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Vegetation dynamics in *Pinus nigra* Arnold subsp. *nigra* 100 years after reforestation: two case studies in the central Apennines

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Abstract
We present here an integrated structural and floristic-vegetational study performed in two representative P*inus nigra* subsp. *nigra* reforestation areas located within Natura 2000 protected areas in the central Apennines, as a mesotemperate thermotype. The aim was to determine the restoration state a century from the reforestation, in terms of a vegetation dynamics study. A diachronic analysis was also performed using data from the literature from a previous phytosociological study in 1973 in the same areas, and considering the adjacent native woods as the control. Although these two reforestation areas had similar ecology and vegetation, this comparison revealed modest structural and flora differences that are mainly related to geographical and topographical factors. This diachronic analysis highlights the structural and flora changes in the reforestation areas considered, and thus the structural and floristic-vegetation stages of the succession that was represented by the plant communities towards *Ostrya carpinifolia* forests (association, *Scutellario-Ostryetum carpinifoliae*) in 1973 and 2012. The minor coverage of conifers that was recorded for the two investigated sites corresponds to an increase in the nemoral species of the class *Querco-Fagetea* and to a widespread decline in ecotone and grassland species. Although the same trend is seen for the structural and floristic-vegetation dynamics, the differences that emerged from the comparison between these two reforestation areas are confirmed by the diachronic analysis. The status of the restoration is a function of the native woods, and thus is a function of the reference site. In this sense, we can consider that for the two sites the restoration status was similar, but not the same, because only within each site can the coenoses in 1973 and 2012 be considered as the developmental stages of the same dynamic process. However, if we consider the situation before reforestation, as derived from the historical documents, it can be seen that the natural vegetation dynamics was favoured, or at least accelerated, in the topographic positions that guaranteed greater edaphic humidity conditions. On the basis of the data obtained, we can say that 100 years after reforestation these two areas produced ecological conditions that guaranteed ingression of the nemoral species that were present in the surrounding woods, with their more than adequate regeneration. As well as representing an essential knowledge base for planning of future silvicultural actions, the knowledge acquired can provide useful indications of auto-ecological features of the species involved in dynamic restoration processes.

Key words: central Apennines, diachronic analysis, dynamism, *Pinus nigra* subsp. *nigra*, restoration ecology, secular reforestation, vegetation.

Introduction

Since the beginning of the last century, widespread reforestation has been carried out throughout Italy using conifers, which were often planted outside their distribution area. Among these, in the Apennines, *Pinus nigra* subsp. *nigra* stands out; this species is generally preferred both for the ease of its nursery propagation and its distinctly pioneering features (Cantiani *et al*., 2005). The aims of this reforestation were essentially the protection and geological restoration of areas that had been subjected to intense erosion and that were degraded because of previous over-exploitation associated with deforestation that was carried out to create areas for agricultural and production activities (e.g., pasture, crops, timber harvesting). More than 100 years have now passed since the start of this reforestation, and in most cases the reforestation was not followed by adequate agricultural management. Thus, although the reforestation has fulfilled its purpose, in terms of reduced erosion processes, today these reforestation areas have problems of efficiency and stability, to varying degrees.

In general, the management objective identified for these coenoses is seen as their restoration, with their natural evolution through the entrance of native species. This represents the process required to guide the system towards the structural and vegetational organisation necessary for their support and maintenance with time. In the literature, there have been numerous studies into conifer reforestation and restoration throughout Italy and in the Apennines. Today, more so than ever before, we are witnessing a cultural evolution that tends to a more ecological view that is more focussed on biodiversity conservation and protection of these populations, especially for those that are within protected areas such as Natural Parks and areas of the Natura 2000 Network, where the primary objective is indeed biodiversity conservation. However, these studies have mostly been silvicultural and dendrometric-

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structural searches (e.g., Amorini & Fabbio, 1992; Nocentini, 1995, 1999; Mercurio *et al*., 2009; Cantiani *et al*., 2005; Gugliotta *et al*., 2006; Nocentini & Puletti, 2009; Barbati *et al*., 2008), and there have been few studies at both the national and European levels that have been based on more distinctly ecological and/or vegetational and phytosociological approaches (Biondi & Ballelli, 1973; Biondi, 1996; Baiocco *et al*., 1996a, 1996b; Vallauri *et al*., 2002; Cristaudo *et al*., 2009, Zerbe, 2002; Gomez-Aparicio *et al*., 2009; Allegrezza *et al*., 2013).

In the present study, we present the results of an integrated structural and floristic-vegetational study of two representative *Pinus nigra* subsp. *nigra* secular reforestation areas in the central Apennines. These fall into the Mesotemperate thermotype, and are located in two Natura 2000 areas: the reforestation of Mt. Predicatore, and of Mt. Tegolaro. These areas were also investigated from a phytosociological point of view in the 1970s (Biondi & Ballelli, 1973). The aims of the present study are: (i) to analyse the structure, vegetation cover, and restoration state of the two reforestation areas 100 years after their planting, through an integrated structural and floristic-vegetation study; (ii) to identify any differences in their restoration states in relation to their environmental and management features; (iii) to define the vegetation succession stages in these two reforestation areas through a diachronic analysis, based on the data in the literature from a previous phytosociological study in 1973 in the same areas, and considering the adjacent native forestation as the control.

Study area

The two areas analysed are located in the central Apennines (Fig. 1). In particular, the reforestation of Mt. Predicatore was along the Marche Apennines in the "Gola della Rossa and Frasassi" Regional Park, while that of Mt. Tegolaro was along the Umbria-Marche Apennines near the Site of Community Importance (SCI) IT5330009 “Monte Gioco del Pallone e Monte Cafaggio” and the Special Protection Zone (Zone di Protezione Speciale; ZPS) IT5330026 “Monte Gioco del Pallone”. From the geological-geomorphological point of view, both Mt. Predicatore and Mt. Tegolaro belong to the lithotype of the “Scaglia Rosata” Formation of the Cretaceous (AA.vv., 1991). The bioclimatic classification sensu Rivas-Martínez *et al*. (2011) indicates that both areas are considered as Temperate macrobioclimate and oceanic bioclimate, with the bioclimatic belt for Mt. Predicatore as upper Mesotemperate upper humid, and for Mt. Tegolaro as lower Supratemperate to the limits of upper Mesotemperate and upper humid (Pesaresi *et al*., 2014).

The reforestation in both of these areas dates back to 1914-1915, with a tree spacing of 1.5 × 1.5 m. According to the available documents, no subsequent silvicultural actions of particular note were recorded. Thus in both cases, these were coenoses left to evolve freely. The Mt. Predicatore reforestation was mainly along the western slopes, and extended over 51 ha, from a minimum of 358 m a.s.l. to a maximum of 736 m a.s.l., which corresponded to the summit of the ridge. At the time of reforestation, the character of these slopes

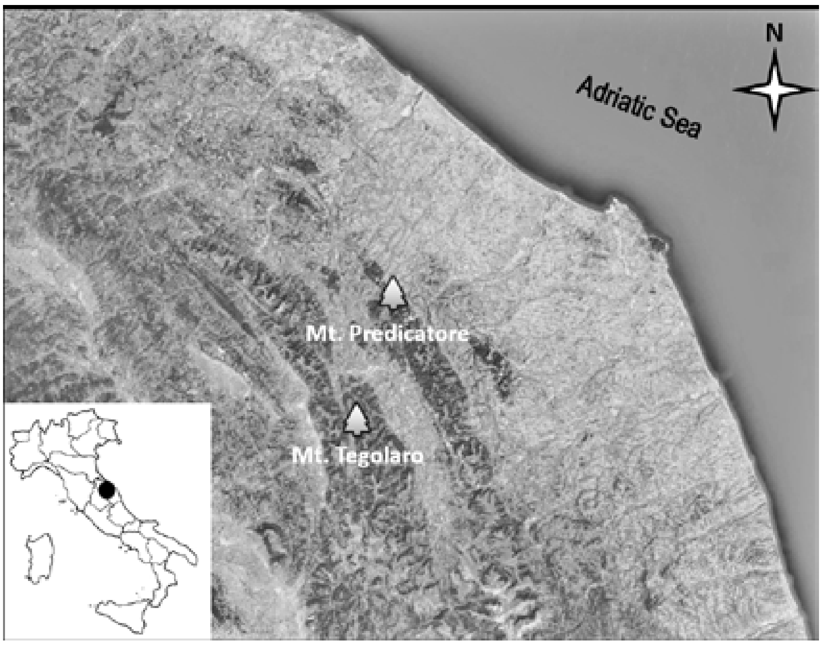

Fig. 1 - The study areas located in the Marche Apennines.

were defined as: "a herbaceous vegetation cover with oak, hornbeam and flowering ash shrubs" (Mannozzi-Torini, 1962). The Mt. Tegolaro reforestation covered 49 ha on the north-western slopes, from a minimum of 550 m a.s.l. to a maximum of 1100 m a.s.l.. The soil at the time of reforestation was extremely degraded and was completely devoid of trees (Mannozzi-Torini, 1962).

The present natural forest vegetation of the adjacent areas to these two reforestation areas (www.ambiente.marche.it) is of mixed autocthonous woods dominated by *Ostrya carpinifolia* with *Fraxinus ornus* subsp. *ornus*, *Acer opalus* subsp. *obtusatum*, and others from the association *Scutellario columnae-Ostryetum carpinifoliae* Pedrotti, Ballelli & Biondi ex Pedrotti *et al*. 1980. This forest coenosis represents the most mature vegetation of the Mesotemperate thermotype, and it is widespread in the central Apennines up to about 1000 m a.s.l. and it corresponds, in these areas, to the "current potential vegetation", in accordance with modern concepts of Synphytosociology (Biondi, 2011).

