values, etc.) as well as the characteristics of the site that will help to determine the kind of vegetation suitable for the restoration. Such characteristics are the altitude (maximum-minimum), slope (maximum-minimum), orientation, climatic conditions (precipitation, temperature, length of the

drought period, etc.), edaphic information (lithology, soil depth, soil pH, granulometry, etc.) and current vegetation. Many of these parameters may be directly extracted from various literature sources or mapping, but the available scales are sometimes not as appropriate as needed. Whenever possible, it is desirable to verify the information with field studies. Trial pits of the ground floor or conducting floristic inventories are generally plausible works that can significantly improve subsequent actions.

Legal constraints should also be considered: ownership of the land; current land uses and land use plans; presence of protected or singular species (rare, endemic, or threatened) of flora and fauna; and protection status (SCI, Natural Park, SPA, etc.) of the area.

The analysis of the group of factors that have led the site to its actual, degraded condition, as well as the identification of potential risk factors, is essential to address a specific diagnosis of the site to be restored - always considering the rest of the parameters previously cited - and will help to identify optimal restoration solutions among the different available alternatives.

2) Project´s specific objectives

Considering all the above items, and taking into account economic and social factors, the project objectives are defined. It is important to differentiate between the goal, or general purpose, and the specific objectives. The latter should be clearly defined -synthetic, explicit- and be consistent with the methodology applied and the results provided. The definition of viable objectives is an essential step to give order, coherence and consistency to the project actions and to establish whether or not it is contributing to the solution of the problem.

3) Strategies and techniques for habitat restoration

From the diagnostic results and project objectives, the strategies and techniques to be developed during the project should be identified, understanding that techniques are the manner in which strategies are applied to optimise results. They could be aimed at the management of the biotic component (a single species/population or to the whole vegetation component), or may be directed to improve the physical environment. In any case, suitable techniques should have high effectiveness and low environmental impact.

In chapter 4, a selection of suitable techniques used in restoration of different Mediterranean habitat types are presented.

4) Characteristics of plant material used for restoration

4.1) Species selection

Traditionally, the selection of species has been made through climatic and edaphic factors, complemented with phytosociology knowledge. Over time, other ecological type criteria have been incorporated, which try to integrate other factors that influence ecosystem dynamics, such as the plant-plant or plant-animal interactions.

When a reference ecosystem is available, a simple approach to the selection of species can be used for studying the structural basis of the habitat (Ferrer, 2007). It has been defined as being composed of three fractions of the vegetation component: structural, functional and singular, which are not mutually exclusive one

from another. The same authors provide quantitative systems for the evaluation of each of these fractions, which is an important step towards the objectivity of the cataloguing.

- The Structural taxa are those with high relative abundance and coverage degree values, and therefore contribute significantly to shaping the habitat physiognomy (structural morphology, appearance), and shaping the habitat physical environment, because they are able to modulate the resources available for other species due to their high biomass production. Structural taxa have a high value for habitat characterisation, and therefore often coincide largely with those defined as typical or characteristic of the habitat.

- Functional taxa are those which show an important or relevant role in the ecosystem. These are taxa defined as facilitators, engineer species, key taxa, etc., with a dominant influence in ecological processes, whose presence in the ecosystem affects the organisation, configuration and composition of the plant community to a much greater extent than their abundance and/or biomass suggests. Examples of functional features are: participation in facilitation processes (e.g. by *Stipa tenacissima* for *Pinus halepensis*; *Juniperus sabina* for *Rives uva-crispa* and *Juniperus communis*); contribution to the habitat resilience (re-sprouting species such as *Chamaerops humilis*); protection and improvement of soil conditions (nitrogen-fixing legumes), fixing land and delaying erosion due to the development of the underground part (*Crataegus monogyna*); and interactions with more disperse wildlife: i.e. ability to provide shelter, food, nesting, and perches (species with fleshy fruits are potentially bird-attractors, which is useful for natural seed dispersal).

- The singular taxa are those that show some degree of endemicity, rarity or threat. These are very valuable elements from the conservation point of view, as they are generally present in very small populations and are therefore very vulnerable to destruction and modification of their habitats. Restoration actions should consider this singular vegetation component, in order to ensure its permanence, promoting population recovery or to motivate their return to previously inhabited areas.

Interpreting the structural basis of a habitat is a useful and practical tool in the development of prioritised lists of identification and selection of species that can potentially be used in restoration projects. They can also help to optimise the collection of reproductive material in those institutions involved in the management of natural habitats, facilitating and saving work in later phases.

4.2) Addressing spatial heterogeneity

The taxa should be selected, also taking into account the different microenvironments that might be present in the system to be restored. Therefore, the study of the habitat's structural basis should consider different floristic inventories for the different microenvironments.

4.3) Origin of reproductive materials

As explained in chapter 2, the origin of reproductive materials to be used for restoration purposes is a key element to be taken into account to guarantee the suitable plant adaptativeness to the site to be restored. Native flora, and moreover, local resources should be used as best option for restoration purposes. Plants of the same species are often distributed across a wide area but develop patterns of local adaptation, meaning they become suited to the specific conditions in the local area. This means that plants have a better chance of survival if they are locally adapted to the area being revegetated. Moreover, by using local resources for restoration, problems of genetic contamination of existing and/or neighbouring populations are avoided. The issue of provenances is not always addressed and sometimes it is recommended to use native species (in a wide sense, referring to

administrative boundaries), providing they will survive and look attractive; this advice should not be followed in restoration projects.

4.4) Suitable collection

Materials to be used for restoration should be collected (and processed) using standard protocols to ensure a wide genetic basis and avoid genetic erosion (i.e. collection from adequate number of individuals randomly selected, balanced amount of seeds per plant, etc.). Of course, seed collection should not in any way threaten fragile populations, and endangered and rare species. A selection of practices may be found in the ECOPLANTMED Manual for the propagation of native plant species (Ballesteros *et al*., 2015). If the reproductive materials are obtained from a supplier, nurseries should be able to guarantee genetic sourcing and provide certified materials where possible.

4.5) Identification of effective propagation methods

It is useless to collect a large amount of seed of certain species if the germination and growing requirements are not known. While designing a restoration action, this issue should not be ignored, as it could lead to a collapsing situation of the project where the planned introduction of certain species cannot be executed due to insufficient knowledge of their germination and growth requirements. Furthermore, vegetative propagation methods should be avoided, and if this is the only possible way, it should be done from as many individuals as possible.

4.6) Plant Quality

The critical moment in the restorative process is the seedling establishment phase. Plants must overpass the post-planting stress to restart the photosynthetic activity and the soil colonisation, overcoming the interface nursery substrate/soil. This critical phase can be minimised by optimising the seedling quality (health, morphological and physiological): experience shows the plants used must meet a series of attributes aimed at maximizing their survival, growth and reproductive potential. For some species, there are specific regulations that set the external-morphological quality standards that relate to the health, vitality and physiological quality, establishing a series of qualitative requirements (the plant must be free of injury, should not show signs of rot, and the root collar should not be damaged, etc.) and quantitative (such as age, height, or diameter of the root collar). In some cases, certain culture characteristics considered appropriate are also specified (it is set, for example, the minimum volume of the container). The plant quality used strongly influences the result of restoration actions, so it is important to achieve the growing requirements aimed at producing quality plants in the nursery and then only use quality plants.

5) Plantation design

The pattern to be selected for the plantation design should not be symmetrical, and should be based on ecological factors. Although currently it is not as common, until relatively recently -and mainly in reforestation projects with productive purposes-, linear patterns that gave an unnatural look to the restored habitats, clearly not integrated into the surrounding landscape, were used. Suitable plantation design it is not only to follow a more or less random and not symmetrical pattern, but also take into account the presence of favourable microhabitats for species establishment and the distance from any threats.

6) Monitoring Plan

An effective monitoring and evaluation system is recognised as an essential component of a successful restoration project, allowing measurements of progress and more importantly helping to identify corrective actions and modifications that may be needed.

A large number of descriptors and indicators at different levels (population, community, ecosystem, landscape) are possible, and many have been described in the technical literature. The scope of the monitoring system should fit with the goals of the project or help to redirect them, so a set of pertinent indicators should be agreed upon and tested to reflect the restoration advances.

In a broad range of projects, the monitoring system is absent or only considers monitoring during the time in which main implementation actions take place (intra-monitoring). However, a suitable monitoring system should continue after the end of the project, since the results of the restoration actions are usually long-term processes.

5.2 Selected Good Practices

After the initial identification of a total of 31 Good Practices respecting the compulsory criteria 1-5 and as many aspects as possible for the technical criteria 1-6, an evaluation was performed for the selection of 15 Good Practices to be included in this Guide. The availability of information submitted in the identified projects, as well as particular strong and weak points found (other than those covered by the criteria provided) were also used to evaluate the projects.

Over the 15 cases selected, 5 refer to forests, 3 to coastal/dunes, 3 arid/semi-arids and 4 to freshwater habitats:

Forests

- The Mediterranean holm oak grove integrated management (Chênaie verte)
- Conservation of Apennine beech forests with Abies alba in SIC Pigelleto - M. Amiata (TUCAP)
- Restoration of Pinus nigra forests on Mount Parnonas through a structured approach (PINUS)
- Integrated Management of the Mid-Atlas Forests in Morocco (GIFMA)
- Returning the Botanical Richness of the Jarrah Forest in Restored Bauxite Mines in Western Australia

Freshwater habitats

- Wetland restoration for fauna and flora recovery in Algemesí Reserve (Llacuna del Barranc)
- Restoration and environmental interpretation of the riparian forest of Nestos Delta
- Restoration and Management of Oroklini Lake in Larnaka (OROKLINI)
- Protection of a territory by ecologic engineering in a catchment area (PROGECO)

Coastal/dune hábitats

- Model of restoration of dunes habitats in 'L'Albufera de Valencia' (Dunas Albufera)
- Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (JUNICOAST)
- Conservation and recovery of dune habitats in sites of the Provinces of Cagliari, Matera and Caserta (PROVIDUNE)

Arid/semi-arid systems

- Demonstration Project to Combat Desertification: Regeneration and Management Plan of degraded semi-arid areas in Albatera
- Mediterranean Quarry Rehabilitation Manual: Learn the Holcim Experience
- Safeguard Thero-Brachypodietea habitat in SCI 'Area delle Gravine' (GRAVINE)

In this section we will summarise each of the Good Practices selected.

The Mediterranean holm oak grove integrated management (Chênaie verte)

Reference: LIFE96 NAT/F/003200

Habitat: Mediterranean forests, Mediterranean screes, grasslands and rocky habitats. In particular EU habitats: 9340 '*Quercus ilex* and *Quercus rotundifolia* forests'; 5210 'Arborescent matorral with *Juniperus* spp.'; 8130 'Western Mediterranean and thermophilous scree'; 6220* 'Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*; 8210 'Calcareous rocky slopes with chasmophytic vegetation'; 8310 'Caves not open to the public'

Duration: 01/01/1997-30/06/2002

Area covered: 11,500 ha

Total Costs: 816,125.85 €

Promoter: Office National des Forêts, Direction Régionale Languedoc-Roussillon (France)

Type of organisation: Public enterprise

Partners:

1. Groupe de Recherche et d'Information sur les Vertébrés et leur Environnement (GRIVE)
2. Conservatoire National Botanique de Porquerolles
3. LPO-Aude
4. Conservatoire des espaces naturels du Languedoc-Roussillon
5. Centre ornithologique du Gard (COGARD)
6. Office National de la Chasse et de la Faune Sauvage (ONCFS)

Case Study Location: SPA 'Montagne de la Clape' and SPA 'Gorges Du Gardon', Languedoc-Roussillon (France)

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Panoramic view of the 'Gorges du Gardon'

Introduction

One of the most widely distributed ecological complexes in the Mediterranean basin is the evergreen oak wood, consisting of various dynamic stages (from grassland to forest). Montagne de la Clape, a small limestone massif rising between the coastal strip and the Aude plain, and gorges of the Gardon in the north-east of Nîmes, are two representative evergreen oak woods of the French Mediterranean. Both sites designated as SPAs and pSCIs host several bird species of Community interest, such as the Bonelli's eagle (*Hieraaetus fasciatus*), as well as species on Annex II of the Habitats Directive and various habitat types on Annex I such as the *Thero-Brachypodietea* pseudo-steppe, a priority habitat. A framework document drawn up before the project for each of these natural complexes was to be used as a reference instrument for the forestry management of these habitat types and as an educational tool to assist communities and private owners in adopting forms of management conform to the requirements of Natura 2000. This document was also meant to act as a management plan laying down the measures to be carried out within the context of the LIFE project.

Degradation

The species and habitats targeted in the project are currently threatened by changes in land use: (1) abandonment of grazing and forestry that is gradually leading to the disappearance of open areas and their associated species, and (2) expansion of leisure activities (touristic activities) that disturb certain sensitive species and degrade fragile environments.

Objectives

Goal: This project overall aim was to implement, as a demonstration measure, a strategy for integrated management of the evergreen oak wood ecosystem on both sites of the Gardon and the Montagne de la Clape.

Specific objectives: Evaluation of the conservation status of the habitats and species of interest for the project; restoration of the evergreen oak woods and the riparian forests to allow the recovery of diverse animal species; and creation of a back-up of *Centaurea corymbosa*.

Tourist activity at the 'Gorges du Gardon'

Methodology

- Elaboration of diverse research works on the conservation status of Bonelli eagle and other raptors, beaver, and *Centaurea corymbrosa*, as well as diverse studies on the impact of tourism frequentation and the status of the natural habitats in the areas selected.
- Restoration and management activities of the areas (from the results of the research works):

  (1) Detour of the hiking trails and elimination of climbing routes to avoid to disturb eagles,

  (2) Mechanical maintenance of open areas (lawn of *Brachypodium*) to favour *Thero-Brachypodietea* pseudo-steppe key species,

  (3) Willows plantations and pruning of poplars along the riparian forest of the Gardon river in order to rehabilitate the habitat itself but also to improve the quality of foraging resources for *Castor fiber*,

  (4) Forestry management of the Aleppo pine forest (cleaning and opening to avoid fires),

  (5) Renewal of Green Oaks (*Quercus ilex*) by cutting coppice, thinning out to promote diameter growth of the remaining trees, and clearing of the oak groves to permit renewal of biodiversity (garrigue species),

  (6) *Ex situ* seed collection of *Centaurea corymbosa* as well as a propagation plan for the species.
- Creation of a management plan for the habitats to assure the implementation of the correct measures for their long-term conservation.

Results

The main results of the project are the following:

- Better knowledge of species and habitats on both sites of the project. The area covered by the different habitat types of community interest is now well defined; the population of the endemic plant of the Clape Mountain, *Centaurea corymbosa*, has been exactly counted and its extinction risks assessed. The threats to the breeding sites of the three pairs of Bonelli's eagles have been identified.
- Protection of the breeding sites of Bonelli's eagles: Some paths and tracks, which were too close to the nests and could generate disturbances, have been closed. Climbing ways have been suppressed and moved to other places where there are no risks of disturbing eagles.
- 30 ha (Clape mountain) and 50 ha (gorges of Gardon) of the priority habitat, *Thero-Brachypodietea* pseudo-steppe, have been restored.

Centaurea corymbrosa, a narrow endemism of the Massif de la Clape that is close to extinction

Castor fiber

- Regeneration of the riparian forest of Gardon. However, a big flood in September 2002 caused a decrease of more than 20% of the surface of this habitat. The area currently identified on the site is 51 ha and its management and restoration is being re-evaluated.
- Regeneration of green oak trees and groves. The techniques investigated allow rejuvenation of the forest and the increase of plant diversity.
- Others actions, such as closing caves hosting bats and cutting down burnt holm oaks have also been carried out.
- Seeds of *C. corymbosa* have been collected and its habitat cleaned for future reintroduction actions.
- Two management plans have been produced and the LIFE project implemented part of the actions of these plans.

All of these measures have been implemented in close collaboration with stakeholders, climbers and hunters in particular. This partnership has been a good means to increase the local population's awareness of their natural heritage. The results of these integrated actions were to be spread through training programmes and the publication of a summary brochure.

Lessons learnt

From this work and the experience of the Office National Des Forêts in Languedoc-Roussillon, one can deduce some conclusions:

- The optimal method for renewal of Green Oaks (*Q. ilex*) was cutting coppice (clear-cutting of coppice or new young branches). Growing plants from seeds is difficult and requires good soil. Plantations of truffle oaks (mycorrhizal) are currently widely practiced, but require significant care. Birds provide natural spread, but this is rather slow (particularly in the re-conquest of Aleppo pine forests by Green Oaks).
- The thinning out of the oak forest promoted diameter growth of the remaining trees, regardless the age of the settlement, but it is necessary that this operation is performed correctly (i.e. the forest must remain closed to avoid high evapo-transpiration in isolated trees).
- Clearing of the oak groves (thinning out) permitted renewal of biodiversity: development of light-demanding species (*Arbutus*, *Cistus*, thyme, etc.) that disappear into the adult and closed oak forest.

Vegetation monitoring at the 'Gorges du Gardon'

Perspectives

The Botanical Garden of Porquerolles performed, after the LIFE project, reintroductions of *Centaurea corymbosa* by the following process: (1) Collection of seeds from La Clape from non-hybrid plants. (2) *Ex situ* conservation of these seeds and culture of plants in the botanical garden. (3) Production of new seeds in isolation rooms anti-hybridisation for long-term *ex situ* preservation. (4) Reintroduction in Clape in ecologically favourable areas (on cliffs).

Gorges Du Gardon has been considered Biosphere Reserve by Unesco in June 2015. New restoration actions to rejuvenate the *Quercus* forests and increase biodiversity are being implemented (complementing those performed in the LIFE project). The destruction/re-colonisation ecology of the riparian forest is being assessed after the 2002 floods and restoration actions are planned if necessary (since it has been observed that the riparian forest recovers in non-human-disturbed areas).

Strong/weak points

- Strong points: Comprehensive plan for animal and plant conservation within the selected habitats. Use of native germplasm for regeneration of the habitats. Upgrade of management plans for the forest attending the necessities and current practices of the XX century, which included the use of native plant material of local origin.

Regional Natural Park of Narbonnaise, Armissan landscape

Conservation of Apennine beech forests with *Abies alba* in SIC Pigelleto - M. Amiata (TUCAP)

Reference: LIFE04 NAT/IT/000191

Habitat: EU habitats 9220 'Apennine beech forests with *Abies alba* and beech forests with *Abies nebrodensis*', 9210 'Apeninne beech forests with *Taxus* and *Ilex*', 92A0 '*Salix alba* and *Populus alba* galleries', and 9180 '*Tilio-Acerion* forests of slopes, screes and ravines'

Duration: 01/10/2004-31/12/2007

Area covered: 1312 ha

Total Costs: 700,000 €

Promoter: Comunità Montana Amiata Val d'Orcia

Type of organisation: Local authority

Partners:

1. Cooperativa Abies Alba scrl.
2. Dipartimento di Scienze Ambientali 'G. Sarfatti' - Università di Siena
3. Dipartimento di Biotecnologie Agrarie - Università di Firenze
4. D.R.E.Am. Italy co-operative society
5. Cooperativa 'La Querce'

Case Study Location: SCI 'Foreste del Siele e del Pigelleto di Piancastagnaio'-Toscana (Italy)

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Top view of two reintroduction areas for *Abies alba* in beech tree woods (Author: Sisto Ghinassi)

Introduction

Apennine beech (*Fagus sylvatica*) forests with indigenous silver fir (*Abies alba*) once covered an area from Monte Amiata to the Maremma plain in western Italy. Today, in Tuscany, the habitat is limited to small isolated areas, at altitudes of between 600 and 900 metres. A proposed Site of Community Importance (SCI) in the area, the Foreste del Siele e Pigetello di Piancastagnaio, is the location for one of the remaining beech forests with autochthonous silver fir, and beech forests with yew (*Taxus baccata*) and holly (*Ilex aquifolium*), another habitat that is rare in the Apennines. However, several factors threaten these forests, which make the need for management and restoration programs more urgent.

