LUIGI PORTOGHESI (*) (°) - MARCO CONSALVO (**) - ALICE ANGELINI (*) - BARBARA FERRARI (*)
ANNA BARBATI (*) - CRISTIANO CASTALDI (***) - PIERMARIA CORONA (***)

MULTIFUNCTIONAL MANAGEMENT OF MOUNTAIN REFORESTATIONS: THOUGHTS AND PERSPECTIVES FROM A CASE STUDY IN CENTRAL ITALY

(*) Department for Innovation in Biological, Agrofood and Forest Systems (DIBAF), Università della Tuscia, Viterbo, Italy.
(**) Corpo Forestale dello Stato (CFS), National Center for the study and maintenance of forest biodiversity, Castel di Sangro (L'Aquila), Italy.
(***) Consiglio per la ricerca e la sperimentazione in agricoltura, Forestry Research Centre (CRA-SEL), Arezzo, Italy.
(°) Corresponding author; Dipartimento per la Innovazione nei Sistemi Biologici, Agroalimentari e Forestali, Università della Tuscia, via San Camillo de Lellis, 01100 Viterbo, Italy. lporto@unitus.it; tel. +390761357406; fax +390761357389.

*The conifer reforestations established during the last century in many mountainous areas of Central and Southern Italy allowed the restoration of thousands of hectares of degraded bare lands. During the last sixty years many social and environmental functions were added to such forests and now they require a multifunctional management approach. A 100-years old reforestation with black pine (*Pinus nigra *Arnold) located in a mountain tourist area and within a Natura 2000 site in Central Italy was taken into consideration as a case study. The stands, although even-aged and dense, have a diversified structure as a consequence of localized wind throws and the growth of an underlayer of hardwoods. The traditional, timber production-oriented management based on strip clear cutting has shown to be inapplicable in such a context. Systemic silviculture grasps this challenge as it assumes as fundamental management goal the search for the functional efficiency of the forest ecosystem. In such a perspective silvicultural practices are guided by an adaptive approach, based on trial and error, rather than on so-called normalisation schemes. Starting from the concept that forest is a complex, self-regulating, dynamically changing system, a management trajectory is proposed to foster the gradual succession of the pine stands towards different types of pure and mixed hardwood forest according to site conditions. The basic silvicultural criterion is to reduce gradually the pine cover by thinning and opening of small gaps in order to increase tree age and size diversity. The public incentives necessary to implement this sort of management are justified by the goal of increasing the functionality and resilience of the forest system: both elements can reduce the risk of damages for the forests. This paper aims to provide general considerations on such issues in the form of a commentary discussion with reference to the considered case study.*

Key words: mountain reforestation; *Pinus nigra*; forest management; systemic silviculture; stand structure.
Parole chiave: rimboschimenti montani; *Pinus nigra*; gestione forestale; selvicoltura sistemica; struttura del popolamento.

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1. INTRODUCTION

Since the end of the nineteenth century, over a million hectares of bare lands were reforested, mainly by conifers, in the hills and mountains of central and southern Italy (CORONA & MARCHETTI, 2002) to render neglected areas productive, protect exposed soils from erosion, prevent flooding, and foster employment in disadvantaged rural territories.

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A tree species widely exploited in these efforts was black pine (*Pinus nigra* Arnold subs. *austriaca*, *italica* and *calabrica*), which proved to be particularly suitable for reforesting slopes with shallow soils and harsh climatic conditions (e.g. prolonged summer drought and intense autumn rainfalls). Black pine was also successfully used in other northern Mediterranean countries (e.g. CASTRO *et al.*, 2002; VALLAURI *et al.*, 2002; REY & BERGER, 2006; FERNÁNDEZ-ONDOÑO *et al.*, 2010).

Over the last sixty years these pine forests have begun to play new social and ecological roles. They are important components in the landscape of several mountain areas where tourism and leisure activities are a fundamental part of the local economy, and become essential to improve forest biodiversity condition and to increase carbon sequestration (CHIRINO *et al.*, 2006; CORONA *et al.*, 2009). Despite their relevant multifunctionality, they have been neglected from management for several decades. This is due to the depopulation of the mountain areas under Mediterranean conditions and to the increase in the costs of forest harvesting vs. the low commercial value of wood.