Materials and Methods

The structural and floristic-vegetational relevés in these two reforestation areas were carried out in the same areas mentioned in Biondi & Ballelli (1973). From the locational data they reported, these were from 650 m to 725 m a.s.l. for Mt. Predicatore, and from 710 m to 755 m a.s.l. for Mt. Tegolaro, and considered homogeneous areas of 400 m2. For each area, a structural analysis was performed according to classical dendrometric-structural methodologies, with the floristic-vegetation analysis carried out following the phytosociological method of the Zurich-Montpelliere Sigmatist school (Br-Bl., 1928), as successively integrated (Tüxen 1978; Géhu & Rivas-Martínez, 1981; Miyawaki, 1986; Géhu, 1991, 2006; Theurillat, 1992; Biondi *et al*., 2004; Rivas-Martínez, 2005; Allegrezza *et al*., 2008; Biondi, 2011; Blasi & Frondoni, 2011; Pott, 2011).

Here, 38 phytosociological relevés were considered: n. 13 in the present study carried out in 2012; n. 17 from the previous study of Biondi & Ballelli (1973); and n. 8 published (Ballelli *et al*. 1982; Allegrezza, 2003) and unpublished relevés from the adjacent woods outside the reforestation areas and/or with the same locational features.

The species were ordered according to their morphologies, considering five structural classes: a, tree-dominated layer; a1, tree-dominated layer as >7 m in height; b, high shrubs layer as 5-7 m in height; b1, low shrubs layer as <3 m in height; c, herbaceous layer, which also included the seedlings of tree species. They were also grouped into syntaxonomic categories according to the phytosociological literature. In particular, these included introduced conifers, nemoral species, ecotonal forest-edge species, and grassland species. The nemoral species were considered as all of those species that according to the phytosociological literature were characterised by the forest classes *Querco-Fagetea* and *Quercetea ilicis*, with the shrubs and herbaceous species of the forest edges included in the classes *Rhamno-Prunetea* and *Trifolio-Geranietea*, respectively. Finally, the grassland species were classified in the 'others' group, along with other species that did not belong specifically to any of the above groups. For each syntaxonomic category, the percentage of coverage was calculated by summing the individual values for each relevé (as the weighted coverage) and then they were transformed into percentages. For the diachronic analysis, the comparison was based on the weighted means of each group of relevés.

The taxonomic nomenclature follows the "Checklist of the Italian Vascolar Flora" (Conti *et al*., 2005, 2007) and the "Flora d'Italia" (Pignatti, 1982). For species from relevés published in the 1970s and 1980s, it was necessary to update the nomenclature for the timely verification of the taxa indicated.

The floristic-vegetational relevés were then subjected to multivariate analysis using the R software (R Core Team, 2012), and in particular the 'vegan' (Oksanen *et al*., 2012) and 'vegclust' (De Cáceres *et al*., 2010) packages. Using the vegclust package, it was possible to analyse the data through a method that is based not only on the specific composition, but also on the structure, with the calculation of the Cumulative Abundance Profile (CAP) (De Cáceres *et al*., 2013).

Results

Mt. Predicatore pine reforestation

Structural analysis

The Mt. Predicatore pinewoods reforestation showed a dominant tree layer that consisted essentially of *Pinus nigra* subsp. *nigra*, occasionally with the sporadic presence of other introduced conifers, such as *Picea abies* and *Abies cephalonica*. The trees were the same age, with a mean height of about 20 m. The plant community structure was primarily determined by the depth and integrity of the black pine canopy, which influenced their coverage too. It was possible to detect the four main structures, as summarised in Figure 2. For the first (Fig. 2A; Table 1, rels. 1, 2), the pine coverage was about 40%, the crowns were not deep (in the upper quarter), with broken treetops for 30% of the plants. The dominated layer was structured and well represented in the different strata (arboreal, high and low shrubs). For the second structure (Fig. 2B; Table 1, rels. 3, 4) the pine coverage was about 50% to 60%, the crowns were mostly not very deep (in the upper quarter), with broken treetops in 30% to 50%

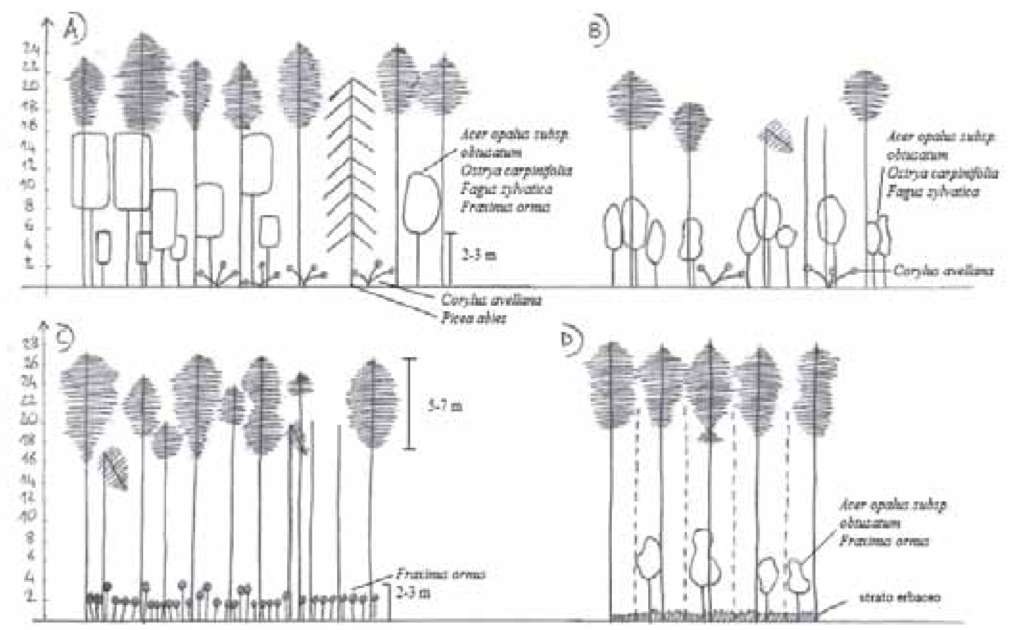

Fig. 2 - Scheme of the main structure for the Mt. Predicatore reforestation.

of the plants. This structure was two layered with the dominated tree layer poorly represented. For the third structure (Fig. 2C; Table 1, rels. 5, 6) the pine coverage reached 70% to 80%, the crowns were about 5 m to 7 m deep, with broken treetops in 30% of the plants. The tree-dominated and high-shrub layers were absent, with a sporadic low-shrub layer that did not exceed 2 m to 3 m in height, and with a well-represented herbaceous layer. Finally, the fourth structure (Fig. 2D; Table 1, rel. 7) was characterised by a pine coverage of 80%, deep crowns, and damaged treetops in 10% of the plants. The high and low shrub layers were poorly represented, with a well-represented herbaceous layer.

Floristic-vegetational analysis

Examination of the phytosociological Table (Table 1, rels. 1-7) revealed that the number of species per relevé varied from 18 to 33. As expected, the relevés that were richest in species were those carried out for the low and medium *Pinus nigra* subsp. *nigra* coverage conditions that did not exceed 50% to 60% (Table 1, rels. 1-4), while the poorest relevés were those for the closed reforestation, with close to 80% coverage (Table 1, rels. 5-7). This was also reflected in the weight of the considered syntaxonomic categories. In particular, under medium and low pine coverage conditions (Table 1, rels. 1, 2, corresponding to structures A and B in Fig. 2), there was an increase in the tree and shrub coverage of the class *Querco-Fagetea*, represented by: *Ostrya carpinifolia*, *Quercus cerris*, *Fraxinus ornus* subsp. *ornus*, *Acer opalus* subsp. *obtusatum*, and others, which were very active in the restoration processes of these areas. Indeed, occasionally these species showed high coverage in the tree-dominated layer and/or in the high and low shrub layers, and they also showed good regeneration in the herbaceous layer. Under these conditions, the contribution of the nemoral species was also important, with *Viola alba* subsp. *dehnhardtii*, *Ruscus aculeatus*, *Galium odoratum, Cephalanthera damasonium*, *Sanicula europea*, *Melica uniflora*, and others, while the forest-edge species and the grassland species were poorly represented. The forest species of the class *Querco-Fagetea* were joined sporadically with those of the class *Quercetea ilicis*, with *Quercus ilex* subsp. *ilex* and *Asparagus acutifolius*, the presence of which highlight the sub-Mediterranean character of the area. Where the pine coverage exceeded 70%, and where *Pinus nigra* subsp. *nigra* was also in the dominated layer, there was the most pioneer feature of these coenoses (Table 1, rels. 5-7): trees and shrubs of the class *Querco-Fagetea*, present almost exclusively in the low shrub layer and mainly represented by *Fraxinus ornus* subsp. *ornus* and a few nemoral herbaceous species. On the other hand, forest-edge shrub species and grassland species (included in the 'other species' category) were more frequent, and included *Brachypodium rupestre*, which is currently considered as a differential heliophilous edge species (Allegrezza *et al*., 2015).

Mount Tegolaro pine reforestation

Structural analysis

The Mt. Tegolaro reforestation structural aspect (Fig. 3, Table 1, rels. 20-25) showed a dominant tree layer that consisted exclusively of *Pinus nigra* subsp. *nigra*. These plants were the same age, and were 18 m to 20 m high, with coverage that never exceeded 70%. Some Pinus nigra exemplars had broken treetops and broken lower branches, with shallow crowns that were in the last quarter. Although the black pine coverage varied from a minimum of 40% to a maximum of 70%, it allowed an almost undifferentiated vegetation development in the tree-dominated and high and low shrubs layers, in all of the investigated areas (Fig. 3).