Degradation

Lack of maintenance of the beech forests with *Abies alba* allowed the diffusion of pathogen fungi, such as *Heterobasidium* and *Armillaria*, which affected the conifers and reduced their natural regeneration. In addition, the presence of exotic silver firs, recently planted in the area, created a serious risk of genetic erosion of the relict autochthonous population of this species. The habitat was also threated by over-exploitation of the beech woods. Finally, the *Salamandrina terdigitata*, one of the amphibians listed in the Habitats Directive, has been recently recognised in the area, where it is threatened by the reduction of its breeding habitat.

Objectives

Goal: Conservation and restoration of autochthonous nucleuses of *Abies alba* growing inside the beech wood of the SCI, increase the prevalence of *Taxus baccata* inside the beech forests, protection of the population of the spectacled salamander (*Salamandrina terdigitata*), and long-term maintenance of habitats and species targeted by the project.

Specific objectives: collection of additional naturalistic information of the SCI, identification of a stricter conservative regime (integral reserve) for the protection of patches with the oldest forest, development of techniques for vegetative propagation of *Taxus baccata*, development of techniques for low cost protection of breeding sites of the spectacled salamander, awareness of local people towards conservation of nature and knowledge of the specific characteristics of the SIC.

Natural Reserve of Pigelletto
(Author: Alfredo Bresciani)

Reintroduction area for *Abies alba* in ReSilFor project, which continued the actions starting in TUCAP
(Autor: Marcello Miozzo)

Methodology

- Preliminary actions with the aim of increasing the naturalistic and genetic information of the SCI and the target species. Preparation of management plans for the targeted woodlands, and land purchase to support more strongly the constitution of a reserve subjected to special protection within the SCI.
- Implementation of specific silvicultural works, aiming at the elimination of diseased plants, the reduction of the risk of further infections, and the restoration of suitable conditions to favour the natural renovation of the species. For exemple, thinning of broadleaf trees in the native silver fir and beech forest to favour the passage of a portion of the young autochthonous silver firs from the lower layer to the intermediate layer of the forest; elimination of the exotic conifers by minor clear cuttings in order to give space to the trees contributing to the regeneration of the autochthonous silver fir; and gradual elimination of the exotic silver fir population, also by minor clear cuttings, to reduce the risk of genetic pollution.
- Reproduction of native silver fir by grafting using 6 clones from diverse mother plants (from which at least 2 showed large phenotypic plasticity to climate conditions). This action was repeated 5 times to get at least 30 plants.
- *Ex situ* reproduction of at least 3000 *Taxus baccata* plants, and their subsequent planting as microcollections inside the wood. Reproduction was initially planned by seed germination, but was later changed to vegetative reproduction (explained below).
- Production of broadleaf tree seedlings by agamic reproduction of local plants (*Sorbus torminalis*, *Carpinus betulus*, *Acer pseudoplatanus*).
- Implementation of small works to slow down water flow in the streams of the area, and restore abandoned old drinking troughs and springs, for the recreation of suitable habitats for *Salamandrina terdigitata*.
- Awareness activities for local people to disseminate results and awake them about the main issues of the Apennine beech forests with indigenous silver fir.

Grafted plants in nursery before planting
(Author: Alfredo Bresciani)

Grafted plants in nursery during aestivation
(Author: Alfredo Bresciani)

Results

The project achieved all the goals foreseen in the application:

- The naturalistic information on the SCI was increased; and the genetic analysis performed helped to understand the origin of the silver fir trees within the SCI and design their optimal reproduction and management.
- Seven hectares of mature forest with autochthonous silver fir and mesophilous broadleaved woodland were purchased, making it possible to support the creation of a reserve subject to special protection within the SCI more effectively.
- The Province of Siena declared the zone with the autochtonous *Abies alba* a Special Area of Conservation (SAC). A management plan for the sites where actions are needed was elaborated and approved by the Comunità Montana. The plan includes details of actions to be carried out until 2027.
- The status of the Apennine beech forest with *Abies alba* across a 36.7 hectares area was improved through the sylvicultural interventions applied. 32 hectares of Apennine beech forest with *Abies alba* were reconstituted. 18 hectares of artificial conifers stands and allochthonous *Abies alba* were re-naturalised with native plants (in order to eliminate genetic pollution of the forest). 20 hectares of Apennine beech woods with *Taxus* and *Ilex* were restored by the plantation of 3000 European *Taxus baccata* and 3000 broadleaf tree saplings.
- Re-creation of eight habitats suitable for *Salamandrina terdigitata* using low-cost techniques.
- Provision of information to local people about the main issues and promotion of the results on the project's website, where the following can be found: the final technical report; proceedings of the workshop held in April 2005; reports on the naturalistic survey and on the genetic survey on the autochthonous population of silver fir; the naturalistic survey database; summary reports in Italian and English; and a summary of the technical-scientific aspects of the project.

Measures in favour of native *Abies alba* submitted to beech tree: girdle beech trees competitors to release the coverage gradually (Author: Enrico Meazzini)

Planting of grafted plants of *Abies alba* (Author: Alfredo Bresciani)

Lessons learnt

The plant reproduction methods initially planned for *Taxus baccata* (seed germination) had to be changed and vegetative reproduction was employed. This decision was made due to the short time allowed for the restoration action in these type of funded projects (i.e. EU-LIFE program), and the long-time required for the standard seed germination protocols of the target species.

This project can be regarded as a positive example of actions aimed at the conservation of nature, carried out in such a way that they can affect both natural and cultural trends that, if lasting, would bring about the extinction of ecotypes, species and habitats. Some examples: the new management of old reforestations that are not longer regarded as forest resources, but as allochthonous areas to be renaturalised; the management of mature broadleaved high forests that are neither seen as crop to be regenerated by forest utilisation, nor as crop to go on cultivating through thinning out, but as forests containing parts to be made more valuable; and the management of wetlands, also by minor works of bioengineering, in order to make it possible the reproduction of a given species.

Perspectives

The success of the restoration actions performed in TUCAP were also applied in other beech and silver fir forests in the Toscan Marches Appennines through the LIFE project LIFE08NAT/IT/000371, ReSilFor (http://www.liferesilfor.eu/): Restoration of beech and silver fir forests in the Toscan Marches Appennines. ReSilFor, that was approved and co-financed by the EU in September 2009, followed and complemented the restoration actions taken place in TUCAP.

Strong/weak points

- Weak points: use of vegetative plant production for the plantation of some species (e.g. *Taxus bacata*, *Ilex aquifolium*) due to the failure of optimal germination protocols.
- Strong points: genetic analysis of the composition of the silver fir forest to design the most appropriate planting and forest management.

A day focussing on the dissemination of *Abies alba* with schools
(Author: Marcello Miozzo)

Restoration of *Pinus nigra* forests on Mount Parnonas through a structured approach (PINUS)

Reference: LIFE+ NATURE LIFE07 NAT/GR/000286

Habitat: EU priority habitat type 9530* '(Sub-) Mediterranean pine forests with endemic black pines'

Duration: 01/01/2009-30/06/2013

Area covered: 631 ha

Total Costs: 3,035,791 €

Promoter: Goulandris Natural History Museum/Greek Biotope-Wetland Centre (Greece)

Type of organisation: Nonprofit institution

Partners:

1. Decentralized Administration of the Peloponnese - Western Greece & Ionian Sea
2. Decentralized Administration of Macedonia - Thrace
3. Management Body of Mount Parnon and Moustos Wetland

Case Study Location: SCI 'Oros Parnonas (and Malevi area)'-Peloponnese (Greece)

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Characteristic landscape of the burnt black pine forest on Mount Parnonas.
(Author: EKBY / Petros Kakouros©)

Introduction

The priority habitat type 9530* '(Sub-) Mediterranean pine forests with endemic black pines' has a fragmented distribution around the Mediterranean Region. Mount Parnonas (1,935 m) lies across the south-eastern part of the Peloponnese, Southern Greece and its black pine (*Pinus nigra*) populations are on the southern-most edges of their natural geographical distribution.

The black pine forests are the habitat of many important species of plants and animals, play an important role in protecting upland soils from erosion, and have economic importance because of their high wood productivity. Although the black pine is adapted to low-intensity understory fires, it is threatened by large crown fires, which have increasingly appeared in recent years. In the case of crown fires, natural regeneration of black pine forests is very precarious due to the special characteristics of the species *Pinus nigra*, which, unlike Aleppo and Calabrian pine, does not maintain dormant cones.

Degradation

Greece and other Mediterranean countries suffered from devastating wildfires during the summer of the year 2007that caused significant losses to several Mediterranean ecosystems including black pine forests. On the Site of Community Importance (SCI) GR2520006 'Oros Parnonas (and Malevi area)' of Mount Parnonas, black pine forests used to cover 5,350 ha. The wildfires destroyed a great percentage of the forests' area (nearly 36%) within the site's limits.

Objectives

Goal: To address the effects of the 2007 wildfire and to improve the planning of post fire restoration of black pine forests.

Specific objectives:

- The development and demonstration of a structured approach to restore burnt areas of the priority habitat type 'Mediterranean pine forests with endemic black pine' (9530*),
- The restoration of 290 ha of the priority habitat 9530* in the SCI GR2520006 'Oros Parnonas (and Malevi area)'.

Unburnt patch with black pine trees. These patches are valuable for natural regeneration of black pine habitat (Author: EKBY / Petros Kakouros©)

Methodology

- Impact assessment of the fire

  The assessment was based on the detailed mapping of the burnt areas, the evaluation of the fire impacts on vegetation, flora and fauna, and the mapping of any 'islands' or scattered healthy trees within the burnt area, as these act as dispersal sources of seeds for natural regeneration, which is the optimal way of restoring the forest. Techniques used were remote sensing, geographical information systems and fieldwork.

- Development and demonstration of a structured approach for the restoration of black pine forests

  The approach developed helps to define priorities for the restoration of affected areas. It includes the assessment of short-term risks of erosion, flood, etc. that should be immediately addressed and a step-by-step process for prioritising and selecting the most suitable areas for restoration, and specifying the restoration techniques. Prioritisation and selection of suitable areas is achieved by applying exclusion criteria, eligibility criteria in terms of abiotic parameters and technical criteria. The approach includes measures that ensure its immediate implementation, such as the maintenance of seed stocks, detailed mapping of flora and fauna, and monitoring the efficiency of the restoration measures.

  In the demonstration of the approach for Mt. Parnonas, the exclusion criteria were (i) the potential of natural regeneration and (ii) the potential of low survival of planted individuals. Then, the areas were ranked according to (1) the representativeness of the habitat type, (2) the inclusion of sites under conservation status, (3) the presence of important species, (4) the need for re-establishment of forest connectivity, and (5) the abiotic variables of the prospective areas in order to select those with the higher potential of reforestation success. The final step was the consideration of the available resources and the cost per hectare and per restoration method (seeding or planting) to determine the total area that would be restored.

- Revegetation actions

  Pinus nigra seedlings of certified quality were planted in pit holes opened with hand tools; they were produced with seeds collected from Parnonas after the fire of 2007.

- Monitoring and evaluation of the restoration

  The monitoring system aimed at the evaluation of the progress of natural regeneration, of the effectiveness of restoration planning and of the success of restoration. Monitoring plots were permanently marked.

Black pine seedlings at the Forest Nursery of Organi, ready for transportation to restoration area on Mount Parnonas (Author: EKBY / Petros Kakouros©)

Workers planting black pine seedlings (Author: EKBY / Petros Kakouros©)

- Dissemination and communication

  The structural approach and the restoration actions implemented were highly promoted. Particularly noted is the holding of an international conference 'New approaches for the restoration of black pine forests', the publication of guidelines (Kakouros & Dafis 2013) concerning the implementation of a structured approach for the restoration of black pine and the movie 'The travelling seed' (http://www.parnonaslife.gr/en/the-travelling-seed) which presents the whole process of the restoration from the collection of seeds and restoration planning, to the production of seedlings and the plantings.

Results

- Restoration of 290 ha of burnt black pine forest, 450,000 seedlings were planted and dried out plants were replenished.
- Overall, 341 ha were naturally regenerated with black pine or evergreen broadleaved vegetation by 2013.
- A network of 33 permanent monitoring sites was installed to monitor both the natural regeneration and restoration.
- The project set the basis for the restoration of another 250 ha of the burnt forest when additional funding became available.

Lessons learnt

- Necessary digital data in adequate format such as habitat maps, geology maps, soil maps and digital data on the distribution of the species should be available in forest services for use in emergencies, so that the restoration planning process can be carried out quickly and accurately.
- An adequate quantity of seeds for each *Pinus nigra* forest should be available in the Central Seed Storage of the Greek Forest Service, because seed collection could be hindered by numerous factors such as low cone production, small number of surviving trees, difficulties to reach locations with survived trees, lack of adequate resources and their shortage may severely delay the restoration.

Natural regeneration of black pine along a micro-shelter created by a fallen log
(Author: EKBY / Petros Kakouros©)

Perspectives

Since 2011, natural regeneration has become difficult because understory vegetation competes the saplings that manage to germinate, while few seeds manage to go beyond the areas where natural regeneration already occurs. When young trees start to produce seeds, large quantities of seeds will disperse, in many cases in areas where planting could not be done due to poor soil conditions. The production of seeds is expected from 2025 for trees in open stands and from 2030 for trees in more dense stands. Finally, it is expected that after 70-100 years, mature black pine stands will be formed in an area of about 880 ha. Due to the lower survival rates of plantings at altitudes lower than 1,000 m, stands will probably be more open than before the fire, at least for the first decades.

Strong/weak points

- Strong point: The project is an excellent example of a structured restoration approach.

Restored slope with emerging black pine trees 2 years after planting.
(Author: EKBY / Petros Kakouros©)

Integrated Management of the Mid-Atlas Forests in Morocco (GIFMA)

Reference: Final report of ecological restoration results in Mid atlas forests. Youssef Melhaoui, Technical assistant of GIFMA project

Habitat: Mid atlas forests (*Juniperus oxycedrus-thuya* ecosystem, *J. oxycedrus* ecosystem and *Cedrus atlantica-Quercus rotundifolia* ecosystem)

Duration: 2010-2014

Area covered: 71617 ha

Total Costs: 3,110,745 US$ (United States dollars)

Promoter: High Commission of Forests and Waters and for the Fight Against Desertification (HCEFLCD) (Morocco)

Type of organisation: Moroccan government

Partners:

1. United Nations Development Program (UNDP)
2. Social Development Agency of Morocco (ADS)
3. Global Environment Fund (GEF)
4. World Wide Fund for Nature (WWF)
5. PCV: US Peace Corps Volunteers

Case Study Location: Guigou and Itzer forests-Skoura and tanourdi communes (Morocco)

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Itzer forest (Author: Youssef Melhaoui)

Introduction

Moroccan forests are one of the most biodiverse regions in the Mediterranean basin. Around 5.7 million hectares are covered by forests with 80% of deciduous forests (*Quercus suber*, *Quercus rotundifolia*, *Argania spinosa*, etc.) and 20% of conifer forests (*Cedar*, *Thuya*, *Juniper*, *Pinus*, etc.). Moroccan endemic flora is represented by 800 species and sub-species taking refuge in the Rif and Atlas mountains. The mid-Atlas contains alone around 237 endemic species. There are also rare and endangered forests as *Abies maroccana*, *Pinus nigra* subsp. *mauretanica*, *Pinus pinaster* subsp. *hamiltonii* var. *maghrebiana* and *Juniperus thurifera* forests.

Degradation

The main causes of the ecosystem degradation of the Middle Atlas forests are:

- Overgrazing (80% of forests affected every year)
- Cutting of fuelwood
- Fires (2700 ha affected every year)
- The irresponsible and irrational exploitation of forest resources (clearing, illegal cutting, conversion of forests into cannabis culture, etc.)

Objectives

Goal: The general purpose of the project was the setting of a restoration process of degraded forest ecosystem in two experimental pilot sites (in Guigou and Itzer forests).

Specific objectives:

- Conservation of biodiversity and natural resources
- To master the techniques for cultivation and production of native plants in the nurseries
- Dissemination of the propagation techniques of native species developed by nurseries (sowing, cutting…)
- Training on ecological restoration actions and their monitoring
- Capitalisation and application of the ecological restoration concept in a larger scale
- Involvement of local population in restoration actions

Livestock damages on Juniper tree
(Author: Youssef Melhaoui)

Overexploitation of Quercus trees
(Author: Youssef Melhaoui)

Methodology

After the selection of the two pilot sites in Guigou and Itzer forests and the nurseries (in Tadout and Ait Oufella) for native plants production, restoration actions were carried out in two components:

A) The propagation of native plants in nurseries

- Selection of native species to be produced in nurseries, woody and herbaceous native species were selected from ecosystem specific phytosociological literature
- Study on the phenology and the fructification calendar of the selected species
- Collect seeds from Guigou and Itzer forests and storage of native plant seeds in a cold room
- Establishment of a sowing calendar for the different species
- Germination tests of collected seeds
- Propagation of selected native species in nurseries (by sowing or cutting)

B) Implementation of the restoration plan in the two pilot sites

- Study of the vegetation cover inside the pilot site
- Suggestion of the adequate restoration practices
- Elaboration of a management plan for each experimental plot

The used restoration practices were the following:

1/ Closure by a setting of a barbed wire fence in order to avoid the overgrazing and the other degradation factors (biological rest)

2/ Plantations:

- Opening of planting holes: 30x30x30 cm
- Density: 50 to 100 plants depending of the existent density
- Plantations were performed under shade protection (nurse plants) and in clearings

3/ Sowing

- Sowing is carried out in 3 m^2 plots under shade protection (nurse plants) and clearings and loosening of the soil to a depth of 10 cm in the middle of the plot

4/ Cultural practices:

- Pruning: it consists of cutting the branches of the basal 1/3 of the trees of *Juniperus phoenicea*, *Juniperus oxycedrus*, *Pinus halepensis* and *Tetraclinis articulata* of more than 2m of height.
- Cutting-back the damaged *Juniperus* trees, dead or infested *Pinus halepensis* trees and replacing them by intact *Juniperus* and *Tetraclinis articulata* plants.

Plantation works (Author: Youssef Melhaoui)

Results

At the time of the mid-term review GIFMA's project had achieved the following:

1) The selection and enclosure of 2700 hectares in total in the forests of the pilot municipalities for a biological rest.

2) The collection of native seeds and subsequent production of plants in two nurseries.

3) The creation of a monitoring committee and partnership agreements with all stakeholders.

