Bulletin of Regional Natural History
Formerly Bollettino della Societá dei Naturalisti in Napoli

Heterotopic European beech (*Fagus sylvatica* L.) stands on Roccamonfina volcano and adjacent areas (Campania-Latium, central-southern Italy): presence assessment and conservation issues

Antonio Croce

DOI https://doi.org/10.6093/2724-4393/12857

***Correspondence:**
antocrx@gmail.com
https://orcid.org/0000-0002-1549-677X

Affiliation:
Via Chiesa, 44, Frazione Tuoro, 81057 Teano

Competing interests: The Author declares that he has no competing interests for this work.

Financial Disclosure Statement: the Author declares that no specific funding was received for this work.

Submitted: 20 June 2025
Revised: 30 Oct 2025
Accepted: 3 Nov 2025
Published: 20 Nov 2025

Associate Editor:
Karl Joseph Duffy

Abstract

Heterotopic populations of *Fagus sylvatica* L. occurring outside their ecological *optimum* represent valuable indicators of paleoclimatic continuity and ecological resilience. This study reports and analyzes such beech populations in the Roccamonfina Volcano and adjacent limestone massifs (Monte Maggiore, Monte Cesima, Monte Sammucro) located in Campania and adjacent Latium (central-southern Italy). Through extensive floristic surveys and 20 phytosociological relevés, the study documents the presence, structure, and ecological features of these stands, many of which had not been previously recorded in scientific literature. Multivariate analyses (PCA and Cluster Analysis) reveal floristic patterns shaped by substrate type, elevation, and disturbance regimes. The vegetation is interpreted within the framework of Italian syntaxonomy, with most communities corresponding to Habitat 9210* (Apennine beech forests with *Taxus* and *Ilex*), despite the absence of *Taxus baccata*. Several rare and conservation-relevant species were identified, including native orchids and regionally rare taxa such as *Lilium martagon* and *Acer cappadocicum* subsp. *lobelii*. The study highlights the precarious conservation status of many of these populations, despite their location within protected areas, pointing to inadequate management practices and threats from logging and infrastructure development. These isolated and relict beech stands are of high biogeographic and conservation value and should be prioritized in regional biodiversity strategies.

Keywords: european beech (*Fagus sylvatica* L.), Heterotopic populations, Campania, Latium, Roccamonfina volcano, vegetation, conservation ecology.

Riassunto

Le popolazioni eterotopiche di *Fagus sylvatica* L., presenti al di fuori del loro optimum ecologico, rappresentano importanti indicatori di continuità paleoclimatica e resilienza ecologica. Questo studio documenta e analizza tali popolazioni di faggio sul Vulcano di Roccamonfina e sui massicci carbonatici adiacenti (Monte Maggiore, Monte Cesima, Monte Sammucro), situati in Campania e nel vicino Lazio (Italia centro-meridionale). Attraverso estese indagini floristiche e 20 rilievi fitosociologici, lo studio descrive la presenza, la struttura e le caratteristiche ecologiche di questi popolamenti, molti dei quali non erano stati precedentemente riportati nella letteratura scientifica. Le analisi multivariate (PCA e Cluster Analysis) evidenziano pattern floristici influenzati da tipo di substrato, altitudine e regimi di disturbo. La vegetazione è interpretata secondo la sintassonomia italiana, con la maggior parte delle comunità riferibili all'Habitat prioritario 9210* (Faggete degli Appennini con *Taxus* e *Ilex*), nonostante l'assenza di *Taxus baccata*. Sono state rilevate diverse specie rare o di interesse conservazionistico, tra cui orchidee spontanee e taxa rari a livello regionale come *Lilium martagon* e *Acer cappadocicum* subsp. *lobelii*. Lo studio evidenzia lo stato di conservazione critico di molte di queste popolazioni, nonostante si trovino all'interno di aree protette, a causa di pratiche gestionali inadeguate e minacce legate a tagli forestali e opere infrastrutturali. Questi nuclei isolati e relitti di faggio rivestono un elevato valore biogeografico e conservazionistico, e dovrebbero essere prioritariamente inclusi nelle strategie regionali per la tutela della biodiversità.

Parole chiave: faggio (*Fagus sylvatica*), Popolamento eterotopico, Campania, Lazio, Vulcano di Roccamonfina, vegetazione, Ecologia della conservazione.

Introduction

European beech (*Fagus sylvatica* L.) is distributed across a wide range of Europe, extending from northern Spain to the Black Sea, and from Sicily to the southern regions of the Scandinavian Peninsula (Euforgen, 2009). In Italy, it is native and widespread in all regions, with the sole exception of Sardinia, where it is not indigenous (Bartolucci et al., 2024). Along the Apennine range, its optimal altitudinal distribution typically lies between 1000 and 1700 (occasionally up to 1900) meters above sea level (Pignatti, 1982, 1998).

In Campania, beech forests are present from the northern to the southern sections of the Apennines and other mountainous areas. According to the vegetation series map of Italy (Filesi et al., 2010), in northern Campania and adjacent areas of Latium, these forests are found above 1000 m a.s.l., particularly on the Matese Massif, and potentially in several isolated patches on mountain summits where suitable environmental conditions persist.

From a phytosociological perspective, and following the classification proposed in the *Prodromo della vegetazione d'Italia* (Biondi & Blasi, 2013; Biondi et al., 2014), the beech woods of southern Italy fall within the class *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937, and belong to the order *Fagetalia sylvaticae* Pawlowski in Pawlowski, Sokolowski & Wallisch 1928. The thermophilous beech forests of the southern Apennines are further classified under the suballiance *Doronico orientalis-Fagenion sylvaticae*.

Heterotopic or extrazonal beech populations are communities that persist in localized microclimatic niches, where conditions remain favorable for their survival despite being outside their optimal climatic zone. These microhabitats provide sufficient moisture and temperature stability, enabling *Fagus sylvatica* to thrive even in areas where the broader phytoclimatic context is less suitable (Pignatti,

1995). Such populations are considered relicts of past paleoclimatic and paleogeographic conditions (Magri, 2008), and their presence is of considerable biogeographical and conservation interest. These relictual heterotopic stands are typically situated outside the main vegetation series to which the species would normally belong.

Several examples of such heterotopic or "depressed" beech populations have been documented across various Italian regions and have been particularly studied in Tuscany and Latium (Roma-Marzio et al., 2017). In Campania, however, the topic has received limited attention, with the only specific study being that of Agostini (1971), who described some degraded populations in the Picentini Mountains. The subject has since been only briefly mentioned, without in-depth treatment, by Saracino (2012).

During floristic surveys conducted in the northern part of the Campania region, we repeatedly encountered populations of *Fagus sylvatica* in areas where its presence had either not been previously recorded or where available information was scant or outdated. For the Roccamonfina volcano, the earliest bibliographic reference to *Fagus sylvatica* is found in the flora compiled by Croce et al. (2008). In the other surrounding territories these plant communities are reported in technical documents recently published by the Campania region, without any reference to their particular interest. With regard to the stands in Latium territory, no prior documentation was found, and thus the data presented in this paper represent new and previously unpublished records.

The most representative beech nuclei discovered during these surveys have been investigated through phytosociological analysis, with the aim of characterizing their vegetation types, assessing their floristic diversity both quantitatively and qualitatively, and highlighting their significance within the broader context of the region's biodiversity.

Materials and methods

For the purposes of this study, we focused on the northern part of the Campania region and the adjacent areas of Latium—territories characterized by relatively limited floristic data (Strumia et al., 2005), and even more deficient with regard to vegetation studies (Filesi et al., 2010). Within this area, heterotopic beech forest stands were identified on the Roccamonfina Volcano, in the Trebulani Mountains (specifically on Mount Maggiore), on Mount Cesima (all located in the province of Caserta, Campania), and on the northern slopes of Mount Sammucro in Latium, together with several isolated individuals (Fig. 1).