Floristic-vegetational analysis

As the phytosociological Table shows (Table 1, rels. 20-25), in all of the relevés, the native forest vegetation coverage exceeded that of the introduced conifers. The restoration process was advanced in all of these studied areas which were relatively homogeneous, at both the structural and floristic-vegetational levels. Among the spontaneous vegetation, widespread diffusion was seen for species of the class *Querco-Fagetea*, which included *Ostrya carpinifolia*, the species that reached the highest coverage in all the relevés carried out. This was accompanied by: *Quercus cerris*, *Fraxinus ornus* subsp. *ornus*, *Quercus pubescens* subsp. *pubescens*, *Acer opalus* subsp. *obtusatum*, *Sorbus aria*, *Lonicera xylosteum*, *Cornus mas*, and others, which were present in all of the structural classes considered, and the vegetation showed good regeneration in the herbaceous layer. The contributions of the herbaceous nemoral species of the class *Querco-Fagetea* were also important, some of which are linked to the more mesophilous *Ostrya carpinifolia* forests, such as: *Sanicula europaea*, *Luzula sylvatica* subsp. *sylvatica*, *Festuca heterophylla*, *Epipactis helleborine* subsp. *helleborine*, *Melica uniflora*, and others. It can also be underlined that the nemoral herbaceous species represent the most consistent syntaxonomic category for the sites investigated, both in terms of the species numbers and the coverage. The forest-edge species of the class *Rhamno-Prunetea* with *Lonicera etrusca*, *Crataegus monogyna*, *Prunus mahaleb*, *Rosa canina*, *Rubus ulmifolius*, and others, and the species of the class *Trifolio-Geranietea*, which was mainly represented by *Digitalis lutea* subsp. *australis* and *Helleborus bocconei* subsp. *bocconei*, were less frequent. Finally, among the typical grassland species, there was mainly *Brachypodium rupestre*, a species of the heliophilous edges that was present in all of the relevés, sometimes with 30% coverage.

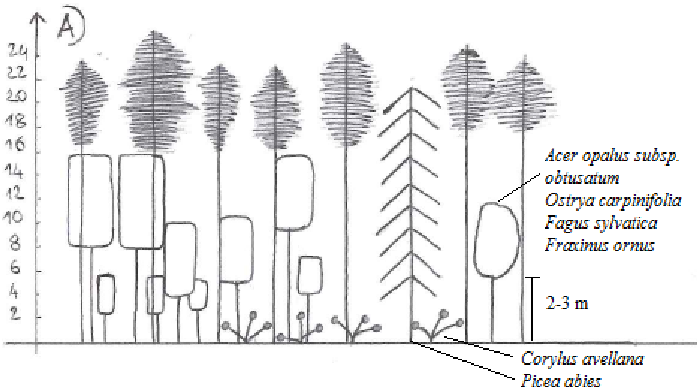

Fig. 3 - Scheme of the main structure for the Mt.Tegolaro reforestation.

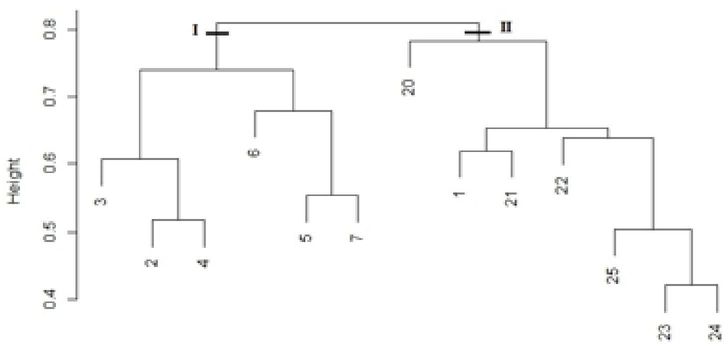

Fig. 4 - Dendrogram of the relevés in the two study areas (Cluster I, Mt. Predicatore; Cluster II, Mt. Tegolaro).

Tab. 1 - Predicatore (rel 1-7) and Tegolaro (rel. 20-25) *Pinus nigra* reforestation areas.
(Legend Tab. 1 layer: a. dominant tree; a1. tree dominated; b1. high shrub; b. low shrub; c. herbaceous)

Biological Form		Layer														Presences
	N. rels.		1	2	3	4	5	6	7	20	21	22	23	24	25	
	Altitude (m s.l.m.)		680	725	660	700	700	650	655	700	775	745	735	720	710	
	Aspect		WNW	WSW	W	W	W	W	W	WNW	WNW	WNW	WNW	WNW	WNW	
	Slope (°)		15	15	25	30	35	40	35	20	28	20	20	25	30	
	Surface (m^2)		400	400	400	400	400	400	400	400	400	400	400	400	400	
	Coverage %		95	95	85	85	75	85	85	90	67	92	90	85	80	
	n. species x rel.		32	27	33	25	24	18	25	39	28	36	38	32	38	
	Conifers introduced															
P scap	Pinus nigra Arnold subsp. nigra	a	2.3	1.2	2.2	2.3	3.3	4.4	4.4	2.2	2.3	3.3	3.4	3.3	2.3	13
		b1	.	.	.	.	+	+	+.2	.	.	.	.	.	.	3
		c	.	.	.	.	.	.	.	+	+	.	.	.	.	2
P scap	Abies alba Mill.	b1	.	.	+.2	+	.	.	.	.	.	.	.	.	.	2
P scap	Abies cephalonica Loud.	a	1.2	.	.	.	.	.	.	.	.	.	.	.	.	1
		b1	+	.	.	.	.	.	.	.	.	+	+	+	.	4
		c	+	.	.	.	.	.	.	+	.	.	.	.	.	2
P scap	Picea abies (L.) H. Karst.	a	1.2	.	.	.	.	.	.	.	.	.	.	.	.	1
	Querco-Fagetea class (trees and shrubs species)															
P scap	Ostrya carpinifolia Scop.	a1	3.3	3.3	1.2	.	.	.	.	1.2	2.2	3.4	3.4	2.3	2.3	9
		b	1.2	+.2	+.2	3.4	.	.	.	1.2	+.2	1.2	+.2	.	1.2	9
		b1	.	.	.	+.2	.	+	.	.	+.2	1.2	.	.	.	4
P scap	Fraxinus ornus L. subsp. ornus	a1	.	1.2	.	1.2	.	.	1.2	1.2	.	.	.	.	.	4
		b	.	+.2	2.2	1.2	.	+.2	+.2	2.3	.	2.3	1.2	.	.	8
		b1	+.2	.	3.3	+.2	1.1	1.1	2.2	2.3	+.2	2.3	1.2	1.1	1.2	12
		c	+	.	+	.	+	.	+	1.1	+	1.1	.	1.1	.	8
P scap	Quercus cerris L.	a1	1.2	1.2	.	1.2	.	.	.	.	.	.	.	.	.	3
		b	.	.	.	1.2	.	.	.	.	.	.	.	.	.	1
		b1	.	+.2	1.2	1.2	+	+.2	+	+.2	+	+.2	+.2	.	.	10
		c	1.1	+	.	.	+	.	+.2	1.1	.	.	.	.	.	5
P scap	Acer opalus Mill. subsp. obtusatum (Waldst. et Kit. ex Willd.) Gams	a1	.	1.2	.	.	.	.	1.2	1.2	1.2	.	.	.	.	4
		b	.	.	.	.	.	.	.	.	.	.	+.2	.	.	1
		b1	+.2	+.2	+.2	+.2	+	.	.	+.2	+	+.2	.	+	+	10
		c	1.1	.	+	.	.	.	.	+	.	.	.	.	.	3
P scap	Quercus pubescens s.l.	a1	.	.	.	.	.	.	.	.	+.2	.	.	.	.	1
		b	.	.	1.2	.	.	.	.	.	1.2	.	.	.	.	2
		b1	.	.	1.2	.	.	.	.	.	+.2	.	.	+	+.2	4
		c	.	.	+	+	.	+	.	.	+	+	.	1.1	+	7
P scap	Acer campestre L.	b	.	.	.	.	.	.	1.2	1.2	.	.	.	.	.	2
		b1	+	+.2	.	.	+	+	.	.	.	+	+	+	+.2	8
		c	.	.	+.2	.	.	.	.	+	.	.	+	.	.	3
P caesp	Lonicera xylosteum L.	b1	+.2	1.1	1.1	1.2	.	+.2	.	.	1.2	2.3	+.2	+	1.1	10
P lian	Hedera helix L. subsp. helix	a	+.2	1.2	.	.	.	.	.	.	.	.	.	2.2	+.2	4
		a1	.	.	.	.	.	.	.	.	.	.	.	2.2	.	1
		c	1.2	1.1	1.1	+.2	.	+	1.1	.	1.2	+	+	2.2	1.2	11
P caesp	Cornus mas L.	b	.	.	.	.	.	+.2	.	.	.	.	.	.	.	1
		b1	.	.	.	+	.	+	.	+.2	+.2	+.2	+	+	+	8
		c	.	.	.	.	.	.	.	.	+	.	.	.	.	1
P caesp	Corylus avellana L.	b	2.3	.	.	.	.	.	.	.	.	.	.	.	.	1
		b1	1.2	+.2	+.2	.	.	.	.	.	+	.	+	.	.	5
		c	+	.	.	.	.	.	.	.	.	.	.	.	.	1
NP	Daphne laureola L.	c	+	+	+	+.2	.	+.2	+	+	+	+.2	+	+	+	12
P caesp	Acer monspessulanum L. subsp. monspessulanum	b1	.	.	.	.	.	.	.	+	.	+	+	.	+	4
P scap	Acer pseudoplatanus L.	b1	.	.	.	.	.	.	.	.	.	+.2	+.2	.	.	2
		c	.	.	.	.	.	.	.	+	.	.	+	.	+	3
P caesp	Carpinus orientalis Mill. subsp. orientalis	b1	.	.	+	.	.	.	.	.	.	.	.	.	.	1
P scap	Castanea sativa Mill.	b1	.	.	.	.	.	.	.	.	.	.	+.2	.	.	1
P caesp	Euonymus latifolius (L.) Mill.	b1	.	+	.	.	.	.	.	.	.	+	.	.	.	2
P scap	Fagus sylvatica L. subsp. sylvatica	b	.	.	+.2	.	.	.	.	.	.	.	.	.	.	1
		b1	.	+.2	.	.	.	.	.	.	.	.	+.2	+	+.2	4
P scap	Fraxinus excelsior L. subsp. excelsior	a1	.	.	.	.	.	.	.	.	.	+.2	.	.	.	1
P scap	Populus nigra L.	b1	.	.	.	.	.	.	.	.	+	.	.	.	.	1
P scap	Pyrus pyraster Burgsd.	b1	.	.	.	.	.	.	.	.	.	+.2	+	.	.	2
P scap	Prunus avium L. subsp. avium	b	+.2	.	.	.	.	+.2	.	.	.	.	.	.	.	2
		b1								+	+.2	.	+	+	+.2	5
P caesp	Sorbus aria (L.) Crantz subsp. aria	b	.	+	.	.	.	.	.	.	+.2	.	.	.	.	2
		b1	.	.	.	.	.	.	.	2.2	+	+.2	+	+	1.2	6
P scap	Sorbus domestica L.	b	.	.	.	.	.	.	.	.	.	+.2	.	.	.	1
		b1	.	.	+.2	.	.	.	.	.	.	.	.	.	.	1
		c	.	.	.	.	.	.	+	.	.	.	.	.	.	1
P caesp	Sorbus torminalis (L.) Crantz	b1	.	.	+	.	.	.	.	+.2	.	.	.	.	.	2
		c	.	.	.	.	.	.	.	.	.	.	.	.	+	1

