Challenges and Successes in Regeneration Practices in The Northern Mediterranean Basin

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Introduction

The objective of this paper is to portray the nature and character of regeneration practices in the northern Mediterranean basin, a region comprising 13 countries: Portugal, Spain, France, Italy, Slovenia, Croatia, Serbia-Montenegro, Albania, Greece, Bulgaria, Cyprus, Malta and Turkey. Oversimplification is a risk when trying to describe forest regeneration in the region, as it is as varied as are forest resources, site conditions, ownership structures, population density, and the general socio-economic and political conditions of respective countries.

In the first part of the paper a general ecological description of the area will be given, as well as of the socio-economic context. The central part of the paper discusses regeneration practices, focusing on forest reproductive material production and stand establishment, considering uniformity and diversity among countries. Subsequently, hot topics surrounding forest regeneration and new issues in the political agenda will be pointed out. Case studies will be presented regarding regeneration.

The Context

The main features of Mediterranean climate are seasonal and daily photoperiodism and rainfall that is concentrated in the cold and relatively cold seasons, with a dry warmer summer season. Of course, this is a gross overgeneralization, as different local conditions generate subtypes of diverse climate: in fact, rainfall ranges from about 100 mm in pre-desertic zones to more than 2,500 mm on some mountains exposed to moist winds; and drought may last from two to six months. Such a climate and other natural factors, as well as human activities, have produced significant impacts on Mediterranean ecosystems, their fragility, instability and degradation (Barbero et al. 1990).

It has been estimated that forest cover was about 82% before the first anthropic settlements in the region, while now it ranges between 15 and 20%.

The Mediterranean basin is a site of exceptional biodiversity. The wealth of vegetation types and tree species located in Mediterranean forests has been recognized as one of the main features that distinguishes them from those in other parts of Europe (Quézel and Médail 2003). In the region forest covers about 66,8 million hectares, about 25% of the total land area and it has been increasing remarkably, even though deforestation in some countries is still significant. During the last decade, the average annual increase of forest cover has been about 2% per year. Main causes for such change are large-scale plantation programs, active conversion of agricultural land and meadow and other wooded lands, and natural expansion of forest into agricultural lands, grasslands and pastures, abandoned as a consequence of the decline of the primary sector's importance (Pettenella and Piussi 2000) after the blast-off of industrial development and the socio-economic growth. Timber harvesting on private and public forest of the region has dramatically decreased since the 1950s, mostly because of the conservation measures put in place in these countries and the weakened ability to compete with foreign wood producers.

As a consequence, growing stock and forest density are increasing, as forests become older. Also, the capacity to provide services may weaken, while risks of fire may increase. In contrast, riparian belts and suburban spaces are increasingly jeopardized by land development for housing, industry or tourism, by transportation infrastructures and by extensive degradation.

Forest degradation because of wars, climate change and desertification, and fires need to be mentioned. Fire has been the dominant disturbance that has shaped the character of the forests in Southern Europe, mostly because of a combination of high temperatures and water deficit during summer. Currently, fires are one of the biggest concerns for the protection of forests and safety of people and property in Southern Europe. The number of fires and area burned fluctuate annually in the Mediterranean region. During the period 1990–2002, an average of 40,000 fires each year destroy around 400,000 hectares of forests and other wooded land in the EU Member States, mostly (95%) concentrated in Southern Europe (Schelhaas et al. 2005), causing huge economic, social and environmental damage. It may be considered that in Spain a large wild fire caused deaths to 14 firemen the 17th of July this year.

Socio-Economic Context of Forest Regeneration

The economic value of Southern European forests is generally low, given the fairly inferior productivity of these ecosystems. In comparison, production of non-wood forest products (cork, resin, fruits, berries, medicinal and aromatic, wild flowers, edible mushrooms, truffles, honey, meat) has great importance. Ultimately, the value of services (biodiversity reservoir, protection of freshwater resources, soil conservation, recreational, historical and cultural values, landscape, climate change mitigation, eco-tourism, etc.) are of major importance in the region (Benoit de Coignac 2001, Weber 2005) and is nowadays even more emphasized in the forest laws of many regional countries.