4) Planting and sowing the selected native species in pilot sites according the ecosystem:

- *Juniperus oxycedrus-thuya* ecosystem: 1225 plants divided in 11 species (*Juniperus phoenicea, Tetraclinis articulata, Pistacia lentiscus, Phillyrea angustifolia, Rosmarinus officinalis, Medicago arborea*, etc.) were produced.
- *Juniperus oxycedrus* ecosystem: 1211 native plants divided in 13 species (*Cistus salviifolius, Medicago arborea, Atriplex numularia, Teucrium polium* subsp. *purpurascens, Phillyrea angustifolia*., etc.) were produced.
- *Cedrus atlantica-Quercus rotundifolia* ecosystem: 1038 native plants divided in 6 species (*Cedrus atlantica, Juniperus oxycedrus, Rosa canina, Crataegus laciniata, Quercus ilex, Fraxinus dimorpha)* were produced.

5) Ensuring plant husbandry and monitoring of the pilot plots.

The results obtained in field plantations are encouraging:

- Almost all planted native species showed satisfying results. Except for *Pistacia lentiscus*, the success rate of survival of the other species was over 80%, despite of climatic constraints (drought and low temperature).
- The success of *Rosmarinus* is satisfying in both ordinary and sloped field

Regeneration of Cedrus atlantica after sowing
(Author: Youssef Melhaoui)

Regeneration of Quercus rotundifolia after sowing
(Author: Youssef Melhaoui)

Lessons learnt

- The dead thuya and *Juniper* plants were due to the poor quality of the soil.
- The plants kept in the shade were more vigorous than those from clearings.
- Three species to retain for planting in clearings: *Juniperus phoenicea*, *Tetraclinis articulata* and *Rosmarinus officinalis.*
- Summer rains are a benefit to the established plants.
- Pruning and cutting back enables the establishment of new native seedlings.

Perspectives

- Continue with the activities in Itzer and Guigou forests and replicate the model on a larger scale in other cities in the mid atlas.
- The involvement of the community groups in the restoration actions.
- Improving the knowhow of the forest managers.

Strong/weak points

- Strong points: The project has developed in an adaptive and implicit manner a model of integrated participatory management for the 'agro-forestry-pastoral' space based on the participation of three types of local and regional stakeholders.
- Weak points: GIFMA's experience indicates that the economic benefit derived from the users participation in the management of the forest ecosystem should be less ambitious as the national legislation obstacles cannot be resolved during the life of the project.

The nursery of Taddout
(Author: Youssef Melhaoui)

Returning the Botanical Richness of the Jarrah Forest in Restored Bauxite Mines in Western Australia

References:

1. Global Restoration Network
2. Alcoa´s Mining and Restoration Process in South Western Australia (Koch, 2007)

Habitat: Jarrah forest

Duration: 1991-ongoing

Area covered: 500-600 ha per year

Total Costs: 34,000/ha AU$ (Australian dollars)

Promoter: Alcoa World Alumina Australia (Alcoa)

Type of organisation: Private company

Partners: Most research and restoration activities are funded and carried out solely by Alcoa, although some projects have been performed with the involvement of universities and other research organisations.

Case Study Location: Huntly and Willowdale mines-Darling Range Plateau (Australia)

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A mined area before restoration
(Author: Alcoa World Alumina Australia©)

The same area after restoration
(Author: Alcoa World Alumina Australia©)

Introduction

Alcoa currently operates two bauxite mines at Willowdale and Huntly in the jarrah forest of the Darling Range of south-western Australia, a Mediterranean-type habitat and biodiversity hotspot. In the jarrah forest there are at least 300–400 plant species in the vegetation that is typically mined and as many as 163 species per 0.1 ha. Alcoa has been restoring its bauxite mines since 1966, and since 1991 it has made a commitment to use only local provenance, indigenous plant species in seeding and planting. Additionally, Alcoa is converting the areas previously restored with non- indigenous plant species to native jarrah as the timber of nonindigenous trees is harvested.

Degradation

Bauxite mining occurs in isolated pods of 1–100 ha in area, averaging 10–20 ha. After timber harvest, the mining sequence involves clearing the remaining vegetation, removing the soil, blasting the cemented bauxite layer or ripping it with a bulldozer, and removing and crushing the bauxite before transporting it to the refineries.

Objectives

Goal: to re-establish a self-sustaining jarrah forest ecosystem, planned to enhance or maintain water, timber, recreation, and conservation values after mining activities cease in a particular area.

Specific objectives:

- to create a restored landscape visually compatible with the adjoining indigenous forest.
- to develop flora, fauna and soil characteristics of the indigenous jarrah forest ecosystem, with a target for the average number of indigenous plant species in 15-month-old restoration sites to be 100% of the number found in representative jarrah forest sites and at least twenty percent from a priority species list.
- to produce an ecosystem that can become self-sustaining without intensive long-term management.

Methodology

- Pre-Mine Surveys: A range of surveys are undertaken at the earliest possible stage prior to mine development. Surveys include vegetation mapping, fauna monitoring, and mapping of the jarrah dieback disease (caused by *Phytophthora cinnamomi*).

Monitoring of the botanical richness (Author: Alcoa World Alumina Australia©)

- Landscaping and Pre-Ripping: Bulldozers push down the pit walls and landscape the mines to blend into the surrounding forest topography. The pit floor is deep ripped at 1.6-m spacing to break up its compaction.
- Overburden and Topsoil Return: Prior to mining soil is stripped in two layers, the top 15 cm (topsoil) and the layer below down to an average of 40 cm depth (overburden) which is stockpiled near the mined area. Using scrapers, first the stockpiled overburden and then fresh topsoil, usually sourced from a pit nearby that is being prepared for mining, are spread on the site in the dry season. This ''directly returned'' topsoil contains most of the forest seed bank, nutrients, and soil microbial activity, allowing a more rapid return of plant species and soil processes. Where direct return is not possible, some fresh topsoil is screened to remove much of the inert gravel, and a fine fraction with its concentrated seed content is then spread over the pits. Seed in returned topsoil is the best re-establishment option for many species for which seed collecting and subsequent seeding is impractical, very expensive or even impossible.
- Contour Ripping: The area is ripped again to a depth of 0.8 m on contour by a bulldozer using three tines in order to remove compaction caused by the soil return operation and produce contour furrows, which allow water infiltration and provide erosion protection until the vegetation develops.
- Return of Logs and Rocks for Fauna Habitat: Waste timber and rocks are placed in the restored areas to provide habitat for both vertebrate and invertebrate fauna.
- Seeding: The areas are seeded with a mix of 78-113 species including the two dominant trees, Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*), and other tree and understory plants. Seeds are collected within a defined zone up to 20 km from each mine to ensure that local genetic material is used. The seeds are applied via an air seeder attached to the ripping bulldozer in the dry season. Germination treatments (e.g. hot water or smoke) are applied to each species as required before sowing.

Topsoil is screened to gather a seed-rich mix used to maximise growth in the restored areas
(Author: Alcoa World Alumina Australia©)

Logs and rocks are returned to provide shelter and nesting sites for animals
(Author: Alcoa World Alumina Australia©)

- Planting: Species that do not readily establish from the topsoil or applied seed are included in a species priority list. Up to 28 species are propagated from cuttings, scarce seed quantities, or by tissue culture. The plants are hand planted during winter. Many species are dryland rushes and sedges that produce little viable seed, and are heavily grazed by kangaroos. These young plants are protected with small mesh bags.
- Fertilising: Diammonium phosphate fertiliser with potassium and micronutrients is applied at 280 kg/ha by helicopter to newly restored areas in late winter. This is a once-off application.
- Monitoring: In March each year, when the restored areas are 9 months old, they are monitored to check that the number of established plants meets the targets. Areas of erosion or weeds are also treated if required. In the second spring after establishment (15 months old), the plant species richness is determined using 80-to 150 randomly located plots of 80 m^2. A subset of these plots is permanently marked and intensively remonitored to become part of a long-term vegetation monitoring programme. These plots are remonitored at 1, 6, 15, 20, 30, and 50 years old.

Results

All measured indicators show that Alcoa has been successful in restoring the jarrah forest ecosystem, and there is a continuous improvement in recovery results. Handling and timing of topsoil movement, developing and applying new technology, and improving the seed mix and its method of application saw a gradual improvement in species richness in mined plots to over 80% by 1995. By further improving soil handling methods, improved seed technology, and by planting the species of the priority list, the target was exceeded and a value of 101.4% was achieved in 2001 restored areas. Late soil ripping in the wet season saw lower richness results for 2002 and 2003, and a very dry year in 2001 produced poor soil seedbanks which also affected richness in 2002 and 2003. In 2004, 96% was achieved, while 2005 again fell to 90% due to the closure of a mining region and the lack of opportunities to directly return topsoil. In 2010, richness was lower because it was the driest year on record. For the remaining years species richness achieved was around the 100% level.

The survival rate of jarrah was high, irrespective of the presence of *P. cinnamomi*.

Marrinup Nursery supplies seedlings of priority species list for planting out in the mine areas being restored
(Author: Alcoa World Alumina Australia©)

A small sedge is protected from kangaroos overgrazing (Author: Alcoa World Alumina Australia©)

Lessons learnt

- A very dry year can affect soil seedbanks in the following years, as can logistical restraints on the timing of soil ripping and topsoil return.
- Directly returning topsoil greatly increases botanical richness.

Perspectives

- Restoring species richness to the 100% target remains a high priority.
- The restored areas are still young (mostly less than 30 years old) and full ecosystem restoration may take centuries. However, the building blocks and processes are in place to successfully re-instate the jarrah forest ecosystem.

Strong/weak points

- Strong point: Restoration technology is continuously improved. Alcoa and collaborative researchers have developed many innovative practices and technologies for seed treatment and application, topsoil handling, mine planning and native plant propagation.

A variety of restoration methods and extensive work ensure that maximum diversity of species is established in the first year after completion
(Author: Alcoa World Alumina Australia©)

Four years later this same area is a young, growing jarrah forest
(Author: Alcoa World Alumina Australia©)

Wetland restoration for fauna and flora recovery in Algemesí Reserve (Llacuna del Barranc)

Reference: Centre for Conservation of freshwater species of Valencia (CCEDCV). http://www.agricultura.gva.es/web/biodiversidad/centro-de-conservacion-de-especies-dulceacuicolas-de-la-cv-flora

Habitat: Wetland: EU Priority habitats 1150* 'Coastal Lagoons' and 7210* 'Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*'

Duration: 08/01/1996-present

Area covered: 1.2 ha

Total Costs: 351,000 € (estimated costs)

Promoter: Valencia Regional Government-City Council of Algemesí (Spain)

Type of organisation: Public authorities

Partners: None

Case Study Location: Natural Park L'Albufera de Valencia-Algemesí Reserve (Llacuna del Barranc), Algemesí, Valencia (Spain)

Contact:

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Algemesí Reserve, first stage of the restoration (Author: CCEDCV)

Algemesí reserve, 6 years after the beginning of the restoration works (Author: CCEDCV)

Introduction

The 'Llacuna del Barranc' project is the case of an integral wetland restoration from a rice field fully operational after the signing of a framework cooperation agreement between Algemesí municipality –which purchased the land and would be in charge of the area maintenance– and Valencian Regional Government –which would execute the adequacy of the area and the reintroduction of aquatic fauna and flora species.

The lagoon was restored with the initial purpose of the establishment of a reserve area for the reintroduction of the endemic endangered fish *Valencia hispanica*, 'samaruc', with consequent restoration of open waters and shoreline vegetation.

Degradation

The silting of various areas of the Albufera lagoon for the generation of rice crops since ancient times, but particularly intensive during S. XVIII–XIX, and subsequent activities such as drainage and waste spill, are estimated as the main habitat´s degradation causes. Besides, the introduced exotic flora and fauna strongly influences the regression of native populations, such as *Arundo* sp. or *Gambusia holbrooki*, which act as competing species for helophytes and riparian species and for the fish *Valencia hispanica*, respectively.

Objectives

Goal: wetland (aquatic and terrestrial habitat) restoration for the establishment of a high biodiversity fauna and flora core, and guarantee long-term conservation.

Specific objectives: Lagoon geomorphologic reconstruction; fauna and flora recovery, including endangered native species; public awareness and education

Methodology

- Some rice fields were explored in order to choose one that could supply quality water from an aquifer, needed by the endemic fish 'samaruc'; the water of the surrounding system fails because it is an intensive cultivation system with eutrophication pollution.

One of the islets fomed in the wetland, just flooded
(Author: CCEDCV)

Wall made with natural material for the protection of the slope in the outer channel of the wetland
(Author: CCEDCV)

The geomorphological reconstruction consisted in make deeper the rice field with a backhoe excavator for further repositioning the extracted material to generate the outer perimeter and the various desired reliefs and internal forms, forming different islets and canals between them. Very soft slopes are made in most of the inner perimeter to facilitate the establishment of selected helophytic species. On the contrary, for the outer one, steeper slopes with an upper bound that the rest of the interior hillocks are made, to prevent entry of outside water during large potential floods.

- Plantations: some natural springs and canals near the area were used as reference systems to select flora species. Plant production was performed in the CCEDCV by seeds collected at surrounding areas, ensuring the variability and genetic origin of plants. In a few cases, cutting or rhizome division or fragmentation techniques were used.

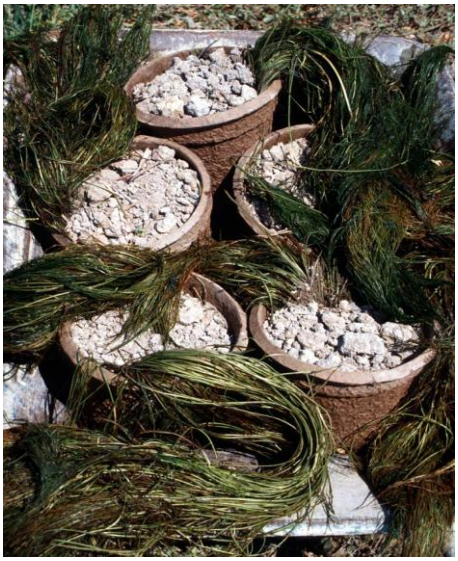
Depending on the water needs of the species different methods are used:

(1) Planting in the aquatic environment with hydrophytes requires special containers: a gravel layer should be added on top to prevent the substrate loss upon contact with water, and they must be biodegradable since they will stay in the middle.

(2) Plantations out of water with helophytes are performed on the shore and in some cases at the start of the sheet of water: species as *Alisma plantago-aquatica* or *Scirpus tabernaemontani* have been planted with their root system completely submerged in the water sheet. Riparian plants, with less water requirements, have been placed from 0-100cm of vertical distance to water, depending on species. In some cases they have been planted by the water level to ensure their survival, such as *Kosteletzkya pentacarpa*, which in many cases grows in their natural environment just at the edge of water. Other times, plantations have been conducted at a greater distance, such as *Lonicera biflora*, planted about 120 cm above the water level because their water requirements are lower.

Large plantations were performed during 1996, 1997 and 1999. From 2000, lower plantations, as reinforcements or introductions of special species were conducted. In total, 29523 saplings from 43 different species of aquatic flora have been planted.

Umbraculum with water pools for the production of macrophytes (Author: CCEDCV)



Potamogeton pectinatus in pressboard biodegradable containers, with a gravel layer on top (Author: CCEDCV)

- Several fauna species were set free in the flooded lagoon, mainly fishes and turtles (*Valencia hispanica*, *Aphanus iberus*, *Emys orbicularis*, *Gasterosteus aculeatus*, etc.)
- Additionally, a perimeter fence was installed to avoid free access to the area and some uses such as sport fishing and hunting were banned.
- Awareness campaigns and environmental education: a nature trail with signs has been built, there have been exhibitions and documentaries, school materials for children's education have been made, etc.

Results

- An analysis of the results up to 2013 reveals that in the 'La Llacuna del Barranc' a natural ecosystem stability has been achieved, where the reintroduced flora has been successfully developed, naturally colonizing the entire reserve area and recreating an aquatic ecosystem with a high biodiversity level that represents an important protection unit of these habitats, which are endangered in many places.

  It is observed that only 4 years after the lagoon restoration, the vegetation development was very satisfactory. Helophytes and riparian plants developed faster than macrophytes. *Scirpus tabernaemontani*, *Kosteletzkya pentacarpa Cladium mariscus*, *Iris pseudacorus*, *Sparganium erectum* or *Hydrocotyle vulgaris* are the most successful species. For macrophytes, the main problem was the presence of numerous crayfish and herbivorous fish, destroying them shortly after planting. Then, plantation cages were installed at least in the early stages of plant development and also more plants were introduced. Finally, good results were obtained. The species most represented are *Myriophyllum verticillatum*, *Myriophyllum spicatum* and *Nymphaea alba*.
- Populations of target fauna species were boosted significantly.
- High number of awareness campaigns were raised, reaching a wide range of target public: students, cultural associations, technician groups, etc.

Different kind of plantation cages installed
(Author: CCEDCV)

Cultivation of *Iris pseudacorus*
(Author: CCEDCV)

Lessons learnt

- The geomorphology, depth and rheophily are very important aspects to consider when creating a new wetland, as well as the quality and quantity of water: it is vital for the establishment of some selected species, and to stop the growth of others that are not desired. For example, in some areas of the lagoon characterised by very shallow water with lentic flow and little water renewal thereof, colonisation by macrophytes has not been possible, even by those less demanding species in terms of water quality.
- It is also important the maintenance over time of clearing actions on nitrophilous, opportunistic or very vigorous growing species, and well as performing reinforcement plantations of some more delicate or demanding species.

Perspectives

It is expected to buy new adjacent land in the town of Algemesí to enlarge the area. In this case, the Regional Valencian Government would continue the activities of vegetation and fauna recovery, similarly to what has already been performed in the current project.

To continue with monitoring, awareness actions and maintenance of the restored area.

Strong/weak points

- Strong points: (1) Creating a new wetland from an active culture field was innovative, since there were no previous experiences in the area. (2) The project constitutes a good example of integral restoration, with fauna and flora consideration.
- Weak points: (1) The entry of unwanted fauna has not been fully controlled: some species are being introduced intentionally, and the needed overflow system installed in the restored area allows in some extent the exchange of water and living organisms with the surrounding system. (2) The initial geomorphology allowed the establishment of species able to grow vigorously causing silting basin by roots and soil generation with rheophily loss and free sheet water reduction, which implies regular maintenance by clearings.

Partial view of Algemesí reserve in 2015
(Author: CCEDCV)

Awareness activities with schoolchilds
(Author: CCEDCV)

Restoration and environmental interpretation of the riparian forest of Nestos Delta

Reference: http://www.ekby.gr/nestos/

Habitat: Riparian forest. EU habitats 91E0* 'Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*' (*Alno-Padion*, *Alnion incanae*, *Salicion albae*), 91F0 'Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)', 92A0 '*Salix alba* and *Populus alba* galleries', 92D0 'Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)'

Duration: 2005-2009

Area covered: 280 ha

Total Costs: 1,652,388.79 €

Promoter: Forest Service of Kavala

Type of organisation: Public authority

Partners:

1. Greek Biotope/Wetland Centre (EKBY)

Case Study Location: Nestos Delta-Region of East Macedonia and Thrace (Greece)

Contact:

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River Nestos with part of the secondary riparian forest (Author: EKBY / Petros Kakouros©)

Introduction

The Nestos Delta covers 55,000 ha and is designated Ramsar Site, Site of Community Importance of the NATURA 2000 Network, and a Special Protection Area. In the early 20th century the riparian forest of the Nestos Delta covered 12,000 ha and was one of the largest of its type in the Mediterranean area. At the start of the project, although the riparian forest of Nestos had been restricted to 150 ha of fragmented forest along both sides of the river, it was still the largest natural riparian forest in Greece.

