FORUM PLINIANUM

INTERNATIONAL CENTER FOR THE ENVIRONMENT - ROMA (ITALY)

European Project PROFORMIOMED "PROMOTION OF RESIDUAL FORESTRY BIOMASS IN THE MEDITERRANEAN BASIN"

The aim is evaluation and monitoring of effects caused by forest biomass removal in natural communities with focus on floristic composition and vegetation.
The vegetation and soil study was assigned to FORUM PLINIANUM.
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INTRODUCTION

Forest management

The classic paradigm for natural resource management is based on the relationship between birth rate, death rate, and growth (Hilborn et al., 1995). According to this approach, if utilization rate does not exceed regeneration rate the resource will not be consumed. Production continuity therefore depends on the possibility of predicting the regeneration rate of the resource. This is the principle behind the theory of the regulated or normal forest: a forest where everything is predictable and controlled (Ciancio et al., 1994a,b). This 'classic' forest management paradigm treats population and ecosystem dynamics as if they acted in an invariable environment and according to predictable trajectories. In this approach, silviculture is based on the control of natural processes. Cultivation methods try to obtain forest regeneration according to a predefined stand structure model: even-aged or uneven aged. Forest management tends towards a 'regulated' distribution of age or diameter classes. Thus silviculture generally favors one or few species, depending on particular characters, such as productivity, growth rate, quality and quantity of wood production, sprouting capacity, etc. (Ciancio and Nocentini, 1997, 2000; Puettmann et al., 2009).

The application of rotation ages being sensibly shorter than natural tree longevity is one of the factors which causes the most evident difference between human impacted forest landscapes and natural landscapes (Spies and Turner, 1999). Undoubtedly, in former times, this approach has contributed to regulate forest exploitation and slow down forest destruction. Nevertheless, if it is examined within recent views on the way ecosystem functions, in particular forest ecosystems, it appears dated and, above all, absolutely incapable of contributing to forest biodiversity conservation. In a forest ecosystem, processes seem linear and states appear as constant only over a limited space and temporal field (Mladenoff and Pastor, 1993). Management centered on a constant, maximum, annual yield cannot be identified with sustainable forest management; as Gane (1992) has observed, this type of management does not guarantee that over time resources and yield are in balance.

The simplification of forest systems does not involve only the number of species it also impacts the variety of structures and processes at different scales, from the stand to the landscape. In forest ecosystems, the most evident symptoms of simplification are difficulties in natural regeneration and the reduction in the variety and quality of habitats. Other less obvious but still negative effects must also be taken into consideration, such as modifications in the geochemical processes and the alteration of soil micro-flora and micro-fauna.

The reductionist approach does not consider the fact that the forest is not a closed system but interacts with other systems such as the social, economical and cultural systems. On the practical side, this type of approach consists of a series of technical adjustments with the aim of reducing the impact of forest management: the Systemic Silviculture. At the management level, the application of systemic silviculture requires a change in approach with respect to classic silviculture. Classic silviculture tends toward a predefined structure: management is based on centralized control and cultivation uniformity. With systemic silviculture, the cultivation unit is the stand. Silvicultural and utilization interventions are cautious, continuous, and capillary in relation to the needs of the various stands. The forest is inhomogeneous and unstructured. There is no predefined rotation age. Regeneration is natural and continuous. Monitoring is an essential element for adapting cultivation and management to the reactions of the system. Management aims toward conserving and increasing complexity. Finally, systemic management implies decentralized control and cultivation diversification. In practice, systemic forest management is characterized by (Ciancio and Nocentini, 1996):

- The abandon of rigid schemes: Different specific objectives need to be adopted for each case, adapting to each particular environment and site;
- Following and sustaining natural regeneration processes: This is done by enhancing the forest's structural complexity, favoring natural irregularities in the spatial and temporal distribution of regeneration (Nocentini, 2000);
- Linking tree felling criteria, in very general terms, to conditions of single trees or tree groups;
- inhomogeneities should be favored, maintaining rare species, trees with cavities that are potential nesting sites, etc.;
- Minimising alterations in nutrient cycles, only removing what is truly important to remove, leaving dead or decaying trees and decomposing branches, which may offer suitable habitats for woodpeckers, birds of prey, insects and many plant species;
- Suitable timing and localization of harvesting operations so as to prevent both interference with the reproductive season of animal species and disturbance of rare or threatened species.

Disturbance

Forest biomass removal represents one of the more common forms of human disturbance influencing biodiversity, vegetation structure and floristic composition of the plant communities in an ecosystem.

Disturbance is a general ecological factor in nature and it is a primary cause of spatial heterogeneity in ecosystems (Platt, 1975; Loucks et al., 1985; Collins and Glenn, 1988; White et al., 2000). Disturbance occurs not only where man exerts his influence, but is ubiquitous also in pristine habitats: winds, landslips, natural fires, pests outbreaks act as a major shaping factor of vegetation (White and Jentsch, 2001).

If disturbance is moderate, it leads to a progressive expansions of plants populations typical of particular habitats that in undisturbed conditions are usually spotty and localized. When disturbance becomes too intensive, biological feedbacks and physicochemical cycles are severely perturbed

Timing of disturbance is crucial (Crawley, 2004); communities developing slowly are stopped by disturbance in the process leading to self-organisation, and transient, chaotic states replace the organized ones. If the time lag between two disturbance events is shorter than recovery time of vegetation, communities collapse (Fanelli and Testi, 2008); but, if disturbance has an intermediate intensity (Connel and Slatyer, 1977), the vegetation recovery is favoured.

In the present study we compared forest sites subjected to more recent tree cutting with earlier cut forest sites to verify if the turnover of biomass removal allowed the vegetation succession, regrowth and recovery to pristine conditions. The comparison is carried out through ecoindicators application and humus/soil parameters measurements.

Ecoindicators relate to Ellenberg biondication model (1974-79) and to hemeroby index (Kowarik, 1990).

Why Ellenberg indicators application?

A primary challenge in characterizing ecosystems is the possibility to develop effective ecoindicators (Dale and Beyeler, 2001). Indicator values (Zeigerwerte) proposed for the species of plants occurring in Germany (Ellenberg, 1974), represent a synthetic and effective way to analyse and express ecosystem complexity (Fanelli et al., 2006a; Testi et al., 2004; Pignatti et al., 2001) and appear a useful tool in ecological bioindication. Such ecological indicator values (in the following indicated as EIV) represent a set of scores for Central European species expressing the average realized niche along the gradients light (L), temperature (T), continentality of climate (K), soil moisture (F), soil pH (R), nitrogen (N). EIV open the possibility to give a fundamentally quantitative expression of ecological gradients (although they have been originally proposed as an ordinal scale), and summarize in scales with 9 degrees the huge amount of ecological observations about plants and plant communities previously carried out in Central Europe. Limitations and strengths of the Ellenberg's approach have been debated (e.g. Ewald, 2003), but a number of studies show a good agreement between indicators and environmental variables (Kaiser and Käding, 2005; Schaffer and Sykora, 2000; Southall et al., 2004; Schmidtlein and Ewald, 2003; Testi et al., 2006).

From Central Europe, Ellenberg values has been extended to Poland (Zarzycky, 1984), Italy (since 1993, see Pignatti et al., 2005), Hungary (Borhidi, 1995), Britain (Hill et al., 2000). Recently, a list of ecological indicators for the flora of Kriti (Greece) has been proposed (Böhling et al., 2002), indeed, in this case scores have a different indication value as in Ellenberg (1974). Extension of ecological bioindication to countries in Northern Europe is not difficult, thanks to the large number of species in common and similar latitudinal distribution; for Eastern and Southern Europe, on the contrary, major adjustments are necessary, and the question arises, how to extend them from the flora of Central Europe to other geographical areas. Several species have differing ecological requirements across their range, so that accounting for some degree of alteration of the Central European values due to local requirements is unavoidable.

The extension of EIV to the Italian flora, is based on a data-base, produced by Pignatti and collaborators and used since 1993 in several occasions (e.g. Celesti and Pignatti, 1993; Lucchese and Monterosso, 1994; Pignatti et al., 2001). In this data-base all the species of the Italian flora are reported, together with ecological and ecophysiological measurements for each species, if available; since the beginning of 2005 the complete data-base is available in the site www.flora.garz.net and in printed form (Pignatti, 2005). After recent developments in treatment of ecological data, an alternative procedure to this painstaking, long-term effort is open: the missing values can be successfully estimated using the so-named reprediction algorithm. This method was introduced by

Hill et al. (2000) for the species of the British flora. For Italy, relying on a dataset of 4207 original relevés of Central-Southern Italy, EIV were calculated using a modified form of the reprediction algorithm and an ecological flora of 1800 species was obtained (Fanelli et al., 2006c).

The number and the strenght of EIV correlation with measured environmental variables were tested in many studies. We expect that reliable EIV should correlate strongly with key environmental variables. In fact, many studied demonstrated that Ellenberg's indicators are correlated with climatic and soil measured parameters. Soil moisture F-Indicator value is strongly correlated with AWC (Available Water Capacity) measured in soil profiles (Testi et al., 2004) and with Carbon, Nitrogen, Phosphorus percentage in weight in soil; temperature T-Indicator value is positively correlated with air temperature and negatively with air humidity (Fanelli et al., 2006b).

Two derived indices

Relationships between humus and vegetation are studied by two combined indices derived from Ellenberg model: the R*N index of humus index quality (Rogister, 1978; Godefroid et al., 2005) and the ratio R/N that are mostly and successfully used in continental and mesophile environments of Central and Northern Europe.

R*N has been interpreted as an index of humus functionality and it expresses the turn-over of organic matter. R/N has been interpreted as an indicator of nitrogen availability.

A well-defined relationship between pH of the soil solution and plant available nitrogen has already been reported (Seidling and Rohner, 1993) and expresses the dependency of quantity and quality of the nitrogen mineralization in forest soils from its acidity status under otherwise equitable constraints. Any medium scale disturbance may stimulate mineralization of organic substances and enhance nitrogen availability and subsequently cause floristic changes. While disturbances are rather discrete events accompanied by a multitude of physicochemical changes, deposition of nitrogen is a sneaky process. Respective effects are much more difficult to detect, especially in the case of nitrogen, a nutrient with a complex interplay in terrestrial ecosystems. Apart from continuous laborious measurements of nitrogen concentrations in the soil solution at intensive monitoring sites, sound data about the actual availability of nitrogen in soils are difficult to achieve. Therefore indirect methods should not be neglected, especially not for large-scale surveying (Seidling et al., 2005). Deviances from expected Ellenberg indicator values for nitrogen are related to N throughfall deposition in forests.

To help the forest manager take advantage of the many opportunities available, an Ecological Site Classification (ESC) is being developed, based on a number of indicators of climate, soil moisture regime and soil nutrient regime. The use of ground vegetation to assess soil moisture and soil nutrients was taken forward by Central European ecologists, notably Ellenberg (1988), who proposed the use of species indicator values (Wilson et al., 2001).

The two combined indices were applied in Italy to analyze the relationships between humus and vegetation in Mediterranean environment (De Nicola et al., in press)

Hemeroby index

Closely related to Ellenberg indicator values is the Hemeroby index (H), expressing the degree of past and present human disturbance on ecosystems according to a ten-point scale (Kowarik 1990; Fanelli and De Lillis 2004). The lowest value (0) represents pristine environments nowadays not existent in Europe, (9) represents completely altered man-made habitats, and the other values intermediate degrees of disturbance (Kowarik, 1990). Details about the scale can be found in Tab.1, where we report the characterization of the range of values. The scale of hemeroby is currently used in particular in Central Europe for the assessment of human impact on vegetation in urban habitats (Kowarik, 1990; Hill et al., 2002), in forests (Grabherr et al., 1998), on lichen communities (Zedda, 2002), and in landscapes (Steinhardt et al., 1999).

Disturbance is a general ecological factor in nature and it is a primary cause of spatial heterogeneity in ecosystems (Platt, 1975; Loucks et al., 1985; Collins and Glenn, 1988). Unfortunately, direct estimation of disturbance and human impact is usually difficult. It is therefore necessary to evaluate disturbance indirectly by means of changes in the composition of communities. So, in practice we do not study disturbance directly, but the response of vegetation to disturbance (Fanelli and Testi, 2008).

In many studies on aquatic as well as terrestrial ecosystems the application of Hemeroby index resulted very useful to detect the influence of human disturbance and to quantify it (Testi et al., 2008-2009; Testi et al., 2009-2010; Testi et al., 2012). In aquatic ecosystems, along the course of Aniene River (Latium, Italy), Hemeroby showed small-scale local variations in correspondence with rapid changes in the surrounding land: mapping the variations of hemeroby along the river, we obtained a fine-scale assessment of the disturbance degree on vegetation and its use can be fine-tuned according to monitoring exigencies (Testi et al., 2008-2009).

The intense tree cutting historically affecting beech forest in the central Apennines caused over time a shifting of the mesophile beech woodlands with low light requirement towards ecotonal conditions, favouring the ingression of species typical of mixed beech woodlands with *Carpinus betulus* at intermediate altitudes and with *Quercus cerris* at the lowest altitudes (Testi et al., 2009-2010).

Tab. 1

Hemeroby	Vegetation types
0	Almost not existing in Central Europe (only in part of high mountains)
1	Virtually uninfluenced primary forests, flat or raised bogs, vegetation of rocks and sea-shores
2	Extensive drained wetlands, forests with minor wood withdrawal, some wet areas, badlands
3	More intensively managed forests, trampled or heavily grazed forests, developed undisturbed secondary forests, dry grasslands (Lygeo-Stipetea, Festuco-Brometea, Thero-Brachypodietea), garigue (Cisto-Lavanduletea)
4	Monocoltured forests, disturbed secondary forests, skirt vegetation (Trifolio-Geranietea), less ruderalized dry grasslands, disturbed maquis, broom and bracken fields
5	Young planted forests, intensively managed meadows and pastures (Arrhenatheretalia), ruderal dry grasslands on man-made sites (Brometalia rubenti-tectorum), neophyte thickets (Chelidonio-Robinietalia)
6	Traditionally managed field vegetation, ruderal rough meadow, ruderal vegetation of tall herbs (Galio-Urticetea, Artemisietea p.p.), disturbed ruderal grasslands (Brometalia rubenti-tectorum, Agropyretalia repentis), pioneer vegetation on river debris (Bidentetea), earlier walls vegetation (Capparetum rupestris)
7	Intensively managed segetal and garden vegetation (Hordeion leporini, Centaureetalia cyani p.p.), some wastelands and rubble heaps (Chenopodion muralis), pioneer ruderal grasslands, disturbed wall vegetation (Parietarion judaicae)
8	Segetal vegetation affected by strong herbicide impact, ruderal pioneer vegetation (Artemisieta vulgaris p.p.), trampled vegetation
9	Pioneer vegetation on railways, rubbish places, dumps, salted motorways. etc.
-	No vegetation or vascular plants

The effectiveness of Ellenberg bioindication method as a new paradigm

The effectiveness of Ellenberg bioindication method concerns the shifting from a multi-dimensional system based on floristic matrices including a mean of almost 100 species in the richer plant associations, to a smaller system reduced to 7 dimensions (or to 9 if the two aggregated indices of humus quality are considered). This new system is able to express and synthesize the environmental requirements of species and communities in an ecosystem. The multi-dimensional reduction is associated to a quantitative expression of a gradient. This shifting opened a new "paradigm" and another approach in the botanic field.

Ellenberg's indicator values -EIV foresaw the development of a multidimensional analysis overcoming the approach exclusively based on floristic analysis.

We report some examples to better explain this change in plant ecology applications and data interpretation: we assign to species indicators the correspondent value of the specific ecoindicator. Indicator values come from Data Banks (Pignatti et al., 2005; Fanelli et al., 2006c).

1) Soils rich in humus with high fertility

Species	pH-R	Nutrients-N	R*N
Neottia nidus avis	7	7	49
Monotropa hypopitys	7	8	56
Lathraea squamaria	6	8	48

2) Euthrophic soils

Species	Nutrients-N
Parietaria judaica	8
Aster squamatus	8
Sonchus tenerrimus	8
Rumex pulcher	7
Robinia pseudoacacia	8
Ailanthus altissima	8
Rubus ulmifolius	7
Malva sylvestris	8
Smyrnium olusatrum	9

3) Shady forests (high coverage of woody layers): *Quercus ilex* woodland

Species	Light-L
Brachypodium sylvaticum	4
Luzula forsteri	3
Rubus ulmifolius	5
Cyclamen repandum	3
Arisarum vulgare	6
Asplenium onopteris	3

The three examples clarify the shifting from a simple list of species indicators of edaphic or climatic conditions, to a bioindication quantification. We can observe that species indicators of eutrophization display high values of the nutrient indicator-N, ranged between 7 and 9 and the quality humus index R*N has very high values ranged between 48 and 56; finally, species indicators of shady environments show low values of the correspondent indicator of light-L, ranged between 3 and 6. Before Ellenberg, bioindication was based on a qualitative approach mainly linked to autoecology, while Ellenberg system quantifies the bioindication.

Humus forms

Soil represents one of the most important reservoirs of biodiversity. It reflects ecosystem metabolism since all the bio-geo-chemical processes of the different ecosystem components are combined within it; therefore soil quality fluctuations are considered to be a suitable criterion for evaluating the long-term sustainability of ecosystems. Within the complex structure of soil, biotic and abiotic components interact closely in controlling the organic degradation of matter and the nutrient recycling processes.

Soil properties determine ecosystem function and vegetation composition/structure, as a medium for root development, and provide moisture and nutrients for plant growth. Disturbances linked to natural forces and to human activities can alter physical, chemical and biological properties of soils, which can, in turn, impact long-term productivity (Buger and Zedaker, 1993; Gupta and Malik, 1996). Humans have extensively altered the global environment and caused a reduction of biodiversity. These change in biodiversity alter ecosystem processes and change the resilience of ecosystems to environmental change.

In a review on changing biodiversity Chapin (2000) considers that land use will be the main cause of change in biodiversity for tropical, Mediterranean and grassland ecosystems. Forests, tropical or temperate, generally represent the biomes with the largest soil biodiversity. Consequently any land use change resulting in the removal of perennial tree vegetation will produce a reduction of soil biodiversity.

Soil quality could be defined as the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, to maintain or enhance water and air quality, and to support human health and habitation (Doran and Parkin, 1994; Karlen et al., 1997). A common criterion for evaluating the long-term sustainability of ecosystems is to assess the fluctuations of soil quality (Schoenholtz et al., 2000). Soil reflects ecosystem metabolism; within soils, all bio-geo-chemical processes of the different ecosystem components are combined (Dylis, 1964). Monitoring ecosystem components plays a key role in acquiring basic data to assess the impact of land management systems and to plan resource conservation. Maintaining soil quality is of the utmost importance to preserving biodiversity and to the sustainable management of renewable resources.

The humus forms are the fraction of the topsoil strongly influenced by organic matter corresponding to the sequence of organic -OL, OF, OH, H- and underlying organo-mineral horizons - A, AE, Aa - (Zanella et al., 2011).

Humus forms are indicators of the conservation status of an ecosystem (Topoliantz and Ponge, 2000), particularly for sites subjected to a long time disturbance affecting the herbaceous layer (Klinka et al., 1990). Humus forms have been considered as indicators of ecosystem cycling and nutrient management strategies (Ponge, 2003).

The humus forms are influenced by biotic (litter amount and quality, soil-dwelling microbial and animal communities) and abiotic factors (climate, bedrock, soil type) according to a variety of key processes. While abiotic factors such as regional climate and geology cannot be back-influenced by humus forms, at least in the short-term (Marland et al., 2003), biotic factors are tightly linked to humus forms according to feedback loops (Ponge et al., 1999), making distal and proximal causes hard to discern and thus any predictions hardly questionable.