In this context, afforestation and reforestation (AR) offer scope for a variety of designs, including afforestation to create forests for special purposes, which could also reduce pressure on existing forests. Forests are specifically dedicated for mountain bikers, horsemen, picnic sites, playgrounds, culture and history, etc.

As a consequence, plantation forestry in this area is expanding into a much broader range of species, e.g., broadleaved and wildlife-crop species, diverse species and local provenances, for which more practical information is needed in many aspects of forest nursery production. This trend is backed by EU forest policy (EC 2003).

In Southern Europe, the linkage of afforestation to agriculture is close. Afforestation on arable lands and meadows on a large scale started in the 1950s, covering several million hectares. AR was a way of addressing problems of agriculture overproduction and rural unemployment. AR was dominated by conifers (*Pinus* spp. and *Cedrus* spp., *Douglasia* spp). Many of these plantations were located in areas occupied by other tree species, notably belonging to the genus *Quercus* or other broadleaves (Krstić 1998).

Currently, industrial plantations of fast growing species (*inter alia,* hybrid poplars, eucalyptus, black locust, maritime and radiata pine), cultivated as intensive, industrial plantations, agroforestry systems or linear plantations and windbreaks, are beginning to meet a significant portion of the needs of local communities as well as of the national requirements in terms of timber supply and energy demand. Chestnut also has an important role.

Nowadays, the establishment of monospecific stands of conifers and other species mentioned before are decreasing, as AR for ecological and amenity reasons is increasingly undertaken

Apart from some countries, such as Bulgaria—where forest stand establishment operations are undertaken principally on state-owned lands and particularly on areas destroyed by fire, stands and plantations damaged by drought, clearings and non-forested areas (GGAF 2003)—most afforestation is done by private landowners, subsided by EC grants to participate in afforestation programs. Private landowners require subsidies for establishment and tending costs as well as additional compensation for lost agriculture income.

State and regional administrations participate to create relatively large programmes (such as the “Lombardy 10 large plain forests”), usually located close to urban areas, aimed at recreational activities, reclamation of disturbed areas, erosion avoidance, land biodiversity conservation.

Regeneration Practices

Natural regeneration

Natural regeneration has traditionally been widely used in Northern Mediterranean countries, especially where conditions are generally more favorable. Natural regeneration is appropriate if the provenances and species already growing in the site correspond to the conditions in time and space. Natural regeneration (and ‘assisted natural regeneration’) relies on existing mature trees expected to generate seeds and produce new forests.

In the part of the region where forestry has high standards, the silvicultural systems in use nowadays are based on the principles of a sustainable, "near-to-nature" forestry. Forest operations are cautiously controlled and restricted, aiming to provide timber production through forest natural regeneration.

Coppice is a woody crop raised from shoots produced from the cut stumps of the earlier crop. Coppicing is done for almost all broadleaves to produce small round-wood products, wood for fuel, fencing materials, and wood for paper and particle boards). Coppicing is largely widespread in some countries. In Italy (Pettenella et al. 2005) and Turkey (Makineci 2001) coppice represents a major silvicultural system, especially in privately owned forestlands.

Although still common in the region, coppice is currently considered an outdated silvicultural system. More and more old coppiced stands in the northern Mediterranean basin, from Portugal to Turkey, are subjected to conversion operations leading to high forest.

Artificial regeneration

Although natural regeneration is of historical importance and a prefered option all over the region, AR is also important, as shown by recent rates of planting in EU member countries, as well as EU access countries, Serbia-Montenegro (Dinić et al. 2001) and Bulgaria (Rafailov et al. 2003). Several thousand hectares of AR are established every year in the area, mostly subsided by EU grant.

