



UNIVERSITY OF PADOVA

DEPARTMENT LAND, ENVIRONMENT, AGRICULTURE AND FORESTRY (TESAF)

Master course in Forest and Environmental Sciences

AN EVALUATION OF BIODIVERSITY INDICATORS CHANGE
THROUGHOUT DIFFERENT CHRONOLOGICAL STAGES
IN A BEECH COPPICE
(Municipality of Mel (BL) - North Eastern Italy)

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Gli alberi ti aiutano a vedere fette di cielo tra i rami
Puntare a cose che non potrai mai raggiungere.
Gli alberi ti aiutano a guardare la crescita accadere,
Guardare i fiori esplodere e poi seccare,
Vedere l'ombra cambiare al ritmo del sole,
Gli uccelli strappare semi riluttanti...
Un albero è una lente,
Un mirino, una finestra.
Attendo sotto di lui
Un messaggio,
O ciò che ancora deve arrivare.
ROCHELLE MASS, *Attendendo un messaggio*

*A Villa di Villa,
luogo privilegiato della partenza:
per le numerose uscite di campo
e per la nuova vita che da qui comincia.*

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ABSTRACT

The present study was conducted in beech coppice stands of different chronological stages belonging to the typologic unit “typical montane esalpic beech forest” according to Del Favero *et al.* (2000) classification.

The aim to analyze the variations in value of the biodiversity indicators – proposed by the same Authors for generally mature stands – was pursued through the study of the ecological and functional characteristics of the forest system in sample areas of different age.

The site traits and the dendrometric and phytosociological characteristics of four coppice compartments in different development stages (0, 6, 12 and 20 years) were investigated, defining their indicators *sensu* Del Favero *et al.* (2000): qualitative (such as actual arboreal composition, natural dynamic tendencies, modalities and limitations of natural regeneration), quantitative (such as the average number of herbaceous species and that of hemerophyte species) and quality indicators (floristic and chromatic).

In addition to this set of indicators, some others were chosen to better analyze the specific diversity (complexity, diversity and evenness indexes).

With coppice and crown density increase we assist to a significant decrease of the number of herbaceous species and of hemerophytes and the same trend is followed by Shannon and Simpson's indexes.

The maximum floristic richness, in fact, is registered right after the cut, while after 6 years, due to the consistent release of standards, the important crown cover limits the number of species in the herbaceous layer.

The nemoral and the so called “*ancient species*”, on the contrary, increase in proportion in older stands.

In conclusion, beyond a certain simplification of the arboreal composition and neglecting the discussion about the stand structure, the present coppice management with 18-20 years cycle appears not to impair the formation biodiversity values and the nemoral conditions recovery seems quite fast.

RIASSUNTO

Variazione degli indicatori di biodiversità in cedui di faggio di diversa età del comune di Mel (BL)

La presente ricerca è stata condotta in cedui di faggio di diversi stadi cronologici ed afferenti all'unità tipologica "faggeta montana tipica esalpica" secondo la classificazione di Del Favero *et al.* (2000).

Lo scopo di analizzare le variazioni di valore degli indicatori di biodiversità - proposti dagli stessi Autori per popolamenti generalmente maturi - è stato perseguito tramite lo studio delle caratteristiche ecologiche e funzionali del sistema boschivo in particelle di diversa età.

Le caratteristiche stazionali, dendrometriche e fitosociologiche di quattro particelle di ceduo in diversi stadi di sviluppo (0, 6, 12 e 20 anni) sono state esaminate, definendone poi gli indicatori qualitativi (come la composizione arborea attuale, le tendenze dinamiche naturali, le modalità e i fattori limitanti la rinnovazione), quantitativi (come il numero medio di specie erbacee e quello di specie emerofite) e di pregio (floristico e cromatico).

In aggiunta a questo set di indicatori *sensu* Del Favero *et al.* (2000), ne sono stati introdotti alcuni altri ritenuti utili per l'approfondimento della diversità specifica (indici di complessità, diversità ed equitabilità).

Con l'avanzamento dell'età del bosco e la chiusura progressiva delle chiome si osserva una significativa diminuzione del numero di specie erbacee e di specie emerofite e lo stesso trend viene seguito di conseguenza dagli indici di Shannon e Simpson.

La massima ricchezza floristica, infatti, viene registrata subito dopo il taglio, mentre già dopo sei anni, in cedui così matricinati, la copertura delle chiome limita il numero di specie dello strato erbaceo.

Le specie nemorali e le cosiddette "*ancient species*", all'opposto, aumentano in particelle più distanti dal taglio.

Al di là, in conclusione, di una certa semplificazione nella composizione arborea dei popolamenti e di questioni puramente strutturali, la presente gestione del ceduo con turno allungato (18-20 anni) non risulta disturbare particolarmente le caratteristiche di biodiversità di questa formazione, dove il recupero della nemoralità sembra veloce.

1. INTRODUCTION

1.1 DEFINITIONS OF BIODIVERSITY AND INDICATOR

In recent years a great deal of interest has emerged in the quantification and valuation of biological diversity. The interest is largely motivated by findings, from natural scientists, that biodiversity is endangered by human activities (e.g. Wilson, 1992), especially the destruction of natural habitats (e.g. Primack, 2000).

Biodiversity has, however, proved difficult to define in practice, as stated by Noss (1990):

"A definition of biodiversity that is altogether simple, comprehensive, and fully operational ... is unlikely to be found."

"Biodiversity" is a relatively new compound word, which may have been coined by W.G. Rosen in 1985, but "biological diversity" (when referring to the number of species) is not. The term "biological diversity" was, in fact, first used by wildlife scientist and conservationist Raymond F. Dasmann in the 1968 work "A Different Kind of Country", advocating conservation. The term was widely adopted only after more than a decade, when in the 1980s it came into common usage in science and environmental policy. It was Thomas Lovejoy, in the foreword to the book "Conservation Biology", to introduce the term to the scientific community. Until then the term "natural diversity" was more common. Since this period the term has achieved widespread use among biologists, environmentalists, political leaders and concerned citizens.

"Bio" is derived from the Greek word *bios*, meaning life, referring therefore to living organisms, assemblages of living organisms, and the activities and interactions of living organisms.

"Diversity", instead, has been characterized as (1) the number of different types of items, (2) the number of different types of items and their relative abundance, and (3) variety. Characterization of diversity in discussions of bio-diversity has also included the structural complexity of landscapes (Huston, 1994).

Over the last decade - since historically species are the fundamental descriptive units of the living world - the definition of biodiversity has incorrectly taken a more reductionist sense, considering it simply as the number of species, or other taxa.

Yet many have argued that biodiversity does not equate to the measure of species richness - number of species in an area and their relative abundance (Pielou, 1977) - which is only one component of biodiversity (Fiedler and Jain, 1992).

On the other hand, “the total variability of life on earth” (Heywood *et al.*, 1995) is a much broader and compact definition of biological diversity, but far too inclusive to be of practical use.

DeLong (1996) offered, instead, a more comprehensive definition:

“Biodiversity is an attribute of an area and specifically refers to the variety within and among living organisms, assemblages of living organisms, biotic communities, and biotic processes, whether naturally occurring or modified by humans. Biodiversity can be measured in terms of genetic diversity and the identity and number of different types of species, assemblages of species, biotic communities and biotic processes, and the amount (e.g., abundance, biomass, cover, and rate) and structure of each. It can be observed and measured at any spatial scale ranging from microsites and habitat patches to the entire biosphere.”

Various authors have proposed other specific and detailed elaborations of this definition, and DeLong himself reviewed 85 different definitions.

Gaston and Spicer (1998) proposed a three-fold definition of “biodiversity”— ecological diversity, genetic diversity, and organismal diversity.

In the more complete definitions, therefore, biodiversity is considered at different levels of biological organization including genes, species and ecosystems.

Whittaker’s definitions of alpha, beta and gamma diversity tries to consider diversity at these different spatial scales, as summarized in the following definition:

“Biodiversity is the variety of life on earth and includes variation at all levels of biological organization from genes to species to ecosystems. Genetic, organismal and ecological diversity are all elements of biodiversity with each including a number of components” (Gaston and Spicer, 2004).

The three hierarchical categories in which biodiversity is in this context divided are as follows defined:

- 1) α diversity refers to the variability observed within a single ecosystem or at a community level. The most typical measure is essentially the number of species within the area (Power, 1975; Wilson, 1984; Puumalainen, 2003).

- 2) β diversity extends to neighbouring ecosystems or communities. Generally, the degree of variation in specific diversity is described along a transect or a gradient between different communities (Power, 1975; Puumalainen, 2003). Different indexes for its evaluation are calculated, among which the best known are those of Shannon and Simpson, indices that attempt to convey the extent to which individuals are distributed among species.
- 3) γ diversity is a measure of the overall diversity across a region (Gaston and Spicer, 2004), at the level of landscape, viewed as a mosaic of different patches, dynamically differentiated as the result of the various processes that regulate the biomass accumulation and the fluxes of matter, energy, nutrients and water (Forman, 1995 in Menozzi, 1997).

Another important and widely used definition is that included within the Convention on Biological Diversity (CBD), signed by over 150 nations in Rio de Janeiro, Brazil, in 1992. It defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Article 7 of the CBD, furthermore, requires the Parties to the Convention to identify and monitor biological diversity, particularly those aspects important for conservation and sustainable use.

This implies the need for a more unequivocal definition of Biodiversity, which may be scientifically sensible and universally applicable, crucial to help guide the design of policy and programs, reaching common agreements on management objectives and strategies for biodiversity conservation (Swingland, 1999).

Reconnecting to the first statement of this chapter, therefore, Noss continues as follows: "More useful than a definition, perhaps, would be a characterization of biodiversity that identifies the major components at several levels of organization. ... (C)omposition, structure, and function... determine, and in fact constitute, the biodiversity of an area. Composition has to do with the identity and variety of elements in a collection, and includes species lists and measures of species diversity and genetic diversity. Structure is the physical organization or pattern of a system, from habitat complexity as measured within communities to the pattern of patches and other elements at a landscape scale. Function involves ecological and evolutionary processes, including gene flow, disturbances, and nutrient cycling." (Noss, 1990)

Ecosystem functions, of course, are hard to see in action. "You can't hug a biogeochemical cycle," says one ecologist. But the ecological processes are those which create landscapes and diverse environmental conditions out of life itself.

Biodiversity is therefore very much linked to the functionality of a system, affecting its resilience and productivity (Tilman *et al.*, 1994; Naeem *et al.*, 1999).

The presence or absence of representative elements may not be sufficient to assure performance, but their relative abundance is important as well (cfr. Simpson's and Shannon-Weaver's indexes) and can lead to a better interpretation of the resistance of the system (Weitzman, 2000).

A part from the Rio Convention (1992) considered above, which we can regard as the starting and reference point of all the actual definitions of biodiversity, especially when connected to the concept of "sustainability", it was the IUCN (International Union for Conservation of Nature and natural resources), at the international level, the first organization to pay attention in an integrated way to the living organisms and their habitat. Founded in 1947, it produced "Red Lists" of endangered species.

After that, with the Washington Resolution of 1973, the so called Convention on International Trade in Endangered Species (CITES), some first limitations to the trade of endangered animal and plant species were posed.

At the European level the Bern Conference, held in 1979, brought to the Bird Directive (originally CEE n. 409/1979) which was then amended in 2009, while the Habitat Directive n. 43/1992 - adopted in Italy with the Presidential Decree n.357/1997 - stated its primary aim as the promotion and maintenance of biodiversity. The latter two directives compose the legal basis for Natura2000 and form the backbone of the EU's internal biodiversity policy.

Both the latter contain long Annexes on the priority species and habitat to protect.

After defining the basic principles, the conferences that followed concentrated on determining the methods of conservation and monitoring.

In the forestry sector, crucial importance have assumed the Interministerial Conference on European Forests of Helsinki (1993), the 1994 meeting of the international organism FSC (Forest Steward Council), the second Montreal meeting of 1996 and the Lisbon Conference of 1998.

The attention was more and more drawn to the search for certifications and indicators that could combine the correct - but theoretical - formulations on biodiversity, with the practical management of the territory. The Ministerial Conference on the Protection of Forests in

Europe (MCPFE) has also included nine forests biodiversity-related indicators within its set of indicators of Sustainable Forest Management (MCPFE 2002, 2003). The species indicators focus primarily on tree species and on species of conservation concern. The BEAR project (Indicators for monitoring and evaluation of forest biodiversity in Europe) – initiated in 1998 as a Pan-European concerted action which brought together 27 European research organizations to build a framework for the development of forest biodiversity indicators at various spatial scales - identified a larger set of some tens of potential indicators for assessment of biodiversity in forest ecosystems (Larsson, 2001).

The analysis of biodiversity of the managed forests - particularly important if considering the complexity of these ecosystems and the variety of goods and services humans derive from them - is actively carried out by the CIFOR, by the European research group BEAR and, in the specific case of Italy, by the ISPRA (Istituto Superiore per la Protezione Ambientale).

These collections of data allow, at the same time, to make inferences on the impact of harvesting practices on the natural diversity and structure of forest ecosystems. Some argue, in fact, that various characteristics of natural forests diminish or disappear in managed forests (Bengtsson *et al.*, 2000), mostly if the human mediated disturbance differs from the natural processes to which species have adapted during evolution (Noss, 1999).

In conclusion, biodiversity is a multidimensional concept, which cannot be reduced to a single number (Purvis and Hector, 2000). This is why it is so difficult to evaluate and quantify.

In this context, research has given crucial importance to the identification of criteria and indicators for a sustainable management of forests, collecting some results in the document of UNEP-SBSTTA on Biological Diversity of Forests.

Since the possibility to quantify biodiversity is often limited, “correlates” and “surrogates” are introduced to function as indicators (Wiegleb, 2003), the only practical and effective approach to assess biodiversity by using relatively few elements of the forest system (e.g., species, processes and habitats) that correlate with as many other unmeasured elements of the system as possible.

An indicator can in fact be defined, as different Authors propose, as follows:

- "An indicator quantifies and simplifies phenomena and helps us understand complex realities. Indicators are aggregates of raw and processed data, but they can be further

aggregated to form complex indexes." (IISD-International Institute for Sustainable Development)

- "Indicators serve four basic functions: simplification, quantification, standardization and communication. They summarize complex and often disparate sets of data and thereby simplify information. They usually assess trends with respect to policy goals. They should provide a clear message that can be communicated to, and used by, decision makers and the general public." (Ad Hoc Expert Group on biodiversity indicators, UNEP/CBD/SBSTTA/9/10)

- "Indicators are bits of information that highlight what is happening in a large system. They are small windows that provide a glimpse of the "big picture"". (Sustainable Seattle 1995)

Biodiversity indicators are therefore information tools, measures based on verifiable data that convey information about the overall status and trends of biodiversity.

In 2006, the Conference of the Parties to the Convention on Biological Diversity (COP) adopted a list of outcome-oriented indicators to measure progress towards the 2010 target of reducing the current rate of biodiversity loss.

As a follow-up on the failure of the 2010 Biodiversity Target, in April 2012 the EU Parliament adopted a new resolution "on our life insurance, our natural capital: an EU biodiversity strategy to 2020 (2011/2307(INI))", stating that the EU "takes the view that the difficulties encountered in meeting the target set for 2010 call for an in-depth review of the methods applied to date; maintains that strategic studies covering all the factors that may affect protected areas must be carried out, and that these studies should be incorporated into urban planning and be accompanied by educational and information campaigns on the importance of local natural resources and their conservation", whereas the United Nations has declared 2010-2020 the Decade on Biodiversity.

Indicators for biodiversity are needed in different contexts, e.g. to prioritize habitats in conservation networks (Sarkar, 2002), to determine and monitor management goals (Rempel *et al.*, 2004; Dziok *et al.*, 2006), to identify stressors on biodiversity (Cairns *et al.*, 1993; Fränze, 2006), to assess impacts on biodiversity (Treweek, 1996), and to analyze habitat conditions (Landres *et al.*, 1988).

Due to the ambiguity of the term "biodiversity indicator", though, and the array of related applications, a multitude of approaches exists in the field.

There is no single indicator for biodiversity, therefore, but the choice of indicators depends on the aspect or entity of biodiversity to be evaluated and is guided by a value system based on personal and/or professional motivation.

So which indicators should be chosen to detect the various aspects of biodiversity? Managers – since it is by now clear that in the study of biodiversity the conservation aim is implicit – will not be able to measure all the potential interesting elements of the forest, so the choice of “what” to measure becomes a critical point, and has given rise to many different approaches, unfortunately often remained untested and lacking validation data.

Although biodiversity can be measured in lots of different ways, the most commonly used measures are those of species richness or indicator species of a territory (Purvis and Hector, 2000; Gaston and Spicer, 2004), even if recent studies have demonstrated how the species diversity in itself is not always as important as the presence of numerous guilds (Bengtsson *et al.*, 2000).

An indicator species is the one that has a sufficiently consistent correlation with some environmental conditions, or with other species, so that its presence can be used to indicate or predict the environmental conditions or potentials suitable for other specific entities (Kimmins, 1997 in Dobbertin, 1998).

Since the variation of “endangered species” is seen as an indicator of change in the overall forest ecosystem (Parvainen and Frank, 2003), rare species are normally the chosen ones to be monitored, or else those which can allow to make judgments on the degree of naturalness of a certain biocoenosis (Dzwonko, 1993; Wulf, 1997; Hermy *et al.*, 1999; Peterken *et al.*, 1999).

Usually the monitored species are those limited by a minimum wooded patch (area-dependent), those limited in dispersion, or conditioned by the presence of particular resources or niches, those limited by specific natural disturbances (as fire i.e.), the “keystone species” and endemic entities, etc... (Noss, 1999).

The problem of using single species as indicators is that the presence-absence of a species could indicate only the vulnerability of a particular niche inside the ecosystem, and negative correlations could also complicate the picture, for example in the case of predation between species of equal value.

Therefore, other authors propose the use of limited groups of species as indicators (Hansson, 2000).

At the present moment, the challenge is to continue and develop a broader set of biodiversity indicators that are aligned against as many valued aspects of biodiversity as

possible, normally expressed in lists (Noss, 1999; Del Favero *et al.*, 2000; Puumalainen *et al.*, 2003).

Although regions and states present peculiarities which make the choices of adequate indicators very different from area to area, it is today also pressing, as Noss (1999) urges, a unification and standardization of the biodiversity monitoring schemes, without which conservation at a broader scale is hardly enforceable.

The future goals could in this sense be connected with the understanding of the key species and guilds and their role in the ecosystem (Bengtsson *et al.*, 2000)

Indeed, in the simple “species richness” indicator, in example, all species are weighted equally, disregarding the fulfillment of different roles in the ecosystem, which can incorrectly lead assigning equal values to areas that have quite different biota.

The optimal approach seems in any case to be the selection of a “basket” of Indicators, connected clearly to the chosen meaning of biodiversity (according to the management goals), to the selected spatial and temporal scale and to the possibility of strengthening the link between science and the decision-making/political process, necessary to help management action take place effectively (Heink and Kowarij, 2010).

1.2 BIODIVERSITY INDICATORS FOR THE FOREST TYPES OF THE VENETO REGION

The European BEAR project (Indicators for monitoring and evaluation of forest biodiversity in Europe) has been carried out in the period 1997-2000 by a group of interdisciplinary experts of 18 European Countries, aiming to the detection of a set of biodiversity indicators for the European forests and the relative appropriate application methodologies (Gasparin and Tosi, 2000).

Among the adopted criteria and indicators there are the indicators on fragmentation of the landscape, the changes in diversity and habitats due to human influence, the importance given to the regeneration processes, the presence of certain animal groups (especially birds), richness and diversity intended as species richness and its temporal variations, and other indicators – such as state of decomposition of the residues, the nutrient cycle and the pollution agents – which are excluded from consideration by Del Favero *et al.* (2000), to which we refer in this work.

According to Del Favero *et al.* (1999), the need to organize an efficient collection of information on biodiversity - which should be maintained or better enhanced - and an incisive way to improve the conservation measures in the forestry sector, leads to the adoption of a “per habitat” approach, connecting the control of biodiversity to the definition of “forest type”.

In the Author’s opinion, the forest typology is a “system to interpret and classify the diverse forest reality, based on compromise”.

The criteria and management objectives pursued are: to maintain and enhance the variability of the forest landscape mosaic, to preserve the variability of species and to create resources supplies (Del Favero *et al.*, 1999); at the same time, some specific indicators that could allow a better evaluation of the forest biodiversity of each singular formation and of the biodiversity of the Region as a whole were researched (Del Favero *et al.*, 2000).

In compliance with the indications of the BEAR group, and in order to have indicators that are generally simple, economic and easy to pick up (Pettenella and Secco, 1998 in Del Favero *et al.*, 2000) - and therefore largely applicable by the field surveyors - the working group that produced the text “Biodiversità ed indicatori nei tipi forestali del Veneto” - Biodiversity and Indicators in the forest types of the Veneto Region – (Del Favero *et al.*,

2000), chose not to elaborate any index (a part from some exceptions), but rather to provide the useful elements (indicators) for their development.

Indexes, in fact, imply careful considerations most of the time connected to local aspects or to priority selection (Del Favero *et al.*, 2000).

The work in question indicates, for each forest type (*sensu* Del Favero, 1990), a set of “reference” values for the forest formation, attributed on the basis both of the scientific knowledge and of the experiences gained with the forestry practice.

For the Veneto Region this project has been carried out using management, inventory, floristic, pedological and geological data and having recourse to the forest fires data base.

These data are then reported in the description and definition of each forest type, arranging for every typological unit a dossier which permits, firstly, to place it in the territory, through the listing of some distinctive places. Afterwards, qualitative and quantitative indications on the system functioning are provided.

In table 1 the biodiversity indicators suggested for the Veneto Region by Del Favero *et al.* (2000) are exposed.

Table 1 Indicators suggested for the Veneto Region by Del Favero *et al.* (2000)

QUALITATIVE INDICATORS		
Current woody plant composition		
Composition of ecologically coherent woody plants		
Anthropogenic disturbance		
Natural dynamic trends		
Possible influences of management methods on natural dynamics		
Natural regeneration	Modalities	
	Factors limiting settlement	
	Factors limiting success	
	Disturbance	
	Tolerance of forest cover	
	Facilitating intervention strategies	
Population structure	Vertical distribution	
	Cover type and density	
	Spatial patterns	
Vegetative state	Early senescence	
	Stress	
	Insects and pathologies attacks	
	Anthropogenic damages	

Interactions with macrofauna	Species negatively sensitive to abandonment	
	Species negatively sensitive to silvicultural practices	
	Silvicultural solutions	
QUANTITATIVE INDICATORS		
Biometric indicators	Natural evolution or not ordinarily managed	Average height, cover type, relative fertility, rates of improvement, appropriate species
	Ordinary coppice	Increment at maturity, number of standards retained/ha, retained species, rotation period, limits of convenience, relative fertility
	Even aged stands	Woody masses/ha, current annual increment/ha, rotation period, fertility, potential trees height, relative fertility
	Uneven aged stands	Min. - max and average mass/ha value, current annual increment, cutting cycle, current trees height, potential trees height
Permanence time (only high forest)		
Naturalness standards of the stands	Compositional differences	
	Disturbance due to management strategy	
	Average number of hemerophyte species	
Biodiversity	Units of the territory	Spread, distribution, active and passive contagion potential
	Standard of management biodiversity	Chronological-structural balance, richness of vegetal species, richness of bird species
QUALITIES		
Naturalistic quality	Quality for the flora and the vegetation	Indicator of floristic quality, valued species, vegetational quality
	Quality for the fauna	Indicator of species of protected habitats, species of protected habitats, other valued species
Chromatic quality	Indicator of chromatic quality	
	Species of chromatic quality	
Technological quality		
SUSCEPTIBILITY TO NATURAL DISASTERS		
Fires	Fire potential	
	Fuel models	
Tree fall susceptibility		
Structural trends		

For a few single concepts, considered particularly important for the aims of this analysis and at the basis of many indicators - especially the quantitative indicators of naturalness and biodiversity and the indicators of quality - an appropriate in-depth description will follow.

Among the naturalness standard of the stands, the indicator “medium number of hemerophyte species” per relevé, which provides a first evaluation of the intensity of the disturbance induced by management actions, appears. The species here considered are synanthropic - meaning those always linked to Man, who voluntarily or unintentionally spreads them - and “autoapophytes”, meaning those species actually belonging to the local flora, but the propagation of which is correlated to the forest practices, altering this way the compositional equilibrium, in terms of cover.

The analysis of the number of adventitious species to evaluate the degree of naturalness of an ecosystem has already been utilized in the past (e.g. during the creation of the vegetation map of the Region Trentino Alto Adige - Minghetti *et al.*, 1999 - or researches conducted in the city of Rome and surroundings - Celesti and Fanelli, 1993 in Pignatti *et al.*, 2001).

The term “naturalness” has been a reference factor for the silvicultural approaches and, in natural sciences, it is a state connected to absence of influence by humans, particularly by technology (Hunter, 1996; Angermeier, 2000). The degree of naturalness therefore indicates the distance between the potential natural and the current status of the stand.

Naturalness, together with diversity, rareness and area, is one of the four commonly used factors that, according to Margules and Usher (1981) have a scientific basis.

In the forestry sector, where in the majority of cases human interference can be notable, the opposite concept of hemeroby is applied: the measure of the influence of the human community on the ecosystem (Kowarik, 1988 in Dobbertin, 1998), that is the degree of anthropogenic disturbances on forests. Some sort of “unnaturalness” index, we could say. In general, for the woody biocoenosis, the terminal stages of the vegetation series (climax) are assumed as models of naturalness.

At the level of the European Commission, forests with high degrees of naturalness are normally intended - with many overlapping meanings among the terms used - as *native forest*, *ancient woodland*, *virgin forest*, *old growth forest*, *primary forest* and *old forest* (Parvianen and Frank, 2003).

Assessing the degree of naturalness of the forests in the Veneto Region, all more or less influenced by human activities, proves very difficult if not hardly impossible, not having at

disposal the reference element for comparison, that is formations that could possibly be defined as “natural”.

That’s why we ought to turn to the use of indicators such as the “average number of hemerophyte species”.

Concerning the quantitative indicators of biodiversity, great importance is assumed by the management standards (“chronological-structural balance”, “richness of vegetal species” and “richness of bird species”).

As indicator of species diversity, the “floristic richness” has been chosen, meaning the “average number of herb/shrub species” found in a standard relevé.

The biodiversity indicator selected by Del Favero *et al.* (2000) is clearly adjusted, according to the Author’s interpretation, to the concept of species richness, rather than to that of specific diversity or to indexes of complexity (as the Shannon index in example), so that - at least in the first run - the information could be more immediate and effective for the practice.

Nevertheless, only the high number of species is not always an indicator of wealth of the ecosystem. If we consider, in example, the number of exotic species recently naturalized, we can agree on the fact that they enrich diversity at the local scale, but they’re not good indexes of naturalness. That’s why, once again, it is useful to compare the previous exposed index to the count of hemerophyte species.

Secondly, the floristic density naturally changes also in relation to the development phase of the forest stand over time, and often enhances after the disturbance induced by forest harvesting.

The management actions themselves have an impact on the number of herb/shrub species of the understory: high species number can be associated with harvesting activities due to invasion of plant and bird species in open vegetation (Wohlgemuth *et al.*, 2002).

But there is more. The woodland management method is as well important in the definition of the number of species that can be found in the same forest type, with minimal disturbance. It is well-known, in fact, that the coppice stands show very often a higher number of species than the high forests (Wulf, 2003).

Other foreign researches have demonstrated how specific richness also responds to the previous land use (Dzwonko, 1993), to tillage practices such as fertilization (Helpern and Spies, 1995) or grazing in the forest (Debussche *et al.*, 2001).

Floristic richness proves therefore to be a very sensitive indicator, but for the same reason must be critically evaluated, according to the type of forest examined, the management system, the cutting system and many other site characters.

Species number alone is not a good indicator, since relatively high values are encountered in disturbed situations, while relatively low species numbers are found in pristine ecosystems.

The indicator of “chronological-structural balance” represents the number of succession stages of a certain formation and their amplitude in years (corresponding to their amplitude in hectares). It helps maintaining biodiversity when all temporal stages are present in the regional network (Parvianen and Frank, 2003) and the distribution of pioneer and advanced stages of the series over the territory is possibly uniform and equal (Puumalainen *et al.*, 2003).

Another indicator selected by the Authors is that of the “number of birds species”, considered to be more connected to specific environments than other categories (Del Favero *et al.*, 2000).

Other authors had concentrated their attention on this animal category before, finding it a good and wide-ranging bio-indicator, including sedentary and short or long-scale migratory species (Hansson, 2000).

Birds are also considered good indicators because they're high in the food chain, they occupy a broad range of ecosystems and a wealth of data can be collected by volunteers or professionals, being meaningful to a wide audience, including the public (Heath and Rayment, 2001).

Finally, the indicators of quality will be considered.

The basic concept for the localization of high value areas is that of rareness - excluding the chromatic quality, for the determination of which rareness is of course not an influencing factor.

Rareness is defined as the property of species to be represented by small populations, either because they're present in a large number of geographically distinct habitats but they're exiguous in densities, or because they're linked to particular habitats, and in their pertaining niche they could even reach high densities, but scarce are the suitable hosting biotopes (Ramade, 1993 in Dobbedin, 1998). Rare species are those which therefore fall at the lower end of the distribution of species abundance (Magurran, 2004).

The “environmental quality”, therefore, is given in presence of “valued” natural resources in the environment, being them rare, sensitive or irreplaceable (Petriccione, 1994). Among a

set of ecologically similar species, in fact, those that are rare will have a greater extinction risk (Matthies *et al.*, 2004), and small populations are more likely to be impacted by chance demographical and environmental events (Boyce, 1992).

The hardest question, in conclusion, in the definition of an environmental value, lies in the choice of the biological elements that act as indicators and in the quantification of the environmental quality they represent.

1.3 AIM OF THE WORK AND LIMITS

On May 3rd, 2011, The EU Biodiversity Strategy was adopted, designed to halt the loss of biodiversity and ecosystems services in the EU by 2020.

The data the Commission has relied on derive from key reports, including those carried out to assess progress in implementing the 2006 BAP, the European Environment Agency's report on "Assessing biodiversity in Europe - the 2010 report", the United Nations Environment Programme's 2005 Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity (TEEB) and the 3rd edition of the Global Biodiversity Outlook.

This ambitious goal is supported by a set of six main targets, the third of which demands "to increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity". "The trend for Europe's forests", it says, "is worrying" (<http://europa.eu>).

The Communication of the strategy by the EU Commission, therefore, also calls for the need to raise awareness for the values of biodiversity in society, and reminds the importance of establishing a baseline and indicators to measure progress towards reaching its biodiversity objectives.

The present work proposes, in this context, a contribution to the knowledge about the variations of the number of species and their features in different stages of the development cycle of a coppice forest under ordinary management.

The study of indicators and biodiversity indexes, in fact, normally relates to mature forest stands, considered as stable or even in their climax phase.

But some biodiversity indicators - especially the quantitative ones, and the naturalness standards connected to the richness of herbaceous species - may be radically different in younger chronological stages with respect to the ones at the end of the productive cycle.

So, as reported by Del Favero *et al.* (2000), in the assessment of standard biodiversity in relation to the number of herbaceous species data from relevés in all development phases of the forest formation should be taken into account.

As a consequence of this call for more data, forest compartments of different ages were chosen in this work for the analysis of variation of a selection of indicators proposed by the Authors.

The concrete aim is therefore to analyse in detail the temporal variability of these indicators, looking at different stages of coppices development, from the newly cut situation to the mature one, trying to detect and explain the differences occurring over

time. This way, this study could be a contribution to the biodiversity indicators evaluation not only viewed as a static representation of reality, but rather as an insight on the trends observed throughout the years of forest growth and ecosystem development.

The selected ordinarily managed forest is a beechwood coppice forest in the pre-alpine area included in the forest property of the Municipality of “Mel”, in the province of Belluno (Veneto Region, North Eastern Italy). Unfortunately, though, the lack of biocoenosis that could be considered natural, in the sense of undisturbed - as recognized also by Del Favero *et al.* (2000) - together with the relatively short rotation cycle, ending at 20 years of age, impedes the comparison with the “untouched” situation and limits the number of stages available.

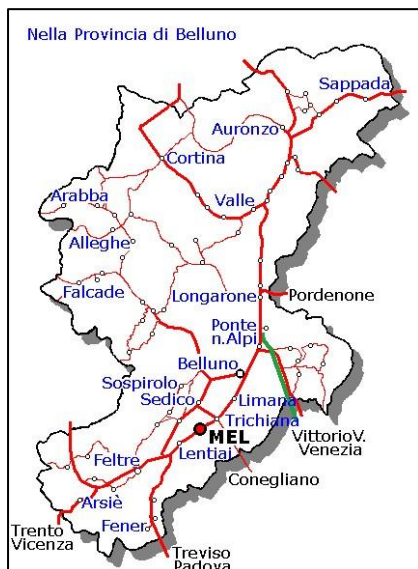
Other more or less predictable limits of the fieldwork are related to the difficulties in detecting homogeneous sample areas, in such a complex micro-orography, and to the particular, uncommon stand structure due to the local harvesting systems: irregular cutting habits, sometimes disregarding management plans rather than real silvicultural choices.

The management carried out in the area of interest, in fact, provides for the release of 150 standards (not necessarily of seed origin, but often individuals of old agamic provenance, although well freed from the stool), which in the real situations normally exceed this threshold (as we will later observe) and other poles are preserved (so called “tirasucchi”) in every stool. These latter ones appear sometimes quite important in diameter and height, so that they act almost like a standard, for the coppice, making it sometimes difficult to figure the structure of the stand out, especially with respect to dendrometric parameters calculation and analysis, where average diameter and basal area are especially sensitive to this particular circumstance. In the following chapters, anyways, we will try to gradually assign a clearer contest to these formations, by presenting different aspects of the stand composition, horizontal and vertical structure and some dendrometric elaborations outputs, never forgetting the considerations just exposed, which differentiates this management system very much from a “simple coppice” and even from a “simple coppice with standards” only.

2. THE STUDIED AREA

2.1 THE WOODED TERRITORY OF MEL MUNICIPALITY (BL) - GENERAL TRAITS

Figure 1: Localization of Mel municipality center in the territory of Belluno province (www.comune.mel.bl.it/)



The municipality of Mel (figure 1) is located in the southern area of the Belluno province (Veneto Region) called “Valbelluna”, on the hydrographic left of the Piave river, which represents its northern border. It shares the southern border with the Treviso Province, the western one with the municipality of Lentiai, the eastern border with the municipality of Trichiana and the northern one with the municipalities of Sedico and Santa Giustina.

The silvopastoral property of Mel municipality covers a surface of 1865 ha, over the 85674 ha of the entire

territory, and forms an almost undivided unit, excluding the few relatively unimportant isolated nucleuses.

The wooded area of the municipality is estimated in 1799 ha out of which 1432 are managed as coppice.

The territory of Mel is included in the Mountain Community “Comunità Montana Val Belluna” and has adhered to the Local Action Group (LAG) “Prealpi e dolomiti bellunesi e feltrine” for the program LEADER II, activating in this context different initiatives for the valorization and preservation of the territory. In particular these were connected to the meadows mowing, the forest fires prevention, the forestry associationism and the detection of biotopes.

The LAG identified the Natural, environmental and landscape resources as strength points for the area, which is also suitable for a good production in renewable energy.

Furthermore, there is in the area a tendency for associative initiatives even in the forestry sector, a quite uncommon trait in the Province context.

Among the weaknesses, instead, we can recall for our purpose the hydrogeological instability phenomena - due to the difficult territory maintenance and recent abandonment phenomena - and the high production costs – mostly due to the existent morphology.

Among the threats, the most important might be the previewed loss of biodiversity in forest ecosystems.

2.2 GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS

The wooded property of Mel municipality extends in the Belluno Pre-alps, which are the result of tectonic deformations or dislocations.

The forest property of Mel municipality stretches from the 341 meters above sea level (lower altitude) to the highest point which coincides with the summit of “Col de Moi”, at 1354 meters above sea level.

The latter makes up, together with the “Col di Varnada” (1321 m) and the mount “Salvedella” (1289 m), the crest of the Belluno Pre-alps, formed by a quite straight and regular ridge at the higher altitude and characterized by a moderate slope toward the Valbelluna axis, opposed to the steep and often craggy side showed toward the venetian plane.

The morphology of the forested area is on the whole uniform, with broad valleys that become quite deep, especially toward the western part. They present a south north-west direction and from east to west we can identify the following main ones: Valle di S. Ubaldo, Val di Botte, Val Foran, Val Farera, Val Barcon, Val di Calt, Val d’Arco, Val Fontane and Val Pissador. The main exposure of the forested sides is north or north west while the average slope ranges from 10°-20° in few forest compartments (mostly managed as tall forest), 20°-30° in most of them, and 30-50° in fewer ones.

The hydrography definitely shows a torrential character and all water bodies flow, directly or indirectly, into the Piave river, being the main ones –from east to west – the Ardo, Puner, Terche and Rimonta streams.

Beech forests are often interrupted by these impluvia, sometimes very pronounced, with participation of *Salix appendiculata* Vill. and hygrophilous herbaceous species.

These torrents cross not very compact, breached calcareous formations and have a limited discharge, with dry/flood periods strictly connected to precipitation.

In the territory of Mel municipality the geological substrate is mainly constituted by sedimentary rocks, deposited in the Mesozoic and Cenozoic era.

The nucleus of the southern anticline, corresponding to the peaks of the area, is mainly formed by flaky or slabby limestone from the Early cretaceous – with flinty inserts - and secondarily from white and black oolitic limestone from the late or medium Giuralias.

Going down along the valleys which depart from the above mentioned syncline, morainal deposits are found, generally from the Wurmian period, alternated with fluvio-glacial deposits and screes deposits.

The montane belt, differently from the piedmont zone, is hydrogeologically stable.

(Andrich *et al.*, 2002)

2.3 PEDOLOGICAL ASPECTS

The different aspects, morphologies and the human interventions are by far the fundamental factors for the current vegetation distribution.

But the edaphic factor must not be forgotten, since even the different pedological characteristics are enough to favor the settlement of some species rather than others.

Due to the poverty of the pedological stratus, soils are not originally rich, but improved with the humus input, so that their fertility differs according to the higher or lower slope gradients, to their exposure and to the anthropic factor which often contributed to their impoverishment (when not degradation), sometimes even in favorable conditions.

Following the FAO-Unesco soil classification, we can distinguish in the area: Rendzic Leptosols, Mollic Leptosols and Phaeozems, Regosols and Cambisols. In the whole municipality property they're present in the following proportions: about 78% are Mollic Leptosols and Phaeozems, 15% Rendzic Leptosols, 5% Cambisols and the remaining 2% Regosols.

The more specific pedological characters pertaining to the single sample areas, their description and significance will be described in paragraph 3.1.

Furthermore, the floristic relevés are often good indicators of the present soil type, at least in the clay component, high in content where *Petasites albus* (L.), *Athyrium filix-foemina* (L.) Roth, *Dryopteris filix-mas* (L.) Schott and *Gymnocarpium dryopteris* (L.) Newman are significantly present.

These marly soils are in fact able to retain water and maintain an almost permanent soil freshness.

Regarding the humus characterization, in the Rendzic Leptosols the prevalent humus is the mull type in the more humid sites, moder in the dryer environments and the so called

“annelids mull” (porous and lumpy, with 5-15% organic matter, CN variable from 10 to 20 and pH around 7,5) in the Cambisols.
(Andrich *et al.*, 2002)

2.4 THE CLIMATE

The area, located in an area of transition between the venetian plane and the internal part of the pre-alpine chain, presents intermediate characteristics between the mountain-alpine climatic type and the sub-littoral one.

Precipitations are abundant, since the humidity from the Padana plane, through the damp winds coming from the Adriatic, tends to concentrate and be released in the impact with the first pre-alpine spur: the range going from the Mount Faverghera to the Valdobbiadene mountains.

The average yearly precipitation, according to registrations of the Hydrological Annals of the “Magistrato delle Acque” at the meteorological observatory of S. Antonio in Tortal (706 m above sea level, Trichiana municipality, <http://www.arpa.veneto.it/temi-ambientali/idrologia/file-e-allegati/rapporti-e-documenti/idrologia-regionale>), ranges from 1300-1800 mm, with a distribution on 137 rainy days and exceeding 100 mm in 8-9 months/year.

In the more recent forest management plan, the precipitation of the forested area we are interested in, is calculated on these data (being the average altitude higher than the latter meteorological station of about 300 m) to be around 2000 mm/year on average.

The rainiest months are May and October, with a equinoctial rainfall pattern that shows a main peak (and more intense one) in autumn and a secondary one in spring.

In summer precipitations never fall below 350-400 mm.

The snowfalls are rather discontinuous, and quantities very variable. First snows normally fall at the beginning of December and remain until April-May.

Damages due to avalanches or snowslides are rarely detected, while significant can be those caused by early snowfall events and especially late heavy ones.

In recent years snowy precipitations have anyways radically diminished.

Concerning the temperatures, in absence of a better local observatory, we can base on data collected by the meteorological station located in Belluno (<http://www.arpa.veneto.it/dati-ambientali/open-data/clima/principali-parametri-meteorologici>), at around 400 meters above sea level, which shows – for the period 1994

to 2011 – an average seasonal temperatures of about 0,7° C in winter, 10,9° C in spring, 19,7° C in summer and 10,7° C in autumn.

Only one month has an average under 0° (January) while for 7 months the monthly average exceeds 10° C.

The average days with frost vary around 90 days/year, while minimum absolute temperatures vary from -13° C to -15° C.

The length of vegetative period goes from a maximum of 170 to a minimum of 150 days, with an average temperature of about 17° C.

The thermic regime is therefore pre-alpine, with cold winter and mild-fresh summer, in the area of the Belluno meteorological station, which is not to be confused with the surveyed zone, localized at higher elevation. Applying to the interested area, however, the known thermic gradient (minus 0,6° C for every 100 meters increase in elevation), we could approximately obtain the averages for each elevation belt we'd like to consider, starting from the above exposed data.

(Andrich *et al.*, 2002)

2.5 THE VEGETATION

Differently from the previous more general descriptions, we will here detail the specific characteristics of the vegetation for the narrow areas analyzed, chosen for the aim of the thesis to be as uniform as possible in altitude, aspect, slope and disturbance.