Soil biota play an essential role in soil functions as they are involved in processes such as the decomposition of organic matter, the formation of humus and the nutrient cycling of many elements (nitrogen, sulphur, carbon). Moreover, edaphic fauna affect the porosity and aeration of, as well as the infiltration and distribution of organic matter within soil horizons. The ecosystem services provided by soil fauna are one of the most powerful arguments for the conservation of edaphic biodiversity. Decomposition of organic matter by soil organisms is crucial for the functioning of an ecosystem because of its substantial role in providing ecosystem services for plant growth and primary productivity.

In forests, past land use (Dupouey et al., 2002) and present-day management options (Godefroid et al., 2005) are known to influence humus forms at the scale of management units. At a more local scale individual trees (Kuuluvainen et al., 1994; Peltier et al., 2001), forest vegetation (Bernier et al., 1993; Emmer, 1994; Bernier and Ponge, 1994), microtopography (Dwyer and Merriam, 1981) and animal/microbial populations (Gourbière, 1983; Wilcox et al., 2002) stem in a pronounced variation of humus forms and ground floor thickness (Arp and Krause, 1984; Riha et al., 1986; Aubert et al., 2006). The environment of soil organisms in managed ecosystems can be influenced by any combination of land use factors, such as tillage, pesticide and fertilizer application, soil compaction during harvest, and removal of plant biomass.

Soil types and humus forms do not vary at the same scale of time (Crocker and Major, 1955; Switzer et al., 1979; Turk et al., 2008), making their causal relationships highly variable in space and time, more especially in forest environments (Ponge et al., 1998, 1999). It has been shown that the thickness of forest floor and the structure of organo-mineral horizons, which are under the paramount influence of ecosystem engineers such as earthworms (Hoogerkamp et al., 1983; Wironen and Moore, 2006; but see Burghouts et al., 1998), can vary according to the age of trees (Godefroid et al., 2005; Chauvat et al., 2007), plant successional processes (Leuschner et al., 1993; Emmer and Sevink, 1994; Scheu and Schulz, 1996) and undergo cycles at the scale of centuries in naturally regenerating late-successional forests (Bernier and Ponge, 1994; Salmon et al., 2008). Litter quality, resulting from the species composition of forest vegetation (Wolters, 1999; Wardle et al., 2003) and conditions of tree growth (Hättenschwiler et al., 2003), is known to influence and be influenced by humus forms and associated soil trophic networks (Nicolai, 1988; Ponge et al., 1999). At last, forest vegetation is locally selected (filtered out from regional pools of species) by forest floor and topsoil properties, combined with species interactions (Gearlierberg, 1982; Falkengren-Grerup and Tyler, 1993) and in turn it influences the activity of soil organisms, and thus the development of humus forms, through litter and rhizosphere effects (Emmer, 1994; Milleret et al., 2009).

The description and the study of humus forms represent a tool for ecosystems or biotic communities characterization; humus forms may be indicative for environmental changes since they evolve together with the whole ecosystem (Ponge, 2003).

The humus forms were sampled and classified in the field according to *European Humus Forms Reference Base 2011* (Zanella et al., 2011) based on the sequence and morphological characters, including morphological evidence of biological activity of organic (OL, OF, OH) and/or organo-mineral (A) horizons.

The classification method proposed by *European Humus Forms Reference Base* 2011 (Zanella et al., 2011) based on the morpho-genetic characters of the diagnostic organic (OH) and organo-mineral (A) horizons. The descriptors of the diagnostic horizons were conceived in accordance with the recent international soil classifications. This European system of classification avoids a hierarchical structure and allows an approach open to additional ecological contributions.

Basic components of humus forms

Recognizable remains correspond to leaves, needles, roots, bark, twigs and wood pieces, fragmented or not, whose original organs are recognizable to the naked eye or with a 5–10× magnifying hand lens.

The humic component is formed by small and non-recognizable organic remains and/or grains of organic or organo-mineral matter, mostly comprised of animal droppings of different sizes. The humic component are classified in three types, called micro- (<1 mm), meso- (1–4 mm) and macroaggregates (>4 mm).

Mineral particles bound to the humic component are considered as part of the humic component. On the contrary, mineral particles of different sizes, free or very weakly bound to the humic component and visible to the naked eye or with a 5–10× magnifying hand lens, form the mineral component.

Zoogenically transformed component (indicated by ‘zo’ after horizon name or not indicated when implicit) is made of recognizable remains and humic components processed by animals and transformed in animal droppings. Non-zoogenically transformed component (indicated by ‘noz’ after horizon name) is made of recognizable remains and humic components processed by fungi or other non-faunal processes. The structure of organo-mineral horizons can be zoogenic, being formed of micro-, meso- or macroaggregates (micro-, meso- or macrostructure, respectively) or non-zoogenic, beingmassive or single-grained.

In order to classify a humus form it is necessary: a) to dig a little cubic pit in the soil (dimensions: 50 cm at least); b) to observe one of the walls of the pit; c) to identify layers, varying in composition, colour, texture, structure and thickness; d) to assign each layer to a pre-defined diagnostic horizon; e) to associate each series of superposed diagnostic horizons to one or more references using a key of classification. The minimum thickness of diagnostic horizons has been established at 3 mm. Below this limit a horizon is considered discontinuous if clearly in patches or absent if indiscernible from other neighbouring horizons. Three types of transition between horizons are considered: very sharp transition within less than 3 mm, sharp transition between 3 and 5 mm and diffuse transition if over more than 5 mm. More detailed descriptions of diagnostic horizons and recognition criteria can be found in Zanella et al. (2011).

Two main types of diagnostic horizons (O for organic and A for organo-mineral) have been distinguished in aerated soils.

Organic horizons

The OL horizon is characterized by the accumulation of leaves, needles, twigs and woody materials, most original plant organs being easily discernible to the naked eye (humic component less than 10%, recognizable remains 10% or more). Suffix letters distinguish between neither fragmented nor transformed/discoloured leaves and/or needles (OLn) and slightly altered, sometimes only slightly fragmented leaves and/or needles (OLv).

The OF horizon is characterized by the accumulation of partly decomposed litter, mainly from transformed leaves/needles, twigs and woody materials, but without any entire plant organ (humic component from 10 to 70%). Decomposition is mainly accomplished by soil fauna (OFzo) or cellulose-lignin decomposing fungi (OFnoz).

The OH horizon is characterized by an accumulation of zoogenically transformed material, mainly comprised of aged animal droppings. A large part of the original structures and materials are not discernible (humic component more than 70%).

In some cases, above defined O horizons cannot be identified because of the specificity of their components, hence the need for defining more specific diagnostic horizons: lignic, rhizic and bryoic diagnostic O horizons (OW, OR, and OM horizons, respectively), are comprised of more than 75% in volume of wood remains, dead or living roots, and dead or senescent moss parts, respectively.

Organo-mineral horizons

Different organo-mineral A horizons are identified in the field by observing the soil mass with the naked eye or with a 5–10× magnifying hand lens. Five diagnostic A horizons may be distinguished according to their structure: three zoogenic or root-structured according to abovementioned sizes of aggregates and two non-zoogenic or non-root-structured.

Zoogenic A horizons (Azo):

1) Biomacrostructured A = Aneci-endovermic; ø granular size > 4 mm;
2) Biomesostructured A = Endo-epivermic; 1 mm < ø granular size > 4 mm;
3) Biomicrostructured A = Enchy-arthropodic; ø granular size < 1 mm.

Non-Zoogenic A horizons (Anoz):

4) Single grain A (sgA) = unbound loose consistence; presence of clean mineral grains; < 10% of fine organic particles and/or dark-colored biogenic peds; pH water < 5**;**
5) Massive A (msA) = heterogeneous but one-piece, no planes or zones of weakness are detectable in the mass; the size of the most common biostructured units being < 1 mm; pH water < 5**.**

The last published classification of humus forms elaborated by Zanella et al. (2011) distinguishes 6 main morpho-functional types: Mull, Moder, Mor, Amphi, Tangel and Anmoor. These main references can be scaled along a gradient of decreasing biological activity, which is revealed by an increasing accumulation of organic remains and a decrease in the abundance of living animals and their pellets.

The humus forms were classified using two hierarchical levels of classification. In the first level six main references (Anmoor, Mull, Moder, Mor, Amphi and Tangel) were defined; each unit of the first level is distinguished into two or more biological sub-types (i.e. Eumull, Mesomull; Hemimoder, Dysmoder). *Terrestrial humus forms* are distinguished into 5 basic forms (Mull, Moder, Mor, Amphi, Tangel) that are *equilibrium* points and ecological attractors in a continuum pattern from neutral and biologically active Mull (with rapid litter turnover) to Moder, with intermediate characters; Amphi present a litter seasonally unavailable to earthworms for climatic reasons (Zanella et al., 2011).

Study Area

The study is carried out on 8 forest areas distributed in central Italy: Tuscany, Latium and Campania (see map). The areas are contiguous and subjected to different forest management: the difference in the cutting turn-over is the mainly factor distinguishing the areas. Floristic composition and plant association are the same to allow the comparison.

Tuscany
2 forest areas, 4 different forest managements,
12 phytosociological relevés,12 humus profiles.

Latium:
4 forest areas, 8 different forest managements,
24 phytosociological relevés, 24 humus profiles.

Campania:
2 forest areas, 4 different forest managements,
12 phytosociological relevés,12 humus profiles.

In September /October 2012, 48 sampling sites were detected and characterized by:

- Geographic coordinates (latitude and longitude)
- Altitude
- Slope
- Aspect
- Geological substrate
- Rockiness
- Stoniness
- Humus forms
- Vegetation

Experimental Design

In order to have an adequate number of surveys to describe the forest areas, in each area we selected three *replicat* for each different forest management: three recently clear-cut stands (the turn ranged between 4 and 15 years) and three clear-cut stands (>16 years).

METHODS

Field Survey

Vegetation Survey: 48 phytosociological relevés according to Braun-Blanquet method (1928) were carried out in each sampling site.

The phytosociological relevè is realized by the *census* of all the vascular plants occurred in the sampling site and the evaluation of species coverage, using the B-B scale, modified by Pignatti (1953):

Braun-Blanquet		**Pignatti**	
1-5%	1	1-20%	1
5-25%	2	20-40%	2
25-50%	3	40-60%	3
50-75%	4	60-80%	4
75-100%	5	80-100%	5

The width of the relevè is defined on the base of *minimum area* representing the plant association we want identify and classify, according to the phytosociological frame of reference.

Humus Survey: 48 soil/humus profiles were done in the same sampling sites of the vegetation. We collected 196 samples of different horizons of humus and soil. In the laboratory the following analyses were done:

- microscope observation: through the use of microscope we observed and validated the field observations;
- calculation of field capacity, measurements of pH and carbon (Walkey Black method) in organic and organo-mineral horizons according to the methods adopted by the Italian Society of Soil Science (Società Italiana della Scienza del Suolo, 1985) and by U.S.D.A. - Soil Survey Staff (Soil Survey Staff, 1975, 1998).

We report below only the description of the humus forms found and classified in this study:

1) Mull, recognizable by the absence of OH horizon and presence of A horizon processed by earthworms with pH ≥ 5; the litter turn-over is rapid (<2 years), the soil carbon is mainly in A horizon;

2) Moder recognizable by presence of OL, OF, OH organic horizons and A horizon-biomesostructured and/or biomicrostructured with pH <5; the litter turn-over is slower than Mull (2-7 years); soil carbon is stored in both organic (O) and organo-mineral (A) horizons;

3) Amphi recognizable by presence of OL, OF, OH organic horizons and A horizon-biomesostructured and/or biomacrostructured with pH ≥5; turnover of litter is similar to Moder (2-7 years); Amphi have a high content of carbon accumulated in both organic (O) and organo-mineral (A) horizons generally much deeper than Moder.

The table below synthesize the biological activity of the humus forms classified.

Ecosystem	***Biological activity***			
	High		*Moderate*	
	Main morpho-functional type	*Detailed morpho-functional types*	*Main morpho-functional types*	*Detailed morpho-functional types*
Terrestrial: on calcareous substrate	Mull	Eumull Mesomull Oligomull Dysmull	Amphi	Leptoamphi Eumacroamphi Eumesoamphi Pachyamphi
Terrestrial: on acid substrate			Moder	Hemimoder Eumoder Dysmoder

The morpho-functional classification of humus forms proposed in a previous issue by Zanella and collaborators for Europe (2011) has been extended and modified, without any change in diagnostic horizons, in order to embrace a wide array of humus forms at worldwide level and to complete and make more effective the World Reference Base for Soil Resources.

Factors or processes most clearly influencing the biological formation of the main sets of Humus Form Reference Groups (see table).

Factors or processes most clearly influencing the biological formation of humus forms		**Humus Form Reference Groups**
Humus forms in which faunal activities and decomposition of organic matter are well visible and occur in aerated conditions	*Biological activities and decomposition of organic matter moderately limited by low temperature and/or acidity of parent material*	*HEMIMODER* *EUMODER* *DYSMODER*
	Contrasted climate conditions (Mediterranean o sub-Mediterranean distribution of rainfall, higher in spring and autumn, very low during summer, causing drought stress especially in the topsoil)	*LEPTOAMPHI* *EUMACROAMPHI* *EUMESOAMPHI* *PACHYAMPHI*
	Faunal activities and decomposition of organic matter weakly or not limited by harsh environmental conditions	*EUMULL* *MESOMULL* *OLIGOMULL* *DYSMULL*

The monitoring of humus forms allows: i) to detect and foresee the impact of global warming on surface-accumulated organic carbon (Ponge et al., 2011); ii) to estimate the contribution of soil to atmospheric CO_2 increase on a worldwide scale (Thum et al., 2011), and iii) to detect changes in hydrological environment (Bullinger-Weber et al., 2007; Sevink and de Waal, 2010), soil acidification and eutrophication (Bernier and Ponge, 1994; Pinto et al., 2007).

Procedure for the Calculation of Ecoindicators

From the phytosociological survey a floristic matrix of 145 species x 48 relevès was obtained. Ellenberg's indicators values –EIV were assigned to each species of the matrix: 6 indicators for light-L, temperature-T, continentality of climate (K), soil moisture (F), soil pH (R), nitrogen (N), two derived indices of humus quality R*N and R/N, and hemeroby index (H). EIV come from Data Bank implemented by Pignatti et al. (2005) and Fanelli et al. (2006c) for the Mediterranean species lacking in the original Ellenberg list. H values come from unpublished data Bank (Fanelli, in press).
Indicator values were weighted on the species coverage of the matrix and an ecological characterization for site was obtained.

To improve the knowledge of the flora and vegetation, life forms and chorotypes were also calculated by the same procedure utilized for the ecoindicator values. To each species of the floristic matrix was assigned the correspondent life form and chorotype derived by Data Bank (Pignatti, 1982).

Statistical Data Treatment

Regression Analysis

We used the scatter plot to identify one by one the relationship between the values of each Ellenberg indicator *versus* hemeroby index and each soil measured parameter. Given a scatter plot, we can draw the line that best fits to the data: the regression line.

Regression analysis is most often used for prediction. The goal in regression analysis is to create a mathematical model that can be used to predict the values of a dependent variable based upon the values of an independent variable. In other words, we used the model to predict the value of the soil measured parameters (dependent Y) when we know the value of EIV (independent X). Correlation analysis is often used with regression analysis because it is used to measure the strength of association between the two variables X and Y.

In regression analysis involving one independent variable and one dependent variable, the values are frequently plotted in two dimensions as a scatter plot. The scatter plot allows us to visually inspect the data prior to running a regression analysis. Often this step allows us to see if the relationship between the two variables is increasing or decreasing and gives only a rough idea of the relationship. The simplest relationship between two variables is a straight-line or linear relationship. R^2 is often interpreted as the proportion of response variation "explained" by the regressors in the model. Thus, $R^2 = 1$ indicates that the fitted model explains all variability, while $R^2 = 0$ indicates no 'linear' relationship between the response variable and regressors. An intermediate value such as $R^2 = 0.7$ may be interpreted as follows: "Approximately seventy percent of the variation in the response variable can be explained by the explanatory variable. The remaining thirty percent can be explained by unknown, lacking variables or inherent variability."

Spearman's Rank Correlation Analysis

Spearman Rank Correlation Coefficient is a non-parametric measure of correlation, using ranks to calculate the correlation. Whenever we are interested to know if two variables are related to each other, we use a statistical technique known as correlation. If the change in one variable brings about a change in the other variable, they are said to be correlated. Spearman Correlation Test is also known as the "spearman rho". The numerical value of the correlation coefficient, **rho**, ranges between -1 and +1. The correlation coefficient is the number indicating how the scores are relating.

In general,

rho > 0 implies positive agreement among ranks

rho < 0 implies negative agreement (or agreement in the reverse direction)

rho = 0 implies no agreement

Closer **rho** is to 1, better is the agreement while **rho** closer to -1 indicates strong agreement in the reverse direction.

Spearman Rank Correlation Test is a non-parametric measure of correlation that tries to assess the relationship between ranks without making any assumptions about the nature of their relationship.

ANOVA TEST

The one-way analysis of variance (ANOVA) is used to determine whether there are any significant differences between the means of three or more independent (unrelated) groups.

The one-way ANOVA compares the means between the groups you are interested in and determines whether any of those means are statistically significantly different from each other. Specifically, it tests the null hypothesis:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k$$

where μ = group population mean and k = number of groups. The alternative hypothesis (HA) is that there are at least two group means that are significantly different from each other. Briefly stated, if the result of a one-way ANOVA is statistically significant (using the F distribution), we accept the alternative hypothesis; otherwise, we reject the alternative hypothesis. To determine which specific groups differed from each other you need to use a post-hoc test. To determine which groups was different from which, the *Fisher LSD test* was carried out with an individual error rate with critical value at P<0.05. In the ANOVA table it was shown the output of the ANOVA analysis and whether we have a statistically significant difference between our group means, but we do not know which of the specific groups differed. Luckily, we can find this out in the second ANOVA table which contains the results of post-hoc LSD tests.

RESULTS FROM VEGETATION AND HUMUS SURVEY

For each area, floristic composition, vegetation structure, humus forms and relationships between EIV and humus measured parameters were described in detail.

LATIUM

1 - Poggio Mirteto (Rieti)

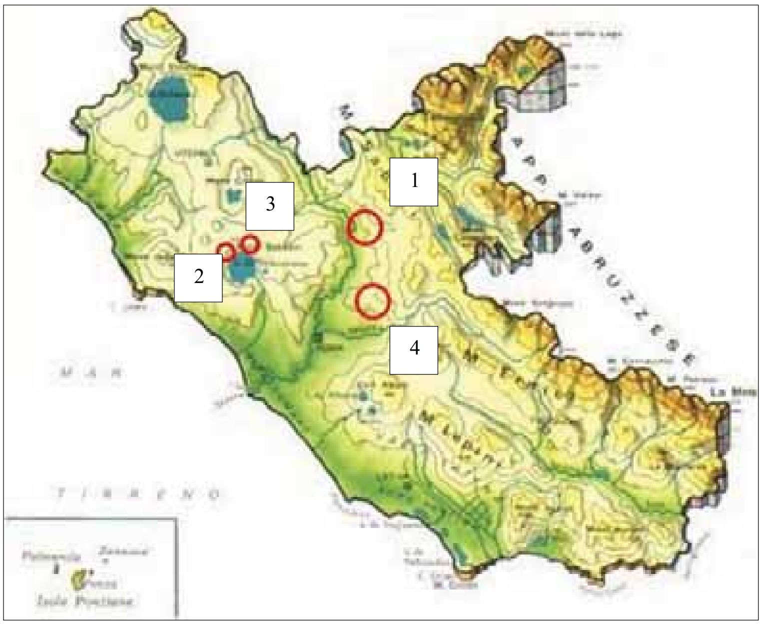

Fig. 1 – Latium forest areas: 1 – Poggio Mirteto; 2 – Trevignano; 3 – Monterosi; 4 – Palombara Sabina.