The lack of silviculture practices resulted in negative effects on the stand stability and in loss of biomass: forest plantations have become more vulnerable to various disturbances (mainly fire, wind storms and biotic attacks) fostered by climate change (recurring drought) and phytotoxic pollutants (CORONA *et al.*, 2009). On the other hand, in many reforested areas site conditions have become more favourable for the establishment of native tree species under the pine cover. These successional dynamics can gradually and continuously transform the forest landscape (e.g. ZERBE, 2002; TONON *et al.*, 2005; GORIS *et al.*, 2007; ZLATANOV *et al.*, 2010).

In Italy forest management traditionally proposed for pine reforestations was timber oriented and based on clear cutting on strips to regenerate pine in uniform, even-aged stands. However, the current ecological and socio-economic changes generate the need for new, multifunctional approaches to forest management and silviculture (SCHLAEPFER *et al.*, 2000; WEBER *et al.* 2002; BARBATI *et al.* 2010; LINDNER *et al.*, 2010) whose goal should be enhancing diversification of tree composition and stand structure. Under this perspective a new approach is referred to as systemic silviculture (CIANCIO & NOCENTINI, 1997; CIANCIO *et al.*, 1999; CIANCIO & NOCENTINI, 2004; CIANCIO & NOCENTINI, 2011): the key concept is the respect of the self-organizing ability of forest systems, which can be achieved by increasing their complexity and biodiversity without predetermining the stand structure. Silvicultural practices are guided by an adaptive approach, based on trial and error, rather than on so-called normalisation schemes (CORONA & SCOTTI, 2011).

This paper aims to provide general considerations on such issues in the form of a commentary discussion with respect to a selected case study. We examined a group of black pine stands created at the beginning of the last century in central Italy, with the aim to characterize their successional trend in order to support it through appropriate silvicultural practices. Specifically, we have addressed the following questions:

1) which changes are taking place in the reforestation after the abandonment of active management?
2) which should be the most appropriate silvicultural criteria to be applied to accommodate current stand dynamics and increase diversity of tree composition and forest structure?

2. FRAMEWORK OF THE SYSTEMIC SILVICULTURAL APPROACH

Traditional silvicultural schemes aiming at predetermining and implementing a specific forest structure, in the search of an optimized timber yield, have been criticized as inappropriate and out of date to deal with multifunctionality and the complex and not linear nature of ecosystems (CIANCIO *et al.*, 1999; PUETTMANN *et al.*, 2009; BARBATI *et al.*, 2010; MESSIER *et al.*, 2013). Furthermore, in many woodlands the disappearance of a local timber market is matched by a greater acknowledgment of the environmental and social role of forest. This change requires a more flexible forest management approach. Management goals must be widened in order to ensure greater stability to the forest ecosystems, both in physical and ecological terms, and to encourage minimal tending practices.

In order to achieve these aims, various concepts have been proposed that encompass all kind of forest types, like Close to Nature Silviculture (MLINSEK, 1996), or refer specifically to mountain silviculture, such as Minimal Tending (SCHÖNENBERGER, 2001; WEBER *et al.*, 2002). In Italy the debate on these issues has led to the concept of systemic silviculture, and to the related concept of re-naturalisation of woodlands (NOCENTINI & COLL, 2013). The latter idea implies a dynamic view of nature (cf. PICKETT *et al.*, 1992; PERRY & AMARANTHUS, 1997; TILMAN, 1999) and does not aim so much at striving to reproduce the pristine state of a forest, but rather at fostering the processes of natural self-organisation of the stands and increasing biodiversity, with positive effects on the functions and stability of the ecosystem (MESSIER *et al.*, 2013).

According to the systemic approach, re-naturalisation is achieved through actions based on the following concepts (CIANCIO & NOCENTINI, 1997; CIANCIO *et al.*, 1999; NOCENTINI & COLL, 2006):

a) forest is a complex biological system that reacts to all natural events or human intervention through self-organisation or self-perpetuation mechanisms (LEVIN, 2005; NOCENTINI, 2011; MESSIER *et al.*, 2013); the stand/forest's reactions to any kind of event results in a situation that can never be exactly the same as before and is difficult to predict because ecosystems are under continuous development;
b) the ability of the system to react to events without regressing depends on its resistance and resilience (HOLLING, 1978; HOLLING, 1986; HOLLING & MEFFE, 1996; CORONA & SCOTTI, 2011); these capacities in turn depend to a great extent on the diversity of the system in its different aspects: species, genetic, structural and functional.