	Querco-Fagetea class (herbaceous species)															
H ros	Viola alba Besser subsp. dehnhardtii (Ten.) W. Becker	c	1.1	1.1	+.2	1.1	+	+	+	1.2	+	1.2	1.1	+.2	+.2	13
H scap	Sanicula europaea L.	c	1.1	+	.	.	.	.	+	+.3	+.2	2.3	2.3	+.2	+.2	9
G rhiz	Cephalanthera damasonium (Mill.) Druce	c	+	+	.	.	.	.	+	1.1	.	.	+	+	+	7
G rhiz	Galium odoratum (L.) Scop.	c	+.3	+	+	+	.	.	.	.	.	+	+.3	+	.	7
G rhiz	Hepatica nobilis Schreb.	c	+.2	.	.	.	.	.	.	+	+.2	+.2	+.2	.	.	5
H caesp	Melica uniflora Retz.	c	1.1	+.2	.	+	.	.	.	.	+.2	+.2	.	.	.	5
H caesp	Luzula forsteri (Sm.) DC.	c	.	.	.	.	.	.	.	.	.	+	1.1	1.1	+.2	4
G rhiz	Ruscus aculeatus L.	c	+	.	+	.	.	+.2	.	.	.	.	.	+	.	4
H caesp	Festuca heterophylla Lam.	c	.	.	.	.	.	.	.	+	+	+	.	.	.	3
H scap	Lactuca muralis (L.) Gaertn.	c	+.3	.	.	.	.	.	.	.	.	.	+	+	.	3
H caesp	Luzula sylvatica (Huds.) Gaudin subsp. sylvatica	c	.	.	.	.	.	.	.	+.3	.	.	+.2	+.2	.	3
H scap	Viola reichenbachiana Jord. ex Boreau	c	+	.	.	.	.	.	.	.	+	.	.	.	1.1	3
H scap	Buglossoides purpurocaerulea (L.) I.M. Johnst.	c	.	+	.	.	.	.	+.3	.	.	.	.	.	.	2
G rhiz	Cephalanthera longifolia (L.) Fritsch	c	.	.	.	.	.	.	.	+	.	+	.	.	.	2
G rhiz	Epipactis helleborine (L.) Crantz subsp. helleborine	c	.	.	.	.	.	.	.	+.2	.	+	.	.	.	2
H scap	Hieracium murorum L. (s.l.)	c	.	.	+.2	.	+.2	.	.	.	.	.	.	.	.	2
H caesp	Brachypodium sylvaticum (Huds.) P. Beauv.	c	.	.	.	.	.	.	.	+.2	.	.	.	.	.	1
H caesp	Bromopsis ramosa (Huds.) Holub subsp. ramosa	c	.	.	+.2	.	.	.	.	.	.	.	.	.	.	1
H caesp	Carex digitata L.	c	.	.	.	.	.	.	.	.	.	.	+.2	.	.	1
G bulb	Cyclamen repandum Sm. subsp. repandum	c	.	.	.	.	.	.	.	+	.	.	.	.	.	1
Ch suffr	Euphorbia amygdaloides L. subsp. amygdaloides	c	+.2	.	.	.	.	.	.	.	.	.	.	.	.	1
G rhiz	Lathyrus venetus (Mill.) Wohlf.	c	1.2	.	.	.	.	.	.	.	.	.	.	.	.	1
G bulb	Lilium bulbiferum L. subsp. croceum (Chaix) Jan	c	.	.	.	.	.	.	.	+.2	.	.	.	.	.	1
G rhiz	Neottia nidus-avis (L.) Rich.	c	.	.	.	.	.	.	.	.	.	.	.	+	.	1
G rad	Tamus communis L.	c	.	.	.	.	.	.	.	+	.	.	.	.	.	1
	Quercetea-ilicis class															
G rhiz	Asparagus acutifolius L.	b1	.	+	+	+	+	+	+	.	.	.	.	.	.	6
P scap	Quercus ilex L. subsp. ilex	b	.	.	.	+.2	.	.	.	.	.	.	.	.	.	1
		b1	.	+.2	.	.	+	.	+	.	.	.	.	.	.	3
		c	.	.	.	.	+	.	.	.	.	.	.	.	.	1
	Rhamno-Prunetea class															
NP	Rubus ulmifolius Schott	b1	+	1.1	+.2	+.2	+	+	1.1	.	1.2	1.1	.	+	+.2	11
NP	Rubus hirtus (group)	b1	+	1.1	.	+.2	.	+	+.1	.	.	.	+.2	+	+	8
P lian	Lonicera etrusca Santi	b1	+	+	1.1	.	1.1	.	.	.	1.2	1.1	.	.	+.2	7
		c	.	.	.	1.1	1.1	.	1.1	1.1	.	.	.	.	+.2	5
P lian	Clematis vitalba L.	b1	.	+	1.1	.	+	+	+.2	+.2	.	.	+	.	.	7
		c	.	+	.	.	+.2	.	.	.	.	.	.	+.2	.	3
P caesp	Crataegus monogyna Jacq.	b1	.	+	+.2	.	.	.	.	.	+	.	+.2	+	.	5
NP	Rosa canina L. (s.l.)	b1	.	.	.	.	.	.	.	+	+.3	.	+	+	+	5
NP	Cotinus coggygria Scop.	b1	.	.	.	+	+	4.4	+	.	.	.	.	.	.	4
P caesp	Prunus mahaleb L.	b1	.	.	.	.	.	.	.	.	.	+.2	+	.	+	3
		c	.	.	.	.	.	.	.	.	.	+	.	.	.	1
P caesp	Prunus spinosa L. subsp. spinosa	b1	+	.	.	+	.	.	.	.	.	+	.	.	.	3
P caesp	Juniperus oxycedrus L. subsp. oxycedrus	b1	.	.	+	.	+	.	.	.	.	.	.	.	+	3
P caesp	Juniperus communis L. subsp. communis	b1	.	.	.	+	.	.	+	.	.	.	.	.	.	2
		c					+									1
	Trifolio-Geranietea class															
H scap	Digitalis lutea L. subsp. australis (Ten.) Arcang.	c	+.3	.	.	.	+.3	.	+	.	+	.	+	+	+	7
G rhiz	Helleborus bocconei Ten. subsp. bocconei	c	.	.	.	.	.	.	.	+	.	+.2	+	+	+	5
H rept	Fragaria vesca L. subsp. vesca	c	.	.	.	.	+	.	+	.	.	.	+	.	+.2	4
H scap	Clinopodium vulgare L. subsp. vulgare	c	.	.	1.1	.	+	.	.	.	.	.	.	.	.	2
G rhiz	Pteridium aquilinum (L.) Kuhn subsp. aquilinum	c	+.2	.	.	.	+	.	.	.	.	.	.	.	.	2
	Other species															
H caesp	Brachypodium rupestre (Host) Roem. et Schult.	c	+.2	+.2	1.2	1.2	1.1	+.2	2.3	2.2	2.3	1.2	+.2	+.2	1.2	13
H scap	Dactylis glomerata L. subsp. glomerata	c	.	.	+.2	+.2	+.2	.	.	+	.	.	.	.	+.2	5
Ch suff	Teucrium chamaedrys L. subsp. chamaedrys	c	.	.	+	+	.	.	+	.	+	.	.	.	.	4
H caesp	Bromopsis erecta (Huds.) Fourr. subsp. erecta	c	.	.	.	.	+.2	.	+.2	.	.	.	.	.	.	2
G rhiz	Carex flacca Schreb. subsp. flacca	c	.	.	.	.	+.2	.	.	+	.	.	.	.	.	2
H bienn	Inula conyzae (Griess.) Meikle	c	.	.	+	.	.	.	.	.	+	.	.	.	.	2
T scap	Trifolium incarnatum L. (s.l.)	c	.	.	.	.	.	.	.	.	.	.	+	.	+	2
	mosses		.	.	.	.	.	.	.	.	+.3	.	+.2	.	+.2	3
	Sporadics species		1	1	1	1	3	0	0	5	1	2	0	1	4	

Comparison between the two reforestation areas

The dendrogram shown in Figure 4 was obtained from the relevé classification, and it clearly separates the Mt. Tegolaro relevés from those of Mt. Predicatore, therefore highlighting differences at both the structural and floristic-vegetational levels.