The wider and complex forest property of Mel municipality includes, in addition to the sub-montane and montane beech forests (“Faggeta montana” and “Faggeta submontana”) that are object of this study: alti-montane beech forests (“Faggeta altimontana”), *Ostrya carpinifolia* woods (“Orno-ostrieto”), hornbeam with *Ostrya* woods (“Carpineto con *Ostrya*”), post cultural maple and ash woods (“Aceri-frassineto con *Ostrya*”) and maple-linden forest (“Aceri-tiglieto di versante”).

2.5.1 Typological and Phytosociological characteristics

The beech coppice stands of the surveyed area can be included in the “Faggeta Montana Esalpica” category of Del Favero *et al.* (2000) Forest Typology derived for the Veneto Region, or as “Faggeta Montana Tipica” in the 1993 work by Del Favero and Lasen (“La Vegetazione Forestale del Veneto”). Elements of the “Faggeta submontana” are also

influencing the site characterization, as will be evident from the floristic data collected and further exposed.

In the Natura2000 classification it is described with the code 91K0 as Illyrian *Fagus sylvatica* forests (Biondi *et al.*, 2009), while for the EUNIS classification (Habitat Classification-European Nature Information System) the formation corresponds to the code G1.6C, the Illyrian *Fagus* forests (Lapresa *et al.*, 2004).

In the *Quercus-Fagetum* phytosociological class (Br.-Bl. et Vlieger in Vlieger 1937), which groups the mesophilous woods characterized by the dominance of deciduous trees, the order *Fagetalia sylvaticae* (Pawłowski in Pawłowski *et al.* 1928) has the Beech tree as the representing species (*Fagus sylvatica*). Following the syntaxonomical scheme produced for the Veneto Region in accordance with the publication “La vegetazione d’Italia” by Blasi (2010), the selected area falls within the alliance *Aremonio-Fagion* (Borhidi 1963, Török *et al.* 1989), the former *Fagion Illyricum* according to the old chorological classification now replaced (Barkman *et al.*, 1986).

Inside this south-east European alliance, which therefore also includes the Italian Adriatic side, we can classify the analyzed beech woods as impoverished forms of the *Dentario pentaphylli-Fagetum* association (Mayer et Hofmann 1969), which belongs to the sub-alliance *Saxifraga rotundifoliae-Fagenion* (Marinček *et al.* ex Marinček *et al.* 1993).

As we will discuss later, the absence (or limited presence, confined to the undisturbed impluvia) of the single indicator species *Dentaria pentaphyllos* is connected with the harvest management disturbance, more than with the unsuitable habitat. Other elements clearly allow to trace the association back to the one indicated above.

2.5.2 Bio-climate and altitudinal belts

The entire territory falls into the “Esalpic region”, which includes the pre-alpine area.

The dominant forest species is the beech tree, both because it forms quite extensive formations and because of its ubiquitous presence. The area belongs in fact to the phytoclimatic district “*Fagetum*”, particularly the warm sub-section (according to Pavari’s classification), where the climax vegetation is formed by the mixed *Abies-Fagus* forest, the vegetative luxuriance of which is favored by the abundant summer precipitations.

The vegetation belt considered in this work falls into the montane belt (three sample areas are placed just around 1000 m above sea level), with transitions to the sub-montane belt,

especially in the lower compartment (850 m). The altitudes might indicate a sub-montane area, but the aspect (North-west) lowers the threshold between this and the montane zone in this particular context.

In contrast with what could be thought, being the "*Fagetum*" a suitable (even if not optimal) area for it, the fir (*Abies alba*) is absent from the property, at least at the adult stage.

In the sub-montane horizon, the forest is localized mainly along the sides of the valleys excavated by the streams that cross the Mel municipality, on the steeper hillsides and on the screes.

The montane horizon is instead characterized by a more uniform macro-morphology and more extended wooded complexes.

The original phytocoenosis were formed by fir and beech, with sycamore maple (*Acer pseudoplatanus*) and with or without spruce (*Picea abies*).

In the **sub-montane beech forests** some thermophile broadleaves are present, especially *Sorbus aria*, *Ostrya carpinifolia* and, in particular, *Fraxinus ornus*. These species are sometimes present in significant densities, and in some cases even from natural regeneration, as in the case of compartment 28 (*Fraxinus ornus*).

These forests show at the floristic level also a respectable quota of species from *Carpinion* and *Quercetalia pubescentis*, especially at the lower altitudes. Even if the threshold between sub-montane and montane areas could be set around 1000 m above sea level, the species of *Carpinion* (especially significant covers of *Vinca minor*) tend to move further above (1100 m), sometimes due to a decisive thermic contribution (SO-O).

On the other hand we can also trace back to montane beech forests some situations at altitudes lower than 1000 m, where the dominant factor becomes the northern exposure, rather than the elevation.

The presence of European hop hornbeam (*Ostrya carpinifolia*) is never abundant and is almost totally missing especially in the eastern part of the forest property, and rather concentrates where sides morphology becomes more structured with steep slopes and debris or superficial rockiness. This species doesn't reach anyways the coverage values sufficient to define the populations as sub-montane beech forest with *Ostrya*, since it never exceeds 15% of cover and the herbaceous layer is not so differentiated from the typical sub-montane beech forest.

The differential species of *Tilio-Acerion* are sometimes present, more in the herbaceous layer (e.g. *Actaea spicata* as the more frequent) than in the arboreal one, where sycamore maple and European ash are rarely represented, concentrating in gorge environments.

In the more degraded stands or in the areas not so long ago abandoned, the hazel (*Corylus avellana*) is present, sometimes occupying decent surfaces, being anyways ephemeral stands, and disappearing where the cuts have correctly been avoided. In some other cases, instead, its presence is the result of too intense silvicultural interventions, with exaggerated soil exposure to light, accompanied by an excess of nutrients.

In the montane belt, anyways, the presence of hazel is obviously reduced.

Interesting characteristic of the beech forests in this altitudinal belt is moreover the presence of local weakly acidified situations (see sample area 16, described in chapter 3.1).

In the shrub layer are often present, in the analyzed restricted area, *Salix* species such as *S. appendiculata* and *S. caprea*.

The herbaceous layer will be described in detail with the elaborations of chapter 4.

In the **montane belt** the **typical esalpic Beech forest** presents all the characteristic species of *Fagetalia*, belonging to the alliance *Aremonio-Fagion* as previously stated.

Conifers and other broadleaves participate very scarcely to the stand composition. Locally the spruce is present, considered anyways as an occasional intruder, normally less competitive in more oceanic areas such as the pre-alpine one, as shown by its state of deterioration and early senescence.

Although species pertaining to the esalpic fir forests are not missing (e.g. *Petasites albus*), *Abies alba* is absent.

As for the sub-montane belt, the herbaceous layer will be described in detail with the elaborations of chapter 4.

2.5.3 Silvicultural characteristics: past and current management

The territory of Mel municipality, for its favorable environmental conditions, has been inhabited since the ancient times.

Originally, the territory was occupied by the deciduous mesophile forest, the structure of which we can still today reconstruct by looking at its few but indisputable residues. The primitive forest has been confined in the areas considered unsuitable for the arable lands, that fed the increasing population of the time.

A clear example of early human impact on the original wood composition, is the Fir, which was probably very abundant in the montane area of Mel territory, but the presence of which has been drastically reduced (where not eliminated) because not considered of any utilitarian value.

The woody heritage of the municipality has often been object of fights and dissidences for its control, going from the Roman and Longobard domination, through the feudal property Era, till the ownership of the “Magnifica Comunità di Zumelle”, which until 1800’s supplied the Venetian Republic of timber floating down the Ardo and Rimonta streams first, and through the Piave river down to the lagoon - on robust rafts - afterwards.

After almost four centuries of forest exploitation, the forest patrimony has been considerably depleted with the two World Wars.

The forest property has been subjected to management planning since 1956. We are now approaching the 4th revision of the management plan, awaited for 2013.

In the period 1956-1965 the coppice wood was harvested with clear cuts with some shoots (so called “tirasucchi”) and standards (90/ha) release, with annual equally productive surfaces (according to the “Metodo Planimetrico Spartitivo”) with a rotation of 16 years, sufficient to bring shoots to 11-12 cm diameter at breast height (dbh), suitable for fire wood use.

In the following period, from 1966 to 1982, the management of beech coppice wood remained almost unchanged, with the exception of the following alterations, based on the previous experience:

- rods under 6 cm of diameter at the shoot base are excluded from the cut;
- no stool should remain completely bare;
- lighter harvests at the margins, where coppice forest vegetation is sparse;
- retain at least 120 standards/ha, in the end showing three age classes, multiple of rotation age and mostly coming from seeds originated from plants in good state or from vigorous shoots.

In the same period, furthermore, rotation age was brought from 16 to 17 years, since the number of coppiced compartments increased from 32 to 34.

With this system the canopy density increased, so that after three-four years from the cut, crowns already were in contact to each other. This new system could also be considered a preparatory phase to the conversion of coppice to high forest.

Nevertheless, delays of harvests were - for different reasons - common, up to 3 years.

In the period 1983-1999 the modifications applied where the following:

- the diameter under which shoots should have been spared from cut was fixed to 5 cm, instead of the previous threshold of 6 cm;
- standards to be retained increased from 120 to 150 individuals/ha, to assure a better crown cover on the soil, uniformly distributed in the compartment at an average distance of 8 m and with a diameter ranging from 12 to 14 cm at breast height.

The rotation was confirmed in 17 years, with the addition of minimal (13 years) and maximal (20 years) age prescription.

After 17 years, in 2001, the forest resulted arranged as planned and fully operational.

Coming to the newest version of the management plan, the beech coppice forest maintained the same management system, with the exception of the rotational cycle that was extended for some compartments up to 20 years, in order to preserve or increase the regeneration capacity of stools, assure a better soil protection and at the same time a better resistance of the retained poles against atmospheric agents.

The already discussed marked monospecificity of the arboreal layer (with *Fagus* the decisively dominant species) occasionally interrupted by other tree species, is partly connected to the forest management actions.

The silvicultural management has obviously influenced the biodiversity not only of the arboreal, but also of the herbaceous layer, presenting sometimes few species compared to the potentialities of the site.

With coppicing, some species are favored (*Hypericum hirsutum*, *Scrophularia nodosa*, *Senecio ovatus*, *Urtica dioica*) which we can define as belonging to the cutting area and which remain until the stand doesn't deplete the accumulation of nutrients and the energy input is reduced by the canopy density increase.

Together with these, different species of *Rubus* (especially *R. idaeus*) develop, reaching in some situations significant cover values and extent.

2.6 THE FAUNA

The faunistic component currently present in the territory of Mel municipality suffers from the environmental changes occurred because of the abandonment of the agricultural and silvopastoral activities which have interested the area, particularly in its mountainous part.

The deep, parallel valleys which insinuate almost perpendicularly to the pre-alpine ridge representing the southern border between the Belluno and Treviso provinces, have in fact witnessed, starting from the years 60's of the last century, a gradual abandonment.

These areas, once exploited and guarded by the farming community, assist today to a progress of the forested surfaces which recolonize the by now former agricultural land, in addition to a diminished frequentation and stable presence of Man.

On the border of these areas, where moreover almost the complete beech coppice property of Mel Municipality object of this study is located, there are others today still sufficiently managed by mowing and pasturing, both in professional (mainly by dairy cattle breeders) and hobby forms by a community still rooted in the territory and proud of its management.

As a consequence, the habitat created is particularly varied and favourable especially to the Ungulates, with wide, quiet and low frequented refuge areas – the deep valleys above mentioned – decidedly dominated by the forest component and others, more externally located, characterized by still well-preserved open spaces.

During the last two decades a sharp increase in the populations of roe deer (*Capreolus capreolus*) first and red deer (*Cervus elaphus*) afterwards have occurred, accompanied by the recent appearance – and by now stable presence – also of the wild boar (*Sus scrofa*).

Observing the census data for the roe deer, relative to the last 20 years, carried out within the territory of the Alpine Hunting Reserve of Mel, we can notice a decisive and progressive increase from the 350-400 heads estimated in the early 90's to the current 750 (Ufficio Faunistico, Amministrazione Provinciale di Belluno, 2012).

Concerning the red deer, in the early 90's within the territory of the Municipality of Mel the presence of some tens of specimens was estimated (26 in 1990, 65 in 1995, 88 in 1999).

Starting from the first years of 2000 the hunting management of this species, characterized by more marked movements within the occupied territories than what happens for the roe deer, is carried out by considering not the single reserve corresponding to the municipal area, but broader management units called "Comprensori", or districts.

In the case of Mel, the "Comprensorio Sinistra Piave" also includes the neighbouring territories of the municipalities of Lentiai and Vas, although represented by much lower

surfaces (Mel: 8592 ha and hunting surface of 6217 ha; Lentiai: 3764 ha and hunting surface of 2388 ha; Vas: 1758 ha and hunting surface of 1022 ha/ Amministrazione Provinciale di Belluno, Piano Faunistico Venatorio update 2009-2014).

From the estimates, the red deer population of this district shows a sharp increase in the last 10 years, from the estimated 250 individuals in the early 2000's to the current 460.

Remaining among the Ungulates, the recent appearance of the wild boar has now brought to a population growth phase as highlighted, in particular, by the increased damages caused by the typical digging activity for feeding purposes of this species, easy to be found in a diffuse way in the territory of Mel.

In addition to the Ungulates, the mammals faunistic component of this territory is the typical one for the pre alpine environment. Among the species strictly connected to the forest we can recall the presence of the European pine marten (*Martes martes*) and of the European badger (*Meles meles*) and among the rodents that of the edible dormouse (*Glis glis*) and of the Eurasian red squirrel (*Sciurus vulgaris*).

Varied and well represented is the micro-mammals component, among which make its appearance the common shrew (*Sorex araneus*), the common vole (*Microtus arvalis*) and the common European mole (*Talpa europea*).

Among the predators worthy of mention is the presence of the beech Marten (*Martes foina*) and of the red fox (*Vulpes vulpes*), this last one currently under monitoring and subject to oral vaccination through baits, due to the recent rabies epidemy which has interested north-eastern Italy, starting from the first verified case in Friuli Venezia Giulia Region (2008) and then extended also to the Veneto Region and to the Belluno Province (first verified case in 2009).

Common and well spread results the European hare (*Lepus europaeus*) which frequents the areas characterized by open spaces interrupted by small woods or in continuity with more extended forest surfaces.

Rich in species is also the ornithic component, which will be better detailed in the results of this work. Here we could only mention the importance of the inclusion of the southern part (and more elevated) of the municipal territory of Mel is included in the Special Protection Area IT3240024 "Dorsale Prealpina tra Valdobbiadene e Serravalle".

Of high faunistic value is the presence of the Black Grouse (*Tetrao tetrix*) and the Capercaillie (*Tetrao urogallus*). The first settles in the southern extreme of its distribution area in the Belluno Province and moreover at rather unusual altitudinal limits for the species: 700-1350 m above sea level (Carlin, 1999). In spring it shows its presence with

the call love notes which resound from the Col de Moi meadows to the areas of Forcella Foran, Vallon Scur, Costacurta, Salvedela and Col de Varnada.

This grouse loves to frequent, in addition, the newly cut areas with high herbaceous cover, particularly during the raising of broods, which here find refuge and food.

Other favourable environments for this particularly valuable group of Tetraoninae are the clearings recolonized by shrub vegetation, such as brambles, bilberry and high herbs; the Capercaillie, of rare presence, also likes to frequent areas characterized by big and sparse beech specimens.

Last but not least, we should consider the reptiles and amphibians component. Among the reptiles we can recall the presence of the viviparous lizard (*Zootoca vivipara*), the western green lizard (*Lacerta bilineata*), the slow worm (*Anguis fragilis*), the smooth snake (*Coronella austriaca*), the aesculapian snake (*Zamenis longissimus*) and, at lower altitudes, the green whip snake (*Hierophis viridiflavus*).

Connected to the water environments is instead the viperine water snake (*Natrix natrix*). Ascertained is the presence of the asp viper (*Vipera aspis*) and of the European Adder (*Vipera aspis*).

Looking at the amphibian population, easy is to encounter in the forests of Mel the common fire salamander (*Salamandra salamandra*) the presence of which is connected to the forest habitats with availability of water environments necessary to the larval development.

To the humid areas, particularly the mountain pasture ponds, is linked the presence of the alpine newt (*Mesotriton alpestris*) and of the great crested newt (*Triturus cristatus*). In the territory are furthermore detectable the European common frog (*Rana temporaria*) and the common toad (*Bufo bufo*). The fire-belly toad (*Bombina orientalis*), species included in annex II and IV of the Habitat Directive, exploits, in addition to the alpine ponds, even more ephemeral water collections as those formed, for instance, on forest roads after the passage of some means of transport.

3. MATERIALS AND METHODS

3.1 DESCRIPTION OF THE SAMPLE AREAS

The analysis of coppice wood compartments of different ages (where the term “age” is, for such an irregular structure and treatment, better defined as the number of “years from the last cut”) is fundamental for the definition of the differences in ecological characters and indicators of functionality among the various development stages.

Four sample areas of different “ages” were chosen in a quite restricted area, the previously described “montane beech forest” (with transitions to the sub-montane) belt of the forest property of the municipality of Mel (BL – North-East Italy), in order to minimize the site characteristics variations and therefore homogenize the samples. This could better allow the isolation of the “age”-related parameters, since we are interested in describing the changes in ecological and biodiversity indicators throughout the chronological stages of the coppice wood; unfortunately, due to the particular silvicultural management applied to this wood (see 2.5.3), these are not so well defined as in a simple coppice.

The areas object of the study - of respectively 0, 6,12 and 20 years from the last cut intervention - were detected by the consultation of the Management Plan (“Piano di Riassetto Forestale – Comune di Mel: 2002-2013”) which contains the indication of the years of intervention on the 34 forest compartments managed as coppice, and allowed to make inferences on the aspect, slope and topography of the same (surveyed with GIS).

The compartments isolated with this first selection were then analyzed in the field, in order to localize the most homogeneous (in height, micro-topography, aspect and slope) and reachable sub-areas of 400 m² each, where a preparatory survey was carried out for the scope.

The main topographical parameters (slope, aspect and altitude) were in this case surveyed through the use of a GPS device.

The choice fell on the Sample Areas (SA) briefly described in table 2 and further below, indicated - from the youngest to the oldest - with the codes: P14, P16, P20 and P28.

The capital letter P stands for “particella” (the Italian for “compartment”), while the two-figures number indicates the reference forest compartment to which the sample area belongs.

Table 2 Descriptive parameters of the four Sample Areas

Code of SA	Forest Compartment	Locality	N° years from last intervention	Av. Altitude (m)	Main Aspect	Av.Slope	Assolation (nh/year)
P14	A014/0	Canidi – Val di Calt	0	1100	NNO	20°	1400-1800
P16	A016/0	Pradegal	6	1050	NO	25°	1000-1400
P20	A020/0	Foral – Val d'Arc	12	980	NNO	25°	1000-1400
P28	A028/0	Scarlir	20	850	NO	15°	1000-1400

These coppice areas presents rather uniform features, although, for contingent reasons, cuts have often been delayed in some compartments.

Its structure, resulting from the cut with the release of officially 150 (but in reality up to 200) standards and shoots under 5 cm dbh, is rather irregular, especially in the younger compartments, and tends to become monoplane in the more mature ones.

While this vertical structure is rather uniform for all the areas, the coverage modalities and intensities are variable. The prevailing horizontal distribution is a full and uniform coverage, but areas of scarce and incomplete regular coverage are not infrequent.

In addition to the differential parameters above exposed in table 2, the four Sample Areas all have a main productive function, with an average dbh at maturity given equal to 25 cm and harvested with cable logging.

They all have in common the soil type - “terre brune”, moderately developed Mollic Leptosols - with a relatively limited depth of about 30-50 cm, a modest water capacity, low mineral nutrients content and limited fertility. The organic horizon often tends to acidify compared to the underlying A/B horizon which is always basic (Andrich *et al.*, 2002). They're characterized by the important water drainage down the soil profile and their delicate equilibrium, easy to alter with improper silvicultural operations as too intense cuts. The maximum soil protection is guaranteed by the adoption of a long rotation cycle and adequate harvesting interventions.

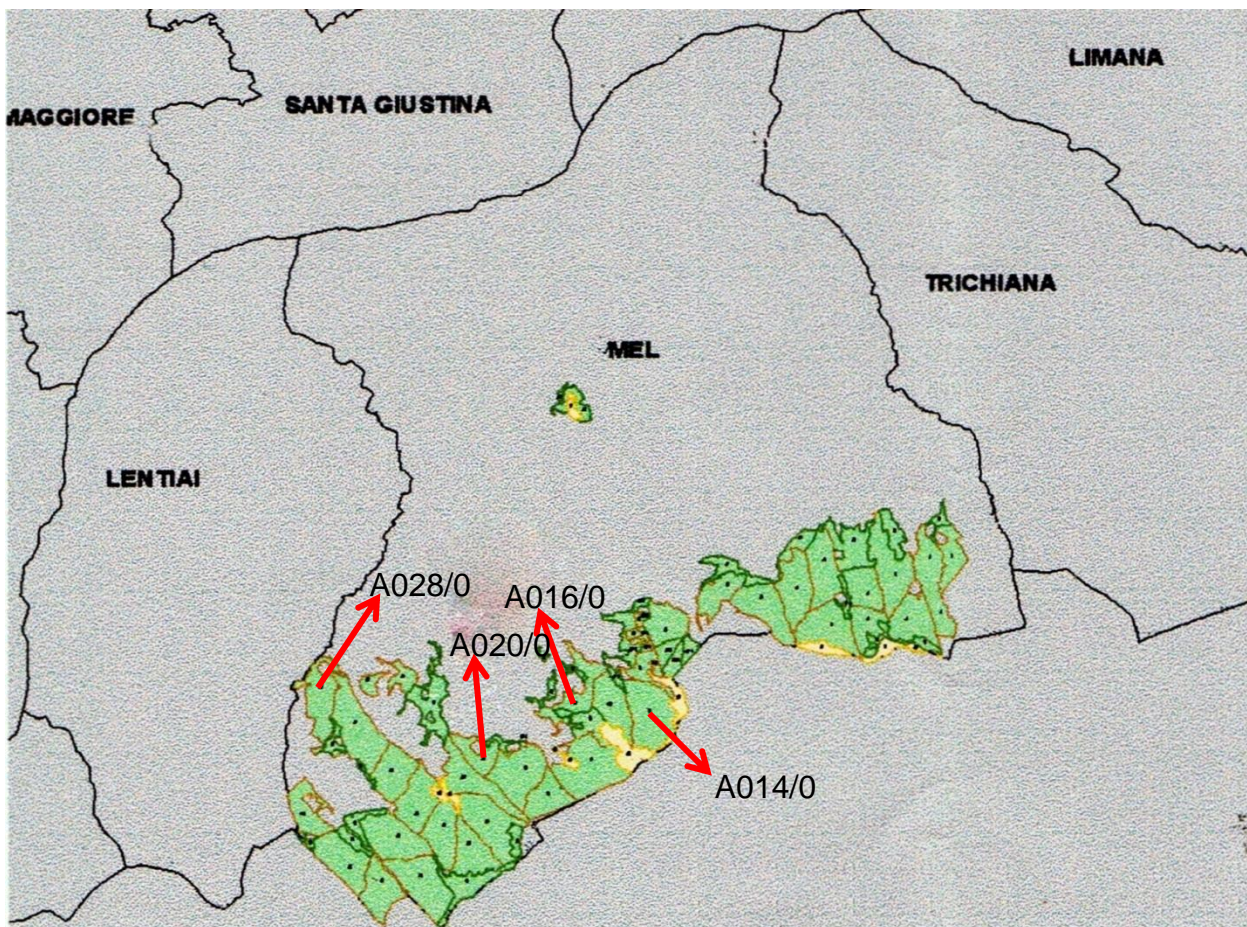
As we can observe, the Sample Area P28 mainly differentiates from the other three in reason of its lower altitude and its more gentle slope. The possibility to survey a different area was taken into account, but it revealed impossible since the only other compartment close to maturity was under harvesting operations during the period of field work.

For the age assignment of the areas, the information contained in the “Felling plan” section of the Management Plan was double checked and corrected or completed with the information registered by the Regional Forest Services and the Municipality Administration

about the real times of intervention in the single 400 m² chosen sample areas, since very often the harvesting operations in a compartment are completed in 2-3 years, and often delay the plot final delivery.

In the regional technical map CTR (“Carta Tecnica Regionale”) of the Belluno Province (scale 1:10000) the areas can be found in section number 084, elements 10 and 20, respectively denominated “Monte Garda” and “Follina”. Their location is showed in figures 2 and 3.

Figure 2: Overview of the silvicultural property of Mel Municipality, with indication of the four compartments to which the 400 m² sample areas belong



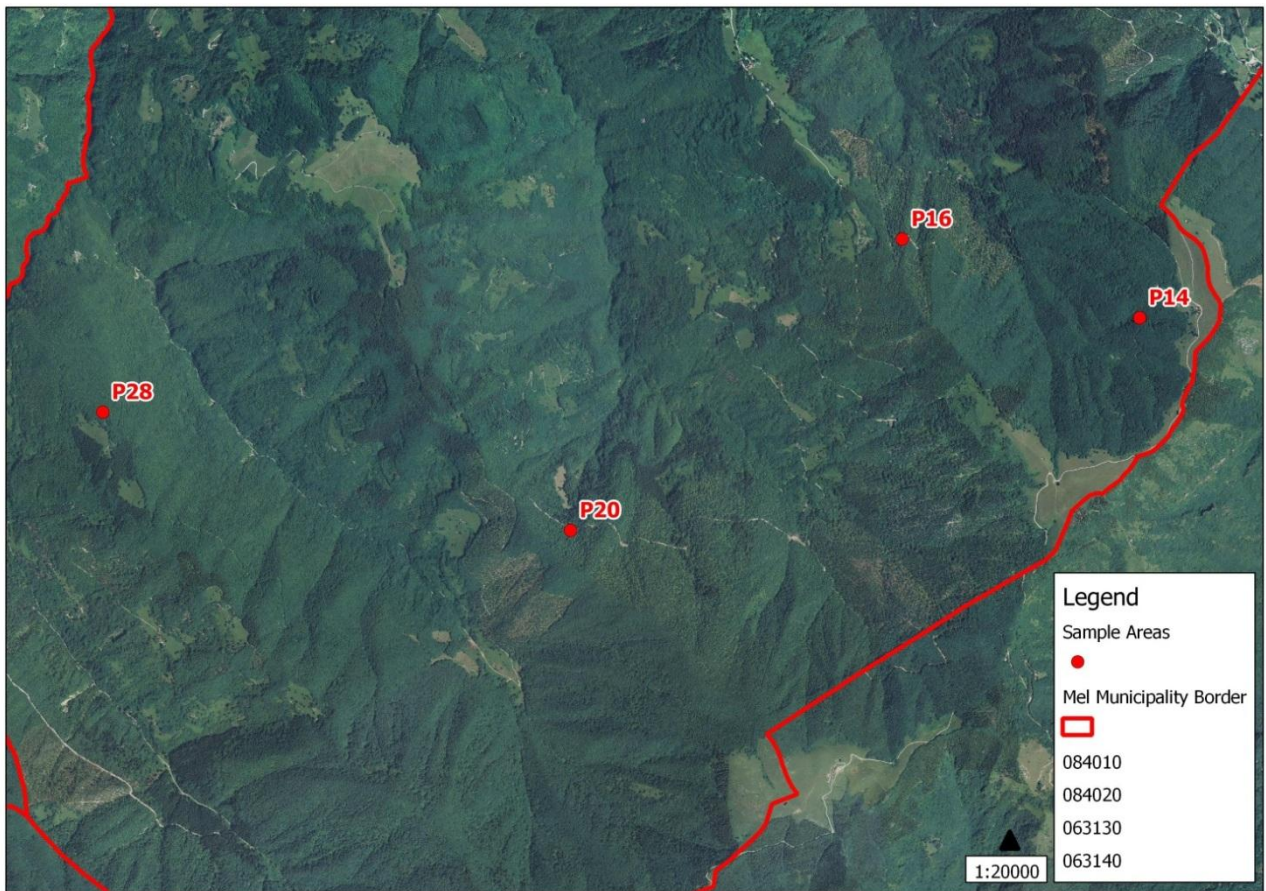


Figure3 Localization of the four Sample Areas

Terraitaly it 2000 NR flight 2006 - 2007 – coloured digital ortophoto ©Compagnia Generale Ripresearee SpA - Parma

3.2 VEGETATION RELEVÉS AND SITE DATA

3.2.1 Collection of dendrometric data

Four square sample areas of 20 m side (400 m² total surface) were located in the beech coppice forest of Mel municipality, and here the dendrometric data were collected.

The diameters measurement was then carried out in all arboreal individuals above or equal to 1 cm diameter at breast height (1,30 m). At the same time the stools were counted, although this operation was complicated by the sometimes difficult distinction between different individuals: when digging very superficially the soil, even apparently isolated stems were found to be linked to a mother stump when roots were followed.

For the diameter assessment the choice fell on avoiding the cumbersome caliper in favor of the circumference measurement through the more time consuming but more precise tape measure (especially in case of eccentric diameters). The diameter distribution was reported by dividing the total number of registered stems in 2 cm wide classes, starting from the class 1-3 cm and proceeding this way.

Where possible, individuals of clear gamic origin (very rare) were kept separated in the count.

The heights were taken with SUUNTO hypsometer, an instrument which requires to know the distance of the operator from the tree, and normally a distance of 20 m (allowed by the instrument) was a good compromise between precision of the measurement and possibility to see the plant's top.

In the choice of the trees to be measured it was paid attention to follow the "model tree" criterion (Bernetti and La Marca, 1999), avoiding deformed and irregularly grown (both for biotic or abiotic factors) stems.

The following hypsometric measures were considered in the 400 m² sample areas:

- average height (Av. H): average of the heights of the shoots which present diameter equal (or very close, up to 0,5 cm difference) to the average diameter of the stand;
- dominant height (H_{d100} with standards): the average height of the 100 bigger (in diameter) plants per hectare. For the examined sample area, therefore, are sufficient 4 plants measurements. Standards were included.
- dominant height (H_{d100} only shoots): the average height of the four biggest shoots registered in the area. In P28 this means excluding the standards (here easy to distinguish, as gamic individuals of big size) and in the other three samples

excluding the “outsiders”, that is to say the high stems released with a standard-like function which would definitely overestimate the derived parameters of dominant height, such as the volume.

The biomass per hectare (m^3/ha) of the four stands was determined through the procedure described in paragraph 3.3.1.2 for the mature sample.

3.2.2 Collection of floristical and phenological data

The floristical and phenological data were collected at two scales: in the complete 400 m^2 sample areas only as coverage indexes (see later) and in 10x1 m linear transects (one for each sample area) also counting the number of stems of each species throughout the season.

The field relevés were carried out from the 13th of April to the 15th September 2012, firstly every week and after the 20th July decreasing the frequency to 15 days, when the vegetative rhythm was already decreasing. Within this period, the detailed transect analysis were made during the first field exit and then on odd field exits, always concluding in the middle of September. In total the relevés at disposal for elaborations are 17 for the phenological and cover density analysis (with the exception of P14, were the first relevé – on the 13th April - was impeded by the snow cover found on the site) and 9 transect detailed surveys.

The species classification and the attribution of plant life forms and chorological types was done after Pignatti (1982), although the adopted nomenclature follows Conti *et al.* (2005) checklist.

The floristical relevés were performed according to the Braun-Blanquet phytosociological method, modified by Pignatti (1995), which evaluates the cover percentage of each species as expressed by table 3.

The transect, necessary for the count of the number of individuals/stems, was permanently delimited in site (for the time of the field surveys) at the four vertexes, further dividing it into 10 quadrats of 1 m^2 each and located along the line of maximum slope.

For this enumeration the choice has been to exclude the species of the *Poaceae* family (*Calamagrostis varia*, *Festuca altissima* and *Melica nutans*) for which the distinction of individuals can result particularly complex, if we consider the number of axis as the number of genetically distinct individuals.

The height limits for the various vegetation strata were fixed according to the following criteria:

- moss layer: differentiated by the type of species;
- herbaceous strata: <0,5 m;
- shrub layer: 0,5-4 m;
- arboreal strata: >4 m.

Table 3 Index of abundance and relative coverage value according to Braun-Blanquet and Pignatti and Van der Maaler scale for the attribution of weights

Symbol	Coverage according to Braun-Blanquet (1928)	Coverage according to Pignatti (1995)	Van der Maarel scale transformation and weight (1979)
r	rare	rare	1
+	<1%	<1%	2
1	1-5%	1-20%	3
2	5-25%	21-40%	5
3	25-50%	41-60%	7
4	50-75%	61-80%	8
5	75-100%	81-100%	9

The phenological data were collected contemporaneously to the overall coverage information, therefore at a higher frequency and in a larger sample (400 m²) than the count of individuals. The symbols utilized are:

- sB = start of blooming (<50% of individuals flowering or with buds ready to flower);
- B = full blooming (>50% individuals in blossom);
- eB = end of blooming (>50% withered individuals);
- F = fructification
- Vs = vegetative state (individuals don't present activities connected to gamic reproduction but only vegetative activities, assumed that leaves are present);
- Vq = Vegetative quiescence (for species that maintain the aerial part even in winter - as all the broadleaves - while the evergreen species that can photosynthesize even in winter are considered in Vs during this period);
- (Vs) = individuals with dried out leaf part or begin of leaves autumnal abscission;
- Sp = presence of spores in the *Pteridophytes* species;
- () = residues from previous vegetation period such as stems of Hemicryptophytes or dried out leaves of *Poaceae* (indicated only if individuals are clearly recognizable).

3.2.3 Acquisition of the site data

The site data are indirectly drawn from the present vegetation through the use of Landolt (1977) and Ellenberg (1974, 1979, 1991) ecological indexes, extrapolated from the database ANASPE.XLS provided by the DAFNE department of the University of Padova. The first set of indices was built on researches conducted in Switzerland, while Ellenberg studied the ecological behavior of plants in Central Europe. The present work uses both indexes to calculate and compare the average values for the sample areas, weighting the single plants values on the species relative cover through Van der Maaler scale (table 3), following the suggestions of Schaffers and Sýkora (2000).

Tables 4 and 5 report the categories and the values respectively considered by Landolt and Ellenberg sets of ecological indicators as utilized in this study.

Table 4 Landolt ecological indicators (1977)

<p>Soil Humidity (U)</p> <p>1 Plants of very dry soils</p> <p>2 Plants of dry soils</p> <p>3 Plants of average dry and average humid soils</p> <p>4 Plants of humid to very humid soils</p> <p>5 Plants of water soaked soils</p>	<p>Light (L)</p> <p>1 Plants of very shady environments</p> <p>2 Plants of shady environments</p> <p>3 Plants of average luminous environments</p> <p>4 Plants of luminous environments</p> <p>5 Plants of very luminous environments</p>
<p>Temperature (T)</p> <p>1 Plants of alpine and arctic areas</p> <p>2 Plants of subalpine areas</p> <p>3 Plants of hilly and mountainous areas</p> <p>4 Plants of hilly areas</p> <p>5 Plants of warm climate areas</p>	<p>Continentality (C)</p> <p>1 Plants of regions with oceanic climate</p> <p>2 Plants of regions with suboceanic climate</p> <p>3 Plants of regions with intermediate climate</p> <p>4 Plants of regions with relatively continental climate</p> <p>5 Plants of regions with marked continental climate</p>
<p>Reaction or soil pH (R)</p> <p>1 Plants on soils with pH from 3 to 4,5</p> <p>2 Plants on soils with pH from 3,5 to 5,5</p> <p>3 Plants on soils with pH from 4,5 to 7,5</p> <p>4 Plants on soils with pH from 5,5 to 8</p> <p>5 Plants on soils with higher pH</p>	<p>Soil nutrients (N)</p> <p>1 Plants of very poor soils</p> <p>2 Plants of poor soils</p> <p>3 Plants of intermediate soils</p> <p>4 Plants of rich soils</p> <p>5 Plants of very rich soils</p>
<p>Humus (H)</p> <p>1 Plants of immature soils</p> <p>2 Plants of soils with low humus content</p> <p>3 Plants of soils with average humus content</p> <p>4 Plants mainly living on developed soils</p> <p>5 Plants exclusively living on developed soils</p>	<p>Granulometry (G)</p> <p>1 Plants of cliffs and rocks</p> <p>2 Plants of soils with rubble and gravel</p> <p>3 Plants of gravel and sandy soils</p> <p>4 Plants of minutely sandy soils</p> <p>5 Plants of clayish and boggy soils</p>

Table 5 Ellenberg ecological indicators (1973, 1991)

<p>Humidity (U)</p> <p>0 Indifferent behavior 1 Indicator of very dry soils 2 Between 1 and 3 3 Indicator of dry soils 4 Between 3 and 5 5 Indicator of fresh soils 6 Between 5 and 7 7 Indicator of humid soils 8 Between 7 and 9 9 Indicator of wet soils 10 Indicator of soils with changeable humidity 11 Aquatic plant 12 Subaquatic plant</p>	<p>Light (L)</p> <p>0 Indifferent behavior 1 Very sciahilous plant 2 Between 1 and 3 3 Sciaphilous plant 4 Between 3 and 5 5 Hemi-sciaphilous plant 6 Between 5 and 7 7 Hemi-heliophile plant 8 Heliophile plant 9 Very heliophile plant</p>
<p>Temperature (T)</p> <p>0 Indifferent behavior 1 Indicator of cold climates 2 Between 1 and 3 3 Indicator of fresh climates 4 Between 3 and 5 5 Indicator of moderately warm climates 6 Between 5 and 7 7 Indicator of warm climates 8 Between 7 and 9 9 Indicator of hot climates</p>	<p>Continentality (C)</p> <p>0 Indifferent behavior 1 Very oceanic 2 Oceanic 3 Between 2 and 4 4 Suboceanic 5 Intermediate 6 Subcontinental 7 Between 6 and 8 8 Continental 9 Very continental</p>
<p>Reaction (R)</p> <p>0 Indifferent behavior 1 Indicator of high acidity 2 Between 1 and 3 3 Indicator of acidity 4 Between 3 and 5 5 Indicator of moderate acidity 6 Between 5 and 7 7 Indicator of weak acidity to weak alkalinity 8 Between 7 and 9 9 Indicator of basic and calcareous soils</p>	<p>Nitrogen (N)</p> <p>0 Indifferent behavior 1 Indicator of soils very poor in Nitrogen 2 Between 1 and 3 3 indicator of soils poor in Nitrogen 4 Between 3 and 5 5 Indicator of soils moderately rich in Nitrogen 6 Between 5 and 7 7 Indicator of soils rich in Nitrogen 8 Indicator of soils very rich in Nitrogen 9 Indicator of soils excessively rich in Nitrogen</p>

3.3 ANALYSIS AND ELABORATION OF COLLECTED DATA

3.3.1 Biodiversity indicators for the forest types of the Veneto Region

The present paragraph will expose the criteria followed for the assessment of some indicators based on the methodology indicated in the reference text “Biodiversità e indicatori nei tipi forestali del Veneto” (Biodiversity and indicators in the forest types of the Veneto Region) by Del Favero *et al.* (2000).

The correlation analysis were carried out through the following statistical software (free trial version): StatSoft.Inc (2011). STATISTICA (data analysis software system). Version 10. www.statsoft.com.

3.3.1.1 Qualitative indicators

a) ACTUAL ARBOREAL COMPOSITION

For every arboreal and shrub species observed in all strata within the 400 m² sample areas, only the maximum coverage value reached by the species was taken into account. The species were this way divided into:

- principal: with coverage values, according to Pignatti's scale, greater than 1 (>20%);
- secondary: coverage index equal to 1 (1-20%);
- accessory: coverage index lower than 1 (<1%).

c) COMPOSITION OF THE ECOLOGICALLY COHERENT ARBOREAL SPECIES

The indications provided by Del Favero *et al.* (2000) in the text “Biodiversità e indicatori nei tipi forestali del Veneto” (Biodiversity and indicators in the forest types of the Veneto Region) were used to make a comparison at regional scale.

c) NATURAL REGENERATION

In the “regeneration” category, all arboreal and shrub individuals below 50 cm of height (including seedlings still provided with cotyledons) and above this threshold but below 1 cm diameter were included. The observation was carried out in the 400 m² area, recording the maximum number of individuals of every species registered in a single relevé and the

number of survived seedlings at the end of the season (middle of September), in order to derive their mortality over the season.

The maximum number of individuals of gamic origin was calculated, for every sample of different age, as the sum of the maximum number of seedlings of each species.

More in-depth analysis were carried out considering the two categories: beech and other species regeneration individuals.

3.3.1.2 Quantitative indicators

a) AVERAGE INCREMENT AT MATURITY

The average increment at maturity (m^3/ha year) is obtained by dividing the volume of the stand at the end of the cycle by the years of the cycle itself.

The assessment of the volume/ha of the mature sample was carried out by the use of the coppices double entrance table (av. basal area and dom. height) prescribed by the “Normativa” (in Del Favero *et al.*, 2000) and, for a comparison, of a second table produced exactly for the beech coppices of Mel Municipality by Del Favero (1980).

The value of the basal area was calculated on all individuals exceeding 1 cm diameter (taken with the diameter measurement procedure exposed in paragraph 3.2.1).

The dominant height utilized for this elaboration excludes the standards and considers the average height of the four biggest shoots registered in the area.

b) DIFFERENCES IN COMPOSITION

The differences between the actual arboreal composition and that of the ecologically coherent species were studied only among the principal and secondary species, with the symbology suggested by Del Favero *et al.* (2000).

c) AVERAGE NUMBER OF HEMEROPHYTE SPECIES

The hemeroby index of every sample area was calculated by counting the number of species (in the 400 m^2 relevés) included in the list provided by Del Favero *et al.* (2000).

The average number of hemerophyte species was assessed by averaging the values of the four sample areas.

Furthermore, in addition to Del Favero *et al.* (2000) indicators, was in this context also considered the number of “ancient species” (Hermy *et al.*, 1999; Wulf, 1997, 2003;

Dzwonko, 1993) and “open space species” (Peterken and Francis, 1999) registered in the floristic relevés.

Species were in this work included in the first category if they were listed by Hermy *et al.* (1999) and in the second category if they presented Landolt ecological index for light greater than 4.

d) AVERAGE NUMBER OF HERBACEOUS SPECIES PRESENT IN A RELEVÉ

For each sample area the number of herbaceous species registered in 400 m² was calculated. The average number was obtained as a simple average.

The indications of the number of species present in this formation in situations of minimal anthropic disturbance were drawn from Del Favero *et al.* (2000).

The crown coverage degree in every compartment was indicated by using the symbols D for dense coverage (>70%) and S for scarce (<70%).