The main implications for forest management can be summarized as follows:

– silvicultural intervention are conceived to be of low impact and to maintain or increase diversity, according to individual circumstances, enhancing the natural forest stand dynamics but without a sequence of treatments defined *a priori*, as is the case in the classical concept of forest normalisation (*sensu* LEUSCHNER, 1984); no somatic or chronological structure is pre-defined and regular in time and space (i.e. normal even-aged or uneven-aged forest); the structure and composition should be the outcome of the intervention and the forest system reaction;
– forest functioning and structure, and distinctively forest reaction to management measures, are neither completely predictable nor completely random (CORONA & SCOTTI, 2011; MESSIER *et al.*, 2013): under such a framework, management relies on monitoring rather than forecasting: the focus is not on the prediction of the effect of each intervention but rather on the reaction to it as tracked by relevant indicators (KAY & REGIER, 2000: much of adaptive management efforts is learning through experimentation);
– the allowable cut is periodic and based exclusively on cultivation criteria;
– the growing stock should not fall below a minimum level corresponding to the application of the economic principle of the Safe Minimum Standard (CALLICOTT, 1997; CORONA *et al.*, 2011a); in order to increase biodiversity and complexity, the size of this variable varies among forest compartments according to site conditions, the structure and composition, and development and evolutionary dynamics of the forest.

3. FROM THEORY TO PRACTICE: THE MONTE GENZANA REFORESTATION

3.1. Study area

The examined reforestations cover about 160 ha and are localised at an elevation of 1000 to 1600 m a.s.l. along the western slopes of Monte Genzana (2170 m) above Lake Scanno in the heart of the Abruzzo Appennines (42° 05' N latitude, 13° 52' E longitude). Monte Genzana is a Mesozoic-Tertiary succession of pelagic limestone, cherty limestone and marls with redeposited sediments derived from the nearby platform margin outcrops. A-C soils rich in limestone skeletons with A horizons often decapitated by erosion prevail on the steeper slopes. A deeper layer of soil frequently containing an accumulated B horizon rich in mineral clays is present on former agricultural lands and the hillside which was terraced during the reforestation (HERMANIN, 1980).

Average annual rainfall for the area is 1130 mm, with no dry period (144 mm in summer). The rainfall regime is bimodal with its main peak occurring in November-December and a secondary peak in February. The average annual temperature is 10.1°C.

On the lower slopes the residual patches of natural forest consist in mixed stands of hardwoods with downy oak (*Quercus pubescens* Willd.), flowering ash (*Fraxinus ornus* L.), hop-hornbeam (*Ostrya carpinifolia* Scop.), hazel (*Corylus avellana* L.) and maples (*Acer campestre* L.; *Acer monspessulanum* L.). Lime (*Tilia cordata* Mill.) is commonly found in the valleys. Above 1400 m a.s.l. and on the cooler, north-facing slopes, downy oak is replaced by Turkey oak (*Quercus cerris* L.) which sometimes forms pure stands. Ample stretches of beech (*Fagus sylvatica* L.) with white beam (*Sorbus aria* Crantz.), rowan (*Sorbus aucuparia* L.), sycamore (*Acer pseudoplatanus* L.) and willow (*Salix caprea* L.) are found above the mixed forests.

3.2. Surveyed reforestations

The Monte Genzana reforestation was carried out since 1910 by public funding to prevent the Lake of Scanno from silting up and to protect agricultural land and farm buildings. At the beginning of the last century, large parts of the slopes were devoid of forest vegetation due to deforestation and over-grazing which had degraded the remaining coppices. The soil was poor in organic substances with extensive, rocky patches and was completely eroded on the steeper slopes.

The higher reaches of the slopes were terraced to facilitate the planting and to dam the rainfall running downhill so that it would soak into the soil. Lower down the reforestation covered abandoned farmland and filled in the extensive glades in the woods.