From a structural point of view, the Mt. Tegolaro reforestation was better stratified. All of the structural classes were well represented in all of the relevés, and they formed part of a complex vertical stratification, that indicated the natural nature of the plant communities (Fig. 5A). On the other hand, the Mt. Predicatore reforestation showed a more simplified vertical stratification (Fig. 5B), and some areas were totally lacking in structural classes. From the comparison of the floristic-vegetational relevés, as more easily seen in the histogram of Figure 6, the Mt. Tegolaro reforestation was in a more advanced restoration state than that of Mt. Predicatore. This can be seen to the lower conifer coverage that was generally recorded in all of the area, which corresponds to a greater presence also in terms of the coverage of the nemoral species of the class *Querco-Fagetea*, and in particular of those herbaceous, with a general decline in ecotonal shrub species and grassland species. The analysis of the floristic-vegetational Table emphasises the more mesophilous character due to the presence of a contingent of species typically linked to the cooler woods, such as: *Cornus mas*, *Fagus sylvatica* subsp. *sylvatica*, *Acer pseudoplatanus*, *Luzula sylvatica* subsp. *sylvatica*, *L. forsteri*, *Festuca heterophylla* and *Epipactis helleborine* subsp. *helleborine*. On the other hand, the Mt. Predicatore reforestation was differentiated by the presence, although sporadic, of Mediterranean and subMediterranean

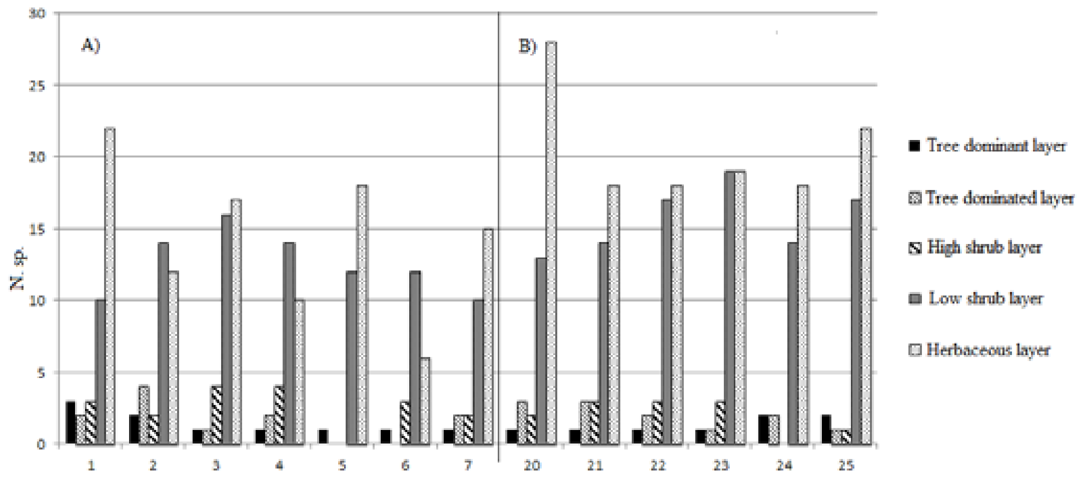

Fig. 5 - Structural classes comparison: (A) Mt. Predicatore; (B) Mt. Tegolaro.

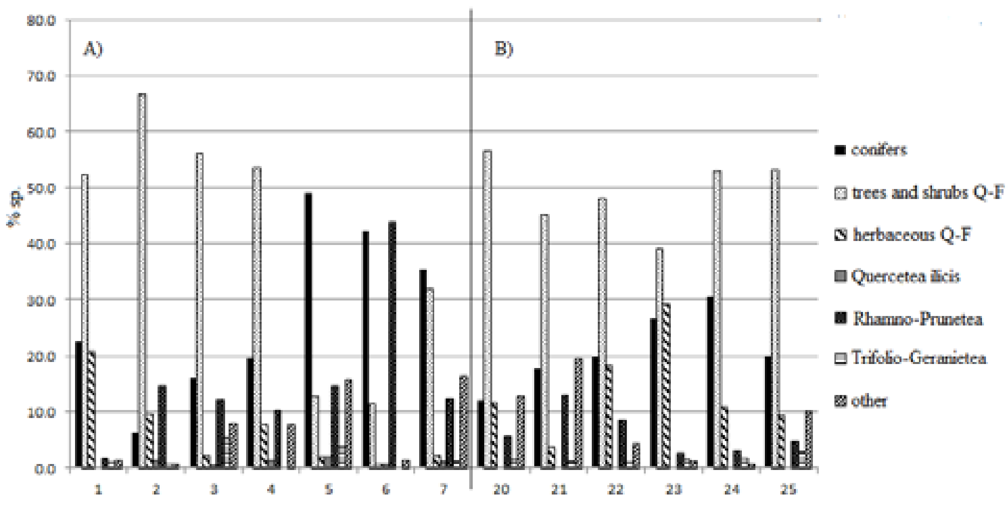

Fig. 6 - Syntaxonomic categories comparison: (A) Mt. Predicatore; (B) Mt. Tegolaro.

Tab. 2 - Conifers and hardwoods sapling regeneration in the two reforestation areas.

	MT. PREDICATORE							MT. TEGOLARO					
N. rel.	1	2	3	4	5	6	7	20	21	22	23	24	25
n. conifers	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**0**
Pinus nigra Arnold subsp. nigra								■	■				
Abies cephalonica Loud.	■							■					
n. species of *Querco-Fagetea* class	**4**	**1**	**4**	**1**	**2**	**1**	**3**	**5**	**3**	**2**	**2**	**2**	**3**
Quercus pubescens Willd. subsp. pubescens			■	■		■			■	■		■	■
Quercus cerris L.	■	■			■		■	■					
Fraxinus ornus L. subsp. ornus	■		■		■		■	■	■	■		■	
Acer opalus Mill. subsp. obtusatum (Waldst. et Kit. ex Willd.) Gams	■		■					■					
Corylus avellana L.	■												
Acer campestre L.			■					■			■		
Sorbus domestica L.							■						
Cornus mas L.									■				
Sorbus torminalis (L.) Crantz													■
Acer pseudoplatanus L.								■			■		■

species of the class *Quercetea ilicis*: *Asparagus acutifolius* and *Quercus ilex*.

In an examination of the plant regeneration (Table 2), in both of the reforestation areas hardwood regeneration was seen for all of the relevés, while that of the conifers was extremely sporadic. The regeneration of the native forest species was mainly for saplings of *Quercus pubescens* subsp. *pubescens*, *Q. cerris*, *Fraxinus ornus* subsp. *ornus*, and *Acer opalus* subsp. *obtusatum*. For Mt. Tegolaro, the presence of *Acer pseudoplatanus* in the regeneration confirms the higher edaphic humidity conditions than for Mt. Predicatore. Although the two reforestation areas indicated the same vegetation potential according to the *Ostrya carpinifolia* forest, the floristic-structural differences, and therefore the state of restoration that can occur was linked to the local differences in locational features. However, these were modest, and included: exposure and altitude (further north and a mean of a further 50 m in altitude for Mt. Tegolaro), and the geographic location of the sites.

Diachronic analysis

The dendrogram obtained identified three main clusters (Fig. 7) that brought together the relevés published in 1973 (cluster I), those of the present study in 2012 (cluster II), and finally, those from the native woodlands of the association *Scutellario-Ostryetum carpinifoliae*, which were adjacent to the two reforestation areas, and which will experience the same site conditions (cluster III). Only a group of relevés from the reforestation of Mt. Predicatore revealed in 2012 (Table 1, rels. 5-7) can be linked to the cluster of 1973 (Cluster I), and these correspond to the conditions where the *Pinus nigra* subsp. *nigra* coverage was higher.

Non-metric multidimensional scaling (NMDS; Fig. 8) confirms the separation of the three groups. In particular, the ordering highlights two floristic gradients: the first (axis NMSD1) primarily relates to time, and then to the vegetation dynamism; the second (NMDS2) is less important in terms of the floristic variance, and is linked to the two sites considered (Mt. Predicatore, Mt. Tegolaro). This shows that the floristic turnover is linked to both the time and the reference sites of the relevés.

At the structural level, the trend from 1973 to 2012 was similar for both reforestation areas (Table 3, Fig. 9), with an increase in species richness in the tree layer and a decrease in the shrub and herbaceous layers, where the fall was particularly sharp. This is in line with the reference woods, except for the herbaceous layer, where in the surrounding forest coenosis, the diversity was high (especially for Mt. Tegolaro). Despite the general decrease in the pine coverage (natural lightening), we noted an increase in the mean heights: in 1973 this was 13.6 m in both reforestation areas, and in 2012 it was about 20 m for Mt. Predicatore and about 15 m for Mt. Tegolaro. Also, both of the pine forests would have finished their growth in 2012 in terms of their height, because 100 years from reforestation, they will be in their maturity/ senescence phase.

For the mean species numbers, there was a clear decrease compared to 1973 (22.2% for Mt. Predicatore, 17.1% for Mt. Tegolaro), although these were clearly lower than the adjacent woods. This was mainly for Mt. Tegolaro, where the highest species richness was recorded for the adjacent woods. As more easily seen in the histogram of the phytosociological category weights in Figure 10, the synthetic Table (Table 3) shows the change in the floristic composition of the reforestation since 1973, which was linked to natural dynamic processes. Due to the reduced conifer coverage in both areas, the nemoral species of the class *Querco-Fagetea* that were spread through the

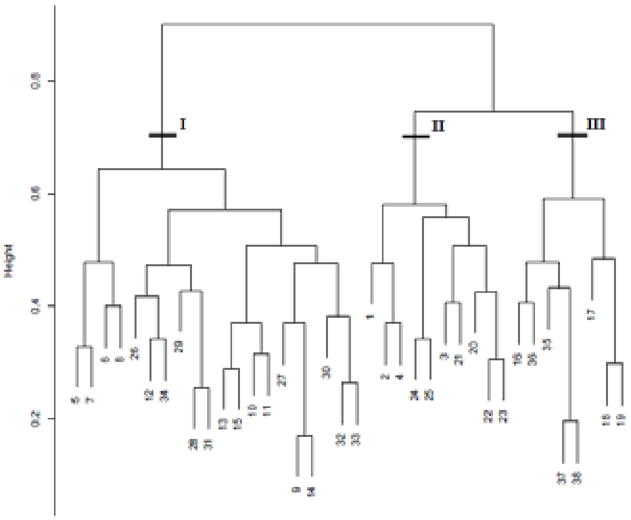

Fig. 7 - Dendrogram from the relevés from the Mt. Predicatore and Mt. Tegolaro reforestation areas and from the native adjacent woods of the association *Scutellario columnae-Ostryetum carpinifoliae* as comparison. Cluster I, reforestation areas in 1973; cluster II, reforestation areas in 2012; cluster III- native woods. (Cap profile – Bray Curtis dissimilarity coefficent – complete linkage).