3.3.1.3 Qualities

a) FLORISTIC QUALITY

This indicator refers to the average number of species included in the following categories:

- species protected in Veneto (according to L.R. n.53/1974);
- species included in the Regional Red List by Conti *et al.*, 1997;
- species considered rare with respect to the national territory;
- species considered rare in the Veneto Region or with non-uniform distribution
- endemic species, with distribution area limited to the Eastern Alps;
- non-endemic species at the limit of their distribution area.
-

For the scope, the list provided by Del Favero *et al.* (2000) was consulted, with the addition of the Red List produced for the Belluno Province (Argenti and Lasen, 2004), where the study areas are located, and the reports of precious findings in the area by Argenti C. and Viane R. (Marchetti, 2006).

The indicator in question was here calculated on the 400 m² surface where the floristic relevés were conducted.

b) FAUNISTIC QUALITY

This indicator is based on the valuable species reported by Del Favero *et al.* (2000), compared to the ones directly observed during the field surveys or of ascertained presence (Andrich *et al.*, 2002; Varaschin M., personal communication).

c) CHROMATIC QUALITY

The assessment of the chromatic quality of the area was carried out considering the arboreal and shrub species registered in the 400 m² sample areas and included in the list produced by Del Favero *et al.* (2000), divided into three categories:

- species with eye-catching flowering and easily visible from the distance (f);
- species with seasonal foliage chromatic variations (c);
- species which present both characteristics.

The index of chromatic quality for a stand has been calculated as the average of the species considered of a certain chromatic value (belonging to one of the above exposed categories) present in the area. It was chosen to consider the simple presence of a species, disregarding its coverage value, since as reminded by the Del Favero *et al.* (2000) even single individuals of chromatic prestige can render a landscape less monotonous.

3.3.1.4 Indexes of floristic richness and α -diversity

The present work also includes an application of some of the complexity and diversity indexes available in literature.

a) COMPLEXITY INDEXES

The complexity indexes are measures of the number of species present for a given number of individuals in a certain area. A higher index value indicates a more complex structure of the investigated system.

The method utilized for the count of individuals has been exposed in paragraph 3.2.2.

The complexity indexes chosen for the scope are the Margalef (1958) and Menhinick (1964) indexes.

Margalef index is calculated as follows:

$$D_{Mar} = \frac{(S-1)}{\ln N} \quad (1)$$

and the Menhinick index (1964):

$$D_{Men} = \frac{S}{\sqrt{N}} \quad (2)$$

where S=number of registered species (floristic richness);

N=total number of individuals counted in the 10 m² transect.

b) DIVERSITY INDEXES

The Shannon-Weaver index (H', 1949) has been used to determine the diversity within the transects:

$$H' = -\sum_{i=1}^S p_i \log_2 p_i = -\sum_{i=1}^S \frac{n_i}{N} \cdot \log_2 \frac{n_i}{N} \quad (3)$$

High values of H' would be representative of more diverse communities.

For comparison, also Simpson diversity index (D, 1949) was used to quantify diversity of the different sample areas:

$$D = \sum_{i=1}^S p_i^2 = \frac{\sum_{i=1}^S [n_i(n_i-1)]}{N(N-1)} \quad (4)$$

where S=number of registered species (floristic richness);

N=total number of individuals counted in the 10 m² transect;

p_i=fraction of the entire population made up of species i;

n=number of individuals of species i.

Simpson's index measures the probability that two individuals randomly selected from a sample will belong to the same species.

Since the index so formulated augments when diversity decreases, it was here expressed in its more intuitive complementary form (1-D), according to the suggestions of Onaindia *et al.* (2004).

c) EVENNESS INDEXES

Evenness indexes measure the equitability of a system, that is to say how equal is the repartition of individuals among the different species. The maximum diversity occurs in fact when all species are equally abundant.

Shannon and Simpson evenness indexes cover the number of different species observed along the transect and their relative abundances (number of individuals). They are calculated by dividing the Shannon and Simpson diversity indexes by their maximum. Therefore they vary between 0 and 1.

Pielou index (J' , 1966, 1969):

$$J' = \frac{H'}{H_{\max}} = \frac{H'}{\log_2 S} \quad (5)$$

Simpson evenness index (E , Pett, 1974):

$$E = \frac{D}{D_{\max}} = \frac{D}{1 - \frac{1}{S}} \quad (6)$$

Even in this case, in order to have an easier interpretation of the Simpson evenness index trend with diversity increase, its complementary formulation (1-E) was chosen.

4. RESULTS AND DISCUSSION

4.1 DENDROMETRIC ANALYSIS

The elaboration of the dendrometric data on the dominant species, the beech, collected in the four 400 m² sample areas, lead to the results exposed in table 6.

Table 6 Dendrometric parameters of beech for the four sample areas (400 m²). N/ha= number of individuals (shoots and standards) per hectare which exceed respectively 1 and 3,5 cm of diameter at breast height (DBH); G/ha= basal area per hectare over the same two thresholds; n. stools/ha= number of stools per hectare, also including those in the newly cut area that appear completely bare; N>1cm/stool= average number of stems per stool. The volume per hectare (Vol/ha) has been calculated according to two different tables, indicated in brackets.

Name of Sample area	P14	P16	P20	P28
Years from last interv.	0	6	12	20
N/ha>1 cm	1825	3225	3050	2525
N/ha>3,5 cm	1375	1800	1725	2375
Average DBH>1 cm	7,9	6,4	6,7	10,1
Average DBH>3,5 cm	11,2	11	11	12
G/ha (m ²)> 1 cm	14,05	18,22	18,92	28,36
G/ha (m ²)>3,5 cm	13,85	17,71	18,3	28,27
n. stools/ha	875	900	650	775
N>1 cm/stool	2,9	3,5	4,2	2,9
Vol/ha ("Normativa")	100,6	134,8	139,3	211,1
Vol/ha (Mel beech coppices - Del Favero, 1980)	99,5	129,8	133,4	216,2

The species *Fagus sylvatica* is definitely the dominant one, when not exclusive, in the stands. To show the very low proportion of other species exceeding 1 cm diameter in the sample area, in table 7 below the number of individuals (shoots and standards) of other species is reported, as a measure of the little contribution to the basal area of the stands, but surely not to be excluded from the overall biodiversity representation.

Table 7 Number of individuals of species different from *Fagus* (to which they are compared) which exceed 1 cm diameter. Numbers are related to the actual quantities in the 400 m² sample area. The regeneration was not taken into account here.

Arb. Species>1cm	P14	P16	P20	P28
<i>Fagus</i>	73	128	121	100
<i>Picea</i>	1(+1cut)			
<i>Sorbus</i>	5	4		
<i>Betula</i>			1	
<i>Salix</i> app.				1
Shrub species>1cm	P14	P16	P20	P28
<i>Corylus</i>			7	

The species found as regeneration in the herbaceous layer or with diameter inferior to 1 cm, are here not considered, and will be separately taken into consideration in a second moment (see discussion of paragraph 4.4.6)

Let's first discuss about the only main species of these formations, looking at the parameters exposed in table 6.

The number of stems per hectare (overcoming the measuring diameter threshold of 1 cm) shows a minimum in the newly cut area, as it appears logically connected with the recent intervention, but it is still more than half of the individuals counted in the following years situations.

This has proved to be a characteristic of this management system, as discussed before in chapter 2.5.3, where the interventions seem particularly concerned to maintain an optimal soil coverage, sometimes without following the clear indications of the management plan, and taking more subjective decisions from time to time, probably according to situations and needs.

The maximum presence of effective individuals in an area is realized in the 6 years old area, with 3225 stems, which differ very slightly, however, from the following 12 years old stage. Taking a closer look to the difference between the two sample areas (P16 and P20), we can notice how, in spite of a very similar total number of individuals, the younger one shows a lower average number of shoots per stool, compensated by a higher number of stools per hectare, while the opposite happens in the older stand.

The number of stools per hectare might easily come from different starting situations of the four sample areas, where it has been observed, in general, a tendency of stools ageing, growing larger and sometimes reaching exhaustion without being reasonably replaced.

Referring to the descriptions contained in the management plan (Andrich *et al.*, 2002), the number of stools/ha can be anyways considered within the average (range 500-1000 in the overall forest property of the municipality of Mel).

Going back to the number of individuals per hectare, a sharper decrease is evident, instead, in the oldest area, where the strong competition between the shoots has come to an end, giving dominance to a number of 2375 individuals. Mortality of the agamic individuals, however, seems not to be very high, at least judging the good number of shoots still present in the middle-age sample area.

The average diameter includes here also individuals that were left as “standards”, hardly ever (with the exception of P28) of gamic origin, and often being just poles of the stools left for a better soil protection, the “best shoots” of an age variably multiple of the coppice cycle.

This situation almost induces to think of an attempt to convert the coppice to a high forest, which is however not documented in the management plan for the considered compartments.

On the other hand, this is probably the best representation of the real conformation of the stands, which returns us a picture which is closer to reality and on which we can make our considerations about structure and effects.

Nevertheless, keeping in mind that individuals falling into elevated diameter classes are included in the calculation of the average diameter can help us interpret the values, where variations in number of standards, even very low, can strongly influence this parameter.

Even in this case, the two central compartments prove very similar, setting up to an average diameter of around 6,4 and 6,7 cm, while the oldest shows a considerable difference in 10,1 cm. The fact that the average diameter of the newly cut area is higher than later on in the succession doesn't surprise, thinking that the individuals which remained uncut are surely standards or standards-like poles, included in higher diameter classes, while the extremely high number of new shoots are at this phase still below 1 cm diameter.

The analysis of the population curves shows an evident distance from the classical Gaussian distribution, typical of the even-aged formations, and rather resemble that of a coppice managed with selection system, especially in the central stages: P16 and P20 (figure 5).

Similar distribution models were discovered by Riondato *et al.* (2005), in coppices dominated by *Ostrya carpinifolia* and *Quercus pubescens* of the Euganean hills (Province of Padova – Veneto Region), and by Cappelli and Colpi (1993) in coppices of the same area and of the Berici hill (Province of Vicenza – Veneto Region).

The Authors suggest that this effect could be due to a continuous emergence of shoots from the stools over time, but it could also be connected with the scarce attention paid to the stand tending and non-authorized cuts. Moreover, in our case the influence of the quantity and type of release is very high.

In P28 and P14 the curve seems instead to get closer to the Gaussian curve (figure 4), or better to the second part of it, missing its left branch, that would probably be evident if shoots under the 1 cm diameter threshold were measured.

The right “tail” of the curve, instead, is composed of the “real standards”, those reaching the most elevated diameters.

Figure 4 Curves of diameters distribution of the 0 and 28 years old sample areas

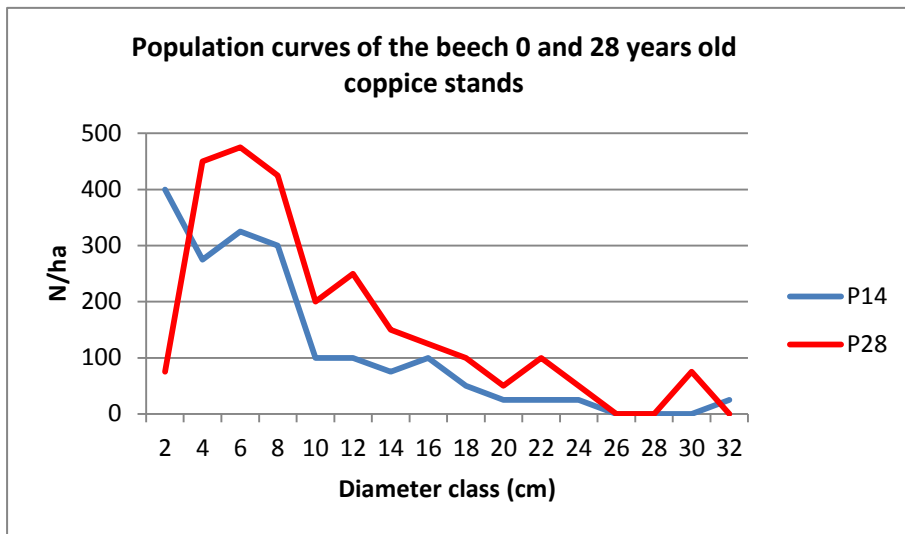
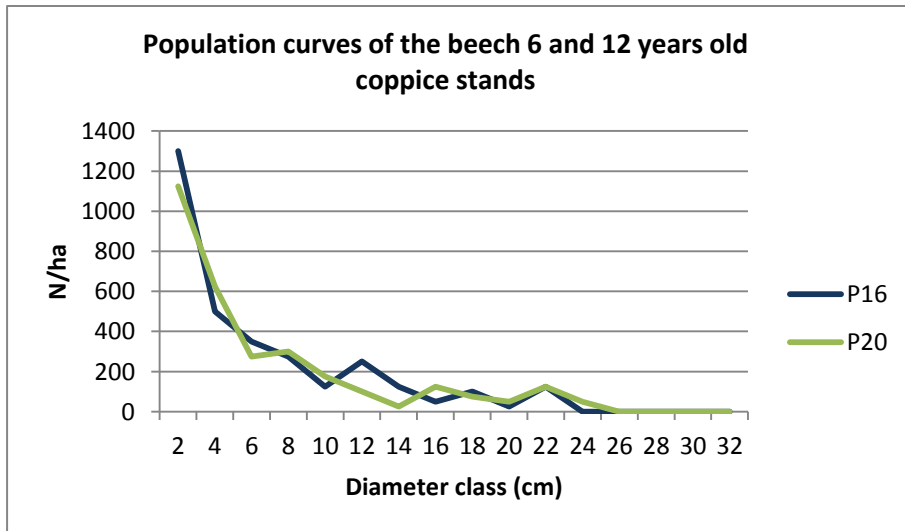


Figure 5 Curves of diameters distribution of the 6 and 12 years old sample areas



The basal area increases significantly with the age of the compartment ($r=0,954$, $p<0,05$) and, we can notice once more, doesn't differ too much among the 6 and 12 years old sample areas, which by now seem to present a quite similar overall structure (figure 6).

On the contrary, as already mentioned before, the two stands differ on the average number of shoots per stool, highest (4,2) in P20, when compared to P16 (3,5). The two extreme stands (the 0 and 20 years old ones) oddly show the same, lower number, which is not anymore so curious if we recall that the newly cut area has just left, the previous winter, the maturity conditions. The percentage contribution, in basal area, of each

diameter class to the total basal area per hectare is visualized in figure 7, for each sample area.

Figure 6 Basal area per hectare (G/ha) for the beech coppice stands of different age

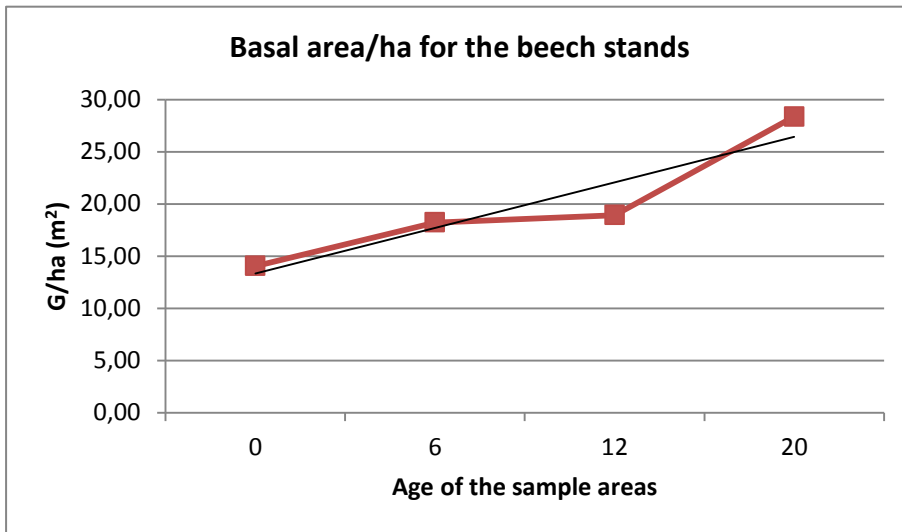
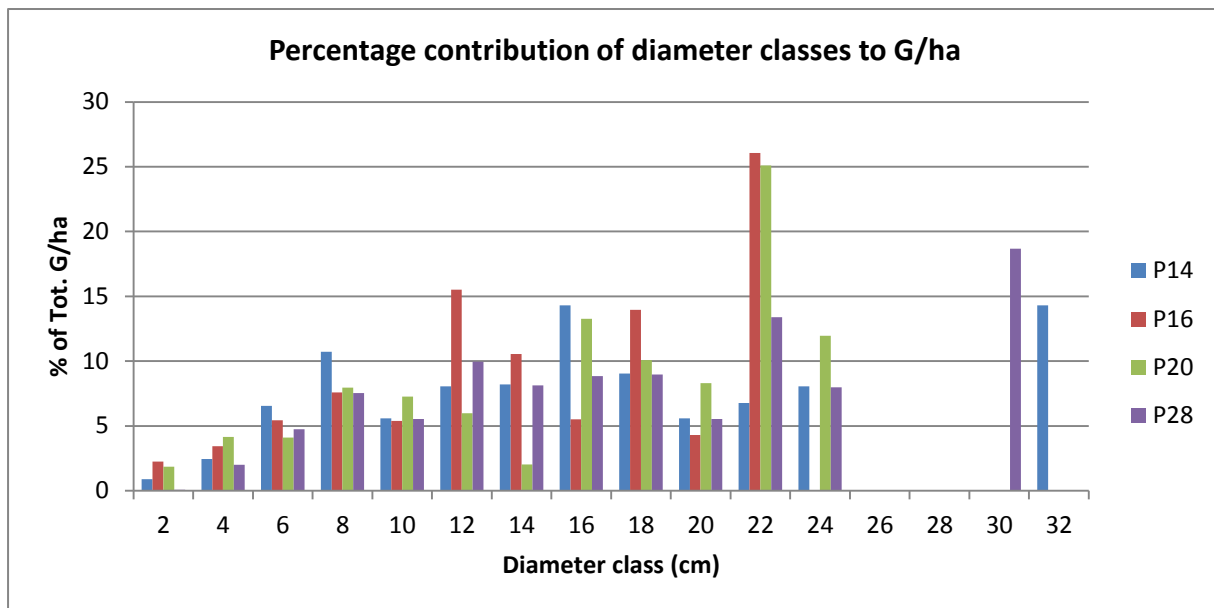


Figure 7 Percentage contribution of each diameter class in every sample area, to the total basal area/hectar



Taking a look at the occasional species appearing in the four stands and exposed in table 7, we can easily comprehend how sporadic their presence is. If this is partially coherent with the behavior of *Fagus sylvatica* as the dominant species, often suppressing every other species attempt to take larger part in the stand composition, it may also induce considerations about the scarce attention paid, in management objectives and actions, in favoring species different from beech. Few individuals, as we can see, are however

preserved from the coppicing operations, although traditionally the beech was considered more worthy of attention, and being so rare there is a reasonable probability (confirmed by the compartments description of the more recent Management Plan of 2002) that not all of the occasional species were detected within the 400 m² area.

As we can furthermore observe, the presence of shrubs over 1 cm diameter is limited to 7 stems of Hazel, all of the same stool, in area P20.

This topic will anyways be further developed in paragraphs. 4.4.1 and following, talking about actual arboreal composition.

In Annex 1 the complete dendrometric data are reported, together with the data about the percentage contribution of each diameter class to the total basal area per hectare, for each distinct sample area.

The tree heights (average, dominant including the standards/released stems and dominant only considering the shoots) were measured and calculated with the procedures described in chapter 3 and are shown in figures 8 and 9.

Table 8 Average (Av. H), Lorey (H_L) and dominant (H_{d100}) heights of the four stands. The third column indicates the average diameter, the fourth the number of model trees used to calculate the average.

	Age	Av.d (cm)	Av. H (m)	H _{d100} (m) with standards	H _{d100} (m) only shoots
P14	0	7,9	8,4	13,6	13,5
P16	6	6,4	7,1	16,5	14,5
P20	12	6,7	9,4	17,0	14,4
P28	20	10,1	9,8	18,9	16,4

The number of trees used to calculate the average height was dependent on the actual presence in the field of model trees (selected as explained in chapter 3) with a difference in diameter of maximum 0,5 cm from the average one.

Once more, the measures (table 8) relate to the species *Fagus sylvatica* and therefore the dominant height can be intended as the maximum height reached by the trees of these species in the sample area.

If, therefore, the height can be considered a measure of fertility, some considerations on the differences can arise, although we should not forget that some shoots included in the calculations may be of different age, for the reasons described in paragraph 1.3 as the ways of managing the analyzed beech coppices.

We can although observe how, in spite of the very close average diameter between P16 and P20, the average height of the older one is about 2 meters higher, while the difference

is reduced (+0,5 m) when looking at the dominant height, which tends to stabilize around 16,5-17 m. the average height of the 12 years old stand, P20, appears quite surprising, especially if compared with the mature sample, which proves only 0,4 m taller on average (9,4 m vs. 9,8 m height).

The fact that the average height of the youngest stand exceeds that of the following stage doesn't surprise, since it is connected to its assessment, based on the shoots and standards released from the recent cut (on which the average diameter is calculated), surely larger and taller, as already discussed in the previous chapter when analyzing diameter distributions.

The dominant heights follow, with age, a gradual increasing trend ($r=0,961$, $p<0,05$), growing up to about 19 meters in the mature stand. By consulting the Forest Management Plan of the area, we can state that this dominant height, if compared with the one of the mature compartments at the time of the publication of the Plan in 2002 (15,5 m), seems quite high. Of course, the mature stand was a different one at the time, different in topography, altitude (mediated among various 400 m² sample areas located within the mature compartment) and other site parameters, and even the age was a bit lower: 17 years old (still considered at the end of the cycle). There is, furthermore, the chance, that some of the tallest stems have been released with a standards-like function, in these situations hard to distinguish, since very rarely the standards present clear gametic origin and appear as single individuals, independent from any stump.

In the last column of table 8, however, an attempt to consider a more significant dominant height, the one used to calculate the volume expressed in table 6, was made by excluding from the count the height "outsiders" and avoiding an excessive overestimation of these parameters. This way, the mature sample (which is actually the one where it is easier to distinguish the "real standards", almost all of gametic origin, and obtain a more reliable data) much better approximates the height indicated by the management plan, still setting 1 meter higher anyways.

Figure 8 Average (Av. H), dominant including standards (Hd100 with standards) and dominant excluding standards (Hd100 only shoots) of the four sample areas in different chronological stages.

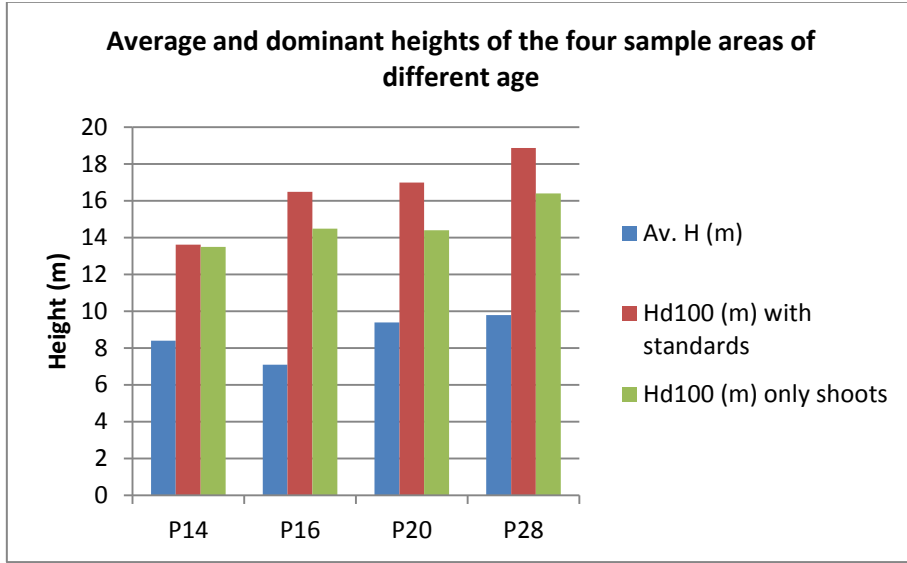
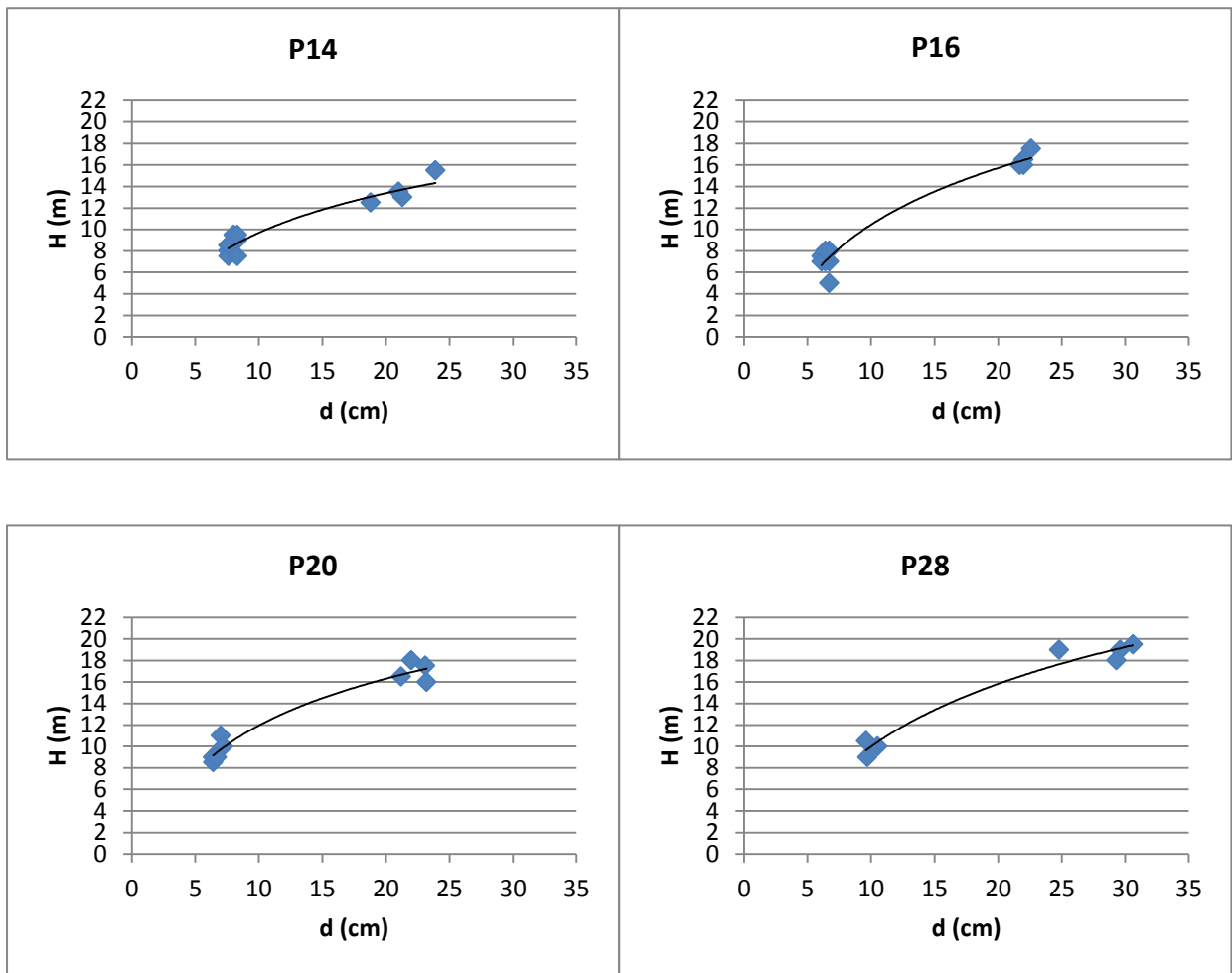


Figure 9 Distribution of the measured heights as a function of the diameter of the beech plants in the four sample areas



4.2 LANDOLT AND ELLENBERG ECOLOGICAL INDEXES

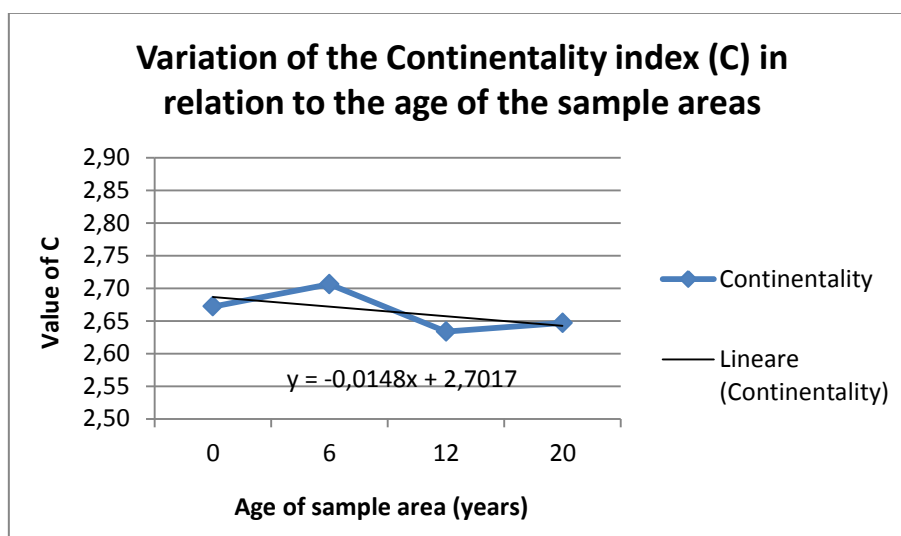
For the site characterization, Landolt and Ellenberg indexes have been applied.

In table 9 the values assessed with Landolt indexes for each sample areas are reported and in figure 11 they are visualized.

Table 9 Landolt average values for each site

	Humidity	Light	Temp.	Cont	pH	Nutrients	Humus	Granul.
P14	2,98	2,26	3,26	2,67	2,80	3,21	3,56	3,76
P16	2,81	2,23	3,17	2,71	2,71	2,93	3,55	3,69
P20	2,94	2,22	3,18	2,63	2,72	3,13	3,50	3,56
P28	2,71	2,03	3,50	2,65	2,56	2,76	3,38	3,68

Figure 10 Variation of the Landolt index of continentality index (C) in relation to the age of the sample areas. The dotted-line indicates the total correlation line, the solid line represents the value of the index in every sampled site.



There isn't a significant correlation ($r=-0,585$, $p<0,05$) between age of sample plot and continentality index, as it would instead be expected (table 9, figure 10). We can although observe that while age increases, the index tends to decrease, i.e. it is shifting to more oceanic climate type. It is well known, in fact, that the wood microclimate tends to mitigate the temperature leaps, particularly in the air layers closer to the soil (Pignatti, 1995). Furthermore, stems and branches of trees tend to slow down air movements. The fact that the relation is not so strong, could be connected to the described coppice harvest management, which releasing so many standards and shoots on the stool - maintained for more rotation cycles – creates a system which very much differs from the simple coppice: this way of acting enables to maintain a very similar canopy density among the different

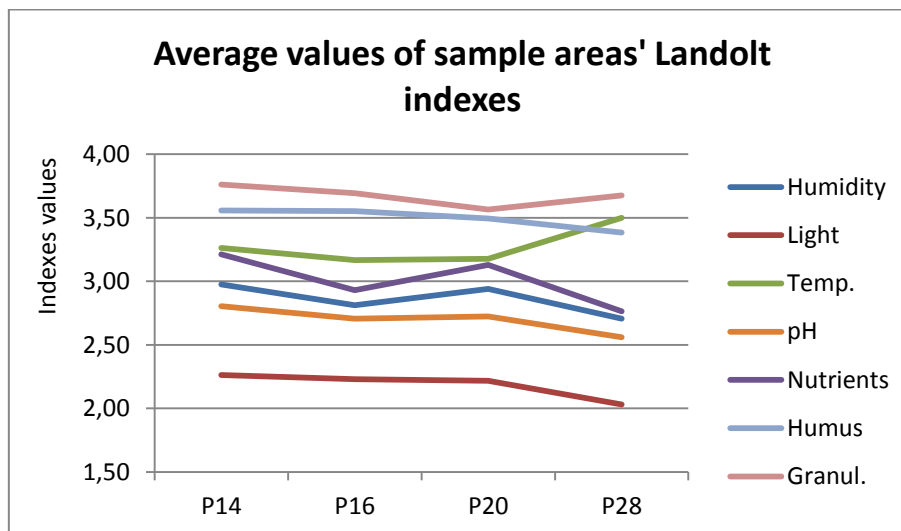
samples, since a strong attention is paid not to excessively uncover the soil, exposing it to atmospheric agents and light with the harvesting intervention.

As the one just exposed, all other Landolt indexes appear not very significantly correlated to the age of the stand, confirming what above described.

In spite of this, light ($r=-0,905$, $p<0,1$), pH ($r=-0,930$, $p<0,1$) and humus ($r=-0,947$, $p<0,1$) indexes appear to slightly relate to the temporal distance from the last coppicing operation, according to a negative trend.

For the other indicators we will here, nevertheless, try to explain the different trends and the reasons of non-significance, always keeping in mind the uncertainties coming from Landolt indexes attribution to the registered plants (since these values were originally elaborated in Switzerland and are not as detailed as e.g. Ellenberg's ones) and the high number of factors that could contribute to the trends, not always easy to schematize and detect as the distinctive ones.

Figure 11 Variation of Landolt Ecological Indexes values with sample areas age



Looking at the negative correlation between light and age of the stand, we can consider how the development of vegetation clearly opposes light penetration, and the sharpest decrease of the index appears in the passage between the 12 and the 20 years old sample stand, going down to almost 2 and therefore clearly indicating an asset of plants of shady environments.

The humus index, as well, appears slightly negatively correlated to the age of sample areas, apparently indicating the shift towards less mature soils, with lower humus content.

Nevertheless, when we look at the real Landolt values for humus (from the younger to the older stand: 3,56 – 3,55 – 3,50 – 3,38) we can easily realize how they all reside within the interval between soils with average humus content (Landolt index=3) and mature soils indicated by plants predominantly (not exclusively) living on them (Landolt index=4), and showing only a 0,2 units difference between the extremes. These differences are actually not significant.

Furthermore, the humus content of the younger stand less than one year before was hosting the mature 20 years old stand. That is to say, the newly coppiced area might still show the humus content of the mature formation, since degradation has not yet been completed.

We should moreover consider that the very low (especially if compared to the other compartments) number of species registered in the mature stand (13 species in P28 with respect to 57 in P16) can be responsible of a higher error in determining site characters and parameters of the sample area through floristic indicators. But, again, the differences are extremely slight and could easily depend on the peculiar characteristics of the different sites where the stands of different age have grown.

The change of pH with coppice age could appear more controversial, since it doesn't follow the trend of variation in humus content: we assist at a slight acidification within the first 6 years from the logging and a stabilization in the third stage, showing a floristic asset indicating soils with $4,5 < \text{pH} < 7,5$ (moderately acidified, as better indicated by the following Elelnberg's indexes results). A slightly more decisive decrease in soil reaction is evident, instead, in the last years of the rotation cycle. This goes along with the results of many Authors, who report an increase in soil acidity with coppice ageing (Ash et Barkham, 1976; Rubio et Escudero, 2003). All differences remain however within a very little interval of variation, which again show a quite good uniformity of the sites regarding these parameters.

A weak negative trend also links age and soil nutrients content and age and granulometric index. After the cut (6 years from it in our contest), in fact, nutrients seem to diminish in the soil - but are still high in the very recently cut sample area - due to their drainage by atmospheric agents (as also documented in Spanish Chestnut coppices by Rubio et Escudero, 2003). They appear to rebuild nutrients and Organic Matter (OM) only after the first 15-30 years, which in our case proves to be true a bit earlier if we look at the sharp increase in soil nutrients curve about 12 years after the cut. At the end of the rotation

cycle, instead, the nutrients appear to diminish and set to values even lower than the 6 years old situation.

One reason for the lower nutrients content of the mature stand could be the decrease in radiation, which normally accelerates litter decomposition (Rubio et Escudero, 2003) and which is stronger in the newly cut parcel, and the registered erosion phenomena, more marked in compartment P16 (6 years from last intervention) and P28 (20 years from last intervention). Furthermore, it is a matter of fact that the oldest sample area shows a higher drainage, indicated also by the presence of the species *Hepatica nobilis*.

On the other hand, such a management as the one here operated, where stools are hardly ever left completely bare and crown cover reaches full density very soon, nutrients loss due to waterwaste is for sure less significant.

One other reason of this nutrients index (mostly built up on the N soil content) trend can be the presence of nitrophile species, definitely higher in the stand that has just been cut. This can also be ascribed to the recent disturbance, the entrance of seeds of more ruderal species, also from the close forest road, and the moderate touristic pressure insisting on the area due to the close mountain hut "Malga Garda" (as compared to the scarce pressure on all other samples and confirmed by the floristic relevés – see chapter 4). Of course, the presence of wild animals (particularly ungulates, found to be very often frequenting the area) is also crucial for the fertilization of the terrain.

The two curves correlating age-nutrients and age-humidity are quite similar: they run almost parallel throughout the years and are, in fact, statistically significantly correlated (with a quite important $p < 0,01$ and $r = 0,998$), as if an increase in soil humidity would imply a higher nutrient retention.

This could suggest that humidity increase favors litter decomposition. The higher humidity index of the newly cut area could, once more, still represent the conditions of the mature stand, since coppicing has only happened last autumnal season there. On the other hand, though, in spite of the already reached complete crown cover, humidity diminishes in the mature stand (P28).

But looking at the quite opposite progress of the two lines representing humidity and granulometry in fig.11 it seems as a more coarse granulometry brings to a lower humidity (and nutrients) content, which can be reasonable if we think that a higher content in rubble and gravel is normally able to drain and wash nutrients away more easily.

The differences on which we have built our discussion, however, are very small, and all the stands show a floristic composition where species typical of fresh soils prevail.

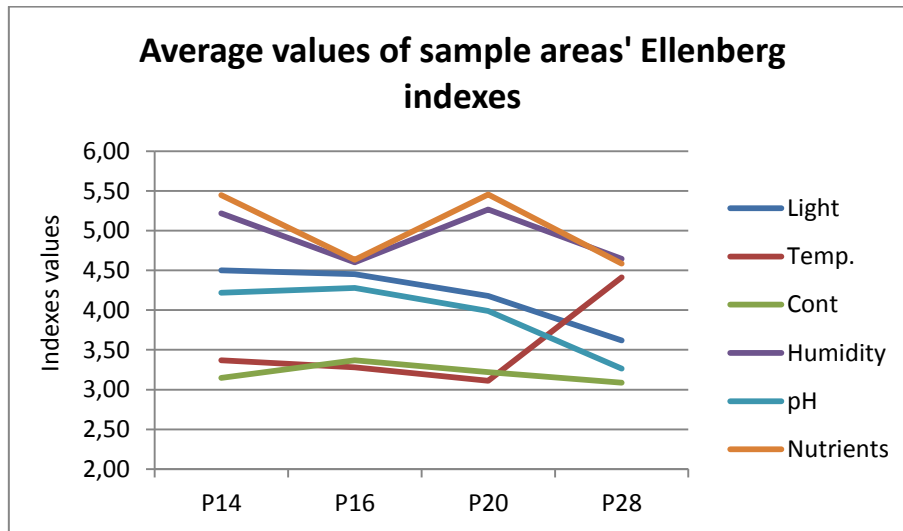
If we look at the soil temperature trend over the years, we could again be surprised of the sharp increase in temperature revealed in the older parcel. But this is most probably connected with the lower altitude of the sample (850 m, about 250 m below the highest one), and the more thermophile conditions, although mitigated by a more gentle slope which allows longer snow accumulation time. If we exclude this last sample area, the trend is slightly decreasing, more significantly between the first and the second stage. This doesn't surprise, since the light index is decreasing throughout the stages in reason of a higher light interception of the increased canopy. But the values remain again within the same short interval (between 3,1 and 3,5 Landolt index value), although some results in literature show a stronger soil temperature increase, up to 10°C higher than in coppices with full crown cover, and a sharper fall after two-three years from the cut (Ash and Barkham, 1976). This shows, once again, a probable floristic asset of the newly cut area still very close to that of a mature stand, the conditions of which were just left with the recent logging. Furthermore, the northern aspect of our sample stands don't allow such an increase in temperature, that occurs only if there is a good exposure to the sun (Ash and Barkham, 1976). On the whole, the index of thermic preferences, close to 3, indicates species of the pre-alpine zone.

In the following table 10 and figure 12 Ellenberg indexes are also reported, and the discussion over the differences with the results obtained with Landolt indexes will follow.

Table 10 Landolt average values for each site

	Light	Temp.	Cont	Humidity	pH	Nutrients
P14	4,50	3,37	3,15	5,22	4,22	5,45
P16	4,45	3,28	3,37	4,60	4,28	4,64
P20	4,18	3,11	3,22	5,27	3,99	5,46
P28	3,62	4,41	3,09	4,65	3,26	4,59

Figure 12 Variation of Ellenberg Ecological Indexes values with sample areas age



The average values calculated with Ellenberg indexes appear more sensitive to variations than Landolt's ones, in consideration of their greater extent as well (ranging, in the extreme case of humidity, from 0 to 12).

In any case the differences prove significantly correlated with the age of the stand only for light ($r=-0,953$, $p<0,05$) and pH ($r=-0,905$, $p<0,1$), confirming the results obtained with Landolt indexes for these two parameters with the increase in significance of the light-age correlation.

The site homogeneity of the sample areas in respect to the different ecological parameters is therefore confirmed, implicitly pointing out a similar floristic composition among the different chronological stages of the coppice, since the ecological indexes are derived from the vegetation.

4.3 BIOLOGICAL AND CHOROLOGICAL SPECTRUM, COMPOSITION IN BOTANICAL FAMILIES

4.3.1. Biological spectrum

The variations in the biological (table 11) and chorological spectrum in the different sample areas are considered important to provide an overview on the evolution of the stand, on the variation of vegetation competition and in some ways could allow to predict the eventual existence of valuable species.

It is in fact clear, for example, that more Geophyte than Therophyte species are commonly included in the category of species of floristic interest.

The chorological spectrum, instead, gives indications on the area of origin of the considered species, therefore allowing the recognition of endemisms or particular vegetations.