Overview

The forest area is located on the Sabine Mountains (pre-Apennines). Vegetation is represented by *Quercus cerris, Fraxinus ornus* and *Ostrya carpinifolia* forest. Furthermore, two types of *Quercus ilex* forest occur: primary forests on exposed rocks, secondary forest in sites where the erosion is strong caused by forest management of the deciduous woodlands.

Geological substrate

Corniola (Pliensbachiano-higher Sinemurian): limestones and marly limestone, gray and dark gray well-stratified, detrital and dolomitic limestones.

Vegetation

The *Quercus cerris* woodlands are impoverished in characteristic mesophile species while shrub species mainly belonging to Mediterranean environments replace the others. *Quercus ilex* prevails in the shrub layer reaching high values of coverage. *Quercus ilex* occurrence is even more pronounced on steep slopes where the rocks emerge because of soil erosion.

The woodlands structure clearly shows the cutting impact in the different layers (correlated with the forest management), especially in coverage values and floristic composition.

Sampling sites

We detected six sampling sites: three in the more recently clear-cut stand (year of cutting: 2007) and three in the earlier cut stand (year of cutting: 2001).

Last cutting year 2007

Altitude: 587-592 m
Slope: 15-20°
Aspect: E-S-SSO
Rockiness: 0-10%
Stoniness: 0-10%

Humus forms:
i) Amphi: **Eumacroterroamphi**
ii) Mull: **Oligo/Dysterromull**
iii) Amphi: **Eumesoterroamphi**

Dominant tree layer (t1)

Layer characterized by low coverage values and composed by *Quercus cerris* and *Quercus ilex*. These trees are the "*matricine*", uncut individuals in the last cutting.

Dominated tree layer (t2)

Layer lacking due to recent cutting.

Tall shrub layer (s1)

Layer characterized by low coverage and few species present only in the first relevé with *Fraxinus ornus, Phillyrea latifolia, Quercus ilex, Styrax officinalis, Sorbus domestica.*

Low shrub layer (s2)

Layer characterized by high coverage values due to the regrowth after cutting of secondary vegetation with *Arbutus unedo, Fraxinus ornus, Phillyrea latifolia, Quercus ilex, Styrax officinalis, Sorbus domestica, Rosa sempervirens, Rubus ulmifolius.*

Herb layer (hl)

Layer characterized by very low coverage values due to large development of the shrub vegetation with *Asparagus acutifolius, Clematis vitalba, Conyza bonariensis, Quercus cerris* and *Fraxinus ornus plantulae.*

Number of species

Average 21,7.

Last cutting year 2001

Altitude: 496-561 m
Slope: 10-30°
Aspect: SE-O-O
Rockiness: 2-5%
Stoniness: 5-7%

Humus forms:
i) Mull: **Dysterromull**
ii) Amphi: **Eumesoterroamphi**
iii) Amphi: **Leptoterroamphi**

Dominant tree layer (t1)

Layer characterized by low coverage values except for relevé 2 and it is composed by *Quercus cerris* and *Quercus ilex* with *Hedera helix.*

Dominated tree layer (t2)

Layer characterized by high coverage and composed by *Quercus cerris, Quercus ilex, Fraxinus ornus, Ostrya carpinifolia*. The high coverage represents the most important difference in forest structure if compared with the previous relevés concerning the recently cut sites (1, 1 *bis* and 1 *ter*).

Tall shrub layer (s1)

Layer lacking because the canopy of dominated tree layer intercepts the light.

Low shrub layer (s2)

Layer characterized by low coverage values due to the regrowth after cutting of trees and it is composed by *Ligustrum vulgare, Fraxinus ornus, Phillyrea latifolia, Quercus ilex, Rosa sempervirens, Rubus ulmifolius.*

Herb layer (hl)

Layer characterized by very low coverage values due to large tree layers development. The most widespread species are: *Asparagus acutifolius, Ajuga reptans, Prunella vulgaris, Carex sylvatica, Clematis vitalba, Viola alba, Quercus cerris, Quercus ilex* and *Fraxinus ornus plantulae.*

Number of species

Average 17,3

Humus forms

The stands with different forest management (recently cutting -2007- and earlier cutting – 2001) display the same humus forms. We can observe only one difference: Eumacroterroamphi (OH horizon > 1 cm) in the recently cut stand and Leptoterroamphi in the earlier cut stand (OH horizon < 1 cm).

Ecoindicators and soil parameters

In each sites we compared EIV values and soil measured parameters (pH, field capacity and %C) in the two forest stands: the earlier cut stand shows values of pH, field capacity and temperature-T indicator higher while %Carbon, L, R, N, R*N and H values are lower than those found in the recently cut stand.

2 – Trevignano Romano (Roma)

Overview

The forest area is located within the "Regional Natural Park of Bracciano and Martignano" on the slopes of Monte Rocca Romana. The vegetation is represented by *Quercus cerris* forest and secondary shrubs mainly belonging to Mediterranean environments.

Geological substrate

The substrate is composed of thin layers of tuff and cineritic pyroclastic produced by the final explosive phases of the Sabatini volcanic complex.

Vegetation

Quercus cerris woodlands show only *Q. cerris* in the dominant tree layer, *Fraxinus ornus* in the dominated tree layer, abundance of *Cytisus villosus, Crataegus monogyna, Rubus ulmifolius* and *Sorbus domestica* in the two shrub layers and a large spread of *Rubia peregrina, Cyclamen hederifolium, Ruscus aculeatus, Buglossoides pupurocaerulea* in the herbaceous layer found in all relevés. Differences between the two forest management emerge in the structure: dominant tree layer coverage displays mean values of 25% in the site more recently cut *vs* 85% in the earlier cut sites; dominated tree layer shows coverage values of 25% *vs* 37%; tall shrub layer 40% *vs* 25%; low shrub layer 40% *vs* 25%; herb layer 23% *vs* 42%. All these differences are due to cutting turnover, in particular the high coverage values of the shrub layers show the vegetation regrowth after cutting.

Sampling sites

We detected six sampling sites: three in the more recently clear-cut stand (years of cutting: 2003/2004) and three in the earlier cut stand (> 16 years, probably years of cutting: 1980/85).

Last cutting year 2003-2004

Altitude: 345-350 m
Slope: 10-20°
Aspect: S-S-S
Rockiness: 0 %
Stoniness: 0-5%

Humus forms:

i) Mull: **Oligoterromull**
ii) Mull: **Oligo/Dysterromull**
iii) Mull: **Oligo/Dysterromull**

Dominant tree layer (t1)

Layer characterized by low coverage values (25%) of *Quercus cerris,* reaching 22m of height.

Dominated tree layer (t2)

Layer characterized by low coverage values (25%) of *Quercus cerris* and *Fraxins ornus*

Tall shrub layer (s1)

Layer characterized by high coverage values (in two of three relevés) of *Fraxinus ornus, Quercus cerris, Sorbus domestica,* among the most common species.

Low shrub layer (s2)

Layer characterized by high coverage of *Crataegus monogyna, Cytisus villosus, Euonymus europaeus, Quercus cerris, Rubus ulmifolius, Sorbus domestica.*

Herb layer (hl)

Layer characterized by low coverage values but characterized by a lot of species occurred in almost all relevés as *Brachypodium sylvaticum, Buglossoides purpurocaerulea, Calamintha sylvatica, Ruscus aculeatus, Carex sylvatica, Cyclamen hederifolium, Rubia peregrina.*

Number of species

Average 27

Last cutting years 1980-1985

Altitude: 400-410 m
Slope: 10-15°
Aspect: S-S-S
Rockiness: 0-5%
Stoniness: 0-5%

Humus forms:

i) Mull:	**Dysterromull**
ii) Amphi:	**Eumesoterroamphi**
iii) Mull:	**Dysterromull**

Dominant tree layer (t1)

Layer characterized by high coverage values and tall individuals of *Quercus cerris* reaching 23m of height.

Dominated tree layer (t2)

Layer characterized by high coverage values of *Fraxinus ornus, Ostrya carpinifolia*, *Quercus cerris.*

Tall shrub layer (s1)

Layer found only in one of three relevés where high coverage values of *Crataegus monogyna* and *Fraxinus ornus* are recorded.

Low shrub layer (s2)

Layer characterized by low coverage values and composed by *Fraxinus ornus, Sorbus domestica, Cytisis villosus, Crataegus monogyna.*

Herb layer (hl)

Layer characterized by high coverage values with a large spread of *Brachypodium sylvaticum, Buglossoides purpurocaerulea, Calamintha sylvatica, Ruscus aculeatus, Carex sylvatica, Carex flacca, Rubia peregrine, Echinops siculus.*

Number of species

Average 28.

Humus forms

The two forest stands have different humus forms. The more recently cut -2003/2004- stand displays only Mull forms (Oligoterromull - OF horizon missing or discontinuous and OLv horizon continuous and thick – and Dysterromull - OF horizon present and continuous). The earlier cut – 1980/85- stand displays Mull (Dysterromull) and Amphi forms (Eumesoterroamphi - OH horizon <

3 cm). It would seem to be a gradient: in the first stand the presence of humus Mull could indicate that the recent disturbance due to cutting accelerated the decomposition not allowing the formation of OH horizon; in the second, the decomposition slows down and there is the formation of OH horizon in the Amphi forms.

Ecoindicators and soil parameters

The earlier cut stand shows higher values of pH, %C, T, K, F, R, R/N while values of field capacity, L, N, R*N and H are lower than those found in the recently cut stand.

3 - Monterosi (Roma)

Overview

The forest area is located within the "Regional Natural Park of Bracciano and Martignano" in the eastern sector of the Sabatino volcanic complex. The vegetation is represented by *Quercus cerris* forest.

Geological substrate

The substrate is composed by lava and scoria cones mainly leucititiche and porphyritic compact tuffs or intercalated with stratified containing fragments of lava and launch products. Furthermore there are levels of trachytic ignimbrite with calcareous inclusions.

Vegetation

Quercus cerris woodlands are generally characterized by total high coverage values (particularly in the low shrub and herbaceous layers) responsible for a very dense vegetation both in young and in mature woodlands. Most common species are *Cornus sanguinea, Crataegus oxyacantha, C. monogyna, Euonymus europaeus* and *Rubus ulmifolius* in the shrub layers; *Arisarum proboscideum, Arum italicum, Calamintha sylvatica, Cyclamen hederifolium, Ruscus aculeatus, Rumex sanguineus* in the herbaceous layer.

Sampling sites

We detected six sampling sites: three in the more recently cut stand (years of cutting: 2007/2008) and three in the earlier cut stand (years of cutting: 1992/93).

Last cutting years 2007-2008

Altitude: 356-366 m
Slope: 2-5°
Aspect: E-NW-S
Rockiness: 0%
Stoniness: 0%

Humus forms:
i) Amphi: **Eumacroterroamphi**
ii) Amphi: **Eumacroterroamphi**
iii) Mull: **Oligo/Dysterromull**

Dominant tree layer (t1)

Layer characterized by very low coverage values (20%) of *Quercus cerris.*

Dominated tree layer (t2)

Layer almost lacking. *Quercus cerris* (coverage values: 30%) occurs only in one of three relevés.

Tall shrub layer (s1)

Layer almost lacking. *Quercus cerris* (coverage values: 30%) occurs only in one of three relevés.

Low shrub layer (s2)

Layer characterized by high coverage values of *Cytisus scoparius* and secondly of *Rubus ulmifolius, Cornus sanguinea, Euonymus europaeus.*

Herb layer (hl)

Layer characterized by high coverage values of *Geranium robertianum, Clematis vitalba, Hypericum perforatum, Rumex sanguineus, Ruscus aculeatus, Silene alba.*

Number of species

Average 37,7.

Last cutting years 1992-1993

Altitude: 354-377 m
Slope: 5-7°
Aspect: SE-SSW-N
Rockiness: 0%
Stoniness: 0%

Humus forms:

i) Amphi:	**Pachyterroamphi**
ii) Amphi:	**Leptoterroamphi**
iii) Amphi:	**Leptoterroamphi**

Dominant tree layer (t1)

Layer characterized by medium coverage values of *Quercus cerris.*

Dominated tree layer (t2)

Layer characterized by high coverage values of *Quercus cerris, Castanea sativa, Carpinus orientalis, Fraxinus ornus.*

Tall shrub layer (s1)

Layer characterized by medium coverage values of *Corylus avellana,* secondly *Ulmus minor* indicating humidity conditions.

Low shrub layer (s2)

Layer characterized by high coverage values of *Crataegus oxyacantha, Cornus sanguinea, Rubus ulmifolius* and *Ilex aquifolium.*

Herb layer (hl)

Layer characterized by high coverage values of *Arisarum proboscideum, Cyclamen hederifolium, Hedera helix, Melica uniflora, Ruscus aculeatus.*

Number of species

Average 33.

Humus forms

The two forest stands have different humus forms. The first was managed by a clear cutting - 2007/2008- and have Amphi (Eumacroterroamphi - OH horizon > 1 cm) - and Mull forms (Oligo/Dysterromull). The earlier cut – 1992/93- stand has only Amphi forms (Pachyterroamphi – OH horizon > 3 cm - and Leptoterroamphi - OH horizon < 1 cm). In the first stand Mull forms are found in the sites where there are good faunal activities, while, where the rate of branches, leaves, woods reaching the ground, is higher than the soil capacity of decomposition, we have found Amphi forms. In the earlier cut stand the Amphi forms are in relationship with the slow litter turnover rate caused by the seasonally contrasted climate conditions -Mediterranean or sub-Mediterranean distribution of rainfall, i.e. higher in spring and autumn, very low during summer, causing drought stress especially in the topsoil-.

Ecoindicators and soil parameters

Earlier cut stand displays values of pH, T, K, R, R*N, R/N higher, while field capacity, %C, L, N, and H values are lower than values recorded in the recently cut stand.

4 - Gattaceca (Palombara Sabina, Roma)

Overview

The forest area is located on the slopes of low limestone hills in the countryside north of Rome. The vegetation is represented by *Quercus cerris* forest and pastures.

Geological substrate

The dominant substrate consists of massive limestone, composed of crystalline variety and white or brown detrital and red limestone massifs with remains of brachiopods (Lias and Malm).

Vegetation

Quercus cerris woodlands show high coverage values in all the layers and a significant presence of *Carpinus orientalis* in several layers. *Ligustrum vulgare* and *Crateagus monogyna* are very common species in the shrub layers and are distributed in all relevés as well as *Cyclamen hederifolium* and *Ruscus aculeatus* in the herbaceous layer.

Sampling sites

We detected six sampling sites: three in the more recently cut stand (years of cutting: 1999/2000) and three in the earlier cut stand (years of cutting: 1966/68; cut thinning: 2010/11).

Last cutting years 1999-2000

Altitude: 174-176 m
Slope: 5-10°
Aspect: N-E-NNW
Rockiness: 0-10%
Stoniness: 0-10%

Humus forms:
i) Mull: **Dysterromull**
ii) Mull: **Dysterromull**
iii) Amphi: **Leptoterroamphi**

Dominant tree layer (t1)

Layer characterized by low coverage values of *Quercus cerris.*

Dominated tree layer (t2)

Layer well represented and characterized by high coverage values of *Quercus cerris.*

Tall shrub layer (s1)

Layer characterized by high coverage values of *Carpinus orientalis* and secondly of *Quercus cerris* and *Fraxinus ornus.*

Low shrub layer (s2)

Layer characterized by high coverage values of *Rubus ulmifolius, Quercus cerris, Ligustrum vulgare, Rosa sempervirens* and *Crataegus monogyna.*

Herb layer (hl)

Layer characterized by high coverage values of *Brachypodium sylvaticum, Buglossoides purpurocaerulea, Carex flacca, Cyclamen hederifolium, Rubia peregrina, Ruscus aculeatus, Viola alba.*

Number of species

Average 30.

Last cutting years: 1966/68 *(cut thinning: 2010/11)*

Altitude: 100-119 m

Slope: 0-5°

Aspect: NE-S-O

Rockiness: 0%

Stoniness: 0%

Humus forms:

i) Amphi:	**Leptoterroamphi**
ii) Amphi:	**Eumesoterroamphi**
iii) Amphi:	**Eumesoterroamphi**

Dominant tree layer (t1)

Layer characterized by low coverage values of *Quercus cerris* with limited presence of *Quercus frainetto* and *Hedera helix.*

Dominated tree layer (t2)

Layer characterized by medium to high coverage values of *Carpinus orientalis,* with a very low presence of *Hedera helix* and *Fraxinus ornus.*

Tall shrub layer (s1)

This layer is not well represented and it is characterized by low coverage values and few species like *Carpinus orientalis, Quercus cerris, Acer campestre.*

Low shrub layer (s2)

Layer characterized by low to medium coverage values of *Carpinus orientalis, Crataegus monogyna, Ligustrum vulgare, Rubus ulmifolius.*

Herb layer (hl)

Layer characterized by high coverage values of *Cyclamen hederifolium, Ruscus aculeatus, Hedera helix, Carex sylvatica, Lonicera etrusca* and a lot of *Quercus cerris* pl.

Number of species

Average 22.

Humus forms:

The two stands have different humus forms. The more recently cut -1999/2000- stand has mainly Mull forms (Dysterromull - OF horizon present and continuous) and Amphi forms (Leptoterroamphi - OH horizon < 1 cm) found in the sites where the slow litter decomposition is due to the inability of the soil to decompose the higher rates of leaves, branches and woods reaching the soil. The earlier cut – 1966/68- stand has only Amphi forms (Leptoterroamphi - OH horizon < 1 cm and Eumesoterroamphi - OH horizon < 3 cm) in relationship with:

- the slow litter turnover rate caused by the seasonally contrasted climate conditions (Mediterranean or sub-Mediterranean distribution of rainfall, i.e. higher in spring and autumn, very low during summer, causing drought stress especially in the topsoil);

- the disturbance cause by the recent cut thinning (2010/11).

Ecoindicators and soil parameters

The earlier cut stand has only the values of field capacity higher while values of pH, %C, L, T, K, F, R, N, R*N, R/N and H are lower than those recorded in the recently cut stand.

TUSCANY

Alpe di Poti (Arezzo)

Overview

The two forest areas are located on the western side of the Arezzo Mountains (Fig. 2) and are characterized by *Quercus cerris* forest spread on moderately to steep slopes.

Fig. 2 – Tuscany forest areas. Alpe di Poti (AR).

Geological substrate

The limestone ridge consists of the following formations:

Rock: Sandstone turbidite with calcite and phyllosilicates, alternate with shale. *Londa formation*: silty shale, marl and sandstone, limestone and quartz-feldspar purposes.

Vegetation

We carried out 12 relevés (from 7 to 10 *ter* in Table A in Appendix) in the *Quercus cerris* woodlands spread on the Mountains near Arezzo: the relevés are ranged from 814 to 845 m of altitude. In all relevés dominant tree and herbaceous layers are well represented with high coverage values, conversely the other layers (dominated tree and shrub layers) show low coverage values. Most common species are (except for *Quercus cerris* ubiquitous) *Fraxinus ornus, Crataegus monogyna, Prunus spinosa, Rubus ulmifolius, Rosa sempervirens, Brachypodium sylvaticum, Festuca heterophylla.*

Sampling sites of Area A

We detected six sampling sites: three in the recently cut stand (≥ 20 years, probably years of cutting: 1992/93) and three in the earlier cut stand (≥ 70 years, probably year of cutting: 1950).