Degradation

River Nestos sustained dramatic modifications of its hydrology and ecosystems during the 20th century. Modifications began at the riparian forest of the delta with intensive demand for farm land after 1930, which led to gradual clearance of the forest, river-straightening, and construction of dykes and an irrigation dam. Part of the forest was handed over to the Forestry Service to grow poplars, and to farmers. Degradation and shrinkage of the forest stopped in 1970 when the remainder of the virgin forest was put under protection in order to preserve the last population of the common pheasant in Greece. However, modifications continued with the construction of two hydroelectric dams at the middle of the river. Intensive poplar plantations and cessation of natural flooding caused a rapid drop in soil fertility which limited the survival of the forest vegetation and limited the vegetation to annual species. Underground water levels dropped resulting in increased water stress for the trees during the dry summer period. The magnitude of pressure was later moderated when it was made obligatory for the electricity company to allow a minimum water flow from the hydroelectric dams throughout the year. This led to the partial recovery of underground water levels in the proximity of the river.

Objectives

Goal: to restore the natural vegetation and valorise the riparian forest of Nestos Delta for the purpose of promoting sustainable tourism.

Specific objectives:

- To update the management plan of the riparian forest
- To restore 280 ha with native plant species and reduce the fragmentation of the forest
- To develop a visitor management plan, environmentally friendly infrastructures and information material.

Old river channel within the preserved old forest
(Author: EKBY / Petros Kakouros©)

Methodology

- A comprehensive Management Plan of the riparian forest updating the previous study of 1998 was developed. The plan considered modifications of the legislation framework pertaining to the area, and recent data on the species, vegetation and ecology of the area.
- A restoration implementation study for the restoration of the vegetation was prepared taking into account previous interventions in the area, evaluating previous attempts, proposing suitable areas for the restoration and species to be planted, and specifying all necessary works. The basic elements of the design for the restoration were:
  - planting material of species of indigenous flora produced with reproductive material collected from the riparian forest,
  - selection of species to be planted on each surface taking into account the soil conditions,
  - soil preparation (felling of poplar plantations, uprooting, tillage, milling, etc.),
  - planting in deep holes in order to facilitate faster access of the plant root system to the more humid soil layers,
  - removal of highly competitive vegetation by milling, creating shallow potholes around plants, etc.,
  - fencing of the planted areas to avoid grazing during the early life of the plants or to favour natural regeneration,
  - irrigation of the planted areas from watering tanks to ensure sufficient ground moisture.
- A monitoring programme for the progress of the restoration and the effectiveness of management was designed and established. Measurements of biotic and abiotic factors were used for the evaluation of the achievement of the management and restoration goals. In particular, for the evaluation of the restoration of plant composition and structure in comparison to that of the remaining virgin forest, the system recorded: success of planting of each species and site quality, plant growth, and vitality of plants.

Preparation of plantings: removal of poplar clones stumps
(Author: Forest Service of Kavala / Dimitris Filiadis©)

Soil ready for plantings and fencing for the protection from grazing animals
(Author: Forest Service of Kavala / Dimitris Filiadis©)

- A Visitor Management Plan was developed indicating ways for better access and circulation of visitors. Infrastructures for information, education and recreation purposes were developed, and the riparian forest and river Nestos were promoted as an area of exceptional ecological, aesthetical and recreational interest. The project was communicated widely, including cooperation with scientific and educational organisations.

Results

- Natural vegetation in the Riparian Forest of Nestos has been increased by 280 ha: about 80,000 planting holes were opened for the planting of White poplar (*Populus alba*), Black poplar (*Populus nigra*), Common adler (*Alnus glutinosa*), White willow (*Salix alba*), Fragile willow (*Salix fragilis*), Common ash (*Fraxinus angustifolia*), Pedunculate oak (*Quercus robur* subsp. *pedınculiflora*), etc.
- 14 permanent monitoring plots were established; monitoring results indicate that the success of the plantings was approximately 50 % and plant growth is satisfactory.
- The valorisation of the riparian forest and the recreation infrastructures contribute to the creation of sustainable development in the wider area.

Lessons learnt

- More detailed mapping of the soil conditions should have been implemented before the restoration.
- The control of the highly competitive vegetation requires substantial efforts and funding.

Perspectives

The perspectives are positive as it is expected that the growing trees will start to regenerate naturally. It is especially positive that the survival rate both of the soft woody species (*Populus* sp., *Salix* sp., etc.) and the hard woody species (*Quercus* sp. and *Fraxinus* sp.) was relatively high. The expansion of the natural forest will certainly benefit the local fauna, especially the species that need high trees for nesting and large forest interior.

Plants ready for planting
(Author: Forest Service of Kavala / Dimitris Filiadis©)

Populus alba and *Populus nigra* trees two years after planting
(Author: EKBY / Petros Kakouros©)

The especially high success of the plantings in the more humid sites raises the issue of investigating the potential of reflooding parts of the old river beds within the forest. This would contribute to the increase of freshwater infiltration in the parts of the Delta with high salinity while also create suitable habitats for a wide range of species such as fish, amphibians, etc.

Considering that the project developed a complete network of infrastructures for dissemination of information, the area has the potential to become a natural workplace for ecological restoration of forest and riparian systems.

Strong/weak points

- Strong point: The project not only achieved its objectives but also produced knowledge and gave the opportunity to a large number of scientists and technicians to gain valuable experience.
- Weak point: The monitoring programme is not functioning to the desired extent due to underfunding.

Open exhibition of machinery used for the cultivation of poplar plantations
(Author: EKBY / Petros Kakouros©)

Restoration and Management of Oroklini Lake in Larnaka (OROKLINI)

Reference: LIFE10 NAT CY 000716.

Habitat: Wetland, lake

Duration: 01/01/2012-31/12/2014

Area covered: 57 ha

Total Costs: 797,070 €

Promoter: Game and Fauna Service (Ministry of Interior)

Type of organisation: National authority

Partners:

1. BirdLife Cyprus
2. Environment Department (Ministry of Agriculture)
3. Department of Forests (Ministry of Agriculture)
4. Voroklini Community Council

Case Study Location: SPA/SCI Oroklini Lake-Larnaka (Cyprus)

Contact:

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http://www.orokliniproject.org/

Oroklini lake landscape (Author: M. Apostolidou©)

Introduction

Oroklini Lake is one of the few natural wetlands present in Cyprus. In 2009, the site was introduced to 'Natura 2000 network of protected areas'. The lake was classified as a Special Protection Area (SPA) under the EU Birds Directive due to the nesting of 2 birds, Black-winged Stilt (*Himantopus himantopus*) and Spur-winged Lapwing (*Vanellus spinosus*). Also, it was classified as a Site of Community Importance (SCI) and a Special Area of Conservation for the presence of halophytic species.

Degradation

The human disturbance represented the biggest threat to the site, especially uncontrolled access, where people usually enter with their vehicles and dogs, affecting the breeding success of birds. In addition, the absence of water management, affected the birds breeding success by the flooding or dryness according to the month of the year. In addition, many other factors lead to the degradation of the site, we mention: the creation of flea-market in the area, the presence of invasive species and the runoff from urban and agricultural areas to the site.

Objectives

Goal: restoration and management of Oroklini Lake to bring it to a favourable conservation status in relation to the species for which the site was selected.

Specific objectives: bring an ecological balance to the lake for long term ecosystem's functions; ensure the stability of the species populations and habitats, specifically to conserve the two qualifying species of the site: the Spur-winged Lapwing and the Black-winged Stilt.

Oroklini Lake, February 2012. The flea market is visible in the background
(Author: C. Papazoglou©)

Methodology

The project included preparatory actions, concrete conservation actions as well as awareness raising actions.

- A preparatory work was carried out, consisting of: a workshop and report on Favourable Reference Values (FRVs), the determination of the lake contour, a permission to build a fence, the elaboration of some studies of the site like: the topography, the hydrological features, ichthyological status of the Lake, analysis of pressures and impacts on runoff water quality, and the elaboration of a management plan (Action Plan).
- The perimeter of the site was fenced to control access on site and restrict the human disturbance. Also, water management works were carried out. Water management allows control of extreme events, especially with regards to spring flooding. Proper operation of water control structures allows drawing down water levels to avoid destruction of nests, as it was well documented in the past. These flooding threats have been dealt with through water management actions implemented during the LIFE Oroklini project. For example: the weir was restored after removal of vegetation on it, scrapes and islets were created and connected to the main drain to serve as a nesting and feeding area for many bird species. Besides, two water control structures were installed to the management of water in the site. In addition, eel pass were fixed to help the migration of eels from the sea to the lake which increase the feeding opportunities of birds.
- Invasive species were removed from the site (mainly the *Acacia trees*) by cutting trees and injecting pesticide into the stem or painting it on the stump (depending on the tree size). Then, native trees and shrubs were planted (mainly *Tamarix* trees) at the areas where invasive species existed, to minimise the probability of re-regeneration of those species. Also, native plant species were planted at the border of the area to provide natural screening for the lake and main breeding areas. Moreover, native *Salicornia* plants and other halophytic native vegetation were planted.
- The illegal flea market was restored by removing waste, concrete and gravel to extend the breeding habitat for birds.

Fencing works
(Author: M. Apostolidou©)

Removing acacias
(Author: M. Apostolidou©)

- Fireflies on the power lines that cross the site were installed to reduce the risk of bird collision.
- Public awareness and interest were increased by: the construction of an information kiosk with an observation platform, the erection of Project Notice Boards, the creation of one hide for nature watching which include interpretation panels with the birds that can be observed at the site, the execution of workshops, production of educational pack, activities with schools, photo album, video, leaflet and sticker for the site.
- Finally, the monitoring plan was set up, taking into consideration the high number of parameters such as: predator control combined with monitoring of nest success, monitoring of water control features, water levels, habitat protection, invasive plant species, Eel population, monitoring infrastructure and the condition of fireflies of electricity cables.

Results

Implementations to achieve the project objectives were accomplished, such as: the installation of the fence, the removal of invasive species, the plantation of native trees and shrubs, the water management, the construction of a visitor kiosk, and the construction of islets. In addition, successful results were reached:

- In 2013, Spur-winged Lapwing (SPA designation species) and Stone-curlew (*Burhinus oedicnemus*), nested in the restored field for the first time.
- In 2014, at least 2 Kentish Plover (*Charadrius alexandrinus*) nested in the area after an absence of 7 years, while the Little-ringed Plover (*Charadrius dubius*) nested where people and cars used to pass before the fence was erected. Furthermore, a breeding colony of 45 Cattle Egrets (*Bubulcus ibis*) nested in Oroklini for the first time. In the winter, one of the largest winter flocks of Spur-winged Lapwing was recorded at the site with 85 birds and this number has been the highest on the island for the 3 years project duration. Similarly, Spur-winged Lapwings have successfully nested on the constructed islets.

People enjoying Oroklini birds through telescopes and binoculars
(Author: M. Apostolidou©)

- High public interest was shown to the Oroklini lake restoration, through workshops, volunteer activities and visits to the lake. Thus, since the start of the project, around 1000 people have had the opportunity to gain knowledge on Oroklini Lake and it is estimated that around 100 people visit the site every month.

Lessons learnt

Before starting the restoration work, large scale studies taking into consideration many ecological features were performed leading to a better restoration management. Besides, methods used in the project to increase public awareness were very efficient. Thus, the more diverse the techniques to increase the public awareness are, the more attracted the public will be. Also, it was revealed that the creation of an information kiosk on the site is an attraction for the public.

Perspectives

A long term monitoring of the site will be carried out.

Strong/weak points

- Strong points:
  - Studies on the site to be restored where performed which leads to a high justified action. Native plant species of the country where planted replacing the invasive species.
  - High visibility of the project actions was respected (website, workshops and the information kiosk).
  - Diverse parameters were taken into consideration for monitoring activities.

Officers from the Game and Fauna Service are putting up the first notice board
(Author: M. Apostolidou©)

Protection of a territory by ecologic engineering in a catchment area (PROGECO)

Reference: Project PROGECO: Protection du territoire par le biais du genie ecologique a l'echelle de bassin versant, REF. 2003- 03-4.3-I-058, within the Cooperation Program Interregg III B Medocc.

Habitat: Freshwaters, Mediterranean river. In particular the EU habitats 5210 'Arborescent matorral with *Juniperus* spp.', 91E0* 'Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)', and 92D0 'Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)'

Duration: 01/05/2004-30/09/2006

Area covered: 0.049 ha

Total Costs: Not available

Promoter: Ente Autonomo del Flumendosa (EAF) of the Sardinian Region

Type of organisation: Body of the regional administration

Partners: PROGECO project partners for Italy:

1. National Institute for Mountains (IMONT)
2. Service Programs for the Spatial Planning Directorate of Territory, Environment, and Infrastructure of the Umbria Region

Case Study Location: Rio Guttureddu, SCI 'Foresta di Monte Arcosu'-Province of Cagliari-Region of Sardinia (Italy)

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Right bank of the Guttureddu River (Author: Enas)

Introduction

PROGECO was a project that involved several Mediterranean partners (Italy, Portugal, Greece, and Tunisia). Its main objective was the development of good practices for the application of naturalistic engineering to water streams and humid zones in the Mediterranean basin with strong human impact. Several case studies were developed, including the one presented here.

The site selected in Italy was the Guttureddu river, which is part of the 'Foresta di Monte Arcosu', property of WWF-Italy. This area is part of the Natura 2000 Network, and includes a Site of Interest Communitarian (SIC) and a Special Protection Area (SPA). The site was selected due to its high natural value, but also due to the high influence of phenomena of geomorphologic modification by intense sporadic and seasonal rain events, which are in turn affecting (flooding) the lower parts of this river and other rivers below it (rivers Santa Lucia and Gutturumannu).

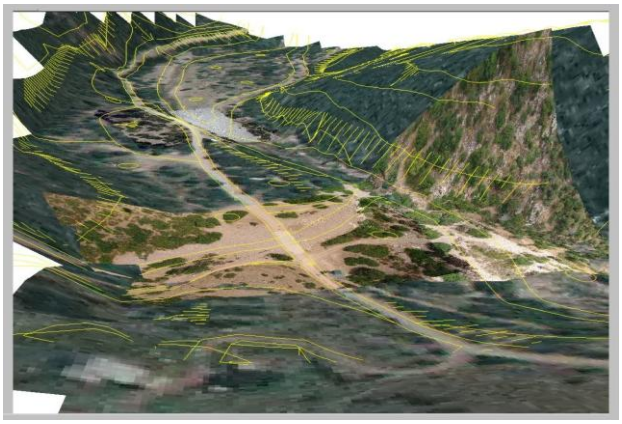
Degradation

- Anthropogenic: past deforestation of mature forests surrounding the river banks have changed the vegetation that produces a larger protective effect on the river; and recent deforestation of the river banks for the production of firewood has diminished the natural riparian vegetation.
- Natural: strong and seasonal rains typical in the Mediterranean are modifying the geomorphology of the riverbanks due to the absence or modification of the natural riparian vegetation.

Objectives

Goal: The main objective of the project was to develop and test, in different environments of the Mediterranean basin, the effectiveness and the potential use of the naturalistic engineering for the hydro-geologic protection and the restoration of the natural habitat.

Specific objectives: In the area selected within Sardinia, the objective was the evaluation of diverse restoration techniques on diverse areas of the Guttureddu River characterised by the absence or large degradation of the autochthonous vegetation due to intense erosion of the river margins.



3D View of the area investigated with overlapped the aerial photos by aerostatic balloon (Author: Enas)

3D Flood simulation (comeback time 5 years) and natural flood of the December 2004 comparison (Author: Enas)

Methodology

- Three sites were selected in the Guttureddu river: a stretch of the right bank with apparent erosion at the foot (site A); a part of the river bed and bank in a ford (Site B) on a tributary of the Guttureddu with visible signs of incision; the left bank of the river subjected to bank erosion with involvement of an unpaved road in the side of the river (Site C).
- Preliminary studies of the sites selected: hydrologic and hydraulic analysis, vegetation analysis, estimate of the functionality of the river, GIS and GPS characterisation of the riverbed and banks.
- Restoration actions: Site A: Protection of the base of the river bank with gabions and stone blocks, consolidation and protection of the river bank slope with metallic nets, jute lattices, wood and small channels to conduce water from rain, and use of seedlings and rooted cuttings from native plants to create an alive stratum over the abiotic stratum. Site B: Reshaping of the riverbed, protection of the river bank with local stones, and re-naturalisation with native species. Site C: Protection to the base of the river bank with gabions and stone blocks, remodelling of the riverbank, and plantation with seedlings and rooted cuttings.
- Several vegetation management practices were also conducted: (1) During the clean-up work, remodelling, and protection with geo-grid and bio-mat the banks of Sites A and C, grubbing of vegetation healthy and thick was avoided. The thickets of vegetation of oleander and willow and other species (such as carob, juniper) that were left intact have played an important role on the protection of the new plants planted from excessive exposure to sun and wind. (2) Plants were produced from germplasm collected and grown locally. (3) Plant species were planted on the slopes of the river banks attending to their eco-physiological characteristics and their capacity to protect the diverse environments (for example, the base of the river bank was planted with seedlings and rooted cuttings from plants that create a long root system to consolidate the soil but also support strong water events such as oleander); slopes of the river bank were planted with local herbaceous-shrub species in the form of rooted plants planted within the cells wood structure. (4) Arrangement of the seedlings on the riverbank slopes considering their water necessities (cells in the lower part were planted with hydrophilous species, cells in the higher part with plants that tolerate a drier environment).
- Monitoring of the individual plants reintroduced within 1 year, and monitoring of the overall system restored during 4 years.

Site A: plantation within the cells wood structure (Author: Enas)

Site C: plantation with seedlings and rooted cuttings (Author: Enas)

Results

- Positive effects of the intervention were observed after the flooding event on January 2006, which seriously affected several river basin within Sardinia: Site A: the upstream part of the site restored was benefited by the flood, which produced sedimentation of material (sand and gravel) between the foot and the protection blocks; the downstream was affected negatively by the impact of the stream with higher flow, which bypassed the security blocks, has eroded the base of the grate leaching of the soil covering and has taken away some of the young seedlings. The plants placed inside the timber grating were not affected by any effects of full and they are all in good health. In the days following the event of January 2006, some measures were implemented to strength Site A, mainly to fix and consolidate the protection boulders at the foot and replace some plants that had been carried away by the flood. Site B: the defence of blocks held up well, but has eroded the river bed immediately after the defence of blocks near the new riverbank. Site C: the tail end of the groyne created to protect the riverbank was remodelled by the current, but this has created a condition even more favourable, because the river deposited coarse material (blocks and large stones) behind the groyne itself, creating a natural condition which allows the river to preserve the existing natural pond. This natural re-deposition of sediment brought the river to occupy permanently the right hydraulic side, and do not invade, except in exceptional conditions of high flow, the left side. During the flood event, the channel exceeded the barrier of rocks and flooded the slope with an average height of 70 cm along 3.50 m from the first defence of blocks. In any case, the technical intervention of bioengineering held up well, expounding all of the expected features, since there was no damage or defence in blocks, or to plant species.
- After 4 years of monitoring: Site A was completely restored, vegetation covered the river bank and erosion was avoided. Site B had no vegetation and the physical restoration was not in very good shape. Site C was partially restored and erosion avoided, with part of the physical restoration in good shape and the vegetation was healthy and covering it.