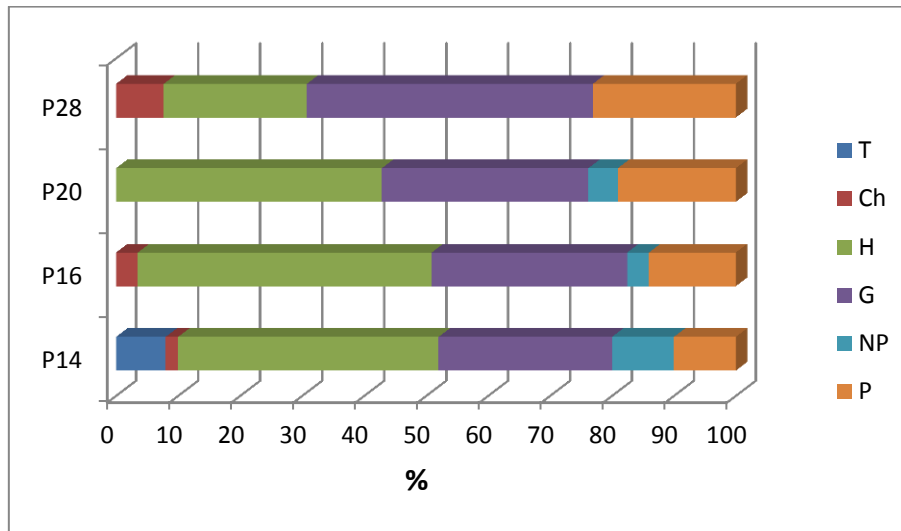
The complete list of vegetal species registered is reported in Annex 2.

Table 11 Biological spectrum of the different sample areas. The numbers refer to the percentage of every life-form on the total of the registered species in every area. (T=therophytes, Ch= chamaephytes, H= hemicryptophytes, G= geophytes, NP= nanophanerophytes, P= phanerophytes).

Life form	P14	P16	P20	P28
T	8,00	0,00	0,00	0,00
Ch	2,00	3,51	0,00	7,69
H	42,00	47,37	42,86	23,08
G	28,00	31,58	33,33	46,15
NP	10,00	3,51	4,76	0,00
P	10,00	14,04	19,05	23,08

Particularly important can be the percentage variation of every biological category among the sample areas (figure 13).

Figure 13 Biological life forms in the different sample areas



As we can observe, the number of life-forms seems to decrease with the age of the plot, which is reasonably associable to the new ecological niches created in a newly cut area and, on the opposite, a more uniform ecological situation in the mature stand.

The Terophytes (T) have their maximum development right after the cut (P14 = 8%), and drastically diminish (or even disappear in our case) in the following years (they are absent after 6 years), probably also in connection with the subsequent increase in basal area of the stand. Terophyte plants are in fact mostly annual, heliophilous plants, which don't stand soil compaction and complete crown cover.

The same results are reached also by Ash and Barkham (1976) in English oak and European hornbeam mixed coppices, by Rubio *et al.* (1999) in acidophilous Chestnut forests, by Debussche *et al.* (2001) in abandoned Downy oak forests, by Bhujju and Ohsawa (2001) in Japanese plantations and by Riondato *et al.* (2005).

The Hemicryptophytes, by far the dominant category (with the exception of the oldest SA), in spite of the negative trend from the most recently coppiced areas to the older ones, reach the highest value (48%) in the 6 years old sample. As we could expect, we assist in the end at a sharp decrease in the mature area, where small clearings (in our 400 m² sample area) are not so represented to allow a more significant entrance of Hemicryptophytes, favored instead by coppicing also according to Barkham (1992) in Wulf (2003).

This negative trend is also pointed out by other Authors as normal (Debussche *et al.*, 2001). The significant correlation of this category with slope, instead ($r= 0,914$, $p<0,1$), it is probably more casual, if we consider the fact that the steepest parcel (P14) is also the highest in altitude (where normally Hemicryptophytes as perennial species are more

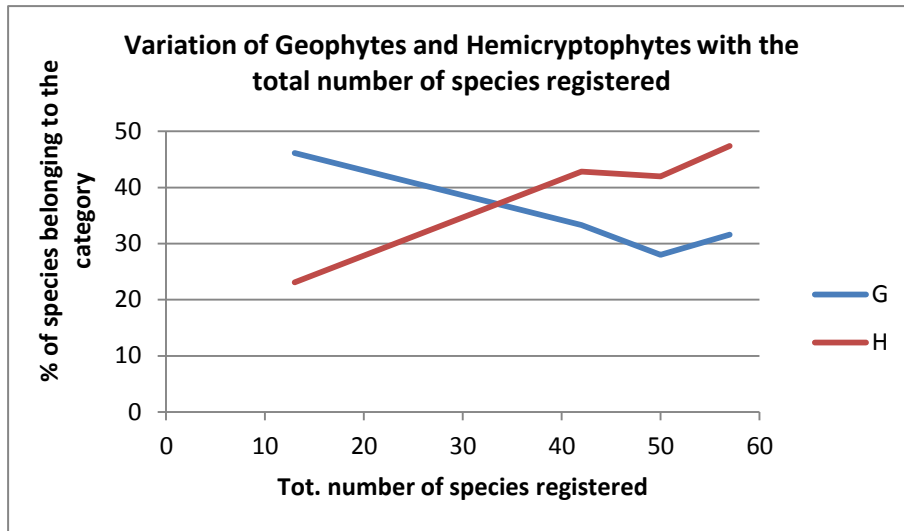
competitive) and that the one with the more gentle slope (P28) is also the one with the fewest number of species.

The biological group of the Chamaephytes is not particularly present in these formations, being only represented by the species *Euphorbia amygdaloides* in P14 and P16, *Vaccinium myrtillus* in P16 and *Vinca minor* in P28. The fact that the percentage of participation of this category to the biological composition seems higher in the oldest parcel must be ascribed to the low species number registered in the same, which increases the contribution of even one species to the overall picture.

On the other hand, if we consider only the presence of *Euphorbia amygdaloides* (since the other two Chamaephytes – *Vaccinium* and *Vinca* – are respectively connected with a localized acidification of the soil and an influence of *Carpinion* due to the lower altitude of the stand) the trend seems clear: the species, as confirmed by other studies conducted by Mason and MacDonald (2002), colonizes recently coppiced areas and decreases its presence after five-six years from coppicing up to its disappearance in older stands (10-12 years from the cut in the English Chestnut coppices studied by Mason and MacDonald).

The Geophytes trend reveal a significant positive correlation with age of the plot ($r=0,932$, $p<0,1$), showing their maximum (and constituting half of the floristic population) in the mature stand, where in fact the basal area and the biomass value per hectare is the highest and confirming the preference of this biological category for elevated forest cover values (significant to $p<0,01$ positive correlations with respectively $r=0,993$ for volume and $r=0,991$ for basal area). As a matter of fact, the number of species assessed in each area, which drastically reduces with the gradual achievement of full crown coverage by the growing stand, is also significantly negatively correlated with the percentage contribution of the Geophytes ($r=-0,950$, $p<0,05$). Exactly the opposite significant trend ($r=0,976$, $p<0,05$) is instead shown by the Hemicryptophyte species, which appear strongly positively dependent on the number of species (figure 14).

Figure 14 Relation between the number of registered species and the percentage contribution of the Geophyte and Hemicryptophyte categories in every sample area.



The Nanophanerophytes are as expected higher in the newly coppiced area, which is reasonable if we think of the species representing this biological group (the gender *Rubus* and *Rosa* especially). Their presence is, nevertheless, not so important, since as other times recalled, the attention paid in the management form not to uncover the soil too much provides the conditions for a quick crown density recover.

The Phanerophytes are here relatively low in number of representing species, which is mostly due to the decisive monospecific trait of these formations, where the dominance of the beech is undisputed.

The increasing contribution trend of of this category throughout the ages is however clear ($r=0,995$, $p<0,01$), where in the mature stand the Phanerophytes occupy 23% of the biological spectrum, although in terms of absolute number of tree species (being this percentage relative to the overall number of registered species within the area, that is 13) this only means the participation of beech, hazel and manna ash (*Fraxinus ornus*).

The relations between the site characters and the percentage of every life-form category are reported in table 12.

Table 12 Coefficients of linear correlation and relative significance calculated by comparing the percentage of plant life forms to age, site characters, dendrometric data and total number of species of every sample area. The adopted significance levels are: $p < 0,1$ (+); $p < 0,05$ (*); $p < 0,01$ (**).

G/ha=basal area of arboreal species per hectare; stools/ha=number of stools of arboreal species per hectare; S%= slope of the area in percentage; N°sp.=total number of registered species.

Plant life forms: T=terophytes; Ch=chamaephytes; H=hemicryptophytes; G=geophytes; NP=nanophanerophytes; P=phanerophytes.

	Age	G/ha	stools/ha	Slope%	N°sp.
T	n.s.	n.s.	n.s.	n.s.	n.s.
Ch	n.s.	n.s.	n.s.	n.s.	n.s.
H	n.s.	n.s.	n.s.	0,914+	0,976*
G	0,932+	0,991**	n.s.	n.s.	-0,950*
NP	n.s.	n.s.	n.s.	n.s.	n.s.
P	n.s.	n.s.	n.s.	n.s.	n.s.

The Hemicryptophyte species include for the most part heliophilous species, as it is demonstrated by their positive link to the Landolt value for light ($r=0,946$, $p < 0,1$), while the geophytes confirm their sciophilous character ($r=-0,994$, $p < 0,01$).

In table 13 the averages obtained for our sample – calculated by averaging the percentage contribution of each category in each sample area - are compared with the values reported by Pignatti (1998) for the association *Cardamini pentaphyllae-Fagetum*.

Table 13 Biological spectra of the phytosociological reference association *Cardamini pentaphyllae-Fagetum*. Comparison with literature data (Pignatti, 1998).

Life form	Average SA - Mel	Average Pignatti, 1998
T	2,00	1,9
Ch	3,30	9,4
H	38,83	30,3
G	34,77	27,4
NP	4,57	6,3
P	16,54	25,1

We can observe how, while the Terophyte species are very similar to Pignatti's relevés results, the number of Chamaephytes and Nanophanerophytes appear slightly below the average, compensated by the more consistent increase in Hemicryptophytes and Geophytes. These results are compatible with the fact that the relevés considered in Pignatti's work were conducted mostly in mature stands, although on the other hand the number of Geophytes the Author registers is still lower than the one resulting from relevés in Mel municipality beech coppices. The lower share of Phanerophytes in our sample areas, finally, can also be linked to the ecosystem simplification induced by coppice

management, where human interventions have a substantial impact in selecting the arboreal species composition, although it can sometimes become, on the opposite, also a relevant factor for the creation of more differentiated site conditions. Furthermore, the northern exposure of these woods can be a limitation to the establishment of different species that prefer to vegetate in more thermophile conditions, explored and included in the average reported by Pignatti's work.

4.3.2 Chorological spectrum

The analysis of the chorological spectrum can be useful, in our research, to define the vegetational quality of the stands.

In example, for the area in question the illiric, pontic and SE European (oriental) element can be considered valuable for phytogeographic reasons: the eastern influence is here close to the limit of its presence (that arrives not further than the Lake Garda in the west direction).

The presence of the different chorotypes, in percentage, for the different Sample Areas is reported in table 14 and showed in figure 15.

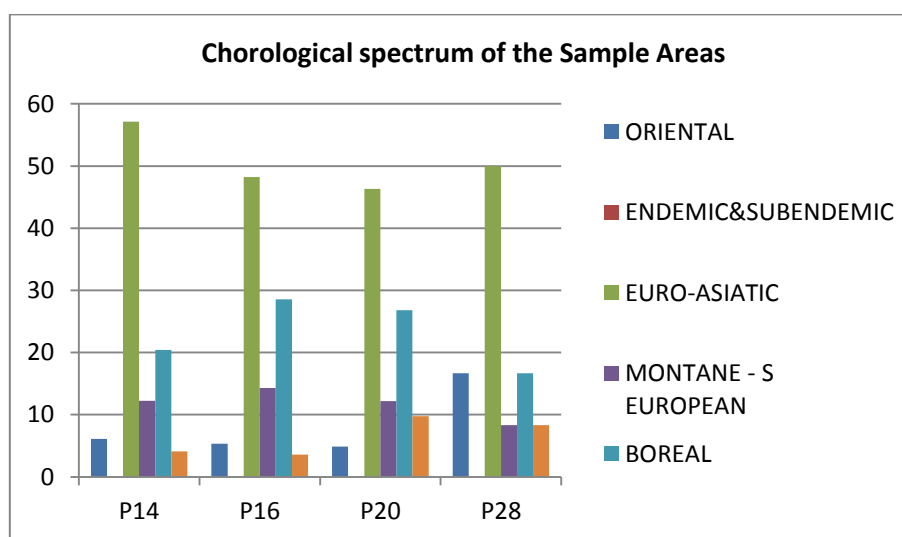
Some of the chorotypes present in the Veneto Region in its whole, but absent in the area, were not considered in the above exposed table, such as the tropical (pan-t., paleo-t....) and the Mediterranean species (steno-m., euro-m. ...).

The Atlantic species were also neglected, in reason of their absence due to the different migratory currents which interested the area, rather hosting some eastern species than Atlantic types, although the climate is relatively rainy and sub-oceanic. The choice was therefore to valorize the SE European, pontic and illyric species, by grouping them under the same "oriental" category.

Table 14 Chorotypes in each sample areas and total: percentage share

CHOROTYPE		P14%	P16%	P20%	P28%	AVERAGE
Oriental	Illiric	2,04	1,79	0,00	8,33	3,04
	SE European	2,04	1,79	2,44	0,00	1,57
	Pontic	2,04	1,79	2,44	8,33	3,65
	TOT. ORIENTAL	6,12	5,36	4,88	16,67	8,26
Endemic and subendemic		0,00	0,00	0,00	0,00	0,00
Euro-asiatic	Paleotemperate	8,16	5,36	4,88	0,00	4,60
	Eurasatic s.str.	26,53	14,29	17,07	25,00	20,72
	S European-S Siberian	0,00	1,79	0,00	0,00	0,45
	European - Caucasian	12,24	10,71	12,20	16,67	12,96
	European	4,08	3,57	2,44	0,00	2,52
	Central - European	6,12	12,50	9,76	8,33	9,18
	TOT. EURO-ASIATIC	57,14	48,21	46,34	50,00	50,42
Montane-S European	Montane - S European s.str.	10,20	14,29	12,20	8,33	11,25
	Endemic - alpine	0,00	0,00	0,00	0,00	0,00
	Montane - Central European	2,04	0,00	0,00	0,00	0,51
	TOT. MONTANE-S EUROPEAN	12,24	14,29	12,20	8,33	11,76
Boreal	Circumboreal	12,24	19,64	19,51	16,67	17,02
	Eurosiberian	8,16	8,93	7,32	0,00	6,10
	Artic-alpine	0,00	0,00	0,00	0,00	0,00
	TOT. BOREAL	20,41	28,57	26,83	16,67	23,12
	Subcosmopolite	4,08	3,57	7,32	8,33	5,83
	Cosmopolite	0,00	0,00	2,44	0,00	0,61
	Adventitious	0,00	0,00	0,00	0,00	0,00
	TOT. MULTIZONAL	4,08	3,57	9,76	8,33	6,44

Figure 15 Chorological types in the four sample areas: percentage share



From these elaborations we can deduce that the Euroasiatic type is here the undisputed dominant one, in accordance with what reported for the Veneto Region (Pignatti, 1994), which reports an average value of 30.8% contribution of these plants to the overall spectrum, here much higher (>50%) in reason of the specific character of the sites and the beech formation, free of the Mediterranean (Steno- and Euri-m.) element and here also of the Atlantic and Endemic one (which in the regional average altogether make up 22,7% of the species), completely substituted by the Euroasiatic species.

Similarly to what has been done for the biological life forms, we can try to relate the chorotypes with some site and stand characters (table 15).

Other site characters were not considered in the statistical analysis, since they were derived from vegetational analysis - through Landolt and Ellenberg ecological indicators - (such as pH) or they were very similar, if not equal, in all sample areas (as for example soil depth, on purpose chosen to be uniform among the areas).

The obtained correlations appear hard to retain valuable for a generalization of the results, but we can however make the following considerations.

The Palearctic species, including normally more thermophile species, decrease with the age of the parcel ($r=-0,967$, $p<0,05$) and the resulting strong correlation with the basal area seems to confirm the dependence on coverage ($r=-0,997$, $p<0,01$).

The European element, instead, has the opposite trend in our samples, which could appear quite unusual, although this loses significance when we look at the Euroasiatic species on the whole, surely including a wider number of species and therefore a smaller error and possibility of randomness.

The Oriental species taken as a complex (more significant than to consider the few species included in the single sub-categories) show a negative trend if linked with slope and the number of species. The first can be due to the particular negative connection between the slope of the areas and their altitude, so that the apparent preference of the oriental species for the more gentle slopes can be explained by the fact that these stands are also the lowest in altitude, normally slightly favored by this eastern chorotype. Other correlations of these eastern types seem quite unimportant, if we consider that their entrance in these formations is mostly a phytogeographical fact.

The slope-altitude connection is also evident in the positive correlation between Boreal species and slope: the slope can be also in this case easily substituted by the altitude effect, which underlines the micro-thermal character of this chorological type.

Table 15 Coefficients of linear correlation and relative significance calculated by comparing the percentage of chorotypes to age, site characters, dendrometric data and total number of species of every sample area. The adopted significance levels are: $p < 0,1$ (+); $p < 0,05$ (*); $p < 0,01$ (**).

G/ha=basal area of arboreal species per hectare; stools/ha=number of stools of arboreal species per hectare; S%= slope of the area in percentage; N°sp.=total number of registered species.

	Age	G/ha	stools/ha	Slope%	N°sp.
Illiric	n.s.	n.s.	n.s.	-0,910+	n.s.
SE European	n.s.	n.s.	n.s.	n.s.	n.s.
Pontic	n.s.	0,939+	n.s.	n.s.	-0,972*
TOT. ORIENTAL	n.s.	n.s.	n.s.	-0,901+	-0,932+
Paleotemperate	-0,967*	-0,997**	n.s.	n.s.	n.s.
Eurasian s.str.	n.s.	n.s.	n.s.	n.s.	n.s.
S European - S Siberian	n.s.	n.s.	n.s.	n.s.	n.s.
European - Caucasian	n.s.	n.s.	n.s.	-0,902+	-0,984*
European	-0,970*	-0,976*	n.s.	n.s.	0,962*
Central - European	n.s.	n.s.	n.s.	n.s.	n.s.
TOT. EURO-ASIATIC	n.s.	n.s.	n.s.	n.s.	n.s.
Montane - S European s.str.	n.s.	n.s.	n.s.	0,938+	n.s.
Montane - Central European	n.s.	n.s.	n.s.	n.s.	n.s.
TOT. MONTANE - S EUROPEAN	n.s.	n.s.	n.s.	n.s.	0,979*
Circumboreal	n.s.	n.s.	n.s.	n.s.	n.s.
Eurosiberian	n.s.	-0,932+	n.s.	n.s.	0,987*
TOT. BOREAL	n.s.	n.s.	n.s.	0,982*	n.s.
Subcosmopolite	0,903+	n.s.	n.s.	n.s.	n.s.
Cosmopolite	n.s.	n.s.	n.s.	n.s.	n.s.
TOT. MULTIZONAL	n.s.	n.s.	-0,962*	n.s.	n.s.

In general, however, we can declare that the differences among the sample areas in the chorological spectrum are very little, even when they relate significantly to age and other characters: these correlations shouldn't be taken as considerably differential for the parcels, which once again prove their substantial homogeneity.

In table 16 below, the chorological spectrum reported by Pignatti (1998) for the association *Cardamini pentaphyllae-Fagetum* is exposed and compared to the average data of the sample areas (SA) in the municipality of Mel, re-calculated according to Pignatti's chorological classification. These data result from the average of the relative percentage of each category in the four sample areas.

Table 16 Chorological spectra of the phytosociological reference association *Cardamini pentaphyllae-Fagetum*. Comparison with literature data (Pignatti, 1998).

Chorotype	Average SA-Mel	Average Pignatti (1998)
Endemic	0,00	0,80
Stenomediterranean	0,00	0,70
Euri-mediterranean	0,00	3,70
Mediterranean-montane	8,36	3,70
Eurasianic	52,95	55,10
Atlantic	0,00	0,00
Montane-S European	9,14	11,60
Boreal	23,12	22,70
Multizonal	6,44	1,60

We can observe how the averages obtained in the Mel municipality samples are very similar to those proposed by Pignatti, especially regarding the Eurasianic, Montane – South European and Boreal contingents (which are also the dominant ones).

The Atlantic element is absent in both description. In our examined areas' floristic composition the only species which could be considered subatlantic (here included in the Central-European category) is *Festuca altissima*.

The Steno- and Euri-mediterranean contingent is in our samples absent, in favor instead of the Mediterranean-montane one. This, however, doesn't surprise, considering the northern aspect of all samples and their micro-thermal conditions.

Finally, the quite important presence of multizonal species is to be considered as a negative sign of disturbance, since it includes predominantly synanthropic species, passed from the primary biotopes to the secondary ones, when not already exclusive of these latter ones (Poldini and Vidali, 1989). This is furthermore confirmed by the absence of endemic species, although even in Pignatti's work they maintain a very low share in the overall composition.

4.3.3 Composition in botanical families

The analysis of the composition in botanical families can result useful to obtain a first, very raw, assessment of α -diversity and on the other hand it can help the comprehension of the relations of certain valuable families (es: *Orchidaceae*) towards the site characters and the age of the coppiced areas.

The presence of a certain botanical family is here expressed in percentage on the total registered species (table 17). Only the most frequent families or those of major importance are considered, while the others are generically grouped under the definition “other families”.

The four ferns families (*Aspidiaceae*, *Aspleniaceae*, *Polypodiaceae* and *Thelypteridaceae*) were, instead, grouped under the more comprehensive category of the “*Pteridophytes*”.

For the complete list of the registered botanical entities the reference is Annex 2.

Table 17 Botanical families: percentage division in every sample area and average values

	P14	P16	P20	P28	Average
Apiaceae	2,00	1,75	0,00	0,00	0,94
Asteraceae	10,00	8,77	9,52	0,00	7,07
Boraginaceae	4,00	3,51	4,76	0,00	3,07
Brassicaceae	4,00	1,75	2,38	0,00	2,03
Euphorbiaceae	2,00	5,26	0,00	0,00	1,82
Fabaceae	2,00	3,51	0,00	7,69	3,30
Guttiferae	2,00	3,51	0,00	0,00	1,38
Lamiaceae	6,00	3,51	4,76	0,00	3,57
Liliaceae	4,00	3,51	2,38	7,69	4,40
Orchidaceae	0,00	3,51	2,38	0,00	1,47
Poaceae	4,00	5,26	2,38	7,69	4,83
Ranunculaceae	4,00	5,26	4,76	7,69	5,43
Rosaceae	14,00	7,02	7,14	0,00	7,04
Scrophulariaceae	4,00	3,51	4,76	0,00	3,07
Pterydophites	8,00	10,53	14,29	7,69	10,13
Other fam.	30,00	29,82	40,48	61,54	40,46
Families N°	29	34	30	13	26,25

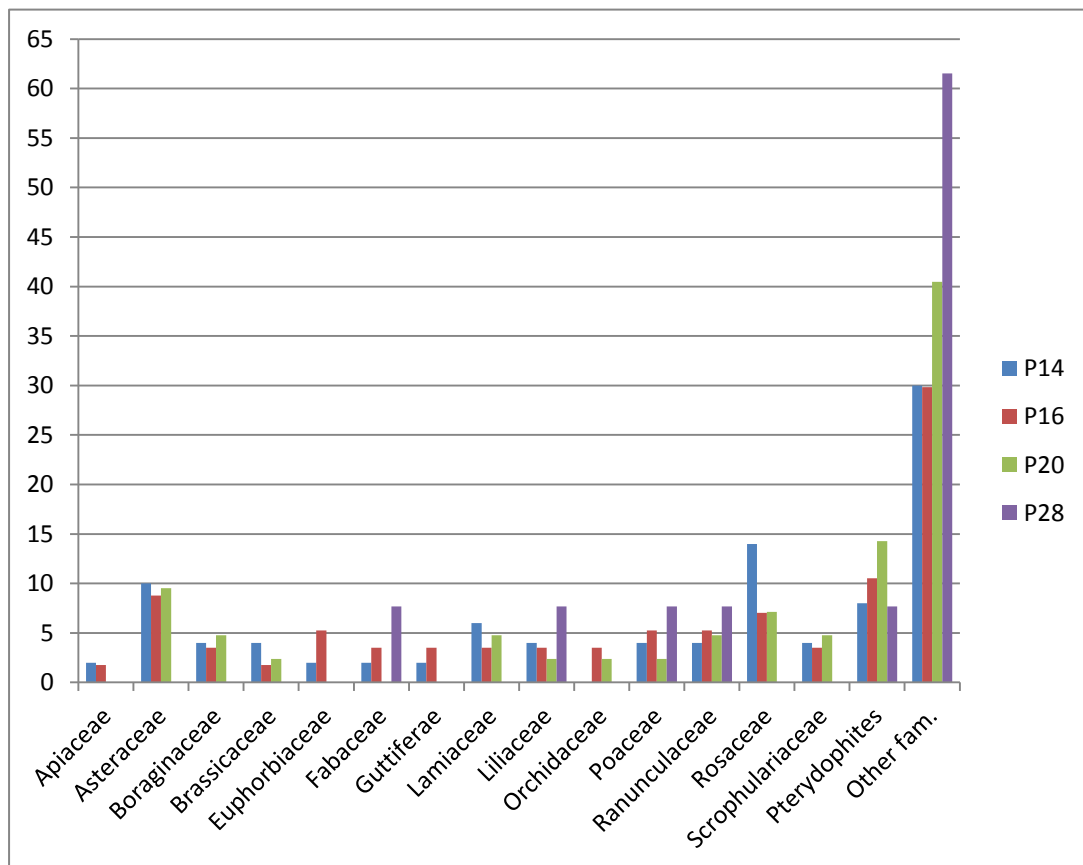
The number of families appears quite elevated, if compared with the number of species present in every sample area, obtaining an average Families/Species factor of 0,72, which also means that the number of species for every family is quite uniform, reaching a maximum of 7 in a single sample area (*Rosaceae* family in P14). This is also represented by the fact that, even choosing to separate 14 families, plus the *Pterydophytes* group, the

average percentage of plants falling into “other families” is still very high (at least 29,8% in the sample with the lowest proportion).

The variation in the number of families could also be considered quite uniform (ranging from 29 to 34) if we exclude the oldest, very peculiar plot, which absolutely presents the fewest families, due to the lower number of species registered, and which confers a great variability to the overall average.

The sharp decrease in families number (13 in P28), therefore, observed toward the last chronological stage appears exaggerated and is probably partly due to the chosen sample area, which shows a very poor species composition, as already verified. The following graph can help analyzing the different percentages in the four sites (figure 16)

Figure 16 Percentage contribution of each family, in number of species, to the total number of registered species in every sample area.



What is evident from the graph even at a first glance is the extraordinary high share of the group “other families” in every sample area, as already discussed.

Furthermore, we can highlight the importance of the *Asteraceae* family, here including various species which are good indexes of disturbance (*Lapsana communis* and *Taraxacum officinale* in primis).

The *Pterydophytes* group are also a quite important presence (especially in P20), as indicators of fresh environments.

Only three families show statistically significant correlations with the age of coppice and they are the *Apiaceae* and *Brassicaceae* with the same slight negative trend ($r=-0,901$, $p<0,1$), and the *Rosaceae* ($r=-0,954$, $p<0,05$) families, which appear to diminish with age.

Indirectly negatively influenced by the increased temporal distance from the coppicing intervention, but through the increase in basal area of the stand, are again the *Rosaceae* ($r=-0,968$, $p<0,05$) and *Brassicaceae* ($r=-0,953$, $p<0,05$) families, with the addition of the *Lamiaceae* ($-0,970$, $p<0,05$) and *Asteraceae* ($r=-0,956$, $p<0,05$) families. This latter family is also positively correlated with the number of species ($r=0,924$, $p<0,1$), probably showing that an area of more recent disturbance, which permits the intrusion of opportunistic species of anthropic origin and therefore often hosts a higher number of species, can be more favorable to them. The increase in total basal area has instead the opposite positive effect on the *Ranunculaceae*, which show an increasing trend ($r=0,983$, $p<0,05$).

Among the families favored by an increase in light index are again, coherently, the *Asteraceae* ($r=0,990$, $p<0,05$), *Lamiaceae* ($r=0,953$, $p<0,05$) and *Rosaceae* ($r=0,905$, $p<0,1$), but also the *Boraginaceae* and *Scrophulariaceae* ($r=0,937$, $p<0,1$); while a family including species with a more sciaphilous tendency is again the one of the *Ranunculaceae* ($r=-0,975$, $p<0,05$).

The *Euphorbiaceae* and *Guttiferae* families seems to stand very well the continental microclimate that is created after the cutting operations (respectively $r=0,980$ and $r=0,981$, $p<0,05$).

The *Rosaceae*, *Brassicaceae* and *Lamiaceae* appear also positively correlated to the nutrients content of the soil, as if they would be favoured by a richer environment, while the opposite proves true for the *Ranunculaceae* family more competitive in poorer soils.

Could be interesting here to observe that, as in the results of the following paragraphs, there is never a correlation with the number of stools in the area. This could once more suggest a consideration on the particular and somehow confused design of these coppices structure, where the number of shoots and poles per stool can be extremely variable, as the diameters dimensions (and consequently crown extent) of the same, making the pure number of stools an unimportant parameter in determining site conditions and floristic characters. This is, however, common in all coppices, where the number of stools remains more or less constant over the rotation, while coverage only changes as a function of shoots number and dimensions.

The relations so far exposed are summarized in table 18 below.

Table 18 Coefficients of linear correlation and relative significance calculated by comparing the percentage contribution of the botanical families to age, site characters (Landolt indexes), dendrometric data and total number of species of every sample area. The adopted significance levels are: $p < 0,1$ (+); $p < 0,05$ (*); $p < 0,01$ (**).
G/ha=basal area of arboreal species per hectare; stools/ha=number of stools of arboreal species per hectare; S%= slope of the area in percentage; N°sp.=total number of registered species.

	Age	G/ha	n. stools/ha	S%	N°sp	Light-L	Nutrients-L	Contin-L
Apiaceae	-0,901+	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Asteraceae	n.s.	-0,956*	n.s.	n.s.	0,924+	0,990*	n.s.	n.s.
Boraginaceae	n.s.	n.s.	n.s.	n.s.	n.s.	0,937+	n.s.	n.s.
Brassicaceae	-0,901+	-0,953*	n.s.	n.s.	n.s.	n.s.	0,962*	n.s.
Euphorbiaceae	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0,980*
Fabaceae	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Guttiferae	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0,981*
Lamiaceae	n.s.	-0,970*	n.s.	n.s.	n.s.	0,953*	0,969*	n.s.
Liliaceae	n.s.	n.s.	n.s.	-0,933+	n.s.	n.s.	n.s.	n.s.
Orchidaceae	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Poaceae	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Ranunculaceae	n.s.	0,983*	n.s.	n.s.	n.s.	-0,975*	-0,945+	n.s.
Rosaceae	-0,954*	-0,968*	n.s.	n.s.	n.s.	0,905+	0,913+	n.s.
Scrophulariaceae	n.s.	n.s.	n.s.	n.s.	n.s.	0,937+	n.s.	n.s.
Pteridophytes	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

4.3.4 Phytosociological spectrum

The definition of characteristic species has been implemented through the consultation of the following publications, of which major importance was given to the tables prepared for more specific areas, considered closer to the one here described in terms of geographic position and forest type :

- Mucina *et al.*, 2003;
- Willner and Grabherr, 2007;
- Willner *et al.*, 2004;
- Oberdorfer, 1979;
- Poldini and Nardini, 2004.

The analysis of syntaxa was carried out only considering the taxonomic categories “class” and “order”, but a more complete look (to the level of Alliances and site conditions indicators) was given in the description and discussion of the results.

In table 19 the list of the registered *taxa* in every sample area and the relative importance on the total of the characteristic species recorded is exposed.

The terms “characteristic” attached to “class” and “orders” indicates the fact that there are other species, included in the “Others” category, which are not differential of a particular order or class., and which will anyways not be taken into account in the percentage calculations. Some species, furthermore, may be characteristic only of a class and not of a particular order, and this explains the difference between the sum of the percentage contributions of the species characteristics of the different orders of a class, and the percentage contribution of the class in its whole (normally higher).

Table 19 Phytosociological categories. In the first five lines are reported: the number of total species registered in every 400 m² sample area, the number of characteristic species, the number of phytosociological classes and orders to which these species belong. For every *syntaxon* the percentage relevance on the total characteristic species registered is indicated.

	P14	P16	P20	P28
AGE	0	6	12	20
Tot. Sp. n°	50	57	42	13
Characteristic Classes n°	5	5	4	1
Characteristic Orders n°	3	4	4	2
N° of characteristic species	41	46	35	12
Querco-Fagetea	80,49	84,78	88,57	100,00
Fagetalia	65,85	60,87	65,71	58,33
Quercetalia-Roboris	0,00	4,35	2,86	0,00
Quercetalia-pubescentis	0,00	2,17	2,86	8,33
Epilobietea-angustifolii	7,32	6,52	5,71	0,00
Galio-Urticetea	2,44	0,00	0,00	0,00
Lamio albi-Chenopodietalia boni-henrici	2,44	0,00	0,00	0,00
Vaccinio-Piceetea	2,44	4,35	2,86	0,00
Mulgedio-Aconitetea	7,32	2,17	2,86	0,00
Adenostyletalia	4,88	2,17	2,86	0,00
Trifolio-Geranietea	0,00	2,17	0,00	0,00

The number of classes registered in every sample is very low, varying from 1 to 5. This is related to the fact that in the analyzed woods the majority of the species fall under the *Querco-Fagetea* class, and particularly the *Fagetalia* order, representing the mesophile European *consortia*, where mostly species used to vegetate under dense crown cover are included, more or less demanding in water availability, favored by deep soils and avoiding excessive sudden temperature changes. These characters are more present, precisely, in formations that have already reached a certain evolution degree, both from the arboreal and the site development point of view.

It is interesting to notice that with the increase of the age of the coppice areas there is a loss of classes ($r=-0,917$, $p<01$), while the number of orders seems to be highest in the central compartments and, again, minimum in the oldest one, where the unique class maintained is the above-mentioned *Querco-Fagetea* with a strong incidence of the *Fagetalia* order in the distribution of characteristic plants. The dominance of this class is confirmed by the correlation with the stand age which shows how it is favored by wood ageing ($r=0,979$, $p<0,05$), due to the sciaphilous traits of its pertaining elements.

Inside the same class, the other two orders *Quercetalia-Roboris* and *Quercetalia-pubescentis* indicate respectively more acidified situations (confirmed by the very similar trend of the class *Vaccinio-piceetea*) and more xero-thermophile ones. In the second case, the fact that the percentage share increases with age ($r=0,958$, $p<0,05$) is probably due, as already mentioned in the previous chapters when talking about soil temperatures, to the casual altitude decrease with age, from 1100 m to 850 m above sea level ($r=-0,981$, $p<0,05$). Furthermore, as Landolt and Ellenberg ecological indexes show, the humidity decreases in the 20 years old parcel quite significantly, due also to a more substantial soil drainage.

The superficial acidification, is worth considering, is also evident in the presence of numerous indicators – stronger or weaker – of this process, that could not be included in the phytosociological elaborations above, since they are not characteristic of any order or class: *Dactylorhiza maculata*, *Maianthemum bifolium*, *Phegopteris connectilis*, *Solidago virgaurea* and *Veronica officinalis*.

Concerning the class *Epilobietea-angustifolii*, the decreasing percentage contribution with age ($r=-0,916$, $p<0,1$) follows that of *Mulgedio-Aconitetea*, both including species characteristic of forest edge or with a wider ecology (i.g. *Fragaria vesca*, *Hypericum montanum*, *Polygonatum verticillatum*, *Rubus idaeus*...).

The opening of clearings in the forest structure, caused by coppicing operations, facilitates in general the intrusion of species able to exploit the nutrients mobilization process triggered by the sudden availability of light and water.

This is why, in the first regeneration phases, species of clear ruderal/nitrophile origins can arise, such as in our case those belonging to the class *Galio-Urticetea* (*Urtica dioica*), which only appears in the newly cut area.

Other ruderal species - connected with man influence - appear, even if not phytosociologically classified, and they will be included in the analysis exposed in table 20 below.

Regarding, instead, the class *Trifolio-Geranietea*, in our sample areas it only appear in the species *Vicia sylvatica*, registered in sample area P16, again a typical forest edge species (the parcel is located not far from a forest road and small clearings are always present in this 6 years old compartment).

Another important element to isolate is that of *Tilio-Acerion* differential species, which here where not immediately highlighted while absorbed by the *Fagetalia* order.

They, nevertheless, deserve special attention as species with this characterization are proper of gorge environments, humid and fresh, belonging to very interesting formations, usually considered of a certain value.

These species are maximum in number in P20, and they include *Acer pseudoplatanus*, *Actaea spicata*, *Polystichum aculeatum* and *Aruncus dioicus*. The humidity and freshness of these environments is also confirmed by the presence, in the studied compartments, of plants such as *Adoxa moschatellina*, *Stachys sylvatica* and *Calamagrostis varia* (vegetating even in areas of superficial runoff). *Chrysosplenium alternifolium*, as well, is furthermore indicating soil humidity, being differential of the alliance *Alnion-incanae* (so as *Dryopteris gr.carthusiana* and *Rubus caesius*), and always favoured by these conditions is *Cystopteris fragilis*.

Taking a quick look at the characteristic species at the alliance level, we can underline the presence of those representing the phytosociological characterization given to the overall beech coppice forest of the area, that is to say the *Fagion* differential species (*Euphorbia amygdaloides*, *Lonicera alpigena*, *Neottia nidus-avis*, *Petasites albus*, *Senecio ovatus* and *Veronica urticifolia*) and more specifically those belonging to the *Aremonio-Fagion* alliance (*Anemone trifolia*, *Calamintha grandiflora*, *Cardamine enneaphyllos*, *Cyclamen purpurascens*, *Galium laevigatum* and *Geranium nodosum*).

In table 20 all registered species (including the non-characteristic ones) of every sample area have been grouped in more synthetic categories. Proper species typical of meadows ecosystems were not recorded, but the term "Wide ecology" was chosen to group those species (such as *Betula pendula*, *Corylus avellana*,...) that are connected to the wood dynamics, but can easily be found outside of forest contexts, or others that don't have a sufficiently marked preference for one environment or the other (such as *Angelica sylvestris*, *Calamagrostis varia*, *Dactylorhiza maculata* (L.) *subbsp.fuchsii*,...).

Graphs 17 and 18 illustrate the percentage values trends of each category and sample area and the relation with coppice age.

We can observe how the "forest" typical species increase with the years, while the ruderal ones tend to decrease ($r=-0,991$ $p<0,01$).

For the groups “forest edge” and “wide ecology” there is no real correlation with the temporal distance from the cutting operations, since they are very much dependent on other factors such as coppice area shape, presence of small clearings and other element connected to the nature of the species with a wide tolerance to different conditions and situations.

Table 20 Grouping of all registered species in “types” and their percentage shares.

Type	P14	P16	P20	P28
Forest	68,00	73,68	71,43	84,62
Forest edge	14,00	7,02	7,14	7,69
Ruderal	6,00	3,51	2,38	0,00
Wide ecology	12,00	15,79	19,05	7,69

Figure 17 Percentage contribution of different “types” of species (belonging to forest, forest edge, ruderal and wide ecology contexts) to the total registered species in every sample area

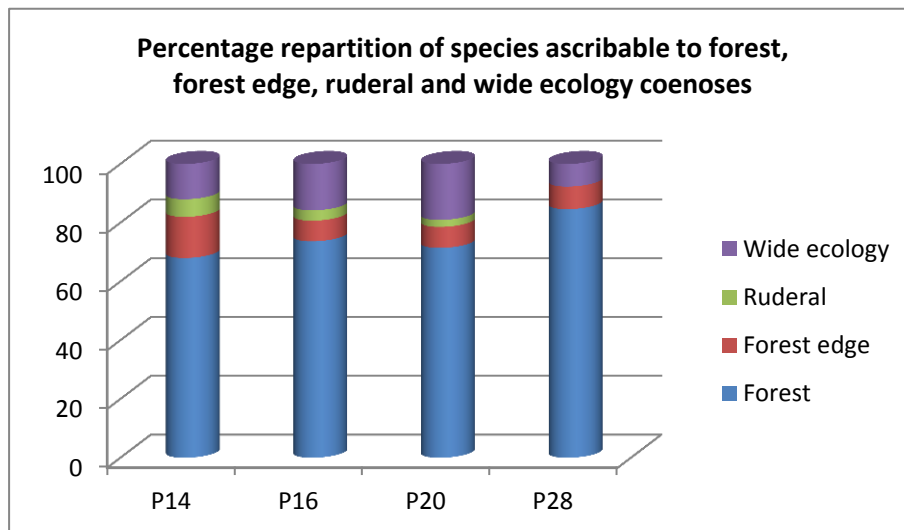
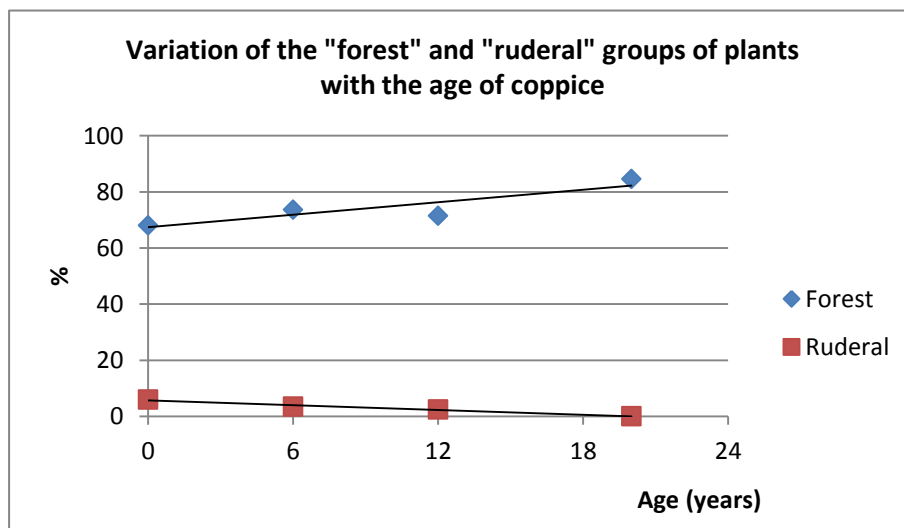


Figure 18 Variations of the “forest” and “ruderal” categories as a function of coppice age



4.4 QUALITATIVE INDICATORS OF FUNCTIONALITY

4.4.1. Actual arboreal composition

The actual arboreal composition is constituted by the list of arboreal species appearing in the studied forest type. This indicator distinguishes the arboreal species registered as principal (if the coverage index according to Pignatti exceeds 1), secondary (coverage index equal to 1) and accessory (coverage index lower than 1), taking into account the maximum coverage index registered in the various strata.