The Roccamonfina Volcano is a Late Pleistocene stratovolcano, whose volcanic activity began approximately 630,000 years ago (De Rita et al., 1997). It features a large summit caldera containing two central domes, with Monte Santa Croce reaching 1005 meters a.s.l. The volcanic complex also includes several secondary extracaldera centers, primarily situated in the southern and eastern sectors. The landscape is predominantly covered by chestnut woodlands—both coppices and cultivated orchards—which extend from the lower slopes to the summit.

The volcanic structure is bordered by tectonic depressions and Mesozoic limestone massifs. Among these are Mount Sammucro, Mount Cesima, and Mount Maggiore, aligned in a northwest–southeast direction and running parallel to the Apennine chain. The highest elevations in these massifs are: Mount Sammucro (1205 m), which marks the regional boundary between Latium, Molise, and Campania; Mount Cesima (1180 m); and Pizzo San Salvatore (1037 m).

During our floristic surveys (Croce et al., 2008 and unpublished data), the presence of isolated beech trees as well as actual beech forest stands was georeferenced. Phytosociological sampling was then carried out in areas where *Fagus sylvatica* formed well-structured stands

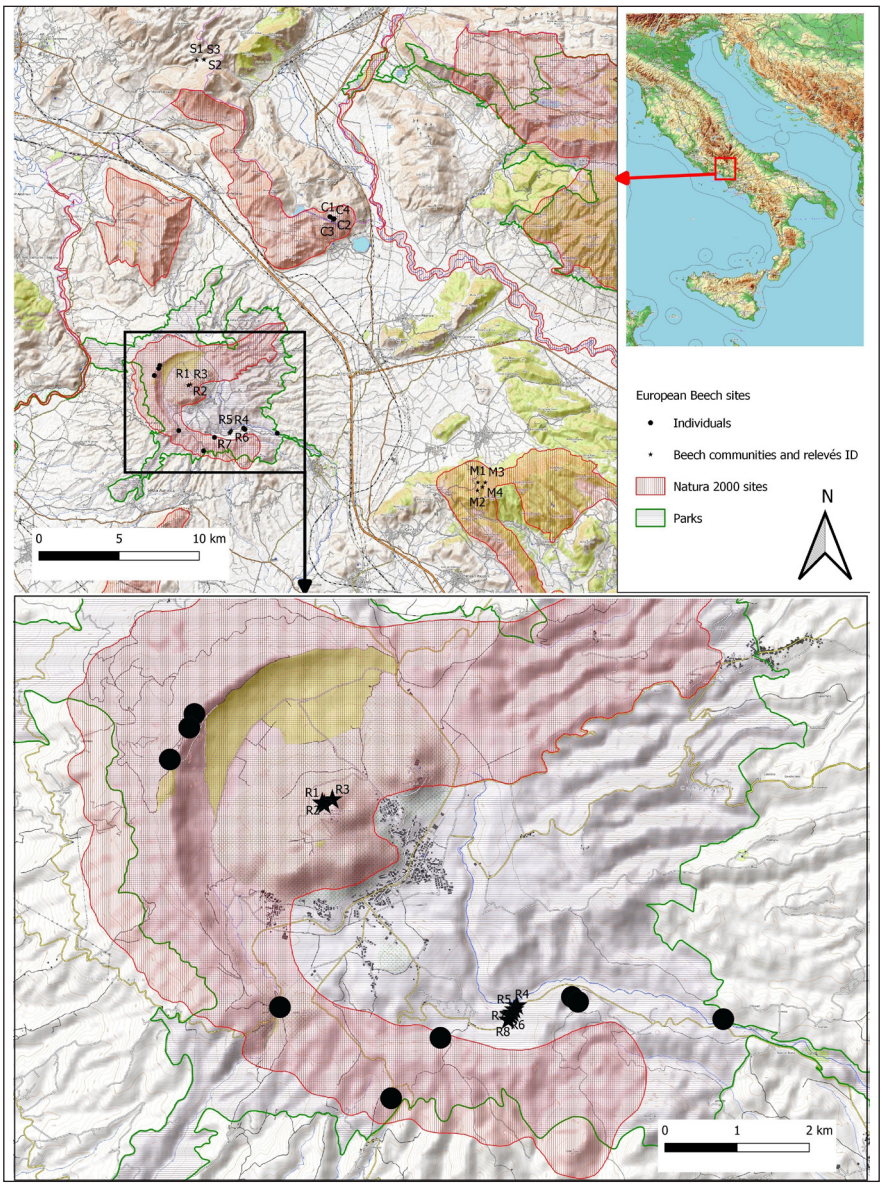

Figure 1: Localization of the sites with *Fagus sylvatica* L. Dots = single individuals, stars = populations and related vegetation relevés.

and possibly reached dominance within the forest canopy (Tab. 1).

A Braun-Blanquet-derived cover-abundance scale was used for vegetation analysis, with the following values:

+ : species present with few individuals and cover <1%

1 : cover between 1–5%

2a : cover between 5–12%

2b : cover between 12–25%

3 : cover between 25–50%

4 : cover between 50–75%

5 : cover between 75–100%

Species recorded only once in the relevés (sporadic taxa) were excluded from the statistical analysis.

The resulting data matrix, was subjected to multivariate analysis. A Principal Component Analysis (PCA) was used to explore patterns of species distribution, and a Cluster Analysis was performed to classify vegetation types. Both analyses were conducted using the PAST software package (Hammer et al., 2001).

Taxonomic nomenclature follows the *Portal to the Flora of Italy* (2024), while syntaxonomic references (Tab. 2) adhere to the *Prodromo della vegetazione d'Italia* (Biondi et al., 2014).

Table 1: Location and site characheristics of the 20 phytosociological relevés in *Fagus sylvatica* stands.

Relevè ID	Locality	Date	Elevation (m a.s.l.)	Aspect (°)	Slope (°)	Surface (m^2)	Tot. Cover (%)	Tree cover (%)	shrub cover %	Herb cover (%)	Geological substrate	litter %	UTMx	UTMy	Management	Species richness
R1	M. S. Croce, Roccamonfina Volcano	08/07/2009	845	25	20	100	95	90	15	40	Latite	90	413704	4572315	Young chestnut coppice	30
R2		08/07/2009	870	330	30	80	95	90	60	30	Latite	70	413727	4572297	chestnut coppice	22
R3		08/07/2009	990	275	40	100	100	90	50	25	Latite	90	414045	4572360	chestnut coppice	31
R4	Savone delle Ferriere (Torano), Roccamonfina Volcano	25/06/2009	425	285	50	150	100	95	60	25	Tuffs	95	416400	4569500	chestnut coppice	53
R5		28/06/2012	420	300	60	150	100	90	40	60	Tuffs	95	416365	4569446	old chestnut coppice	56
R6		28/06/2012	420	300	60	150	100	90	30	60	Tuffs	90	416341	4569398	old chestnut coppice	46
R7		28/06/2012	420	300	60	150	100	90	40	30	Tuffs	80	416306	4569366	old chestnut coppice	45
R8		28/06/2012	420	300	60	150	100	100	30	30	Tuffs	90	416283	4569302	beech forest	34
C1	Piano, M. Cesima massif	28/06/2011	665	45	40	150	100	90	80	30	Limestones	95	422750	4582715	beech forest	47
C2		28/06/2011	665	45	30	100	100	90	70	20	Limestones	95	422728	4582658	beech forest	42
C3		28/06/2011	680	45	30	150	100	95	60	50	Limestones	60	422707	4582645	beech forest	28
C4		28/06/2011	715	45	40	150	100	90	70	50	Limestones	90	422730	4582616	beech forest	35
C5		28/06/2011	645	0	40	100	100	95	50	20	Limestones	90	422613	4582809	beech forest	35
S1	Radicosa, M. Sammucro massif	09/07/2011	525	10	60	120	100	95	0	10	Limestones	50	414233	4592612	beech forest	38
S2		09/07/2011	546	20	60	100	100	90	0	30	Limestones	90	414695	4592654	beech forest	25
S3		09/07/2011	555	350	45	100	100	90	0	50	Limestones	60	414680	4592641	beech forest	32
M1	Fosso della Neve, M. Maggiore massif	18/05/2012	585	230	45	200	100	90	50	90	Limestones	90	431781	4566246	beech forest	32
M2		18/05/2012	730	290	45	200	100	90	20	90	Limestones	90	431748	4565734	beech forest	45
M3		08/06/2012	465	290	30	150	100	95	20	90	Limestones	90	432245	4566237	mixed woodland	40
M4		08/06/2012	570	80	50	150	100	90	10	80	Limestones	90	432066	4565948	beech forest	28

