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MODIFICATIONS OF MYCOCOENOSES AND PHYTOCOENOSES DUE TO DEGRADATION OF CHESTNUT COPPICES IN CENTRAL ITALY

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Abstract - Phytosociological and mycocoenological comparisons were made between chestnut coppices, belonging to the *Quercetalia robori-petraeae,* and one stage of degradation of these communities, heathlands often reafforested with *Pinus pinaster* belonging to the *Calluno-Ulicetalia.* Fire is the most important factor of the degradation. The classifications, performed by multivariate analysis, were found to be different for phytocoenoses and mycocoenoses: chestnut coppice phytocoenoses were much more heterogeneous than those of heathlands, and the latter did not considerably vary in relation to the effect of burning. On the other hand, the mycocoenoses of chestnut coppices were more homogeneous than those of heathlands, in which the principal factor determining the mycofloristic component seems to be the period elapsed since the last fire. Many fungal species were found to disappear in the degradated stages and a scanty number of species, mostly associated to conifers, appear in the heathlands.

Riassunto - Sono stati effettuati confronti fitosociologici e micocenologici fra cedui di castagno, ascrivibili ai *Quercetalia robori-petraeae,* e uno dei loro stadi di degradazione, lande, spesso rimboschite con *Pinus pinaster,* ascrivibili ai *Calluno-Ulicetalia.* Il fuoco è il più importante fattore di questa degradazione. Le classificazioni, ottenute tramite l'analisi multivariata, hanno mostrato notevoli differenze fra le fitocenosi e le micocenosi: le fitocenosi dei castagneti risultano molto più eterogenee di quelle dei calluneti e queste ultime non variano molto in relazione agli effetti del fuoco. Contrariamente le micocenosi dei castagneti risultano più omogenee di quelle dei calluneti, nei quali il fattore principale che determina la componente micofloristica sembra essere il tempo trascorso dall'ultimo incendio. Molte specie fungine scompaiono durante questa degradazione e soltanto un numero ridotto di specie, principalmente associate alle conifere, compare nelle lande a *Calluna.*

Introduction

Oak woods, belonging to the association *Rubia peregrina-Quercus cerris* Pignatti & Pignatti 1968 (Stortelder et al., 1986) (*Quercetalia robori-petraeae* Tx. 1931), in which the chestnut *(Castanea sativa)* is naturally spread, may be found on the acid soils of the Tuscan hills (Central Italy). In the past the chestnut was also favoured or planted by man in order to form pure chestnut groves for the harvest of nuts. Sometimes these oak woods were also converted into shrubby pastures for sheep by burning. For centuries the harvest of

Castanea nuts and pastures were of primary economic importance for local populations.

Since the nineteenfifties, with the death of many trees due to *Endothia parasitica* (Murr.) P.J. & H.W. Anderson, mature chestnut forests have been replaced by chestnut coppices or have degenerated to heathlands belonging to the association *Tuberario lignosae-Callunetum* De Dominicis & Casini 1979 (*Calluno-Genistion* Duvign. 1944). In the same period the use of periodical burning stopped and so pastures turned into the *Tuberario lignosae-Callunetum.* These heathlands consist of dense scrub and are dominated by *Ericaceae (Calluna vulgaris, Erica scoparia* and *Arbutus unedo).* In places pines *(Pinus pinaster),* introduced as forestry species, spread spontaneously and form a dense canopy (De Dominicis & Casini, 1979). At present *Pinus pinaster* is so widely distributed that it is impossible to find heathlands far from conifers. The natural succession of heathlands to oak woods is prevented by frequent fires and by the presence of pines, themselves vulnerable to fire and acidifiers of the soil (Fig.1).

For further informations on the origin of chestnut woods and heathlands of the southern Tuscany see De Dominicis & Casini (1979).

Chestnut woods and *Calluna* heathlands have been studied from a mycocoenological point of view (Barluzzi et al., 1986; Barluzzi et al., 1990; Barluzzi et al., 1992), but oak woods have not been investigated so far.

In the present study we compare phytocoenoses and mycocoenoses of chestnut woods and heathlands in order to reveal changes during degradation and effects of fire.

Study sites

The study was carried out in five plots in chestnut coppices (Barluzzi et al., 1992) and in six heathland plots (Barluzzi et al., 1986). All plots measured 2000 m^2, have mostly a rectangle shape and are located in the surroundings of Siena (Fig. 2).

The general climate of the area is submediterranean with a modest summer drought, mainly in July and August. Annual rainfall often exceeds 1000 mm and the mean annual temperature ranges from 12°C to 14°C . The thermopluviometric diagram according to Walter & Lieth (1960) is shown in Figure 3.

