New approaches concerning forest restoration in a protected area of central Italy: an introduction

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Abstract

Following a review of the traditional afforestation techniques in Italy, the new forest restoration criteria and techniques require creativity with a solid scientific knowledge and further aims need to be pursued to maintain or enhance biodiversity and repair ecosystem functions. A case study concerning forest restoration of abandoned agricultural land in the Gran Sasso and Monti della Laga National Park (central Italy) was analysed. The choice of native tree species was carried out according to the symphytosociological approach; the restoration of vegetation may be accelerated by planting early successional tree species belonging to the same series of vegetation. The cultural techniques included the partial release of shrub vegetation invading abandoned land, and site preparation techniques of low environmental impact (i.e. clustered arrangement, curved rows) applied according to soil morphology. Five years after planting, damage by animals, survival rates, vitality status and total height of different tree species, and effects of competition by shrub vegetation on tree growth were assessed.

Keywords: forest restoration, Italy, protected areas.

Introduction

In areas with a long history of human activity, such as the Mediterranean basin, intense exploitation or complete destruction of forests for agricultural and pastoral purposes has, in many cases, altered the original composition of species and the natural environment. Therefore, the afforestation of bare land has been carried out since the nineteenth century.

In Italy, afforestation has traditionally been the main practice of forest and mountain policy. The species most used were conifers: black pine (Pinus nigra Arn.), maritime pine (Pinus pinaster Ait.), Aleppo pine (Pinus halepensis Miller), stone pine (Pinus pinea L.), radiata pine (Pinus radiata Don.), Douglas fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii Franco), cypresses (Cupressus sp.) and cedars (Cedrus sp.). This has led to the creation of extensive monocultures of conifers. During 1994–2000, 100,000 ha were afforested in Italy and 97% of these were planted with broadleaves.

Recently, in addition to economic and productive objectives, the creation of new forest areas has become increasingly important in the context of their environmental functions. Forest restoration of abandoned agricultural land may be pursued mainly inside protected areas.

A secondary succession (perennial grass, light-demanding shrubs, light-demanding fast growing trees and late successional trees) would take >100–150 years (Odum, 1971; Miyawaki, 1999; Quézel & Médaillé, 2003; Kimmins, 2004), whereas the final native forest could be reached in a very short time (a few tens of years) with human intervention.

Since the 1980s, the traditional techniques of afforestation have been revisited on the basis of new knowledge on forest ecosystem functioning and symphytosociological studies (Miyawaki, 1998, 1999; Quézel & Médail, 2003; Rivas-Martinez, 2005) summarizing and simplifying the principle of “consulting nature in planting forest”.

In Italy no cases of afforestation according to the above-mentioned approach have been documented.
This report presents a study of forest restoration in a protected area in central Italy, with the aim of comparing the success of different tree species.

Materials and methods

Study site

The study was conducted in the Valle del Bove, Campotosto (AQ) in the Gran Sasso and Monti della Laga National Park, located in central Italy (42°36′ N, 13°22′ E, 1480–1560 m a.s.l., north to north-east aspect, slope 25–40%).

Mean annual precipitation is 1047 mm and summer precipitation is 163 mm, without a dry period. Snow cover usually extends from November to March/April. The mean annual temperature is 7.1°C; the mean temperature of the coldest month is −2.5°C and of the warmest month 18.0°C. According to the bioclimatic classification of Rivas-Martinez, the thermopluviometric station of Campotosto (1430 m a.s.l.) belongs to a temperate macroclimate (bioclimate: oceanic; bioclimatic belt: upper supratemperate; ombrotype: upper humid).

The predominant bedrocks are sandstones. Soils classified as Typic Haploxerept (Soil Survey Staff, 2003), are silt loam, acid and deep (> 60 cm).

The vegetation type was a regression of a subseral stage of acid beechwoods belonging to Veronico urticaefolia–Fagetum Montacchini 1972 (Longhitano & Ronisivalle, 1974; Feoli & Lagonegro, 1982).