Results

A total of 20 phytosociological relevés were conducted in European beech forest communities, resulting in a data matrix composed of 20 relevés and 111 species (Tab. 3). Of the 154 species recorded, 43 were considered sporadic (i.e., occurring in only one relevé). Species richness per relevé ranged from a minimum of 22 species (R2) to a maximum of 56 species (R5).

Roccamonfina volcano

The presence of *Fagus sylvatica* on the Roccamonfina Volcano, between 320 and 990 meters above sea level, has previously been documented (Croce et al., 2008; Croce, 2024) and cited in a regional review on beech forests of Campania and Basilicata (Saracino, 2012). In particular, beech stands were identified in the gorge of the Savone delle Ferriere stream, between the municipalities of Teano and Roccamonfina. Isolated individuals were also recorded near the village of Chiovari and upstream from the village of Preta, often growing on the grey tuff canyon walls. Notably, young trees were observed within chestnut orchards along the provincial road connecting Teano and Roccamonfina—sites relatively distant from the humid microclimate typical of the gorge.

Beech becomes dominant in forest cover downstream of the village of Torano, with scattered individuals found along the stream branches extending westward and northward up to about 600 meters elevation. Isolated young trees were also found along the road from Roccamonfina to Valogno (at 525 m a.s.l.) and near Ponte i Grottoni (535 m a.s.l.) atop the Rio della Selva fluvial incision. These two localities lie approximately 1.5 km southwest and 2 km west, respectively, from the Torano population, within the municipality of Sessa Aurunca.

At higher elevations, close to the species' ecological optimum, a small beech population was found in a chestnut coppice forest on the summit of Monte Santa Croce, on its N–

NW slope between 950 and 990 m a.s.l. A few mature individuals were also observed along the caldera rim north of Monte La Frascara, at about 900 m a.s.l.
Five phytosociological relevés (R4–R8) were conducted in the Torano beech population, representing different degrees of canopy cover. Three additional relevés (R1–R3) were carried out in the Monte Santa Croce population (Tab. 1).
According to the Vegetation Series Map (Filesi et al., 2005), all these sites fall within the central Tyrrhenian pre-Apennine subacidophilous series of *Quercus cerris*, with *Sorbus domestica*, *S. torminalis*, and *Acer opalus* subsp. *obtusatum* in the tree layer, and shrubby mantles dominated by *Cytisus scoparius*. The latter is present exclusively in the Monte Santa Croce communities, where it represents the initial successional stage following coppice cutting.
All beech populations lie within the boundaries of the Roccamonfina-Foce Garigliano Regional Park, with the exception of the Savone gorge sites, which fall outside the Natura 2000 Special Area of Conservation (SAC) IT8010022 "Vulcano di Roccamonfina".

Monte Maggiore

The beech communities of Monte Maggiore are located between 465 and 730 m a.s.l. in the locality of *Fosso della Neve*, within the municipality of Pietramelara. They occur on NW to NE-facing slopes and are represented by four relevés (M1–M4). These communities fall within the central Tyrrhenian Apennine neutro-basiphilous series of the hop hornbeam (*Melittio melissophylli–Ostryio carpinifoliae* sigmetum), dominated by *Ostrya carpinifolia* and *Carpinus orientalis*. *Cercis siliquastrum*, typically associated with this series, is absent or sporadic in the relevés.
While *Acer cappadocicum* subsp. *lobelii* is frequent in the broader area, it is rare in the sampled sites. In contrast, *Acer opalus* subsp. *obtusatum*, *Castanea sativa*, *Fraxinus ornus*, *Ostrya carpinifolia*, and *Quercus ilex* are frequent in the tree layer. The presence of *Quercus ilex*, albeit with low coverage, underscores the thermophilous nature of these communities, further supported by species such as *Anemone apennina*, *Asparagus acutifolius*, *Rubia peregrina*, *Cyclamen repandum*, *Drymochloa drymeja*, *Ruscus aculeatus* and, even as sporadic species, *Polypodium cambricum*, *Phillyrea latifolia*, *Smilax aspera*. The herbaceous layer is dominated by *Sesleria autumnalis*, a characteristic species of this vegetation series.
All beech stands fall within the SAC IT8010006 "Catena di Monte Maggiore".

Monte Cesima

The small beech community on Monte Cesima is located in Valle Casale area, at the base of the NE slope of Monte San Leonardo, and in Piano di Cesima area, at the base of the N slope of Colle Aruta and Colle Traverso. The site ranges in altitude from 645 to 715 m a.s.l., and is represented by five relevés (C1–C5) carried out in the first locality, where beech reaches higher cover values in the tree layer. It falls within the Adriatic neutro-basiphilous series of *Quercus cerris* and *Quercus pubescens* (*Daphno laureolae–Querco cerridis* sigmetum) as defined by Filesi et al. (2010).
The tree layer is dominated by *Quercus cerris*, with accompanying species including *Ostrya carpinifolia*, *Fraxinus ornus*, *Acer opalus* subsp. *obtusatum*, and *Acer campestre*. The shrub layer is poorly developed, with only *Rubus ulmifolius* and *Crataegus monogyna*, both belonging to *Rhamno-prunetea* communities, being frequent - likely due to historical or ongoing grazing pressure or to the fragmentation of this community. The herbaceous layer is diverse, with *Euphorbia amygdaloides*, *Carex sylvatica*, *Lathyrus venetus*, *Melica uniflora*, *Ruscus aculeatus*, *Viola reichenbachiana*, and the regionally rare *Lilium martagon* being of particular interest. Other frequent species include *Sesleria autumnalis*, *Galium odoratum*, and *Daphne laureola*. This site is

Table 2: Syntaxonomic scheme.

```
Cl. QUERCO ROBORIS-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger 1937
 └ Ord. Fagetalia sylvaticae Pawłowski in Pawłowski, Sokołowski & Wallisch 1928
    └ All. Geranio versicoloris-Fagion sylvaticae Gentile 1970
       └ Suball. Doronico orientalis-Fagenion sylvaticae
          (Ubaldi, Zanotti, Puppi, Speranza & Corbetta ex Ubaldi 1995)
          stat. nov. Di Pietro, Izco & Blasi 2004
          └ Ass. Anemono apenninae-Fagetum sylvaticae (Gentile 1970) Brullo 1

   Ord. Quercetalia pubescenti-petraeae Klika 1933
    └ All. Carpinion orientalis Horvat 1958

Cl. QUERCETEA ILICIS Br.-Bl. in Br.-Bl., Roussine & Nègre 1952
 └ Ord. Quercetalia ilicis Br.-Bl. ex Molinier 1934

Cl. RHAMNO CATHARTICAE-PRUNETEA SPINOSAE Rivas Goday & Borja ex Tüxen 1962
```

included in the SAC IT8010005 "Catena di Monte Cesima".