Last cutting years 1992-1993

Altitude: 814-845 m

Slope: 25-35°

Aspect: NW-S-W

Rockiness: 0-15%

Stoniness: 5-10%

Humus forms:

i) Amphi:	**Hemiterromoder**
ii) Mull:	**Dysterromull**
iii) Mull:	**Oligo/Dysterromull**

Dominant tree layer (t1)

Layer characterized by the highest coverage values of *Quercus cerris* recorded in the whole data set, except for *Quercus cerris.* The only forest species displaying low coverage values is *Castanea sativa.*

Dominated tree layer (t2)

Layer characterized by low coverage values of *Quercus cerris, Cornus mas, Fraxinus ornus.* This layer is lacking in the relevé 7.

Tall shrub layer (s1)

Layer lacking in all the relevés.

Low shrub layer (s2)

Layer characterized by low coverage values, lacking in relevé 20.

Herb layer (hl)

Layer characterized by discontinuous coverage values (70%, 50%, 5%) of *Festuca heterophylla,* (occurring in all the relevés), *Brachypodium sylvaticum, Dactylis glomerata, Prunella vulgaris,* and *Sesleria autumnalis* found with high coverage values in the relevé 7 (Table in appendix).

Number of species

Average 19,7

Last cutting year 1950

Altitude: 799-839 m

Slope: 0-15°

Aspect: S-/-SW

Rockiness: 0-2%

Stoniness: 0-2%

Humus forms:

i) Moder: **Hemiterromoder**

ii) Moder: **Euterromoder**

iii) Moder: **Euterromoder**

Dominant tree layer (t1)

Layer characterized by high coverage values of *Quercus cerris* with limited presence of *Castanea sativa.*

Dominated tree layer (t2)

Layer lacking in relevé 8, while relevés 8 *bis* and 8 *ter* are characterized by low to medium coverage values, mainly of *Acer campestre* and a very low frequency of *Castanea sativa.*

Tall shrub layer (s1)

Layer lacking (relevé 8) or characterized by low coverage values of *Cornus mas, Malus sylvestris* and *Pseudotsuga menziesii,* an exotic species from neighboring crops.

Low shrub layer (s2)

Layer characterized by very low coverage values of *Rosa sempervirens, Rubus ulmifolius* and *Prunus spinosa.*

Herb layer (hl)

Layer characterized by high coverage values of *Brachypodium sylvaticum, Festuca heterophylla, Quercus cerris, Acer campestre* and *Rubus ulmifolius* pl.

Number of species

Average 22,3

Humus forms

The two stands have different humus forms. The more recently cut -1992/1993- stand has Mull (Oligo/Dysterromull and Dysterromull - OF horizon present and continuous) and Moder forms (Hemiterromoder – OH horizon discontinuous or in pocket), while the earlier cut – 1950- stand has only Moder forms (Hemiterromoder and Euterromoder - OH horizon continuous < 1 cm). In the first stand the recent disturbance and the slope (25-35°) not allowed the formation of only Moder forms as in the second stand. In fact, the litter slides down accumulating in low-lying areas, where the Moder humus forms are developed. The Moder forms are due to the geological substrate and to the altitude: these forms are characterized by biological activities and decomposition of organic matter moderately limited by low temperature and/or acidity of the parent material. Low temperatures slow the process of litter biodegradation and increase the number and thickness of organic horizons (OL, OF and OH); in these conditions Moder unit dominates (Sartori et al., 2007; Bonifacio et al. 2011).

Ecoindicators and soil parameters

The earlier cut stand displays values of field capacity, %C, R, N, R*N, and H higher while pH, L, T and H values are lower than those found in the recently cut stand.

Sampling sites Area B

We detected six sampling sites: three in the recently cut stand (≥ 20 years, probably year of cutting: 1992) and three in the earlier cut stand (≥50 years, probably year of cutting: 1960).

Last cutting year 1992

Altitude: 825-841 m
Slope: 20-40°
Aspect: WSW-SW-SW
Rockiness: 10-15%
Stoniness: 2-5%

Humus forms:
i) Moder: **Hemi/Euterromoder**
ii) Mull: **Dysterromull**

iii) Mull: **Dysterromull**

Dominant tree layer (t1)

Layer characterized by high coverage values of *Quercus cerris.*

Dominated tree layer (t2)

Layer characterized by low coverage values of *Quercus cerris, Fraxinus ornus* and *Cornus mas.*

Tall shrub layer (s1)

Layer lacking.

Low shrub layer (s2)

Layer characterized by low coverage values except for the reléve 10 *ter*. Most of the coverage is due to *Prunus spinosa;* other species are *Rosa canina, Rubus ulmifolius, Crataegus monogyna, Fraxinus ornus.*

Herb layer (hl)

Layer characterized by high coverage values of *Brachypodium sylvaticum, Festuca heterophylla* and *Dactylis glomerata.*

Number of species

Average 17.

Last cutting year 1960

Altitude: 828-833 m
Slope: 5-10°
Aspect: NW-NW-NNW
Rockiness: 0%
Stoniness: 0-2%

Humus forms:
i) Moder: **Hemi/Euterromoder**
ii) Moder: **Dysterromoder**
iii) Moder: **Hemi/Euterromoder**

Dominant tree layer (t1)

Layer characterized by high coverage values of *Quercus cerris,* reaching 12-15 m of height.

Dominated tree layer (t2)

Layer characterized by low coverage values of *Cornus mas* and *Fraxinus ornus,* the only species with coverage values > 1%.

Tall shrub layer (s1)

Layer lacking.

Low shrub layer (s2)

Layer characterized by medium coverage values of *Fraxinus ornus, Prunus spinosa, Cytisus scoparius* and by low coverage values of *Rosa canina, Rubus ulmifolius, Crataegus monogyna.*

Herb layer (hl)

Layer characterized by high coverage values of *Brachypodium sylvaticum, Dactylis glomerata, Galium mollugo, Luzula sylvatica, Quercus cerris* and *Fraxinus ornus* pl.

Number of species

Average 20.

Humus forms

The two stands have different humus forms. The recently cut -1992- stand has Moder (Hemi/Euterromoder) and Mull forms (Dysterromull - OF horizon present and continuous). The earlier cut – 1960- stand only Moder forms (Hemi/Euterromoder and Dysterromoder - horizon continuous and ≥ 1 cm). In these two stands the distribution of the humus forms are the same that we have found in the previous sampling sites of Area A.

Ecoindicators and soil parameters

The earlier cut stand displays values of field capacity, %C, L, T, K, R, N, R*N and R/N higher while pH and H values are lower than those recorded in the recently cut stand.

CAMPANIA

Pratella (Caserta, Monti del Matese)

Overview

The forest areas are located on Monte Cavuto, (Monti del Matese). The vegetation at low altitudes is represented by *Quercus cerris* forest.

Geological substrate

The limestone substrate consists of dolomite and dolomitic limestone in layers and tables with frequent stromatolitic foils (Lower Lias - Upper Triassic).

Fig. 3 – Campania forest areas. Pratella (CE)

Vegetation

We carried out 12 relevés (from 13 to 16 *ter* in Table) of *Quercus cerris* woodlands in Province of Caserta. These woodlands are characterized by low coverage values of the dominant tree layer; high coverage values (except for the relevés 15, 15 *bis*, 15 *ter* where the layer is lacking) of dominated tree layer; low coverage values of low and tall shrub layers; and high coverage values of herbaceous layer. There are several structural differences between the two groups of the relevés belonging to this set, as indicated below.

Sampling sites of Area A

We detected six sampling sites: three in the recently cut stand (years of cutting: 2006/2007) and three in the earlier cut stand (years of cutting: 2002/2003).

Last cutting years 2006-2007

Altitude: 473-479 m

Slope: 5-8°

Aspect: SE-SE-E

Rockiness: 0-5%

Stoniness: 0-5%

Humus forms:

i) Amphi: **Eumesoterroamphi**
ii) Mull: **Dysterromull**
iii) Amphi: **Eumacroterroamphi**

Dominant tree layer (t1)

Layer characterized by low coverage values of *Quercus cerris, Fraxinus ornus* and *Acer obtusatum.*

Dominated tree layer (t2)

Layer characterized by very high coverage values almost only represented by *Carpinus orientalis.*

Tall shrub layer (s1)

Layer lacking.

Low shrub layer (s2)

Layer characterized by very low coverage values due to the high coverage of the dominated tree layer (t2). The more spread species are *Rosa sempervirens, Rubus ulmifolus* and *Crataegus monogyna.*

Herb layer (hl)

Layer characterized by high coverage values mainly of *Ruscus aculeatus, Sesleria autumnalis, Cyclamen hederifoilus* and secondly of *Viola alba, V. reichembachiana, Melittis melissophyllum, Hedera helix, Helleborus foetidus*.

Number of species

Average 27,3

Last cutting years 2002-2003

Altitude: 389-399 m
Slope: 10-25°
Aspect: NE-NW-E
Rockiness: 0-5%
Stoniness: 0-5%

Humus forms:

i) Mull:	**Dysterromull**
ii) Mull:	**Dysterromull**
iii) Amphi:	**Leptoterroamphi**

Dominant tree layer (t1)

Layer characterized by very low coverage values (lowest values are recorded in the whole data set) of *Quercus cerris.*

Dominated tree layer (t2)

Layer characterized by high coverage values; it is composed mainly by *Quercus cerris, Fraxinus ornus, Acer obtusatum.*

Tall shrub layer (s1)

Layer characterized by low coverage values of *Carpinus orientalis,* and by a large distribution of *Fraxinus ornus.*

Low shrub layer (s2)

Layer characterized by low coverage values due mainly to *Carpinus orientalis, Rosa sempervirens, Rubus ulmifolius.*

Herb layer (hl)

Layer characterized by discontinuous- low to high- coverage values of *Carex sylvatica, Sesleria autumnalis, Brachypodium sylvaticum* and *Ruscus aculeatus.* Other common species are *Cyclamen hederifolium* and *Quercus cerris* pl. In the last relevè *Echinops siculus,* character species of the plant association *Echinopo siculi-Quercetum frainetto* Blasi and Paura, 1993, occurs.

Number of species

Average 23,7

Humus forms

The two stands have the same humus forms. The recently cut -2006/2007- stand displays Mull (Dysterromull - OF horizon present and continuous) and Amphi forms (Eumacroterroamphi – OH horizon ≥ 1 cm - and Eumesoterroamphi - OH horizon < 3 cm). The earlier cut – 2002/2003- stand has Mull (Dysterromull) and Amphi forms (Leptoterroamphi - OH horizon < 1 cm). In this second stand the Amphi forms found, Leptoterroamphi, are close to Mull forms. In general, we can observe that in these two stands the Mull forms are characterized by a fast litter decomposition, which is rapidly integrated by large earthworms (Bouché, 1977) in underlying biomacro-structured A horizon (no formation of stable OH horizon). Increasing dryness generates a progressive replacement of Mull by Amphi forms (Andreetta et al., 2010). The process is revealed along the gradient by the appearance of thin to thick OH horizons, which are partially and progressively integrated in underlying dark (rich in organic matter) A horizons by earthworms avoiding the superficial periodical dryness.

Ecoindicators and soil parameters

The earlier cut stand has values of field capacity, %C, pH and H higher while T, K, F, R and R*N values are lower than those recorded in the recently cut stand.

Sampling sites B

We detected six sampling sites: three in the recently cut stand (years of cutting: 2005/2006) and three in the earlier cut stand (>40 years, probably years of cutting: 1960/70).

Last cutting years 2005-2006

Altitude: 394-398 m
Slope: 8-30°
Aspect: NNW-SW-SW
Rockiness: 2-10%
Stoniness: 2-5%

Humus forms:
i) Mull: **Eu/Mesoterromull**
ii) Mull: **Oligoterromull**
iii) Mull: **Oligoterromull**

Dominant tree layer (t1)

Layer characterized by low coverage values of *Quercus cerris.*

Dominated tree layer (t2)

Layer lacking.

Tall shrub layer (s1)

Layer characterized by very high coverage values represented almost only by *Carpinus orientalis, Quercus cerris, Fraxinus ornus.*

Low shrub layer (s2)

Layer characterized by very low coverage values due to the high coverage values of the tall shrub layer (s1). The more common species are *Rubus ulmifolus, Crataegus monogyna, Euonymus europaeus, Rosa sempervirens.*

Herb layer (hl)

Layer characterized by high coverage values of *Sesleria autumnalis, Ruscus aculeatus, Echinops siculus, Cyclamen hederifoilus, Calamintha sylvatica,* secondly of *Helleborus foetidus, Lonicera etrusca, Geranium robertianum.*

Number of species

Average 36

Last cutting years 1960-1970

Altitude: 389-424 m

Slope: 10-15°

Aspect: N-N-N

Rockiness: 0-5%

Stoniness: 0-5%

Humus forms:

i) Mull: **Dysterromull**

ii) Mull: **Dysterromull**

iii) Mull: **Dysterromull**

Dominant tree layer (t1)

Layer characterized by low coverage values of *Quercus cerris.*

Dominated tree layer (t2)

Layer lacking.

Tall shrub layer (s1)

Layer characterized by very high coverage values of *Carpinus orientalis, Quercus cerris, Fraxinus ornus.*

Low shrub layer (s2)

Layer characterized by very low coverage values of *Rubus ulmifolius,* secondly of *Crataegus monogyna, Quercus cerris* pl., *Euonymus europaeus.*

Herb layer (hl)

Layer characterized by medium coverage values mainly due to *Sesleria autumnalis, Ruscus aculeatus, Echinops siculus, Calamintha sylvatica.* A lot of species are well distributed in all of three relevés like *Asparagus acutifolius, Brachypodium sylvaticum, Cyclamen hederifolium, Geranium robertianum, Helleborus foetidus, Lonicera etrusca.*

Number of species

Average 28

Humus forms

In these last two stands we have found only Mull humus forms. In the recently cut stand – 2005/2006 - we have found Eu/Mesoterromull - OF horizon missing and OLv horizon missing or present but discontinuous - and Oligoterromull - OF horizon missing or discontinuous and OLv horizon continuous and thick. In the earlier cut stand – 1960/70 – only Dysterromull - OF horizon present and continuous. In the Mull humus forms, organic rests disappear rapidly ingested by earthworms (and enchytreids) who release organo/mineral faeces into the underlying soil. These organo-mineral complexes are very stable, preserving organic molecules from rapid mineralisation (Ponge et al., 1999; Six et al., 2004; von Lüetzow et al., 2006, 2008; Köegel-Knabner et al., 2008). A biomacro-structured A horizon of Mull is generally thick (> 20 cm) and its structure corresponds to a morphological expression of organo-mineral stable aggregates. It would seems to be a gradient from the more recently disturbed stand where the Mull forms are characterized by the fast litter decomposition (Euterromull, Mesoterromull and Oligoterromull) to the “undisturbed” earlierer cut stand where the Mull forms (Dysterromull) are characterized by a slower decomposition.

Ecoindicators and soil parameters

The earlier cut stand has values of field capacity, T, K, R and R/N higher while pH, %C, L, R*N, N and H values are lower than those found in the recently cut stand.

GENERAL DISCUSSION

Flora and vegetation

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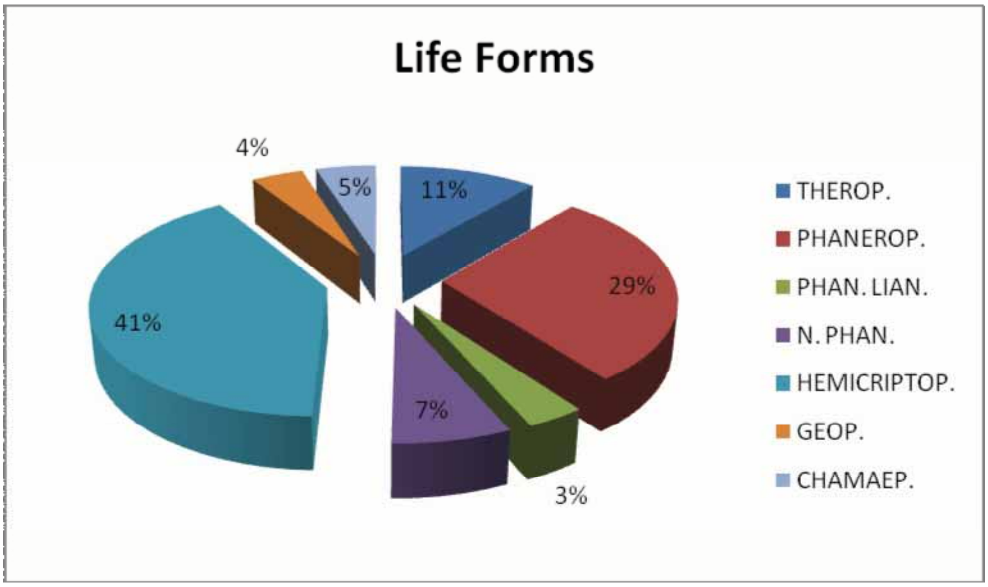
LIFE FORMS



Hemicriptophytes 40,6%

Are the most represented species, including typical elements from herb layer with ingression of species from forest clearings and edges (*Echinops siculus, Melittis melissophyllum, Viola alba*).

Phanerophytes 28,7%

Phanerophytes (P scapos) are woody plants including species of the dominant and dominated layers (*Quercus cerris, Quercus ilex, Carpinus orientalis, Acer* ssp.)

Therophytes 11,2%

This group include annual herb species: few species from herb layer and more species from forest clearings and edges (*Geranium robertianum, Galium aparine, Sedum cepea, Lamium bifidum*).

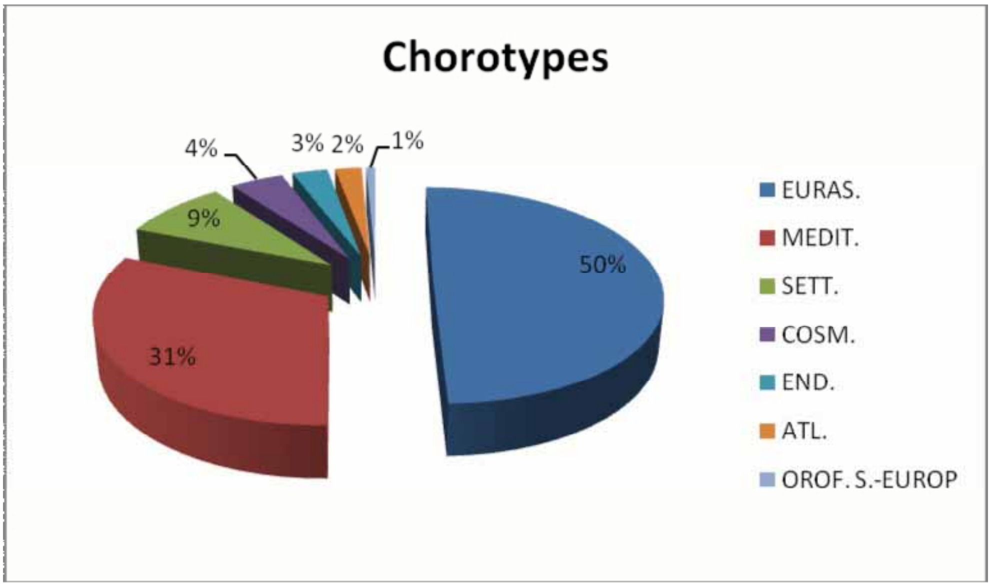
Nano-Phanerophytes 7,0%

These species are mainly related to recent cutting, where the shrub component is very developed (*Rubus ulmifolius*, *Cistus salvifolius, Cytisus salvifolius., Osyris alba, Rosa canina, R. sempervirens*).

Other life forms 12,6%

Chamaephytes 4,9% like *Ruscus aculeatus, Ajuga reptans;* Geophytes 4,2% like *Cyclamen hederifolium, Arisarum proboscideum, Arum italicum* and Lianas-Phanerophytes 3,5% like *Clematis vitalba, Hedera helix, Rubia peregrine* (the scarcity of the geophytes maybe related to the season relevés).

CHOROTYPES



Eurasiatic 50%

It is the largest component including continental species occurring in all layers (i.e. *Melittis melissophyllum, Ulmus minor, Quercus frainetto*).