Land cover on the study site consisted of shrub species (28%), while 72% was bare land. In part of this area, initially forming agricultural land and pastures, abandonment led to a secondary succession with bracken (Pteridium aquilinum L.), followed in a short time by shrub vegetation with broom (Cytisus scoparius L.) (Tammaro, 1998), associations dynamically joined to acid beechwoods.

Following Mercurio (2001), two criteria guided the present forest restoration procedures:

- Tree species were chosen after a field investigation of the area according to a symphytosociological approach (Rivas-Martinez, 1976, 1987, 2005), a sequential establishment of species of different characteristics or stages of succession. Forest restoration means the speeding up of a progressive succession which tends upwards to the potential natural vegetation (Tüxen, 1956) using native species of these vegetation series. The first idea was to introduce at different times, first early successional species, to create a canopy cover, and then late successional species, but bureaucratic rules did not allow this option, so all tree species were planted simultaneously.

- The pattern of plant distribution aimed to reduce the impact of the artificiality of plantations (Lucas, 1991; Del Peso & Bravo, 2008), providing diverse habitats for birds, insects, etc. For this, curved rows (Lucas, 1991) and clusters (Schoenenberger, 2001; Twedt, 2006) were considered.

Two different planting techniques were used in relation to soil inclination:

- Sites with a slope < 25% and flat morphology. Soil preparation consisted of a full deep cultivation (ploughing) up to 70 cm and plants were arranged in curved rows (3 m between rows and 2 m along the rows). This reduces planting costs and the following tending operations. Tree species composition concerned: early successional species (in the same percentage among species): goat willow (Salix caprea L.), birch (Betula alba L.), aspen (Populus tremula L.), rowan (Sorbus aucuparia L.), whitebeam (Sorbus aria Crantz.), wild cherry (Prunus avium L.) and sycamore (Acer pseudoplatanus L.); and late successional species: beech (Fagus sylvatica L.) (70%), Norway maple (Acer platanoides L.), ash (Fraxinus excelsior L.), lime (Tilia cordata Mill.), silver fir (Abies alba Mill.) and yew (Taxus baccata L.) (30%). Stocking was 1100–1600 plants ha⁻¹.

- Sites with slope > 25%, and with rough morphology. The technique mirrors natural, ecological succession, favouring the transition from pioneer shrubland to mature forests. All this translates into economic and, particularly, ecological benefits, reducing the visual impact of the afforestation, helping to create spatially non-uniform and more diverse stands that are more resistant to pathogens, herbivores and climatic hazards (Schoenenberger, 2001). This approach also largely avoids the problems of erosion caused by traditional, more aggressive techniques that eliminate the shrub cover using heavy machinery. These advantages are particularly relevant in protected areas where conservation and minimization of impact are a major priority or in mountain areas with complex orography. Soil was prepared in holes and seedlings were arranged in clusters (inside the cluster the seedlings were placed at a distance of 2 m while the distance between clusters was 4 m). Tree species composition was the same as the previous technique, and stocking was 400 plants ha⁻¹.
In all cases 1–2-year-old bare root seedlings were used. Planting was carried out in spring 2001.

Tending operations involved fencing of the entire afforested area with a 1.25 m high wire mesh, replacement (beating up) of failed seedlings and manual cultivation around the seedlings.

**Data collection and statistical analysis**

At the end of the fifth growing season, damage by animals, survival rates, vitality status and total height of different tree species were surveyed in a randomized sample of 30 individuals of each tree species only in the sites with slope <25% and with flat morphology.

The levels of vitality used were: vigorous (seedling is healthy, densely foliated and undamaged or only slightly damaged), moderate vitality (seedling is reasonably healthy, fairly foliated and/or moderately damaged) and weak (seedling is unhealthy, poorly foliated and/or severely damaged).

Differences between different tree species were analysed using one-way anova (Sigmastat 3.1; Systat Software, USA) and Duncan’s test. The results shown in the figures are expressed as mean ±SD.

**Results**

**Damage by animals**

Most of the juvenile seedlings in the mountainous areas suffered from higher wild fauna pressure. The type of fencing applied was not able to prevent browsing damage by hare (*Lepus europaeus* L.), roe deer (*Capreolus capreolus* L.) and wild boar (*Sus scrofa* L.). Such damage could be avoided by using plastic shelters (mainly against hares), but this treatment was excluded because of the high costs and visual impact. Figure 1 shows the percentage of damage by game. Hares eat the vegetative apex and bark (60% of broadleaves damaged), which could kill the seedlings. Damage by roe deer reached 70% (only in the silver fir).