Monte Sammucro

The beech stand on Monte Sammucro is located on the northern slope along the "Rio di S. Vittore" stream, near the village of Radicosa, in the municipality of San Vittore del Lazio (Latium), at elevations between 520 and 560 m a.s.l. (relevés S1–S3). These communities belong to the pre-Apennine neutro-basiphilous series of *Quercus pubescens* (*Roso sempervirentis–Querco pubescentis* sigmetum).

Fagus sylvatica dominates the canopy, with *Acer obtusatum*, *Fraxinus ornus*, and *Quercus cerris* also present. *Carpinus orientalis* is less frequent. Notably, both *Quercus pubescens* and *Quercus ilex*, characteristic of the series, are absent, reinforcing the mesophilic nature of these stands. The shrub layer is composed of deciduous species such as *Ligustrum vulgare* and *Cornus sanguinea*, with no evergreen elements. Similarly to the M. Cesima Relevès, species of *Quercetea ilicis* are here poorly represented. Grazing appears to play a major role in shaping the vegetation structure, as reflected in a herbaceous layer where *Euphorbia amygdaloides*, *Mercurialis perennis*, *Helleborus foetidus*, and *Sesleria autumnalis* are common.

Only a portion of the beech forests, specifically the lower-elevation section, is included within the protected area Monumento Naturale "Monte Sammucro – Terra di Confine", established in 2021 by Latium administrative Region. In particular, the relevé S1 falls within the boundaries of the protected area, while S2 and S3 fall outside it.

Multivariate analysis

Cluster analysis (Fig. 2) revealed distinct groupings among the relevés, mainly structured along substrate. Communities on volcanic soils (Roccamonfina) form a separate cluster from those on carbonate substrates (Monte Maggiore, Cesima, Sammucro), where species of the thermophilous *Carpinion orientalis* alliance (e.g., *Ostrya carpinifolia*, *Fraxinus ornus*, *Sesleria autumnalis*) are more prevalent.

Within the volcanic sites, *Castanea sativa* is always dominant in the tree layer, except in rel. R8, where it is codominant with *Fagus sylvatica*. The species of the *Geranio–Fagion* alliance (e.g., *Cardamine chelidonia*, *Lamium flexuosum*, *Senecio ovatus* subsp. *stabianus*) are well represented. Monte Santa Croce relevés form a compact group with low floristic richness (22–30 species), while the Savone gorge communities show the highest richness (34–56 species).

Relevés from Monte Maggiore host thermophilous elements of the *Quercetea ilicis* class (*Quercus ilex*, *Ampelodesmos mauritanicus*, *Arisarum vulgare*, *Asparagus acutifolius*), and cluster closely with Monte Sammucro relevés, which lack a shrub layer—likely due to grazing, as observed also on Monte Cesima. This disturbance correlates with lower herbaceous richness in these sites. The patterns described above are confirmed by the Principal Component Analysis of the relevés (Fig. 3). The first principal axis accounts for 32.1% of the total variance and primarily represents the substrate gradient separating the volcanic from the limestone sites. The second axis explains 14.6% of the total variance and is associated with a gradient of disturbance or management, with relevés showing lower shrub layer cover positioned in the lower part of the ordination diagram.

Discussion and conclusion

The floristic composition allows to consider the populations here studied as representative of the Priority Habitat 9210*- *Apennine beech forests with Taxus and Ilex* despite the lack of *Taxus baccata*.

The following detected species are, indeed, typical of this habitat: *Ilex aquifolium*, *Anemone apennina*, *Aremonia agrimonioides*, *Cardamine bulbifera*, *C. chelidonia*, *Euphorbia amygdaloides*, *Galium odoratum*, *Lathyrus venetus*, *Melica uniflora*, *Mycelis muralis*, *Potentilla micrantha*, *Ranunculus lanuginosus*, *Rubus hirtus*, *Sanicula europaea*, *Viola reichembachiana*, *V. riviniana*, *Athyrium filix-femina*.

A group of species are of some conservation issues as the native orchids *Neottia nidus-avis*, *Cephalanthera longifolia*, *C. rubra* and *Arisarum proboscideum, Lilium bulbiferum* and *Lilium martagon*, *Acer cappadocicum* subsp. *lobelii* (Regional Law n. 40/1994) and *Ruscus aculeatus* (Habitat Directive 92/43/EEC, annex V).

The most recent observation taken in the studied sites (spring 2025) highlights the critical conditions of most of them, despite they are included in SAC areas, or in Regional parks. The habitat 9210 is recorded in the Standard Data Forms of SACs IT8010005 and IT8010006, but not in IT8010022. Therefore, no specific conservation measures are planned for the latter site. Conversely, beech forests are reported for the studied areas – although not always correctly located due to the adopted scale – in the Habitat Map of Campania (Bagnaia et al., 2017) for Monte Maggiore, Monte Cesima and for the lower sites on Roccamonfina Volcano, but they were either not detected or not reported in the Habitat Map of Latium (Casella et al., 2008) for the Monte Sammucro site. On Roccamonfina Volcano the community on Mount S. Croce underwent the same fate as the surrounding coppiced chestnut woodland and was subject to clear-cut. Only a few shoots or seedlings less than 2 m high along with a few adult plants growing in a protected spot in an impluvium were visible in the site. The beech in Savone gorge is affected by sporadic cuts and its importance is poor known by administrators. As a result, projects affecting the area often fail to properly consider the impacts on the beech population and the surrounding ecosystem. These observations let us think that although the majority of the communities fall within designated protected zones, their management—often guided by assessments that inadequately consider ecological and conservation criteria—raises significant concerns regarding the long-term effectiveness of habitat (and species) preservation.

Table 3: Phytosociological relevés in *Fagus sylvatica* sites on Roccamonfina Volcano (R), Monte Maggiore (M), Monte Cesima (C), and Monte Sammucro (S).