Site A: state of the art in September 2005 (Author: Enas)

Lessons learnt

It was important to perform seeding in dry periods, rain use to wash the seeds that had been sown. It was important to calculate and keep a good proportion of seeds from the different species that need to be used; otherwise one species can dominate over the others. Irrigation is necessary (mandatory) during the first month after the plantation for a good success of the biotic restoration (root growth before the heavy rains), even if plants are from local germplasm and grown in local conditions. It is very important to plant in the optimal seasons, for example, in this work plantations were more successful when performed in October instead than June. For a successful plantation, plants used must be selected in function of the slope of the area to be vegetated, taking into account the structural characteristics of the root system.

Perspectives

The successful methodology used in this restoration has been successfully applied in other Mediterranean river system within Sardinia (e.g. *Flumendosa* river).

Strong/weak points

- Weak Points: Success of the restoration actions were not homogeneous between the sites, indicating that methodology did not work well for all sites selected. No new reinforcement actions have been planned to restore the sites where the methodology did not work.
- Strong points: In 2006, PROGECO was awarded as the top 'Best practices' project within all the Interreg projects conducted during 2004-2006.

The tree selected sites in the Guttureddu river (Author: Enas)

Model of restoration of dunes habitats in 'L'Albufera de Valencia' (Dunas Albufera)

Reference: LIFE00 NAT/E/007339

Habitat: Maritime dunar system, first dune fringe

Duration: 01/01/2001-30/06/2004

Area covered: 13.5 ha

Total Costs: 1,951,482 €

Promoter: City Council of Valencia (Devesa-Albufera Service) (Spain)

Type of organisation: Local authority

Partners: None

Case Study Location: Devesa de la Albufera-Valencia-Valencian Region (Spain)

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Project site previous restoration
(Author: Devesa-Albufera Service)

Project site in 2012
(Author: Devesa-Albufera Service)

Introduction

The 'Albufera de Valencia' Nature Park contains the last enclave in Valencia Region where there is still a good example of dune vegetation of great biological and scenic interest. Between L'Albufera Lake and the coastline is the 'Devesa del Saler', consisting mainly of chains of mobile and fixed dunes. Noteworthy flora and fauna can be found in the park, as prickle juniper (*Juniperus macrocarpa*), two endangered fish species, Iberian toothcarp (*Aphanius iberus*) and Valencia toothcarp (*Valencia hispanica*), and bird populations of *Ardeidae* and *Laridae* families.

Degradation

For decades, urban pressure has been the main threat to the site. Strong public opposition blocked an urban development project starting in the 1960s along the Devesa coastline. However, the construction of some infrastructures, such as a seafront promenade, parking and a road network, caused some of the dune formations of the site and their vegetation to be destroyed, as well as the silting up of some temporary pools typical of the area, which leads the populations of the two endangered fish species decreased.

Objectives

Goal: dunar habitats restoration and diffusion of the project to citizens and scientific community.

Specific objectives: geomorphologic dune reconstruction; restoration of plant cover; adaptation of restored area to visitors; sensibilisation campaigns; fauna recovery.

Methodology

- Dune reconstruction was carried out using heavy equipment for earthmoving, using ancient cartography and aerial photographs to recover the past geomorphological characteristics.

  The sand was obtained from the site but also from an area near the port of Valencia, where it accumulates in excess by the barrier effect. In the latter case, the sand has a grain size finer than that found in the area to be restored, so it was deposited inside of the dune and was coated with coarser-grained sand, thereby providing greater dune wind stability.

Demolition of past infrastructures
(Author: Devesa-Albufera Service)

Building palisade systems
(Author: Devesa-Albufera Service)

Having gained the proper morphology, a biodegradable palisade system was stablished, which retains the accumulated sand and captures new sand. Here, that one of *Arundo donax* and *Spartina versicolor* is used, with a wind permeability of 40-50%. Over time they are covered by sand (2nd-3rd year), rot (4th-5th year), and disappear after the 6-7th year. In the leeward, the palisades take longer to disappear.

- Plantations: 27 plant species (autochtonous psammophytes) were used (*Pancratium maritimum*, *Elymus farctus*, *Ammophila arenaria*, *Calystegia soldanella*, *Lotus creticus*, etc.). Seeds were collected in the field (seed orchards were deliberately avoided) from the very near populations and from the higher number of individuals possible. In the few cases where vegetative multiplication was needed, same considerations were addressed.

  Species were selected under the existing reference systems that are less degraded and taking into account the different sectors of the dune (windward, leeward, crest and embryonic dune). Plantation modules for each sector were performed (a combination of species and the number of individuals for each in 100 m^2), and implemented in a manual way: the conditions of terrain advise against other kinds of technique. Small machines with rubber tracks for the distribution of plants and tools inside the dune field are used.

- Adapting the restored area to visitors: The regenerated area was temporary closed by fencing of canes and stakes, and posters were further placed, warning on of a temporary ban on entering into repopulated area. The accesses from the parking to the beach were adjusted by creating wooden walkways that avoid transit through the restored area.

- Awareness campaigns: The information campaign was carried out with leaflets and posters explaining the purpose of the work performed.

- Fauna recovery: introduction of two fish threatened species through the creation of suitable habitat conditions in one of the lagoons restored, where a permanently flooded section was created.

Palisades permormed
(Author: Devesa-Albufera Service)

Works to restore one of the coastal lagoons
(Author: Devesa-Albufera Service)

Results

The project achieved all of its objectives. The conservation status of the site was improved soon afterwards. Some of the achievements during the project include:

- Demolition of past infrastructures (sea promenade, roads, etc.), and construction of new ones accordingly with the restoration purposes (trail for non-motorized vehicles, wooden walkways, etc.).
- Restoration of 2,100 m of the first dune ridge, where 2 million plants of 27 species were used. In addition, 52,618 examples of 7 species were saved from the intervened area before the work started.
- Regeneration of 15,600 m^2 (c.1.5 ha) of coastal lagoons ('malladas').
- Populations of two endangered fish species (*Valencia hispanica* and *Aphanius iberus*) importantly boosted
- Awareness raising campaign reaching a wide range of target public.

The monitoring conducted by the Devesa-Albufera Service after the project until now have confirmed that the restoration of the first dune fringe has largely erased the effects of past urban development in the Natura 2000 site: the restored system has recovered its natural look, with a plant cover virtually identical to adjacent systems that were used as reference. Most introduced plants survive and reproduce autonomously, and it has not been necessary additional measures to ensure the habitat conservation.

The work directly benefited the EU habitat types lost or altered after the destruction of the first dune fringe: 2210, 2220, 2230, 1410, 1420, 1430 and 2260.

Lessons learnt

When dunes reconstituted with sand come from temporary pools earth over artificially, a plant growth of a higher vigour than normal and an increased occurrence of unwanted nitrophilous plants was observed. It is suspected to be due to a wealth of nutrients higher than in usual substrate, because of the recharging in organic matter experienced by the sand during the time when, after being artificially covered the temporary pools, it was colonised by grassland. However, nutrients gradually disappeared, and after 2 or 3 years the dunes regained normal physiognomy and the presence of nitrophilous plants was drastically reduced.

For sand extraction for the reconstruction of the coastal lagoons, shovel excavators without teeth should be used; if not, there will be differential plant growth within and between the grooves (which remains long-term), leaving an artificial appearance.

Plants growing in the area, where remains of palisades can be seen
(Author: Devesa-Albufera Service)

Monitoring in one of the coastal lagoons restored
(Author: Devesa-Albufera Service)

Perspectives

The beneficiary was awarded LIFE 2004 co-funding for the restoration of priority habitat 2250 (Coastal dunes with *Juniper* spp.) along the second dune fringe, which improved the re-naturalisation of the site and the sustainable tourism objectives. However, today, holiday resorts remain an active threat in the area.

To continue with monitoring, awareness campaigns, and maintenance of the area (waste cleaning, removal of exotic plants in some cases, etc.)

Strong/weak points

- Strong points: Good compilation of study area background, which leads to a high justified action. The project constitutes a good example of the integral restoration process. High visibility of the action, during and after project. The project details meticulously the aspects related with the conservation of species' genetic diversity, and sufficiently justifies the actions that could be controversial (utilisation of vegetative multiplication only in few needed cases; utilisation of heavy machinery only for demolition of past infrastructures and for the dune reconstruction, so without impacts for flora and fauna). The project is built on the basis of previous ecosystem restoration actions, providing an unbeatable starting point.

Awareness campaigns: plantation activity
(Author: Devesa-Albufera Service).

Actions for the conservation of coastal dunes with *Juniperus* spp. in Crete and the South Aegean (JUNICOAST)

Reference: LIFE+ LIFE07 NAT/GR/000296

Habitat: EU Priority habitat type 2250* 'Coastal dunes with *Juniperus* spp.'

Duration: 01/01/2009-31/08/2013

Area covered: 239.31 ha

Total Costs: 1,501,210 €

Promoter: Mediterranean Agronomic Institute of Chania (MAICh) (Greece)

Type of organisation: Research institution

Partners:

1. National and Kapodistrian University of Athens, Faculty of Biology, Department of Botany
2. Decentralised Administration of Crete, Forest Directorate of Chania, Forest Directorate of Lasithi, Regional Development Fund of Crete

Case Study Location: Gavdos, Kedrodasos, Chrysi and Falasarna-Crete (Greece)

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The habitat in Gavdos (Author: MAICh©)

Introduction

Coastal dunes with *Juniperus* spp. are widespread along the sandy coasts of 8 countries of Southern and Western Europe, mainly on Mediterranean and Atlantic coastlines as well as in Denmark. In Greece, they are mainly found in 17 Natura 2000 sites in Western and Southern Greece, the Aegean islands and Crete. This rare and beautiful habitat has been classified as a 'priority habitat' (code 2250*) by the EU 92/43 Habitat Directive which means a type of habitat in danger of disappearance for which the Community has a particular responsibility for its conservation.

Degradation

Over the last decades, coastal dunes with *Juniperus* spp. have been subjected to severe anthropogenic and natural pressures and are mainly threatened by uncontrolled tourism growth (i.e. unsustainable recreational activities), lack of public awareness, forest fires, grazing and browsing, littering and the naturally restricted regeneration of the *Juniperus* species. Moreover, climate change is expected to affect all natural ecosystems including coastal dunes with *Juniperus* spp.

Objectives

Goal: The goal of the Junicoast project was to promote and enable the long term conservation of the coastal dunes with *Juniperus* spp. in Greece.

Specific objectives:

- to contribute to the consolidation and dissemination of a knowledge base for the protection, restoration, monitoring and evaluation of the habitat,
- to understand, quantify and minimise natural and anthropogenic threats contributing to the long-term degradation of the habitat,
- to design and implement actions for the protection and long-term restoration of the habitat, and
- to provide support for better environmental governance in Natura 2000 sites.

Juniperus macrocarpa
(Author: MAICh©)

Juniperus phoenicea
(Author: MAICh©)

Methodology

Scientific data on the abiotic and biotic factors that influence the habitat were collected and analysed in order to develop site-specific protection and restoration specifications for 4 Cretan sites (Gavdos, Kedrodasos, Chrysi and Falasarna). The specifications were developed according to the habitat attributes, identified problems and pressures at each site and were provided in a comprehensive form in order to be easily applicable, evaluated and amendable. Following these preparatory works and the mapping of all sites, concrete conservation and restoration actions were implemented at the 4 sites targeting in each case the main natural and anthropogenic threats identified:

- Seeds/plant material of *Juniperus macrocarpa*, *Juniperus phoenicea* and 30 keystone species were collected from all sites and stored for future restoration use in the seed bank of MAICh.
- Protocols for seed collection, handling and storage, and seed germination of the collected species were developed.
- Seeds/plant material of *Juniperus macrocarpa* and major keystone species from all Cretan sites were propagated to be used for the enhancement of *Juniperus* regeneration and the restoration of the floristic composition of habitat 2250*.
- Naturally established and planted juvenile *Juniperus* individuals were fenced.
- The floristic composition was restored by planting/fencing several individuals of keystone species (*Pancratium maritimum* and *Centaurea pumilio*), by planting female individuals of *Juniperus macrocarpa* to balance the female/male ratio among the *Juniperus macrocarpa* subpopulations, and by manually eradicating invasive species.
- Foredune restoration was conducted by erecting sand trapping cane fences perpendicular to the prevailing wind, in order to reduce wind erosion, inhibit sand removal and support the formation of embryonic dunes.
- Long-term monitoring protocols for the habitat were established. The indicators included a number of *Juniperus* spp. broken branches and seedlings, percentage of ground cover and exposure of *Juniperus* spp. roots, total number of plant species, and presence of invasive species.

Sand trapping fences for the creation of embryonic dunes in Chrysi
(Author: MAICh©)

Small fence for regeneration enhancement
(Author: MAICh©)

- Habitat demarcation, information signage, wooden boardwalks, path delineation, benches, tables and waste bins were put in place to reduce visitors' negative impacts.
- Governance structure and legal status of the protected habitat were investigated.
- Dissemination actions such as information and training workshops, public awareness and environmental education campaigns targeted visitors and local communities.

Results

- Increased knowledge about the geomorphology and the ecology of the habitat, and about the *Juniperus* species and the remaining flora of the habitat,
- Increased public awareness on coastal dunes with *Juniperus* spp.,
- Elaboration of site-specific protection and restoration specifications, habitat protection and restoration guidelines and habitat long-term monitoring protocols (Junicoast deliverables D-A.8, D-D.5, and D-A.7; www.junicoast.gr/en/publications/deliverables/),
- Improved conservation status of habitat 2250* and minimisation of the threats and negative impacts on all 4Cretan sites.

More specifically:

- Regeneration of the *Juniperus* species has been enhanced in all 4 Cretan sites.Naturally established and planted juvenile *Juniperus* individuals have been fenced in all 4 Cretan sites.
- Floristic composition (in Gavdos, Kedrodasos and Chrysi) has been restored, female individuals of *Juniperus macrocarpa* were planted and fenced (in Chrysi), keystone species were planted and fenced within the habitat boundaries (in Kedrodasos), invasive species, seedlings of *Pinus brutia* and *Carpobrotus edulis*, were eradicated from within the habitat boundaries (in Chrysi and Gavdos).
- Embryonic dune zone of the habitat has been restored (in Chrysi); 14 units of sand trapping fences (200m long in total) were erected.
- Threats and visitors' negative impacts on all 4 Cretan sites have been minimised.

Boardwalk in Chrysi
(Author: MAICh©)

Information sign and boardwalk in Gavdos
(Author: MAICh©)

Lessons learnt

- Adverse physical impacts may be reduced if the relationship between nature-based tourism and conservation is symbiotic. There is a need for further visitor education and raising public awareness about the potential impacts associated with recreational activities in natural settings.
- The existing National and European legislation is not considered to be a problem, but the lack of its enforcement is.

Perspectives

Continuous efforts and involvement of all stakeholders are needed to enable the long-term conservation of the habitat. After-LIFE plans were developed for regular monitoring, communication and conservation activities and an adaptive management approach.

Strong/weak points

- Strong points:
  - The project results and especially the 'habitat protection and restoration guidelines' provide best practices techniques that can be used as reference studies and techniques for other sites in the Mediterranean region.
  - The whole concept of the project had a strong innovative character since it tackled for the first time a long lasting conflict between nature conservation and campers.
  - High visibility of the actions during and after project.

The habitat in Kedrodasos
(Author: MAICh©)

Conservation and recovery of dune habitats in sites of the Provinces of Cagliari, Matera and Caserta (PROVIDUNE)

Reference: LIFE07NAT/IT/000519

Habitat: EU Priority habitat type 2250* 'Coastal dunes with *Juniperus* spp.'

Duration: 01/01/2009-31/12/2014

Area covered: 1000 ha

Total Costs: 3,352,392 €

Promoter: Province of Cagliari (coordinator)

Type of organisation: Three provinces of Italy (public administration), a public University and an association of local authorities

Partners:

1. Province of Caserta
2. Province of Matera
3. Tecla Association
4. University of Cagliari: Centre for the Conservation of Biodiversity (CCB)
5. Coastal and Marine Environment Monitoring Centre (OCEANS, from Osservatorio Coste e Ambiente Naturale Sottomarino in Italian)

Case Study Location: SCI 'Porto Campana', SCI 'Stagno di Piscinnì', SCI 'Isola dei Cavoli Serpentara e Punta Molentis'-Province of Cagliari (Italy). SCI 'Pineta della Foce del Garigliano'-Province of Caserta (Italy). SCI 'Bosco Pantano di Policoro e Costa Ionica Foce Sinni'-Province of Matera (Italy)

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Sand containment structures and dune vegetation: *Elymus farctus*
(Author: Martino Orrù)

Introduction

The EU priority habitat 2250* (Coastal *Juniper* dunes) of Council Directive 92/43/EEC, and other habitats characterising Mediterranean sandy coasts (2270*; 2230; 2240; 2120; 2210), are distinguished by high cenotic biodiversity and elevated number of endemic entities. These habitats are among all the most threatened due to the high anthropic impact, in particular tourist pressure.

Degradation

The major causes for habitat degradation in the area of this restoration project were:

- Uncontrolled access of vehicles to the dunes.
- Uncontrolled access of pedestrians causing creation of paths and trampling effects on the dunes.
- Coastal erosion and insufficient knowledge of the effects on the sedimentology of the sites and on the substrate of habitats.
- Presence and spread of non-native plant species, such as *Pinus pinaster*, *Eucaliptus* spp., *Acacia* spp., *Agave* spp., *Carpobrotus* spp..
- Lack of knowledge among the users of the value and importance of dune habitats.

Objectives

Goal: Apply best practice and demonstration actions to protect and restore one of the more threatened habitat of the EU (Coastal *Juniper* dunes 2250*) and the related habitats within 5 Natura 2000 sites.

Specific objectives:

- Establish a common approach for the long-term protection of these habitats based on the monitoring of biotic and abiotic characteristics.
- Decrease/eliminate the threats affecting the habitats in the sites identified
- Physical and biological restoration of the dunes where they have disappeared to allow its own regeneration.
- Increase the level of awareness of local population (students, local inhabitants and tourists) and stakeholders on the importance of these habitats not only for their landscape value but also as a mean to face climate change effects (e.g. increase sea level).

Juniperus macrocarpa, one of the species used
(Author: Gianluigi Bacchetta)

Reintroducing Pancratium maritimum
(Author: Martino Orrù)

Methodology

- Preparatory actions, including geobotanical and sedimentary studies for the creation of a database, mapping of the habitats, implementation and monitoring of a tele-control system of the extreme events and their impact, and the design of future conservation actions.
- Elaboration of management plans for the diverse sites.
- Concrete conservation and restoration actions, including:

  (1) *Ex situ* conservation of seeds of dune plant species.

  (2) Manual seeding with 3 structural species: *Pancratium maritimum* (inside 40 sand fences of embryonic dunes), and *Juniperus macrocarpa* and *Pistacia lentiscus* (below 12 biodegradable protection systems of the fixed dunes).

  (3) Manual eradication of invasive plants.