The tree species planted were mainly Austrian black pine (*Pinus nigra* Arn ssp. *austriaca* Hoess-Novak) and Villetta Barrea pine (*Pinus nigra* ssp. *italica* Hochstetter), although some Norway spruce (*Picea excelsa*, Link) and Scots pine (*Pinus sylvestris*, L.) were used as well.

Currently over 80% of this reforestation is included in the Natura 2000 network area of Monte Genzana (code IT7110100). It is part of a breeding ground for bears (*Ursus arctus marsicanus*, L.), harbours wolves (*Canis lupus*, L.), wildcats (*Felis sylvestris*, Sch.) and a rich variety of birds, including *Alectoris graeca saxatilis* (Bech.), *Pyrrocorax pyrrocorax* (L.) and *Lullula arborea* (L.).

Besides its value as a nature conservation area, Monte Genzana is also popular as tourism place. Scanno village has a population of 2000 people that doubles during the summer and winter tourist seasons, with a peak of 7000 visitors in August.

In 1980, a Forest Plan aimed at the productive management of these reforestations was set up. It was based on the perpetuation of black pine in even-aged pure stands by strip cutting or clear cutting in groups with an 80-year rotation, correlating the size of the cutting area to the mean height of the stands (HERMANIN, 1980). This plan has never actually been put into practice because of the high costs of harvesting and the low commercial value of the timber, which made an intensive management scheme of this type non-cost effective. The only intervention carried out in some sites was the removal of dead and diseased standing trees.

3.3. Data collection

The reforestations were subdivided into homogeneous strata on the basis of stand density, composition and age. The five oldest strata (with stands aged from 85 to 103 years) where successional processes were supposed to be more evident were selected for the investigation, for a total area of 77 ha. The topographic features of the site (altitude, aspect, slope) and the stem diameter at breast height (DBH) of all the trees above 2.5 cm were recorded by two 900 m^2 squared plots randomly selected in each stratum (for a total of 10 sample plots). A sample of 20 tree heights per plot was also collected to determine the height-DBH relationship and to calculate the stand top height. The topographic position of all the stems within two 10-m-wide transects along the diagonals on each sample plot was mapped, and tree crown size was measured on four perpendicular radii.

Natural tree regeneration was surveyed within two 1x30 m orthogonal transects located in each plot. The transects were divided into squares of one square meter each. Density and height of the trees with DBH lower than 2.5 cm were measured in each square segment, distinguishing the following regeneration classes:

– class A: trees higher than 1.3 m (saplings), considered as advanced regeneration;
– class B: trees with a total height lower than 1.3 m (seedlings).

The regeneration index proposed by Magini (RI; MAGINI, 1967) was used to compare regeneration conditions among the plots, separately for hardwoods, black pine and Norway spruce. The index estimates the degree of advancement of natural regeneration by the seedlings and sapling density (number per m^2) times their average height (expressed in cm). A RI value higher than 100 expresses a suitable level of stand reinitiation. The Shannon Index (SI) was used to quantify the diversity of tree species regeneration in the plots. The SI was calculated on the basis of the frequencies of tree species. The stand profile of each plot was drawn using the Stand Visualization System program (http://faculty.washington.edu/mcgoy/svs.html).

3.4. Results

In all the examined sample plots, black pine dominated the stand overstorey, accounting for 90 to 100% of total basal area, with the exception of plot ID 8 which had a significant number of Norway spruce trees. In terms of number of trees per hectare, the percentage of black pine was found to be far more variable (Table 1). The hardwoods in the understorey had low average DBH values compared to black pine, and thus they made up a low percentage of stand basal area despite amounting to over 60% of the total number of trees in some sample plots (Table 1).

The density of natural regeneration was low (Table 2), both for seedlings and saplings, and negatively related to altitude (Pearson correlation coefficient = -0.81): harsher site conditions at higher altitudes hinder regeneration both at the seedling and the sapling stage. Sapling development is also affected by geomorphologic conditions, particularly by

Table 1 – Main stand features in the sample plots (SP).