		R1	R2	R3	R4	R5	R6	R7	R8	C1	C2	C3	C4	C5	S1	S2	S3	M1	M2	M3	M4	Presence	Frequence
	Char. assoc. *Anemono apenninae-fagetum*																						
Paleotemp.	*Melica uniflora* Retz.	1	.	1	2a	1	1	1	1	2a	1	1	+	1	2a	1	.	.	+	+	+	17	V
Pontico	*Lathyrus venetus* (Mill.) Wohlf.	.	.	+	+	.	.	.	.	2a	1	1	1	1	+	.	1	1	+	+	+	13	IV
Submedit.-Subatl.	*Ilex aquifolium* L.	+	.	.	2a	1	.	1	1	.	.	2a	2b	2b	.	.	+	.	2a	+	.	11	III
C-Europ.Caucas.	*Euphorbia amygdaloides* L. subsp. amygdaloides	.	.	.	.	.	.	.	.	1	+	+	+	+	1	+	+	.	.	.	.	8	II
Euri-Medit.	*Potentilla micrantha* Ramond ex DC.	.	.	+	+	+	.	.	.	2a	1	.	+	+	.	.	.	.	.	+	.	8	II
SE-Europ.	*Anemone apennina* L.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	2a	+	+	.	5	II
	Char. all. *Geranio versicoloris-Fagion*																						
Submedit.-Subatl.	*Daphne laureola* L.	.	.	.	.	+	+	+	+	1	+	+	1	.	.	.	+	+	+	+	+	13	IV
NW-Medit.	*Lamium flexuosum* Ten. subsp. *flexuosum*	.	.	.	2a	+	2a	1	1	.	.	.	.	.	.	.	.	.	.	+	+	7	II
Medit.-Turan.	*Drymochloa drymeja* (Mert. & W.D.J.Koch) Holub	2b	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	2a	4	3	6	II
Subendem.	*Cardamine chelidonia* L.	.	.	.	1	.	+	1	.	.	.	.	.	.	.	.	.	.	.	+	.	4	I
Steno-Medit.-Occid.	*Allium pendulinum* Ten.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	3	I
Orof. NE-Medit.	*Aremonia agrimonoides* (L.) DC. subsp. *agrimonoides*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	3	I
Endem.	*Senecio ovatus (G.Gaertn., B.Mey. & Scherb.) Willd. subsp. stabianus (Lacaita) Greuter*	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Eurasiat.	*Polygonatum multiflorum* (L.) All.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
Endem.	*Acer cappadocicum* Gled. subsp. *lobelii* (Ten.) A.E.Murray	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	1	I
	Char. ord. *Fagetalia*																						
Centroeurop.	*Fagus sylvatica* L.	2a	4	1	2a	4	4	2a	5	4	4	3	5	5	4	4	5	5	5	4	3	20	V
Eurosiber.	*Viola reichenbachiana* Jord. ex Boreau	.	.	.	.	+	.	+	+	+	+	+	+	1	+	.	+	1	+	1	+	14	IV
Europ.-Caucas.	*Mycelis muralis* (L.) Dumort. subsp. *muralis*	+	.	+	+	1	+	1	+	+	+	.	.	+	1	.	.	.	.	+	.	12	III
Europ.-Caucas.	*Mercurialis perennis* L.	.	.	.	.	.	.	.	.	+	+	2a	1	.	1	2a	2a	.	1	+	+	10	III
Circumbor.	*Polystichum setiferum* (Forssk.) T.Moore ex Woyn.	.	.	.	2a	2a	1	2a	2a	.	.	.	.	.	.	.	.	.	+	2a	.	7	II
Eurasiat.	*Galium odoratum* (L.) Scop.	.	.	1	.	.	.	.	.	1	1	2a	.	+	.	.	.	.	.	1	.	6	II
Subcosmop.	*Geranium robertianum* L.	.	.	2a	.	.	.	+	.	.	+	+	1	.	+	.	.	.	.	.	.	6	II
Eurasiat.	*Carex sylvatica* Huds.	.	.	.	.	.	.	.	.	2a	1	1	1	+	.	.	.	.	.	.	.	5	II
Orof. Eurasiat.	*Salvia glutinosa* L.	.	.	.	2a	+	1	1	.	.	.	.	.	.	+	.	.	.	.	.	.	5	II
Paleotemp.	*Sanicula europaea* L.	.	.	.	+	.	.	.	.	1	.	.	.	+	+	.	.	.	.	+	.	5	II
Eurasiat.	*Neottia nidus-avis* (L.) Rich.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	.	+	4	I
W-Medit.	*Arisarum proboscideum* (L.) Savi	.	.	.	1	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	3	I
Eurasiat.	*Cephalanthera longifolia* (L.) Fritsch	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	3	I
Eurasiat.	*Moehringia trinervia* (L.) Clairv.	.	.	+	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	3	I

Pontico-C-Europ.	*Cardamine bulbifera* (L.) Crantz	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
Eurasiat.	*Cephalanthera rubra* (L.) Rich.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	2	I
Orof. SE-Europ.	*Luzula sylvatica* (Huds.) Gaudin subsp. *sylvatica*	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	1	.	.	2	I
	Char. All. Carpinion orientalis																						
SE-Europ.	*Sesleria autumnalis* (Scop.) F.W.Schultz	.	.	.	.	.	.	.	.	2b	.	+	1	3	2a	1	3	3	4	.	4	10	III
Circumbor.	*Ostrya carpinifolia* Scop.	.	.	.	.	.	.	.	.	3	3	.	2b	2a	.	+	.	.	2a	3	2b	8	II
Europ.-Caucas.	*Carpinus orientalis* Mill. subsp. *orientalis*	*2a*	.	.	*2a*	.	.	.	.	.	*1*	.	.	.	*3*	.	*1*	*+*	*1*	.	.	7	II
S-Europ.	*Pseudoturritis turrita* (L.) Al-Shehbaz	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	5	II
NE-Medit.	*Melittis melissophyllum* L. subsp. *albida* (Guss.) P.W.Ball	.	.	2b	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	4	I
S-Europ.	*Staphylea pinnata* L.	.	.	.	.	2b	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	3	I
	Char. ord. *Quercetalia pubescenti-petraeae*																						
Euri-Medit.	*Ruscus aculeatus* L.	.	.	.	3	2a	2a	2b	2a	+	1	+	+	1	+	1	+	3	1	2a	1	17	V
Euri-N-Medit.-Pontico	*Fraxinus ornus* L. subsp. *ornus*	.	.	.	.	.	1	.	.	2b	.	+	2b	1	+	2a	2a	2b	2b	+	2b	12	III
Steno-Medit.	*Viola alba* Besser subsp. *dehnhardtii* (Ten.) W.Becker	1	.	.	1	.	.	.	.	1	+	.	+	.	.	+	1	1	1	.	+	10	III
Subatl.	*Helleborus foetidus* L. subsp. *foetidus*	.	.	.	.	.	.	.	.	+	+	+	.	+	+	+	+	.	+	+	.	9	III
Europeo-Pontico	Quercus pubescens Willd. subsp. pubescens	.	.	.	1	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	5	II
Eurasiat.	*Lilium martagon* L.	.	.	.	.	.	.	.	.	+	1	1	1	1	.	.	.	.	.	.	.	5	II
Endem.	*Digitalis micrantha* Roth ex Schweigg.	+	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	5	II
SE-Europ.-Pontico	*Cornus mas* L.	.	.	.	.	.	.	.	.	2a	.	.	1	.	.	.	.	.	2a	.	1	4	I
Subendem.	*Teucrium siculum* (Raf.) Guss.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	4	I
Pontico-SE-Europ.	*Mespilus germanica* L.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	3	0,15
SE-Europ.-Caucas.	*Sorbus torminalis* (L.) Crantz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	2	I
	Char. cl. *Querco-Fagetea*																						
Submedit.-Subatl.	*Hedera helix* L. subsp. *helix*	2a	+	2b	2a	2b	3	2b	2a	3	3	2b	3	4	2b	1	.	2a	2b	3	1	19	V
SE-Europ.	*Acer opalus* Mill. subsp. *obtusatum* (Waldst. & Kit. ex Willd.) Gams	.	.	2b	2a	1	2a	1	.	3	3	4	2b	.	2b	3	3	3	3	1	2b	16	IV
Europ.-Caucas.	*Ajuga reptans* L.	+	.	.	+	+	+	.	+	1	+	.	+	+	1	.	+	+	+	+	+	15	IV
SE-Europ.	*Castanea sativa* Mill.	5	5	5	5	5	5	5	5	.	.	.	.	.	+	.	.	+	+	+	2a	13	IV
Europ.-Caucas.	*Hieracium racemosum* Waldst. & Kit. ex Willd. subsp. *crinitum* (Sm.) Rouy	2a	2a	+	+	+	.	.	.	1	.	.	1	1	+	+	+	.	+	.	.	12	III
SE-Europ.-Pontico	*Lonicera caprifolium* L.	.	.	.	2a	3	2a	1	2a	2a	1	2a	1	1	+	.	.	.	1	.	.	12	III
Euri-Medit.-Sett.	*Quercus cerris* L.	.	.	.	+	+	.	.	.	3	+	3	1	2a	1	+	+	+	.	.	.	11	III
Euri-Medit.	*Luzula forsteri* (Sm.) DC.	1	+	.	+	+	+	+	+	1	1	.	.	+	.	.	.	.	.	.	.	10	III
Europ.-Caucas.	*Acer campestre* L.	.	.	.	+	1	.	+	.	2a	2a	+	.	1	2b	.	.	+	.	.	.	9	III
Paleotemp.	*Campanula trachelium* L. subsp. *trachelium*	+	.	.	+	+	1	.	+	.	.	.	+	+	+	.	+	.	.	.	.	9	III