  (4) Bio-engineering schemes to protect the habitat, promoting the use of bio-materials (such as certified wood, coconut fibre nets, hemp ropes and bars) in non-permanent structures with low visual impact.

  (5) Creation of pedestrian walkways and vehicle parking areas to regulate access.
- Public awareness and dissemination of results, including education and information to tourists, schools and all stakeholders.
- Long-term monitoring of the actions executed.

Results:

- Seeds from 139 accessions (52 species) collected and stored *ex situ* in BG-SAR seed bank.
- 6400 m^2 of dune systems were manually sowed with 3 structural species.
- Installation of 39,060 m^2 of sand retention systems (several models of fences) in embryonic or transition dunes.
- Installation of 45,100 m^2 of biodegradable protection systems for fixed dunes.

Sand containment structures
(Author: Martino Orrù)

Monitoring of reintroducion of *Pancratium maritimum*
(Author: Martino Orrù)

- Eradication of alien species favouring the regeneration of 65 ha of dunes.
- Construction of 976 m of wooden walkways to connect beaches and parking areas, and delimitation of 7148 m of dunes, to avoid access and trampling of the dunes.
- Installation of public restrooms and a parking for bikes.
- Installation of 41 information panels and sensitization campaigns reaching more than 40,000 people.
- Development of management plans for two SICs.
- Monitoring plan for five years after the end of the project.

The restoration actions applied have shown a noticeable result in a short period of time (<5 years), the dunes present a better ecological health, new dunes are being formed, growing and colonised by native plants.

Lessons learnt

Working with several public administrations leaded to large delays in the execution of the project, in fact one of the initial partners abandoned due to the impossibility to reach the objectives. One of the causes was the repeated change of public managers.

During the project, and after the project, it is important to take care of, and replace if needed, the installations made (e.g. walkways, informative boards, etc.). It has been learnt that in areas where the public found old or damaged installations, they were not respected, and thus their main objective was not fully achieved.

From pilot studies, researchers demonstrated to the public managers that the use of plants for plantation programs are not suitable if they are not acclimated in the local conditions and obtained from local germplasm.

Environmental conservation at work: coir mesh (Author: Martino Orrù)

Perspectives

Attending to the lessons learned, at least another LIFE project (RES-MARIS, LIFE13 NAT/IT/000433) has been approved in order to complete the work developed by PROVIDUNE in one of the SICs. The main upgrades are:

(1) Increase of the area of action (from 3427 ha to 9281 ha) and the priority habitats (1120*, 2250*, 2270*), leading to the integral management of the submerged and the emerged beach. These changes will imply the management of new native (e.g. *Posidonia oceanica*) and invasive (e.g. *Caulerpa racemosa*) plant species.

(2) Development of germination protocols for the structural species in the priority habitats managed, and use of plantations to support the plant restoration of the dunes.

Strong/weak points

- Weak points: Only manual seeding with structural species was performed, and no plantations were designed, thus no comparative results exist to demonstrate which method is optimal.
- Strong points: With the preliminary actions designed in the project, the sites were fully characterised. The conservation and restoration actions implemented have shown a result already visible since the dunes present a better ecological health. There has been a strong public awareness, showing a good understanding the importance of the habitat and denounce incorrect practices if observed. The collaboration among partners has leaded to good relationships previously inexistent that have promoted the design and preparation of new restoration projects. The development of a monitoring plan after the finalisation of the project assures the correct long-term implementation of the project.

Environmental conservation at work: sand containment structures and coir mesh
(Author: Martino Orrù)

Demonstration Project to Combat Desertification: Regeneration and Management Plan of degraded semi-arid areas in Albatera

Reference: Effects of landscape spatial heterogeneity on dryland restoration success. The combined role of site conditions and reforestation techniques in southeastern Spain (H. Kribeche *et al*., 2012).

Habitat: Semiarid thermo-mediterranean shrubland (*Querco-lentiscetum*; *Rhamno cocciferetum*)

Duration: 2003-2004

Area covered: 24.5 ha

Total Costs: 180,000 €

Promoter: General Directorate for Nature Conservation (Ministry of Environment, Spain) and Valencia Regional Government (Alicante Forest Services)

Type of organisation: Public Organisations

Partners:

1. Ecology Department of Alicante University
2. Mediterranean Centre for Environmental Studies (CEAM)
3. Desertification Research Centre (CIDE)

Case Study Location: Albatera-Alicante (Spain)

Contact:

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Albatera project site in 2014 (South Unit) (Author: Alberto Vilagrosa)

Introduction

The Albatera pilot area is a 25 ha catchment located in the Alicante province, in Southeast Spain, one of the areas that is most affected by desertification in Europe. According to the Land Action Plan to Prevent Flooding in the Valencia Region, the Albatera-Crevillente range, which includes the pilot area, is one of the hot spots for flooding risk in the province of Alicante. In this area, previous reforestation programs through *Pinus halepensis* plantations obtained poor results, and in some cases even aggravated the situation of the zone with regard to the initial condition.

Degradation

Local land degradation has been driven by the synergistic effect of past exploitation and management grazing, marginal agriculture, wood gathering and harsh environmental conditions such as scarce (around 280 mm year) highly variable rainfall, and soils prone to erosion. Further anthropogenic disturbances, such as terracing and further abandonment, roads, and water channelling for irrigation have deeply altered soils and landscape. Three main problems appear in the area: loss of plant species, soil erosion, and damage due to flooding.

Objectives

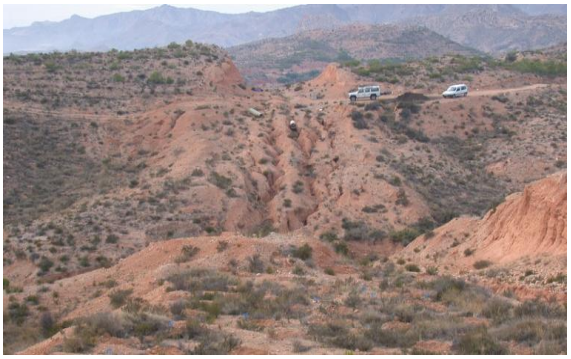
Goal: Repair ecosystem functioning using best available techniques and strategies, and to serve as a demonstration project that validated them at management scale and to increase their visibility.

Specific objectives: (1)To contribute to regulate the processes of capturing water, materials and nutrients, and to enhance the general productivity of the territory; (2)To increase ecosystem diversity, stability, and resilience; and (3)To prevent further ecosystem and landscape degradation, soil erosion, and torrential floods.

Methodology

To achieve these goals, themethodology used considered many aspects:

- Site-specific restoration strategies were designed through addressing within-site heterogeneity and designing specific actions for each unit.



High degraded area affected by a pipe installed in the past
(Author: Alberto Vilagrosa)

Terrace Unit: furrows made at the foot of the slope to favor the arrival of runoff water, and then planted
(Author: Alberto Vilagrosa)

Different functional units were designed, based on type of existing vegetation, previous reforestation works, degradation degree and soil typology: River Bed, Water Channel, Head Basin, Pine, South, North, and Terrace units

- The introduction of vegetation was carried out according to small scale heterogeneity, natural spatial patterns, the potential vegetation in the area, and the functional value of the species: native evergreen trees and shrubs with high potential cover, high capacity to develop a dense canopy and accumulate litter in patches -favouring the formation of 'resources islands'-, and fast recovery from disturbance were selected, to confer increased resilience to the whole ecosystem. A relatively large number of species were planted in the various habitats identified in the site: *Olea europaea* var. *sylvestris*, *Pistacia lentiscus*, *Quercus coccifera*, *Juniperus oxycedrus*, *Nerium oleander*, *Pinus halepensis*, *Ceratonia siliqua*, *Rhamnus lycioides*, *Tetraclinis articulata*, *Retama sphaerocarpa*, *Ephedra fragilis*, *Chamaerops humilis*, *Tamarix africana*, *Salsola genistoides* and *Stipa tenacissima* for the most degraded soils. The seedlings proceed from certified materials, ensuring the seeds used are of local provenance, enough diversity, germinative capacity proved.
- Avoidance of clearance of existing vegetation; to foster spontaneous plant growth by applying soil organic amendments.
- Different methods of site preparation were used to enhance the restoration action: small catchment areas to collect runoff, and addition of pruning forest remnants mulch to the planting site.
- Use of two types of plant protectors, depending on the needs: plant netting shelter to avoid predation, or opaque tree shelters to avoid predation and reduce stress due to sun exposition
- Stone walls (different from classic reforestation terraces) were built as measures for erosion control, in a small eroded area as a result of a pipe installed in the past.

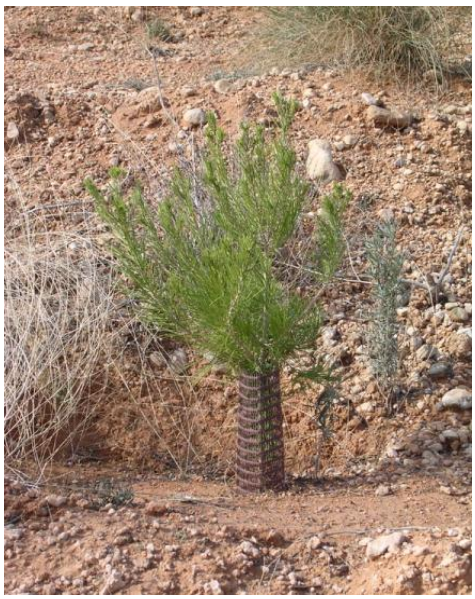
First steps in the restoration of the area affected by the pipe: adjusted slopes with little stone walls (Author: Alberto Vilagrosa)

Planted species in alternating rows, breaking water flows to avoid gullies formation (Author: Alberto Vilagrosa)

Results

Results were controlled through a monitoring plan carried through 2003-2007 by CEAM, where growth (height and basal diameter) and survival of introduced plants; vegetation cover; and surface soil properties, were measured in sampling plots.

- After 4½ years, it is remarkable the height and diameter reached by some species, and the median overall survival is 54%. Although, it is not a high value it can be considered a good result, considering that previous reforestation actions carried out in the same area reached very unfavourable results, with mortalities close to 100% in some cases. In addition, the annual rainfall regime for the years after planting can be considered poor, as it was 20-30% lower than the historical average for that area.
- Technological improvements implemented have enhanced abiotic conditions for the seedlings. Better results than in previous experiences have been obtained and even high survival and growth was observed in sunny areas where greater investment in technology was applied, than in north-face areas and terraced slopes (which, *a priori*, are areas with less environmental stress).
- The survival and growth among the various species was very variable. Those which showed the best survival were generally the ones with higher growth. On the other hand, very common species such as *Q. coccifera* continue to have low survival rates, reflecting unresolved problems. Some species flowered and fructified during the monitoring phase, which should contribute significantly to the recovery of the area.
- The realisation of micro-catchments in sunny areas improved the response of the introduced plants and facilitated the development of other species; this can be detrimental for the seedling development in some cases, but in terms of vegetation cover and stability of the area it is an advantage.
- The opaque tree shelter (75% suppression) and the netting tree shelter have prevented damage by rabbits very efficiently.



Pinus halepensis with netting tree shelter
(Author: Alberto Vilagrosa)

Olea europaea var. sylvestris on individual terrace with small catchment, and jute-netting to protect from erosion
(Author: Alberto Vilagrosa)

Lessons learnt

- In carrying out micro-catchments certain precautions must be taken: a side exit should be performed to avoid large accumulations of water in the holes during heavy rain; and secondly, in steep areas with little vegetation and bare soil it involves many risks due to the low stability of these slopes.
- All of the treatments applied (watersheds, tree shelters, adding amendments) have played an important role in the restoration, but the mulch has been the one that submitted less lasting effects due to sediment dragging.
- The opaque tree shelters stimulate the growth of the species, which often stand above, although the best time to move them away is not already determined as visual observations have shown that some seedlings suffer high levels of stress after removing them.

Perspectives

After 2007, an assessment of the impact of the restoration on the functionality and diversity of the ecosystem, compared with other non-reforested semi-arid areas, was performed

Strong/weak points

- Strong points: The monitoring tasks carried out in the project detected a successful establishment of introduced plants and the reduction of soil erosion. Both achievements are considered positive signs of the restoration action effectiveness, especially in degraded areas of the Mediterranean basin. Some pitfalls were also detected.
- Weak points: In some places, plants were buried (and dead) due to improper calibration of the impact of the rains in highly degraded sites with some erodible types of soil.

Area with gullies in Albatera. This kind of areas are difficult to recover due to active erosive processes (Author: José Antonio Alloza)

Mediterranean Quarry Rehabilitation Manual: Learn the Holcim Experience

Reference: CNRS-L/AFDC/IUCN/Holcim. 2014. Mediterranean quarry rehabilitation manual: learn the Holcim experience. 71pp.

Habitat: Mediterranean scrubland

Duration: 01/01/2012-01/04/2014

Area covered: 4.62 ha

Total Costs: 255,000 US$ (United States dollars)

Promoter: Holcim Lebanon and IUCN's regional office for west Asia (ROWA)

Type of organisation: Private organisation

Partners:

1. National Council for Scientific Research (CNRS-L) Lebanon
2. Association for Forest Development and Conservation (AFDC) Lebanon
3. Abou-Chacra and Frangieh Contracting (AFC) Lebanon
4. Eco-Med France

Case Study Location: Holcim quarry-Kfarhazir-Batroun (Lebanon)

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General view of the quarry from the low land section
(Author: Christine Maksoud - CNRS-L)

Introduction

Due to the ecological restoration importance of degraded sites, Holcim Lebanon chose a quarry located in the village of Kfarhazir, on the edge of the coastal plain of El Heri in the centre of Chekka Bay, North of Lebanon for this purpose. The quarry site lies at the northern foothills of Chekka Mountain and is surrounded by typical Mediterranean scrubland areas.

Degradation

The excavation activities in 2006, the un-controlled grazing and the arid environment made the site a degraded one. Besides, these factors led to the failure of a tentative rehabilitation using Pine trees (*Pinus pinea*) in 2009.

Objectives

Goal: the restoration of Holcim quarry site (HQS) in Chekka and the usage of the project achievements for other restoration tentative.

Specific objectives: 1- Limit the soil erosion and the water runoff while reducing water speed by improving water harvesting and increasing rainwater infiltration. 2- Improve the biodiversity and promote landscape integration within the surrounding zone through the restoration of the natural floristic composition of the area and the use of native flora species. 3- Serve for educational and research purposes. 4- Develop management guidelines and ensure annual monitoring.

Methodology

- Preparatory work was performed such as: reviewing existing reports on HQS (assessments on the biodiversity, the geology and hydrology of the site), field visits, drafts of two preliminary restoration scenarios, topographic survey, water flow model, evaluation of cost for implementation, developing technical drawings and descriptions.

Seedlings in the highland section (Author: Alexi Feghaleh)

- The structure design of the restoration project was set and several aspects were taken into consideration, such as the season of intervention, the ecological functionalities of the site, the integrated energy design, the landscape context, the site features, the water availability on site, the choice of plants, the available substrates, the natural dynamic zones, the technical tools to be used, the budget, the project timeline, and the expected technical outputs.
- The restoration design was defined as: 'A Hidden Loop across Dryland' and is based on dividing the site into 5 subunits: High-land, Cliff-land, Core-land, Low-land and Rest-land. In the High-land, 2 sections were created: planted gabions with native-shrub-species and unplanted gabions. In the Cliff-land, the area was covered with an irregular layer of topsoil and planted with native species and shrubs. The lower parts of the natural landform were used as an 'impluvium' (catchment basin) to retain soil and gravels. Moreover, gabion structures were installed as a second defence line. The Core-land represents the 'water web' of the site; 3 ponds were created and merlon-like-substrates units (referred as 'S structures') (rocks, gravels and topsoil mixed with organic compost) were planted and seeded with native species. At the left side of the second pond, the area was treated similarly to the cliff-land by adding topsoil and planting, respecting the edge of the path that goes up to the cliff-land. In the Low-land, stone wall of 100 cm was built to retain soil and stabilise the structure and gravels were added on the top of the clinker to improve water drainage. In addition, a topsoil layer was added and planted with native species. Finally, in the Rest-land, the existing housing was rehabilitated and equipped with toilets, benches and garbage baskets. Hedge-like structure around the housing was created and planted with adapted tolerant species.
- Once the land is prepared, seeds of native species (*Calicotome villosa*, *Salvia triloba*, *Oreganum syriacum*, *Thymbra spicata*) were sown in the site and 1533 seedlings that belong to 9 native species (*Quercus calliprinos*, *Olea europaea*, *Ceratonia siliqua*, *Pinus brutia*, *Ficus carica*, *Pistacia palaestina*, *Pistacia lentiscus*, *Spartium junceum*, *Thymbra spicata*) were planted in different proportions in the Lands.
- Finally, a monitoring plan was prepared taking into consideration different indicators (fauna, flora and hydrology indicators).

Plantation process in the lowland terraces (Author: Christine Maksoud- CNRS-L)

Results

- Water availability was improved by creating wet areas in the site which enhance the site ecological functionalities.
- A productive structured land was constructed by adding stone walls, merlon S structure, gabions and new top soil mixed with organic matter and fertilisers.
- The merlon structure added in the site was immediately vegetated
- For species germination tests, the germination percentage were: 60% for *Quercus calliprinos*, 45% for *Ceratonia siliqua*, 75% for *Pinus brutia*, 65% for *Pistacia palaestina*, 90% for *Spartium junceum*, 80% for *Salvia triloba*, 50% for *Oreganum syriacum* and 50% for *Thymbra spicata*. However, the germination test for *Rhus cariaria* and *Tamarix* sp. was not successful; thus, those species were not planted in the site.
- Seeding and plantation of native species were implemented by creating vegetated and non-vegetated patches.

Lessons learnt

- Seeds should be sown after the trees and shrubs are planted to avoid burying the seeds deep under the soil.
- Mosaics consisting on vegetated and non-vegetated patches are important to create in order to enhance habitat variety, leading to a future rich biodiversity.
- For the natural aspect of the site, irregular topsoil layers and structures must be performed.
- In the case of potential flooding on the site caused by the nearby area, structures for water management must be created even if they are not inside the restored site.
- Flexibility in implementation is key to success: being flexible and creative helps to better adapt to constraints.
- It is important to keep an emergency budget in the planning in order to be able to adapt to sudden difficulties.
- Setting clear and concise objectives and goals from the beginning of the project, respecting the project timeline and in case of complications, adapting to reality while always considering time priorities are basic elements to achieve a successful implementation.

Post restoration vegetation dynamics in the lowland (Author: Alexi Feghaleh)

Perspectives

To use a restoration program designed in this project as an example to other sites in Lebanon and throughout the Mediterranean basin.

Long-term annual monitoring of the site, based on a rapid assessment of key species (fauna and flora indicators) and on the assessment of hydrology indicators.

Strong/weak points

- Strong points: Good compilation of study area background, which leads to a high justified action. The mosaic patches created enhanced habitat variety and enriched biodiversity. The long-term monitoring of the site involves choosing various indicators.
- Weak point: The high visibility of the project actions was not highly respected (website, media news, workshops).