Because of climate and disturbances, natural regeneration is difficult and demand for artificial AR exists. In fact, for some species, natural regeneration, though desirable, is problematic and insufficient, and at times impossible (Frochot et al. 1986, INRGREF, 1998, Merouani et al. 1998). Afforestation is normally used in former (abandoned) agricultural lands, and highly disturbed lands (after fires, etc.).

As plantation forestry in this area is expanding into a much broader range of species, e.g., broadleaved and wildlife-crop species, diverse species and local provenances, more practical information is needed in many aspects of forest nursery production. “They are not weeds, they are local plants”. These sentences by a US landscape designer, reported by McMullen (2005) expresses the worldwide trend in forestry to expand into a much broader range of species, e.g., broadleaved and wildlife-crop species, and local provenances, for multiple purposes (Colombo 2004).

Seed propagation

The trend of forestry on ‘new’ species is particularly relevant in Europe, where practical information is needed in many aspects of forest nursery production of a large variety of species. The role of research in implementing techniques for seed propagation is crucial. In this regard, outstanding studies have been carried on germination of a number of Mediterranean species. Transfer of know-how and knowledge about germination patterns have still to be improved.

Know-how is still incomplete and in need further development in many fields. A central issue is the study of ‘recalcitrant’ seeds of genera like *Quercus* and *Castanea*, of which natural regeneration is problematic and jeopardized by land fragmentation, especially in coastal areas, and it is something that can be a serious risk for genetic resource management (Piotto 2004).

Lack of investments for storing and pre-treating seeds (chilling, warming, etc.) facilities is a limit in many countries, as well as poor funding of research and extension programs on the issue of seed propagation.

Production of forest planting stock

Currently, two main types of nursery stock are produced in the region: bareroot stock, and container stock; greenhouse transplant stock is very rare. The use of containerized stock has successfully increased in the last decade, at the expense of bareroot stock. In Portugal more than 90% of nursery stock is produced in containers (Neves 2004). In Spain (Pardos et al. 2003, Ribeiro and Marques 2004) and Croatia (Orlić and Perić 2002) bareroot stock prevails.

For bareroot production, nursery beds are formed by hand or with a bed forming machine. In some countries—where undercutting is a routine practice—beds are raised 10-15 cm above the path level, and afterwards go down 2.5 to 5 cm, owing to transplanting operation.

Broadleaves like walnut, oak, chestnut and other species that have large seeds are grown for one season and are sown in the nursery beds at the final density. Sowing normally takes place in spring. Conifers (and broadleaves that have poor and unpredictable germination) are sown at high density, then seedlings are transplanted next season to the final density. Transplanting is done by hand or, in some countries and in some nurseries, by machine.

Final density varies from species to species and depends on the final target wanted by the nurserymen: it ranges from 25 to 100 seeds per m^2. For broadleaved species to be used for protection and environmental purposes adequate spacing to obtain sturdy plants, with a well balanced shoot/root ratio, is 120 cm^2 cm per plant, shaped 15 cm (between rows) by 8 cm (on the row). For species like *Juglans*, *Quercus*, *Celtis*, *Platanus*, *Acer*, spacing ranges from 100 up to 400 cm^2 cm per plant.

Undercutting (once or twice during the growing season), when practiced, is a very important operation in order to promote formation of second-order lateral roots and to make easier final lifting. The timing of root pruning is critical and many authors suggest it be done when the taproot has elongated at least 20 cm (Ciccarese 1997, McCreary and Canellas 2005).

Several studies carried out in many countries of the region show that lifting date (and the way it is done) is really crucial for performance (survival and growth) of the planting stock of certain species. Lifting is done in winter, when plants are dormant. The results of Root Electrolyte Leakage (REL) measurements on elm seedlings, at three different growing steps suggest that the best period for lifting from open nursery beds (for subsequent out-planting in plantations) starts in early November (Ciccarese et al. 2005). Pardos et al. (2003) have demonstrated that the best period for lifting *Pinus halepensis* and *Quercus ilex* is mid-December.