Europ.-Caucas.	*Festuca heterophylla* Lam.	+	+	+	+	1	+	+	.	.	.	.	1	1	.	.	.	.	.	.	.	9	III
Centroeurop.	*Rubus hirtus* Waldst. & Kit. group	+	+	1	1	2a	1	2b	2a	.	.	.	.	.	.	.	.	.	1	.	.	9	III
Europ.-Caucas.	*Corylus avellana* L.	1	.	4	2b	.	+	1	1	.	.	.	.	.	.	.	.	.	.	+	.	7	II
Eurasiat.	*Euonymus europaeus* L.	.	.	.	1	1	1	+	.	2a	.	.	.	.	.	.	.	+	1	.	.	7	II
Orof. Centroeurop.	*Lilium bulbiferum* L.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	+	+	+	+	.	.	7	II
Circumbor.	*Geum urbanum* L.	.	.	.	.	+	.	+	.	+	+	.	.	.	+	.	.	.	.	+	.	6	II
Submedit.-Subatl.	*Rosa arvensis* Huds.	.	.	.	.	.	.	.	.	2a	1	.	.	1	+	.	+	+	.	.	.	6	II
Eurosiber.	*Solidago virgaurea* L. subsp. *virgaurea*	1	1	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	6	II
Cosmop.	*Fragaria vesca* L. subsp. *vesca*	1	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	+	.	.	5	II
Euri-Medit.	*Silene italica* (L.) Pers. subsp. *italica*	.	+	.	.	+	+	.	.	1	.	+	.	.	.	.	.	.	.	.	.	5	II
Medit.Atl.(Steno-)	*Clinopodium menthifolium* (Host) Merino subsp. *menthifolium*	.	.	.	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	4	I
Orof. S-Europ.	*Laburnum anagyroides* Medik. subsp. *anagyroides*	.	.	.	.	.	.	.	.	.	.	.	4	.	.	+	+	.	.	.	.	3	0,15
Europ.-Caucas.	*Primula vulgaris* Huds. subsp. *vulgaris*	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Europ.-Caucas.	*Prunus avium* (L.) L.	.	.	.	+	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Paleotemp.	*Brachypodium sylvaticum* (Huds.) P.Beauv. subsp. *sylvaticum*	.	+	.	.	.	.	.	.	.	.	.	.	.	2a	.	+	.	.	.	.	3	I
Medit.-Mont.	*Crepis leontodontoides* All.	.	.	.	.	.	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	3	I
Europ.-Caucas.	*Carpinus betulus* L.	+	.	3	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Euri-Medit.	*Sorbus domestica* L.	1	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Orof. Eurasiat.	*Veronica officinalis* L.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
	Char. cl. *Quercetea* and ord. *Quercetalia-iliciis*																						
Medit.-Macarones.	*Asplenium onopteris* L.	.	.	+	1	1	+	+	1	+	+	+	.	.	.	.	.	+	1	+	+	13	IV
Steno-Medit.	*Asparagus acutifolius* L.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	1	.	.	.	4	I
N-Medit.	*Cyclamen repandum* Sm. subsp. *repandum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	4	I
Steno-Medit.	*Quercus ilex* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	3	I
Medit.-Macarones.	*Rubia peregrina* L.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	2a	.	.	.	3	I
Steno-Medit.-Sudoccid.	*Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	2	I
Steno-Medit.	*Arisarum vulgare* O.Targ.Tozz. subsp. *vulgare*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	2	I
	Char. cl. *Rhamno-Prunetea*																						
Euri-Medit.	*Dioscorea communis* (L.) Caddick & Wilkin	.	.	+	2a	1	+	1	+	.	.	.	.	.	+	1	2a	.	.	+	+	11	III
Euri-Medit.	*Rubus ulmifolius* Schott	.	.	.	.	.	.	.	.	4	4	3	3	3	1	.	.	+	.	+	+	9	III
Paleotemp.	*Crataegus monogyna* Jacq.	.	.	.	.	1	1	1	.	3	2b	+	.	1	+	.	.	.	.	.	.	8	II
SE-Europ.	*Cornus sanguinea* L. subsp. *hungarica* (Kárpáti) Soó	.	.	.	2b	1	1	1	1	.	2b	.	.	.	+	.	+	.	.	.	.	8	II
Eurasiat.	*Ligustrum vulgare* L.	.	.	.	+	+	+	+	+	.	.	.	.	.	1	.	.	.	.	.	.	6	II
Europ.-Caucas.	*Clematis vitalba* L.	.	.	.	.	.	.	.	.	1	1	.	+	.	.	+	.	.	+	.	.	5	II
	Other species																						
Cosmop.	*Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*	+	+	.	.	+	+	+	+	.	.	+	.	2b	.	+	2a	.	.	.	.	10	III

Cosmop.	*Asplenium trichomanes* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	+	+	.	4	I
Eurasiat.	*Cardamine impatiens* L. subsp. *impatiens*	.	.	.	1	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Eurasiat.	*Cruciata glabra* (L.) C.Bauhin ex Opiz	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	4	I
Euri-Medit.-Subatl.	*Dryopteris pseudomas* (Woll.) Holub & Pouzar subsp. *pseudomas*	.	.	.	1	+	+	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Europ.-Caucas.	*Hypericum montanum* L.	.	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	4	I
Endem.	*Linaria purpurea* (L.) Mill.	.	.	.	+	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Medit.-Atl.(Euri-)	*Polypodium interjectum* Shivas	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	4	I
Cosmop.	*Stellaria media* (L.) Vill.	.	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	4	I
Paleotemp.	*Dactylis glomerata* L. subsp. *glomerata*	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	3	I
Paleotrop.	*Hypericum perforatum* L. subsp. *perforatum*	.	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	3	I
Circumbor.	*Prunella vulgaris* L. subsp. *vulgaris*	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	3	I
Submedit.-Subatl.	*Sedum cepaea* L.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	3	I
Europ.	*Viola riviniana* Rchb.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	I
Steno-Medit.	*Arum italicum* Mill. subsp. *italicum*	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	2	I
Europ.-Sudsiber.	*Astragalus glycyphyllos* L.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	2	I
Eurasiat.	*Centaurium erythraea* Rafn subsp. *erythraea*	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
Europ.-Caucas.	*Emerus major* Mill. subsp. *major*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	2	I
Europ.	*Cytisus scoparius* (L.) Link subsp. *scoparius*	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	I
Orof. S-Europ.	Laburnum alpinum (Mill.) Bercht. & J.Presl	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	+	2	I