Mediterranean 31%

It is the second component with species related to the Mediterranean woodlands (i.e. *Viola alba, Crataegus monogyna, Quercus cerris*).

Northern 9%

These species like *Geum urbanum, Prunella vulgaris, Agrimonia eupatoria*, are related mainly to herb layer.

Cosmopolitan 4%, Endemic 3%, Atlantic 2%, Orophytic Southern-European 1%

Minor components reaching together the 10%. *Arisarum proboscideum, Cardamine chelidonia, Digitalis micrantha* and *Echinops siculus* are endemic species.

Phytosociological classification

All woodlands detected belong to *Echinopo siculi-Quercetum frainetto* Blasi et Paura 1993 (syn. *Carpino orientalis-Quercetum cerridis* Blasi 1984) association.

Differences among the woodlands analyzed are mainly due to the cutting turnover mainly influencing forest structure and floristic composition.

The recent cutting changes the floristic composition in all layers, coverage values vary significantly in relationship with the years of cutting, following the vegetation succession.

Syntaxonomic scheme

QUERCO-FAGETEA Br.-Bl. et Vlieger in Vlieger 1937

QUERCETEA PUBESCENTIS Doing-Kraft ex Scamoni et Passarge 1959

- ***Fraxino orni-Cotinetalia*** Jakucs 1961
- ***Quercetalia pubescenti-petraeae*** Klika 1933 corr. Morav. In Béguin et Theurillat 1993
  - ***Melitto-Quercion frainetto*** Berbero et Quezel 1976 (Incl. *Teucrio. siculi-Quercion cerridis* (Ubaldi, 1988) Scoppola et Filesi 1993)
    - **Rubio-Quercetum cerridis** (Pignatti E. e S., 1968) Bas Petroli et al. (1988)
    - **Echinopo siculi-Quercetum frainetto** Blasi et Paura 1993 (syn. *Carpino orientalis-Quercetum cerridis* Blasi 1984)

Soil

Several studies considering the effects of silvicultural practices on soil fauna found important impacts on soil forest fertility/productivity and in the terrestrial food chain (Hill et al., 1975; Moore et al., 2002). It is generally accepted that the removal of trees by clear-cutting, or other methods, has a significant effect on the invertebrate fauna of the forest floor (Heliovaara and Vaisanen, 1984; Hoekstra et al., 1995).

Otherwise for the microarthropod communities, in central Italy, the silvicultural practices and the composition of deciduous forests do not seem to have any important effect. The absence of a change in this soil community structure could be linked to the litter layer that in these hardwood stands is thick enough to maintain a high level of organic matter and a favourable microclimate in every season. The microarthropod communities seem to recover quickly after disturbances such as tree cutting indicating a good level of ecosystem integrity (community resilience).

In general, we can assess that the human activities frequently cause a degradation of soil environmental conditions which leads to a reduction in the abundance and to a simplification of animal and plant communities, where species able to tolerate stress predominate and rare *taxa* decrease in abundance or disappear. The result of this biodiversity reduction is an artificial ecosystem that requires constant human intervention and extra running costs, whereas natural ecosystems are regulated by plant and animal communities through flows of energy and nutrients.

<u>*Carbon content in A horizon*</u> <u>(Fig.4)</u>

The relationships between carbon stock and humus forms were investigated for the topsoil layer (0–20 cm), which was supposed to contain the soil C pools most sensitive to climate change. We found that humus forms can be grouped in statistically different populations, with respect to topsoil C stocks (Tab. B in Appendix).

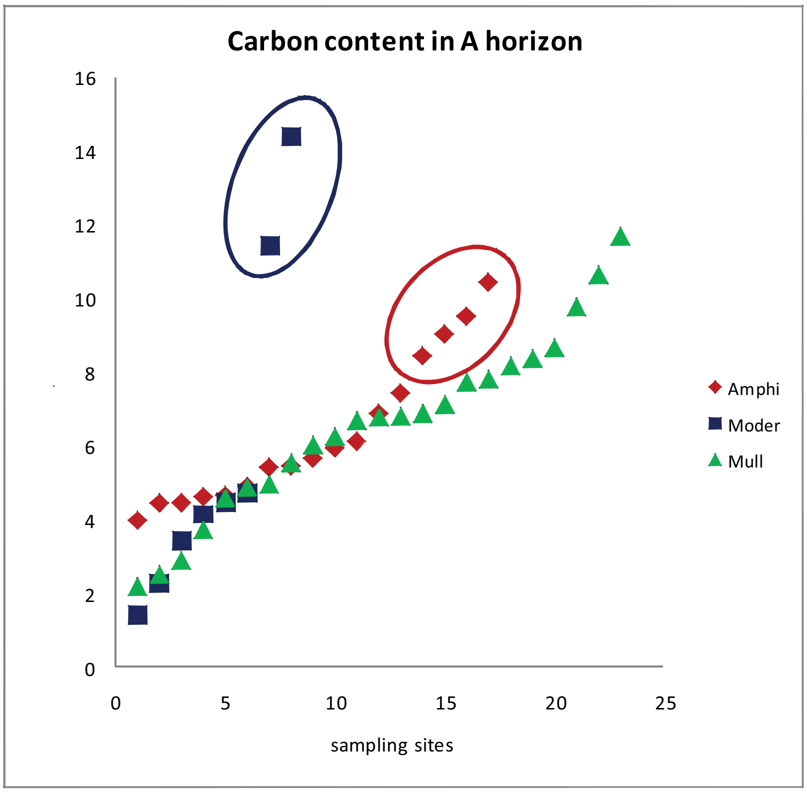


Fig. 4

Even if different researchers highlighted a very large inter-unit variability, a trend in organic carbon content was statistically shown from Mull to Moder or Amphi units. Amphi was found as the richest in organic carbon in the West sector of Alpine chain, while Moder was at the first place in the Centre and East of the chain; however, Mull unit (average of a large range of values) was poorer in organic carbon than the others; on the contrary, in Mediterranean forests Mull unit had the highest stock of organic carbon, close to Amphi and absolutely more (2.5 x) than Moder, as resulted in our study (Fig. 4). Sharing biomacro- from biomeso-structured Mull and Amphi, Andreetta et al. (2010) distinguished three groups of topsoils (OL + first 20 cm of underlying soil horizons) with an increasing content of organic carbon: 1. (Moder + meso-structured Mull), 2. (meso + macro-structured Amphi), 3. macro-structured Mull.

The use of A horizon structure was the main diagnostic criterion and represented the most effective approach to humus classification in Mediterranean conditions. It appears that humus forms have a clear potential as indicators of organic carbon *status* in Mediterranean forest soils.

Low temperatures slow the process of litter biodegradation and increase the number and thickness of organic horizons (OL, OF and OH); in these conditions Moder unit dominates (Sartori et al., 2007; Bonifacio et al., 2011). On the other side, when high temperatures and precipitations are favourable to pedofauna, Mull forms develop, with high content of stable organic molecules in biomacro-structured A horizons (Bonifacio et al., 2011). Intermediate climate conditions or periodical dryness allow to intergrade from Mull to Moder forms on one hand and/or from Mull to more complex Amphi (OH + A) forms on the other hand. The new Medimull could be an intermediate form, a sort of Mediterranean Mull from arthropods, close to a Eumesoamphi without a true OH horizon. This new form could explain the outliers shown in the figure: two highlighted Moder forms, in the upper sector of the plane, and four Amphi forms in the central sector could be classified as the new Medimull in Mediterranean forest.

Relationship between Ellenberg indicators, hemeroby index and measured soil parameters

Regression analysis

We applied this statistical model to EIV *versus* soil measured parameters (field capacity, pH and C%) and hemeroby index. All values were normalized dividing each value by the maximum.

The highest values of linear regression are reported below:

L vs H, field capacity, pH, Carbon content

L indicator is correlated with hemeroby-H in all woodlands (Fig 5a: R^2=0,635) with the highest R^2 (0,751) in the recently cut forest: this result focuses that the recent cutting allows the ingression of more radiation (Fig 5b).

The correlation with measured pH is negative and exists only in the earlier cut woodlands (Fig. 5c: R^2 =0,608).

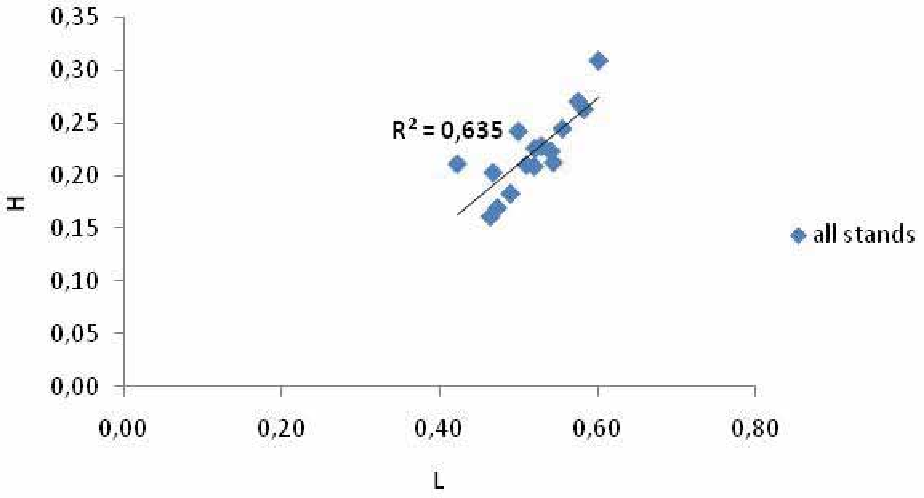


Fig. 5a – L *versus* H

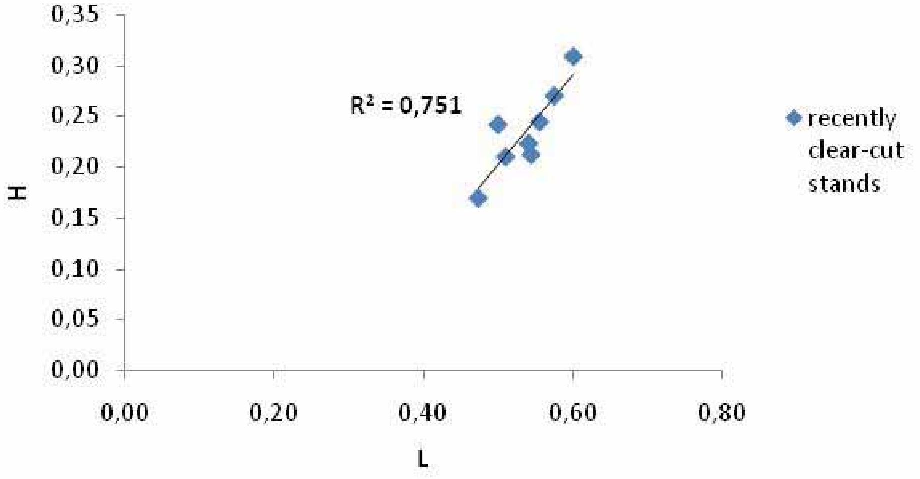


Fig. 5b – L *versus* H

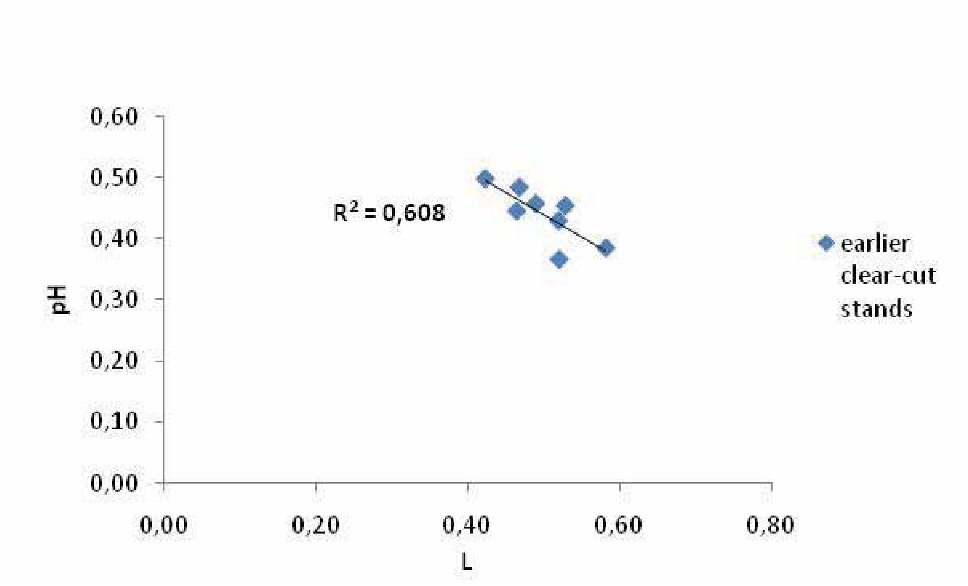


Fig. 5c – L *versus p*H

T vs H, field capacity, pH, Carbon content

T indicator doesn’t show any significant correlation; however T is linked (Fig 6: R^2 = 0,255) to pH in recently cut woodlands.

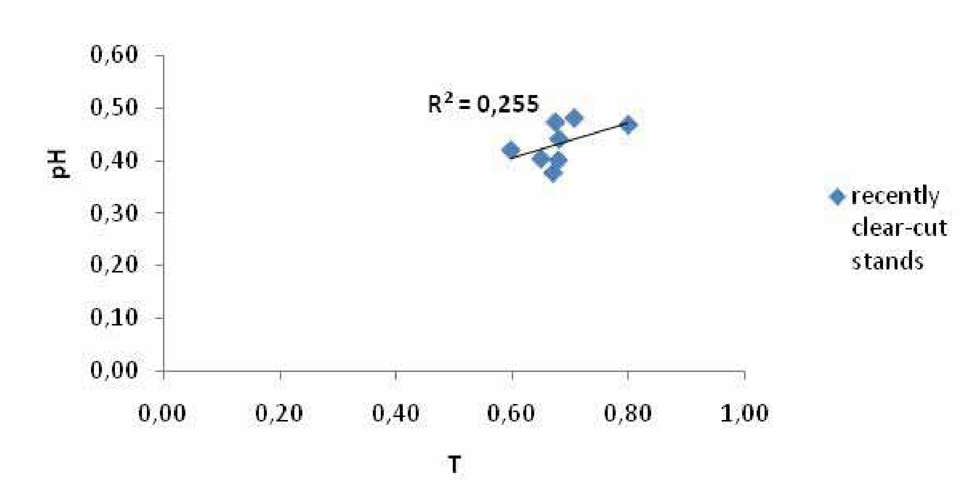


Fig. 6 – T *versus p*H

K vs H, field capacity, pH, Carbon content

K indicator displays a similar trend to L: negative correlation with pH (Fig 7a: R^2 =0,627) in the earlier cut stands and with H (Fig 7b: R^2 = 0,760) in the recently cut stands.

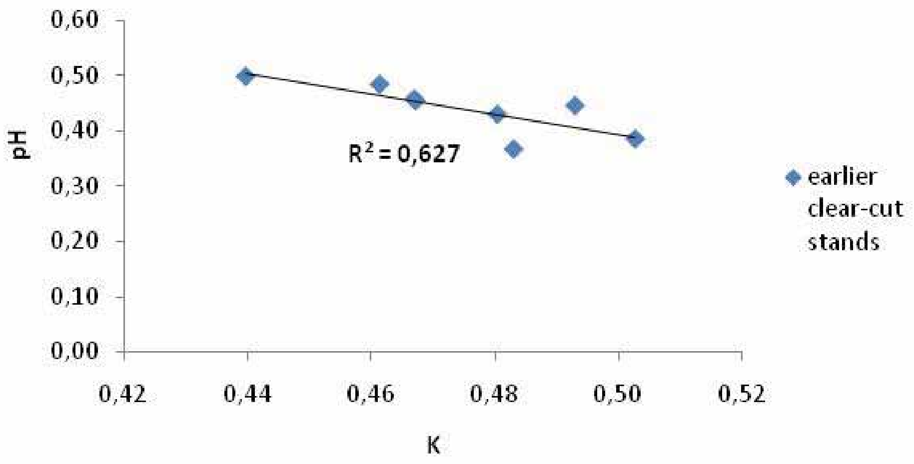


Fig. 7a – K *versus* *p*H

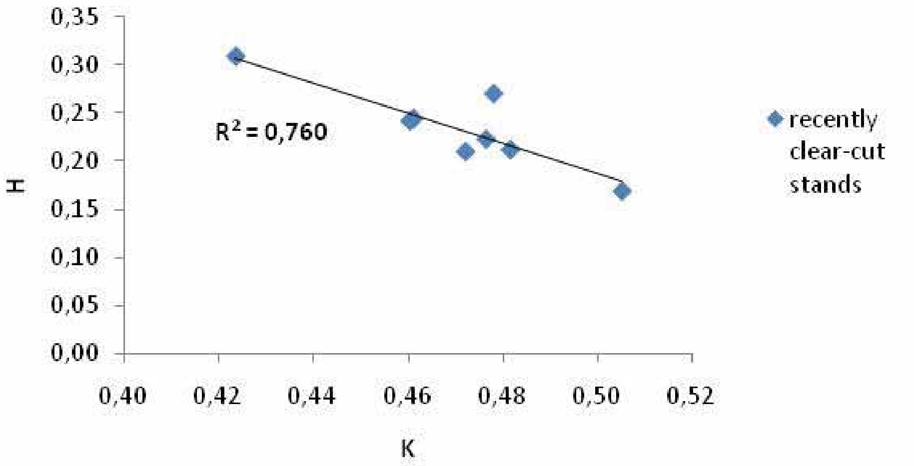


Fig. 7b – K *versus* H

F vs H, field capacity, pH, Carbon content

F indicator doesn't show any significant correlation, however some tendencies are recognizable:

- negative correlation with measured pH (R^2 =0,399) in all the data set, but the regression line (Fig. 8a) best fits in the recently cut (Fig. 8b: R^2 = 0,413) than in the earlier cut (R^2= 0,389) woodlands;
- negative correlation with C% in the recently cut woodlands (Fig. 8c: R^2 =0,425).