Although the composition is clearly poor, due to the undisputed dominance of *Fagus*, we can observe the below exposed table 21 and make some considerations, more than a full statistical analysis that with these data would appear redundant.

Table 21 Actual arboreal composition calculated on the 400 m² sample areas. The coverage index refers to the Braun-Blanquet scale, modified by Pignatti [r=rare; +=<1%; 1=1-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%]

Arboreal species	P14	P16	P20	P28
<i>Acer pseudoplatanus</i>			+	
<i>Betula pendula</i>		1	+	
<i>Fagus sylvatica</i>	5	5	5	5
<i>Fraxinus ornus</i>			r	+
<i>Picea excelsa</i>	r	r	+	
<i>Salix caprea</i>		+		
<i>Salix appendiculata</i>	+	1	+	
<i>Sorbus aria</i>	+	+		

As it clearly shows up, the beech obtains in every sample the supremacy, with the maximum coverage index of 5. Furthermore, it is the only arboreal species present in all the studied stands, followed by the spruce (*Picea excelsa*) and the large leaved willow (*Salix appendiculata*), which are only missing in the mature area, the silver birch (*Betula pendula*), the manna ash (*Fraxinus ornus*) and the common whitebeam (*Sorbus aria*), appearing in two of the four samples.

The sycamore maple (*Acer pseudoplatanus*) and the goat willow (*Salix caprea*), instead, are occasional presences in only one compartment each.

It is evident, therefore, how the *Fagus* is the only principal species, in all of the four samples (appearing 100% of the cases as so), while the two secondary ones, the birch and the large leaved willow, are respectively present with the index 1 in half and one third of the cases, both in parcel P16.

All other species are accessory ones, and two of them (manna ash and spruce) are often rare.

We can observe how the richest areas, in terms of composition, are the two central stages, with the presence of five arboreal species, followed by the four tree species of the newly cut area and the two of the mature one.

More than a correlation to the nutrients content of the different soils, the age of the stand, the slope or the basal area, which all seem insignificant, there seems to be a difference in contingent situation that differentiates the plots, otherwise very much similar and uniform, as this was a criterion for the choices of the sample areas. This could be, in our case, the presence of small clearings, created by the cut or the fall of a trees group, creating different niches in the overall full coverage context (especially in areas closer to meadows and where part of the woody compartment was probably a former-meadow itself, where *Salix caprea* can enter) combined with an articulated micro-topography which favors the superficial runoff observed in the areas - and consequent superficially acidified situations where the birch is more competitive, especially in poorer soils, and the common whitebeam and large leaved willow also vegetate easily, preferring fresh slopes.

In this context, a local acidification of P16 especially, is confirmed at the floristic level by the presence of *Vaccinium myrtillus* and *Majanthemum bifolium*. It is interesting to notice how the researchers conducted for the production of the management plan of the area, revealed the reiterated gathering of litter in the past times, probably to be retained one of the causes of this phenomenon.

The sycamore maple, as well, indicating the participation of gorge-like environment species, enriches the arboreal composition of P20 only, thanks to the close presence of interesting impluvium situations.

The presence of the spruce is here mostly connected to seedlings in the herbaceous strata, due to the close bordering of the compartments with conifers stands (mostly artificial), which in P20 (indicating a higher participation of the species) are even within the management forest compartment A20 to which the sample area belongs.

The manna ash, instead, appears naturally in the two areas located at lower altitude, gradually increasing its index toward the more thermophile station, although remaining an accessory species.

For every forest compartment to which these sample areas belong, the forest management plan indicates the sporadic participation of other species (*Prunus avium*, *Tilia cordata*, *Quercus pubescens*, *Sorbus aucuparia* and *Ostrya carpinifolia*) and a richer arboreal composition, but these data are not to be compared to our research, since the

constricted extension of our sample areas (400 m²) and the careful selection of uniform situations carried out limits the detection of the much more differentiated situations (in terms of slopes, exposure, soil types, human pressure and so on) characterizing a compartment of about 40 ha (on average) in a very variable mountainous morphological complex.

By comparing, now, the local actual arboreal composition to the one proposed by Del Favero *et al.* (2000) for the type “Faggeta Montana tipica esalpica” (table 22) to which our sample is ascribable, we can make some considerations.

Table 22 Comparison between actual arboreal compositions of the analyzed stands and the regional average described for the forest type “Typical esalpic mountain beech forest” by Del Favero *et al.* (2000)

	Del Favero <i>et al.</i>, 2000	Mel sample areas
Principal species	Fagus sylvatica	Fagus sylvatica
Secondary species	Picea excelsa	Betula pendula Salix appendiculata
Accessory species	Acer pseudoplatanus Sorbus aria Fraxinus excelsior Salix appendiculata Abies alba Laburnum alpinum Laburnum anagyroides Populus tremula Prunus avium Ilex aquifolium	Acer pseudoplatanus Sorbus aria Fraxinus ornus Salix caprea Picea excelsa

At a first glance, our samples are clearly poorer in number of participating species, although some specifications are needed for a better interpretation of the comparison.

We can, in fact, try to give a reason for the absence of some of the species included by the Authors’ work, which in some cases could also be excluded from the comparison. Particularly, the species *Ilex aquifolium* is absent from the whole pre-alpine area, and concentrates in these consortiums of the Province of Verona, for the Veneto Region.

We should furthermore remember that not all species included in the 2000 work on Biodiversity Indicators can appear contemporaneously, and that they are calculated on a regional average.

The fir, as well, presents well known gaps in these formations, partly also due to the historical management practices, which have continuously and massively get rid of it, according to the cultural background exposed in the introductory chapters.

Also *Laburnum anagyroides* appears too thermophile for these formations, all with northern aspects, while the absence of *Laburnum alpinum* (which is apparently a matter of fact also in the global composition of the four complete forest compartments) is surely more indicative for the coherent traits of the species with those of the site, as similarly we could say for *Populus tremula*.

In the forest management plan, as above mentioned, *Prunus avium* is recorded as a sporadic species in three of the four forest compartments (A14, A16 and A20), but not in the 400 m² belonging samples, although individuals of the species were observed out of the border of the studied areas, that couldn't therefore be included in the count.

The more demanding *Fraxinus excelsior* is here absent in the most elevated stands (P14 and P16), while it is instead substituted by the more frugal and thermophile *Fraxinus ornus* in the other two, where it is actually an intrusion element from the submontane beech forest. The reasons for this vacancy could be connected with the elevated slopes of this part of the property and with high drainage terrains, in contrast with the needs of the species.

Another tree species which is present less than expected is the spruce, in our sample included in the accessory rather than in the secondary species.

This is not surprising, for the fact that in the "Biodiversity and Indicators" work the montane beech forest includes also the higher altitudes, where conifers are favored both by natural conditions and by human interventions.

Two species are, on the contrary, present in the area more than expected, even conquering the role of secondary species (index=1) in one of the areas (P16): the silver birch, which is absent from Del Favero *et al.* description, and the large leaved willow, which is instead included only as an accessory species.

Salix caprea, present in the situations previously described, is also not considered in the Author's picture, being somehow a sign of human influence.

It is also true, on the other hand, that very few of the individuals of these two species were recorded as exceeding the 1 cm diameter threshold, and were mostly concentrated in the herbaceous/shrub layer as seedlings or small plants, which would be worth of further considerations about the possible evolution of these stands toward a more varied composition, in dependence of the management objectives of course.

Acer pseudoplatanus and *Sorbus aria* are equally considered by this research and the work on Biodiversity Indicators as accessory species, and the beech as the exclusive principal one.

Generally speaking, the composition of our stands shows in some traits more similar to the esomesalpic, rather than the esalpic, montane beech forest according to Del Favero *et al.* description (2000). This fact can be due to two reasons: firstly the valleys articulation, orographically quite complex, can induce a microclimate and particularly a rainy pattern that resembles more the esomesalpic situation (and we should remember that the precipitation data exposed in chapter 2.4 are interpolated and not locally registered); secondly the quite well-drained soils where our stands vegetate can favor a behavior closer to esomesalpic situations.

Even more simplified appears the actual shrub composition, which reflects the data of table 23 below.

Table 23 Actual composition of the shrub layer in the four sample areas

Shrub species	P14	P16	P20	P28
<i>Corylus avellana</i>	r	+	+	+
<i>Lonicera alpigena</i>		+		
<i>Rosa pendulina</i>	r			

The only species which is present in all compartments is the hazel (rarer in the younger stand, although a sign of disturbance), while *Lonicera* and *Rosa* only participate respectively in areas P16 and P14: they are structural presences in the whole montane and up to the subalpine belt, *Lonicera alpigena* always as a forest component and *Rosa pendulina* also in sparsely vegetated environments (as confirmed by its presence in the newly cut area). The two older stands are poorer in shrub species.

In general terms, the presence of *Corylus* is to be attributed not only to areas of artificial disturbance created by the cut, but also to the clearings produced by tree crashes and falls, due to the instability of the stands (superficial substrata, with emerging rocks), easily temporarily recolonized by the hazel.

4.4.2 Composition of the ecologically coherent species

The composition of the ecologically coherent species was calculated at regional scale as the result of statistical elaborations on presence-absence data of a certain species in particular environmental contexts, thereafter related to other biological and floristic traits of the same.

According to Del Favero *et al.* (2000), the only ecologically coherent species of the typical esalpic montane beech forest is *Fagus sylvatica*, and the same is true for the submontane belt, which as we have seen presents some influences in our area of interest.

4.4.3 Anthropogenic disturbance

The montane beech forest is here in its near-natural aspect. Surely, being it an ordinarily managed coppice, with entrance and intervention in the plots every 18-20 years, this can be considered the main element of human disturbance which impacts on the stands composition and structure, which will be discussed in paragraph 4.4.5.

These forests have been since centuries ago exploited, and signs of the past use as coal production woods can still be observed, in the presence of coal storage yards for instance. Especially where slopes were prohibitive, in fact, beech wood was transformed into coal - with an operation of controlled combustion which lasted some days - in order to facilitate the valley transport.

Nowadays, excluding therefore the silvicultural operations conducted in the stands, there aren't very significant factors of disturbance deriving from human influence.

The occasional human visits (mostly local mushroom searchers) are never elevated to the degree of "touristic pressure", and transit toward mountain huts or dewes are limited to the forest roads.

Possible situations tracing back to "human disturbance" could be the closeness to mowed meadows or temporary pastures with seasonal houses, but this is not important (although slight differences are actually present among the four samples) for the restricted analyzed area.

Thinking about the role of these woods for the local population, people seem happy to maintain the firewood production function of the coppices, moreover placed in difficult terrains, surely not suited for agrarian cultivations.

For these reasons, we can approximate these beech forests to the natural conditions, while if we could point out at someone who consistently puts a strain on the stands with its

trampling, defecating and feeding effect, this would be the massive ungulate population living in the area.

4.4.4 Natural dynamic trends

The typical montane beech forest type is generally considered a stable formation (Del Favero *et al.*, 2000), especially in its *optimum*, which we can affirm largely corresponds to our case.

This means that the future of these woods would be the self-perpetuation over time.

As already underlined in paragraph 4.3, with coppice ageing we assist to the loss of the adventitious species and those floristic elements which indicate some degree of disturbance, typical of the first regeneration phases following the cut.

The potential natural vegetation *sensu* Tüxen (1956) is therefore here reached, not being these formations an intermediate stage of the succession.

If the man-exerted action would stop, the change would be seen more in the structural traits than in the floristic and compositional ones, until the climate will remain the same.

Particular instable and loose conditions of the terrain, enough to induce landslides, have neither been observed in the field surveys nor documented in the forest management plan, so that important rejuvenations of the stands are not expected and the *facies* can even from this point of view remain the *climax* condition.

Naturally, if all silvicultural interventions were abandoned slowly the evolution toward high forest would occur, with the gradual exhaustion of the stools and the production of seed giving birth to new gamic individuals to substitute them (since it is only coppicing that gives rise to new shoots regenerating from the stools). The crushes of old, instable or attacked trees (by abiotic or biotic agents), would then allow new openings, creating the conditions for other broad-leaves to enter the consortium, always leaving the supremacy to the beech, which in untouched by man environments would survive and not be negatively selected. More rarely, in such a sub-oceanic environments, conifers will also participate, further enriching the composition, thanks also – especially in the case of the more demanding fir - to an expected greater maturation of the soils (permitted by a longer undisturbed time).

4.4.5 Influence of the silvicultural interventions on the natural forest dynamics

The utilizations over the centuries, and especially in the last decades, have surely had a simplifying effect on the formations, but for the resilience of this forest type they haven't probably irreversibly altered the floristic and arboreal composition.

Especially in the last 40 years, the different forest treatments have undergone substantial changes, as described in the last forest management plans of the forest property belonging to the municipality of Mel. The first type of coppicing, practiced in the first half of last century, has been progressively abandoned after the introduction of new energy sources, but after a few years characterized by very low utilization rates, a revival of the cuts with partially different techniques occurred.

The disturbance produced by the frequent cuts, in terms of physiognomy of the area, is clearly more evident in the recently utilized areas, but the structural modifications induced by coppice management with respect to the typical high beech forest remain undisputed and persist over the years, being this alternative (coppice-high forest) the first silvicultural choice with all the naturalistic, economic and social consequences it brings.

In this context, we can describe the effect of silvicultural interventions (in accelerating or slowing down the natural forest dynamics) referring to the different possibilities of anthropic interventions, which appear to be the maintenance of the already practiced cut, the development of a method with a higher landscape and environmental function (and all the possible hybrids between the two alternatives), and the conversion to high forest – while the improbable abandonment of all silvicultural practices has been discussed in the previous paragraph.

It is obviously not worthy to re-discuss the evolution of the stand in case of maintenance of the actual coppice treatment (a compromise between the clear cut and the coppice selection system, as described in chapter 2.5.3 of the introduction) since, as we've already seen, the conditions are stable and would basically remain as such.

The forest managers have so far certified the effectiveness of the present treatment, particularly where the utilizations are carried out by qualified and conscientious forest companies.

In the second case, the hypothesis of applying a closer to nature and landscape method, surely some esthetic values and ecosystem functions would be valorized, but in the case of Mel municipality's coppice woods, overall scarcely subject to touristic use and landscape perception, this concept appears exaggerated. Furthermore, the methodology -

as explained by Andrich *et al.* (2002) – would require a level of silvicultural detail which is hardly compatible with the management reality and even more difficultly with the customs of the forest companies, and in the end would create more confusion and negative economic consequences than positive effects.

Finally, regarding the possibility of conversion into high forest, experiences signal some unsatisfactory results in two experimental compartments, although the reasons have not been deeply analyzed yet, and one reason of the failure could be the type of arboreal individuals candidate to the conversion. This type of evolution is anyways surely possible, and in part of the stand, where the number of standards is, as in our samples, sometimes higher than the prescriptions, it would be even simplified or already launched.

Furthermore, the type of particular coppice treatment currently applied could be easily considered, in case the economic prerequisites for a coppice wood maintenance would fail, a preparatory cut for conversion.

In this case a possible evolution would be toward the entrance of other broadleaves (not only those – e.g. *Fagus* - which are more resistant to utilization stress or with a higher sprouting capacity) and, especially in some areas, of the spruce, the propagation of which would have a fundamental role in the composition of the future high forest (mixed beech-spruce forest).

The sporadic species would surely be moreover favored by the augmentation of the time of permanence of the species, allowing a better soil evolution by reducing the alterations of the biogeochemical cycles of the forest systems which happen with every coppicing operation, especially with the impoverishment in soil phosphorous.

4.4.6 Natural regeneration

In coppice woods the gamic regeneration surely assumes a limited importance if compared with the artificial rejuvenation of the stand through coppicing. On the other hand, however, the presence and composition of the seedlings could result crucial in the operations of standards release. The biodiversity of the stand will consequently be influenced by the survival of seedlings of different species.

At the moment, in the studied sample areas, the individuals released at the end of the cycle are, for the principal species, mostly shoots of consistent diameter (except for some beech trees in the mature area, clearly of gamic origin) and only in the case of occasional

species, such as *Salix caprea* and *Sorbus aria* (and obviously *Picea abies*) we are in front of gamic regeneration.

4.4.6.1 Regeneration modalities

It is necessary to specify that the number of seedlings vary consistently over the season and mortality is very important.

The observation was carried out in the 400 m² area and all data were reported to the measure per hectare.

Table 24 reports the maximum number of individuals of every species registered in a single relevé for each sample area and the number of survived seedlings at the end of the season. The comparison between the two situations is shown with figures 19 and 20.

Belonging to regeneration were considered all arboreal plants that didn't reach the 1 cm diameter threshold, afterwards divided into the more classical definition of regeneration according to height (plants below 50 cm of height) and plants above 50 cm height but below 1 cm diameter (which were therefore considered neither in the arboreal composition nor in the dendrometric analysis).

In the first category, seedling of beech that still presented the two cotyledons were also considered.

Figures 19 and 20 Maximum individuals per ha and number of survived individuals at the end of the vegetative season (15th September). Distribution among *Fagus* and other species of the seedlings in each sample area

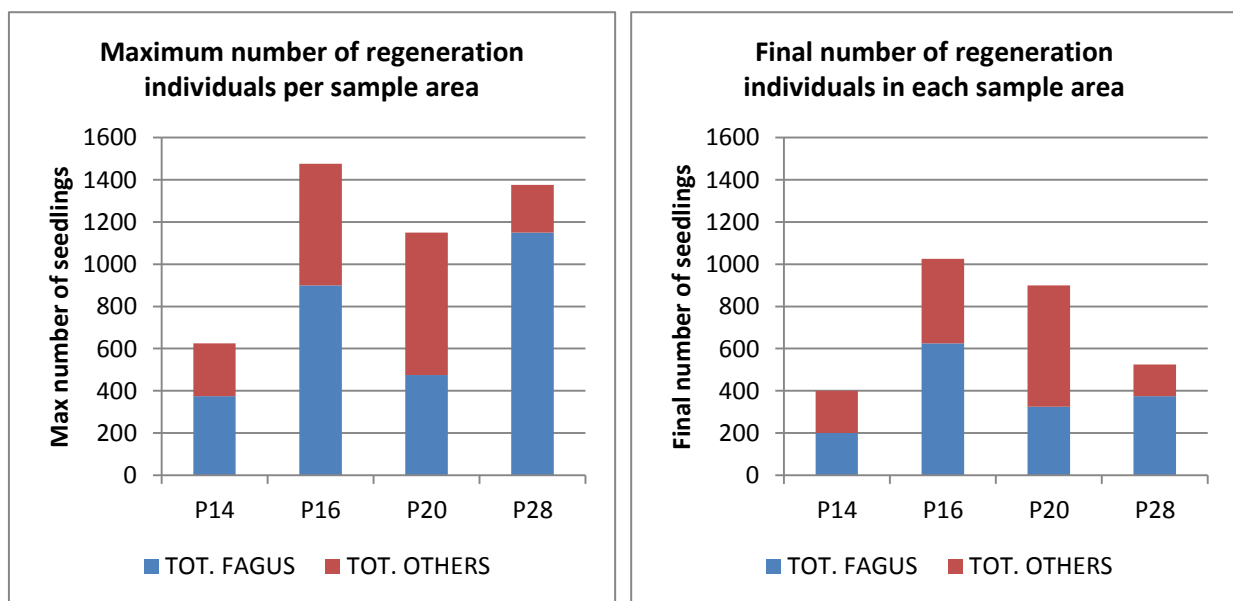


Table 24 Maximum number of individuals/ha (P#max) for every arboreal species registered in a single relevé and respective number of survived individuals at the end of the vegetative season, on September 15th (P#surv). *Corylus avellana* was here included in the analysis, although being a shrub species, because considered an important indicator.

		P14 max	P14 surv	P16 max	P16 surv	P20 max	P20 surv	P28 max	P28 surv
Fagus sylvatica	<50cm	225	50	525	250	250	100	900	125
	>50cm	150	150	375	375	225	225	250	250
TOT. FAGUS		375	200	900	625	475	325	1150	375
Sorbus aria	<50cm								
	>50cm	75	75	50	50				
Fraxinus ornus	<50cm					75	75	125	75
	>50cm								
Betula pendula	<50cm			175	25	100			
	>50cm			275	275	100	100		
Acer pseudoplatanus	<50cm					75	75		
	>50cm					75	75		
Corylus avellana	<50cm	125	75			75	75	100	75
	>50cm					50	50		
Picea abies	<50cm	50	50	75	50	125	125		
	>50cm						0		
TOT. OTHERS		250	200	575	400	675	575	225	150
TOT.		625	400	1475	1025	1150	900	1375	525

Table 25 Percentage share of the two regeneration categories, Fagus and other species, on the total maximum number of seedling registered over the season for every sample area (ON THE TOT. MAX) and on the total number registered at the end of the season (ON THE TOT. FINAL)

		P14	P16	P20	P28
ON THE TOT. MAX.	Fagus	60,0	61,0	41,3	83,6
	Others	40,0	39,0	58,7	16,4
ON THE TOT. FINAL	Fagus	50,0	61,0	36,1	71,4
	Others	50,0	39,0	63,9	28,6

Generally, as stated by Del Favero *et al.* (2000) the beech forest presents a relatively easy regeneration, which is however abundant mostly in the years after the mast.

Apparently, *Fagus* in the area hasn't shown a massive production of seeds in the recent previous years, as confirmed by the above exposed numbers.

Simply looking at the total (*Fagus* and other species) maximum number of individuals, we can observe how the stand which shows the best performance in allowing natural regeneration appears the six years old one, immediately followed by the mature sample. In spite of the very similar total number (1375 and 1475), however, the distribution between seedlings of *Fagus* and other species appears greatly different between the two areas, as we will later discuss, looking at table 25.

The sharpest decrease is evident in the newly cut area, where gamic regeneration seems to suffer more and presents a number of individuals less than half those of the following stage, probably due to the preference of beech regeneration to thin coppices rather than more open areas.

The beech has the supremacy among the other species, in terms of percentage of seedlings over the maximum total registered over the season, except for stand P20, where the composition of regeneration is slightly in favor of the other species (see table 25). The newly cut area, P14, and the following stage, P16, present an almost equal distribution, with about 60% beech seedlings and 40% others, while incredibly high results the percentage of *Fagus* share in maximum number of individuals: almost 84%.

The fact that P20, although being so similar for many aspects to P16 (including the important structural ones) - as we have by now explored in all the previous chapters -, shows a poorer regeneration, can partially be attributed to the quantity of Pteridophytes covering an important percentage of the area (about 15%, as we have seen in paragraph 4.3.3) which impede seeds germination.

This pattern confirms the data collected about arboreal composition and species diversity exposed in paragraph 4.4.1, which sees P28 as the less diverse area, where *Fagus* has reached its complete dominion.

The seedlings survived over the vegetative season (for new-borns the first step to overcome) were checked at the end on the 15th of September.

The summer 2012, we can indicate, has been longer than the average, although quite normal in terms of precipitations, but the previous winter and spring, fundamental in these climates for the snowy precipitations and early rains that provide the first hydric resources for the start of vegetative season, were decisively dry.

Continuing on the analysis, this autumnal presence of regeneration can give indications about the survival of the year-born seedlings over the summer climate, or the number of seedling more than one year of age that have good probability of survival over next winter.

The first consideration, in fact, regards the number of seedlings exceeding 50 cm of height, which we all find again in the middle of September, although for some of them may be hard to preview the future, showing sometimes a suffering aspect.

The total (below and above 50 cm height) number of seedlings, checked in Spring and again at the end of the season, is reported in table 24 and showed in figure 21.

Figure 21 Comparison between the maximum number of *Fagus* regeneration individuals registered over the season and the number of survived plants in Autumn. The solid line indicates the *Fagus* presences trend, while the dotted line the number of seedlings of other species.

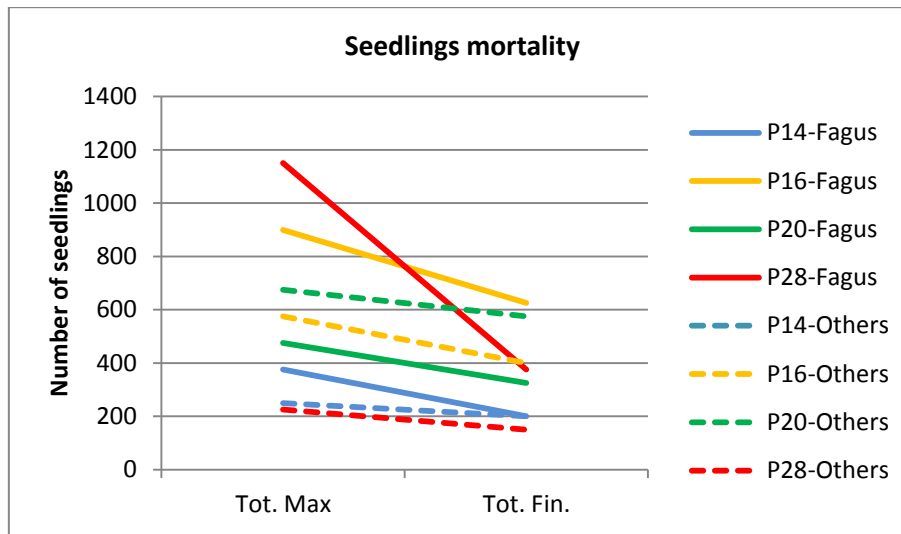


Table 26 Percentage of disappeared seedlings (sum of <50 cm and >50 cm, but below 1 cm diameter) at the end of the season with respect to the maximum number registered over the season.

Mortality	P14	P16	P20	P28	Average
Fagus	46,7	30,6	31,6	67,4	44,0
Others	20,0	30,4	14,8	33,3	24,6
Tot.	36,0	30,5	21,7	61,8	37,5

The mortality percentage illustrated in table 26 was calculated as the number of disappeared seedlings (difference between maximum number over the season and number at the end of the season) over the maximum number registered over the season, and appears quite striking.

The sharpest decrease in beech individuals happens in the mature area, followed by the newly cut one, most probably for at least partially different reasons, as we will try to derive in the following paragraphs.

Once again, the behavior of the two intermediate stage looks quite alike, setting to about 31% beech seedlings mortality.

A different trend characterizes the number of other seedlings change over the season, where the highest mortality is still experienced by stand P28, but immediately followed by the 6 years old compartment (P16), with quite low percentages of loss (20 and 15% respectively) in the newly cut area and P20. This latter stand, therefore, shows good prerequisites to a possible future as a better mixed stand, thinking at its already diversified composition (in comparison to the other sample areas), at the higher percentage of other regeneration seedlings against the beech ones and at their lower mortality.

On average, anyways, the beech experiences in the four analyzed stands a 44% mortality rate, against the 25% of the other species.

At the end of the season, as a combination of the number of emerged seedlings and the experienced mortality of each stand, P16 ends up to be the richest parcel in total number of survived regeneration individuals, closely followed by the next stage, P20, and with more substantial differences by the mature and finally the newly cut area, which only shows about 40% of the seedlings of the stand with the highest number (P16).

In September, then, the distribution of seedlings among *Fagus* and other species changes in the following way: P14 levels out the difference existing in the middle of the season, and shows a 50 to 50 division of regeneration individuals among the two groups; a similar leveling out happens also in P28, starting from much differentiated percentages, so that *Fagus* here dominates with 71% instead of 84%; in P16 distribution remains exactly the same as during the best period of the season; while in P20 as we have noticed the proportion of seedlings of other species increases again up to 64%, to the detriment of the beech.

With respect to the composition of seedlings belonging to the class "Other species", we can notice how every arboreal species included in paragraph 4.4.1 about the actual arboreal composition of the stand, presents some regeneration in the same plot, and furthermore the number of regeneration individuals follows the more or less abundant presence of the adult trees of the same species.

This induces to preview a more than ephemeral presence of these species for the future, although survival is not complete. This would also surely greatly depend on the silvicultural decisions about the maintenance of a more mixed composition rather than a purer beech coppice and on the competition exerted by the beech in the following development phases. For the diversity of regeneration, therefore, the reference remains the above mentioned paragraph, which describes arboreal composition and similarly guides seedlings presences.

4.4.6.2 Factors limiting regeneration settlement

In the northern exposure of these beech coppices, the factors which most appear to limit regeneration settlement are the excessive thickness of undecomposed litter strata and, as also reported by Del Favero *et al.* (2000), the lack of early precipitations at the start of the

vegetative season. Especially the first problem has been particularly detected in all samples, although the more open, younger areas are favored in this sense by the higher mineralization rate facilitated by the higher amount of solar radiation entering the stand, although the presence of an adequate layer can also mean a reduction in evaporation and increase in soil moisture, which favors seeds germination (Bilek *et al.*, 2009).

According to Madsen (1995), the three main drivers of natural regeneration in beech stands are light intensity, soil water content and nutrient supply. Although all factors should be better quantified in detail and investigated accordingly for the correct interpretation of the complex effects on seedlings growth, we can try to use Landolt Indexes (Light, Humidity and Nutrients) to derive some information about their action on forest seedlings settlement.

The correlations of Landolt Indexes and the basal area (as a probable measure of crown cover) of a sample area to the total maximum number of seedlings of all species in the same area are never significant, showing a probable more complex interaction among the factors, including others such as the humus horizon - as underlined in literature by Bilek *et al.*, 2009 - and predation by insects, birds, hares, rabbits, mice and deer who can decimate seed crops before and after seed fall, especially in years where only few seeds are produced.

Beech seedlings can establish and survive at very low light levels for the first year (Emborg 1998, Szwagrzyk *et al.* 2001). It was anyways observed that ground vegetation was more frequent outside the crown projections of overwhelming trees, and especially in the oldest, full coverage stand, concentrated in small clearings.

In addition to the ground conditions, it is important for the germination of seedlings, furthermore, a certain level of flowering, which is itself connected to the presence of well-developed crowns. This could partly explain the exceptionally high number of regeneration seedlings of the mature area and the lowest one in the newly cut sample, considering the above described as a crucial driver (Huss and Manning, 2003).

Seed production is then, for the species *Fagus sylvatica*, connected to age of the trees and mast years, in addition to environmental facilitating factors. Burschel and Huss (1997) states that fructification begins between 50-80 years in trees located in a stand, with a maximum of 500 seeds produced in a full mast year. Full masts tend to occur once every ten years, as do half masts, with approximately three small masts every ten years.

4.4.6.3 Factors limiting regeneration establishment

With particular reference to the very poor 2011 winter in terms of snow, we can recall how beech seeds stored in litter during years with little frost during the winter are often infected by fungi and die (on acidic substrates, upon which many of the beech forests in Central Europe are situated degradation occurs more slowly and the more acidic the soil the larger the number of moulds present) or may be dried out by short warm and dry winter periods (Huss and Manning, 2003).

Particularly significant can be, also in this case, the major presence of seedlings in area P28, with a significantly gentler slope, where probably snow can remain longer.

Furthermore, an excessive competition (especially for water) of herbaceous species has been by different authors, Del Favero *et al.* (2000) *in primis*, appointed as a major limiting factor for beech regeneration establishment.

The peak mortality is experienced by seedlings of less than one year of age, and the presence of ground vegetation can in this phase inhibit the further development by reducing light intensity and depriving seedlings of necessary water.

This can also be true in clearings with ferns and high vegetation, as observed in the lower part of P20, where beech regeneration is completely absent, highly reducing the total number of seedlings registered in the whole area.

In these northern, fresh exposures, mosses also play a role in partly determining an obstacle to forest regeneration. Here again, a possible explanation of the disproportional number of seedlings registered in P28, when compared to the other three samples: it presents a very scarce moss layer (<5%), especially when compared to the 40% shown by P16. In general, it is interesting to notice how, according to Hofmann (1991), differently from the high forests, beech coppices of the Pre-alpine area of the Veneto Region are particularly rich in mosses, among which have the maximum diffusion *Homalotecium sericeum*, *Rhytidiadelphus triquetrus*, *Hylocomium splendens* and *Ctenidium molluscum*, - which testify a constant elevated atmospheric humidity - and mosses of the gender *Polytrichum*, furthermore indicators of acidification.

Reinecke (1982) dividedes ground vegetation into three categories, according to the impact on the ability of beech to regenerate: 1) species which continuously endanger seedlings from the time of germination; 2) plants which only cause damage at certain times or densities and 3) plants with no negative impact.

In the studied area, we can find among the first category *Calamagrostis spp.*, but present as a species with a maximum cover index of 1, arising sparsely in the two younger stands

(P14 and P16) and therefore not really threatening the penetration of seedlings, as instead observed not far from the newly cut sample area, in the same forest compartment, where thicker covers of *Calamagrostis varia* were noticed.

Excessive growth of *Rubus spp.*, *Epilobium spp.* and *Galeopsis spp.*, belonging to the second category, can also deprive seedlings of light, although this barrier can be set only at thigh density, and this is generally not the case for our investigated areas, although the diffusion of the individuals of the different species of *Rubus* all together can probably restrict beech seedlings growth.

Species included in category three, instead, such as *Anemone nemorosa* and *Hypericum perforatum*, are not a source of competition and will continue to grow together with the seedlings (Huss and Manning, 2003).

4.4.6.4 Disturbance

In the coppices of Mel municipality, and particularly evident in our small sample areas as well, the major (and probably unique, but very crucial) disturbance to natural regeneration comes from the constant and massive presence of Ungulates populations, deers especially.

To have an impression about their considerable density, please refer to paragraph 2.6, while here we will focus on the impact they produce on regeneration.

Studies conducted by Veneto Agricoltura in the Cansiglio Forest (Belluno and Treviso Provinces, North East Italy) have demonstrated the heavy impact of these animals when present in high concentration, especially connected to the excessive underwood browsing (in addition to defecation with N release, fraying, bark peeling trampling).

The damage is often easily identifiable, more than in the disappearance or clearly bitten small seedlings, in the “bonsai” shape assumed by the attacked plants, spruce and beech especially, which impedes regular wood growth.

The great corporal dimensions, nutritional needs – 3-4 Kg of green substance per day for an average size roe-deer, 9 Kg for an average size female deer and 15 Kg for an average size male deer (Bottazzo, 2002) - and vital spaces required, together with the tendency to gregariousness and high mobility of the deer, make it a particularly challenging species.

Focusing on browsing, which decisively appears the most important of the observed damages, we can specify it consists in the removal of parts of arboreal and shrub species,

that is to say leaves, sprigs and buds from Ungulates in order to satisfy their need for raw fiber in their daily diet.

In our samples similar damages were repeatedly observed, and even the effects of older browsing actions on young trees, now presenting the above mentioned “bonsai” shape (figure 22).

Figure 22 and figure 23 Signs of presence of Ungulates populations. On the left bonsai-shaped beech trees and on the right recent defecations.



Their presence was also confirmed by abundant defecations (figure 23) found in the areas and nearby, by the frequent direct observation of the animals and their tracks, by the hearing of close roe-deer barks and the evidence of even herbaceous vegetation bites. With a prolonged impact Ungulates can also modify the vegetal communities and forest ecosystems as well: this can happen for example with the disappearing of some more appetizing species such as *Abies alba* or *Sorbus aucuparia* (Berretti and Motta, 2005). Studies conducted by Angeli and Malesani (2001) on the natural regeneration in forests of the Trento Autonomous Province, which show a percentage of browsing incidence of 52% in broad leaves, second only to *Abies alba* which shows a 68% incidence.

Looking at the more detailed data, the Authors highlight a 40% of browsing incidence on *Fagus sylvatica* in the surveys carried out in the Vanoi and Val Canali forest ecosystems, the ones bordering with the Belluno Province.

Furthermore, the impact of a population is amplified by the low green forage capacity of beech coppices, occupying the last position for production of green substance according to Bottazzo (2002), who indicates 2 Kg per ha in these formations. The difference with a recently cut coppice, instead, is great: 53 Kg per ha of green forage production.

From a silvicultural point of view, in fact, we can notice how the growth of herbs, shrubs and new shoots occurring in newly cut areas, due to the increased amount of light on the terrain, represent the main food source of Ungulates.

Natural wood regeneration, after these cuts, can happen only if Ungulates load is adequate (Casanova *et al.*, 1982).

On the other hand, the regular coppicing assumes great importance, in consideration of the fact that a reduction of the forest cover favors, as mentioned, the underwood growth, contributing to improve the food offer of the forest complex. This diminishes the attraction that these woods have on red deers in terms of cover-refuge, both intended as thermic environment and from anthropic disturbance (Mattioli and Nicoloso, 2002), and this can reduce the damage from bark peeling.

4.4.6.5 Tolerance to forest coverage

Del Favero *et al.* indicate the tendency of beech gamic regeneration to grow slowly and with twisted trunks when not freed by canopy cover after 15-20 years. In our samples, however, the cutting cycle is set to 18-20 years, therefore quite satisfying this condition.

According to Bilek *et al.* (2003), high crown covers increase both the interception and the root competition for water and so negatively influence the conditions for germination.

But once seedlings are born, beech establishment is optimal under a 50% crown canopy cover, according to Peters (1997), and at about 75% of canopy cover they start reducing height growth and changing leaf morphology, although many can survive for long periods in dark conditions and are able to resume active growth after canopy opening (Collet *et al.*, 2001).

Furthermore, in order to underline the complexity of these interactions, it is important to specify that the growth and morphology of seedlings may be influenced not only by current year light conditions but also by previous-year light (Welanders and Ottosson, 1997).

In the sample areas located in the beech coppice stands of Mel municipality we can observe that gamic regeneration individuals over 50 cm of height are always present in all the chronological stages analyzed, and have not disappeared also in the last, mature, fully covered stage.

4.4.7 Vegetative state

The surveys conducted in the four sample areas haven't shown particularly stressed states of the trees, which appear on the whole vital and healthy, confirming the literature data on these montane beech formations which normally don't present significant alterations (Del Favero *et al.*, 2000). There seem, however to be a strict cohabitation with the galligen insect *Mikiola fagi*, but the very abundant production of galls and their observed maturation over the season don't apparently impact on the diminution in leaf size reported in literature and the reduction of height and diameter growth is hard to determine and eventually quantify, for the lack of uninfested formations to use as comparison.

M. fagi is classified as a major pest, local and occasional, especially on young trees in submountain and mountain zones (Skuhrová and Roques, 2000), belonging to the second group of the four-degree scale for evaluation of harmfulness of forest pests, which includes species which, after attack, significantly reduce the assimilation processes of the tree (Skuhrový and Skuhrová, 1996). In spite of this, it is known that the presence of natural enemies of this galligen can highly reduce their impact on forest stands, especially parasitoids and birds. Furthermore, in a close to natural formation as this is, the defensive activity of the plant tissues kills up to 22% of larvae in galls (Urban, 2000).

Other possible damages, due to hydric or nutritional stress, were not detected and even less (due to the altitude and distance of the stands from industrialized centers) the so called "new damages" connected to pollution.

4.4.8 Interactions with macrofauna

In table 27 suggestions on the topic by Del Favero *et al.* (2000) for the typical montane esalpic beech forest are reported.

Different birds of these species were observed during the months of surveys, and particularly: *Buteo buteo*, *Tetrao tetrix* (here in addition to *T. urogallus*) and *Dendrocopus major*.

To have a more complete overview of the faunistic richness of the area, please refer to paragraph 2.6.

Table 27 Interactions with macrofauna. Indications for the Typical montane esalpic beech forest (Del Favero *et al.*, 2000)

Category	Species	Silvicultural Indications
Species negatively sensitive to interventions	Pernis apivorus, Accipiter gentilis, Accipiter nisus, Buteo buteo, Tetrastes bonasia, Tetrao urogallus, Glaucidium passerinum, Aegolius funereus, Strix aluco, Dryocopus martius, Dendrocopus major	Sparing from the cut trees with cavities, trees with nests and surrounding area, lek and mating areas. Avoid to intervene in proximity of nests in reproduction periods. In case of monospecific and structurally monotone coenosis favor the presence of some conifers and of 4-5 dead trees per hectare, where present.
Species negatively sensitive to abandonment	In general those species connected to big dimensions trees	In aged coppices the excess of competition among arboreal individuals brings to the lack of trees of remarkable size and consequently to a reduction of the connected macrofauna.

The attention should be therefore concentrated on the preservation of these bird species (in the surveyed beech forest especially the *Tetraonidae* family), while ungulates are generally less vulnerable in relation to their higher adaptability.

These forests are in fact well inhabited by both the roe deer (*Capreolus capreolus*) - which prefers broad-leaves woods rich in underwood, fragmented and broken up by clearings – and the red deer (*Cervus elaphus*), requiring big forest complexes.

Among the ungulates of recent introduction an important role is played by the wild boar (*Sus scrofa*), which is by now a stable presence even in the explored area, although fortunately still not reaching extremely high densities. Signs of presence of this species have however not been detected in the specific small sample areas.

Belonging the most part of the sylvopastoral property of Mel Municipality to the SPA (Special Protection Area) “Dorsale prealpina tra Valdobbiadene e Serravalle” (IT3240024), the indications of the forest management plan are coherently applied with the necessary connected environmental preservation claimed by the European Directive, especially respecting the reproductive periods of birds in interventions planning and management.

Furthermore, the structure of these coppices appears quite suitable for the gender *Tetrao*, which takes advantage from the clearings in the forest complex, where density is not elevated and shrub coverage is discrete, characterized by blackberries, blueberries and raspberries which offer food and refuge for the broods.

The release of old, dried out or decaying individuals - which constitute the ideal habitat for the woodpeckers – is also a followed suggestion, as observed in all samples, and particularly in the newly cut one, which truly suggests the occurred release.

The possibility to maintain a certain degree of biodiversity in the vegetal community also signify, indirectly, a certain variability in the animal community.

In particular, the diffusion of those arboreal and shrub species producing fruits and berries is included among the interventions finalized to the conservation and development of the faunistic suitability of the forest habitat (cherries, cornel, hazel and whitebeam for instance) relevant for the diet of the macrofauna (Various Authors, 2001a; Various Authors, 2001b).