Some parameters of the eleven plots examined are reported in the heading of Table 1. The chestnut coppices (plots 1-5) are situated on different siliceous substrates at approximately the same altitude (more or less 500 m). The heathlands (plots 6-11) are all located on the same lithological substrate, at an altitude of 260 to 525 m. Plot 6 is the only heathland without *Pinus pinaster*; it grows, however, not far from the plot. Some plots burnt fairly recently: plot 9 was burnt out ten years before the beginning of our observations, plot 10 five years before and plot 11 the previous year.

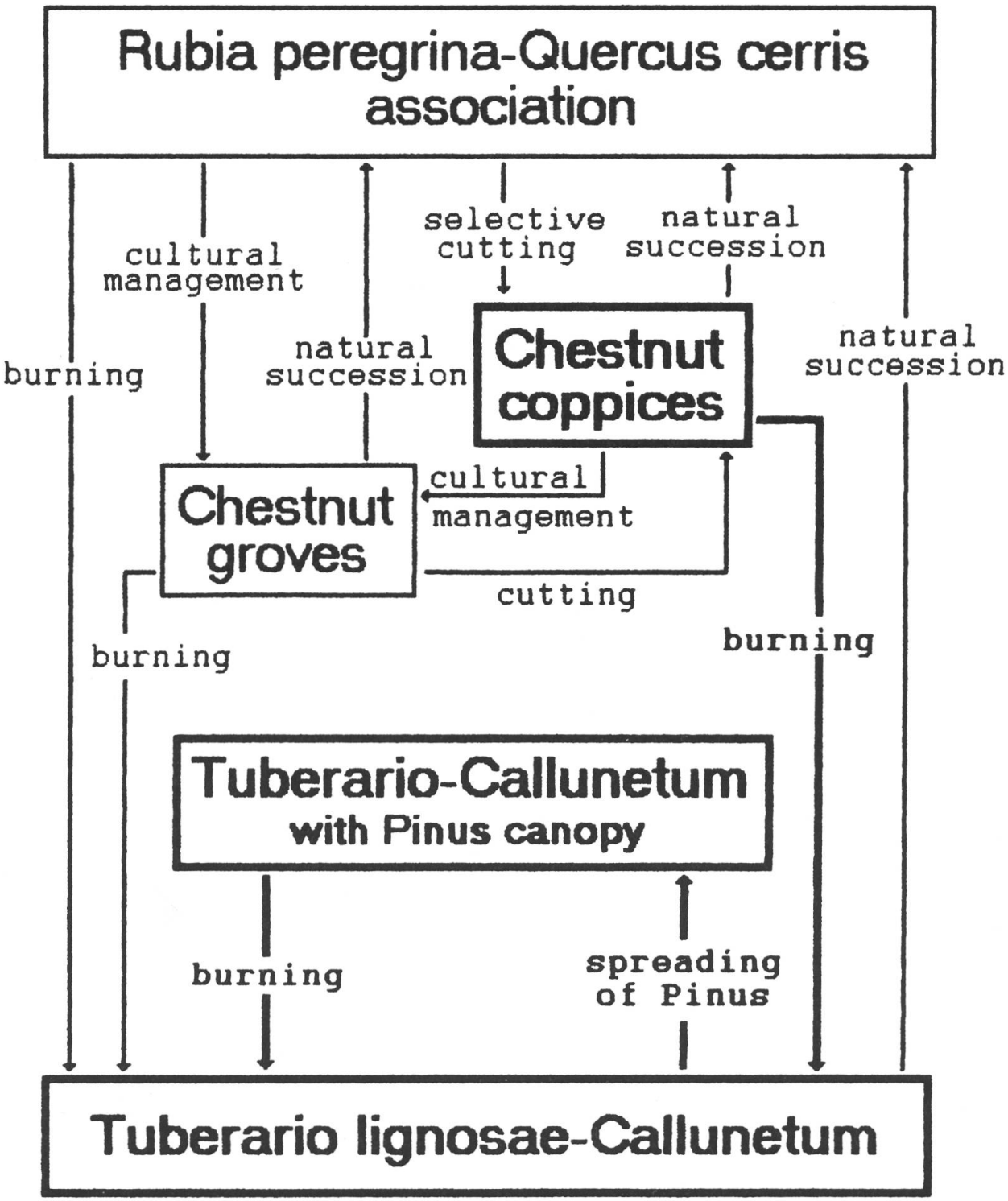

Figure 1 - Scheme of vegetation dynamism.