SP ID	Altitude m a.s.l.	Slope %	Age year	Trees per ha		Basal area (m^2 ha^{-1})		Mean b.h. diameter (cm)		Top height (m)
				total	Pine (%)	total	Pine (%)	Total	Pine	Pine
1	1130	57	93	981	38.7	38.8	91.5	22.0	34.5	21.3
2	1010	51	85	986	60.6	49.3	98.2	25.0	32.1	20.9
3	1400	46	103	576	95.7	44.3	99.1	31.3	31.9	19.6
4	1530	53	103	886	100.0	75.3	99.7	30.5	32.8	18.9
5	1490	51	103	717	96.9	61.8	99.9	33.1	33.6	18.9
6	1550	37	103	1457	91.8	39.0	99.4	18.5	19.2	18.9
7	1590	53	93	710	74.6	52.7	99.2	30.8	35.5	20.4
8	1490	50	93	1150	36.6	56.4	59.9	25.0	32.0	19.9
9	1420	48	103	905	63.4	59.2	95.7	28.9	35.4	20.4
10	1390	67	103	1348	37.1	50.7	92.1	21.9	34.5	20.3
Mean				972	69.6	52.8	93.5	26.7	32.2	20.0

Table 2 – Characteristics of the natural regeneration under the black pine cover (SP = sample plots; RI = Magini regeneration index; Hardw = hardwood species; SI = Shannon index).

SP	RI	RI	Regeneration (class A)			Regeneration (class B)		
ID	Hardw	Pine	No. of species	n m^{-2}	SI	No. of species	n m^{-2}	SI
1	3.0	55.0	5	0.08	1.42	5	1.38	1.04
2	175.0	0.3	4	0.22	1.00	8	2.77	1.35
3	28.5	42.0	1	0.04	0.00	1	1.26	0.87
4	20.4	19.0	2	0.03	0.56	5	0.68	1.41
5	23.2	1.4	0	0.00	0.00	6	0.53	0.98
6	22.9	38.6	3	0.13	0.46	5	0.38	1.05
7	22.3	3.0	2	0.02	0.69	7	0.40	1.38
8	33.5	0.5	2	0.07	0.69	10	0.44	1.62
9	43.0	1.0	2	0.02	0.69	8	0.82	1.09
10	102.0	3.1	6	0.13	1.35	8	2.47	0.82
Mean	47.4	16.4	2.7	0.07	0.69	6.3	1.11	1.16

site steepness, which is negatively correlated with regeneration height (Pearson correlation coefficient = -0.70).

Regeneration was dominated by hardwoods that had an average RI value twice that of black pine (Table 2). The hardwoods had RI higher than 100 in two sample plots where the reforestation mixed with patches of old residual coppices. Black pine had a higher RI than the hardwoods in the three sample plots where the stand overstorey was opened by windthrows or thinning. There was however a good variety of species present. Twelve species of hardwoods were present in regeneration class B: beech, Turkey oak, downy oak, hop-hornbeam, maple, flowering ash, rowan, cherry (*Prunus avium* L.) and laburnum (*Laburnum anagyroides* Medik), as well as black pine and Norway spruce.

On average, six different species were found in each transect used for surveying tree regeneration. The only species present in all the transects was pine. Turkey oak and downy oak were present in two transects out of ten, respectively. All the other species were surveyed in four to six transects.

The same species were present in regeneration class A with the exception of downy oak and spruce. The absence of downy oak from regeneration class A is remarkable when we consider that it represents more than 40% of the regeneration class B in several transects. There was only an average of three different species in each single transect. Black pine was found in five transects, Turkey oak and beech in four. However, the Shannon index calculated for the top class A proved to be significantly correlated to the top height of black pine (Pearson correlation coefficient = 0.79): as expected, the greater the fertility of the site, the greater the chance of success for multi-species regeneration.