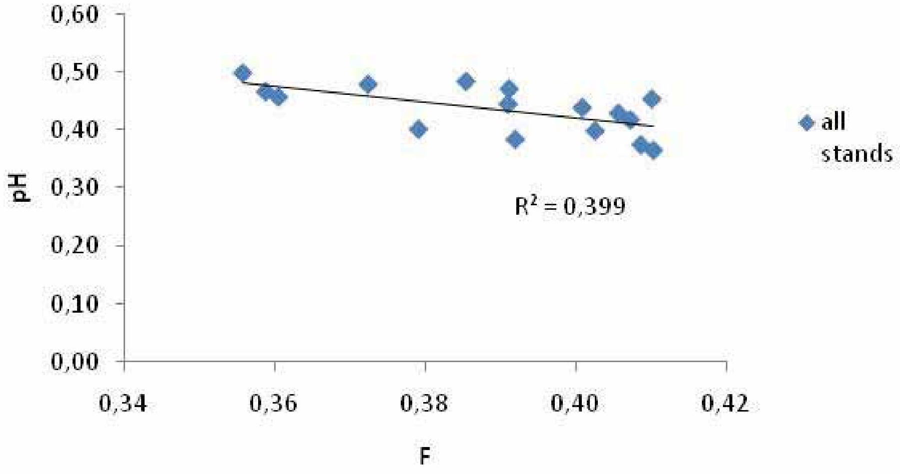


Fig. 8a – F *versus* pH

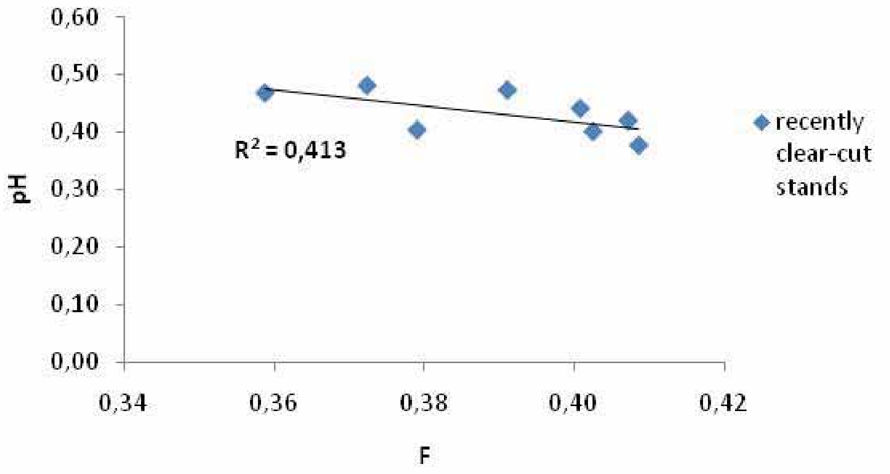


Fig. 8b – F *versus* pH

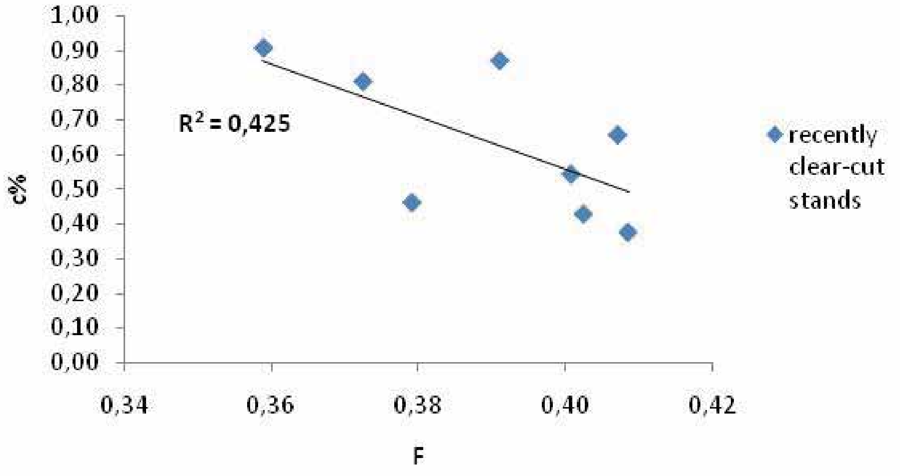


Fig. 8c – F *versus* C%

R vs H, field capacity, pH, Carbon content

R indicator displays the same negative correlation with H observed for K: R^2 =0,526 only in the recently cut woodlands (Fig 9).

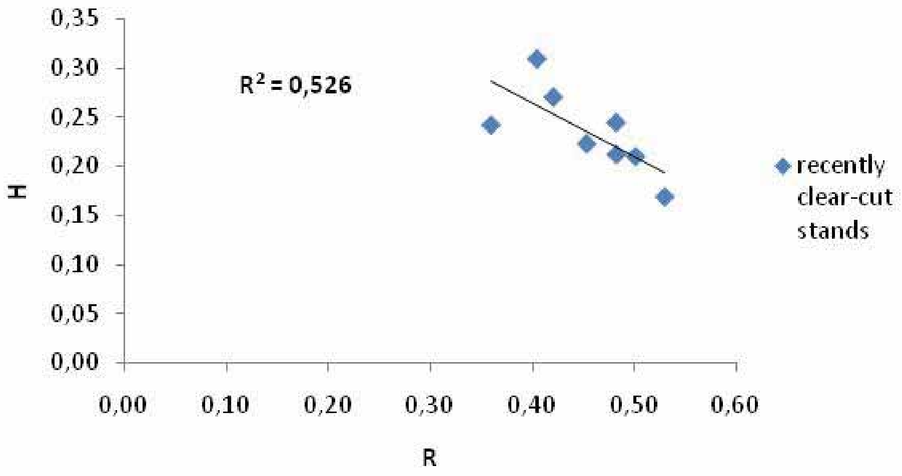


Fig. 9 – R *versus* H

N vs H, field capacity, pH, Carbon content

N indicator shows a positive correlation (Fig.10: R^2 = 0,580) with field capacity in the recently cut woodlands.

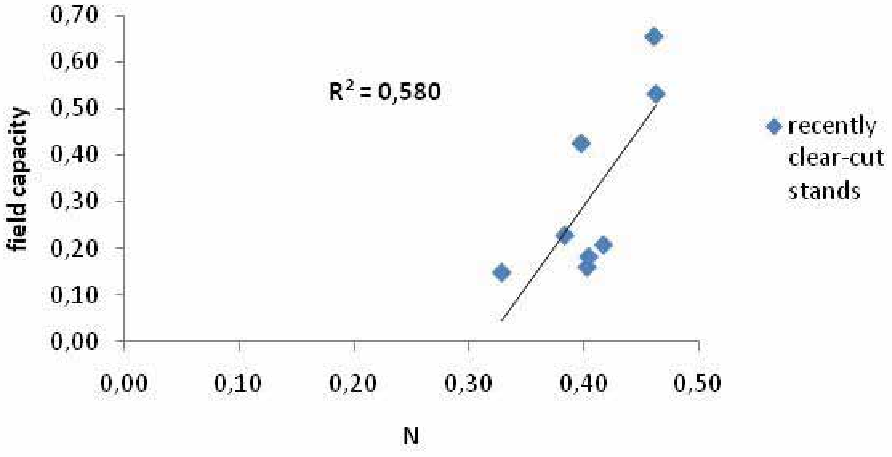


Fig.10 – N *versus* H

H vs field capacity, pH, Carbon content

The hemeroby index doesn't show any significant correlation; however H is linked (Fig. 11: R^2 = 0,242) to pH in the earlier cut woodlands.

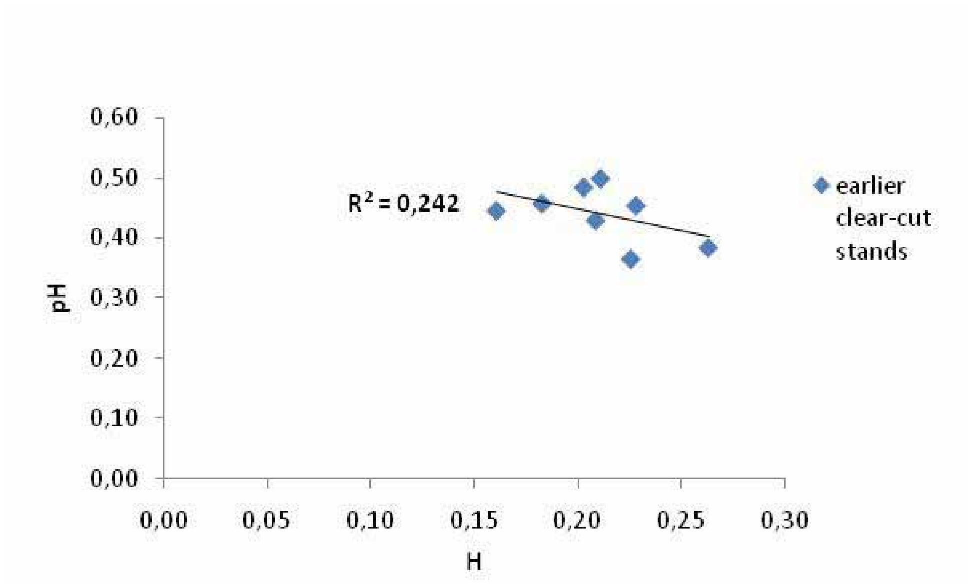


Fig.11 – H *versus* pH

Spearman Correlation Test

Output of Spearman correlation test among EIV, Hemeroby index and measured soil parameters showed (Table 2):

- significant correlations ($p<0.01$) on 30% of the data set
- significant correlations ($p<0.05$) on 11% of the data set

We focus only the correlation between EIV *versus* hemeroby-H index and measured soil parameters:

Spearman's rho	*L*	*T*	*K*	*F*	*R*	*N*	*R*N*	*R/N*	*H*	*Field capacity*	*pH*	*C%*
L	1											
T	**-0,377****	1,000										
K	0,005	0,109	1,000									
F	0,200	-0,360*	0,273	1,000								
R	-0,105	-0,086	**0,649****	**0,511****	1,000							
N	-0,056	**-0,479****	**0,381****	**0,420****	**0,645****	1,000						
*R*N*	-0,132	-0,257	**0,579****	**0,492****	**0,907****	**0,884****	1,000					
R/N	0,044	0,332*	**0,504****	0,219	**0,581****	-0,098	0,270	1,000				
H	**0,706****	**-0,369****	**-0,370****	-0,067	**-0,396****	-0,176	-0,341*	-0,249	1,000			
Field capacity	-0,029	**-0,374****	-0,057	0,216	0,196	0,365*	0,296*	-0,031	-0,121	1,000		
pH	**-0,453****	0,317*	-0,112	**-0,384****	-0,070	-0,005	-0,047	-0,072	-0,326*	0,036	1,000	
C%	-0,128	0,145	-0,014	-0,016	-0,021	-0,001	0,022	-0,016	-0,074	0,283	0,256	1

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Tab. 2: Output of Spearman correlation test. In bold the more significant correlations and in yellow the correlations of EIV *versus* hemeroby-H index and measured soil parameters.

- EIV have the highest number of correlations with the hemeroby index (H), secondly with the measured pH and field capacity, otherwise the carbon content doesn't show any correlation;

- L indicator displays the highest positive correlation (0,706**) with H, while the other correlations between H and EIV are negative (T=-0,369**; K=-0,370**; R=-0,396**; R*N=-0,341*);
- The correlation between measured pH and T indicator is the only positive correlation (=0,317*), while the others are negative (L=-0,453**; F=-0,384**; H=-0,326*). It's very interesting that the correlation between pH and L-F indicators are negative: it is well know that the soil acidification is caused by the acid rainfall and also by the leaching of basis in the soil (Likens and Bormann, 1974): the acidification of the soil is strongest where the canopy is more open due to forest management; in this case also the heliophile species increase;
- The correlation between field capacity and T-indicator is the highest and negative (-0,374**), while the correlations with N (0,365*) and R*N (0,296*) are positive.

ANOVA test

We applied ANOVA test to the 8 forest areas distinguishing for each area recently and earlier cut stands, obtaining 16 groups in total. ANOVA output showed that each group had different means of L, T, R, N, R*N, R/N, pH and C% (Tab. 3). The *post- hoc* LSD test (Tab. 4) showed which stands differed from which and which indicator is more discriminator. Light-L and Hemeroby-H showed the highest positive differences between recently and earlier cut stands: tree -cutting disturbance favors radiation ingression promoting a chaotic vegetation structure. Soil/humus measured parameters didn't show any significant difference between different forest managements.

		sum of squares	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	10,486	15	0,699	8,205	0,000
	Within Groups	2,727	32	0,085		
	Total	13,213	47			
T	Between Groups	12,866	15	0,858	13,633	0,000
	Within Groups	2,013	32	0,063		
	Total	14,879	47			
K	Between Groups	2,111	15	0,141		0,001
	Within Groups	1,253	32	0,039		
	Total	3,365	47			
F	Between Groups	1,623	15	0,108	2,734	0,008
	Within Groups	1,267	32	0,04		
	Total	2,89	47			
R	Between Groups	23,365	15	1,558	5,225	0,000
	Within Groups	9,54	32	0,298		
	Total	32,905	47			
N	Between Groups	14,432	15	0,962	7,149	0,000
	Within Groups	4,307	32	0,135		
	Total	18,739	47			
R*N	Between Groups	962,38	15	64,159	6,389	0,000
	Within Groups	321,34	32	10,042		
	Total	1283,72	47			
R/N	Between Groups	0,487	15	0,434	6,188	0,000
	Within Groups	0,413	32	0,07		
	Total	0,9	47			
H	Between Groups	6,516	15	0,434	6,188	0,000
	Within Groups	2,247	32	0,07		
	Total	8,763	47			
Field capacity	Between Groups	16603,12	15	1106,874	5,671	0,000
	Within Groups	6246	32	195,188		
	Total	22849,12	47			
pH	Between Groups	14,892	15	0,993	4,212	0,000
	Within Groups	7,543	32	0,236		
	Total	22,436	47			
%C	Between Groups	140,782	15	9,386	1,446	0,186
	Within Groups	207,756	32	6,492		
	Total	348,539	47			

Tab. 3: Output of Anova test

EIV - hemeroby-H	**forest stands**	**mean difference**	**std error**	**Sig**	**95% confidence interval**	
					lower bound	**upper bound**
L	1 recently *vs* 1 earlier	0,8000*	0,23834	0,002	0,3145	1,2855
	3 recently *vs* 3 earlier	0,5667*	0,23834	0,024	0,0812	1,0521
	6 recently *vs* 6 earlier	0,7000*	0,23834	0,006	0,2145	1,1855
T	3 recently *vs* 3 earlier	0,4333*	0,2048	0,042	0,0162	0,8505
	6 recently *vs* 6 earlier	-0,5333*	0,2048	0,014	-0,9505	-0,1162
K	6 recently *vs* 6 earlier	-0,4667*	0,16159	0,007	-0,7958	-0,1375
	7 recently *vs* 7 earlier	0,4333*	0,16159	0,011	0,1042	0,7625
R	1 recently *vs* 1 earlier	0,9667*	0,44581	0,038	0,0586	1,8748
N	1 recently *vs* 1 earlier	0,9000*	0,29954	0,005	0,2899	1,5101
R*N	1 recently *vs* 1 earlier	5,6333*	2,58739	0,037	0,363	10,9037
R/N	2 recently *vs* 2 earlier	-0,3333*	0,0928	0,001	-0,5224	-0,1443
	3 recently *vs* 3 earlier	0,2000*	0,0928	0,039	0,011	0,389
H	6 recently *vs* 6 earlier	0,8000*	0,21635	0,001	0,3593	1,2407
	8 recently *vs* 8 earlier	0,4667*	0,21635	0,039	0,026	0,9073

Tab. 4 Output of *post- hoc* LSD test

Main Remarks

1. Ellenberg indicators of light-L and continentality-K are highly correlated with the disturbance –H: after cutting, more radiation is available promoting the ingression of heliophile species belonging to Mediterranean environments, consequently the continentality decreases. The same pattern was found in the *Fagus sylvatica* forest in Central Apennines (Testi et al., 2009-2010).
2. Radiation is also negatively correlated with measured pH (Tab. B in Appendix) in the earlier cut woodlands: the soil acidification is caused by the acid rainfall and basis leaching when the top soil is less protected by canopy in the recently cut stands.
3. In the recently cut woodlands the prevalent humus forms are mull, indicating a more rapid decomposition of organic matter promoted by the radiation. If the process becomes too intense, it's possible to lose the humus form characteristic of that forest ecosystem.

We can asses that forest biodiversity conservation is really possible only if silviculture and forest management change paradigm and take into account forest ecosystems as complex biological systems characterized by the inherent and unpredictable environmental changing. Silviculture and management should be oriented toward the re-naturalization of simplified forest systems, fostering the rehabilitation of natural processes, i.e. the natural self-regulating and self-perpetuating mechanisms of the system that increase its resistance and resilience (Ciancio and Nocentini, 1996; Nocentini, 2000; Puettmann et al., 2009). The aim is to maximize the contribution of natural energy to the functioning of the system and minimize artificial energy inputs (Allen and Hoekstra, 1992). In practice, this means adopting systemic silviculture that is non-linear, extensive silviculture (Ciancio and Nocentini, 1996).
Our data suggest the importance to calibrate the tree-cutting maintaining the woodland structure to avoid the radiation (L) increase and the consequent disturbance (H).

The analysis of the ecosystem through the humus/soil parameters and Ellenberg ecological indicators applied to flora and vegetation demonstrated to be an effective tool to detect and monitor the conservation forest *status*.

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APPENDIX

Tab. A: Headers and Phytosociological relevés

N. progr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODplot	1	1 bis	1 ter	2	2bis	2 ter	3	3 bis	3 ter	4	4 bis	4 ter	5	5 bis	5 ter	6
Region	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium	Latium
Province	RI	RI	RI	RI	RI	RI	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Municipality	Poggio Mirteto	Poggio Mirteto	Poggio Mirteto	Poggio Mirteto	Poggio Mirteto	Poggio Mirteto	Trevignano	Trevignano	Trevignano	Trevignano	Trevignano	Trevignano	Gattaceca	Gattaceca	Gattaceca	Gattaceca
East	311568	311578	311592	311116	310892	310852	271271	271241	271308	271281	271337	271344	308802	308737	308073	310664
North	4682947	4682767	4682964	4682642	4682677	4683082	4672571	4672642	4672513	4672658	4672634	4672568	4657312	4657292	4657365	4658893
Altitude (m.a.s.l.)	587	592	589	561	544	496	280	282	284	286	290	290	174	175	176	119
Aspect	SSW	E	S	SE	W	W	S	S	S	S	S	S	N	E	NNW	NE
Slope (degree)	20°	15°	20°	25°	10°	30°	10°	20°	12°	15°	10°	15°	10°	5°	10°	5°
Rockiness (%)	0	10	5	2	5	2	0	0	0	0	5	5	0	0	10	0
Cover stone (%)	0	10	8	5	5	7	5	0	0	0	5	5	0	5	10	0
Area (sm)	150	100	100	80	80	100	200	150	100	150	150	150	150	150	150	150
Total coverage (%)	80	95	90	100	95	90	95	95	80	100	90	95	90	90	90	90
Coverage tree layer T1 (%)	25	15	20	75	25	30	25	25	25	90	85	80	30	40	25	55
Heigh T1 (m)	12-15	10-12	12-15	12	15	16-18	18-20	20-25	25	25	20-25	20	15	15-18	15-18	18-20
Coverage tree layer T2				80	75	75		30	20	25	35	50	80	70	80	30
Heigh T2				5	5	5		5	5	5	2-5	10-12	10-12	10	8-10	4-6
Coverage shrub layer S1	70						50		30		25		30	30	30	30
Heigh S1	2-4						3-5		3		3		3-5	2-5	2-6	2-3
Coverage shrub layer S2	10	90	85	10	8	10	75	40		15		40	40	40	50	30
Heigh S2	0,5-2	0,5-2,5	0,5-2,5	0,5-1	0,5-1	0,5-1	0,5-3	3		2		4	0,5-3	0,5-2	1-2	0,5-2
Coverage herb layer Hl	15	5	5	5	5	5	20	40	10	40	60	25	40	10	50	50
Last cutting (years)	5	5	5	11	11	11	8	8	8	>16	>16	>16	13	13	13	45