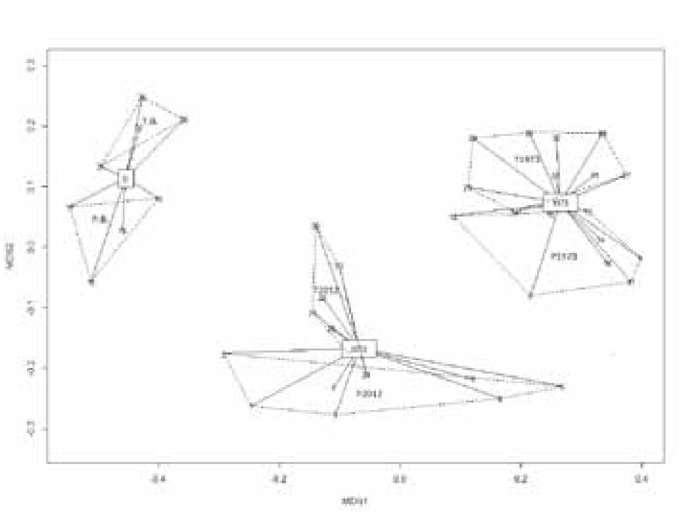

Fig. 8 - NMDS plot of the stratified vegetation data from the Mt. Predicatore and Mt. Tegolaro reforestation areas (1973, 2012) and from the native adjacent woods of the association *Scutellario columnae-Ostryetum carpinifoliae* as comparison. P1973, P2012, Mt. Predicatore's reforestation; T1973, T2012, Mt. Tegolaro reforestation; BP, Mt. Predicatore; BT, Mt. Tegolaro native adjacent wood (Cap profile – Bray Curtis dissimilarity coefficent).

surrounding woods penetrated the reforestation areas effectively (increased by about 30%). In particular, the herbaceous nemoral species entered, and they reached their highest levels for Mt. Tegolaro, in step, however, with its surrounding woods. A net decline in the grassland species (30%) corresponded to the increase in nemoral species. In particular, in 1973, *Brachypodium rupestre* was the grass species with the highest coverage. Despite the same trend in the structural and floristic-vegetational dynamics, differences emerged from the comparisons between the two reforestation areas, although they were modest, and these were also confirmed by the diachronic analysis. The restoration status is a function of the native woods, and then of the reference site. In this sense, we can consider that in the two sites, the restoration status was similar but not the same, because only within each site can the coenoses of 1973 and 2012 be considered the evolutionary stages of the same dynamic process.

Conclusion

This integrated detailed study allowed the analysis of the structural and floristic-vegetational setting of two representative *Pinus nigra* subsp. *nigra* reforestation areas 100 years from their planting. Despite the two reforestation areas being in similar ecological and vegetational areas, their comparisons show that structural and floristic differences emerge, and even though these were modest, they were mainly related to topographical and geographical factors (i.e., altitude, exposure), and so to the bioclimatic factors. The diachronic analysis highlighted the structural and floristic changes in the reforestation areas considered, and then it highlighted the structural and floristic-vegetational stages of the succession. These were represented by the plant communities in 1973 and 2012, for the *Ostrya carpinifolia* forest of the association *Scutellario-Ostryetum carpinifoliae*. The lower conifer coverage that was recorded in general for the two investigated sites corresponded to increases in the numbers and coverage of the nemoral species of the class *Querco-Fagetea*, and particularly for the herbaceous species, with a widespread decline in the ecotone and grassland species. These modest differences were also confirmed by the diachronic analysis. The status of the restoration was a function of the native woods, and then a function of the reference site. In this sense, we can consider that for the two investigated sites the restoration status was similar but not the same, because only within each site can the 1973 and 2012 coenoses be considered as developmental stages of the same dynamic process.

However, if we consider the situation before the reforestation, as derived from historical documents, it can be assumed that the natural vegetation dynamics was favoured and accelerated in topographic positions that guaranteed greater edaphic humidity conditions (i.e., altitude, exposure). On the basis of the results obtained, we can say that 100 years after the reforestation, these two areas produced ecological conditions that guaranteed the ingression of the nemoral species that were present in the adjacent woods, which was more than adequate for their regeneration. As well as significant floristic turnover, the vegetation dynamics established under the pine coverage led to a plant community structuring that was typical of the native reference wood. The knowledge gained here represents an essential knowledge base to plan future selvicultural actions, and it has helped to provide useful indications about the autoecological features of the species involved in the dynamic process of restoration ecology. The present study may contribute to the setting of methodologies for assessing reforestation as part of ecological restoration, a term that includes actions

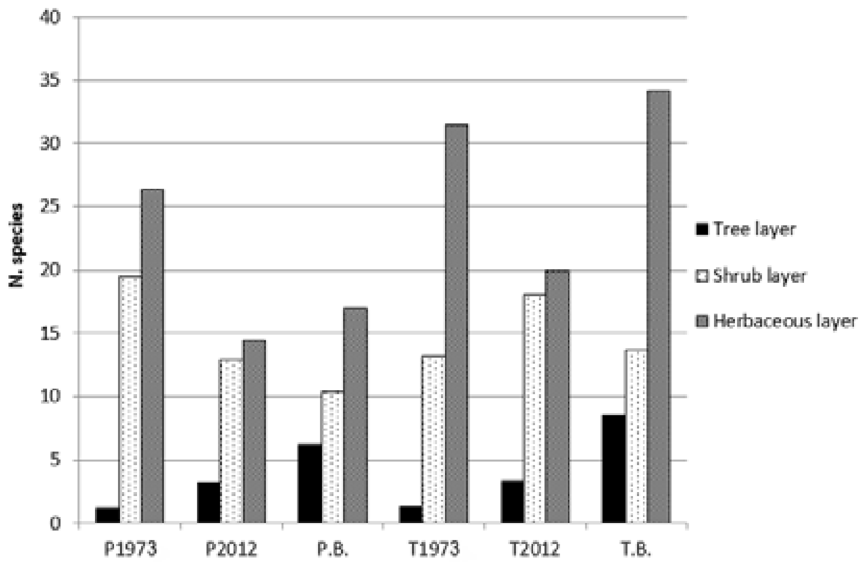

Fig. 9 - Diachronic analysis of the structural classes. P1973, P2012, Mt. Predicatore reforestation; BP, Mt. Predicatore native adjacent wood; T1973, T2012, Mt. Tegolaro reforestation areas,; BT, Mt. Tegolaro native adjacent wood.

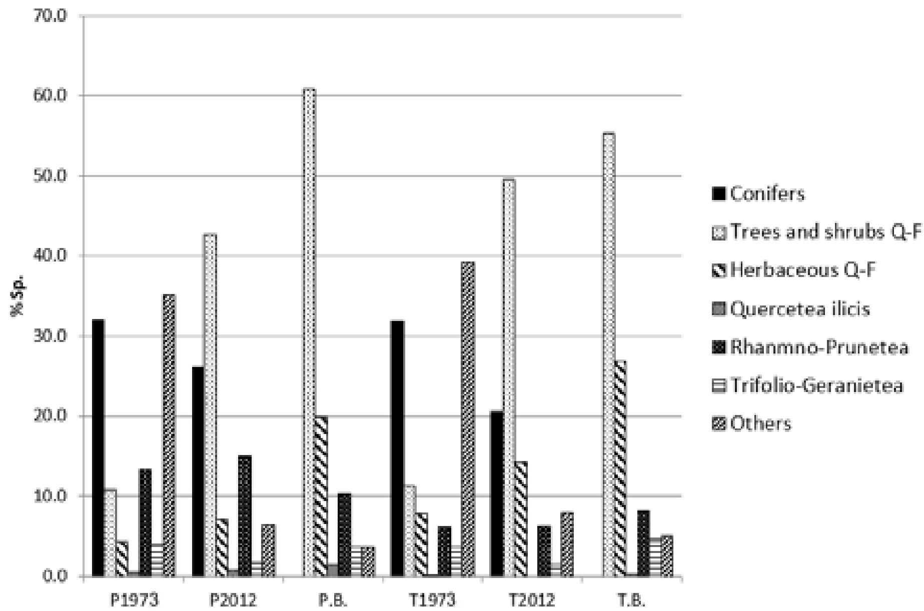

Fig. 10 - Diachronic analysis of the syntaxonomic categories. P1973, P2012, Mt. Predicatore reforestation; BP, Mt. Predicatore native adjacent wood; T1973, T2012, Mt. Tegolaro reforestation. BT, Mt. Tegolaro native adjacent wood.

Tab. 3 - Synoptic table of the groups of relevés from the Mt. Predicatore and Mt. Tegolaro reforestation (1973 and 2012) and the native woods of the association *Scutellario-Ostryetum carpinifoliae* for comparison.
(Legend Tab. 3: col. 1. 1973 Mt. Predicatore reforestation; col. 2. 2012 Mt. Predicatore reforestation, col. 3. Mt. Predicatore native adjacent wood; col. 4. 1973 Mt. Tegolaro reforestation; col. 5. 2012 Mt. Tegolaro reforestation; col. 6. Mt. Tegolaro native adjacent wood; Layer: a. tree; b. shrub; c. herbaceous)