4. Discussion

Systemic silviculture can be applied successfully following a careful analysis of the stand structure in order to highlight the type of natural dynamics which may be fostered by intervention. In the case of the Monte Genzana reforestation, the following points emerged from the analyses carried out:

– the structure of the oldest pine stands is on the whole still uniform and simplified, dominated by the black pine that forms extensive even-aged stands deriving from the initial planting;
– pine cover is still predominant but not with a continuous cover, thanks to the presence of: (a) small groups of pre-existent hardwood sprouts: the original reforestation was “irregular” since pine was planted among scattered patches of hardwoods to increase the tree coverage; this explains why there are isolated standards of beech, Turkey oak and downy oak in the overstorey (Figure 1) and the conifer stands are broken by small clumps of stumps that have produced a

large number of sprouts which now form an understorey of beech, Turkey oak, downy oak, black hornbeam, maples, flowering ash and common laburnum, depending on site conditions (Figure 2); (b) gaps created by natural disturbances;

– the layer of regeneration under the cover of the black pines is neither abundant nor uniform despite the fact that it consists of numerous species of hardwoods; in many cases it hardly has further development because of the dense overstorey; the

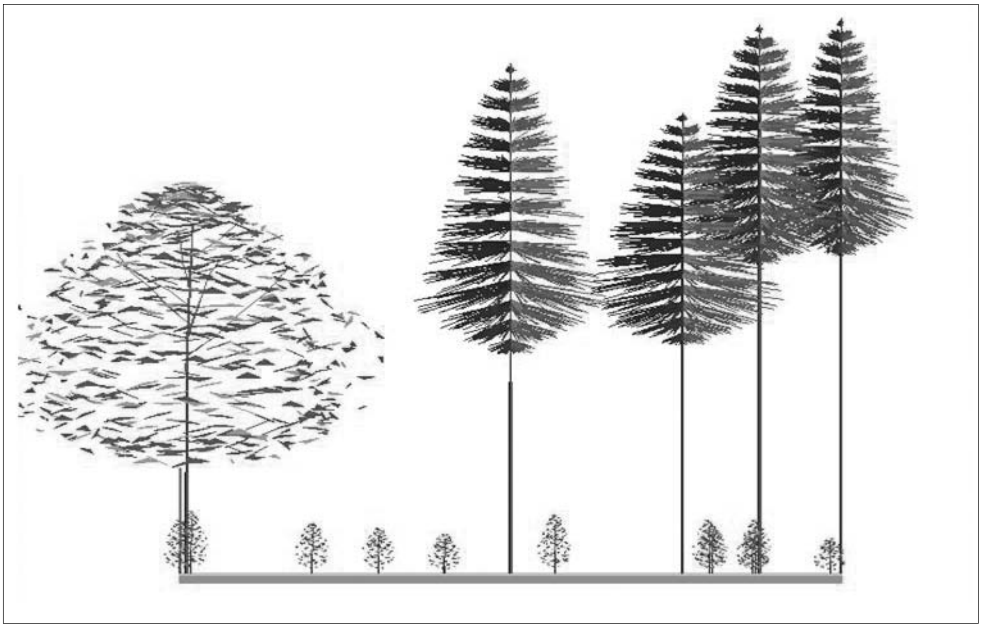

Figure 1 – Stand profile of the sample transect in the plot ID 10. Isolated aged standards of beech and oak scattered in the pine stands produced seeds for natural regeneration.

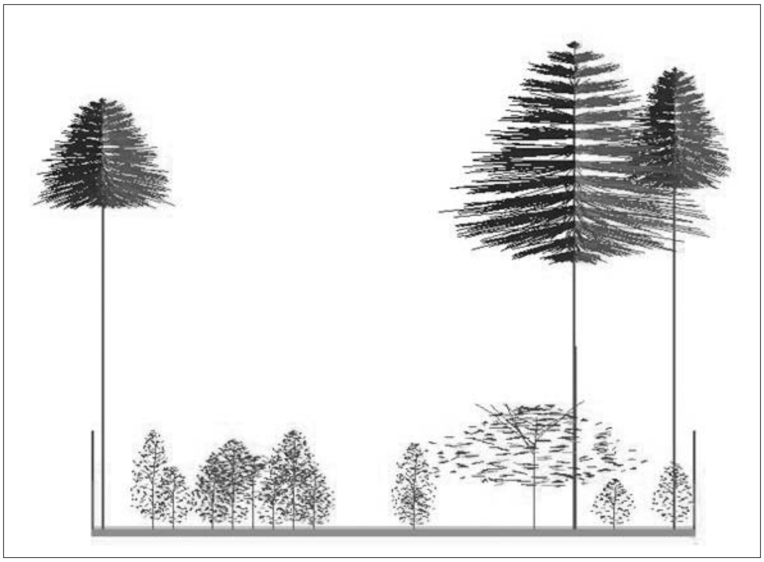

Figure 2 – Stand profile of the sample transect in the plot ID 2. Where small openings allow the sunlight to reach the forest floor, the resprouting from stumps creates a layer of hardwoods under the pine cover.

composition and density of the regeneration depend on variable site conditions and soil fertility.