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
6 bis	6 ter	7	7 bis	7 ter	8	8 bis	8 ter	9	9 bis	9 ter	10	10 bis	10 ter	11	11 bis	11 ter	12
Latium	Latium	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Tuscany	Latium	Latium	Latium	Latium
RM	RM	AR	AR	AR	AR	AR	AR	AR	AR	AR	AR	AR	AR	RM	RM	RM	RM
Gattaceca	Gattaceca	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Arezzo	Monterosi	Monterosi	Monterosi	Monterosi
310724	310854	740821	740760	740845	740803	740741	740763	740656	740690	740704	740619	740672	740692	275178	275259	275102	274648
4658934	4658693	4818125	4818067	4818179	4818169	4818145	4818147	4818440	4818348	4818349	4818415	4818321	4818293	4673334	4673298	4673186	4672744
103	100	830	814	845	839	799	812	828	833	832	830	825	841	363	356	366	354
S	0	NW	S	W	S	assente	SW	NW	NW	NNW	WSW	SW	SW	E	NW	S	SE
3°	0°	25°	35°	25°	5°	0°	15°	10°	5°	5°	20°	40°	40°	5°	5°	2°	5°
0	0	0	5	15	2	0	2	0	0	0	10	15	10	0	0	0	0
0	0	5	5	10	0	2	0	2	0	0	2	5	5	0	0	0	0
150	150	150	100	120	150	150	130	100	100	100	150	100	150	100	100	100	100
95	100	90	75	90	95	85	95	90	95	100	95	95	100	95	95	90	95
80	40	80	70	80	75	75	75	70	75	70	80	75	75	20	20	20	40
20-25	20-25	16-18	23-25	20	23-25	20-22	20-22	12-15	12-15	12-15	22-25	18-20	18-20	12-15	10-12	10-12	12-15
50	60		15	10		15	30	10	45	5	25	10	5			30	60
6-8	6-10		6-8	2-5		10-12	2-5	2-8	3-6	3-6	3-8	8-12	2-6			2,5-3	7-10
5					25	5									30		
2-3					2-4	1-3									3		
15	10	15		5	5	0,5	5	30	15	10	15	8	0,2-2	85	60	50	60
1	1	0,5-1,5		0,5-2	0,5-2	0,5	0,5,2	0,5-2	0,5-3	0,5-3	0,5-3	0,5-3	60	1-2,5	1-1,5	0,5-2	1-2,3
30	50	70	5	50	55	50	65	80	50	60	60	80		30	40	30	30
45	45	20	20	20	62	62	62	20	20	20	52	52	52	4	4	4	20

35	36	37	38	39	40	41	42	43	44	45	46	47	48
12 bis	12 ter	13	13 bis	13 ter	14	14 bis	14 ter	15	15 bis	15 ter	16	16 bis	16 ter
Latium	Latium	Campania	Campania	Campania	Campania	Campania	Campania	Campania	Campania	Campania	Campania	Campania	Campania
RM	RM	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Monterosi	Monterosi	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella	Pratella
274818	274769	429842	429890	429958	430078	430103	430164	430100	430120	430186	430368	430394	430514
4673027	4672941	4583722	4588732	4583733	4580858	4583801	4583750	4530903	4583828	4583749	4583635	4583619	4583435
373	377	479	473	479	424	389	408	394	398	398	399	397	389
SSW	N	SE	SE	E	N	N	N	NNW	SW	SW	NE	NW	E
7°	5°	8°	5°	5°	10°	15°	15°	8°	20°	30°	25°	15°	10°
0	0	5	0	0	0	5	0	2	10	5	5	0	5
0	0	5	0	0	0	5	0	2	5	5	5	0	5
100	100	150	150	150	150	150	150	100	100	100	100	60	100
95	95	95	95	95	95	100	100	90	95	100	100	90	95
40	50	85	80	55	80	75	50	40	15	20	15	15	15
12-15	16-18	12-15	14-15	15-18	16-18	12-15	10-12	10-12	12-15	10-13	15	15-18	10-12
60	70	60	40	80	80	75	70				50	50	40
7-10	5-10	8-10	10-12	8-10	10-12	10-12	8-10				5-8	8-10	3-5
30								50	60	60	25	10	30
3-5								1-4	2,5	0,5-3	4	1-3	1-3
30	60	5	5	5	5	5	5	25	30	10	15	25	20
1-2	1-3	0,5-2	0,5-5	0,5	0,5-2	0,5-3	2-5	0,5	0,5	0,5	0,5	0,5	0,5-1
50	60	60	85	60	70	75	85	40	20	40	60	25	50
20	20	6	6	6	10	10	10	6	6	6	43	43	43

Authors: D'Angeli, De Nicola: all relevés
Testi: Trevignano, Gattaceca, Monterosi, Pratella
Crosti: Trevignano, Gattaceca
Bianco: Monterosi

N. progr.	Layer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
QUERCUS CERRIS L.	t1	2	1	1	3	2	2	2	2	2	5	5	4	2	3	2	3	4	5	5	4	4	4	4	4	4	4	4	5	4	4	1	1	2	2	2	3	1	3	3	4	4	3	1	1	1	1	1	1
QUERCUS FRAINETTO TEN.	t1																		+																														
FRAXINUS ORNUS L.	t1																																					2	1	+									
ACER OBTUSATUM W. ET K.	t1																																					1											
CASTANEA SATIVA MILLER	t1																					+		+										+															
SORBUS AUCUPARIA L.	t1																																														+		
QUERCUS ILEX L.	t1	+	1	1	1	+	+																																										
HEDERA HELIX L.	t1					+												+	+																+														
ACER CAMPESTRE L.	t2																							1	1																								
ACER OBTUSATUM W. ET K.	t2																																					+			+						1	1	
CARPINUS ORIENTALIS MILLER	t2																2	3	3																+		1	3	3	4	4	4	2					+	+
ACER PSEUDOPLATANUS L.	t2																													+																			
CASTANEA SATIVA MILLER	t2																							+	+					+						2	2												
CORNUS MAS L.	t2																					+			+		3		1																				
CORYLUS AVELLANA L.	t2																																				1												
FRAXINUS ORNUS L.	t2				2	+			1		1	1	3				+					+			+	1			1	+					+	+			+		+	+	2				1	1	1
MALUS SYLVESTRIS MILLER	t2										+		+											+																									
PRUNUS AVIUM L.	t2																									+		+																					
PSEUDOTSUGA MENZIESII	t2																				+																												
PYRUS COMMUNIS L.	t2																										+																						
OSTRYA CARPINIFOLIA SCOP.	t2				+	2	1				1	1									1								+																				
QUERCUS ILEX L.	t2				3	2	4																																										
QUERCUS CERRIS L.	t2				+				2					4	4	4		+				1									1			2	3	1	+						+				2	2	1
SORBUS DOMESTICA L.	t2											+	+																																				
SORBUS TORMINALIS (L.) CRANTZ	t2										+		+																												+	+							
QUERCUS PUBESCENS WILLD.	t2														+																																		
JUNIPERUS COMMUNIS L.	t2																											+																					
HEDERA HELIX L.	t2																	+	+																						+								
ACER CAMPESTRE L.	s1							+									+						+	+									+													1			+
ACER OBTUSATUM W. ET K.	s1																																													1		+	
ACER MONSPESSULANUM L.	s1																																													1			
CARPINUS ORIENTALIS MILLER	s1													2	2	2	1	+																		+								2	2	1	1	1	1
CERCIS SILIQUASTRUM	s1														+																																		1
CORNUS MAS L.	s1											+											1																										
CORYLUS AVELLANA L.	s1																																+			2													
CRATAEGUS MONOGYNA JACQ.	s1							+				1			+								+																										
CRATAEGUS OXYACANTHA L.	s1																																														+		
CYTISUS VILLOSUS POURRET	s1							1																																									
EUONYMUS EUROPAEUS L.	s1							2																																					+				

FRAXINUS ORNUS L.	s1	1						+				1		+	+	+								+																				+	1	1	+	+	+
MALUS SYLVESTRIS MILLER	s1																						1																										
MESPILUS GERMANICA L.	s1							+																																									
OSTRYA CARPINIFOLIA SCOP.	s1									+																																							
PRUNUS SPINOSA L.	s1																																																
PSEUDOTSUGA MENZIESII	s1																							+																									
QUERCUS CERRIS L.	s1	+						+		1				+	+	+	1																2											2	1	1	+		
QUERCUS ILEX L.	s1	3																																															
SORBUS DOMESTICA L.	s1	+								+		+																																					
SORBUS TORMINALIS (L.) CRANTZ	s1																																												+		+		
STYRAX OFFICINALIS L.	s1	+																																															
ULMUS MINOR MILLER	s1							+																												+													
ACER CAMPESTRE L.	s2													+	+		+			+												+		1			+			+									
ACER MONSPESSULANUM L.	s3																																													+			
ACER OBTUSATUM W. ET K.	s2																							+																								+	
ARBUTUS UNEDO L.	s2		+	+																																													
CARPINUS BETULUS L.	s2																																	+															
CARPINUS ORIENTALIS MILLER	s2																+	1	1																+				+				+		+			1	+
CASTANEA SATIVA MILLER	s2																							+												+													
CERCIS SILIQUASTRUM L.	s2														+																																		+
CORNUS MAS L.	s2													+		+									+				+									+				+	+		+	+			
CORNUS SANGUINEA L.	s2										+																					+	1	+	2	+	+												
CORONILLA EMERUS L.	s2																																										+			+			
CORYLUS AVELLANA L.	s2																															+		+			+												
CRATAEGUS MONOGYNA JACQ.	s2							1	+	+	+		+	+		1	+	+	+	+		+	+				+	+		+	+	+	+		+	+	+	+		+	+	+	+	+	+		+	+	
CRATAEGUS OXYACANTHA L.	s2																																+	+	1	1	2			+									
CYTISUS SCOPARIUS (L.) LINK	s2									+			+									+			+	1				+	+	3	3	2															
CYTISUS VILLOSUS POURRET	s2								2	1	+		+																																				
DAPHNE LAUREOLA L.	s2																																								+						+		
PSEUDOTSUGA MENZIESII	s2																								+																								
EUONYMUS EUROPAEUS L.	s2							1	+								+			+			+							+		+	+	+	+	+	+		+		+			+	+			+	
FRAXINUS ORNUS L.	s2		1	2					+				1	+		+				1		+				2			+	+		+		+								+			+				
ILEX AQUIFOLIUM L.	s2																																			1	+												
LABURNUM ANAGYROIDES MEDICUS	s2																																												+				
LIGUSTRUM VULGARE L.	s2				+									2		1	2	+	+													1		+															
MALUS SYLVESTRIS MILLER	s2												+																																				
MESPILUS GERMANICA L.	s2																																	+															
PHILLYREA LATIFOLIA L.	s2	+			+	+																																											
PHILLYREA LATIFOLIA L.	s2																																																
OSTRYA CARPINIFOLIA SCOP.	s2					+	+				+																			+																			
PRUNUS SPINOSA L.	s2								+	+			+	+	+	1	+		+			+	+	+			1	1	1		2			+	+	+								+	+				

PYRUS COMMUNIS L.	s2																											+																					+			
QUERCUS CERRIS L.	s2		+					+	+		+			1	+	+			1	+												3													+	+		+		
QUERCUS ILEX L.	s2		5	2	+	+	1																																											
QUERCUS PUBESCENS WILLD.	s2								+																																								
ROSA CANINA L.	s2								+	+									+							+	+		+	+	+	+	1										+					
ROSA SEMPERVIRENS L.	s2	+	+	+	1	+	+	+						+	+	1		+		+		+	+	+	+													+	+	+	+			+		+	1	+	+
RUBUS ULMIFOLIUS SCHOTT	s2	1		1	+		1	2	+	1	1			1	2	+		+				+	+	+	+	+		+	+		+	1	1	+	1	+	+	+	+		+			1	2		+	1	1
SORBUS DOMESTICA L.	s2	+							+	+	+		+	+																																	
SORBUS TORMINALIS (L.) CRANTZ	s2								+		+													+																	+				+		+		
ULMUS MINOR MILLER	s2																																	+	+	+														
ACER CAMPESTRE L.	hl													+	+			+				+	+	+	+									+	+			+	+	+	+								
ACER OBTUSATUM W. ET K.	hl																																						+									+	
AGRIMONIA EUPATORIA L.	hl																											+				+			+	+	+	+	+				+		+	+	
AJUGA REPTANS L.	hl			+		+							+			+	+			+														+					+		+	+	+	+		+	+				+
ALLIARIA PETIOLATA (BIEB.) CAVARA ET	hl																																			+												
ARABIS TURRITA L.	hl			+																																											
ARCTIUM MINUS (HILL) BERNH.	hl																																				+											
ARISARUM PROBOSCIDEUM (L.) SAVI	hl																															+	+		+	+	+		+		+								
ARUM ITALICUM MILLER	hl																															+		+	+		+		+					+					
ASPARAGUS ACUTIFOLIUS L.	hl	+	+	+	+			+					+		+	+	+	+																							+		+		+	+	+	+	+	+	
ASPLENIUM ONOPTERIS L.	hl																																					+		+				+					
ASPLENIUM TRICHOMANES L.	hl																					+									+	+																			
ASPLENIUM ADIANTUM-NIGRUM L.	hl																					+									+	+																			
BALLOTA NIGRA L.	hl																																+															
BRACHYPODIUM SYLVATICUM (HUDSON)	hl	+						1	2			+	1	1	+	1		+		+		2	3	2	3	3	1		1	1				1		+		+		+	+		+	+	+	+	+	+	1
BUGLOSSOIDES PURPUROCAERULEA (L.) J	hl							+	+	+	+	+	+	1	+	1																								+	+								
CALAMINTHA SYLVATICA BROMF.	hl	1					+	+	+	+					+	+																+	+	1	+									1	+	+			+
CAMPANULA TRACHELIUM L.	hl																			+			+													+												
CARDAMINE CHELIDONIA L.	hl																																	+														
CAREX DISTACHYA DESF.	hl																																		+													
CAREX FLACCA SCHREBER	hl											2	1	1	+	1																																	
CAREX SYLVATICA HUDSON	hl			+		+		+	+	+	2						+	+				+							+				+						+	+	1	2	+			2	1	+
CATAPODIUM RIGIDUM (L.) HUBBARD	hl							+																																								
CELTIS AUSTRALIS L.	hl				+																																											
CETERACH OFFICINARUM DC.	hl																																																+
CHENOPODIUM ALBUM L. ??	hl							+	+																																							
CISTUS SALVIFOLIUS L.	hl	+																																															
CLEMATIS VITALBA L.	hl	+	+	+	+		+			+					+			+												+	+	+	+										+				
CLINOPODIUM VULGARE L.	hl											+	+																	+	+																	
CONYZA BONARIENSIS (L.) CRONQ.	hl	+	+	+				+				+																		+	+										+					
CORNUS MAS L.	hl																			+			+																										

CRATAEGUS MONOGYNA JACQ.	hl																											+				+												+					
CRUCIATA GLABRA (L.) EHREND.	hl																																					+										+	
CYCLAMEN HEDERIFOLIUM AITON	hl		+	+				+	+	+	+	+	+	+	+	1	+	1	+													+		1	1	+	+	+	1	+	1	+	+	+	+	+	+	+	+
CYTISUS SCOPARIUS (L.) LINK	hl																			+				+																									
CYTISUS VILLOSUS POURRET	hl												+																																				
DIANTHUS CARTHUSIANORUM L.	hl																+																																
DACTYLIS GLOMERATA L.	hl							+	+												+	1	+	+			+	1	+	2	2			+															
DAUCUS CAROTA L.	hl																																											+	+				
DIGITALIS MICRANTHA ROTH	hl																			+	+													+			+							+	+				
DORYCNIUM PENTAPHYLLUM SCOP.	hl	+	+	+																																													
ECHINOPS SICULUS STROBL	hl											+	+	+																						+								1	+	+			+
EUONYMUS EUROPAEUS L.	hl												+				+		+	+		+	+													+	+			+		+		+					
EUPHORBIA AMYGDALOIDES L.	hl											+	+	+																			+		+	+											+		
EUPHORBIA CHARACIAS L.	hl																															+																	
FESTUCA HETEROPHYLLA LAM.	hl																			+	+	+	+	+	+	+			1	1	1								+	+	+								
FRAGARIA VESCA L.	hl	+							+		+						+	+												+								+											
FRAXINUS ORNUS L.	hl	+			+	+							+	+	+					+			+	+		+	+	+			+								1	+	+	+						+	
GALIUM ALBUM MILLER	hl																															+	+																
GALIUM APARINE L.	hl																															+	+																
GERANIUM LUCIDUM L.	hl																																			+													
GALIUM MOLLUGO L.	hl																			+			+		+	+	+	+																					
GERANIUM ROBERTIANUM L.	hl							+					+							1				+		+		+	+	+	+	+	+	+	+	+								+	+	+			+
GERANIUM ROTUNDIFOLIUM L.	hl							+																			+	+		+																			
GEUM URBANUM L.	hl																			+																													
GLECHOMA HEDERACEA L.	hl					+																																											
HEDERA HELIX L.	hl					+			+	+		+		+	+			+	+		+		+	+										+	+	2	2	+	+	+	+	+	+		1	+		+	
HELLEBORUS FOETIDUS L.	hl	+																																				+	+	+	+	+		+	+	+		+	
HOLCUS LANATUS L.	hl																																	+															
HYPERICUM PERFORATUM L.	hl																									+		+		+		+	+	+															
INULA VISCOSA (L.) AITON	hl	+																																										+					
LAMIUM BIFIDUM CYR.	hl																																+																
LATHYRUS APHACA L.	hl																																	+		+	+												
LATHYRUS VENETUS (MILLER) WOHLF.	hl																	+																		+				+	+	+							
LIGUSTRUM VULGARE L.	hl																															+	+																
LYCHNIS FLOS-CUCULI L.	hl																+																																
LONICERA ETRUSCA SANTI	hl								+			+		+	+		+	+												+				+	+	+				+				+	+	+			
LONICERA JAPONICA	hl																															1																	
LUZULA SYLVATICA (HUDSON) GAUDIN	hl																					+			+	+	+	+	+		+																		
MELICA UNIFLORA RETZ.	hl																	+																1	+	1	+			+	+	+							
LEOPOLDIA COMOSA (L.) PARL.	hl																					+																											
ORYZOPSIS MILIACEA (L.) ASCH. ET SCHW	hl							1		+		+																						+										1	+				+

OSTRYA CARPINIFOLIA SCOP.	hl					+																																											
OSYRIS ALBA L.	hl	+																																															
PHLEUM PRATENSE L.	hl																											+																					
PHILLYREA LATIFOLIA L.	hl					+																																											
PICRIS ECHIOIDES L.	hl	+															+															+		+										+	+				
PLANTAGO LANCEOLATA L.	hl																																											+	+				
POA SYLVICOLA GUSS.	hl																							+																									
POLYPODIUM AUSTRALE FEE	hl																																							+	+								
POTENTILLA REPTANS L.	hl																																	+															
PRIMULA VULGARIS HUDSON	hl			+																						+				+																				
PRUNELLA VULGARIS L.	hl					+				+										+		+																											
PULICARIA ODORA (L.) RCHB.	hl																																	+															
PULMONARIA OFFICINALIS L.	hl																			+																													
QUERCUS CERRIS L.	hl	+	+		+	+				+	1	+	1	1	1	1	1		2	1			1	+	1	+	+	+	+		+	+			+	+	1	+	+		+	+		+		+	+	+	+
QUERCUS ILEX L.	hl	+		+		+	+																																				+						
RANUNCULUS LANUGINOSUS L.	hl																			+													+	+			+												
ROSA SEMPERVIRENS L.	hl					+								+		+																																	
RUBIA PEREGRINA L.	hl	+	+	+	+			1	+	+	1	+	+	+	+	+																		+	+	+		+				+	1		+	+			
RUBUS ULMIFOLIUS SCHOTT	hl	+															+			+	+		+	+	+													+						+					
RUMEX SANGUINEUS L.	hl																															+	+	+		+	+												
RUSCUS ACULEATUS L.	hl							+	+		+	1	1	1	+	+	2	1	2													1	+	+	1	2	2	2	2	2	2	2	3	+	1	+	+	+	1
SEDUM CEPAEA L.	hl																1	+		+								+		+	+		+	+	+									+					
SENECIO VULGARIS L.	al																																+	+										+					
SESLERIA AUTUMNALIS (SCOP.) SCHULTZ	hl																			3																		2	+		+			+	2	2	1	1	
SILENE ALBA (MILLER) KRAUSE	hl							2						+																		1	2	1		+	+										+		
SILENE LATIFOLIA POIRET	hl																					+																											
SMILAX ASPERA L.	hl		+				+																																			+	+		+		+	+	
SOLIDAGO VIRGAUREA L.	hl																									+					+																		
SONCHUS ASPER (L.) HILL	hl																																											+					
SORBUS DOMESTICA L.	hl				+																																												
SORBUS DOMESTICA L.	hl										+		+			+																																	
SORBUS TORMINALIS (L.) CRANTZ	hl										+													+															+									+	
STACHYS OFFICINALIS (L.) TREVISAN	hl								+			+		+		+																												+		+			
STELLARIA PALLIDA (DUMORT.) PIRE	hl																									1			1			+	+	+	+	+	+												
STYRAX OFFICINALIS L.	hl	+																																															
TEUCRIUM CHAMAEDRYS L.	hl								+													+						+		+																			
TORILIS ARVENSIS (HUDSON) LINK	hl			+																																													
VERBASCUM THAPSUS L.	hl							+																																									
VERBENA OFFICINALIS L.	hl	+	+																															+															
VICIA CRACCA L.	hl													+																																			
VIOLA ALBA BESSER	hl				+	+			+			+	+	+	+	+						+									+			+	+	+		+	+	+				+	+			+	+