**Mortality**

Excluding the mortality caused by game, high rates of mortality were recorded in beech (15%), silver fir (33%) and yew (64%). In the other tree species mortality was less than 8% (Figure 2).

**Vitality status**

The level of vitality was: “vigorous” in all tree species, while it was classified as “weak” in the sites with slope >25% and with rough morphology because seedlings were frequently bent by snow accumulation.

**Total height**

As shown in Figure 3, tree species with the highest total height were birch (2.26 m), goat willow (2.18 m), aspen (2.05 m), rowan (1.95 m), sycamore (1.82 m), wild cherry (1.62 m) and whitebeam (1.61 m). Intermediate height was achieved in Norway maple (1.39 m), ash (1.10 m) and lime (1.00 m), while low total height was recorded in beech (0.95 m), silver fir (0.83 m) and yew (0.49 m).

Light-demanding species, or pioneer trees, such as goat willow, birch, aspen, rowan, whitebeam, wild cherry and sycamore, grow rapidly in height and
form an upper canopy stratum, unlike late successional species (beech, etc.).

**Discussion**

The results confirm that game browsing is a very important factor that needs to be taken into account, as it can have profound effects on the long-term afforestation success (Didion et al., 2009). This has been noted in other Italian protected areas where hunting activities are prohibited (Cutini & Mercurio, 1998; Paci & Bianchi, 2009). Hares are responsible for most of the damage (bark stripping and browsing) during the winter months (Gill, 1992). Silver fir is the species preferred by roe deer (Gill, 1992a). The damage was more severe than in broadleaves, owing to the habit of roe deer selectively browsing the terminal buds of juvenile conifer trees, especially during winter, when they represent one of the most important food sources for the deer.

Five years after planting, birch, goat willow, aspen and rowan showed the highest development in height and good individual vitality under the given environmental conditions of the study site. Birch, in particular, showed high growth, as would be expected from this early successional species, which can grow on altered soils owing to its low nutrient demands (Fiedler et al., 1973).
In general, pioneer trees grow rapidly in height, allocate more growth to the stem and branches, and have crowns with low leaf area density (Canham et al., 1994; Haggard & Ewel, 1995; Sheil et al., 2006).

Previous afforestation techniques treated pre-existing shrub vegetation as a source of competition for the newly planted young trees and, consequently, shrubs were cleared by different methods or seedlings were planted far from shrubs. However, interactions among plants may be positive (Callaway, 1995), conserving soil moisture and enriching nutrient content (e.g. Cytisus sp. are nitrogen-fixing species). Shrubs provide regeneration niches, thereby increasing reforestation success by ameliorating the microclimate and by protecting seedlings (although not in this study) against ungulate herbivores (Castro et al., 2002, 2004; García et al., 2000; Gomez et al., 2001, 2003; Pommereining & Murphy, 2004; Padilla & Pugnaire, 2006; Valladares & Gianoli, 2007). The effect of competition by shrubs on tree growth in this study was observed only in yew and silver fir, but not in the broadleaves (not shown in figures). Verification is needed in the next few years.

The afforestation method here proposed differs from those of Miyawaki (1998, 1999) because it uses fewer species (from local nurseries) and involves mechanization of all planting and tending operations.

This experience has produced some preliminary conclusions. First, the success and retention of afforestation in protected areas depend on reducing the game population. Secondly, benefits were gained by using carefully designed species mixtures, i.e. complementary resource use between species that arise from development of a stratified canopy (and possibly root stratification) and facilitative improvement in nutrition. Furthermore, afforestation with mixed species enhances ecological resilience, promotes the conservation of biological diversity, increases species diversity to diminish pathogen attacks, and represents an important preventive measure to cope with climate change effects.

The very different development of the tree species suggests that afforestation could be completed at different times, first with early successional species, as a nurse crop, then underplanting the late successional species.

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