Under these circumstances, fostering the natural processes already evident in the stands means to facilitate the replacement of the pine stands with hardwood forests, in particular with beech woods at higher altitudes and mixed oak woods at lower altitudes. Given the different site conditions along the slopes of Monte Genzana, the development of the coverage will lead to a finely-grained mosaic of different forest types ranging from pure pinewoods to pure beech woods and to mixed oak woods, with all possible intermediate stages. However, this process can be suitably supported over a period of time through a series of silviculture interventions in order to preserve the whole range of tree species present in the area and to ensure the survival of black pine for as long as possible to make sure that the landscape is transformed gradually.

In the more fertile areas that are characterized by a top height ≥ 20 m and at altitudes below 1400 m, selective thinning can be carried out. Reducing overstorey density will help the groups of existing sprouts to reach the overstorey and further encourage the spontaneous production of hardwood seedlings. Given the variety of situations found in terms of pinewood density and in terms of density and composition of the underlying layers of hardwoods, it will be necessary to customise the intervention, evaluating how urgent it is and how many trees need to be cut at each site, bearing in mind that if the upper layer is drastically reduced this favours the regeneration of black pine. Distinctively, the residual standing volume must not be lower than 100-150 m^3 ha^{-1}, a limit that can be considered as precautionary in application of the Safe Minimum Standard principle (CALLICOTT, 1997; CORONA *et al.*, 2011a).

In areas with no natural regeneration and where the soil is particularly thin, it may be useful to prolong the presence of the pines in their role as a species which prepares the soil, delaying the vegetation development towards a more complex system. These areas, which are still relatively unfavourable to the development of hardwoods, are found at higher altitudes and on the steeper slopes. In this case, silvicultural intervention will be limited to the partial removal of some dead, decaying or suppressed trees. Where there is a significant presence of pine seedlings the creation of a gap with a diameter equal to the average height of the surrounding trees will usually foster the rapid growth of the young trees and the formation of new age classes without sparking erosion (CIANCIO *et al.*, 2006). However, it is necessary to check and, if possible, quantify the effects and rates of successional dynamics: monitoring becomes the basis for the action (CORONA *et al.*, 2011b; NOCENTINI & COLL, 2013).

A gradual approach to the transformation of the woodland to a more varied and stable system will also increase the complexity of the landscape, making it into a mosaic of different habitats and microhabitats.

Forest management must also comply with the conservation objectives of the Natura 2000 area the stands are located in (CIANCIO *et al.*, 2003). The habitats to be safeguarded in this case are the semi-natural calcareous grasslands and *Juniperus communis* (L.) formations. At the moment, they are well-preserved: however, their maintenance in the areas bordering on the reforestations requires a check to be placed on the natural expansion of the black pine, which tends to take over adjacent open space.

Leaving dead trees, whether still standing or fallen, is an important component of systemic silviculture. Decomposing trees both contribute to biodiversity and supply an alternative source of food for birds and wild animals, especially bears, during certain periods of the year (POSILLICO *et al.*, 2002). However, because the Monte Genzana area has a lot of tourists, it would be inadvisable to leave dry deadwood near the most popular paths in order to reduce the risk of fire (MOREIRA *et al.*, 2011).

The landscape and naturalistic value of these artificial woodlands calls for low environmental impact logging, to minimise the disturbance to the local fauna. Traditional methods using horses and mules, still applied by the local harvesting cooperative firms, should be encouraged because they can use existing bridle paths without having to push new access roads through the woods.

The proposed measures must be put into practice over a period of time, carried out with all due caution and adapted, site by site and stage by stage, to the reactions of the forest system. Therefore monitoring will be fundamental in order to decide what further action should be taken: thus, forest management becomes an adaptive management process which evolves together with the system itself, with the main aim of fostering complexity and biodiversity in the woodland.