Spontaneous vegetation dynamics on the highland within the gabion section
(Author: Alexi Feghaleh)

Safeguard Thero-Brachypodietea habitat in SCI 'Area delle Gravine' (GRAVINE)

Reference: LIFE03 NAT/IT/000134

Habitat: Drylands (grasslands, steppes, screes). EU habitats: mainly 6220* 'Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*', but also 9250 '*Quercus trojana* woods', 9340 '*Quercus ilex* and *Quercus rotundifolia* forests', 9540 'Mediterranean pine forests with endemic Mesogean pines', 5320 'Low formations of *Euphorbia* close to cliffs', and 8310 'Caves not open to the public'.

Duration: 01/10/2003-01/12/2006

Area covered: 200 ha

Total Costs: 505,360 €

Promoter: Comune di Palagianello (Province of Taranto, Italy)

Type of organisation: Local authority

Partners:

1. Comunità Montana Murgia Tarantina
2. Bari University-Botanical Garden Museum
3. University of Urbino-Faculty of Sciences
4. Ecoazioni snc
5. Terre del Mediterraneo

Case Study Location: SCI 'Area delle Gravine'-Comune di Palagianello (Italy)

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Cliffs of the ravine

Introduction

The Jonic arc ravine system constitutes an interesting and complex environmental system. The tight and lengthened shape of the ravines generates, on the edge of ravine, the presence of numerous ecotonal habitats, in the greater part of the cases characterised by the presence of *Thero-Brachypodietea* habitat, which is considered as priority natural habitat by EU. The particular shape of this system also provides an enormous value, as it generates ecological corridors in a territory strongly threatened by anthropic activities. 'GRAVINE-The Safeguard *Thero-brachypodietea* habitat in 'Area delle Gravine' pSCI' is a Life Natura project, which saw its start in 2002 from the Palagianello municipality. Previously, municipal conservation guidelines for the 'Area delle Gravine' were produced as part of a previous LIFE-Nature project, 'NATURA 2000 network in Italy: management models' (LIFE99 NAT/IT/006279).

Degradation

An aggressive and widespread anthropic influence has impoverished the biodiversity of eco-mosaic typical of the ravines, reducing priority habitat to little substantial pieces separated among them. The lack of knowledge about the importance of biodiversity conservation between the landowners and local inhabitants leads us to consider the priority habitats as lands of possible cultivation for the formers and of uselessness for the latter. A large number of farmers and other rural residents live in the project area, which has experienced habitat losses of up 20,000 hectares in the last twenty years, mainly attributed to over-grazing and limestone quarrying. More recently, the growth of tourism and its infrastructure has also increased pressure on the high value environment.

Objectives

Goal: The primary objective of this LIFE project was the conservation and restoration of the *Thero-Brachypodietea* grasslands, over an area of 200 hectares owned by the Municipality, which was further enhanced by restoration of natural habitats at three disused limestone quarries.

Specific objectives: Implement a program of cutting, mowing and indigenous species planting. Purchase an adjoining 25 hectares of the same habitat in order to guarantee habitat continuity. Increase knowledge on the topics of the biodiversity within the local community

Stipa austroitalica, one of the main species planted in the intervention area

Priority habitat pseudo-steppes with *Thero-Brachypodietea* grasses and annuals

Trail to be restored in the Gravine Area SCI

Methodology

- Census of local flora and development of a complete management plan of the SIC.
- Establishment of a seed bank for local species: Seed collection, cleaning and selection of seeds, dehydration and seed conservation at -20°C.
- Restoration of the *Thero-Brachypodietea* habitat by:

  (1) Seed collection *in situ*, cleaning and selection of seeds, pre- sowing treatments, germination tests.

  (2) Preparation of mixtures of seeds from 15 different species for the constitution of small groups of garriga or Mediterranean bush. The garriga species selected were: *Calicotome villosa*, *Cistus incanus*, *C. monspeliensis*, *C. salvifolius*, *Coronilla emerus*, *Daphne gnidium*, *Helichrysum italicum* subsp. *italicum*, *Phyllirea latifolia*, *Phlomis fruticosa*, *Pistacia lentiscus*, *Rhamnus alaternus*, *R. saxatilis* subsp. *infectorius*, *Rosa sempervirens*, *Teucrium polium* and *Thymus capitatum*.

  (3) Ground treatment.

  (4) Introduction of herbaceous, shrubby and arboreal species with a carefully controlled seeding regime (direct sowing) over sub-divided intervention areas. A management strategy was prepared for each of the species planted in the intervention areas, which included local ecotypes of *Stipa austroitalica* subsp. *austroitalica* (main grass for the grasslands), mixtures of seeds as indicated above, and some arboreal element such as *Quercus ilex*.

  (5) Monitoring.

  (6) Maintenance.
- Conservation agreement, including a sustainable grazing plan, with a private landowner.
- Restoration of three abandoned stone quarries, using natural engineering techniques (as the implementation of biomats in the slopes of the quarry) and planting shrubs typical of the Mediterranean maquis.
- Construction of a didactic nursery in a small section of the quarry to be restored in order to produce plants for the restoration works.
- Clean and close illegal dumping sites around the Gravine SCI.
- Manage access to sensitive areas by closing public roads, strengthening walls and installing fencing.
- Open a nature trail network in the area, including interpretation panel on the priority habitat features and LIFE project actions.
- An awareness raising campaign was also proposed for local people and administrators, together with educational activities for the area's school children.

Logo of the GRAVINE project

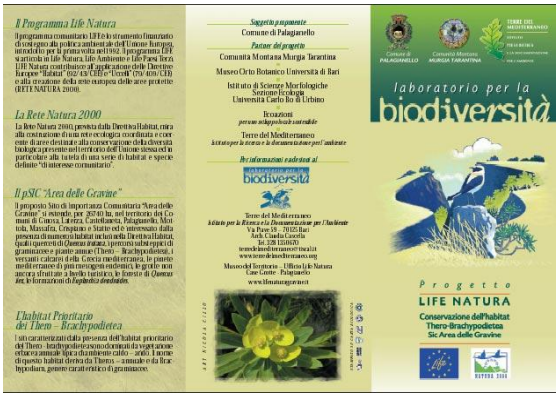
Awareness campaign

Educational activities

Results

The project has achieved almost all of its intended objectives and has made important contributions to the restoration of the priority habitat pseudo-steppes with *Thero-Brachypodietea* grasses and annuals. Positive conservation results have been attained in the Gravine's fragile environment, which can be summarised as:

- Census of local flora and a complete management plan of the SIC.
- Direct sowing or transplantation of indigenous species over an area of ca. 100 ha.
- Signature of a conservation agreement, including a sustainable grazing plan, with a private landowner, covering an area of ca. 30 ha.
- Establishment of a seed bank that contains over 100 local species.
- Creation of a didactic nursery, covering 3,000 square metres within the Gravine, where local species are reproduced for education.
- Restoration of three abandoned stone quarries (2 ha): the works secured the slopes formed by loose material that delimit the different areas of the quarry, through the remodelling of the slopes and their stabilisation using bioengineering techniques.
- Illegal dumping in the Gravine controlled.
- Opening 12 km nature trail network in the area, including interpretation panels on the priority habitat features and LIFE project actions; creation of the Laboratory for Biodiversity; 20 meetings with the local community; 63 educational workshops with schools; 42 educational excursions; educational competition with 9 schools; and 3 public meetings to present the project.
- Management of access to sensitive areas by closing 1.5 km of public road, strengthening walls and installing fencing.
- 3 years monitoring plan designed to control the success of the restoration actions performed.



Flyer of the Laboratory for Biodiversity

Management of access to sensitive areas (fencing)

Lessons learnt

Community participation has played an important role in securing the desired results and efforts to involve local schools are expected to generate long-term benefits through the Biodiversity Laboratory that was established during the project. The main challenge experienced by project involved establishing a cooperation network with other institutions managing similar habitats.

Perspectives

Sustainability of the project results will also be assisted by the project area's inclusion in the Regional Reserve 'Terra delle Gravine', which should further guarantee the success and continuation of the conservation and restoration actions carried out by the beneficiary.

Strong/weak points

- Weak points: Only direct seeding was made for the grass, shrub and tree species introduced in the *Thero-Brachypodietea* habitat, and no plantations for these species were designed, thus no comparative results exist to demonstrate which method is optimal.
- Strong points: The development of a monitoring plan after the finalisation of the project assures the correct long-term implementation of the project.

Panoramic view of Gravine Park - Source: www.bridgepugliausa.it

6

RESTORATION EXAMPLES FROM ECOPLANTMED PROJECT

Under ECOPLANTMED project, two restoration actions are implemented in two Mediterranean countries, Lebanon and Tunisia. The main objective of those trials is to restore the pilot sites areas while optimising economically and technically restoration methodologies in order to scale them up to the Mediterranean level.

6.1 ECOPLANTMED pilot site of Lebanon

The pilot site of Lebanon is located in Kfardebian on the western slopes of Mount-Lebanon, Northeast of Beirut (34°1'4.26'N - 35°53'3.77'E). It is a public land owned by the Municipality of Kfardebian (Figure 1). The climate in the study area is Mediterranean sub-humid with cold very humid winter and temperate dry summer. Clay loam is the soil type of the area.

The restoration actions under the ECOPLANTMED project started in September 2014, and several activities were carried out:

(1) Fencing: Installation of a fence by the local NGO, Jouzour Loubnan, to protect the site from grazing;

(2) Site preparation: Installation of an irrigation system to provide water during the plantation experiments;

(3) Planting: Design and implementation of two plantation experiments (one with seedlings and another with seeds).

The experiment with seedlings, in order to be statistically legible, was carried out into 6 plots of 1 ha each, selected randomly along the pilot site (Figure 2). Plots were separated from each other by 200 metres at elevation ranging from 1994 m to 2036 m. Three of them were exposed to the East and three to the West.

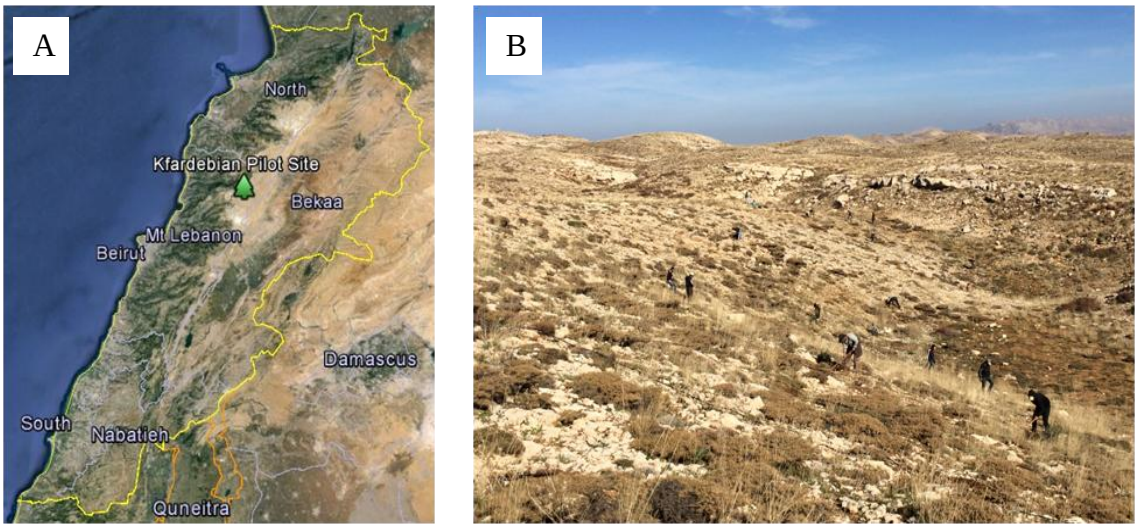


Figure 1: (A) Satellite image showing the Pilot site location on the Lebanese map, (B) Plot of the pilot site in Kfardebian

Figure 2: Seedlings and seeds plots distribution map

Cedrus libani (1200 seedlings) and *Juniperus excelsa* (1200 seedlings) were planted following an experimental design to study three different ecological parameters: exposition, irrigation and the effect of planting under plants spontaneously established in the plot (nurses). The species used as nurses were *Astragalus echinus* and *Astragalus cruentiflorus*. As illustrated in Figure 3, in each plot, 400 seedlings were planted (200 cedars seedlings and 200 junipers seedlings), and 4 different treatments where applied: 50 irrigated seedlings planted in open space, 50 non irrigated seedlings planted in open space, 50 irrigated seedlings planted under nurses, 50 non irrigated seedlings planted under nurses.

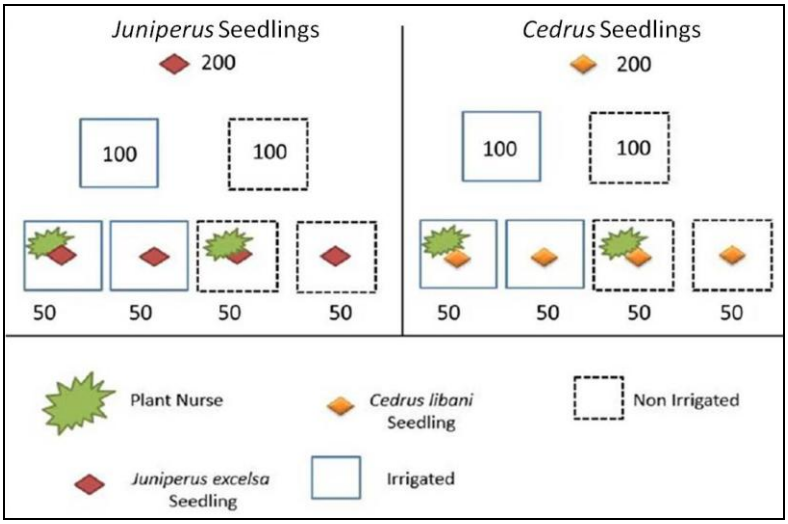


Figure 3: The experimental design of seedling plantation in each plot

Each planted seedling was marked by a wood stick with red or blue colour regarding the irrigation status. Moreover, the upper parts of *Cedrus libani* seedling sticks were marked by a white colour to easily monitor the study, especially when a seedling is lost. (Figure 4)

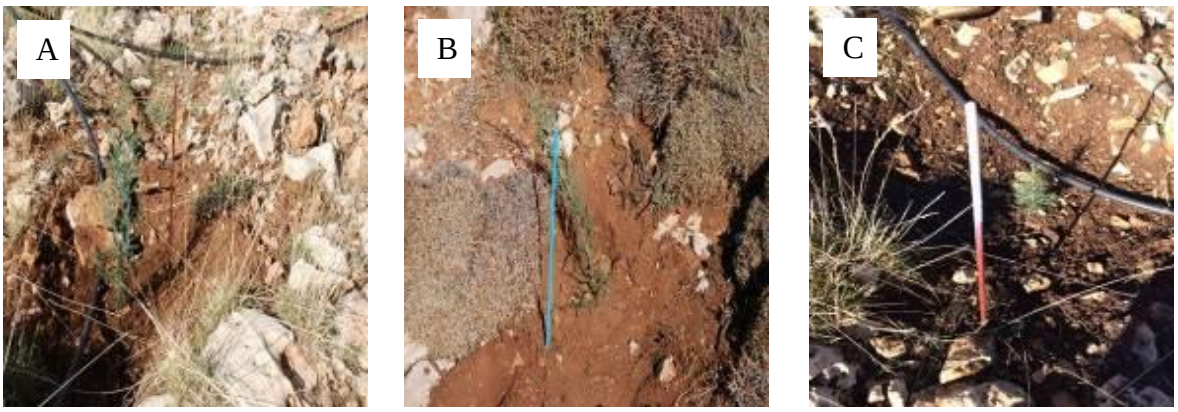


Figure 4: Seedling plantation examples**:** *Juniperus excelsa* (A) with irrigation without plant nurse, (B) without irrigation with plant nurse and (C) *Cedrus libani* with irrigation without plant nurse

In this restoration project, special attention was paid to seed and seedlings origin and quality. Thus, one year seedlings grown in 'Deepot' containers were purchased from nurseries close to the restoration site and used certified local seeds.

The experiment with seeds was carried out in two plots, the first one with North East (0.4 ha) exposition and the second one with North West (0.6 ha) exposition. Seeds from five species (*Cedrus libani, Crataegus monogyna, Cotoneaster nummularia*, *Juniperus excelsa*, and *Rosa canina)* were collected and sown in the plots, following an experimental design testing the effect of existing nurse plants on seed germination (Figure 5). The same nurse plants were used as in the seedling plantation tests. The number of seeds per spot varied from a species

to another according to previously known germination rate (Table 1). Each sown spot was marked using a wood stick with different colour according to the treatment for each species.

Species	Sowing spots under plant nurse	Stick Colour	Sowing spots in open space	Stick Colour	Seed/Spot	Total Seeds
Juniperus excelsa	100	Blue	100	Blue	7	1400
Cedrus libani	125	Red	125	Red	3	750
Rosa canina	100	Green	100	Green	2	400
Crataegus monogyna	100	Orange	90	Orange	2	380
Cotoneaster nummularia	100	Yellow	100	Yellow	2	400

Table 1: The number of seeds sown per sowing spot, the total number of seeds per species and stick colour code

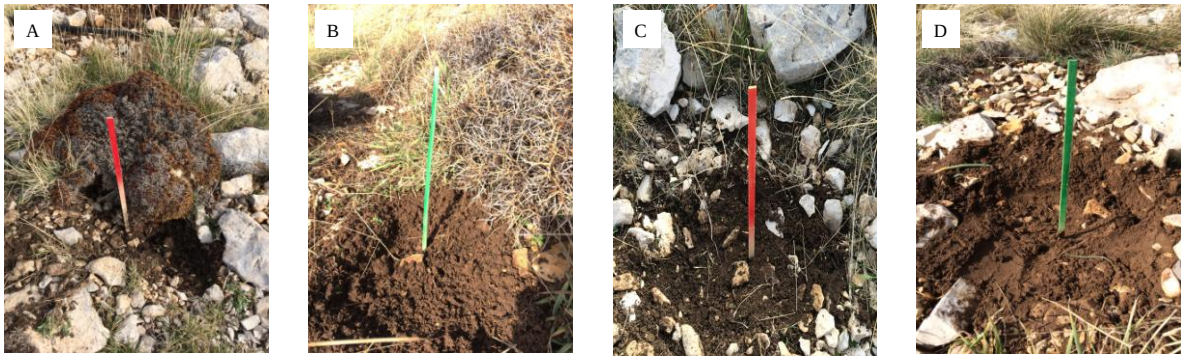


Figure 5: Seeds sowing of Cedrus *libani* and *Rosa canina* with (A, B) and without (C, D) plant nurse

In summer 2015, after the snowmelt, monitoring of seedlings survival and seeds germination rate was executed each month. Seedlings status were categorised as alive, damaged, or dead. The damaged seedlings were those having more than 2/3 of their stem and needles dead. However, some of these damaged seedlings can recover. To evaluate the restoration action success, monitoring of the pilot site will be executed by the NGO 'Jouzour Loubnan', for 2 years after the end of ECOPLANTMED project.

6.2 ECOPLANTMED pilot site of Tunisia

Located in the northwest (36º 56´N, 9º 03´E), Nefza is a small town with about 20,000 inhabitants and a distance of 200 km from Tunis city. The forest area covers 22,398 ha (DGF, 2005), with two managed forests with a valid management plan: Bellif and Tabouba.Tabouba forest comprises the two triages of T'baba and M'sid. The pilot site is located in triage of M'sid on a former forest of cork oak, covered currently by shrub. The pilot site belongs to a public land owned by the forest service and used as rangeland by people living in the village near to the site area (Figure 1).