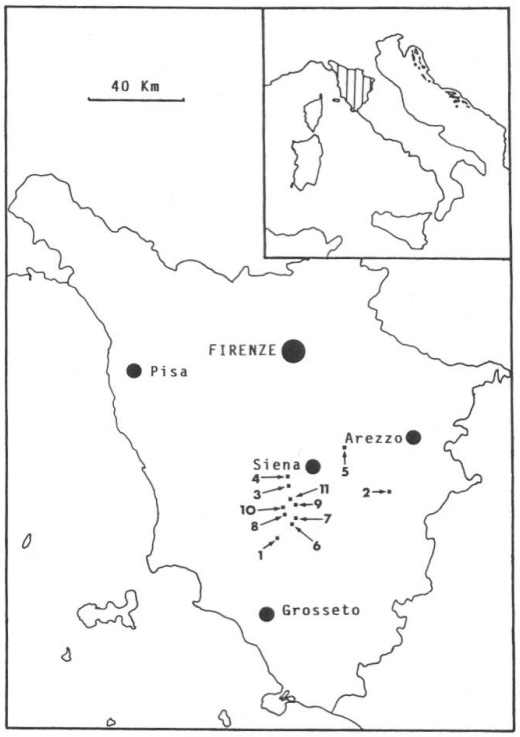

Figure 2 - Map of the studied area. Plot 1-5 = chestnut coppices; plot 6-11 = heathlands.

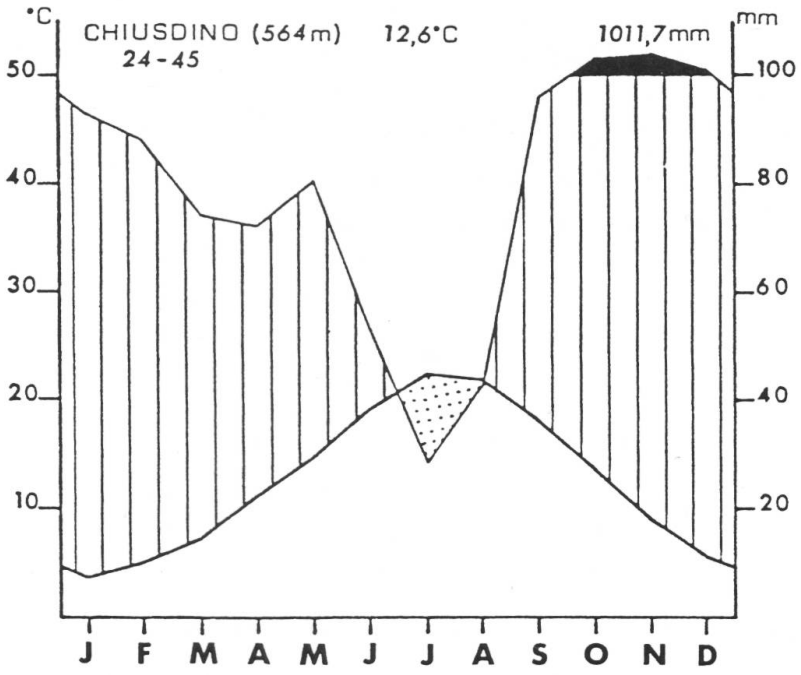

Figure 3 - Thermo-pluviometric diagram of Chiusdino constructed according to Walter & Lieth (1960). Dotted area indicates summer drought, hatched and black areas indicate pluviometric surplus.

Methods

Phytosociological and mycocoenological relevés were performed by the methods of Braun-Blanquet (1964) and Arnolds (1981) respectively. Mycological observations were carried out every month from October 1979 to December 1982 in plots 1-2, from January 1980 to December 1982 in plots 3, 4, 5 and from May 1978 to January 1980 in plots 6-11.

The relevés were numerically classified on binary data using single linkage (Anderberg, 1973) as clustering function and Jaccard's (1901) Index as similarity measure.

The phytocoenological and mycocoenological tables have been constructed according to the results of cluster analysis. Plant species occurring in only one plot with coverage less than 5% and fungi occurring in only one plot with less than 3 carpophores per 1000 m^2 are reported at the bottom of the tables.