Bareroot stock can be transferred to cold storage (1°C) during winter to be used for spring planting from the middle of March until the early May. Alternatively, it can be heeled-in, in shaded and well-drained soils.

Root Growth Potential (RGP) is a good indicator of plant quality and subsequent field performance, as demonstrated by several studies and, recently, by an EU-funded research project. Research on field performance of planting stock grown with different methods have demonstrated significantly better survival and growth for larger caliper stock, with abundant and fibrous root system.

Containerized forest nursery stock is produced mostly in private nurseries, with use of irrigation systems, peat (sometimes in mixture with soil) and other artificial components. Composted pine bark is sometimes used in place of peat. In many countries, natural soil is now used in tree forest containerized production.

A wide array of containers are used, different in material, size, form, concept. Large containers are used, particularly for producing planting stock to be used on more xeric zones and difficult sites. The standard container is from 200 to 1500 cc (for one growing season) and even larger (Sardin et al. 2001). Marien and Drouin (1977) suggest using seedlings grown in container as big as 700 cm^3. Normally sowing in containers is done by hand; the use of high quality seed-lots is rare. For many reasons, the use of precision sowing machines is still sporadic. Containers are placed in greenhouses or protected areas or located outdoor.

Assessing plant quality

Poor quality planting stock is recognized as one of the main reason for failure of forest tree plantations (Ciccarese 1997b, Louro 1999, Radoglou, 2003, Ribeiro 2003). The focus on planting quality assessment has become more intense after the disappointing performance of a significant part of the forest stands established within the European Commission 2080/92 Regulation, which introduced a grant scheme for AR.

The Council Directive (EEC) No 105/99, entered into force in 2003 in all EU countries, lays down the conditions governing the marketing of forest reproductive materials in the Community (EC 2003). The Directive refers to the certification of genetic quality of reproductive material, as well as of their physical features. However, the Directive mentions morphological parameters to define planting stock quality.

With the aim to improve planting stock quality, private and state owned nurseries have adopted procedures and standards for producing forest reproductive material responding to the requisite asked by the Directive (which only asks for morphological attributes).

Various morphological, physiological and molecular methods have been developed to test the seedlings' condition before planting. It was also the topic of a 1994 IUFRO conference (Making the grade). A EC research project, "European approach for assessing re-growth potential of woody plants: parameters for plant vitality and dormancy of planting stock", studied morphological, physiological and molecular parameters for predicting survival and the rate of growth of tree planting stock. Root electrolyte leakage (REL) and root growth potential (RGP) are two seedling quality assessment methods that have been investigated widely and applied in laboratories: However, their operational use, by nurseries, is inconsistent. Very few nursery have adopted methods and instruments for assessing plant quality through physiological performance tests. In Portugal, since 1997, a process of certification has been approved, which involves assessing the quality of 52 million plants, using morphology attributes (Ribeiro and Marques, 2004) according to the rules introduced by the EC Directive (EC 2000).

Forest reproductive material

An EU scheme was set up in 1999 by Council Directive 1999/105 (EC 2003) on the marketing of forest reproductive material (FRM). The Directive ensures the plentiful supply of high quality FRM of the species concerned within the EU, by stipulating that forest reproductive material may not be marketed unless it is of one of four categories specified by the Directive, and that only approved basic material (the trees from which FRM is harvested) may be used for its production if the material is to be marketed.

Basic material must be approved by an official body as fulfilling the minimum requirements laid down in the legislation. This approval is subject to regular re-inspection. The categories differ in the strictness of the quality criteria which must be fulfilled by material. All information on FRM approved on a Member State's territory is held in a national register, including information about the area(s) in which the material is found or the geographic location (depending upon the category). The Directive introduces the concept of 'region of provenance': for a species or sub-species, the region of provenance is the 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, taking into account altitudinal boundaries where appropriate. The new directive reflects both the modern state of plant breeding and the increased public awareness of nature conservation.