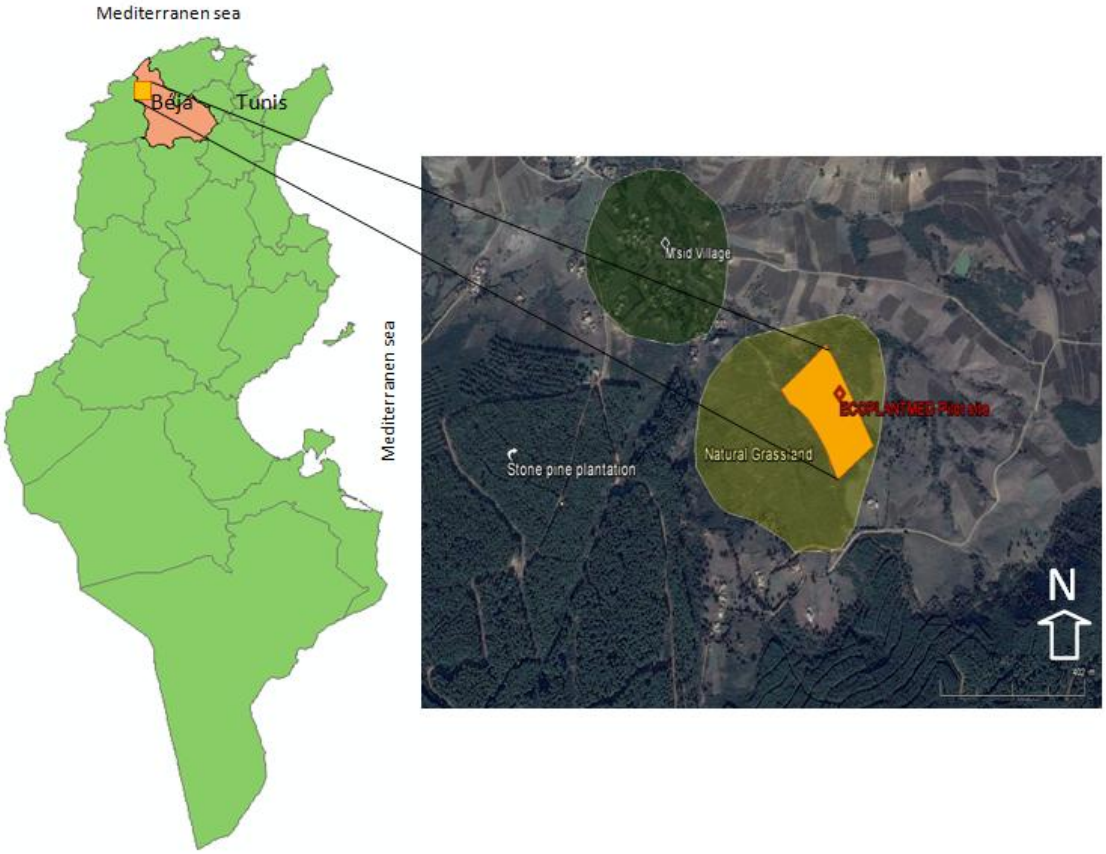


Figure 1: Location of ECOPLANTMED pilot site

Nefza region, where the pilot site is located, is included in humid bioclimatic stage with mild winter. The mean annual rainfall is 922 mm and the mean annual temperature is 19.2ºC. The soil has mostly a clay sandstone texture. The east and the middle of the parcel are covered by marl with a high percentage of clay (35-65%). The main woody and herbaceous species present are: *Cistus monspeliensis, Pistacia lentiscus, Olea europea, Myrtus communis, Phillyrea media, Hedysarum coronarium, Scilla maritima* and *Trifolium subterranum*. The Tunisian ecological resources (forest, grassland, steppes, etc.), like all south Mediterranean countries, are undergoing continuous degradation for several decades like the pilot site (Figure 2). This situation results from the combined effects of several historical, socio-economic, silvicultural and natural factors. It concerns the

clearing by man in search of farmland, repeated fires and lack of silvicultural operations. Several explanations are given by foresters about abiotic or biotic factors such as: (1) the absence of appropriate silvicultural practices to promote seed production; (2) illegal seed and wood collection by inhabitants; (3) damage caused by overgrazing, etc. In the pilot site of Nefza, we will develop an integrated approach to reduce degradation and to promote land rehabilitation (planting woody and herbaceous native species according to a multipurpose scheme and local needs).

Figure 2: Landscape of the pilot site of Nefza

The restoration actions under the ECOPLANTMED project will start in September-October 2015. It will include four main activities:

(1) Fencing: The pilot site is located near a village where people are accustomed to pasture in the nearby areas. To succeed the restoration, the area will be protected from grazing. Fencing should be established before the plantation;

(2) Soil preparation: The work is usually made to leave bands of natural vegetation along level curve. The width of these bands is based on the floor and the topography of the area. The planting technique was based firstly on total clearing and stumping of vegetation. The preparation of holes of 40x40x40cm in level curve (contour line);

(3) Planting: Native species and local provenances are used for this restoration project. For our restoration study, seed and seedlings quality are used from a public nurseries using certified local seeds. Species to be planted in the pilot site are: *Anthyllis barbajovis*, *Capparis spinosa*, *Celtis australis*, *Ceratonia siliqua*, *Crataegus azarolus*, *Cytisus triflorus*, *Genista cinerea*, *Laurus nobilis*, *Medicago arborea*, *Pinus pinaster*, *Quercus coccifera*, *Rhus pentaphylla* and *Ruta chalepensis*. Planting will be done in bands and bandwidth will be 25 m. Two techniques will be tested, planting with seedling and direct sowing (Figure 3). For planting with seedling, soil preparation, requires the creation of holes. Selected species seedlings will be carefully planted in the middle of the hole to enable an optimal development of roots. Distance between holes in the same band will depend of the species. At the end, the root system is covered; the soil should be, later, compacted moderately by hands or by feet. A half-moon of land will be made down the hole to retain runoff. For planting with direct sowing, soil must be plough before sowing the seeds;

(4) Site maintenance: It is recommended to continue plantation maintaining until at least the 3rd year. It has been shown in earlier work that the success of planting is influenced by hoeing and weeding. During the first three years, the seedlings are still young and characterised by a relatively slow growth rate; they cannot directly be exposed to competition from vegetation, which may sprout again after partial or total clearing. Hoeing-weeding operation offers the advantage to seedlings of easy development in the new environment. Evaluating the restoration status of these plantations is essential for their long-term management. For this reason, monitoring of the planted seedlings and the sown seeds will be performed once per month and they will be categorised as alive or dead. Growth parameters will be also measured, such as seedling height and collar diameter. The maintenance and monitoring of the pilot site after the end of the project and for at least two more years will be performed by INRGREF in collaboration with the local forest services.

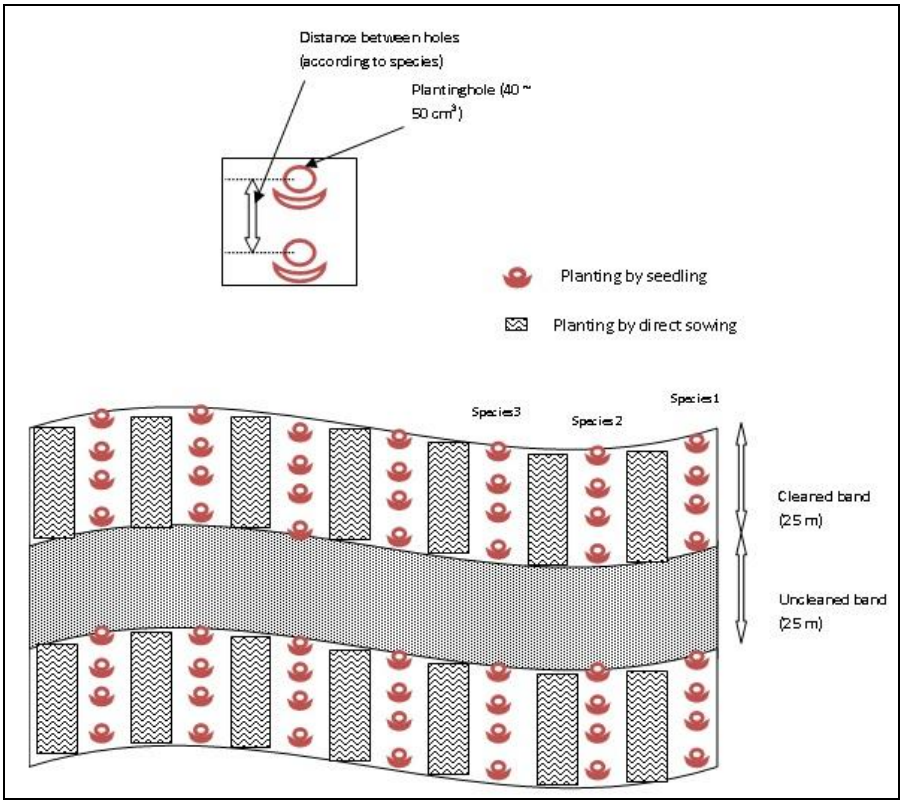


Figure 3: Management plan of the pilot site

7
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ANNEX:

LITERATURE REVIEW ON ECOLOGICAL PRACTICES FOR MEDITERRANEAN HABITATS

In the framework of the ECOPLANTMED project, 31 Good restoration Practices have been identified and 15 have been selected to be published in this guide, with regard to four different habitat types accorded previously (forests, freshwater, coastal/dune habitats and arid/semi-arid habitats). As it has been explained in chapter 5, the search of the practices was limited to the Mediterranean Basin (26 projects), and in some extent also in other regions with the same climate (5 projects).

LIFE[23] projects database and websites were mainly used in order to identify appropriate restoration projects. It was the most accessible and comprehensive database, with summaries of a major part of the required information to identify and evaluate the projects. In addition, several organisations, as the Global Restoration Network of the Society for Ecological Restoration, and other stakeholders involved in restoration projects were identified and contacted in order to collect more information about restoration actions using native plants from the area. Moreover, at national level, databases and local contacts were used to find ecological restoration projects. In this case, information were mainly provided either by the national competent authority or directly by the team working in the project, in case it have been possible to contact them.

Generally, for LIFE projects, most of the details required in our guide were found in their websites and databases or in linked papers. For non-LIFE projects, details were more difficult to achieve through technical publications, reports or websites and, in some cases, it was problematic to obtain adequate information. Although direct contact was often attempted, either there was no reply or no information was finally sent. When asking about examples of restoration projects to societies or specialised groups dedicated to habitat restoration, not enough information was obtained because their own databases were still under construction or information already published was very limited.

Due to difficulties found when a ECOPLANTMED project partner was searching projects outside its own country, in the Mediterranean Basin, 21 of the 26 Practices identified are located within the territories of the partners, as local contacts and interactive dialogue were necessary to get the suitable information: Greece (5), Tunisia (5),

[23] LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU. Since 1992, LIFE has co-financed some 4 171 projects, contributing approximately €3.4 billion euros to the protection of the environment and climate. Source: http://ec.europa.eu/environment/life/ (19 of June 2015)

Spain (5), Italy (4) and Lebanon (2). Practices in other countries than those of the partners have also been found: Algeria (1), Morocco (1), France (1) and Cyprus (2). In non-Mediterranean regions that possess Mediterranean type habitats, appropriate practices have been identified in Australia (2), South Africa (1) and USA (2 in California), although for the same reasons as expressed above, part of the information was missing in some cases. After evaluation of the projects, 15 were selected to be presented in this guide. They are located in Italy (4), Spain (3), Greece (3), Lebanon (1), France (1), Cyprus (1), Morocco (1) and Australia (1).

Of the 31 cases identified, 10 refer to forests, 6 to coastal/dune, 8 arid/semi-arid and 7 to freshwater habitats, but some practices deal with a landscape perspective and refer to more than one kind of habitat among those proposed in the project. Project partners have not expressed special difficulties in the search of certain habitat types, except the Lebanese partner, which has not been able to find an appropriate restoration project regarding coastal/dune habitat. The most frequent restoration practices in Greece and Spain were for forest habitats. Most practices within Sardinia (and Italy) were on dune restoration and it was very difficult to find restoration projects on arid-lands, drylands or dry Mediterranean grasslands. In Lebanon (and surrounding countries), the most commonly worked on habitat types are forests and wetlands, with fewer concerning dune habitat. In Tunisia, the most frequent projects concern arid and forest systems and fewer wetland systems.

For ‘forests habitats’, 5 Good Practices have been selected for being presented in detail in this Guide, which concern 3 conifer forests and 1 oak wood restoration projects/practices taking place in Mediterranean countries, and 1 Eucalyptus forest from Australia. In most of the selected cases, the causes of habitat degradation were anthropogenic actions like fires, overgrazing, progression of cultivated areas associated to bad practices or the irrational exploitation of resources. For 'coastal habitats', 3 Good Practices have been selected, 2 of which concern ‘Coastal dunes with *Juniperus* spp.’ and 1 ‘Maritime dunar system (first dune fringe and temporary pools)’, all taking place in European Mediterranean countries. In most of the selected cases, the causes of habitat degradation were anthropogenic actions such as urban pressure and fires but also natural pressures, such as soil erosion or restricted regeneration of some species, in particular *Juniperus* spp. Climate change is also expected to be a future degradation factor. All Good Practices selected for ‘semi-arid systems' took place in Mediterranean countries. Three have been selected, 2 of which concern ‘Mediterranean scrubland’ in Spain and Lebanon, with problems of flooding, soil erosion, over-grazing and excavation activities, and 1 ‘*Thero-Brachypodietea* grassland’ in Italy where degradation was attributed to over-grazing, limestone quarrying, and more recently to the growth of tourism. Finally, for ‘freshwater habitats’, 2 projects for lakes and 2 for riparian systems have been selected, all of them in European Mediterranean countries, and in most of them, the causes of habitat degradation were invasive species, drainage, deforestation, flooding, soil erosion and other activities such as agriculture or tourism.

Among the 31 practices identified, 6 cases concerned old or long-lasting projects, with more than 10 years ongoing (the oldest one, a Tunisian project, dates from 1953); 19 projects had duration of 4 to 10 years, and 6 are short-term projects, with durations less than or equal to 3 years. Two of those short-term projects have recently finished (2014) and one is still ongoing; even so, these short-term cases have already provided some tangible and measurable results and monitoring data are optimistic. Among the 15 selected projects presented in this guide, 3, 10 and 2 cases had duration of 3 years, between 4 a 10 years and more than 10 years, respectively. It is noteworthy that LIFE projects used to be short or mid-term projects (3 to 5 years) while national or local authorities projects usually are mid- or long-term initiatives (more than 5 years).

One of the basic criteria to identify the restoration projects was the use of native plants, which was the case for all identified practices, but in 6 of these, non-native plants were also used. This occurs because in some regions and in particular in the South region of the Mediterranean, the use of non-native plants in restoration projects is still a widespread practice. Thus, the necessity to spread out the use of autochthonous species in restoration projects is pointed out.

Three main conclusions could be generated from the search on Good Practices for natural habitat restoration:

- A great number of scientific publications talking about ecological keys (as for example plant facilitation interactions) or other techniques that could be applied to a restoration project can be found. However, many ecological restoration practices have not taken advantage of this knowledge to restore habitats. It seems that these methods are applied only in a very few cases and the difficulty of transferring research results into practical cases may be one of the reasons, as seen in other areas of scientific research.
- In the Mediterranean region, although it was possible to select practices in a great number of areas (all the territories involved in that region), a general inaccessibility of information about restoration projects through conventional media (papers, on line publications, online databases, etc.) has been detected.
- There is a need to establish efficient information channels. Habitat restoration is a very complex process, and in the same manner we must learn from our own mistakes, it would be advisable to learn from others through the results and conclusions of their restoration actions. The current publication aims to contribute somehow to fill this gap.

The 31 Good Practices identified for Mediterranean habitat restoration[24]

Forests

- The Mediterranean holm oak grove integrated management (Chênaie verte)*
- Conservation of Apennine beech forests with Abies alba in SIC Pigelleto - M. Amiata (TUCAP)*
- Restoration of Pinus nigra forests on Mount Parnonas through a structured approach (PINUS)*
- Integrated Management of the Mid-Atlas Forests in Morocco (GIFMA)*
- Returning the Botanical Richness of the Jarrah Forest in Restored Bauxite Mines in Western Australia*
- Reforestation project in Sierra Calderona Natural Park, Spain. Reference: Regional Ministry for Infrastructure, Territory and Environment- Regional Government of Valencia.
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Freshwater habitats

- Wetland restoration for fauna and flora recovery in Algemesí Reserve (Llacuna del Barranc)*
- Restoration and environmental interpretation of the riparian forest of Nestos Delta*
- Restoration and Management of Oroklini Lake in Larnaka (OROKLINI)*
- Protection of a territory by ecologic engineering in a catchment area (PROGECO)*
- Wetland restoration and management: Canal de Castilla Special Protection Area, Spain. Reference: LIFE06 NAT/E/000213
- Conservation Management of Amvrakikos Wetlands, Greece. Reference: LIFE 99 NAT/GR/006475 (http://users.hol.gr/~etanam/life/english.htm)
- Protected Areas Management Project (PGAP) study case: National Park of Ichkeul, Tunisia. Reference: General Directorate of Forestry (DGF), Agriculture Ministry, Tunisia

[24] Practices marked by an asterisks are the selected ones

Coastal/dune habitats

- Model of restoration of dunes habitats in 'L'Albufera de Valencia' (Dunas Albufera)*
- Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (JUNICOAST)*
- Conservation and recovery of dune habitats in sites of the Provinces of Cagliari, Matera and Caserta (PROVIDUNE)*
- LAX dunes endangered El Segundo blue butterfly recovery and habitat restoration, California. Reference: Los Angeles World Airports (http://www.lawa.org/welcomeLAWA.aspx)
- Combating desertification in Menzel Habib (Gabes), Tunisia. Reference: Regional Commission of Agricultural Development (CRDA) of Gabes, Tunisia
- Coastal dune fixation in Nefza area, Tunisia. Reference: Forest Regional Service of Nefza, CRDA Beja. Agriculture Ministry, Tunisia

Arid/semi-arid systems

- Demonstration Project to Combat Desertification: Regeneration and Management Plan of degraded semi-arid areas in Albatera*
- Mediterranean Quarry Rehabilitation Manual: Learn the Holcim Experience*
- Safeguard Thero-Brachypodietea habitat in SCI 'Area delle Gravine' (GRAVINE)*
- Renosterveld Restoration Project, South Africa. Reference: Implemented by the University of Stellenbosch and funded mainly by WWF-South Africa/Table Mountain Fund (ZA5035), case study in SER publication (Cramer *et al*., 2007)
- Protected Areas Management Project (PGAP) study case: Bou-Hedma Park, Tunisia. Reference: General Directorate of Forestry (DGF), Agriculture Ministry, Tunisia
- Upland Invasive Species Control and Restoration, California. Reference: Implemented at the Starr Ranch Sanctuary by the National Audubon Society (http://www.starrranch.org/invasives.html)
- Algerian green Dam Project, Algeria. Reference: Forestry Direction, Algeria
- Restoration of Trachila mine on Milos Island, Greece. Reference: S&B Industrial Minerals (http://www.sandb.gr/)