4.5 QUANTITATIVE INDICATORS OF FUNCTIONALITY

4.5.1 Coppice biometric data

4.5.1.1 Mean annual increment at maturity (I/ha at mat.)

The average values indicated by Del Favero *et al.* (2000) for the typical montane esalpic beech forest are of 6-7 m³/ha; the reference mass, at maturity, reported by the Forest Management Plan of the Silvopastoral Property of Mel Municipality (Andrich *et al.*, 2002) for these formations is 143 m³/ha (conversion from q to m³ through the Specific Weight of fresh beech wood=1,05 t/m³=10,5 1/m³), although it was calculated for compartments of 17 years of age, therefore signifying a higher mean increment of 8,4 m³/ha. These data were calculated with the complete diameters enumeration and using the coppices double entrance table (av. basal area and dom. height) prescribed by the “Normativa”.

For the assessment of the Vol/ha at maturity of the studied sample areas the same table for the pure submontane and montane beech forests (coppice) was utilized, and the following results were obtained.

The oldest sample area presents a dominant height of the shoots of 16,4 m (much different from the one calculated including standards, which results in 18,9 m) and basal area equal to 28,3 m²/ha: the output mass is therefore 211,1 m³/ha, corresponding to an mean annual maturity increment of 10,6 m³/ha year.

For a comparison, another double entrance table utilizing the same information was utilized: the table produced exactly for the beech coppices of Mel Municipality by Del Favero (1980), which gives a slightly higher output volume of 216,2 m³/ha, corresponding to an average maturity increment of 10,8 m³/ha year.

Although recognizing the high productivity of this site, it is necessary to specify that probably the value obtained for the increment, about 4 m³ higher than the regional average, is in large part due to the important presence of the standards, which are here numerous, of different age variably multiple of the cutting cycle and of remarkable dimensions: their contribution in terms of basal area is therefore above the average.

4.5.1.2 Number of standards/ha and species released

According to Del Favero *et al.* (2000) the number of standards to release varies from 100 to a maximum of 150 units, not to depress the subsequent shoots outbreak.

In the Forest Management Plan, however, the release of 150 standards is required, in order to assure a better crown cover on the soil, and they are supposed to be uniformly distributed in the compartment at an average distance of 8 m and with a diameter ranging from 12 to 14 cm at breast height.

Table 28 Number of standards per hectare: parameters of the newly cut area P14.

P14	N standards/ha	N stools/ha
Fagus	1575	575
Picea	25	25
Sorbus	125	25
TOT.	1725	625

In table 28, referring to the newly cut sample area P14, it appears clear that the number of “released individuals”, reaching 1725, greatly exceeds the numbers above suggested. It is also true, on the other hand, that these are not “real standards”, but for the largest part shoots that were left uncut (the so called “tirasucchi” also mentioned by Del Favero *et al.* as the type of individuals to be released), distributed in the number of stools exposed in the third column of table 28, that are anyways quite elevated.

One reason for the high number of standards in our 400 m² sample area we can probably derive from the Management Plan, which states that the standards should concentrate (so make closer than 8 m one to each other) in the more exposed areas, as in ridges or sunny slopes, as it appears to be the case of our zone. The higher density of standards of the area could be therefore not representative of the per ha value according to this reasoning.

These released individuals are moreover of very different dimensions (av. diameter=7,9 with a st. dev. of 6) and age, while concerning the species composition it is very simplified, with only 1 massive spruce left uncut in the 400 m² sample area and 1 stool of whitebeam formed by 5 shoots of different size. The individuals released as standards also aim to preserve or increase the presence of minoritarian species, constitute particular niches for the animal population or elements of chromatic value, or to start the buildup of a first skeleton in the hypothesis of a future conversion to high forest (Del Favero *et al.*, 2000). Standard can furthermore improve the coppice system in terms of naturalness by increasing the “age of the system” itself (Del Favero *et al.*, 2001).

For the montane beech forest the species fir which the release is suggested are the beech “tirasucchi”, as indicated, and species different from the beech, and the same is declared in the scopes of the Forest Management Plan (Andrich *et al.*, 2002).

These prescriptions are normally respected, although the high monospecificity of the stands leaves little margin. A couple of whitebeam and large leaved willows individuals where however cut last year in P14, the only area where it was possible to still recognize the species that were eliminated.

4.5.1.3 Cutting cycle

The minimum cutting cycle, at regional scale, for this forest type, is fixed at 15 years and the suggested one is 18 to 22 years.

The Forest Management Plan of Mel Municipality, during the last review indicated a minimum cutting cycle of 13 years, but extended to up to 20 years of age (before set at 17 years) the maturity of some compartments in order to preserve or increase the regeneration capacity of stools, assure a better soil protection and at the same time a better resistance of the retained poles against atmospheric agents.

It is also true that often cuts are delayed, at least in some parts of the compartments, according to the contingent situations, and utilizations spread out in 2-3 years, so that we can incur in older parts of the property.

4.5.1.4 Relative fertility and limits for the conversion to high forest

The value of fertility indicated, on a regional base, for the typical montane esalpic beech forest is (on a scale from 1 to 10) set to 8.

Limits to a possible conversion to high forest are not detected by Del Favero *et al.* (2000), although as already expressed in paragraph 4.4.5, in this area the experiment conducted in two compartments in this direction have produced so far not really satisfactory results.

Looking, however, at the high number of standards already released in practice, and the type of coppice treatment carried out, we could affirm that the launch of a conversion would not be problematic from a structural and ecological point of view. The economical benefits and the possible effects of interrupting the coppice management well-rooted tradition in the area, instead, should be further analyzed in order to make the more adequate choice, considering also socio-economical concerns.

4.5.2 Naturalness standards of the stands

4.5.2.1 Differences in composition

The typical montane esalpic beech forest is generally considered a forest type where there is a good correspondence between the actual arboreal composition and that of the ecologically coherent species.

The significance of the results obtainable with this indicator, however, also depends on the number of relevés on which the average actual arboreal composition has been calculated (Del Favero *et al.*, 2000).

For the Veneto Region the arboreal composition of the ecologically coherent species, and therefore the differences in composition, have been assessed on the basis of 35 relevés for the formation in question.

The comparisons with the results of every sample area are exposed in table 29. For the actual arboreal composition and that of the ecologically coherent species, please refer to paragraph 4.4.1 and following.

By comparing the average of the differences found in the composition of Mel Municipality's beech coppices and that reported by Del Favero *et al.* (2000) on a regional basis, we can observe the higher species diversity in the studied area. Nonetheless, the regional data appears quite strict in considering in practice no difference from the actual arboreal composition of the stands and that of the ecologically coherent species (0 (1)), which in our case means the presence of no other species than *Fagus* in the consortium.

Looking at the description of the submontane esalpic beech forest and that of the esomesalpic beech forest by the same Authors, the proposal is slightly more flexible, with respectively a +1 (1) and a +2 (3) compositional difference (in this second case including *Abies alba* and *Acer pseudoplatanus* in addition to *Fagus* among the ecologically coherent species), and knowing the influence of both these forest type in our sample areas, this could partly explain and level-out the distance between the two data.

The total additional species in all the four chronological stages are seven, as evident at the end of table 29, but none of them is present in all the sample areas and only two (*Salix appendiculata* and *Picea excelsa*) are found in three of them, always missing in the poorer site: the mature stand P28. The composition is therefore quite differentiated in the four areas, although we must consider how most of the mentioned species are not only inconstant presences, but sometimes even entities of very localized importance or very

sparse and rare distribution (as expressed in the coverage indexes described again in paragraph 4.4.1 and following).

Obviously, as already discussed, the botanical additional elements have a different probability to participate to the consortium according to local site characters such as aspect, slope, edaphic humidity etc., and to the natural and management history of the stand (including therefore both abiotic and biotic events and the silvicultural choices) which is hard to frame in such a simplified picture.

For all these reasons it the compositional differences indicated are to be examined critically: for example the 12 years old sample P20, which present a very diversified composition from the ecologically coherent one, actually shows all cover indexes inferior to 1 (+ or r), and none of them reach the A stratus. It is also true that they may not be only ephemeral presences, but that they could grow and establish, actually bringing an element of biodiversity to the stand, which is also strongly suggested by the management plan directives.

The mature stand shows instead the closer composition to the natural one, with *Fraxinus ornus* as the only additional element, moreover detected only as seedling in the herbaceous and low-shrub strata as a clear thermophile influence of the submontane belt, which P28 sample is bordering.

Biodiversity, as we can here confirm with an interesting example, is often not a synonym of naturalness, and the choice in managed systems is up to the managers which will act according to the possible different aims, perspectives, opportunities and limits.

Of course, in the sense of this dissertation, naturalness is intended as the difference existing between the actual state and the one we should have if Man wouldn't have exerted any activity.

If we consider this definition, therefore, being the formation in question a coppice (with the well-known management disturbance it implies), we can easily comprehend the great differences existing between the composition proposed as ecologically coherent, and the one found in the field

Furthermore, very rare, and in some cases of impossible scientific comparison, are the really natural states (Wolynsky, 1998), although for the case of the beech forest in general terms we may refer to some intact patches of untouched forests in Romania, as one of the closest and most spectacular examples in Europe As a consequence, the evaluation of naturalness, we should remember, is always an estimate (Del Favero *et al.*, 2000).

Table 29 Differences in composition: average value reported at regional scale and values calculated in the different sample areas. For every sample area the additional species (when compared to the ecologically coherent ones –only the beech in our case) are reported in the third column. In the case of the average for Mel Municipality the third column reports the complete list of the additional species registered in all the samples.

	Differences in composition	Additional species
Regional scale (Del Favero <i>et al.</i> , 2000)	0 (1)	
P14	+3 (1)	<i>Salix appendiculata</i> , <i>Sorbus aria</i> , <i>Picea excelsa</i>
P16	+5 (1)	<i>Salix appendiculata</i> , <i>Betula pendula</i> , <i>Sorbus aria</i> , <i>Salix caprea</i> , <i>Picea excelsa</i>
P20	+5 (1)	<i>Salix appendiculata</i> , <i>Betula pendula</i> , <i>Picea excelsa</i> , <i>Acer pseudoplatanus</i> , <i>Fraxinus ornus</i>
P28	+1 (1)	<i>Fraxinus ornus</i>
Average of the samples located in Mel Municipality beech coppices	+3,5 (1)	<i>Salix appendiculata</i> , <i>Picea excelsa</i> , <i>Betula pendula</i> , <i>Sorbus aria</i> , <i>Acer pseudoplatanus</i> , <i>Fraxinus ornus</i> , <i>Salix caprea</i>

4.5.2.2 Disturbance due to the type of management

The number of years retained to assure a certain recover of the coppice managed woods nemoral conditions is 30. The disturbance is calculated as the difference between this threshold and the cutting cycle usually adopted. Both on a regional scale and in our formations the disturbance deriving from management is therefore equal to 10, since the suggested rotation cycle in Del Favero *et al.* (2000) is 18-22 (therefore 20 years on average) and the prescriptions of the Forest Management Plan of Mel Municipality call for a 20 years rotation.

4.5.2.3 Average number of hemerophyte species

The presence of hemerophyte species, that is to say indicators of a certain degree of alteration of naturalness produced by human activity, allows to evaluate the impact induced on the forest by the coppice management.

The vegetal species considered for the assessment of this index have been divided into two categories, differentiated by the frequency they appear in concomitance with anthropogenic activities. The first category includes the synanthropic species, those which are always directly or indirectly diffused by Man, while to the second one, the “autoapophyte” group, belong all the species which are normally naturally present, but which are a sign of disturbance when they reach high coverage values (≥ 2 in Pignatti’s scale in our case).

Table 30 presents the number of hemerophyte species detected in every sample area, and the local average, divided by categories.

Table 30 Number of hemerophyte species present in the sample areas according to the list reported in Del Favero *et al.* (2000): in the second column the synanthropic species are highlighted (a), in the third those “autoapophytes” that can potentially indicate anthropic disturbance, in the fourth the number of these latter ones that have a coverage index ≥ 2 and in the fifth column the total number of hemerophyte species in every sample area. The last row shows the average for the area.

SA	Synanthropic (a)	Potential Autoapophytes	Autoapophytes with coverage index ≥ 2 (b)	N. of hemerophyte species (a+b)
P14	2	5	0	2
P16	1	4	0	1
P20	0	2	0	0
P28	0	0	0	0
Average	0,75	2,75	0	0,75

According to Del Favero *et al.* (2000), the average number of hemerophyte species at regional scale is 0,29, while in our assessment the resulting value is 0,75.

Our area seems therefore slightly more disturbed, which is not surprising if we recall that the regional average was calculated also including beech high forests, while differences emerge if we deal with coppices. Surely this is not the only influencing factor for the expected hemeroby degree, but floristic composition depend also on the different origin of the wood and on the position of the same with respect to meadows, pastures or arable land (Wulf, 2003; Dzwonko, 1993).

The two synanthropic species are *Galeopsis tetrahit* and *Taraxacum officinale*, both nitrophilous species good indicators of Man-disturbed habitats, and they are also the only

two species on which we can average the number of hemerophytes, since in the area no “autoapophyte” species were present with remarkable coverage.

These species, distributed in the four parcels as exposed in table 30, are 9 in total: *Cardamine impatiens*, *Euphorbia cyparissias*, *Hypericum perforatum*, *Moehringia trinervia*, *Rubus caesius*, *Rubus hirtus*, *Salix caprea*, *Solanum dulcamara* and *Urtica dioica*.

The number of hemerophyte species shows a significant negative correlation with the age of the plot both with respect to the total species - which equal the synanthropic ones ($r=-0,917$, $p<0,1$) - and if we refer to the potential “autoapophytes” ($r=-0,994$, $p<0,01$).

The number of potential “autoapophytes” furthermore positively correlates with the number of species registered in every relevé ($r=0,906$, $p<0,1$), and a similar relation links the total number of species and the total number of hemerophytes, although in this case the significance is lost for the non-constant variation over time, showing a sharper decrease from the third chronological stage (12 years of age). This can lead us to conclude that the maximum anthropogenic disturbance is experienced in the newly cut areas, followed by a slow gradual recover during the following years and a sharper decrease in disturbance indicators about 12 years after the cut, although we would probably need intermediate data at different coppice ages in order to better detail this trend. Interesting is however to notice that the mature stand is completely free of hemerophyte species, although as we’ve already specified, the indicator may be susceptible to the proper traits of the analyzed site and of its surroundings (for instance we might consider the proximity, within 1 Km as the crow flies, of a pastured mountain hut to the newly cut area P14).

On completion of the discussion about the disturbance degree of the system, a useful contribution comes from the introduction of the so called “*ancient species*”, on which different central European studies have concentrated in the last 20 years (Hermy *et al.*, 1999; Wulf, 1997, 2003; Dzwonko, 1993 and other Authors). These species can indirectly, through the indication of the naturalness of a forest, give a complementary information to what so far elaborated in this paragraph, showing in fact the continuative persistence of the forest on the site (and not of the age of the trees as the term “ancient” may lead to think).

The computation of their number, in absence of a list for southern Europe, was based on the publications produced for central Europe, in particular collected and coherently re-analyzed by Hermy *et al.* (1999).

In addition to this assessment, in table 31 is also reported the number - and percentage on the total registered species - of “*open species*”, that is to say plants of open spaces or

coming from forest margins, hedges or cultivated land, on which different Researchers have recently worked, as well (Peterken and Francis, 1999; Le Coeur *et al.*, 1999).

Table 31 Number of species included in the categories “ancient species” (according to Hermy *et al.*, 1999) and “open species” (Landolt index for light ≥ 4) and respective percentage on the total registered species in every 400 m² sample area.

	P14	P16	P20	P28	Average
N. "open species"	1	3	2	0	1,5
N. "ancient species"	20	27	19	9	18,8
N. total species	50	57	42	13	40,5
% open species	2,0	5,3	4,8	0,0	3,0
% ancient species	40,0	47,4	45,2	69,2	50,5

There is a clear tendency, with age of the coppice, toward the increase of the percentage of ancient species, although (as we’ve already had the chance to notice for different ecological factors) the two intermediate sites – P16 and P20 - show a very similar value, so that the correlation is not significant, being the increase not linear. On average, the percentage of ancient species in these beech coppices reaches 50%, which appears a considerable value, showing there has probably been a good persistence of forest environment over time.

This positive trend is a confirmation of Hermy *et al.* (1999) deductions on “ancient species” ecology, which affirms their higher shade-tolerant behavior. Other Landolt indexes calculated for the sites strongly confirm the Authors’ conclusions on the mesophile character of the “ancient species” with respect to pH, nutrients and humidity (see chapter 4.1), which here assume clear intermediate values and could well explain the high proportion of these species in the area.

Although the lowest value, the number of “ancient species” in the newly cut area appears still quite high, representing 40% of the total. This could also be due to the considerable release of standards observed in the area (see paragraph 4.5.1), which still maintain the shaded conditions necessary for the life of the more sciaphilous plants.

These category also show a positive significant correlation with the number of total registered species in every sample area ($r=0,969$, $p<0,05$) and with the geophyte group ($r=0,987$, $p<0,05$), which is more frequent among the ancient species, in fact, according to Hermy *et al.* (1999)

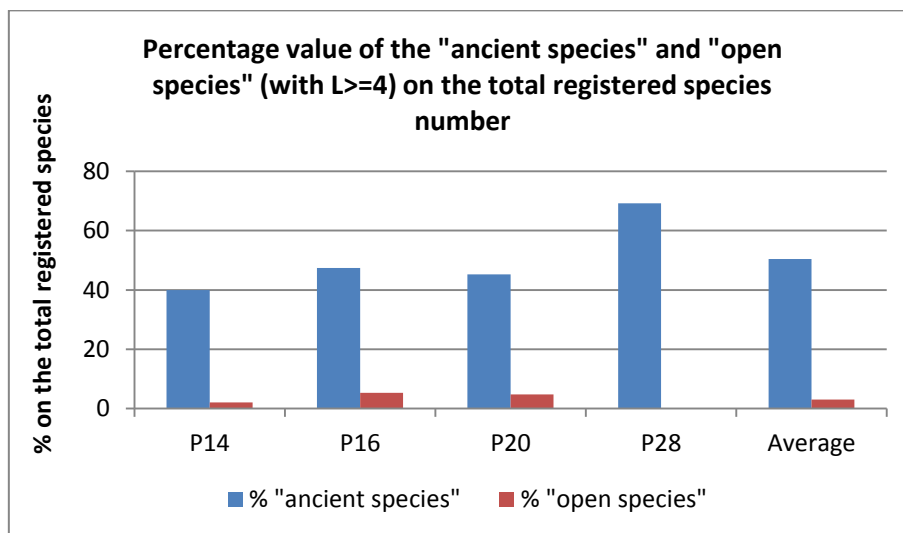
The “open species” apparently follow a stranger trend, as we would expect a higher percentage of their presence in the newly cut area, surpassed instead by the following stage (6 years old P16), after which the decrease is gradual and ends up in the absence of heliophilous plants in the mature compartment, as more comprehensible.

One reason for this low proportion of heliophilous species in P14 could be the connection, still very strong, with the floristic composition of the mature stand, which was dominating the site only until a few months ago, and which has probably still not completely abandoned its nemoral conditions. Furthermore, occurrences of heliophilous plants but actually more connected to other site characters (such as the birch in P16 and P20) can have an impact, in a not very rich sample, on this percentage data.

Once more, this type of coppice management seems to be able to maintain quite well the nemoral conditions through the important release of individuals that will protect the soil and very soon close the canopy to a full crown cover, as expressed by the very low average percentage of "open species", resulting in only 3% of the total.

The comparison between the percentages reached by the two categories in the different sample areas is better evident from figure 24.

Figure 24 Variation of the number of "ancient species" and "open species" in every chronological stage



4.5.3 Biodiversity indicators

4.5.3.1 Cohesion in the territory

DIFFUSION

The beech forests are in Italy concentrated in the whole Pre-alpine and external Alpine range, as far as the Liguria Region from which they start interest the Apennine and dissolve in Sicily, which boasts the last nucleus (Hofmann, 1991). In the Veneto Region (having a wooded surface of 414894 ha) these formation occupy the second place, after the *Ostrya* woods in general terms, with a surface of about 50106 ha, although the category is further subdivided in different forest types. They have, in fact, a remarkable diffusion also in terms of altitude, being present from the submontane up to the altimontane belt (Del Favero and Lasen, 1993).

In the Belluno Province (having a wooded surface of 221293 ha, about 53,3% of the regional data) the beech forests occupy the second place, after the spur forests and slightly above the larch and larch-arolla pine forests, with a surface of 32180 ha, the 14,5% of the provincial wooded surface and the 64,2% of the surface occupied by these formations in the Veneto Region (raw data from Various Authors, 2012).

The most part of these beech forests are actually managed as coppice, in the Veneto Region, for a main socio-economical reason (need for fire-wood), coupled with the high capability of the beech to sustain, with the requisites of soil and climate, this type of treatment (Hofmann, 1991). Today, however, many of these beech coppices are launched toward conversions into high forests.

The surface occupied, in the Mel Municipality property, by the beech coppice forest, is about 1402 ha, with a percentage incidence with respect to the wooded area, of about 81%.

A small percentage is then to be added to this data, in order to include the submontane and montane beech forests of the property managed as high forests.

DISTRIBUTION

The beech forests of the Veneto Region are merged in a substantially compact pattern.

Even if interrupted for geographic and orographic reasons (or, in the specific situation of the Pre-alpine chain by small pastures, mountain huts or similar private properties), the forest type still has a marked zonal character, expression of a generally defined climate (Hofmann, 1991).

The beech forests find in the Pre-alpine area of the Veneto Region the optimal sub-atlantic climate, and extend as far as the external slopes of the Cansiglio plateau.

In these context, then, the local climate influences the distribution of these formations, given the notable uniformity of other parameters (geo-pedological especially).

We can therefore conclude that the fragmentation of these habitats - constituting in the area a quite continuous belt - is, so far, not a significant problem for the maintenance of the ecosystems.

ACTIVE CONTAMINATION

In the Veneto Region the typical montane esalpic beech forest is described as a formation with low active contamination, and even in our sample no characteristic species can be considered aggressive in terms of invasive potential.

PASSIVE CONTAMINATION

According to Del Favero *et al.* (2000) the typical montane esalpic beech forest is characterized by an average passive contamination, which means that only one species of the surrounding formations can invade the formation in question. In general this species is *Picea aexcelsa*, although in the submontane belt the more thermophile *Robinia pseudoacacia*, far more aggressive, can easily enter the consortium and in rare cases reach the montane horizon. This is not the case, however, of our sample patches.

4.5.3.2 Management biodiversity standards

CHRONOLOGICAL-STRUCTURAL EQUILIBRIUM

The chronological-structural equilibrium is retained to be reached, for the purpose of optimal biodiversity, when individuals of all chronological stages are present in the forest complex. The minimal surface necessary for the purpose is dependent on the type of structure and corresponds, in the end, to the minimum "compresa", the forest management compartment which is the union of all the smaller silvicultural compartments on which the utilizations are planned. Biodiversity is this way increased (both in terms of species richness and form a landscape point of view) thanks to the mosaic structure, which including different development stages of the arboreal coenosis mimics the effects of natural disturbances (Puumalainen *et al.*, 2003, Noss, 1999).

The regional situation indicates, for this coppice managed montane beech forest, 4 chronological classes of 5 years amplitude and an average surface occupied by each class of 12,5 ha. The rotation here utilized is 20 years. In the case of 34 compartments of the coppice beech complex of Mel Municipality property, there is a unique management plan for the whole beech forest, although other forest types are present in addition to the typical montane esalpic beech forests, and those are: the typical submontane beech forest (14 compartments as the main type, 8 compartments as the secondary one), the submontane beech forest of the mesic soils (2 as the main type, 6 as the secondary one) and the typical altimontane beech forest (2 as the secondary type).

Del Favero *et al.* (2000) actually indicate a different chronological-structural asset for the typical submontane and altimontane beech forests (7 chronological classe of 4 years of amplitude and 10 ha per class), while the same we've seen for the typical montane beech forest is true also for the submontane beech forest of the mesic soils.

Considering, anyways, that the montane aspect is the most common in the property and that the same has for long been managed as a whole, we will choose here to discuss the asset proposed for this formation, although smaller percentage of other (similar) types are part of the complex.

Following this principle, the total surface occupied by the coppice formation (1402 ha) is divided by the minimum suggested rotation (17 years) in order to obtain the annual surface to be utilized (82,5 ha). Considering that the number of utilization compartments in which the coppice forest is divided is 34, the surface of a single utilization unit results 2,4 ha, which very much approximates the standard utilization surface indicated for a coppice by Del Favero *et al.* (2000). This surface can also be reduced by the fact that often the cuts are distributed in more than one year (Andrich *et al.*, 2002). On the whole, the chronological-structural balance of the forest complex is then to be considered good, for the contemporaneous presence in space of many successional stages, and even more diversified if we think that some compartments, in which the utilizations are delayed, easily reach 20 years of age (as the mature sample P28 of our survey). This longer rotation, as we've seen in paragraph 4.5.1, is actually the suggested one in the Forest Management Plan of the area, but since organizational and accidental delays are well known to happen, the choice was to set the maturity at 17, as the lower threshold, already often consciously exceeded.

VEGETAL SPECIES NUMEROSITY

The total number of herbaceous, arboreal and shrub species registered in every sample area is reported in table 32 and shown in figure 25.

The maximum species presence occurs in the 6 years old parcel, where there is an intermediate situation between a completely closed cover and more open areas produced from the last cut. This situation indicates, as different Authors suggest, that the ideal conditions for the presence of many species is in the ecotonal areas, where there is the contemporaneous presence of different habitats, which in the transition area produce, in addition, an attenuation of the limiting factors (Pignatti, 1995).

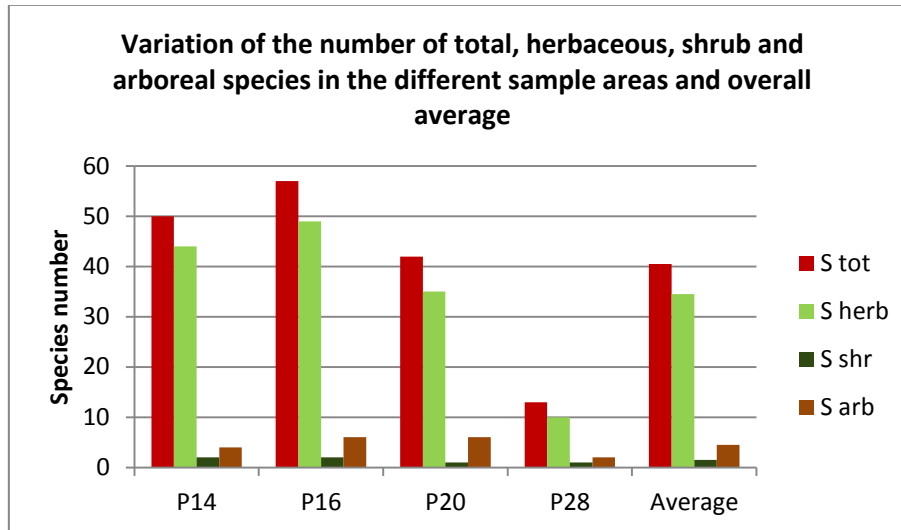
The number of species changes therefore also in dependence of the chronological stage of the coppice, defining a “variable” type, as Del Favero *et al.* (2000) report, which means that the number of species (in the Authours’ consideration only herbaceous) in the analyzed forest type is tendentially not constant over the years.

Considered the greater importance of the herbaceous layer, as more strongly influenced by the biophysical environment and its limiting factors (Susmel, 1988), we will here concentrate on this type of species richness - coherently with what chosen in Del Favero *et al.* 2000 work on biodiversity of the forest types at regional scale - from now on. Important is furthermore to notify that the herbaceous species represent here on average 83,6% of the overall composition. For the discussion on arboreal and shrub species, instead, the reference remains paragraph 4.4.1 and following.

Table 32 Specific diversity of the 400 m2 sample areas (SA) of different age. Number of total species (S tot), herbaceous (S herb), arboreal (S arb), shrub species (S shr) percentage of the herbaceous species on the total registered species (last column) in every area. The simbols D and S indicate respectively a dense (>70%) and scarce (>70%) A-stratus coverage.

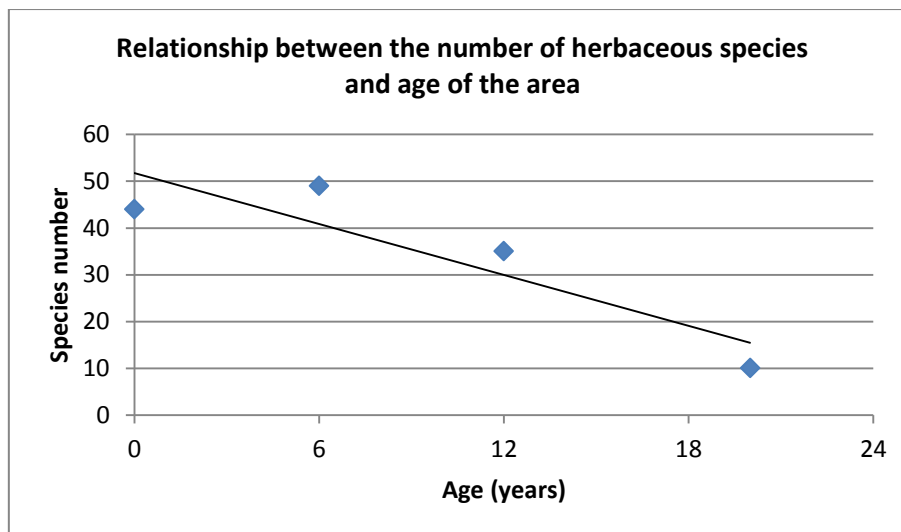
SA	age	Coverage	S tot	S herb	S shr	S arb	%S herb
P14	0	S (50%)	50	44	2	4	88,0
P16	6	D (80%)	57	49	2	6	86,0
P20	12	D (90%)	42	35	1	6	83,3
P28	20	D (90%)	13	10	1	2	76,9
Average		D (77,5%)	40,5	34,5	1,5	4,5	83,6

Figure 25 Variation in the number of total species (S tot), herbaceous (S herb), shrub (S shr) and arboreal species (S arb) in the different Sample Areas and average for locality.



Due to the peak of presences in the 6th year after the cut, the linear correlation coefficient between the age of the stand and the number of herbaceous species doesn't exceed the significance threshold. However, the two variables are negatively related (figure 26).

Figure 26 Variation of the number of herbaceous species throughout the different chronological stages



The beech forest in question appears quite rich in specific biodiversity, with an average species number of 41,3 calculated at regional scale and 40 in a situation where the forest type (the typical montane esalpic beech forest) experiences the minimum disturbance (Del Favero *et al.*, 2000). This number, however, appears richer than the average herbaceous species richness found in the sites located in Mel Municipality forest property (34,5), of about 7 species.

There is a great variability among the chronological stages, where the 20 years old sample approximates the regional average (42 species), while the younger sites quite strongly

exceed it (50 and 57 species) and the mature stand presents an impoverished composition (only 10 herbaceous species).

The comparisons with the regional data exposed in table 33 also show a striking difference in the number of herbaceous species registered in case of lowest disturbance, here poorer by 30 species than what regionally described. In this case, however, the choice to assimilate the oldest sample to the one with a minimum disturbance as intended by Del Favero *et al.* (2000) may be controversial, and could partially explain this huge difference. Furthermore, the differences in sampling quantities and modalities between the two works in addition to the geographical and site specificities of the area can also be part of the differences in the overall comparison. This appears particularly confirmed by the incredibly similar number, instead, of herbaceous species registered for the association *Dentario pentaphylli-Fagetum* (in Pignatti, 1998 described as *Cardamini pentaphyllae-Fagetum*) exposed with other parameters in table 33. We should, however, take cognizance of the previous data as a probable sign of the biodiversity impoverishment caused by the continuous coppicing disturbance. In this second comparison, in fact, although remaining within the same alliance, the number of species registered in the mature area appears again undisputedly low, if we look at the minimum number of species recorded by Pignatti (1998) which is 15 units higher (25 with respect to 10), and adding the fact that two different scales were chosen for the relevés (100 m² for Pignatti, 1998; 400 m² in our samples).

Table 33 Specific diversity: comparison between regional and local data. With the symbol D it is indicated a dense A-stratus cover (>70%).

	S herb - min. disturbance	Coverage	S herb - average	Interval (min-max)
Regional data (Del Favero <i>et al.</i>, 2000)	40	D	41,3	18-62
Average Mel SA	10	D (77,5%)	34,5	10-49
Cardamini pentaphyllae- Fagetum in Pignatti, 1998		D	35	25-51

BIRD SPECIES NUMEROSITY

Various Authors suggest the use of bird communities for biodiversity assessment purposes, for all the reasons better specified in paragraph 1.2, as their level in the food chain (Heath and Rayment, 2001) and the fact that they represent good wide-ranging indicators (Hansson, 2000), although they are to be considered only one aspect of the diversity of the forest fauna (Del Favero *et al.*, 2000).

Their dependence on foliage height diversity and plant species diversity (MacArthur and MacArthur, 1961; Ferrari *et al.*, 1996 in Del Favero *et al.*, 2000), however, they can indirectly provide interesting information on these parameters, to cross with other data differently collected and allow to draw more complete conclusions.

The opening or closure of the crown cover plays also a crucial role in the bird species that will prefer to frequent the different habitats (Bengtsson *et al.*, 2000), and therefore age of the coppice seem to be able to play a role, especially with respect to this crown density and disturbance. Actually, however, the behavior of birds with respect to these parameters is not so clear: Del Favero *et al.* (2000) indicate a general increase in number of bird species with forest age, in structurally similar forest types, but other Authors register a higher diversity in managed forests, and in particular in the first wood regeneration stages (Aubert *et al.*, 2003, Scarascia *et al.*, 2000). Surely a very variable landscape - as the one expressed by a mosaic of wood patches of different age and partially different structure created in a regularly managed coppice - can positively influence birds diversity, if the disturbance effects of utilization don't exceed the advantages produced by this differentiation.

Del Favero *et al.* report for the formation in question an almost constant average number of 25 bird species, ranging only from a minimum of 23 to a maximum of 27.

When compared to the other coppice formations of the forest property (submontane beech forests - "Faggeta submontana", alti-montane beech forests - "Faggeta altimontana", *Ostrya carpinifolia* woods - "Orno-ostrieto", hornbeam with *Ostrya* woods - "Carpineto con *Ostrya*", Post cultural maple-ash woods - "Aceri-frassineto con *Ostrya*" and maple-linden forest - "Aceri-tiglieto di versante") which all present an average bird species number of 20, this type presents a higher ornithic diversity.

In the analyzed area, however, according to Andrich *et al.* (2002), the nesting birds community appears quite simplified (*Cuculus canorus* and *Anthus trivialis* for instance), but if we consider also the immediately surrounding area, the enrichment is quite significant, including both common species (such as *Turdus merula*, *Sylvia atricapilla*, *Fringilla coelebs*, *Troglodytes troglodytes* etc.) and rarer ones (such as *Falco peregrinus* and *Aquila chrysaetos*). The regular presence of *Bubo bubo* is also attested among the night birds of preys, and other species also frequent the area with spectacular mass flights over, such as *Apus apus*, *Delichon urbica* and *Apus melba*.

Particularly interesting, as we will see later, is in addition the presence of *Tetrao tetrix* and *Alectoris graeca* in the biotope.

4.6 QUALITIES

4.6.1 Naturalistic quality

4.6.1.1 Floristic quality

The beech forests of the municipality of Mel are not particularly known for their peculiar floristic quality.

Major naturalistic value assume the residual peat bogs of the near pre-alpine reliefs, and some rare species are indicated in the Special Protection Area called “Dorsale Prealpina tra Valdobbiadene e Serravalle” (IT3240024) to which part of the territory belongs, as the species *Saxifraga petraea* (indicaed also by Del Favero *et al.* (2000) as a particularly vulnerable species and an indicator of floristic quality for the montane esalpic beech forest) which unfortunately seems not to reach exactly the forest property of Mel.

No species listed in the valuable ones for the Veneto Region (Del Favero *et al.*, 2000) are present in the area, although if we consider the Red List produced for the Belluno Province, the following plants living in the analyzed forest complex have been recorded as NR - Near Threatened (Argenti and Lasen, 2004): *Aremonia agrimonioides*, *Calamintha grandiflora*, *Philadelphus coronarius*, *Polystichum setiferum*, *Vicia oroboides* and *Scrophularia vernalis*. Of these, only one – *Calamintha grandiflora* – was registered within one of the four chosen sample areas, and particularly in sample P16. All other species, however, vegetate nearby and were just not detected in the 400 m² relevé areas.

In addition, some rare Pteridophytes (especially hybrids) were signaled in the forested valleys and headlands belonging to Mel municipality, and precisely (Marchetti, 2006):

- *Polystichum x wirtgenii* (= *setiferum x braunii*) - Val Fontane (Mel), signaled by Argenti C. and Viane R.;
- *Polystichum x bicknellii* (= *aculeatum x setiferum*) - Val di Calt and Val Fontane (Mel), signaled by Argenti C.;
- *Polystichum setiferum* – Val d’Arc, Val Fontane, Cordellon, Val di Calt (Mel), signaled by Argenti C.

In spite of these considerations, the floristic quality of the area, when calculated with Del Favero *et al.* (2000) categories, results null in the area, since there are no species

pertaining to the following groups: protected species (according to the LR 53/74 art.7), rare species at national level, rare species at regional level (Conti, 1997 in Del Favero *et al.*, 2000), endemic species and species at the limit of their distribution area.

This indicator is therefore lower than the one indicated by Del Favero *et al.* (2000) for the forest type in question, equal to 1 at regional scale.

If we try to explain the absence, here, of the three species of a certain floristic value potentially present in the typical montane esalpic beech forest according to Del Favero *et al.* (2000), we can observe how the above mentioned *Saxifraga petrea* prefers to vegetate in fresh areas of more southern slopes of the prealpine chain - avoiding therefore the analyzed area – while *Ilex aquifolium* and *Helleborus niger* have well-known large gaps in this pre-alpine chain (although being the second present on the opposite side mountain chain of the Piave River).

4.6.1.2 Vegetational quality

The vegetational quality of the typical montane esalpic beech forest is described for the Veneto Region as “average”.

However, this forest type is here in its optimum area, expressing the climax succession stage. The phytogeographic importance is here therefore very low, not being a rarity at all.

In the forest complex of the Mel municipality forest property, we can affirm that the element that can assume a certain vegetational value are those of *Tilio-Acerion*, observed in the gorge environments of Val d’Arc and other close localities, rarer and richer in noble broadleaves, therefore also more diversified with respect to the marked monospecific character of the pure beech forests. These habitats are, in fact, also a priority habitat of the European Habitat Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora).

4.6.1.3 Faunistic quality

The evaluation of the faunistic quality is here based, in accordance with Del Favero *et al.* (2000), on the ornithic species, including those only temporarily frequenting the area, here abundant during the spring and autumn migration periods. For a wider spectrum discussion about the faunistic richness of the area, please refer to paragraphs 2.6 and 4.4.8.

Birds of particular faunistic value can be divided into species the habitats of which must be protected according to the national and communitarian legislation and the species considered rare or protected for a certain territory.

Table 34 Faunistic quality, at regional scale, of the forest type: typical montane esalpic beech forest (Del Favero *et al.*, 2000). The species in green are those of communitarian interest (Birds Directive - Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds)

	Typical montane esalpic beech forest (Del Favero <i>et al.</i> , 2000)
Indicator species of protected habitat	11
Species of protected habitat	<p><i>Pernis apivorus</i>, <i>Accipiter gentilis</i>, <i>Accipiter nisus</i>, <i>Buteo buteo</i>, <i>Bonasia bonasia</i>, <i>Tetrao urogallus</i>, <i>Glaucidium passerinum</i>, <i>Aegolius funereus</i>, <i>Strix aluco</i>, <i>Dryocopus martius</i>, <i>Dendrocopos major</i></p>
Other valuable species	<p><i>Columba palumbus</i>, <i>Phylloscopus sibilatrix</i></p>

The indicator for species of protected habitats and the other valuable species indicate a quite important quality of the forest type in question.

The analyzed territory presents a discrete faunistic diversity, as well, and almost all the above listed species have been described for the area, with the exception of the Hazel Grouse (*Bonasia bonasia*) and the Eurasian Pygmy-owl (*Glaucidium passerinum*) which presence has not been ascertained and excluding the Wood Warbler (*Phylloscopus sibilatrix*) which prefers to live at lower altitudes and fresher environments (Andrich *et al.*, 2002; Varaschin M, personal communication). All the species of communitarian interest (in green in table 34) are present in the studied area, and an extra one has been ascertained in addition to Del Favero *et al.* (2000) list: the black grouse (*Tetrao tetrix*), which – unique among the species listed in table 34 - frequents also the young coppice, while all other prefer the mature, aged coppice or even the high forest (in the case of *Aegolius funereus* exclusively the high stand).

Particularly interesting is, here, the migration of diurnal birds of prey, which from August to October fly over the area in number of some thousands individuals mostly represented by

the above listed European Honey Buzzards (*Pernis apivorus*) and Common Buzzards (*Buteo buteo*).

This last species has furthermore been personally observe more than once during the field surveys and a nest has been detected in the area which indicates the stable presence and reproduction of the species, while the Common Woodpigeon (*Columba palumbus*) has been heard singing in sample area P20.

Other species, although not included in the valuable species list, that were personally observed or recognized through the songs thanks to the field presence of an expert (Varaschin M.) are the following: *Troglodytes troglodytes*, *Erithacs rubecula*, *Turdus viscivorus*, *Turdus merula*, *Turdus philomelos*, *Sylvia atricapilla*, *Cuculus canorus*, *Fringilla coelebs*, *Phoenicurus phoenicurus*, *Periparus ater* and *Dendrocopos major*.

The ornithic community is then enriched by the ascertained presence, in the forested area of Mel, of the following bird species: *Phylloscopus collybita*, *Periparus ater*, *Poecile montanus*, *Aegithalos caudatus*, *Sitta europaea*, *Garrulus glandarius*, *Nucifraga caryocatates* and *Corvus corone* (in the nearby of meadows).

Scolopax rusticola and *Coccothraustes coccothraustes* are present as migratory species and *Fringilla montifringilla* only as wintering species.

Some species, present in the forest property, live however preferably in conifer habitats and these are: *Regulus regulus*, *Regulus ignicapilla*, *Lophophanes cristatus*, *Certhia familiaris*, *Pyrrhula pyrrhula* and *Loxia curvirostra* (for the first two species single conifer plants or small groups within the beech forest is enough to make the habitat suitable for them).

4.6.2 Chromatic quality

For the assessment of the indicator of chromatic quality the reference is, as usual, chapter 3. In table 35 the situation of the forest type in question at regional scale is reported (Del Favero *et al.*, 2000).