The species of fungi were classified into three functional groups (ectomycorrhizal, saprophytic and facultative parasitic fungi), but the classification of some fungi as either mycorrhizal and saprophytic is doubtful, in particular concerning the genera *Clavulina* and *Ramaria*. These groups are often regarded as soil saprophytes (e.g. Kreisel, 1987), but some *Ramaria* species were indicated by Trappe (1962) and Arnolds (1985) as (probably) ectomycorrhizal on the basis of field observations. We have assigned the large, soil inhabiting *Ramaria* species and *Clavulina* to the mycorrhizal fungi since they always grow near woody plants, their basal mycelia seem not to be connected with decaying litter and their patterns of decline in Northwestern Europe are similar to those of other ectomycorrhizal fungi (Arnolds, 1985; Derbsch & Schmitt, 1987). However, definite proof can only be given after successful inoculation or demonstration of decomposition abilities in vitro. The mycorrhizal fungi were subdivided according to host preference into species exclusively or mainly associated with broad leaved trees, species exclusively or mainly associated with coniferous trees, and species without distinct preference. The saprophytic fungi were subdivided into several niche-substrate groups (Arnolds, 1988), based on a combination of way of life and substrate characteristics: on humus, on litter, on wood. The saprophytes have been assigned to only one "group" according to their highest frequency within the communities studied. The litter fungi comprise species growing on twigs less than 1 cm thick and also species growing on mosses.

The approximate number of carpophores has been calculated by an ordinal transformation of the density value according to Arnolds (1981).

The nomenclature of plants follows Pignatti (1982). For the nomenclature of fungi we refer in general to Moser (1983) for *Agaricales* and *Boletales*, to Corner (1966, 1967) for cantharelloid and clavarioid fungi, to Demoulin

(1968) for *Gasteromycetes*, to Dennis (1968) for *Ascomycetes*, to Maas Geesteranus (1975) and to Coker & Beers (1951) for hydnaceous fungi, to Bernicchia (1990) for *Polyporaceae*.

Results and discussion

Phytocoenoses - Two main relevé groups emerge from the dendrogram (Fig. 4): the one including the chestnut coppices and the other the heathlands. The chestnut woods are more heterogeneous than the heathlands: the most related plots (3,4) are clustered at a lower level than all heathland plots. It is interesting to note that burnt heathlands are not clustered separately from those which have not burnt in the last 20 years. Plots 9 and 10 form a subcluster with plot 8, while the most recently burnt plot 11 is apart from all the others. Although the fire modifies the structure of vegetation the floristic composition of the heathlands does not change considerably.

The phytosociological relevés are reported in Table 1. The chestnut woods are richer in species than the heathlands; in total 105 species were gathered in the former and 48 in the latter. 17 species are common to the two vegetation types. The average number of species per relevé are 44 in the chestnut wood plots and 25 in the heathland ones. The heterogeneity of the chestnut coppices is probably due either to the difference in geological substrate or in the climate. The plots of chestnut coppices are in fact distributed in a wider area than those of heathlands.

Mycocoenoses - The dendrogram of mycocoenological relevés (Fig. 5) shows a greater affinity between plots of chestnut woods (rel. group I) than between those of heathlands. Three groups are evident in heathlands: one (rel. group II) consists of plots (6, 7 and 8) which have not had recent fires; another (rel. group III) consists of plots (9, 10) burnt 10 and 5 years, respectively, before the study; the last one (rel. group IV) consists only of plot 11, which burnt the previous year. Hence fire has a strong effect on the floristic composition of mycocoenoses.

191 macromycetes were collected in 5 chestnut coppices, 143 in 6 heathlands; 59 species are common to both types, but only 16 species are common to heathland burnt the previous year and chestnut coppices. A decrease in species in relation to burning is evident in the heathlands: on the average 58 species occurred in heathlands which had not recently been burnt, and 43 in those burnt during the last ten years.

Mycorrhizal species associated with broad leaved trees, associated with conifers and without distinct preference are reported in Table 2. 70 mycorr-

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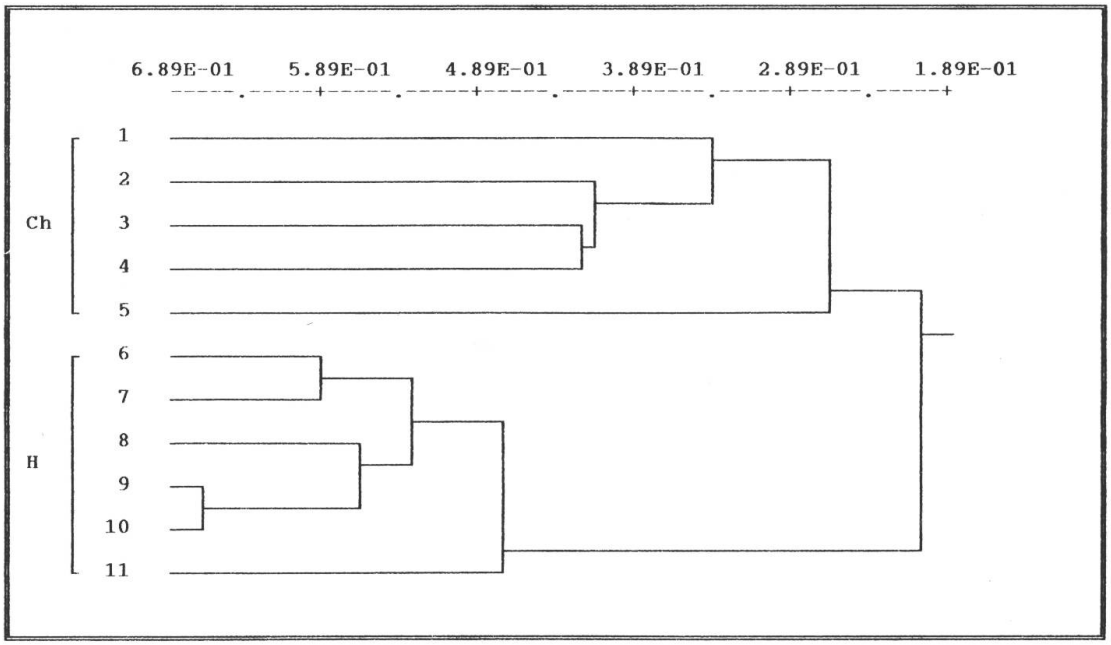