Biological Form	N. column	Layer	1	2	3	4	5	6
	Group rel. sites/year from NMDS (Fig. 8)		P1973	P2012	P.B.	T1973	T2012	T.B.
	N. rels x column.		8	7	4	9	6	4
	Average n. species x group of rels.		48,4	26,2	34,2	52,7	35,1	58,8
	Conifers introduced							
P scap	Pinus nigra Arnold subsp. nigra	a	V	V	.	V	V	.
		b	V	II	.	IV	.	1
		c	III	.	.	IV	II	.
P scap	Abies alba Mill.	b	I	II	.	.	.	1
P scap	Abies cephalonica Loud.	a	I	I	.	I	.	.
		b	.	I	.	.	III	.
		c	.	I	.	.	I	.
	Querco-Fagetea class (trees and shrubs species)							
P scap	Ostrya carpinifolia Scop.	a	.	II	4	.	V	4
		b	I	III	.	IV	IV	.
P scap	Acer campestre L.	b	I	III	2	II	III	3
		c		I			II	
P scap	Fraxinus ornus L. subsp. ornus	a	.	II	3	.	I	3
		b	V	IV	1	IV	III	3
		c		III			III	
P scap	Acer opalus Mill. subsp. obtusatum (Waldst. et Kit. ex Willd.) Gams	a	.	II	2	.	II	4
		b	II	IV	.	II	IV	2
		c	.	II	1	.	I	.
P caesp	Corylus avellana L.	b	I	II	3	I	II	3
		c		I				
P caesp	Cornus mas L.	b	II	II	1	I	V	4
		c					I	
P scap	Quercus cerris L.	a	.	II	3	.	.	3
		b	III	IV	.	II	III	.
		c	.	III	1	.	I	.
P scap	Quercus pubescens subsp. pubescens	a	.	.	4	.	I	3
		b	V	I	.	V	III	2
		c	.	II	.	.	III	.
P caesp	Sorbus aria (L.) Crantz subsp. aria	b	III	1	3	IV	V	3
P scap	Prunus avium L. subsp. avium	b	IV	II	1	II	IV	1
P caesp	Lonicera xylosteum L.	b	V	IV	4	V	IV	4
NP	Daphne laureola L.	c	IV	IV	2	IV	V	4
P caesp	Acer monspessulanum L. subsp. monspessulanum	b	II	.	.	II	III	3
P scap	Acer pseudoplatanus L.	b	.	.	.	I	II	1
		c	.	.	.	.	II	
P caesp	Carpinus orientalis Mill. subsp. orientalis	b	.	I	2	.	.	2
P scap	Castanea sativa Mill.	b	.	.	.	I	I	.
P caesp	Euonymus latifolius (L.) Mill.	b	.	I	3		I	3
P lian	Hedera helix L. subsp. helix	a	.	II	1	.	II	.
		b	I	.	.	.	.	.
		c	II	IV	3	II	IV	4
P caesp	Laburnum anagyroides Medik. subsp. anagyroides	b	.	.	1	.	.	2
P scap	Malus sylvestris (L.) Mill.	b	I	.	.	I	.	2
P scap	Pyrus pyraster Burgsd.	b	.	.	1	.	II	.
P scap	Sorbus aucuparia L. subsp. aucuparia	b	I	.	.	I	.	.
P scap	Sorbus domestica L.	b	.	I	.	.	I	3
		c	.	I	.	.	.	.
P caesp	Sorbus torminalis (L.) Crantz	b	.	I	1	.	I	2
		c	.	.	.	.	I	.
	Querco-Fagetea class (herbaceous species)							
G rhiz	Cephalanthera damasonium (Mill.) Druce	c	I	II	1	II	III	1
G rhiz	Hepatica nobilis Schreb.	c	I	I	4	I	III	4
H caesp	Melica uniflora Retz.	c	I	II	2	I	II	3
H scap	Sanicula europaea L.	c	I	II	1	I	V	2
H ros	Viola alba Besser subsp. dehnhardtii (Ten.) W. Becker	c	V	V	4	IV	V	4
G rhiz	Ruscus aculeatus L.	c	I	II	3	I	I	4
H caesp	Bromopsis ramosa (Huds.) Holub subsp. ramosa	c	I	I	1	I	.	1
Ch suffr	Euphorbia amygdaloides L. subsp. amygdaloides	c	I	I	2	I	.	3
H caesp	Festuca heterophylla Lam.	c	I	.	3	II	III	4
H scap	Viola reichenbachiana Jord. ex Boreau	c	I	.	1	I	II	2
H scap	Buglossoides purpurocaerulea (L.) I.M. Johnst.	c	I	II	3	.	.	3

G rhiz	Cephalanthera longifolia (L.) Fritsch	c	I	.	1	I	II	.
G rhiz	Epipactis helleborine (L.) Crantz subsp. helleborine	c	II	.	.	II	II	1
G rhiz	Euphorbia dulcis L.	c	I	.	2	I	.	4
G rhiz	Galium odoratum (L.) Scop.	c	.	III	1	I	III	.
G rhiz	Lathyrus venetus (Mill.) Wohlf.	c	I	I	.	I	.	4
H caesp	Luzula forsteri (Sm.) DC.	c	II	.	.	IV	III	3
H caesp	Carex digitata L.	c	.	.	2	.	I	1
H caesp	Luzula sylvatica (Huds.) Gaudin subsp. sylvatica	c	.	.	.	I	III	1
H scap	Solidago virgaurea L. subsp. virgaurea	c	II	.	1	.	.	1
G rhiz	Arum italicum Mill. subsp. italicum	c	.	.	1	.	.	1
H caesp	Brachypodium sylvaticum (Huds.) P. Beauv. subsp. sylvaticum	c	.	.	.	.	I	3
H scap	Campanula trachelium L. subsp. trachelium	c	.	.	2	.	.	2
G bulb	Cyclamen repandum Sm. subsp. repandum	c	.	.	.	.	I	3
H scap	Hieracium murorum L. (s.l.)	c	.	II	.	.	.	1
H scap	Lactuca muralis (L.) Gaertn.	c	.	I	.	.	II	.
G bulb	Lilium bulbiferum L. subsp. croceum (Chaix) Jan	c	.	.	.	.	I	2
H scap	Melittis melissophyllum L. subsp. melissophyllum	c	.	.	1	.	.	4
G par	Monotropa hypopitys L.	c	I	.	.	I	.	.
G rhiz	Neottia nidus-avis (L.) Rich.	c	.	.	.	.	I	1
G bulb	Orchis purpurea Huds.	c	I	.	.	I	.	.
G rad	Tamus communis L.	c	I	.	.	I	I	4
	Quercetea-ilicis class							
G rhiz	Asparagus acutifolius L.	c	V	IV	2	II	.	2
P scap	Quercus ilex L. subsp. ilex	b	I	I	1	.	.	1
		c	.	I	1	.	.	.
	Rhamno-Prunetea class							
P lian	Clematis vitalba L.	b	V	IV	3	II	II	1
		c	.	II	.	.	I	.
P caesp	Cornus sanguinea L. (s.l.)	b	.	.	2	.	.	2
NP	Cotinus coggygria Scop.	b	III	III	.	.	.	1
P caesp	Crataegus laevigata (Poir.) DC.	b	.	.	1	.	.	1
P caesp	Crataegus monogyna Jacq.	b	III	II	4	II	III	4
P caesp	Cytisophyllum sessilifolium (L.) O. Lange	b	I	.	.	III	I	3
NP	Emerus majus Mill. subsp. emeroides (Boiss. et Spruner) Soldano et F. Conti	b	II	.	1	II	.	4
		c	.	.	.	.	I	.
P caesp	Juniperus communis L. subsp. communis	b	V	II	.	III	.	2
		c	.	I	.	.	.	.
P caesp	Juniperus oxycedrus L. subsp. oxycedrus	b	.	II	.	.	I	.
P lian	Lonicera caprifolium L.	b	II	.	1	II	.	2
P lian	Lonicera etrusca Santi	b	III	III	.	.	III	.
		c	.	II	.	.	II	.
P caesp	Prunus mahaleb L.	b	II	.	.	IV	III	1
		c	.	.	.	.	I	.
P caesp	Prunus spinosa L. subsp. spinosa	b	I	II	3	.	I	3
NP	Rosa canina L. (s.l.)	b	III	.	2	IV	IV	3
NP	Rubus caesius L.	b	V	.	1	V	I	.
NP	Rubus hirtus (group)	b	.	IV	.	.	III	2
NP	Rubus ulmifolius Schott	b	.	V	3	.	III	.
NP	Osyris alba L.	b	I	I	.	.	.	.
	Trifolio-Geranietea class							
H scap	Digitalis lutea L. subsp. australis (Ten.) Arcang.	c	III	II	.	V	III	1
H rept	Fragaria vesca L. subsp. vesca	c	II	II	4	II	II	3
H scap	Cruciata glabra (L.) Ehrend. subsp. glabra	c	I	.	2	III	I	3
H scap	Geum urbanum L.	c	I	.	2	IV	I	3
H scap	Calamintha nepeta (L.) Savi subsp. nepeta	c	IV	.	.	I	I	.
G rhiz	Helleborus bocconei Ten. subsp. bocconei	c	.	.	1	IV	IV	.
Ch suffr	Helleborus foetidus L. subsp. foetidus	c	I	.	2	.	.	3
H scand	Lathyrus sylvestris L. subsp. sylvestris	c	II	.	.	IV	I	.
H ros	Primula vulgaris Huds. subsp. vulgaris	c	.	.	1	II	.	3
G rhiz	Pteridium aquilinum (L.) Kuhn subsp. aquilinum	c	III	II	.	.	.	2
H scap	Ptilostemon strictus (Ten.) Greuter	c	II	.	.	II	I	.
H bienn	Arabis turrita L.	c	.	.	.	.	I	1
H scap	Prunella vulgaris L. subsp. vulgaris	c	I	.	.	II	.	.
H scap	Trifolium rubens L.	c	.	.	.	.	I	1
H scap	Tanacetum corymbosum (L.) Sch. Bip. subsp. achilleae (L.) Greuter	c	.	.	.	I	I	.
	Other species							
H scap	Dactylis glomerata L. subsp. glomerata	c	V	II	1	V	II	3
Ch suff	Teucrium chamaedrys L. subsp. chamaedrys	c	V	II	.	IV	I	1
H caesp	Brachypodium rupestre (Host) Roem. et Schult.	c	V	V	3	V	V	.
G rhiz	Carex flacca Schreb. subsp. flacca	c	III	I	.	I	I	1
H bienn	Inula conyzae (Griess.) Meikle	c	III	I	.	I	I	.
H caesp	Bromopsis erecta (Huds.) Fourr. subsp. erecta	c	IV	II	.	V	.	.
H scap	Eryngium amethystinum L.	c	III	I	.	IV	.	.
H scap	Galium corrudifolium Vill.	c	V	I	.	IV	.	.
H scap	Lotus corniculatus L. subsp. corniculatus	c	III	I	.	IV	.	.
H scap	Vicia grandiflora Scop.	c	I	.	1	III	.	.
	Sporadics species		29	5	6	30	7	30

aimed at creating self-supporting and resilient ecosystems (SER, 2002). The effectiveness of these actions has been recognized also by the Convention to Combat Desertification of the United Nations (UNCCD, 1997), within the wider framework of all proposed actions to control desertification, which is one of the main environmental problems related to the impact on the land by human activities and where vegetation is a key control factor (Scotti *et al*., 2004). In addition this study emphasizes the importance of a synergic approach by specialists of different disciplines and the need to integrate within the methods of ecological restoration assessment the synphytosociological concepts such as that of "current potential vegetation" and "vegetation series". This is useful to define the specific dynamic, biogeographical and landscape context of each evaluated project.