Occasional species

Ril. R1 *Agrotis* capillaris L. +, *Poa nemoralis* L. +; **Ril. R2** *Aira elegans* Willd. subsp. *elegans* +, *Antoxanthum odoratum* L. +, *Erica arborea* L. +, *Polypodium vulgare* L. 1, *Rosa canina* L. +; **Ril. R3** *Aristolochia pallida* Willd. +, *Asperula taurina* L. subsp. *taurina* +, *Cardamine hirsuta* L. +, *Rabelera holostea* (L.) M.T.Sharples & E.A.Tripp +, *Symphytum tuberosum* L. subsp. *angustifolium* (A.Kern.) Nyman +, *Vinca major* L. subsp. *major* +; **Ril. FS1** *Athyrium filix-femina* (L.) Roth 1, *Circaea lutetiana* L. subsp. *lutetiana* +, *Hypericum androsaemum* L. +, *Ranunculus neapolitanus* Ten. +, *Rumex sanguineus* L. +; **Ril. FS2** *Asplenium scolopendrium* L. subsp. *scolopendrium* +, *Dactylorhiza maculata* (L.) Soó subsp. *saccifera* (Brongn.) Diklić +, *Erica arborea* L. +, *Hypericum androsaemum* L. +, *Laurus nobilis* L. +; **Ril. FS3** *Dactylorhiza maculata* (L.) Soó subsp. *saccifera* (Brongn.) Diklić +, *Ranunculus lanuginosus* L. +; **Ril FS4** *Pulmonaria hirta* L. 1, *Sambucus nigra* L. +; **Ril. FS5** *Silene viridiflora* L. +; **Ril. C1** *Orchis pauciflora* Ten. +, *Trifolium ochroleucon* Huds, +; **Ril. C2** *Cercis siliquastrum* L. subsp. *siliquastrum* 1, *Epipactis helleborine* (L.) Crantz +, *Galium rotundifolium* L. subsp. *rotundifolium* +, *Veronica chamaedrys* L. +; **Ril. C3** *Oenanthe pimpinelloides* L. +; **Ril. C4** *Katapsuxis silaifolia* (Jacq.) Reduron, Charpin & Pimenov +; **Ril. C5** *Silene viridiflora* L. +; **Ril. S1** *Asplenium ceterach* L. subsp. *bivalens* (D.E.Mey.) Greuter & Burdet +, *Cytisophyllum sessilifolium* (L.) O.Lang +, *Geranium versicolor* L. +, **Ril. S2** *Geranium purpureum* Vill. +, *Phillyrea latifolia* L. +, *Polypodium cambricum* L. +, **Ril. M2** *Sorbus graeca* (Spach) hort. Lodd. ex S.Schauer 1, *Tilia platyphyllos* Scop. subsp. *platyphyllos* 1; **Ril. M3** *Asplenium ceterach* L. subsp. *bivalens* (D.E.Mey.) Greuter & Burdet +, *Scutellaria columnae* All. subsp. *columnae* +, *Smilax aspera* L. +

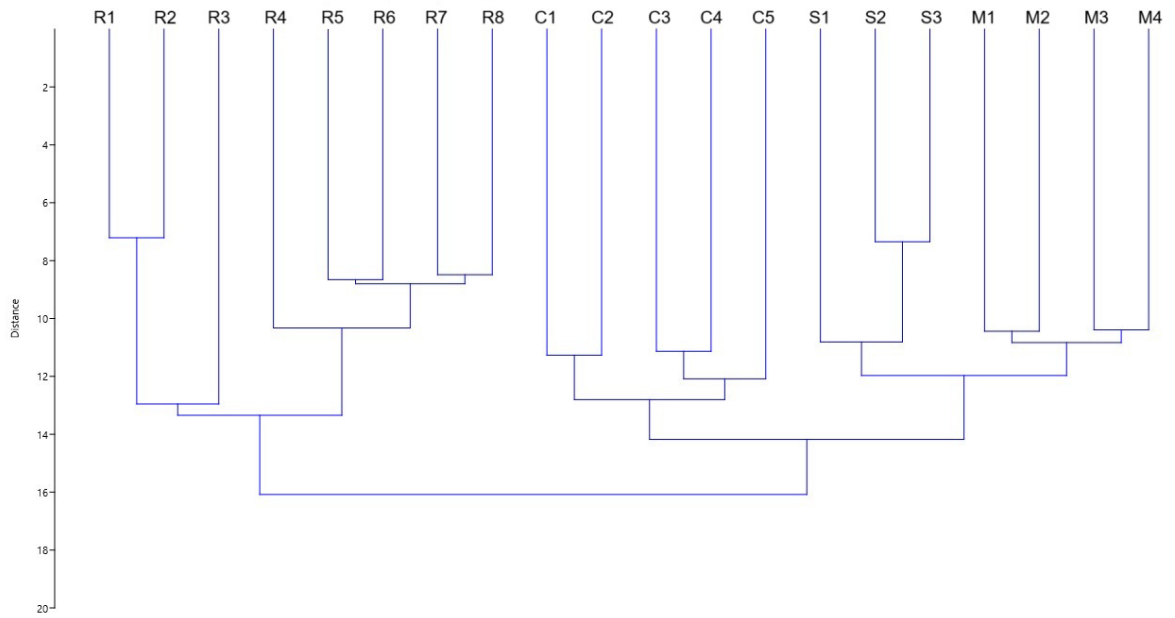

Figure 2: Cluster analysis dendrogram of 20 phytosociological relevés in *Fagus sylvatica* stands, based on species composition. The grouping reflects ecological and biogeographical gradients among the surveyed sites. Relevés from volcanic substrates (Roccamonfina Volcano: R) cluster separately from those on calcareous substrates (Monte Maggiore: M; Monte Cesima: C; Monte Sammucro: S), indicating marked floristic differentiation between geological contexts.

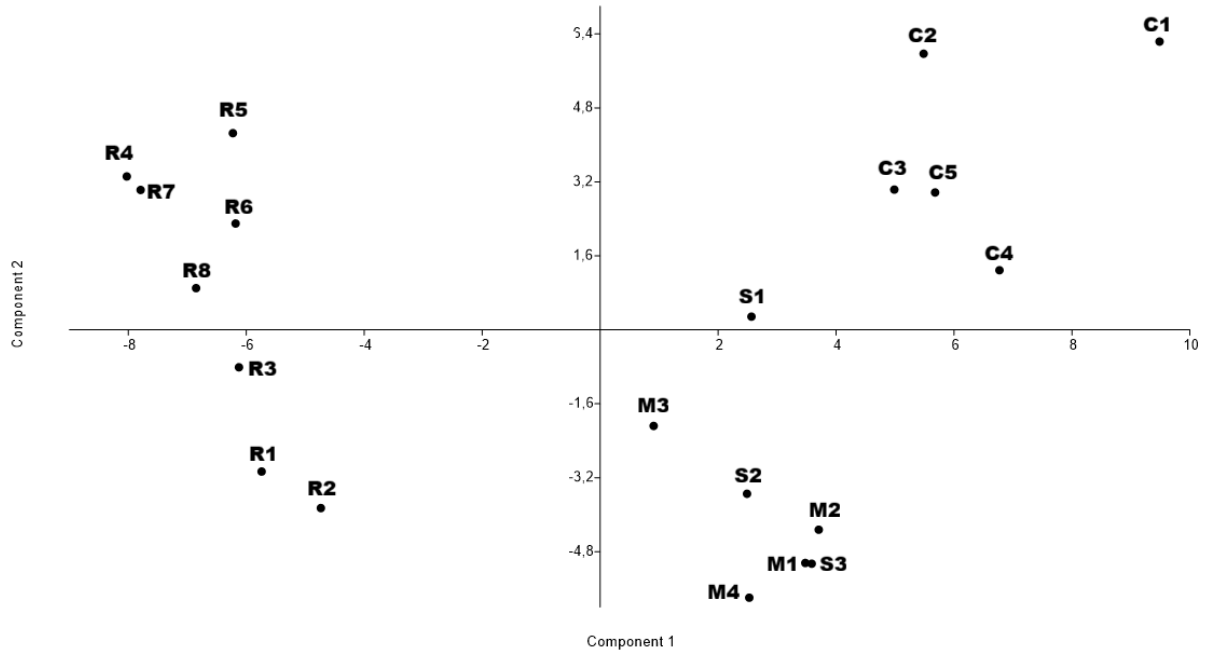

Figure 3: Principal Component Analysis (PCA) of 20 phytosociological relevés in *Fagus sylvatica* stands. The ordination is based on species composition. The first two components explain 32.1% and 14.6% of the total variance, respectively. Letters indicate the different sites: Roccamonfina Volcano (R), Monte Maggiore (M), Monte Cesima (C), and Monte Sammucro (S).