Figure 4 - Phytocoenoses dendrogram. Relevé groups: Ch = chestnut coppices; H = heathlands.

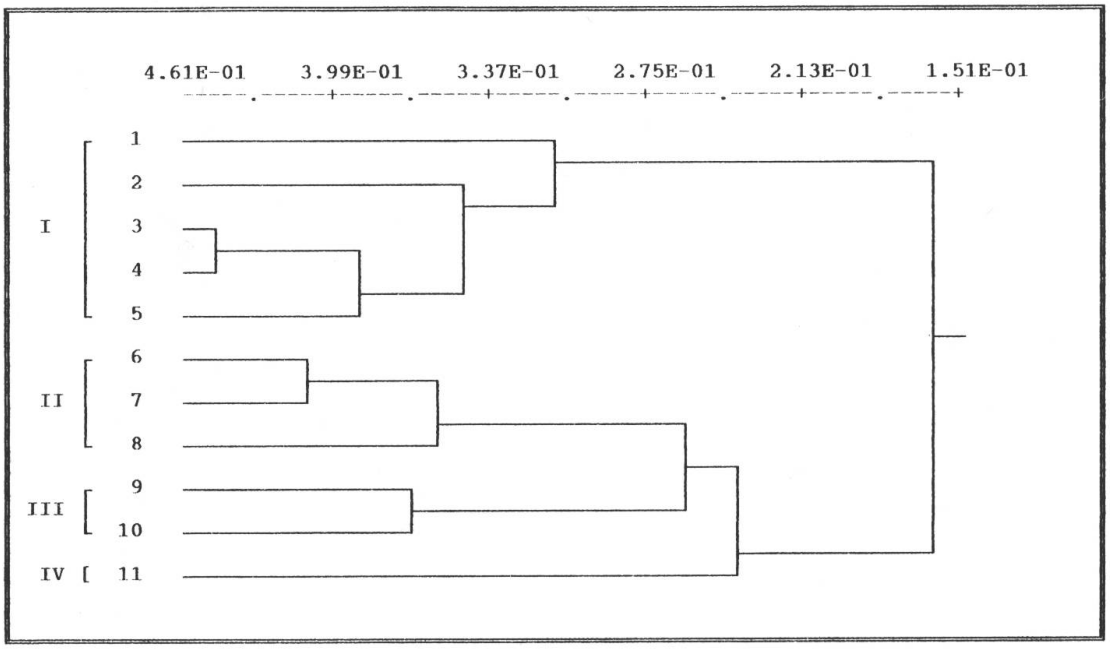

Figure 5 - Mycocoenoses dendrogramm. Relevé groups: I = chestnut coppices; II = not recently burnt heathlands; III = heathlands burnt 10 and 5 years before the study: IV = heathland burnt the previous year.

Table 1 - Phytosociological relevés. R - Rhyolite lava-flows; S = quarzitic-feldspatic sandstone with alternation of argillites and silt marls; Sc = polychrome