VIOLA REICHENBACHIANA JORDAN EX B	hl												+				+		+					+						+								1	+	+	+	+				+		+	
MELITTIS MELISSOPHYLLUM L.	hl										+	+																										+	+	+	+	+	+	+		+	+		
SCUTELLARIA COLUMNAE ALL.	hl										+																																					+	
EUPHORBIA AMYGDALOIDES L.	hl										+																										+												
VERBASCUM THAPSUS L.	hl																																	+															
VINCETOXICUM HIRUNDINARIA MED.	hl											+	+																																				

Tab. B: Soil/Humus measured parameters

CODplot	Horizon	thickness	%moisture	% moist. average O	% moist. only soil	% moist. Average O+A	% moist. Total average	pH	% Carbon
1	OLn+Olv	0,2-2	5,67	15,43	22,10	18,41	18,10		
1	OF	0,2-0,5	13,40						
1	OH	0,2-4	27,22					6,71	12,31
1	A	0-1,5/2,5	27,34					6,75	9,02
1	B	1,5/2,5-6/10 and over	16,86					6,51	3,36
1 bis	OLn+Olv	0,5-3	3,95	6,51	17,60	11,50	12,05		
1 bis	OF	0,2-1,5	9,06						
1 bis	A	0-1/3	21,48					6,68	7,79
1 bis	B	1/3-20 and over	13,72					5,89	3,22
1 ter	OLn+Olv	0,1-2	2,66	12,47	16,96	14,46	14,26		
1 ter	OF	0,2-1	8,90						
1 ter	OH	2_3	25,85					6,6	12,10
1 ter	A	0_3	20,42					6,18	10,42
1 ter	B	3-13/16 and over	13,49					5,86	3,72
2	OLn+Olv	1,5-3	10,23	9,42	15,57	11,47	11,47		
2	OF	0,5-1,5	8,60						
2	A/B	0-10/12 and over	15,57					6,98	2,50
2bis	OLn+Olv	0,1-0,8	10,95	24,12	17,04	24,16	21,29		
2bis	OF	0,2-0,5	24,09						
2bis	OH	1-2,5	37,31					6,24	11,63
2bis	A	0-3/5	24,28					6,09	8,43
2bis	B	3/5-15 and over	9,80					5,71	2,99
2 ter	OLn+Olv	0,5-1,5	5,92	15,24	11,04	14,19	14,19		
2 ter	OF	0,8-1	16,10						
2 ter	OH	0,5-1	23,69					6,79	13,16
2 ter	A	0_15 and over	11,04					7,89	4,45
3	OLn+Olv	0,2_2	5,82	5,91	17,58	9,80	9,80		
3	OF	0,2_0,5	6,00						
3	A	0-17/20 and over	17,58					6,09	2,88
3 bis	OLn+Olv	0,5-6	9,65	12,96	20,92	15,94	16,94		
3 bis	OF	0,2-0,8	16,27						
3 bis	A/A1	0-3/6	21,91					5,5	3,72
3 bis	A2/B	3/6-15 and over	19,93					4,79	2,22
3 ter	OLn+Olv	1_2	47,52	41,78	23,03	35,53	35,53		
3 ter	OF	0,5-1,5	36,04						
3 ter	A	0_10 and over	23,03					5,2	6,24
4	OLn+Olv	3_4	8,40	13,95	19,45	17,09	16,70		
4	OF	1-1,5	19,50						
4	A	0-5/9	23,38					5,88	6,78
4	B	3/8-20 and over	15,53					4,83	2,66
4 bis	OLn+Olv	1,5-2	7,99	20,86	13,88	19,58	18,07		
4 bis	OF	0,8-1,5	20,42						
4 bis	OH	0,5-1,5	34,16					6,1	10,48
4 bis	A	0-3/6	15,75					6,06	5,94
4 bis	B	3/6-20 and over	12,01					4,95	2,78
4 ter	OLn+Olv	1-3,5	8,84	13,42	23,83	16,89	16,89		
4 ter	OF	0,3-1	17,99						
4 ter	A	0_20 and over	23,83					6,13	6,67
5	OLn+Olv	0,5-1	9,66	13,60	12,73	13,31	13,31		
5	OF	0,5-0,8	17,54						
5	A	0_10 and over	12,73					6,42	7,11
5 bis	OLn+Olv	0,5-0,8	15,39	15,11	15,44	15,22	15,22		

CODplot	Horizon	thickness	%moisture	% moist. average O	% moist. only soil	% moist. Average O+A	% moist. Total average	pH	% Carbon
5 bis	OF	0,5-0,6	14,83						
5 bis	A	0_10 and over	15,44					6,61	7,72
5 ter	OLn+Olv	1_2	10,65	21,13	14,42	19,45	19,45		
5 ter	OF	0,5-1,2	29,99						
5 ter	OH	1-1,2	22,76					6,99	8,30
5 ter	A	0_15 and over	14,42					7,12	9,50
6	OLn+Olv	1,5-2	7,32	24,58	14,52	22,06	22,06		
6	OF	1,5-2	32,03						
6	OH	0,5-1,5	34,38					5,89	14,25
6	A	0_12 and over	14,52					6,01	4,46
6 bis	OLn+Olv	0,2-1,5	8,59	17,95	10,89	17,02	15,13		
6 bis	OF	0,2-1	21,32						
6 bis	OH	0,5-0,8	23,94					6,39	8,14
6 bis	A	0_6	14,25					6,56	3,98
6 bis	B	6/8-20 and over	7,54					5,57	0,74
6 ter	OLn+Olv	0,8-1,5	17,85	31,51	9,65	26,04	26,04		
6 ter	OF	0,5-0,8	35,95						
6 ter	OH	1,5-2	40,73					6,54	14,51
6 ter	A	0-9/10 and over	9,65					6,67	4,66
7	OLn+Olv	0,5-1,5	26,90	29,67	10,56	25,90	22,03		
7	OF	0,2-1	31,58						
7	OH	0,1-0,8	30,54					5,51	9,86
7	A	0-8,5/10	14,57					5,76	4,14
7	B	8,5/10-20 and over	6,56					4,73	0,80
7 bis	OLn+Olv	0-0,5	14,39	20,76	8,03	17,10	14,39		
7 bis	OF	0-0,2	27,12						
7 bis	A	0-2/5	9,80					4,56	2,17
7 bis	B	2/5-18 and over	6,25					4,37	0,31
7 ter	OLn+Olv	1-2,5	23,01	24,25	12,07	21,97	18,16		
7 ter	OF	0,5-1	25,48						
7 ter	A	0-2,5/5	17,43					5,46	4,95
7 ter	B	2,5/5-14 and over	6,71					4,73	1,87
8	OLn+Olv	0,3-1,5	19,99	26,50	7,95	22,40	19,08		
8	OF	0,2-0,8	29,46						
8	OH	0,1-0,5	30,06					5,28	7,58
8	A	0-8/10	10,09					5,35	1,40
8	B	8,5/10-20 and over	5,80					5,59	1,87
8 bis	OLn+Olv	0,6-1,2	29,93	33,35	12,51	30,16	25,02		
8 bis	OF	0,4-1	35,94						
8 bis	OH	0,8-1	34,19					5,79	13,30
8 bis	A	0-4/6	20,56					5,33	4,46
8 bis	B	4/6-12 and over	4,47					4,41	0,46
8 ter	OLn+Olv	1-2,5	29,46	33,45	7,95	28,06	23,25		
8 ter	OF	0,5-1,5	38,90						
8 ter	OH	0,5-0,8	32,00					5,8	9,40
8 ter	A	0-4/6	11,86					4,7	11,41
8 ter	B	4/6-18 and over	4,03					4,68	0,63
9	OLn+Olv	1-2,5	35,36	34,17	5,59	26,49	22,74		
9	OF	0,5-0,8	29,93						
9	OH	0,1-1	37,24					5,12	3,44
9	A	0-4/6	3,43					5,27	2,27
9	B	4/6-12 and over	7,74					5,49	2,12
9 bis	OLn+Olv	0,5-1	32,05	35,64	16,21	33,05	27,87		
9 bis	OF	0,5-1,5	33,88						

CODplot	Horizon	thickness	%moisture	% moist. average O	% moist. only soil	% moist. Average O+A	% moist.Total average	pH	% Carbon
9 bis	OH	1,5-2,5	40,98					5,78	11,67
9 bis	A	0-4/6	25,28					5,25	14,38
9 bis	B	4/6-20 and over	7,15					6,15	0,80
9 ter	OLn+Olv	1-1,5	22,83	34,22	13,47	30,60	25,92		
9 ter	OF	0,5-1	45,05						
9 ter	OH	0,2-0,5	34,77					5,68	12,26
9 ter	A	0-2,5/4,5	19,73					5,65	4,70
9 ter	B	2,5/4,5-12 and over	7,20					4,16	1,27
10	OLn+Olv	2-2,5	36,77	31,99	12,85	28,27	24,38		
10	OF	1,5-3,5	27,21						
10	OH	1-1,5	32,20					5,81	9,63
10	A	0-4/8	16,91					5,65	3,44
10	B	4/8-14 and over	8,80					4,39	1,63
10 bis	OLn+Olv	3_5	28,59	28,37	18,16	24,97	20,30		
10 bis	OF	0,3-1	28,15						
10 bis	A	0-5/9	18,16					5,51	5,53
10 bis	B	5/9-24 and over	6,32					4,62	1,29
10 ter	OLn+Olv	1_2	22,92	34,20	13,20	29,38	23,70		
10 ter	OF	0,5-1	45,48						
10 ter	A	0-6/10	19,73					5,75	4,86
10 ter	B	6/10-22 and over	6,66					4,77	1,09
11	OLn+Olv	0-0,5	37,70	35,39	30,26	34,11	34,11		
11	OF	0,5-1	50,49						
11	OH	1_2	17,97					6,7	8,07
11	A	0_12/13 and over	30,26					5,63	6,12
11 bis	OLn+Olv	0,5-3	52,44	47,17	100,00	41,91	60,38		
11 bis	OF	0,5-1	51,88						
11 bis	OH	2_4/5	37,17					6,38	11,33
11 bis	A	0_10 and over	26,15					5,76	5,42
11 ter	OLn+Olv	0,1-0,5	22,61	36,33	29,90	33,12	33,12		
11 ter	OF	0,2-1	50,06						
11 ter	A1	0_3/4	31,21					6,2	8,15
11 ter	A2	3/4-10/12 and over	28,60					5,99	2,97
12	OLn+Olv	1,5-4	46,04	40,60	21,30	35,78	35,78		
12	OF	1-2,5	44,33						
12	OH	2_6	31,44					6,36	7,80
12	A1	0_2/6	30,12					6	5,66
12	A2	2/6-12/15 and over	21,30					6,33	5,36
12 bis	OLn+Olv	1,5-2	39,67	39,66	19,01	35,75	31,40		
12 bis	OF	0,5-1	48,05						
12 bis	OH	0,1-1	31,25					6,24	11,64
12 bis	A1	0-9/14	24,04					6,58	5,45
12 bis	A2/B	9/14-25 and over	13,99					6,08	2,27
12 ter	OLn+Olv	1-1,5	35,19	33,73	19,71	29,05	29,05		
12 ter	OF	0,5-1	32,26						
12 ter	A1	0_12/14 and over	19,71					6,19	7,42
13	OLn+Olv	1,5-2	56,36	13,27	31,05	28,61	13,27		
13	OF	0,5-1	55,79						
13	OH	0,5-2	47,96					6,43	14,26
13	A	0_6 and over	31,05					6,62	4,90
13 bis	OLn+Olv	1-1,5	51,81	23,49	27,89	76,23	76,23		
13 bis	OF	0,5-1	51,52						
13 bis	A	0_7/8 and over	27,89					5,63	6,77
13 ter	OLn+Olv	0,2-1	60,04	21,30	28,40	69,87	69,87		

CODplot	Horizon	thickness	%moisture	% moist. average O	% moist. only soil	% moist. Average O+A	% moist.Total average	pH	% Carbon
13 ter	OF	0,5-1	56,58						
13 ter	OH	1_3	53,19					6,66	12,58
13 ter	A	0_9 and over	28,40					6,22	4,62
14	OLn+Olv	1-1,5	52,41	20,66	165,72	63,05	93,19		
14	OF	0,5-1	76,77						
14	A	0_3/5	26,89					7,08	4,58
14	B	3/5-15and over	25,42					6,6	2,30
14 bis	OLn+Olv	1,5-2,5	59,01	34,85	24,36	57,45	50,26		
14 bis	OF	1_3	44,01						
14 bis	A	0_10 and over	24,36					4,93	6,01
14 ter	OLn+Olv	0,5-1,5	56,94	28,47	26,05	54,97	54,97		
14 ter	OF	0,5-2	51,33						
14 ter	A	0_12 and over	26,05					6,72	8,35
15	OLn+Olv	0-0,5	34,56	34,56	127,39	96,03	92,76		
15	A	0-4,5/5,5	35,87					6,88	6,86
15	B	4,5/5,5-10 and over	23,85					6,43	4,82
15 bis	OLn+Olv	0-0,5	31,41	31,41	74,49	54,37	56,57		
15 bis	A	0-3/4	43,81					6,34	10,62
15 bis	B	3/4-10 and over	24,20					5,5	7,14
15 ter	OLn+Olv	0,5-1	50,41	22,52	71,25	36,75	46,88		
15 ter	OF	0-0,5	32,61						
15 ter	A	0-2,5-4	29,82					6,6	8,64
15 ter	B	2,5/4 12 and over	19,83					6,35	4,69
16	OLn+Olv	0,5-1	53,59	17,33	88,92	44,50	51,96		
16	OF	1-1,5	53,61						
16	A	0-2/6	31,73					6,63	9,75
16	B	2/6-15 and over	27,50					6,63	6,33
16 bis	OLn+Olv	1_2	58,13	31,19	131,69	77,76	81,44		
16 bis	OF	1-1,5	51,98						
16 bis	A	0-4/7	31,21					6,86	11,67
16 bis	B	4/7-15 and over	25,32					6,71	6,01
16 ter	OLn+Olv	2_3	55,12	28,30	101,87	58,72	57,73		
16 ter	OF	2_4	65,52						
16 ter	OH	0,2-0,8	36,07					7,09	11,49
16 ter	A	0-6/8	25,43					6,87	6,87
16 ter	B	6/8-15 and over	22,84					6,64	4,53

Tab. C: Humus forms

CODplot	Humus forms	CODplot	Humus forms	CODplot	Humus forms
1	EUMACROTERROAMPHI	4 bis	EUMESOTERROAMPHI	7 ter	OLIGOTERROMULL/DYSTERROMULL
1		4 bis		7 ter	
1		4 bis		7 ter	
1		4 bis		7 ter	
1		4 bis		8	HEMITERROMODER
1 bis	OLIGO/DYSTERROMULL	4 ter	DYSTERROMULL	8	
1 bis		4 ter		8	
1 bis		4 ter		8	
1 bis		5	DYSTERROMULL	8	
1 ter	EUMESOTERROAMPHI	5		8 bis	EUTERROMODER
1 ter		5		8 bis	
1 ter		5 bis	DYSTERROMULL	8 bis	
1 ter		5 bis		8 bis	
1 ter		5 bis		8 bis	
2	DYSTERROMULL	5 ter	LEPTOTERROAMPHI	8 ter	EUTERROMODER
2		5 ter		8 ter	
2		5 ter		8 ter	
2bis	EUMESOTERROAMPHI	5 ter		8 ter	
2bis		6	LEPTOTERROAMPHI	8 ter	
2bis		6		9	HEMITERROMODER/EUTERROMODER
2bis		6		9	
2bis		6		9	
2 ter	LEPTOTERROAMPHI	6 bis	EUMESOTERROAMPHI	9	
2 ter		6 bis		9	
2 ter		6 bis		9 bis	DYSTERROMODER
2 ter		6 bis		9 bis	
3	OLIGOTERROMULL	6 bis		9 bis	
3		6 ter	EUMESOTERROAMPHI	9 bis	
3		6 ter		9 bis	
3 bis	OLIGOTERROMULL/DYSTERROMULL	6 ter		9 ter	HEMITERROMODER/EUTERROMODER
3 bis		6 ter		9 ter	
3 bis		7	HEMITERROMODER	9 ter	
3 bis		7		9 ter	
3 ter	OLIGOTERROMULL/DYSTERROMULL	7		9 ter	
3 ter		7		10	HEMITERROMODER/EUTERROMODER
3 ter		7		10	
4	DYSTERROMULL	7 bis	DYSTERROMULL	10	
4		7 bis		10	
4		7 bis		10	
4		7 bis		10 bis	DYSTERROMULL

CODplot	Humus forms	CODplot	Humus forms
10 bis		**13 ter**	EUMACROTERROAMPHI
10 bis		**13 ter**	
10 bis		**13 ter**	
10 ter	DYSTERROMULL	**14**	DYSTERROMULL
10 ter		**14**	
10 ter		**14**	
10 ter		**14**	
11	EUMACROTERROAMPHI	**14 bis**	DYSTERROMULL
11		**14 bis**	
11		**14 bis**	
11		**14 ter**	DYSTERROMULL
11 bis	EUMACROTERROAMPHI	**14 ter**	
11 bis		**14 ter**	
11 bis		**15**	EU/MESOTERROMULL
11 bis		**15**	
11 ter	OLIGO/DYSTERROMULL	**15**	
11 ter		**15 bis**	OLIGOTERROMULL
11 ter		**15 bis**	
11 ter		**15 bis**	
12	PACHYTERROAMPHI	**15 ter**	OLIGOTERROMULL
12		**15 ter**	
12		**15 ter**	
12		**15 ter**	
12		**16**	DYSTERROMULL
12 bis	LEPTOTERROAMPHI	**16**	
12 bis		**16**	
12 bis		**16**	
12 bis		**16 bis**	DYSTERROMULL
12 bis		**16 bis**	
12 ter	LEPTOTERROAMPHI	**16 bis**	
12 ter		**16 bis**	
12 ter		**16 ter**	LEPTOTERROAMPHI
13	EUMESOTERROAMPHI	**16 ter**	
13		**16 ter**	
13		**16 ter**	
13		**16 ter**	
13 bis	DYSTERROMULL		
13 bis			
13 bis			
13 ter	EUMACROTERROAMPHI		

Photos:

Photos 1,2,3,4,5: Differences in the woodland structure in relationship with different forest management.

Photos 6, 7, 8: Soil and Humus field sampling.

1) Poggio Mirteto (RI): recently cut (2007).

2) Gattaceca (RM): earlier cut (1966-1968).

3) Monterosi (RM): recently cut (2007-2008).

4) Alpe di Poti (AR): earlier cut (1950).

5) Pratella (CE): recently cut (2002-2003).

6) Humus profile.

7) Soil profile.

8) Sieves for the evaluation of the structure of the A zoogenic horizons.