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Appendix I: Sporadic species

Tab. 1 - Rel. 1: T scap Cardamine graeca L. (c) +. Rel. 2: H scap Galega officinalis L. (c) +. Rel. 3: Silene vulgaris (c) +. Rel. 4: NP Osyris alba L. (b1) +.3. Rel. 5: H scap Eryngium amethystinum L. (c) +, H scap Galium corrudifolium Vill. (c) +, H scap Lotus corniculatus L. subsp. corniculatus (c) +. Rel. 20: H scap Geum urbanum L. H scap (c) +, H scap Ptilostemon strictus (Ten.) Greuter (c) +.2, H scap Tanacetum corymbosum (L.) Sch. Bip. subsp. achilleae (L.) Greuter (c) +.2, H scap Trifolium rubens L. (c) +, NP Rubus caesius L. (b1) +. Rel. 21: H scap Calamintha nepeta (L.) Savi subsp. nepeta (c) +, H scap Cruciata glabra (L.) Ehrend. subsp. glabra (c) +, H scap Cruciata laevipes Opiz (c) +. Rel. 24: H bienn Arabis turrita L. (c) +. Rel. 25: H rept Astragalus glycyphyllos L. (c) +.2, H scand Lathyrus sylvestris L. subsp. sylvestris (c) +, P scap Juglans regia L. (b1) +, H ros Silene italica (L.) Pers. subsp. italica (c) +.

Tab. 3 - Col. 1: Ch suffr Acinos alpinus (L.) Moench subsp. alpinus (c) III, G bulb Bunium bulbocastanum L. (c) II, H scap Carlina corymbosa L. (c) III, H scap Crepis leontodontoides All. (c) III, H bienn Daucus carota L. subsp. carota (c) I, H scap Galium mollugo L. subsp. erectum Syme (c) I, Ch suffr Helianthemum apenninum (L.) Mill. subsp. apenninum (c) I, Ch suffr Helichrysum italicum (Roth) G. Don subsp. italicum (c) I, H caesp Hypericum montanum L. (c) I, H scap Leucanthemum vulgare Lam. subsp. vulgare (c) I, Ch suffr Ononis spinosa L. subsp. spinosa (c) I, H scap Ononis pusilla L. subsp. pusilla (c) I, H ros Pilosella officinarum Vaill. (c) IV, H scap Ranunculus bulbosus L. (C) I, H scap Sanguisorba minor Scop. subsp. balearica (Bourg. ex Nyman) Muñoz Garm. & C. Navarro (c) III, H scap Scabiosa columbaria L. subsp. columbaria (c) III, Thymus sp. (c) IV, Tragopogon sp. (c) II, T scap Trifolium campestre Schreb. (c) I, T scap Vicia tetrasperma (L.) Schreb. (c) I, P caesp Phillyrea latifolia L. (c) I, P caesp Pistacia terebinthus L. subsp. terebinthus (b) III, P scap Pinus sylvestris L. (a) I, P scap Pinus sylvestris L (b) I, P caesp Colutea arborescens L. (b) II, G rhiz Anemone apennina L. subsp. apennina (c) I, P caesp Spartium junceum L. (b) III, Ch suffr Dorycnium hirsutum (L.) Ser. (c) IV, H scap Urospermum dalechampii (L.) F.W. Schmidt (c) III. Col. 2: P scap Picea abies (L.) H. Karst. (a) I, H scap Clinopodium vulgare L. subsp. vulgare (c) II, H scap Galega offcinalis L. (c) I, T scap Cardamine graeca L. (c) I, H scap Silene vulgaris (Moench) Garcke subsp. vulgaris (c) I. Col. 3: H scap Stachys officinalis (L.) Trevis. (c) 1, H ros Asplenium adiantum-nigrum L. subsp. adiantum-nigrum (c) 1, H ros Polypodium vulgare L. (c) 1, G bulb Cyclamen hederifolium Aiton subsp. hederifolium (c) 1, G bulb Lilium martagon L. (c) 1, H scap Lamium album L. subsp. album (c) 1. Col. 4: Ch suffr Acinos alpinus (L.) Moench subsp. alpinus (c) IV, G bulb Bunium bulbocastanum L. (c) IV, H scap Carlina corymbosa L. (c) II, H scap Crepis leontodontoides All. (c) V, H bienn Daucus carota L. subsp. carota (c) IV, H scap Galium mollugo L. subsp. erectum Syme (c) V, Ch suffr Helianthemum apenninum (L.) Mill. subsp. apenninum (c) V, Ch suffr Helichrysum italicum (Roth) G. Don subsp. italicum (c) I, H scap Leucanthemum vulgare Lam. subsp. vulgare (c) II, Ch suffr Ononis spinosa L. subsp. spinosa (c) II, H scap Ononis pusilla L. subsp. pusilla (c) I, H ros Pilosella officinarum Vaill. (c) III, H scap Ranunculus bulbosus L. (C) II, H scap Sanguisorba minor Scop. subsp. balearica (Bourg. ex Nyman) Muñoz Garm. & C. Navarro (c) IV, H scap Scabiosa columbaria L. subsp. columbaria (c) III, Thymus sp. (c) IV, Tragopogon sp. (c) I, T scap Trifolium campestre Schreb. (c) II, T scap Vicia tetrasperma (L.) Schreb. (c) II, P scap Cedrus atlantica (a) I, P scap Cedrus atlantica (b) I, P scap Pinus pinaster Aiton subsp. pinaster (a) I, H scap Bupleurum falcatum L. subsp. cernuum (Ten.) Arcang. (c) I, T scap Geranium robertianum L. (c) I, H caesp Festuca inops De Not. (c) IV, Luzula sp. (c) I, T scap Medicago lupulina L. (c) II, H scap Polygala vulgaris L. subsp. vulgaris (c) II, H bienn Tragopogon dubius Scop. (c) II, H scap Trifolium pratense L. subsp. pretense (c) II. Col 5: H ros Silene italica (L.) Pers. subsp. italica (c) I, P scap Populus nigra L. (b) I, P scap Fraxinus excelsior L. subsp. excelsior (a) I, H rept Astragalus glycyphyllos L. (c) I, H scap Cruciata laevipes Opiz (c) I, Pscap Juglans regia L. (c) I, T scap Trifolium incarnatum L. (s.l.) (c) II. Col. 6: H scap Stachys officinalis (L.) Trevis. (c) 2, H ros Asplenium adiantum-nigrum L. subsp. adiantum-nigrum (c) 1, H caesp Hypericum montanum L. (c) 1, H ros Polypodium vulgare L. (c) 1, H ros Silene italica (L.) Pers. subsp. italica (c) 2, P lian Rubia peregrina L. subsp. peregrine (c) 1, NP Rosa arvensis Huds. (b) 1, P scapTilia platyphyllos Scop. subsp. platyphyllos (c) 1, P scap Carpinus betulus L. (b) 1, P caesp Euonymus europaeus L. (b) 4, G rhiz Cardamine bulbifera (L.) Crantz (c) 1, G rhiz Dryopteris filix-mas (L.) Schott (c) 1, G rhiz Mercurialis perennis L. (c) 1, G bulb Dactylorhiza maculata (L.) Soó (c) 1, H ros Potentilla micrantha Ramond ex DC. (c) 3, H scap Vicia sepium L. (c) 1, NP Rubus canescens DC. (b) 2, NP Ligustrum vulgare L. (c) 1, H rept Ajuga reptans L. (c) 1, H scap Campanula persicifolia L. subsp. persicifolia (c) 1, Ch suffr Genista tinctoria L. (c) 1, H rept Glechoma hirsuta Waldst. et Kit. (c) 1, H scap Calamintha ascendens Jord. (c) 2, H ros Ceterach officinarum DC. (c) 1, H scap Cnidium silaifolium (Jacq.) Simonk. subsp. silaifolium (c) 1, T scap Galium aparine L. (c) 1, G bulb Ornithogalum umbellatum L. (c) 2, H caesp Poa pratensis L. (c) 1, Ch frut Urtica dioica L. subsp. dioica (c) 1, T scap Veronica chamaedrys L. subsp. chamaedrys (c) 2.

Appendix II: Localities and dates of relevès

Tab. 1 - Rels. 1, 3, 5. Predicatore's Pinus nigra reforestation 20/06/2012; rels. 2, 4, 6, 7. Predicatore's Pinus nigra reforestation 02/07/2012; Rels. 20, 21, 25. Tegolaro's Pinus nigra reforestation 25/06/2012; Rels. 22, 24. Tegolaro's Pinus nigra reforestation 10/07/2012.

Tab. 3: Col 1. Predicatore's Pinus nigra reforestation 1973 (rels. 10-17 from Tab. 1 in Biondi & Ballelli, 1973); Col 2. Predicatore's Pinus nigra reforestation 2012 (rels. 1-7 of Tab. 1 in this paper); Col. 3. Mt. Predicatore native adjacent wood (rel. 1: Allegrezza & Tesei, Mt. Predicatore 08/06/2012 unpublished; rels. 2-4: Biondi, Allegrezza & Pettinari, Mt. Murano 9/06/1995 unpublished); Col. 4: Tegolaro's Pinus nigra reforestation 1973 (rels. 1-9 from Tab. 1 in Biondi & Ballelli, 1973); Col. 5: Tegolaro's Pinus nigra reforestation 2012 (rels. 20-25 of Tab. 1 in this paper). Col. 6: Mt. Tegolaro native adjacent wood [(rel. 1 of Tab. 1 in Allegrezza, 2003 (Mt. San Vicino); rels. 22, 25, 26 of Tab. 1 in Ballelli, Biondi & Pedrotti, 1982 (Mts. around Valleremita)].