	Chestnut coppices					Heathlands					
Plot number	1	2	3	4	5	6	7	8	9	10	11
Altitude (m)	470	470	475	525	550	500	525	310	506	425	260
Exposition	NE	NW	NE	NNE	NE	S	S	NW	N	S	W
Slope (°)	7	7	5	5	15	20	3	5	0	7	15
Tree layer (cover%)	95	95	90	90	85	0	30	50	40	0	0
Shrub layer (cover%)	40	40	60	30	15	80	80	70	100	80	40
Herb layer (cover%)	30	30	20	40	30	5	3	40	5	5	25
Geological substrate	R	S	V	Sc	S	V	V	V	V	V	V
Differential species of chestnut coppices:											
Festuca heterophylla Lam.	1	1	1	1	1						
Luzula forsteri (Sm.) DC.	+	+	1	1	1						
Viola reichenbachiana Jordan	+	+	+	+	+						
Brachypodium sylvaticum (Hudson) Beauv.	1	+	1	2	+						
Cruciata glabra (L.) Ehrend.	+	+	+	1	+						
Hedera helix L.	+	+	+	+							
Platanthera clorantha (Custer) Rchb.	+	+	+	+							
Quercus ilex L.	+	+	+	+							
Hieracium sylvaticum (L.) L.	1	1	+		2						
Epipactis helleborine (L.) Crantz	+	+		+	+						
Poa nemoralis L.	1		1	1	1						
Cytisus scoparius (L.) Link		+	1	+	+						
Physospermum cornubiense (L.) DC.	+	1		+							
Tamus communis L.	+	+		+							
Teucrium scorodonia L.	+	+			+						
Campanula trachelium L.	+	+			+						
Ruscus aculeatus L.	+	1			+						
Dactylis glomerata L.	+	1			+						
Ajuga reptans L.	+		+	+							
Erica arborea L.	+		1	+							
Crataegus monogyna Jacq.		+	1	+							
Daphne laureola L.		+	+	+							
Lathyrus montanus Bernh.		+		+	+						
Symphytum tuberosum L.		+		+	+						
Ilex aquifolium L.	1	+									
Crocus napolitanus Mord. et Loisel.	+		+								
Cyclamen repandum S. et S.	+			+							
Anemone nemorosa L.	1				1						
Melica uniflora Retz.	1				1						
Viola alba Besser	+				+						
Digitalis micrantha Roth	+				+						
Polypodium vulgare L.	+				+						
Rosa canina L.		+		+							
Quercus pubescens Willd.		+		+							
Clinopodium vulgare L.		+		+							
Fragaria vesca L.		+		+							
Acer campestre L.		+		+							
Oenanthe pimpinelloides L.		+		+							
Orchis maculata L.		+		+							
Asplenium onopteris L.		+			+						
Cardamine hirsuta L.		+			+						
Cerastium scaranii Ten.		+			1						
Ligustrum vulgare L.			+	+							
Malus sylvestris Miller				+	+						
Helleborus bocconei Ten.				+	+						
Corylus avellana L.		2									
Lathyrus venetus (Miller) Wohlf.		2									

sericitic scists; V = "Verrucano": metasandstones phyllites and metaconglomerates.

	Chestnut coppices					Heathlands					
Plot number	1	2	3	4	5	6	7	8	9	10	11
Common species:											
Pteridium aquilinum (L.) Kuhn.	2	1	3	2	1	+	+	1	+	+	1
Castanea sativa Miller	5	5	5	5	5	+	+	+		+	+
Arbutus unedo L.	+	1	+			2	2	+	1	1	2
Stachys officinalis (L.) Trevisan	+	+	+	+				+	1	+	+
Erica scoparia L.	+			+		3	4	2	2	3	2
Juniperus communis L.		+	1	+	+		+	+			
Potentilla erecta (L.) Rauschel			+	+		+		1	+	+	
Sorbus torminalis (L.) Crantz	1	1		+		+	+	+			
Carex flacca Schreber	+			+				+	1	+	+
Fraxinus ornus L.	+	+				+		+	+		+
Rubus hirtus W. et K.	+		3	2	1			+			
Populus tremula L.	+		1	+				+	+		
Sorbus domestica L.	+	+		+				+		+	
Quercus cerris L.	+	+					+	2			+
Solidago virgaurea L.	+	2		2				+			
Serratula tinctoria L.	+							1	1	1	
Euphorbia cyparissias L.	+										+
Differential species of heatlands:											
Calluna vulgaris (L.) Hull.						3	3	4	3	3	1
Genista pilosa L.						1	1	1	1	1	1
Cistus salvifolius L.						1	1	+	1	2	1
Tuberaria lignosa (Dunal) Spach						1	+	+	2	1	1
Molinia arundinacea Schrank						+	1	2	1	+	1
Rubus ulmifolius Schott						+	1	1	+	+	+
Brachypodium ramosum (L.) R. et S.						1	1	1	1	1	
Pinus pinaster Aiton							3	3	4	3	1
Danthonia decumbens (L.) DC.						+	+		+		+
Daphne gnidium L.						+	1		+		1
Vincetoxicum hirundinaria Medicus						+	+		+		+
Inula conyza DC.						+			+	1	+
Pulicaria odora (L.) Rchb.						+			+	1	
Lotus corniculatus L.						+				+	+
Viola canina L.								1	1	1	
Inula hirta L.								+	+	+	
Polygala vulgaris DC.									+	+	+
Asphodelus albus Miller						1	2				
Phillyrea angustifolia L.							1				+
Peucedanum cervaria (L.) lapeyr.								1	+		
Carex hallerana Asso										+	1