Establishment

Direct seeding

In Europe, direct seeding—the method of creating or restoring woodlands by sowing tree seed directly into their final growing position—stretches back to the Middle Ages (Willoughby *et al*.). After being neglected for a long time, the method is gaining interest among forest managers as an alternative to planting nursery stock, especially when seeds are available in large quantities and at low costs, and when planting seedlings is difficult. Direct seeding can be an economical method for forest restoration, especially for establishing deciduous species (Montero and Caňellas 1999, Nabos and Epaillard 1995, Ciccarese 1997a; McCreary and Canellas 2005). Sardin et al. (2001) and Balandier et al. (2005) have proposed direct seeding for accelerating the establishment of late-successional broadleaved species, for the advantages of direct seeding over planting, such as more rapid establishment, the permanence of a leading shoot, and better root system form.

Seeds may be sown as a single tree species, or as a mixture of species, or occasionally in combination with an annual 'cover crop', such as cereal. The experiences carried out so far on direct seeding advise that some prerequisites need to be met: high germination capacity of seedlots, appropriate sowing technique, and absence of excessively competitive vegetation. Torres (1995) suggests the use of rodent repellent and Sardin et al. (20001) recommend for oak species the use of individual seed protection (metallic grid) and more than one seed per spot. Croizeau and Roget (1986) and Louro (1999) advise that seeding pre-germinated seeds in early spring may be an effective solution to regenerate oak species.

Planting and maintenance

Planting and maintenance depend on species, management objectives and an array of other factors, such as physiography, climate and weather conditions. Guidelines for AR in Southern Europe are available, at regional, national and sub-national levels, providing basic information to landowners and forest managers. Additional information on incentive programs and enrolment procedures is provided at local offices of national and provincial forest offices.

In the region, planting out is made from late winter to early spring. Poor survival and re-growth is associated with later planting. Most forest planting stock is 1-year-old (with exceptions, like poplar).

Site preparation practices are generally minimal, since planting occurs on abandoned agricultural lands. The public favors sound and sustainable management practices and dislikes mechanical and chemical weed control in forest plantations.

In Europe, in general, there is a reluctance to control weeds by herbicides, even though studies have demonstrated the incremental benefit of repeated vegetation control, particularly in the first years after planting.

The establishment of high quality broad-leaved crops is normally achieved by planting at close plantings, in keeping with high-yield objectives and poor seedling survival. High planting densities, such as 3m x 3m spacing, promote apical dominance ('positive competition') and restrict branch development. In this case, with the increasing request for and price of smaller logs, some land owners have adopted commercial thinning (cherry, walnut, oak, willow, elm). Vice versa, negative aspects are high cost for planting, establishment, and tending.

Promising is the establishment of mixed, multi-objectives plantations for production of biomass for industrial or energy use (*Salix*, *Robinia*) and for timber medium (e.g. *Populus*, 10-year rotation) and long rotation (*Juglans*, *Prunus*, *Tilia*, *Fraxinus*, etc.) species (Buresti et al. 2001).

For oak plantations, the minimal initial density should be 625 plants per ha (Montero e Canellas 1999).

Short rotation coppices (wood for energy) are expanding, as the production of energy from biomasss is supported by national energy policies. Willows and black locust, planted at high densities (from 10^3 to 40^3 plants per ha). Establishment occurs in late winter, using high genetic quality stock, at a initial plantation density ranging from 400 to 1100 plants per ha. Protection (fencing, tree shelter) is necessary, even though it raises cost. Growth results of many field trials on stands of noble hardwoods on former agricultural lands in combination with *Leguminosae* and other nitrogen-fixing species have been demonstrated successful (Gavaland et al. 2002). However, if species are not chosen correctly, to meet site environment, success is not guaranteed.

In France, *Quercus petraea* and *Quercus robur* are the major native species used for afforestation and reforestation. Guibert and Généré (2000) suggest using seedlings with a minimum hight of 20 cm. *Quercus ilex* and *Quercus suber* in Portugal, *Juglans regia* and *Prunus avium* in Italy and *Quercus robur* in Croatia are the most common broadleaved species used in AR.