5. Conclusions

The examined case study highlightes the need for a flexible silvicultural approach to support the management of black pine reforestation in the Italian Mediterranean mountain areas. Past traditional approach is no longer appropriate in the face of woodlands' new diversified role in a social context that has changed radically. This is a necessity wherever the economic and environmental values of artificially created woodlands today has outstripped its value in terms of timber.

Designing and applying systemic silviculture involves more than simply transferring theoretical reasoning and research to management problems. Setting into motion a process of gradually replacing the conifers based on re-naturalisation along the lines discussed above leads to economic and ecological advantages that have been already experimented in some environmental contexts (e.g. Zerbe, 2002; Zerbe & Kempa, 2005; Zlatanov *et al.*, 2010; Mirschel *et al.*, 2011). The landscape develops without the abrupt changes which sometimes arouse protests from that segment of society which places a high value on the cultural and aesthetic aspects of woodland. Low impact interventions are compatible with soil protection and the goal of enhancing biodiversity. Harvesting a certain amount of lumber both cuts costs and contributes to "eco-compatible" development.

Re-naturalisation leads to the presence of human beings in the forests as a part of the system, with accompanying benefits in ecological, social and cultural terms. This is the woodlands' best protection against various natural adversities and those caused by man (e.g. fires), and thus justifies the public spending necessary to implement this type of management. The ultimate goal is not to maintain an optimal condition of the resource (a concept that becomes meaningless under ever changing environmental and socio-economic contexts) but to develop an optimal management capacity (Corona & Scotti, 2011).

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RIASSUNTO

Gestione multifunzionale dei rimboschimenti montani: considerazioni e prospettive con riferimento a un caso di studio in Italia centrale

I rimboschimenti di conifere realizzati durante il secolo scorso in molte aree montuose del Centro e Sud Italia hanno permesso il recupero di migliaia di ettari di terreni nudi soggetti a erosione. Negli ultimi 60 anni, in aggiunta a quella protettiva, altre funzioni sociali e ambientali sono state attribuite a tali popolamenti per la cui gestione è ora richiesto un approccio multifunzionale. Come caso di studio è stato preso in considerazione un rimboschimento di 100 anni di pino nero (*Pinus nigra* Arnold) situato in una zona turistica in Abruzzo, all'interno di un sito Natura 2000. I popolamenti, sebbene nel complesso puri e omogenei, presentano a tratti struttura diversificata a causa di schianti da vento localizzati e il conseguente sviluppo di uno strato inferiore di latifoglie autoctone in corrispondenza delle aperture della copertura. I tradizionali metodi di pianificazione forestale, orientati alla produzione legnosa e basati sul taglio raso a strisce per favorire la rinnovazione del pino, sono risultati inapplicabili in un tale contesto a causa della scarsa redditività della coltivazione. Viene qui proposto un diverso approccio alla gestione dei rimboschimenti, basato sull'adozione della selvicoltura sistemica, ponendo come obiettivo fondamentale la ricerca dell'efficienza funzionale dell'ecosistema forestale. In questa prospettiva le pratiche selvicolturali sono guidate da un approccio adattativo, basato sul me-

todo per tentativi ed eliminazione degli errori, piuttosto che sui cosiddetti sistemi di normalizzazione. Partendo dal concetto che il bosco è un sistema complesso, capace di auto-regolazione e in continuo cambiamento, l'articolo propone una traiettoria di gestione in grado di favorire la graduale successione della pineta verso diversi tipi forestali in base alle condizioni micro-stazionali presenti nell'area rimboschita. Il criterio colturale è di ridurre gradualmente la copertura del pino mediante diradamenti e l'apertura di piccole buche per aumentare nel tempo la diversità di specie, età e dimensione degli alberi senza bruschi mutamenti del paesaggio. Gli incentivi pubblici necessari per attuare questo tipo di interventi sono giustificati dall'obiettivo di aumentare la funzionalità e la resilienza del sistema forestale: entrambi gli elementi possono ridurre il rischio di danni per le foreste. Questo lavoro si propone di fornire considerazioni generali su tali questioni nella forma di una discussione con riferimento al caso di studio analizzato.

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