Sporadic species: **Ril.1:** Aquilegia vulgaris L. (+), Brachypodium pinnatum (L.) Beauv. (+), Crepis leontodontoides All. (+), Cyclamen hederifolium Aiton (+), Fagus sylvatica L. (+), Hypericum montanum L. (+), Primula vulgaris Hudson (+), Scilla bifolia L. (+), Thesium linophyllum L. (+); **Ril.2:** Anemone apennina L. (+), Coronilla emerus L. (+), Euphorbia dulcis L. (+), Lonicera caprifolium L. (+), Malus florentina (Zuccagni) Schneider (+), Polypodium interjectum Shivas (+), Prunus avium L. (+), Prunus spinosa L. (+), Quercus robur L. (+), Silene italica (L.) Pers. (+); **Ril.3:** Anthoxanthum odoratum L. (+), Vicia cracca L. (+); **Ril 4:** Asparagus acutifolis L. (+), Clematis vitalba L. (+), Limodorum abortivum (L.) Swartz (+), Pyracantha coccinea M.J. Roemer (+), Sanicula europaea L. (1); **Ril.5:** Acer obtusatum W. et K. (+), Bunium bulbocastanum L. (+), Carpinus betulus L. (+), Cornus sanguinea L. (+), Silene alba (Miller) Krause (+), Myosotis caespitosa C.F. Schultz (+), Myosotis ramosissima Rochel (+), Neottia nidus-avis (L.) L.C. Rich. (+), Poa sylvicola Guss. (+), Ranunculus bulbosus L. (+), Ranunculus lanuginosus L. (1), Rumex acetosa L. (1), Salvia glutinosa L. (+), Saxifraga bulbifera L. (+), Sedum cepaea L. (+); **Ril.6:** Cytisus villosus Pourret (+), Quercus suber L. (+); **Ril.9:** Echinops ritro L. (+), Frangula alnus Miller (+); **Ril.11:** Carlina corymbosa L. (+), Echium vulgare L. (+), Hieracium pilosella L. (+), Sonchus asper (L.) Hill (+), Teucrium chamaedrys L. (+), Urospermum dalechampii (L.) Schmidt (+).

Table 2 - Mycocoenological relevés of ectomycorrhizal species. B = mainly or exclusively associated with broad leaved trees; C = mainly or exclusively associated with conifer trees; CB = associated with both conifer and broad leaved trees; (?) = mycorrhizal way of life not certain, possibly saprophytic. Relevé