In the areas object of our study, the indicator of chromatic quality has been calculated referring to all the arboreal and shrub species, registered in the 400 m² sample areas, which present eye-catching flowering and/or variations in the foliage color.

Table 35 Chromatic quality at regional scale, compared with that of the sample areas analyzed for the same forest type in the beech coppice forest of Mel Municipality (BL).

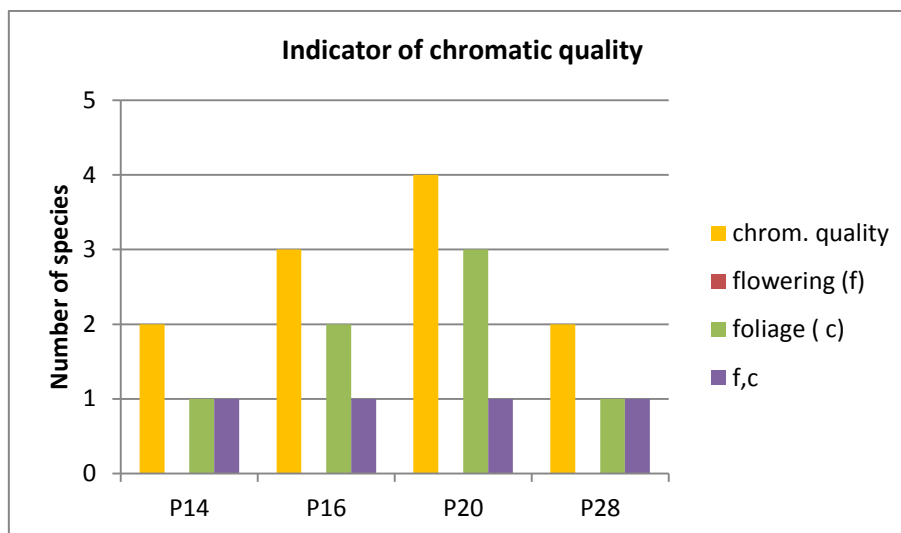
	Typical montane esalpic beech forest (Del Favero <i>et al.</i> , 2000)	Mel SAs
Indicator of chromatic quality	2,74	2,75
Species of chromatic quality	Acer pseudoplatanus, Fagus sylvatica, Fraxinus ornus, Sorbus aria, Cornus sanguinea, Daphne mezereum, Fraxinus excelsior, Laburnum alpinum, Laburnum anagyroides, Larix decidua, Prunus avium, Viburnum lantana	Acer pseudoplatanus (c), Fagus sylvatica (c), Fraxinus ornus (f,c), Sorbus aria (f,c), Betula alba (c)

These formations usually don't have a very important chromatic value, one of the lowest in the Veneto Region forest types picture, although 2-4 species with these characteristics are hardly ever missing in the consortium. We should however remember how in these formations the absolute number of arboreal and shrub species is much lower than in other forest types, and when we consider the proportion of species of chromatic interest relative to the total, it is not negligible, reaching almost half of the composition (48,7 % on average).

The average value of the indicator of chromatic quality for the analyzed area, as evident from table 35, results basically equal to that proposed in literature, setting at 2,75 if we also include the species *Betula alba*, absent from Del Favero *et al.* (2000) list as a species proper of the formation, but considered of chromatic value by the same Authors.

Fagus sylvatica is obviously the constant in the four sample areas of different age, while all other species change, counting a minimum of two species of chromatic interest in a sample (in the youngest and oldest compartments) to a maximum of four (in P20, 12 years old stand).

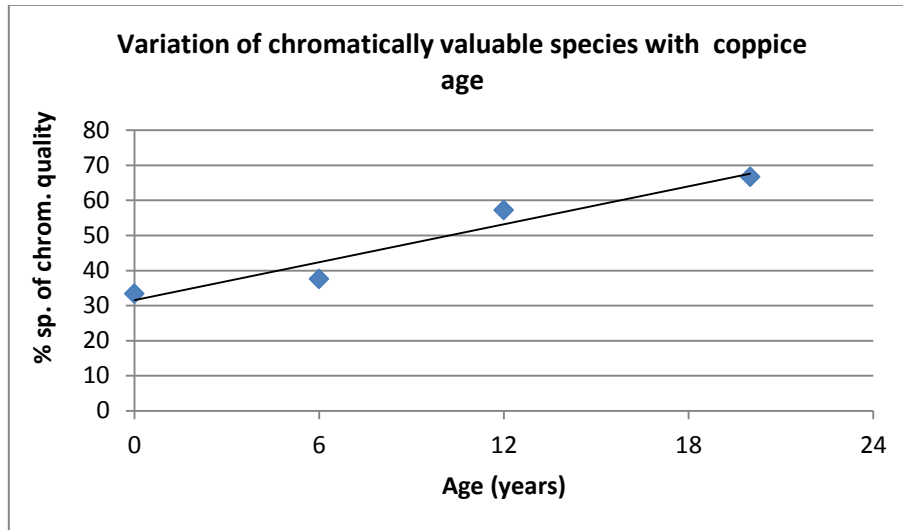
Figure 27 Indicator of chromatic quality, intended as number of species which present foliage color variation (c), particular flowering colors (f) or both (f,c)



In the above graph (figure 27), it is interesting to notice how no species are considered of chromatic interest for their flowering only, but two of them (*Sorbus aria* and *Fraxinus ornus*) present both peculiarities. The most evident chromatic effect of these formations, however, is based on the colour variation of the foliage of some trees (no shrub species is included), and therefore these formations are better “coloured” in the autumnal season than in early spring (March-May) when *Fraxinus ornus* flowers and the early summer (May-July) when it is *Sorbus aria* to produce an interesting bloom.

The temporal distance from the cut seems to have a positive impact in the number of species of chromatic value, with a drastic reduction, though, in the last sample, which apparently shows an equal composition to the youngest stand. However, if we consider the percentage of species of chromatic quality with respect to the total number of arboreal and shrub species of the sample, the trend is clearly an increase with age, as evident in figure 28 below ($r=0,971$, $p<0,05$).

Figure 28 Variation of the number of arboreal and shrub species valuable from a chromatic point of view (f+c) with the age of the coppice



Although it is true that trees and shrubs are those that confer the most important chromatic characters to the forest type, we can also add that the plants of the herbaceous layer, with the blossom of some eye-catching flowers or fruits, may be equally interesting for the coloration of the underwood, especially in spring when the geophytes appear before trees emit their covering foliage.

4.7 SUSCEPTIBILITY TO NATURAL CALAMITIES

4.7.1 Forest fires

The typical montane esalpic beech forest is considered, at regional scale, a typologic unit of average-low fire risk. Also in the analyzed area this problem is not particularly felt, since the recurrence of the calamity is not frequent.

The indicator considers the “pirologic potential”, which is described as the prediction of the destructive force of a fire combined with the estimate of the probability of the same to occur in the current conditions (Bovio and Camia in Del Favero *et al.*, 2000).

The value of the pirologic potential (calculated as a regional average on the base of parameters like forest region, altitude, aspect, position, slope, traits of arboreal, shrub and herbaceous species) for this forest type in the region is averaged to 20, in a scale ranging from 6 to 37. For the same formation, the “fuel model”, that is a model of fire propagation behavior and a better insight in the probability of its trigger (considering more in detail the alive and dead vegetation characteristics), is indicated as 3. These models were identified by Rothermel in number of 13 (Rothermel, 1972 in Del Favero *et al.*, 2000) then experimentally recalculated with the addition of new parameters (about the forest stands characteristics) by the Veneto Region.

Fundamental in this sense is the quantity of dead wood in the stands.

Regarding the standing dead poles, in our sample areas there was an average of 225 dried out shoots per ha, higher in the two extreme chronological classes and lower in the intermediate ones, all of medium diameter.

Concerning, instead, the more important dead wood on the ground (mostly residues of utilizations and crushed material) a non-negligible quantity has been noticed in all stands, clearly higher in the newly utilized area and the 6 years old compartment, where it hasn't yet had the time to decay completely.

In general, according to the forest management plan of the area, the removal of prunings is mandatory in order to prevent forest fires, but if the fire trigger and development probability (and therefore the pirologic potential) is low and the tolerance of the stand is high this can be avoided. This is why sometimes leaving utilization residues in the coppiced area is here considered a good practice, which avoids the Phosphorous impoverishment coming for the biomass removal and permits a better maintenance of the biogeochemical cycles of the forest systems.

Furthermore, dead wood can provide an appropriate establishment for tree species in certain forest types (Standovar and Kenderes, 2003), therefore the compromise between ecological functions and fire prevention is never a one-for-all decision.

4.7.2 Other calamities (wind- and snow-breakages)

The formation stability has been evaluated by Del Favero *et al.* (2000) according to the following criteria: soil depth of 40-80 cm (intermediate class); superficial or obstructed root system although the beech presents good anchorage; monoplane, regular and full-coverage structural tendency.

In our local situation, the soil depth even lower, falling almost in the first class <40 cm (30-50 cm in all the four sample areas), therefore increasing the breakages probability.

Regarding the root system of the beech, we can affirm it has robust main roots and secondary ones that go vertically deeper into the soil in fertile soils. However, in more superficial soils also the root apparatus doesn't become deeper.

Finally, the monoplane structure has been confirmed in the analyzed stands, which reaches very soon full crown cover after few years from the cut, thanks to the extremely high number of standards left uncut. This synthetic index of the height-diameter relationship (essential for the definition of tree stability) indicates a certain vulnerability to wind-breakages especially, since a better poly-stratified structure could improve the collective resistance of the wood to these abiotic events. However, being the forest regularly managed through the described coppice system, there is hardly ever a situation of excessive density which could further damage the stand vigor, and only some too thin standards or uncompetitive poles were observed to be broken, probably mainly in concomitance with strong wind events, more than for the limited snow experienced the past winter.

4.8 FLORISTIC RICHNESS AND OTHER INDEXES OF α -DIVERSITY

This paragraph will expose the results obtained in the assessment of the diversity degree of each relevé according to formulas and indexes described in chapter 3.

While interpreting these data, we must not forget that the dimension of the sample area highly influences the number of species registered and therefore final floristic richness results (Weaver, 1995).

4.8.1 Floristic richness

The maximization of “species richness” –a variable at the basis of many models of community structure representing the simplest way to describe community and regional diversity (Magurran, 1988) - is often one of the main goals of conservation studies (May, 1998). The term refers to the number of species registered in a given sample, representing the basic indicator of the α -diversity assessment.

This paragraph will deepen the discussion exposed in the previews section 4.5.3.2 about the “vegetal species numerosity”, exploring here the results obtained in the 10 m² transects located in each sample area and observed throughout the season.

Table 36 reports the maximum number of species registered during the vegetative period within each transect, while for the complete floristic list the reference is Annex 4.

Table 36 Number of species registered throughout the vegetative season in the 10 m linear transects of the different sample areas (Tot sp/trans), maximum number of species registered in a unique relevé (Max sp) and correspondent date/period (Date max), minimum number of species registered in a unique relevé (Min sp) and correspondent date/period (Date min)

Sample area	P14	P16	P20	P28
Age (years)	0	6	12	20
Tot sp/trans	40	31	20	6
Max sp	40	31	19	6
Date max	27 Jun- 12 Jul	27 Jun	12 Jul	12 May- 12 Jul
Min sp	25	16	9	4
Date min	27 Apr- 12 May	13 Apr- 27 Apr	13 Apr- 27 Apr	7 Aug- 15 Sept

Considering all the four transects, 57 species were registered, while the average number of species per area, within the 10 m² relevé, is 24,25, a very poorly significant value if we consider the wide range it assumes from 6 (in the mature area) to 40 (on the newly cut

one). Significant is, instead, the negative correlation of this variable with age, shown in figure 29 ($r=-0,999$, $p<0,01$).

The “disturbance” factor is essential for the definition of the floristic richness of an area, which stimulated the studies of many different Authors (Ash and Barkham, 1976; Lenssen *et al.*, 2000; Mishra *et al.*, 2004 etc.).

The floristic richness as the result of physical (fires, storms, silvicultural management...) and biological (predation, competition...) disturbances has been explained by Main (1999) through the following scheme (table 37):

Table 37 Likely species richness in ecosystems as a result of interactions between disturbances of physical (e.g. fire, storm) and biological (e.g. predation, herbivory, disease) origin.

From Main, 1999

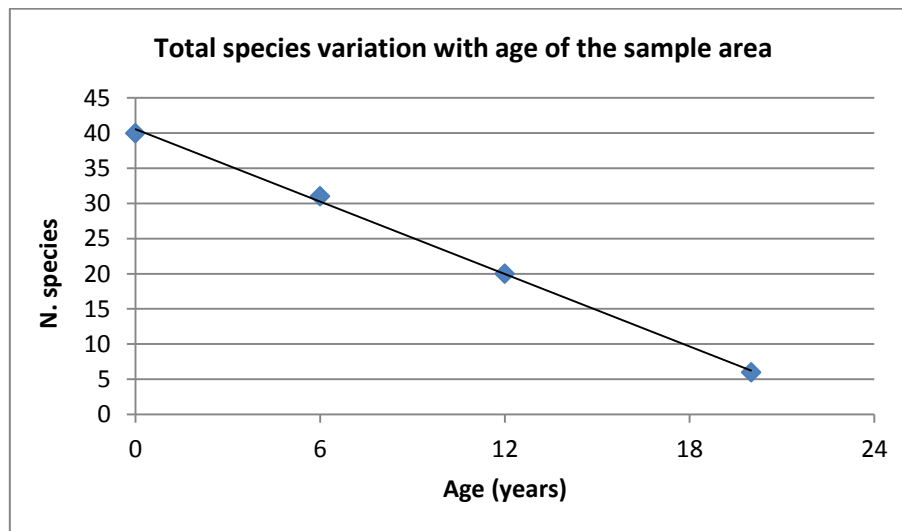
Biological	Intensity of physical disturbance		
	Infrequent	Moderate	Intense
Rare or slight	Few dominant or long lived species	Species richness maintained by disturbance	Few species tolerant of stress
Moderate	Species rich: species intolerant of physical but tolerant of biological disturbances	Highest species richness	Species presence determined by tolerance of physical stress; richness maintained by biological factors
Very intense	Species poor: dominated by species tolerant of grazing or predation	Richness determined by response to moderate physical disturbance and tolerance of grazing or predation	Species poor: species presence determined by tolerance to physical and biological factors

In literature, different models of species variation over time can be found, the most important of which are well summarized by Howard and Lee (2003).

The data collected and elaborated in the present research (table 36) tend to follow the model proposed by Egler (1954), the so called “initial floristic composition model of succession”: according to the Author all species are present at the beginning of the succession, but they manifest at different times (germinating and expressing earlier or later in the succession) and some of them are eliminated over time, so that biodiversity is tendentially higher at the beginning of the succession rather than at the end. Other Authors

hypothesize that this trend can be explained by the “sample size effect”, meaning that the size of the individuals augment with community ageing and therefore, as an effect of decreased density, a correspondent decrease in biodiversity occurs: longer living, larger and slower growing plants eventually outcompete smaller pioneer species.

Figure 29 Variation of the total species registered in 10 m² transects as a function of stands age



We have already discussed the fact that forest management can influence species composition and the dominance of some species over others.

In general, some researchers have demonstrated how floristic richness is often higher in managed ecosystems or in artificial stands, rather than in primary forests, and in our case it seems to be particularly true that more open spaces favor a higher resource availability.

This is true, obviously, only if we are talking about all the possible species and we are not exclusively concentrating on the nemoral ones, which are instead positively related with management practices abandonment (Wulf, 2003) to the detriment of the pioneers of the first seres. The coppicing type of management, especially, favors the maintenance of a high floristic richness, increasing also the reactivity of the herbaceous layer (depending more tightly on stand dynamics) opposite to the selective thinning which instead favors few, dominant species and maintains similar conditions over time.

Different theories, however, have been built on the topic, disproving Elgar (1954) approach and proposing, for instance, a peak in specific richness curve 3-4 years after the cut, as confirmed by researchers' results (Howard and Lee, 2003; Auelair and Goff, 1971 in Howard and Lee, 2003; Ash and Barkham, 1976; Mason and MacDonald, 2002; Riondato, 2004). Actually, in the sampling set of this work we are lacking an intermediate compartment of 3-4 years, which could better confirm this second theory, as far as we

know, showing in that stage a higher species number than in the newly cut area and impeding us to decisively exclude the adherence of this situation to the above exposed model.

Nonetheless, a common point reached by these two models (which are, moreover, not the only ones) is the following: the visible negative trend toward lower values of species richness with forest ageing, which is also the experience of the present analysis. This is due not only to the age of the stand itself, but also to the arboreal and shrub cover which can significantly limit the richness of the herbaceous layer through shading (Wohlgemuth *et al.*, 2002). This result is also reached in the beech coppice sample areas located in Mel municipality, where the negative correlation is confirmed also with the basal area ($r=-0,916$, $p<0,1$) and with the volume per hectare ($r=-0,945$, $p<0,1$). According to Schaffers (2002), high biomass values are more detrimental to species richness than high productivity levels, due to a competition for light and space, keeping constant the environmental stress level which is a major limiting factor.

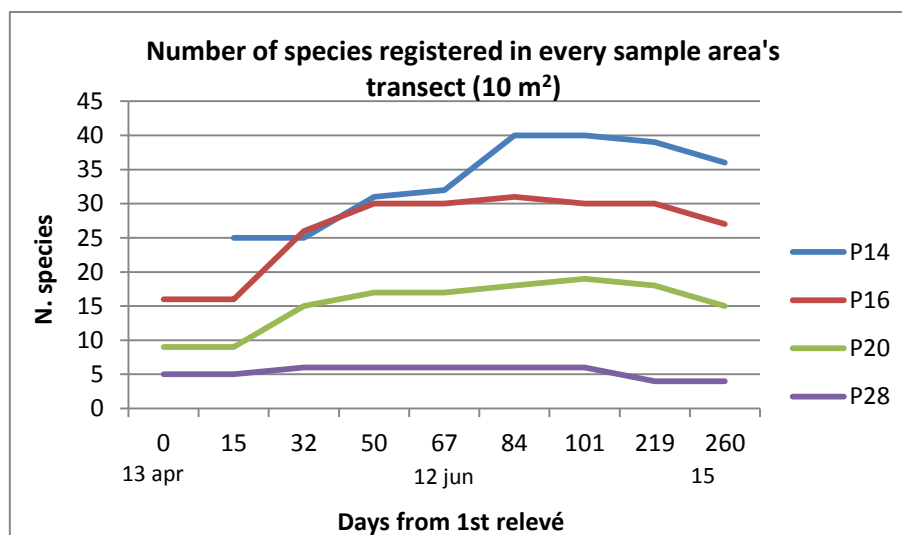
From table 36 we can also deduce that, at least for the analyzed formation, the number of species recognized during the most favorable period (when the maximum number is registered) approximates very well (in three cases even equals, and in one case is only one unit lower) the total species present, suggesting therefore a quite contemporaneous vegetative development of the different botanical entities. In practice, this consideration could be useful for the field surveys planning, since often the opportunity to repeat the relevé more than once during the year, although more rigorous from a scientific point of view, results in practice hard to combine with the time and resources at disposal in a project (Lasen, 1998).

Important is to notice, however, the difference of these data with those exposed in section 4.5.3.2, which reported the number of species registered in the 400 m² sample areas: in this larger samples the total number of species goes up to 84 – therefore more than double the resulting richness in 10 m² transects - and the average per sample is 40,5, again almost two times higher. The problem of the reference scale is well known in this field of studies, since often happens that only a part of the species present in a given ecosystem is actually counted in such a sampling (Bengtsson, 1998).

An interesting consideration, instead, is the fact that the newly cut area alone provides 70% of the total species, probably indicating that many of the additional species (when compared to the floristic richness of the other three stands) are the more heliophilous

ones, or those which appeared as a consequence of disturbance produced by management, often appearing only as single plant or very low number of individuals. The number of species registered in the following chronological stage (6 years old), however, remains still quite high (still more than half the total), since probably the high spatial heterogeneity of the sites – created by the different niches produced in an intermediate succession stage – favors the competitive force of normally subordinate species (Grime, 1987 in Lenssen *et al.*, 2000). This seems to be confirmed by other studies, where the floristic richness is correlated with the type of territory management, so that coppices can present higher biodiversity values than the corresponding high forests (Ito *et al.*, 2004).

Figure 30 Number of registered species in every floristic relevé (10 m²) throughout the vegetative period (13 April - 15 September)



The culmination of the number of species during the season shows some differences in dependence of the age and site characters of the forest stands, and the same is true for the floristic enrichment or impoverishment trend throughout the season (figure 30).

The two younger stands (P14 and P16) have the same culminating date (27th June) and a similar enrichment pattern: they both show sharper increases in species number at the beginning of the season (the newly cut area then shows an extra increase towards the end of June) and an almost parallel stabilization and decrease in September. The lack of data for P14 on the 13th April is due to the complete snow cover present in this stand (higher in altitude) on that date, which impeded the relevé.

The 20 years old parcel doesn't move away too much from this trend, as well, although culminating about 2 weeks later, probably as a consequence of the slower vegetative rhythm of the species when under thicker forest foliage cover.

The mature stand shows, as always, a very different behavior, maintaining an almost constant species number, with slight variations following the progress of the season, culminating very early (12 May) thanks to the higher percentage of geophytes – but this data can also be partially spoiled by the lower altitude of this more thermophile sample – and reaching the minimum already at the beginning of August.

However, by comparing the number of species registered in every relevé with the total for the complete season we can extract an indication about the best period for floristic surveys: in the analyzed area this seems to be from the end of June to the middle of July, when all samples (P20 more toward the end of this period) show more than 95% of the total species.

We can affirm, however, that the end of the vegetative quiescence is almost contemporaneous in all the four samples, which can be also attributed to a compensation of the different site characters, especially age and altitude: the youngest area is also the highest in latitude and the mature one is by chance the lowest, so where the vegetative season could start earlier (in P14) due to the greater amount of light entering the consortium, the snow remains longer and the temperatures are more limiting; vice versa happens for the oldest compartment.

4.8.2 Complexity indexes

For every 10 m² transect, the Margalef and Menhinick complexity indexes were calculated, relating the number of individuals and the number of species registered within it.

Increases in this index value indicate a high complexity degree of the system, as well intended as equal repartition of resources among the species.

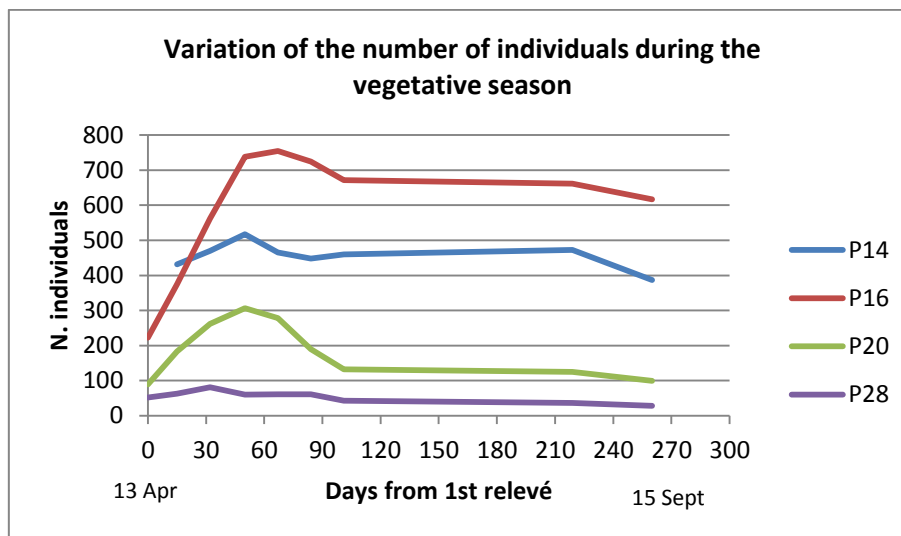
Table 38 reports the values assumed by the different indexes calculated on the basis of the sum of the maximum number of individuals registered for every species, with the exception of those for which the distinction of genetically different individuals proved impossible (see chapter 3 for more details).

Annex 5 shows the complete list of the values for every single relevé carried out during the vegetative season.

Table 38 Indexes of complexity: values calculated on the number of individuals. S_{tot} indicates the number of species registered in the 400 m² sample areas, S_{10} the number of species registered in the 10 m² transects, N the maximum number of individuals (intended as the sum of the maximum number reached by every species), S the number of species of the transect used for the assessment of these indexes.

	P14	P16	P20	P28
Age (years)	0	6	12	20
S_{tot}	50	57	42	13
S_{10}	40	31	20	6
N	760	810	350	83
S	40	29	19	6
complexity				
Menhinick	1,451	1,019	1,016	0,659
Margalef	13,538	9,627	7,468	2,605

Figure 31 Number of individuals registered during the season. In the case of sample area P14 the interruption of the curve at the beginning April is due to the presence of snow on the ground which impeded the floristic relevé



Analyzing the number of individuals during the season in the different 10 m² transects we can try to explore their growth model (figure 31). All samples, with the exception of the mature one which we will later discuss about, show a decisive increment in the number of individuals in the second half of May. This is surely also connected to the significantly higher number of species present in these plots if compared with those registered in the mature compartment, which leave little margins for marked changes in number of individuals. This parameter, in fact, proves here to be quite constant throughout the season, ranging from 28 to 81 individuals only, at least half of which are belonging to a unique species - *Vinca minor* – although the increase from 63 individuals up to the peak (81) occurs in the same period as the other samples (a little anticipated, to be precise), still showing a similar trend, once the correct proportions are made. The fact that the culmination in number of individuals is gradually slightly anticipated with the increasing age

of the stand is to be attributed to the higher presence of the Geophytes (such as *Cyclamen purpurascens*, *Anemone trifolia*, *Cardamine enneaphyllos* and *Geranium nodosum* among those with the denser coverage) which appear earlier than other plants.

The presence of dominant species (as the geophytes monopolizing the underwood composition) brings to the fall of the Margalef index (P28 as the minimum, with *Vinca minor* monopolizing), while higher values of the index indicate situations of higher diversity (P14 as the maximum, with a more equal distribution of the number of individuals per species). This relation is confirmed by the significant decrease of this complexity index with the increase in geophytes ($r=-0,955$, $p<0,05$). Remaining in the biological forms discussion, there is also a significant correlation of the index with the Phanerophyte group, which depresses diversity ($r=-0,984$, $p<0,05$).

The Margalef index shows therefore a significant decrease with age of the stand ($r=0,998$, $p<0,01$), with an extremely wide range of values from 13,54 in the newly cut area to the 2,61 of the oldest one.

Analyzing the variation of the Margalef complexity index over time, calculated for each date of relevé (figure 32) we can distinguish periods with dominance of a species (lower values of the index) from those with greater diversity (higher values of the index for a more equal distribution of individuals among the species). In the three younger areas, in fact, after the early explosion of the Geophytes at the beginning of the season, diversity grows higher in correspondence with the settlement of new species and the gradual numeric reduction of *Anemone trifolia*, *Cardamine enneaphyllos* and *Geranium nodosum*.

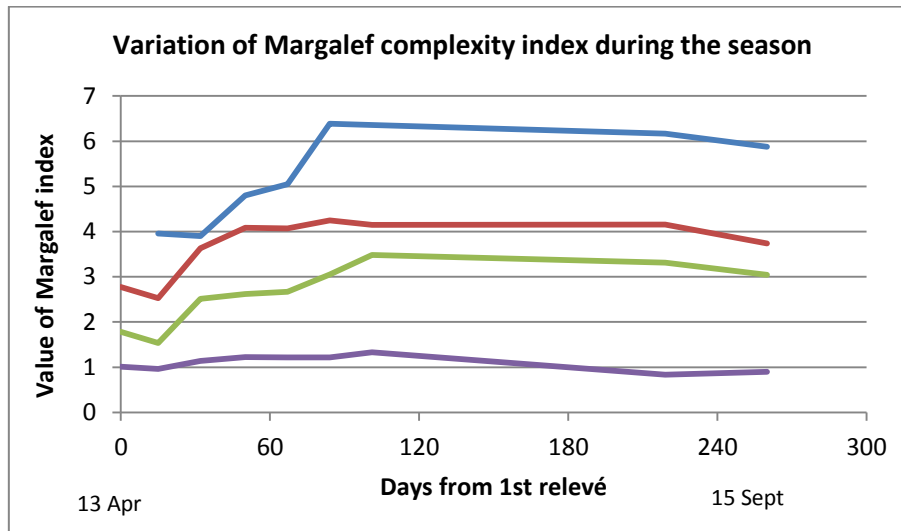
The oldest compartment, once again, shows a different behavior, with an almost constant value of the index, indicating a repartition of individuals per species all shifted to the sole *Vinca minor*, as already discussed above.

These trends of the Margalef index show very similar to the variation in number of individuals throughout the season exposed in figure 31, indicating a good correspondence between the two indicators.

The maximum complexity values occur around the end of June for P14 and P16, while the culmination is shifted to the middle of July for the two oldest samples, P20 and P28.

The minimum values are, of course, those registered at the start of the season, when vegetative winter has just gone.

Figure 32 Variation of Margalef complexity index over time during the relevés carried out in the different dates



4.8.3 Diversity indexes

The α -diversity assessment of the area has been carried out through the use of Shannon (H') and Simpson (1-D) indexes - among the most employed ones for the scope - on the basis of the number of individuals registered in each 10 m² transect. The second index, in particular, performs well in disturbed areas, according to Onaindia *et al.* (2004), who also suggest to use (1-D) instead of the original D index, less intuitive (see paragraph 3.3.2).

The two indexes are obviously strictly correlated, since they're based on the same variables, but they present substantial differences: Shannon's H' is more sensible to species richness, while the more abundant species have stronger impact on D Simpson index.

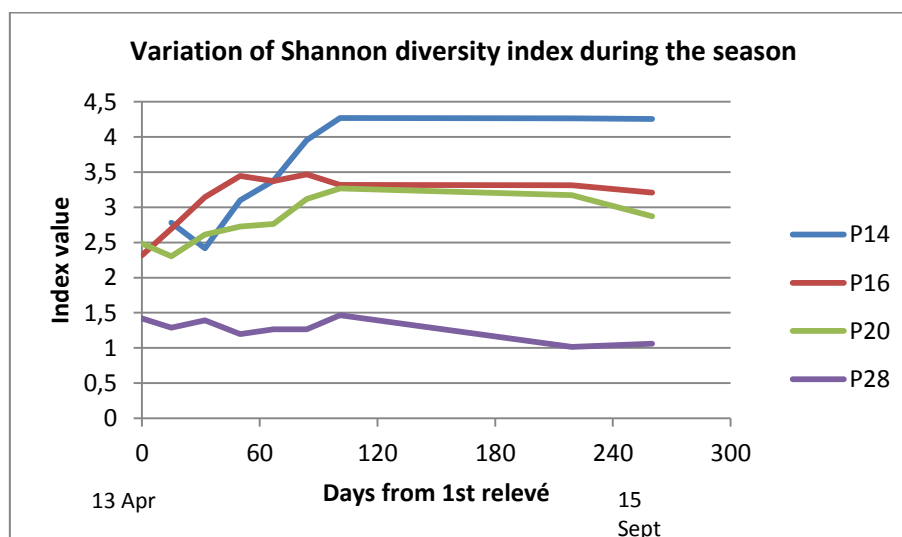
Annex 5 remains the reference for the complete visualization of the values calculated throughout the vegetative period.

Table 39 reports the values assumed by Shannon and Simpson's indexes in the four sample areas, while figure 33 and 34 report respectively Shannon index seasonal variations and the values assumed by the two indexes with compartments' age.

Table 39 Indexes of diversity: values calculated on the number of individuals. S_{tot} indicates the number of species registered in the 400 m² sample areas, S_{10} the number of species registered in the 10 m² transects, N the maximum number of individuals (intended as the sum of the maximum number reached by every species), S the number of species of the transect used for the assessment of these indexes.

	P14	P16	P20	P28
Age (years)	0	6	12	20
Stot	50	57	42	13
S10	40	31	20	6
N	760	810	350	83
S	40	29	19	6
diversity				
Shannon H'	3,718	3,452	2,925	1,431
Simpson (1-D)	0,859	0,859	0,824	0,487

Figure 33 Variation of Shannon diversity index (H') over time during the relevés carried out in the different dates

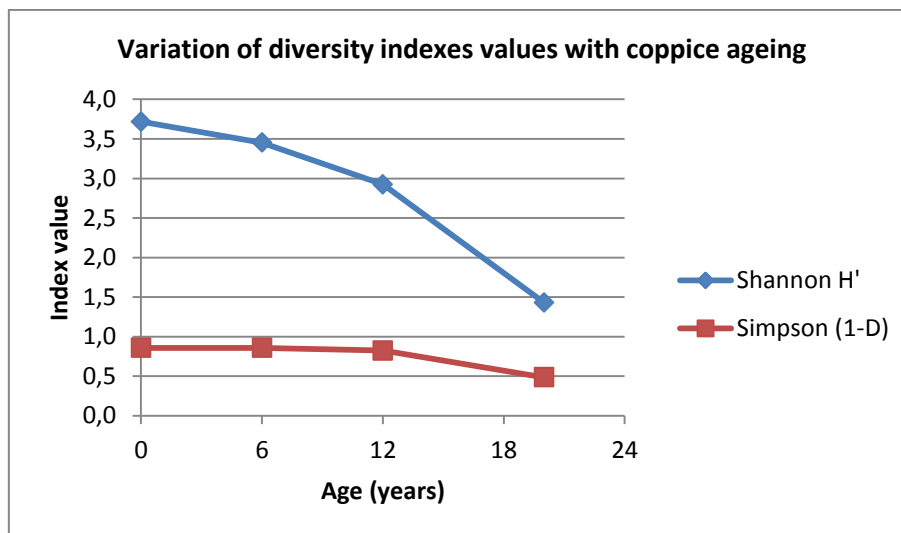


The Shannon diversity index draws even nearer the behaviors of the two central stages of coppice, P16 and P20, which show a very similar trend, with the exception of the earlier and faster diversity enrichment demonstrated by the newly cut area. Beyond this consideration, the trend over time of this index is very similar to that of Margalef complexity index. Notable is, again, the very poor diversity of the oldest area, P28, which is moreover the only one to reach the minimum diversity values in fall, at the end of the vegetative season rather than at its start. This can be connected to the fact that about 50% of the herbaceous strata is composed by Geophyte species, having an anticipated explosion and an earlier end, accordingly. Confirming the results obtained for the complexity index, then, Geophytes accompany less diversified stands ($r=-0,992$, $p<0,01$).

Regarding Simpson's (1-D) index, the higher the value the greater the sample's diversity (the index represents the probability that two individuals randomly selected from a sample will belong to different species): as expected, the index decreases with age of the plot.

The same is true, with different scales, for the Shannon's index (conceptually quantifying the uncertainty in predicting the species identity of an individual that is taken at random from the dataset), which confirms these results and the theory of maximum floristic richness in succession phases close to the disturbance (in this case the last coppicing intervention) exposed at the beginning of this chapter.

Figure 34 Shannon and Simpson's indexes variation in the sample areas of different age



4.8.4 Evenness indexes

The evenness index, complementary of richness in defining diversity, indicates how equal (or even) the community is numerically. It is a standardized index, so compared to Shannon and Simpson's indexes it tends to remove the influence of species numerosity (Neuman and Starliger, 2001).

The evenness index is here calculated through the Shannon index (the so called Pielou index, J') and the Simpson index (1-E) for every relevé of the vegetative period in the transects and (table 40) on the maximum number of individuals of each.

The complete results are available in Annex 5.

Figure 35 and 36 report respectively the seasonal variations of the evenness index calculated on Shannon's diversity (J') and the values assumed by both evenness indexes with compartments' age.

The very evident fall in Pielou index (figure 35) observable at the end of May in P14, right after an equally remarkable peak of evenness (index close to 1), is due to the vegetative explosion of *Anemone trifolia* - reaching 21 individuals/m² – before all other species have grown to their final density.

As we can see from figure 36, then, Simpson's index intensifies the differences existing among the sample areas in the more or less equal repartition of individuals and in particular the role of the least performing one (P28). It is in fact more responsive to the dominant cover type (Harini, 2002)

Table 40 Indexes of evenness: values calculated on the number of individuals. S_{tot} indicates the number of species registered in the 400 m² sample areas, S_{10} the number of species registered in the 10 m² transects, N the maximum number of individuals (intended as the sum of the maximum number reached by every species), S the number of species of the transect used for the assessment of these indexes.

	P14	P16	P20	P28
Age (years)	0	6	12	20
Stot	50	57	42	13
S10	40	31	20	6
N	760	810	350	83
S	40	29	19	6
evenness				
Pielou J'	0,699	0,711	0,689	0,554
Simpson (1-E)	0,855	0,854	0,814	0,384

Figure 35 Variation of Pielou Evenness index (calculated on Shannon's diversity H') over time during the relevés carried out in the different dates

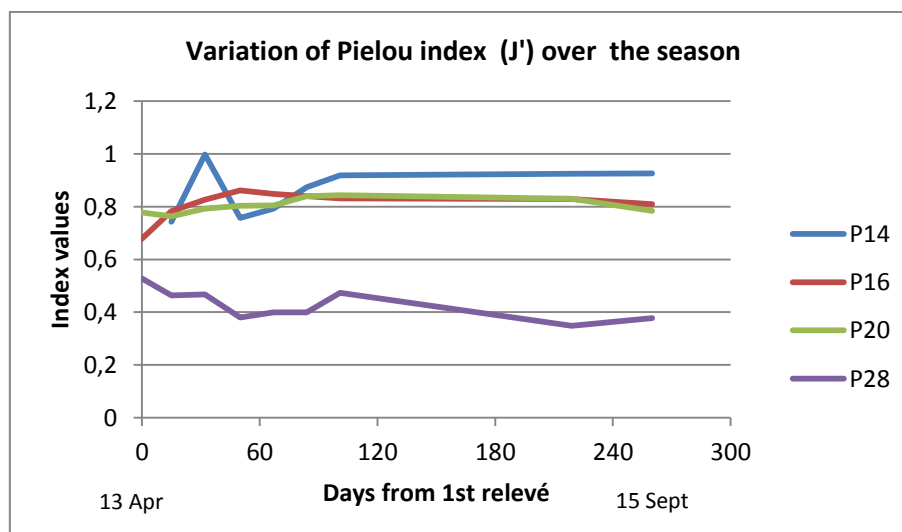
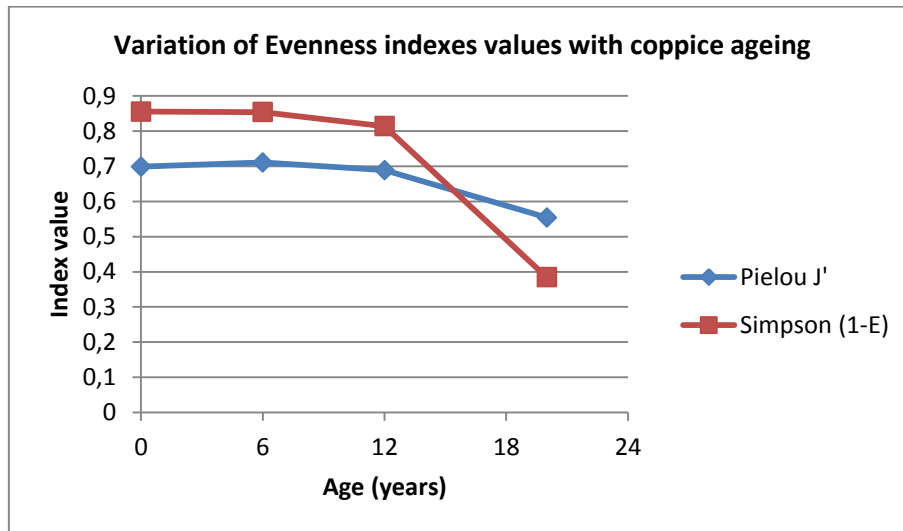


Figure 36 Pielou and Simpson's evenness indexes variation in the sample areas of different age



5. CONCLUSIONS

The study of the differences in biodiversity (and other characteristics of the environment and their alterations) existing along a forest age gradient have only recently been an object of forest ecology and silviculture.

Even the reference publication on biodiversity indicators on the scheme of which the present work was built (Del Favero *et al.*, 2000) considers the situation of mainly mature formations (coppices and high forests).

The lack of knowledge about biodiversity variations in stands of different chronological stages incentivized this research, where the same indicators were calculated and compared among coppices of different age (four stages from the newly coppiced to the mature situation) pertaining to the type “typical montane esalpic beech forests”.

The variability of the number of species along the forest cultural cycle reported by Del Favero *et al.* (2000) for this formation is confirmed by the results.

The most adherent model in explaining this trend is in this case the one elaborated by Egler (1954) for the ecological successions, which attributes the peak in specific diversity to the first phases after disturbance has occurred: in this case, that refers to much shorter time process, the disturbance is the coppicing cut, which leaves enough standards and “tirasucchi” to allow anyways differentiated ecological situations within the stand. A gradual and constant decrease during the cycle brings then the floristic richness to its minimum values under the maximum forest cover, probably until the formation of new openings (due to natural mortality of the shoots) can allow its recovery, before the new cut is done. In our situation, the mature 20 years old sample is not so old and still presents full crown cover, so it didn't allow demonstrating this last consideration about the entrance of new species in natural clearings.

This is confirmed by the trend of the diversity indexes of Shannon and Simpson, which show similar variations, with maximum values reached right after the cut, although an intermediate stage (between 0 and 6 years old) would be necessary to confirm this affirmation.

The number of herbaceous species is by far the most sensitive to forest age changes, while that of tree species results quite constant and characteristic of the formation, ranging from 3 to 6 species per sample area (400 m²), probably thanks to the higher inertia of the arboreal vegetation but also due to the past silvicultural practices that tend to simplify the composition of this strata.

The total number of specific entities registered in the four 400 m² sample areas (84) can be considered quite high, although the average number of herbaceous species registered in a single compartment (34,5) is slightly lower than the one indicated by Del Favero *et al.* (2000) at regional scale for a formation of the same type experiencing the least disturbance (40).

Although the four sample areas have been accurately selected in order to minimize the site differences among them, it would surely be interesting and useful, for the future, to deepen the knowledge about the relations existing between different site conditions and the specific diversity of the same forest type. Furthermore, the type of treatment to which the different stands have been subjected (in spite of the rigorous and clear forest management plan interesting the area) and their consequently different silvicultural history can introduce an additional variable on the assessment of the differences existing among the areas. Another future goal, as a consequence, would be the possibility to study more in depth the effects of different management systems on the same forest type and their different variations over time and stand age.