Case studies

The paper will focus on a few case studies and success stories. They are represented by:

- An EU research project aimed at facilitating the creation of partnerships between tree nurseries and forest research agencies from Sweden, Denmark, and Italy, in order to address common technological problems and acquire innovation (Ciccarese et al. 2005)
- A project funded by the Government of Croatia and the World Bank, with the main objective to rehabilitate forests damaged by fires during the last war and to reconstruct a nursery to grow seedlings of species utilized in reforestation of coastal areas (Anonymous 2001)
- In Situ Conservation of Genetic Biodiversity. This is the title of a project funded by GEF and implemented by the World Bank in Turkey, whose main objective was to restore natural resource degradation because of overgrazing, deforestation, and soil erosion caused by inappropriate cultivation
- A project carried by the French CEMAGREF, on cryopreservation of varieties or cultivars of *Ulmus minor*, *Ulmus glabra* and *Ulmus laevis* (Harvengt et al 2004)
- AR projects for the implementation of the Kyoto Protocol
- Nursery production and establishment of plants with Tuber spp., of mycorrhizae for producing truffles

Conclusions

In general, even though important advances have been done in certain European nurseries, the standard of production technology regarding all types of forest regeneration materials has to be elevated in order to improve biological, physiological and genetic quality, as well as cost efficiency. Reports of failed reforestation attempts more often than not mention poor quality as the main cause for these failures (Radoglou 1999, Ciccarese et al. 2005).

Unfortunately, the lack of capital investment in technical developments has created a situation where cost efficiency in the production of forest regeneration materials is low and nurseries are often burdened with environmental problems.

The small size of most forest nurseries and the fact that—normally—forest nurseries are publicly-owned are barriers for implementation for technical development. Fortunately, the call for introducing innovative systems is timely with the existing call for re-organization, modernization, and privatization of forest nurseries occurring in the area.

The use of containerized stock should be enlarged, but in doing so many obstacles have to be overcome The role of research is also important in aspects of seed and vegetative propagation.

In the management of existing forests, one of the first issues is the fact that coniferous stands have started to pose stability problems and regeneration troubles. In these stands a priority is silvicultural treatment to diversify composition and modify structure. In this regard, mixed forests are promoted and the spontaneous recolonization of broadleaved species in coniferous plantations is today strongly encouraged.

An important issue is post-fire management of forest lands. The effects of fire on the ecosystem and its resilience may be very diversified, depending on a multitude of factors, such as fire regime (persistence, frequency, intensity, severity, extent, etc.), vegetation type and site conditions. Artificial restoration may be necessary and much work is to be done, particularly on the aspect of cost of rehabilitation. In this respect, direct seeding is promising.

Since the 1970s, invasion of exotic species, such as *Robinia pseudoacacia* and *Ailanthus altissima*, have become a problem of increasing environmental focus and concern (Tassin and Balent 2004), raising critical questions (which species make good invaders? Which communities are most easily invaded? What will be the rate of spread of invasive species?) that need to be addressed by scientists and land and forest managers.

The role of biotechnology may be helpful to improve regeneration in the region. Research is carried out in all countries of the region, with different objectives. Most public research involving forest biotechnology does not relate to Genetically Modified Plants. Developments and applications of genetic modification technology is carried out mainly on *Populus* and *Salix* with the objective of achieving varieties to be used for bio-remediation and resistance to diseases. (Balestrazzi *et al*. 2000).

The EU policy on rural development and other multilateral environmental agreements (namely the Kyoto Protocol and its mechanisms that allow use of new forest establishment as a mean to fulfill green-house gas emission reduction commitments) now gives incentives for the governments to boost afforestation and reforestation, as well sustainable management of forest resources.

Improving dialogue and exchange of experience on available technology alternatives at the Mediterranean level is essential in order to build capacity in adopting correct plant domestic strategies and nursery programs and use to suitable propagation and regeneration techniques.

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