The presence of small beech forest sites represents a crucial element for the conservation of local biodiversity, serving not only as ecological refuges but also as valuable paleogeographic indicators of past climatic and environmental conditions. The high-altitude populations, located on the Tyrrhenian side of the peninsula and within a heavily anthropized landscape, are interpreted as heterotopic relicts—important remnants of a formerly more widespread beech distribution, influenced by geological and climatic history as well as past and present human activity.
Despite their often fragmented and isolated nature, these relict ecosystems host unique assemblages of flora and fauna, contributing significantly to regional ecological networks. It is therefore essential that local authorities implement targeted conservation measures aimed at halting habitat degradation, supporting the natural expansion of beech populations, and safeguarding the integrity of these rare ecosystems. Ensuring their protection is not only a matter of preserving biodiversity, but also of maintaining the historical and ecological memory embedded within these ancient woodlands.

References

Agostini R. (1972). Analisi fitosociologica di una cenosi a Faggio a bassa quota in Irpinia. *Delpinoa*, **12-13,** 105-113.

Bagnaia R., Viglietti S., Laureti L., Giacanelli V., Ceralli D., Bianco P.M., Loreto A., Luce E., Fusco L. (2017). Carta della Natura della Regione Campania: Carta degli habitat alla scala 1:25.000. ISPRA. Downloaded from https://www.isprambiente.gov.it/it/servizi/sistema-carta-della-natura/cartografia/carta-della-natura-alla-scala-1-50.000/campania on 05 may 2025

Bartolucci F., Peruzzi L., Galasso G., Alessandrini A., Ardenghi N. M. G., Bacchetta G., Banfi E., Barberis G., Bernardo L., Bouvet D. et al. (2024). A second update to the checklist of the vascular flora native to Italy. *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology,* **158(2)**, 219-296. DOI: 10.1080/11263504.2024.2320126

Biondi E., Blasi C. (2013). Prodromo della Vegetazione d'Italia. Check-list sintassonomica aggiornata di classi, ordini e alleanze presenti in Italia. Società Botanica Italiana, Firenze, Italy, 2013; Downloaded from: http://www.prodromo-vegetazione-italia.org on 05 may 2025.

Biondi E., Blasi C., Allegrezza M., Anzellotti I., Azzella M.M., Carli E., Casavecchia S., Copiz R., Del Vico E., Facioni L., et al. (2014). Plant communities of Italy: The Vegetation Prodrome. *Plant Biosystematic* **148 (4)**, 728-814.

Casella L., Agrillo E., Cardillo A., Carbone M., Cattena C., Laureti L., Lugari A., Spada F. (2008). Carta della Natura della Regione Lazio: Carta degli habitat alla scala 1:50.000. ISPRA. Downloaded from https://www.isprambiente.gov.it/it/servizi/sistema-carta-della-natura/cartografia/carta-della-natura-alla-scala-1-50.000/lazio on 05 may 2025

Croce A., La Valva V., Motti R., Nazzaro R., Strumia S. (2008). La flora vascolare del Vulcano di Roccamonfina (Campania, Italia). *Webbia*, **63(2)**, 251-291. DOI: https://doi.org/10.1080/00837792.2008.10670844

Croce A. (2024). Siti, habitat e specie di maggiore interesse per la biodiversità vegetale del parco Regionale Area Vulcanica di Roccamonfina e Foce Garigliano, pp. 25-38. In: *Il patrimonio naturalistico del Parco Regionale Area Vulcanica di Roccamonfina e Foce Garigliano*, Teano, 23 September 2023, fedOA Press. DOI: https://doi.org/10.6093/978-88-6887-231-1

De Rita D., Giordano G., Milli S (1997). Forestepping-backstepping stacking pattern of volcaniclastic successions: Roccamonfina volcano, Italy. *Journal of volcanology and Geothermal Research*,

78.3-4, 267-288. DOI: https://doi.org/10.1016/S0377-0273(97)00005-X

Euforgen (European Forest Genetic Resources Programme) (2009). Distribution map of Beech (*Fagus sylvatica* L.). Downloaded from http://www.euforgen.org/fileadmin/templates/euforgen.org/upload/Documents/Maps/JPG/Fagus_sylvatica.jpg on 25 May 2025.

Filesi L., Rosati L., Paura B., Cutini M., Strumia S., Di Pietro R., Blasi C. (2010). Le serie di vegetazione della Campania, p. 351-373. In *La Vegetazione d'Italia con Carta delle Serie di Vegetazione in scala 1:500.000*. Palombi & Partner, Roma.

Hammer Ø., Harper D.A., Ryan P.D. (2001). PAST: paleontological statistics software package for education and data analysis. *Palaeontologia electronica* **4(1)**, 9. Downloaded from https://palaeo-electronica. org/2001_1/past/issue1_01.htm on 01 March 2020.

Magri D. (2008). Patterns of post-glacial spread and the extent of glacial refugia of European beech (Fagus sylvatica). *Journal of Biogeography*, **35(3)**, 450-463. DOI: https://doi.org/10.1111/j.1365-2699.2007.01803.x

Pignatti S. (1982). *Flora d'Italia vol. 1*. Edagricole, Bologna.

Pignatti S., Avena G. (1995). *Ecologia vegetale*. Utet, Torino, 548 pp.

Pignatti S. (1998). *I boschi d'Italia: sinecologia e biodiversità*. Utet, Torino, 696 pp.

Portale della Flora d'Italia/ Portal to the Flora of Italy 2024.3 (2024). Downloaded from http:/dryades.units.it/floritaly on 31 May 2025.

Roma Marzio F., Carta A., Peruzzi L., Bedini G. (2017). Heterotopy remastered with a quantitative tool: the case study of the European beech (Fagus sylvatica L. subsp. sylvatica) in peninsular Italy and Sicily. *Atti della Società Toscana di Scienze Naturali residente in Pisa. Memorie. Serie* B, **124**, 87-93. DOI: https://dx.doi.org/10.2424/ASTSN.M.2017.08

Saracino A. (2012). Le faggete campane e lucane: gli usi e le tipologie, pp. 61-72. In: *Sul trattamento delle faggete in Italia: dal metodo scientifico all'empirismo dei nostri giorni*, *I Georgofili, Quaderni 2012-III*, Firenze, Accademia dei Georgofili: DOI: https://dx.doi.org/10.13140/RG.2.1.2221.7120

Strumia S., Santangelo A., Esposito A., Ricciardi M., La Valva V. (2005). Carta dello stato delle conoscenze floristiche della Campania, 179-183. In *Stato delle conoscenze sulla flora vascolare d'Italia*, Palombi & Partners, Roma.

Bulletin of Regional Natural History (BORNH) ISSN 2724-4393.