Another important consideration concerns the confusion sometimes existing between biodiversity and naturalness. The investigated case confirms how an increase in species number doesn't necessarily signify a higher level of naturalness: the number of hemerophyte species demonstrates to be considerably higher in the first stages after the coppicing disturbance, when the floristic richness is maximum.

The quite good recovery of the nemoral conditions in the compartment close to the end of the cutting cycle is testified by the higher proportion of species belonging to the *Quercus-Fagetea* class and the complete disappearance of the more synanthropic elements (*Galio-Urticetea* and other ruderal species) or those characteristic of forest edge, with a wider ecology (*Epilobietea-angustifolii* and *Mulgedio-Aconitetea*).

Although with different species, the plant life forms show a clear tendency, with coppice age, toward a dominance of the Geophytes and Phanerophytes, while the Terophytes disappear very early in the succession.

The Eurasiatic elements hold the undisputed majority among the chorological categories, making up for more than half of the present chorotypes, followed by the boreal ones. Interesting is to notice how, although these two elements prove very similar in proportion to the ones proposed by Pignatti (1988) for the same phytosociological association (*Cardamini pentaphyllae-Fagetum*), the multizonal species perform much better in the sample areas located in Mel Municipality (BL), implying a negative sign of disturbance including predominantly synanthropic species.

From a naturalistic point of view the most interesting elements are by far the closeness to precious and rare (although localized) gorge environments, afferent to other forest types but surely influent in the overall composition of the forested complex of Mel Municipality, where the beech wood detains the unquestioned supremacy. Maintaining for a moment a wider view on the forest property in question, we can affirm that major naturalistic importance is assumed by the spatial (and probably also temporal) continuity of the beech formation and the forested area in general, rarely interrupted by other land uses types. The beech formations are here, moreover, in their optimum *facies* and therefore correspond to the typical beech forest formation, disregarding the management disturbances.

The low chromatic value of these formations (2,75), expressed by Del Favero *et al.* (2000) chromatic quality indicator, is strictly confirmed in the explored site (average of 2,74 species in 400 m²), although 2-4 arboreal species with eye-catching characteristics in the foliage or flowering colors are hardly ever missing in the consortium. Moreover, if also the herbaceous layer was included in this evaluation these formations would surely appear more interesting from this point of view, considering the early white flowering of *Anemone trifolia*, followed in sequence by the violet *Geranium nodosum* and the scented fuchsia late explosion of *Cyclamen purpurascens*.

In conclusion, the coppicing management as so far carried out proves to be a successful silvicultural choice not only from a productive point of view, but also in terms of landscape diversification, with the existence of all chronological stages in a wide forest complex, which - in addition to what so far exposed - favors a consistent ornithic diversity thanks to the mosaic of different wood patches which provide differentiated services (such as shelter and food for the grouses).

Of course, the age of the stands is greatly reduced in comparison with a high forest management type which comes closer to the functional permanence time of the trees, but this disadvantage is partially compensated by the effort of releasing a good number of standards, to which the function of guaranteeing the presence of individuals well on in years is delegated. The possibility to maintain good biodiversity levels in the herbaceous layer (while the arboreal one could result more simplified by the coppicing practice) appears guaranteed and in general terms there seems not to be extreme impacts of the management on the numerosity of species considered of floristic quality, probably also thanks to the abundant release of standards and shoots which very soon allow the nemoral conditions recovery.

From a naturalness and structural point of view it would, instead, be interesting to see the development of a beech high forest in the area, given that it should and could acquire new

functions other than the fire-wood production, which in the short term remains the most socially and economically convenient treatment.

Finally, the choice is surely not only between coppice and high-forest management, but within the type of treatment the careful selection of objectives and strategies. Such could be the choice, aiming at improving the forest complex from a compositional structural point of view, of preserving the ecological processes and elements typical of more natural forests and favoring the survival of a more differentiated arboreal component.

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ANNEXES

ANNEX 1: Dendrometric data

Table 2.1 Number of stems/ha registered in every sample area (400 m²) distributed in diameter classes

Diam. class	Limits (cm)	P14	P16	P20	P28
2	1-3	400	1300	1125	75
4	3,1-5	275	500	625	450
6	5,1-7	325	350	275	475
8	7,1-9	300	275	300	425
10	9,1-11	100	125	175	200
12	11,1-13	100	250	100	250
14	13,1-15	75	125	25	150
16	15,1-17	100	50	125	125
18	17,1-19	50	100	75	100
20	19,1-21	25	25	50	50
22	21,1-23	25	125	125	100
24	23,1-25	25	0	50	50
26	25,1-27	0	0	0	0
28	27,1-29	0	0	0	0
30	29,1-31	0	0	0	75
32	31,1-33	25	0	0	0

Table 1.2 Basal area: percentage contribution of the different diameter classes

SA	P14	P16	P20	P28
Age	0	6	12	20
Diam. Class				
2	0,89	2,24	1,87	0,08
4	2,46	3,45	4,15	1,99
6	6,54	5,43	4,11	4,73
8	10,73	7,58	7,97	7,53
10	5,59	5,39	7,26	5,54
12	8,05	15,51	5,97	9,96
14	8,21	10,56	2,03	8,14
16	14,30	5,51	13,28	8,86
18	9,05	13,96	10,08	8,97
20	5,59	4,31	8,30	5,54
22	6,76	26,07	25,10	13,40
24	8,05	0,00	11,95	7,97
26	0,00	0,00	0,00	0,00
28	0,00	0,00	0,00	0,00
30	0,00	0,00	0,00	18,68
32	14,30	0,00	0,00	0,00

Table 1.3 Hypsometric measures: heights measured for the assessment of average height, dominant height including standards and shoots' dominant height

P14		P16		P20		P28	
Diam. (cm)	H (m)	Diam. (cm)	H (m)	Diam. (cm)	H (m)	Diam. (cm)	H (m)
7,6	8,0	6,4	7,0	7,0	10,0	9,1	8,5
7,6	8,5	6,7	7,5	7,2	9,0	9,2	9,0
8,0	9,5	6,7	7,0	7,3	11,0	9,2	8,5
15,3	12	18,2	13	17,8	13	18,0	15,0
16,2	13,5	18,2	15,5	18,3	14,5	20,4	15,5
17,2	13	18,2	14,5	18,5	15	21,5	16,5
18,8	15,5	18,8	15	19,1	15	21,5	17,0
21,0	13,0	22,0	16,0	21,0	16,0	22,9	19,5
21,3	13,5	22,0	16,0	23,1	14,5	23,9	18,0
23,9	15,5	22,6	17,5	23,2	16,5	23,9	18,0

ANNEX 2: List of the registered species

BOTANICAL FAMILY	SPECIES: name according to the Checklist of the Italian Vascular Flora (Conti <i>et al.</i> , 2005)	PLANT LIFE-FORM	COROTYPE	SYNTAXON (Class/Order)
Aceraceae	<i>Acer pseudoplatanus</i> L.	P scap	European-Caucasian	Querco-Fagetea/Fagetalia
Adoxaceae	<i>Adoxa moschatellina</i> L.	G rhiz	Circumboreal	Querco-Fagetea/Fagetalia
Apiaceae	<i>Angelica sylvestris</i> L. s.l.	H scap	Eurosiberian	
	<i>Sanicula europaea</i> L.	H scap	Mont. S European s.str.	Querco-Fagetea/Fagetalia
Apocynaceae	<i>Vinca minor</i> L.	Ch rept	European-Caucasian	Querco-Fagetea/Fagetalia
Aspidiaceae	<i>Dryopteris filix-mas</i> (L.) Schott	G rhiz	Subcosmopolitan	Querco-Fagetea
	<i>Dryopteris gr.carthusiana</i> (Vill.)	G rhiz	Circumboreal	Querco-Fagetea
	<i>Gymnocarpium dryopteris</i> (L.) Newman	G rhiz	Circumboreal	Querco-Fagetea/Fagetalia
	<i>Polystichum aculeatum</i> (L.) Roth	G rhiz/H ros	Eurasiatic s. str.	Querco-Fagetea/Fagetalia
Aspleniaceae	<i>Athyrium filix-femina</i> (L.) Roth	H ros	Subcosmopolitan	Querco-Fagetea
	<i>Cystopteris fragilis</i> (L.)	H caesp	Cosmopolitan	
Asteraceae	<i>Hieracium murorum</i> L.	H scap	Eurosiberian	Querco-Fagetea
	<i>Lapsana communis</i> L.	T scap	Paleotemperate	Galio-Urticetea/Lamio albi-Chenopodietalia boni-henrici
	<i>Petasites albus</i> (L.) Gaertn.	G rhiz	Mont. S European s.str.	Querco-Fagetea/Fagetalia
	<i>Prenanthes purpurea</i> L.	H scap	European-Caucasian	Querco-Fagetea
	<i>Senecio ovatus</i> (P. Gartn., B. Mey. & Scherb.) Willd. S.l.	H scap	Central-European	Querco-Fagetea/Fagetalia
	<i>Solidago virgaurea</i> L.	H scap	Circumboreal	
	<i>Taraxacum officinale</i> Weber	H ros	Circumboreal	
Betulaceae	<i>Betula pendula</i> Roth	P scap	Eurosiberian	Querco-Fagetea/Quercetalia roboris
Boraginaceae	<i>Myosotis sylvatica</i> Hoffm.	H scap	Paleotemperate	Querco-Fagetea/Fagetalia
	<i>Pulmonaria officinalis</i> L.	H scap	Central-European	Querco-Fagetea/Fagetalia
	<i>Symphytum tuberosum</i> L.	G rhiz	Pontic	Querco-Fagetea/Fagetalia
Brassicaceae	<i>Cardamine impatiens</i> L. subsp. <i>impatiens</i>	T scap	Eurasiatic s. str.	Querco-Fagetea/Fagetalia
	<i>Cardamine enneaphyllos</i> (L.) Crantz	G rhiz	SE European	Querco-Fagetea/Fagetalia
Campanulaceae	<i>Phyteuma spicatum</i> L.	H scap	Central-European	Querco-Fagetea/Fagetalia
Caprifoliaceae	<i>Lonicera alpigena</i> L.	P caesp	Mont. S European s.str.	Querco-Fagetea/Fagetalia
Caryophyllaceae	<i>Moehringia trinervia</i> (L.) Clairv.	T scap/H scap	Eurasiatic s. str.	Querco-Fagetea/Fagetalia
	<i>Stellaria nemorum</i> L. subsp. <i>montana</i> (Pierrat) Berher	H scap	European-Caucasian	Querco-Fagetea/Fagetalia

Celastraceae	<i>Euonymus europaeus</i> L.	P caesp	Eurasian s. str.	Querco-Fagetea
Corylaceae	<i>Corylus avellana</i> L.	P caesp	European-Caucasian	Querco-Fagetea
Cyperaceae	<i>Carex digitata</i> L.	H caesp	Eurasian s. str.	Querco-Fagetea/Fagetalia
Ericaceae	<i>Vaccinium myrtillus</i> L.	Ch frut	Circumboreal	Vaccinio-Piceetea
Euphorbiaceae	<i>Euphorbia amygdaloides</i> L.	Ch suffr	European-Caucasian	Querco-Fagetea/Fagetalia
	<i>Euphorbia cyparissias</i> L.	H scap	Central-European	
	<i>Euphorbia dulcis</i> L.	G rhiz	Central-European	Querco-Fagetea/Fagetalia
Fabaceae	<i>Lathyrus vernus</i> (L.) Bernh.	G rhiz	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Vicia sylvatica</i> L.	H scap	Eurosiberian	Trifolio-Geranietea
Fagaceae	<i>Fagus sylvatica</i> L.	P scap	Central-European	Querco-Fagetea
Geraniaceae	<i>Geranium nodosum</i> L.	G rhiz	Mont. S European s.str.	Querco-Fagetea/Fagetalia
Guttiferae	<i>Hypericum hirsutum</i> L.	H scap	Paleotemperate	Epilobietea-angustifolii
	<i>Hypericum montanum</i> L.	H caesp	European-Caucasian	Querco-Fagetea/Quercetalia pubescentis
	<i>Hypericum perforatum</i> L.	H scap	Paleotemp./subcosmop.	
Juncaceae	<i>Luzula nivea</i> (L.) Lam. et DC.	H caesp	Mont. S European s.str.	Querco-Fagetea/Fagetalia
Lamiaceae	<i>Calamintha grandiflora</i> (L.)	H scap	Mont. S European s.str.	Querco-Fagetea/Fagetalia
	<i>Galeopsis tetrahit</i> L.	T scap	Eurasian s. str.	
	<i>Lamium galeobdolon</i> L. subsp. <i>flavidum</i> (F. Herm.) A. Löve & D. Löve	H scap	European-Caucasian	Querco-Fagetea/Fagetalia
	<i>Salvia glutinosa</i> L.	H scap	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Stachys sylvatica</i> L.	H scap	Eurosiberian	Querco-Fagetea/Fagetalia
Liliaceae	<i>Maianthemum bifolium</i> (L.) Schmidt	G rhiz	Circumboreal	
	<i>Paris quadrifolia</i> L.	G rhiz	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Polygonatum multiflorum</i> (L.) All.	G rhiz	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Polygonatum verticillatum</i> (L.) All.	G rhiz	Eurasian s. str.	Mulgedio-Aconitetea
Oleaceae	<i>Fraxinus ornus</i> L.	P scap	Pontic	Querco-Fagetea/Quercetalia pubescentis
Onagraceae	<i>Epilobium montanum</i> L.	H scap	Eurasian s. str.	Querco-Fagetea/Fagetalia
Orchidaceae	<i>Dactylorhiza maculata</i> (L.) subsp. <i>fuchsii</i> (Druce) Hyl.	G bulb	Paleotemperate	
	<i>Neottia nidus-avis</i> (L.) L. C. Rich.	G rhiz	Eurasian s. str.	Querco-Fagetea/Fagetalia
Oxalidaceae	<i>Oxalis acetosella</i> L.	G rhiz	Circumboreal	
Pinaceae	<i>Picea abies</i> (L.) H. Karst.	P scap	Eurosiberian	Vaccinio-Piceetea
Poaceae	<i>Calamagrostis varia</i> (Schrader) Host	H caesp	Eurasian s. str.	
	<i>Festuca altissima</i> All.	H caesp	Central-European	Querco-Fagetea/Fagetalia
	<i>Melica nutans</i> L.	H caesp	European-Caucasian	Querco-Fagetea/Fagetalia
Polypodiaceae	<i>Polypodium vulgare</i> L.	H ros	Circumboreal	Querco-Fagetea/Quercetalia roboris
Primulaceae	<i>Cyclamen purpurascens</i> Miller	G bulb	Mont. S European s.str.	Querco-Fagetea/Fagetalia

Ranunculaceae	<i>Actaea spicata</i> L.	G rhiz	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Anemone trifolia</i> L. s.l.	G rhiz	Mont. S European s.str.	Querco-Fagetea/Fagetalia
	<i>Hepatica nobilis</i> Miller	G rhiz	Circumboreal	Querco-Fagetea
	<i>Ranunculus serpens</i> Schrank subsp. <i>nemorosus</i> (DC.) G. López	H scap	S European-S Siberian	
Rosaceae	<i>Aruncus dioicus</i> (Walter) Fernald	H scap	Circumboreal	Querco-Fagetea/Fagetalia
	<i>Fragaria vesca</i> L.	H rept	Eurosiberian/cosmop.	Epilobietea-angustifolii
	<i>Rosa pendulina</i> L.	NP	Mont. Central-European	Mulgedio-Aconitetea/Adenostyletalia
	<i>Rubus caesius</i> L.	NP	Eurasian s. str.	Querco-Fagetea/Fagetalia
	<i>Rubus hirtus</i> Waldst. & Kit.	NP	European	
	<i>Rubus idaeus</i> L.	NP	Circumboreal	Epilobietea-angustifolii
	<i>Sorbus aria</i> (L.) Crantz	P caesp	Paleotemperate	Querco-Fagetea
Rubiaceae	<i>Galium laevigatum</i> L.	H scap	illiric	Querco-Fagetea/Fagetalia
Salicaceae	<i>Salix appendiculata</i> Vill.	P caesp/P scap	Central-European	Mulgedio-Aconitetea/Adenostyletalia
	<i>Salix caprea</i> L.	P caesp/P scap	Eurasian s. str.	Epilobietea-angustifolii
Saxifragaceae	<i>Chrysosplenium alternifolium</i> L.	H scap	Circumboreal	Querco-Fagetea/Fagetalia
Scrophulariaceae	<i>Scrophularia nodosa</i> L.	H scap	Circumboreal	Querco-Fagetea/Fagetalia
	<i>Veronica officinalis</i> L.	H rept	Eurasian s. str.	
	<i>Veronica urticifolia</i> Jacq.	H scap	European	Querco-Fagetea/Fagetalia
Solanaceae	<i>Solanum dulcamara</i> L.	NP	Paleotemperate	
Thelypteridaceae	<i>Phegopteris connectilis</i> (Michx.) Watt	G rhiz	Circumboreal	
Urticaceae	<i>Urtica dioica</i> L.	H scap	Subcosmopolitan	
Violaceae	<i>Viola riviniana</i> Rchb.	H scap	European	Querco-Fagetea/Fagetalia

LEGEND

Code	Description
Pscap	Phanerophyte -scapose
G rhiz	Geophyte - rhizomatous
H scap	Hemicryptophyte - scapose
H ros	Hemicryptophyte - rosette
H caesp	Hemicryptophyte - caespitose
T scap	Therophyte - scapose
P caesp	Phanerophyte - caespitose
G bulb	Geophyte - bulb
Ch suffr	Chamaephyte - suffruticose
H rept	Hemicryptophyte - reptant
NP	Nanophanerophyte
Ch frut	Chamaephyte - fruticose
Ch rept	Chamaephyte - reptant

ANNEX 3: Phenological tables

Table 3.1 Phenological table of the species registered in the different sample areas. The grey area indicates the presence of snow on site.

P14	13-apr	20-apr	27-apr	5-may	12-may	19-may	28-may	5-jun	12-jun	20-jun	27-jun	5-jul	12-jul	20-jul	7-aug	21-aug	15-sept
<i>Actaea spicata</i>			Vs	Vs	Vs	Vs	Vs	sB	sB	B	eB	F	F	F	Vs	Vs	Vs
<i>Anemone trifolia</i>	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F/(Vs)	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs
<i>Angelica sylvestris</i>						Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F
<i>Aruncus dioicus</i>						Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	Vs	Vs
<i>Athyrium filix-femina</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Vs
<i>Calamagrostis varia</i>		()	()	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	F
<i>Cardamine impatiens</i>			Vs	Vs	Vs	Vs	sB	B	B	F	F	Vs	Vs/(Vs)				
<i>Carex digitata</i>	Vs	Vs	sB	B	B	B	eB	F	F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Corylus avellana</i>						Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cyclamen purpurascens</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	B	B
<i>Cardamine enneaphyllos</i>	Vs	sB	B	B	B	eB	eB/F	F	F	F	(F)	(F)	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs
<i>Dryopteris filix-mas</i>		()	()	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Vs
<i>Epilobium montanum</i>					Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	(F)	(F)/Vs	Vs
<i>Euphorbia amigdaloides</i>			Vs	sB	B	eB	F	F	(F)	(Vs)	(Vs)	(Vs)	(Vs)				
<i>Fagus sylvatica</i>		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Fragaria vesca</i>				Vs	Vs	Vs	sB	B	B	F	F	F	F/Vs	(F)/Vs	Vs	Vs	Vs
<i>Galeopsis tetrahit</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	B	F	(F)
<i>Galium laevigatum</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	F	F	(F)	Vs
<i>Geranium nodosum</i>			Vs	Vs	Vs	Vs	Vs	Vs	B	B	eB	F	F	(F)/Vs	Vs	Vs	Vs
<i>Gymnocarpium dryopteris</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Vs	Vs
<i>Hypericum hirsutum</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	Vs	Vs
<i>Lamiastrum galeobdolon subsp. flavidum</i>			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	(F)	(Vs)/Vs	(Vs)/Vs

Lapsana communis					Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Lathyrus vernus			Vs	sB	B	eB	F	F	Vs	Vs	Vs	(Vs)	(Vs)	(Vs)			
Luzula nivea	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	eB	F	F/Vs	Vs	Vs	Vs	Vs
Melica nutans					Vs	sB	B	B	B	F	F	F	Vs	Vs	Vs	Vs	Vs
Moehringia trinervia					Vs	Vs	sB	B	B	F	F	(F)	Vs	Vs	(Vs)	(Vs)	
Oxalis acetosella		Vs	Vs	Vs/sB	sB	B	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Paris quadrifolia				Vs	Vs	Vs	Vs	sB	B	B	F	(F)	(Vs)/Vs	(Vs)/Vs	(Vs)/Vs		
Petasites albus	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Picea abies	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Polygonatum verticillatum				Vs	Vs	Vs	sB	B	B	F	F	Vs	Vs	Vs	Vs	Vs	Vs
Polystichum aculeatum		()	()	()	Vs	Vs	Vs	Vs	Vs	Sp	SP	SP	Sp	Sp	SP	Vs	Vs
Prenanthes purpurea				Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	B/F	F	(F)/Vs	Vs
Pulmonaria officinalis		Vs	sB	sB	B	B	B	(B)/F	F	(F)	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Rosa pendulina				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Rubus caesius				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Rubus hirtus				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Rubus idaeus		()	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	F	F/Vs	Vs	Vs	Vs
Salix appendiculata		Vs	Vs	sB	B	B	B/F	F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Solanum dulcamara				Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	F	(F)	Vs	
Solidago virgaurea				Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	F	F	Vs
Stachys sylvatica				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	F	Vs
Stellaria nemorum L. ssp. montana		Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/	F	F/Vs	Vs	Vs	Vs	Vs	Vs
Symphytum tuberosum		B	eB/F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs		
Taraxacum officinale			Vs	Vs	sB	B	B	B	eB/F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs
Veronica officinalis						Vs	Vs	Vs	sB	B	eB	F	(F)/Vs	Vs	Vs	Vs	Vs
Veronica urticifolia						Vs	sB	sB	B	B	eB/F	F	F	F/Vs	Vs	Vs	
Viola riviniana				Vs	Vs	sB	B	B	B/F	F	F	F/Vs	Vs	Vs	Vs	Vs	

P16	13-apr	20-apr	27-apr	5-may	12-may	19-may	28-may	5-jun	12-jun	20-jun	27-jun	5-jul	12-jul	20-jul	7-aug	21-aug	15-sept
<i>Actaea spicata</i>			Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	F	F	Vs	Vs	Vs	Vs
<i>Anemone trifolia</i>	Vs	Vs	Vs	Vs/sB	sB	B	B	B	eB/F	F	F	F	Vs	Vs	Vs	Vs/(Vs)	Vs/(Vs)
<i>Athyrium filix-femina</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Vs
<i>Betula pendula</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Calamagrostis varia</i>	()	()	()	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	(F)/Vs
<i>Calamintha grandiflora</i>						Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	F	Vs
<i>Carex digitata</i>	Vs	Vs	sB	B	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Corylus avellana</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cyclamen purpurascens</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	B	B
<i>Dactylorhiza maculata subbsp.fuchsii</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cardamine enneaphyllos</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Dryopteris filix-mas</i>	Vs/()	Vs/()	Vs/()	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Vs
<i>Dryopteris gr.carthusiana</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp
<i>Epilobium montanum</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	F	(F)	(F)/Vs	Vs
<i>Euphorbia amygdaloides</i>	Vs	Vs	Vs	sB	B	eB	F	(F)	(F)	Vs	Vs	Vs	Vs				
<i>Euphorbia cyparissias</i>			sB	B	B	eB	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Euphorbia dulcis</i>			Vs	Vs	Vs	sB	B	B	eB	F	(F)	(F)/Vs	Vs	Vs	Vs		
<i>Fagus sylvatica</i>		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Festuca altissima</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/F	F	Vs	Vs	Vs
<i>Fragaria vesca</i>	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	F	F/Vs	(F)/Vs	Vs	Vs	Vs
<i>Galium laevigatum</i>	Vs		Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	B	F	F	(F)	Vs
<i>Geranium nodosum</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	B	B	B	eB	eB/F	F	(F)	Vs	Vs	Vs
<i>Gymnocarpium dryopteris</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Vs	Vs
<i>Hieracium murorum</i>			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	(F)	Vs	(Vs)	(Vs)
<i>Hypericum montanum</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	Vs	Vs	
<i>Hypericum perforatum</i>						Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/F	Vs	
<i>Lamiastrum galeobdolon subsp. Flavidum</i>			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	(F)	(Vs)/Vs	(Vs)/Vs

Lathyrus vernus	Vs	Vs	sB	B	B	eB	eB/F	F	F	F	(F)/Vs	Vs	Vs	Vs			
Lonicera alpigena	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Luzula nivea	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	B	eB	F	F	F/Vs	Vs	Vs
Maianthemum bifolium		Vs	Vs	Vs	Vs	Vs/sB	sB	B	B	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs
Melica nutans					Vs	sB	B	B	B	F	F	F	Vs	Vs	Vs	Vs	Vs
Neottia nidus-avis	()	()	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	(F)/Vs	Vs	Vs	Vs	
Oxalis acetosella	Vs	Vs	Vs	Vs/sB	sB	B	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Paris quadrifolia	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Petasites albus	B	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Phyteuma spicatum			Vs	Vs	Vs	Vs	Vs	sB	B	B	B	F	F	(F)	Vs	Vs	Vs
Picea abies	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Polypodium vulgare	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp	Sp	Sp	Vs	Vs	Vs	Vs	Vs	Vs
Prenanthes purpurea	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	F	(F)	Vs
Pulmonaria officinalis	sB	sB	sB	B	B	Vs	F	F	(F)	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Ranunculus nemorosus				Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/F	F	(F)	Vs	Vs	Vs
Rubus hirtus				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Rubus idaeus	()	()	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	F	F/Vs	Vs	Vs	Vs
Salix appendiculata	Vs	Vs	Vs	sB	B	B	B/F	F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Salix caprea			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Sanicula europaea			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/F	F	(F)	Vs	Vs	
Scrophularia nodosa				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	(F)	Vs
Solidago virgaurea					Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	F	Vs
Sorbus aria			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Symphytum tuberosum	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
Taraxacum officinale			Vs	Vs	Vs	sB	B	B	B	eB/F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs
Phegopteris connectilis		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp	Sp	Vs
Vaccinium myrtillus	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
Veronica urticifolia	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs
Vicia sylvatica			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	(F)/Vs	Vs
Viola riviniana	Vs		Vs	Vs	Vs	sB	B	B	B/F	F	F	F/Vs	Vs	Vs	Vs	Vs	

P20	13-apr	20-apr	27-apr	5-may	12-may	19-may	28-may	5-jun	12-jun	20-jun	27-jun	5-jul	12-jul	20-jul	7-aug	21-aug	15-sept
<i>Acer pseudoplatanus</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Actaea spicata</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	F	Vs	Vs	Vs	Vs
<i>Adoxa moschatellina</i>			Vs	sB	B	B	eB/F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs		
<i>Anemone trifolia</i>	Vs	Vs	Vs/sB	sB	B	B	B	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	(Vs)	(Vs)
<i>Athyrium filix-femina</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Vs	Vs
<i>Betula pendula</i>					Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Carex digitata</i>	sB	sB	B	B	eB	eB/F	F	F	(F)	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Chrysosplenium alternifolium</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	Vs	Vs
<i>Corylus avellana</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cyclamen purpurascens</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B
<i>Cystopteris fragilis</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp	Sp	Sp	Vs	Vs
<i>Dactylorhiza maculata subbsp.fuchsii</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cardamine enneaphyllos</i>		Vs	sB	B	B	eB	eB/F	F	F	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)	Vs/(Vs)
<i>Dryopteris filix-mas</i>	Vs/(/)	Vs/(/)	Vs/(/)	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp
<i>Epilobium montanum</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	F	(F)/Vs	Vs
<i>Euonymus europaeus</i>		sB	B	B	eB/F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	(Vs)
<i>Fagus sylvatica</i>		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Fragaria vesca</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Fraxinus ornus</i>						Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	(Vs)	(Vs)		
<i>Geranium nodosum</i>	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	sB	B	B	B	eB	eB/F	F	(F)/Vs	Vs
<i>Gymnocarpium dryopteris</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp	Vs	Vs
<i>Lamium galeobdolon subsp. Flavidum</i>			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	(F)	(Vs)/Vs	(Vs)/Vs
<i>Luzula nivea</i>	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	B	eB	F	F	F/Vs	Vs	Vs
<i>Melica nutans</i>					Vs	sB	B	B	B	F	F	F	Vs	Vs	Vs	Vs	Vs
<i>Myosotis sylvatica</i>			Vs	Vs	Vs	Vs	Vs	sB	B	B	B	eB/F	F	F	Vs	Vs	

<i>Oxalis acetosella</i>	Vs	Vs	Vs	Vs/sB	sB	B	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Paris quadrifolia</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Petasites albus</i>	B	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Picea abies</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Polystichum aculeatum</i>	()	()	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	SP	SP	Sp	Sp	SP	Vs	Vs	
<i>Prenanthes purpurea</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	sB	B	B	F	(F)	Vs	
<i>Pulmonaria officinalis</i>	sB	B	B	F	F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Rubus hirtus</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Rubus idaeus</i>	()/Vs	()/Vs	Vs	sB	B	B	eB	F	F	F	F	F	F	F	F	Vs	Vs	Vs
<i>Salix appendiculata</i>		Vs	Vs	sB	B	B	B/F	F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Salvia glutinosa</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	(Vs)
<i>Scrophularia nodosa</i>		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs							
<i>Senecio ovatus</i>						Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB/F	F	Vs	
<i>Solidago virgaurea</i>				Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	
<i>Phegopteris connectilis</i>		Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Sp	Sp	Sp	Sp	Sp	Sp	Vs	
<i>Urtica dioica</i>						Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs				
<i>Veronica urticifolia</i>	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	eB	F	F	F	(F)/Vs	Vs	Vs	Vs	

P28	13-apr	20-apr	27-apr	5-may	12-may	19-may	28-may	5-jun	12-jun	20-jun	27-jun	5-jul	12-jul	20-jul	7-aug	21-aug	15-sept
<i>Fagus sylvatica</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Carex digitata</i>	sB	sB	B	B	B	eB/F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Corylus avellana</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Cyclamen purpurascens</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB/Vs	sB/Vs	sB/Vs
<i>Dryopteris filix-mas</i>			Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs			
<i>Fraxinus ornus</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Galium laevigatum</i>			Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	B	B	F	F	(F)	Vs
<i>Hepatica nobilis</i>	B	eB/F	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Lathyrus vernus</i>	Vs	Vs	sB	B	B	F	F	F	(F)/Vs	Vs	Vs	Vs	Vs	Vs			
<i>Melica nutans</i>	Vs					Vs	sB	B	B	B	F	F	Vs	Vs	Vs		
<i>Oxalis acetosella</i>	sB	B	F	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs
<i>Polygonatum multiflorum</i>	Vs	Vs	Vs	Vs	Vs	Vs	Vs	sB	B	B	F	(F)	(Vs)				
<i>Vinca minor</i>	(F)	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs	Vs

ANNEX 4: Number of individuals/axes of every species registered in the 10 m² transects

P14 (0 years)

Date of the relevé	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
N. days from the first relevè	0	15	32	50	67	84	101	219	260
N. days from 1 st January	104	118	135	153	170	187	204	322	363
% total coverage									
n. species		25	25	31	32	40	40	39	36
SPECIES									
<i>Actaea spicata</i>						7	7	7	7
<i>Anemone trifolia</i>		176	209	234	198	139	99	76	43
<i>Angelica sylvestris</i>						5	4	4	4
<i>Aruncus dioicus</i>				1	1	1	1	1	
<i>Athyrium filix-femina</i>				5	5	5	6	6	6
<i>Cardamine impatiens</i>		1	1	1	1	1	1	1	1
<i>Carex digitata</i>		4	4	6	7	7	8	8	8
<i>Corylus avellana</i>						1	1	1	1
<i>Cyclamen purpurascens</i>		19	19	19	25	27	44	65	65
<i>Dentaria enneaphyllos</i>		127	100	88	57	49	32	19	19
<i>Dryopteris filix-mas</i>		4	3	3	3	3	3	3	3
<i>Epilobium montanum</i>						16	21	21	20
<i>Euphorbia amigdaloides</i>		2	3	3	7	7	8	8	6
<i>Fagus sylvatica</i>		1	1	1	1	1	1		
<i>Fragaria vesca</i>		1	1	1	1	1	2	2	2
<i>Galeopsis tetrahit</i>						1	6	6	4
<i>Galium laevigatum</i>		6	10	10	13	14	25	25	25
<i>Geranium nodosum</i>		10	12	15	15	16	16	16	15
<i>Hypericum hirsutum</i>		2	4	7	7	7	6	6	6
<i>Lamium galeobdolon</i> subsp. <i>flavidum</i>		4	17	26	18	32	32	32	
<i>Lapsana communis</i>				1	1	1	1	1	

Luzula nivea						1	2	2	2
Moehringia trinervia						1	1	1	1
Oxalis acetosella		11	13	15	15	16	20	20	18
Paris quadrifolia		8	8	7	7	7	7	6	6
Petasites albus		2	4	4	4	4	4	4	4
Polygonatum verticillatum		7	15	17	19	19	18	16	12
Polystichum aculeatum				4	3	3	3	3	3
Prenanthes purpurea		1	2	2	2	2	2	2	2
Rubus caesius		10	10	10	10	10	17	26	25
Rubus idaeus		13	7	7	7	4	4	4	3
Rubus hirtus						1	1	1	1
Solanum dulcamara				1	1	1	1	1	1
Stachys sylvatica		8	8	8	14	15	29	51	46
Stellaria nemorum L. ssp. glochidisperma		2	2	2	2	2	2	2	2
Symphytum tuberosum		7	9	10	9	9	9	9	9
Taraxacum officinale		5	6	6	5	5	5	5	5
Veronica officinalis					1	1	1	1	1
Veronica urticifolia				1	1	1	1	1	1
Viola riviniana		1	2	2	5	5	9	10	10

P16 (6 years)

Date of the relevé	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
N. days from the first relevè	0	15	32	50	67	84	101	219	260
N. days from 1 st January	104	118	135	153	170	187	204	322	363
% total coverage									
n. species	16	16	26	30	30	31	30	30	27
SPECIES									
<i>Anemone trifolia</i>	38	79	150	123	107	103	62	60	33
<i>Athyrium filix-femina</i>						1	1	1	1
<i>Calamagrostis varia</i>			11	11	11	11	11	11	11
<i>Calamintha grandiflora</i>				4	7	7	12	12	10
<i>Corylus avellana</i>	1	3	7	8	8	5	5	5	5
<i>Cyclamen purpurascens</i>	23	20	16	12	9	5	5	5	5
<i>Dryopteris filix-mas</i>			6	8	8	8	8	8	8
<i>Dryopteris gr.carthusiana</i>				1	1	1	1	1	1
<i>Epilobium montanum</i>			1	1	1	1	1	1	
<i>Euphorbia amygdaloides</i>	1	1	1	1	1	1	1	1	
<i>Fagus sylvatica</i>	6	6	6	5	5	8	8	8	7
<i>Fragaria vesca</i>	1	1	1	4	2	2	2	2	2
<i>Galium laevigatum</i>	5	10	11	19	17	9	11	11	9
<i>Geranium nodosum</i>	3	35	53	74	64	58	46	40	37
<i>Gymnocarpium dryopteris</i>			2	6	8	8	9	9	9
<i>Lathyrus vernus</i>	3	6	10	10	7	6	6	6	6
<i>Luzula nivea</i>	118	139	139	139	139	139	139	139	139
<i>Maianthemum bifolium</i>			4	32	32	27	24	24	23
<i>Melica nutans</i>			13	18	20	20	20	20	20
<i>Oxalis acetosella</i>	13	58	67	163	204	204	204	204	204
<i>Picea excelsa</i>	2	2	2	2	2	2	2	2	2
<i>Polypodium vulgare</i>	1	1	1	1	1	1			
<i>Prenanthes purpurea</i>			5	5	4	4	4	4	4

<i>Pulmonaria officinalis</i>	3	4	8	9	9	9	6	6	6
<i>Rubus idaeus</i>			11	12	13	13	13	13	13
<i>Rubus hirtus</i>	4	7	7	10	10	10	10	8	8
<i>Scrophularia nodosa</i>			21	21	21	21	20	20	20
<i>Symphytum tuberosum</i>			2	2	2	2	2	2	2
<i>Taraxacum officinale</i>				1	1	1	1	1	
<i>Veronica urticifolia</i>				20	21	17	17	17	12
<i>Viola riviniana</i>	1	3	7	16	20	21	21	21	20

P20 (12 years)

Date of the relevé	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
N. days from the first relevè	0	15	32	50	67	84	101	219	260
N. days from 1 st January	104	118	135	153	170	187	204	322	363
% total coverage									
n. species	9	9	15	17	17	18	19	18	15
SPECIES									
<i>Acer pseudoplatanus</i>			1	1	1	1	1	1	1
<i>Actaea spicata</i>	5	4	4	4	5	5	5	5	3
<i>Anemone trifolia</i>	34	65	76	60	58	22	3	3	
<i>Athyrium filix-femina</i>	1	1	1	6	6	6	6	6	6
<i>Cyclamen purpurascens</i>			2	2	2	3	3	3	3
<i>Dryopteris filix-mas</i>			6	4	4	4	4	4	4
<i>Epilobium montanum</i>							1	1	1
<i>Fagus sylvatica</i>	1	1	1	1	1	1			
<i>Geranium nodosum</i>	9	31	50	42	29	20	11	7	3
<i>Gymnocarpium dryopteris</i>	11	44	70	92	79	46	44	44	42
<i>Lamium galeobdolon</i> subsp. <i>Flavidum</i>			2	6	5	5	5	5	1
<i>Luzula nivea</i>	6	5	5	5	5	5	5	5	5
<i>Melica nutans</i>				1	1	1	1	1	
<i>Oxalis acetosella</i>	20	30	33	68	67	51	20	20	12

Petasites albus			1	1	1	1	1	1	1
Prenanthes purpurea							1	1	1
Pulmonaria officinalis				4	4	4	4	2	
Rubus idaeus	2	2	9	9	9	4	3	3	3
Rubus hirtus						10	13	13	13
Solidago virgaurea			1	1	1	1	1		

P28 (20 years)

Date of the relevé	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
N. days from the first relevè	0	15	32	50	67	84	101	219	260
N. days from 1 st January	104	118	135	153	170	187	204	322	363
% total coverage									
n. species	5	5	6	6	6	6	6	4	4
SPECIES									
Cyclamen purpurascens	11	9	9	5	5	5	3	3	3
Fagus sylvatica	5	7	9	4	4	4	4	2	2
Fraxinus ornus	1	1	2	2	2	2	2	2	1
Hepatica nobilis			2	1	2	2	2		
Polygonatum multiflorum	1	1	1	1	1	1	1		
Vinca minor	34	45	58	47	47	47	31	29	22

ANNEX 5: Complexity, diversity and evenness indexes calculated on the basis of the individuals/axes registered in the 10 m² sample areas

Days from 1st Jan	104	118	135	153	170	187	204	322	363
Days from 1st relevé	0	15	32	50	67	84	101	219	260
P14	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
S ₁₀		25	25	31	32	40	40	39	36
N		432	470	517	465	448	460	473	387
S		25	25	31	32	40	40	39	36
Menhinick		1,203	1,153	1,363	1,484	1,890	1,865	1,793	1,830
Margalef		3,955	3,901	4,802	5,047	6,388	6,361	6,170	5,874
H'		2,782	2,415	3,102	3,377	3,956	4,270	4,264	4,255
J'		0,599	0,520	0,626	0,675	0,743	0,802	0,807	0,823
1-D		0,743	0,998	0,758	0,793	0,874	0,919	0,925	0,926
1-E		0,732	0,998	0,750	0,786	0,871	0,917	0,923	0,924

P16	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
S ₁₀	16	16	26	30	30	31	30	30	27
N	223	375	562	738	755	725	672	662	617
S	16	16	24	28	28	29	28	28	25
Menhinick	1,071	0,826	1,012	1,031	1,019	1,077	1,080	1,088	1,006
Margalef	2,774	2,531	3,633	4,088	4,074	4,251	4,147	4,157	3,735
H'	2,317	2,693	3,144	3,444	3,373	3,47	3,317	3,314	3,208
J'	0,579	0,673	0,686	0,716	0,702	0,714	0,690	0,689	0,691
1-D	0,678	0,783	0,827	0,862	0,849	0,840	0,832	0,829	0,810
1-E	0,657	0,769	0,819	0,857	0,843	0,834	0,826	0,823	0,802

P20	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
S ₁₀	9	9	15	17	17	18	19	18	15
N	89	183	262	307	278	190	132	125	99
S	9	9	15	16	16	17	18	17	15
Menhinick	0,954	0,665	0,927	0,913	0,960	1,233	1,567	1,521	1,508
Margalef	1,782	1,536	2,514	2,619	2,665	3,049	3,482	3,314	3,047
H'	2,486	2,302	2,613	2,727	2,764	3,117	3,267	3,172	2,874
J'	0,784	0,726	0,669	0,682	0,691	0,763	0,783	0,776	0,736
1-D	0,778	0,763	0,793	0,803	0,805	0,840	0,843	0,830	0,784
1-E	0,750	0,733	0,778	0,790	0,792	0,830	0,834	0,819	0,769

P28	13-apr	27-apr	12-may	28-may	12-jun	27-jun	12-jul	7-aug	15-sept
S ₁₀	5	5	6	6	6	6	6	4	4
N	52	63	81	60	61	61	43	36	28
S	5	5	6	6	6	6	6	4	4
Menhinick	0,693	0,630	0,667	0,775	0,768	0,768	0,915	0,667	0,756
Margalef	1,012	0,965	1,138	1,221	1,216	1,216	1,329	0,837	0,900
H'	1,419	1,29	1,391	1,196	1,264	1,264	1,465	1,013	1,062
J'	0,611	0,556	0,538	0,463	0,489	0,489	0,567	0,507	0,531
1-D	0,528	0,464	0,467	0,380	0,399	0,399	0,473	0,348	0,378
1-E	0,410	0,330	0,360	0,256	0,279	0,279	0,368	0,131	0,171

LEGEND:

S₁₀= total number of species registered in the transect, N= number of individuals/axes counted in the transect, S= number of species utilized for the complexity, diversity and evenness indexes assessment (excluding the species for which the count was very difficult and unreliable), H'= Shannon diversity index, J'= Pielou evenness index (based on Shannon diversity), 1-D= complementary of Simpson diversity index, 1-E= complementary of Simpson evenness index.

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