Relevé groups	I					II			III	IV
Plot number	1	2	3	4	5	6	7	8	9 10	11
Differential species of chestnut coppices										
CBCantharellus tubaeformis Fr.	5	4	2	3	2					
B Russula chamaeleonthina (Fr.) Fr. ss. Rom.	1	1	1	1	1					
B Lactarius pergamenus (Swartz.:Fr.) Fr.	+	1	1	2	+					
B Cortinarius torvus (Bull.:Fr.) Fr.	1	4	+	1	3					
CBTricholoma atrosquamosum (Chev.) Sacc.	+	+	1	1						
B Russula rosacea Pers. ex S.F. Gray	2	1		+	4					
B Cortinarius croceo-coeruleus (Pers.:Fr.) Fr.	+	2		+	1					
B Russula cyanoxantha Schaeff.:Fr.	1	1		1	2					
B Russula vesca Fr.		2	+	1	2					
B Ramaria fumigata (Pk.) Corner	1	+		2						
B Lactarius vellereus (Fr.) Fr.	1	2		+						
B Craterellus cornucopioides (L.:Fr.) Pers.	5	4			2					
B Russula alutacea (Pers.:Fr.)Fr.	1	1			+					
B Russula laurocerasi Melzer var fragrans Rom.	3	+			+					
CBClavulina cristata (Fr.) Schroet. (?)	3		2		1					
B Lactarius controversus Pers.:Fr.	1			2	+					
B Russula aurata With.:Fr.		+	1		1					
CBRussula delica Fr.			1	+	3					
CBTricholoma acerbum (Bull.:Fr.) Quél.			+	2	1					
B Cortinarius crystallinus Fr.			+	2	+					
B Clitopilus prunulus (Scop.:Fr.) Kumm. (?)			+	1	+					
CBLactarius uvidus Fr.	2	+								
B Entoloma nidorosum (Fr.) Quél.	1	1								
B Tricholoma sulphureum (Bull.:Fr.) Kumm.	1		+							
B Entoloma rhodopolium (Fr.) Kumm. (?)	+		3							
B Lactarius zonarius Fr.	3			2						
B Boletus calopus Fr.	2				+					
B Boletus aereus Bull.:Fr.	1				1					
B Boletus appendiculatus Schaeff.:Fr.	+				1					
B Pseudocraterellus sinuosus (Fr.) Corner ex Heinem.		1		+						
B Xerocomus spadiceus (Fr.) Quél.		1			1					
CBInocybe geophylla (Sow.:Fr.) Kumm.		+			+					
B Russula nigricans (Bull.) Fr.	3									
B Otidea cochleata (L. ex St-Am.) Fuck. (?)					3					
B Lactarius camphoratus Bull.:Fr.	2									
B Sarcodon amarescens Quél.	2									
B Clavariadelphus pistillaris (Fr.) Donk (?)	2									
B Leccinum aurantiacum (Bull. ex St-Am.) S.F.Gray			2							
CBRussula densifolia (Secr.) ss. Rom.					2					
Common species										
CBAmanita citrina (Schaeff.) S.F.Gray var. citrina	2	+	+	1	+	1	3	3		
CBAmanita rubescens (Pers.:Fr.) S.F.Gray	2	2	1	+	1	1	2	2		
CBHydnum repandum L.:Fr.	4	1	4	3	3	2		1		
CBCantharellus cibarius Fr.	5	1	3	3	2	1	2			
B Cortinarius elatior Fr.	1	4	2	1		1	1	+		
B Amanita vaginata (Bull.:Fr.) Quél.	1	+	1		2	2				
B Amanita pantherina (DC.:Fr.) Secr.	+	1			+	1	+			
B Cortinarius trivialis Lge.	2	4			2		+			
B Tricholoma ustale (Fr.:Fr.) Kumm.	1		1	2				+		
CBCortinarius duracinus Fr.	1	2				+	1	1		
CBRussula albonigra Krbh.	2	1				+				
B Hygrophorus cossus (Sow. ex Fr.) Fr.	1		1				+	1		

groups: I = chestnut coppices; II = not recently burnt heathlands; III = heathlands burnt 10 and 5 years before the study; IV = heathland burnt the previous year.

Relevé groups	I					II			III		IV
Plot number	1	2	3	4	5	6	7	8	9	10	11
CBHydnum rufescens Fr.	+			+		+		3			
CBCortinarius obtusus Fr.			1	1	1	2	2	3			
CBCortinarius uraceus Fr.			1	1	1		+				
B Cortinarius castaneus (Bull.:Fr.) Fr.					3			+			
B Ramaria botrytis (Pers.:Fr.) Boud.					2	2					
B Lactarius chrysorrheus Fr.	3	2	1	+		3	2	1	3	2	
CBHydnellum concrescens (Pers. ex Schw.) Banker	4	4		4	4	2			1		
CBTricholoma saponaceum (Fr.) Kum.	3			+		3	2			1	
C Dermocybe semisanguinea (Fr.) Mos.	+					2	1		1	1	
CBHebeloma crustuliniforme (Bull.:Fr.) Quél.		1					+	2	2	1	
CBTricholoma sejunctum (Sow.:Fr.) Quél.					+	2				+	
CBLaccaria amethystina (Bolt. ex Hooker) Murr.	1	2							2		
CBHebeloma sinapizans (Paul.:Fr.) Gill.	+			1					+		
B Lactarius subdulcis Bull.:Fr.		+		1					+		
CBTricholoma scalpturatum (Fr.) Quél.	1									+	
CBLaccaria laccata (Scop.:Fr.) Bk.& Br.	+	2	+		+	1	4	1	4	1	3
CBCortinarius acutus Fr.	1	2	1	2	+	1	1		2	1	2
CBRussula fragilis (Pers.:Fr.) Fr.	2	1	+		+	+	2	1	+	3	+
CBBoletus edulis Bull.:Fr.		+	1		+	1				2	1
CBPhellodon niger (Fr.;Fr,) P. Karst.	2	2			2	4	2				3
B Tricholoma ustaloides Rom.	1			1	3			1			1
B Ramaria formosa (Pers.:Fr.) Quél.	4			1	4						2
C Dermocybe cinnamomeofulva (R. Hry.)	1						+	1			+
CBTricholoma flavobrunneum (Fr.) Kumm.	+						1	+			+
CBClavulina cinerea (Bull.:Fr.) J. Schroet. (?)		1						2		2	
CBClavulina rugosa (Bull.:Fr.) J. Schroet. (?)	2									+	
B Amanita caesarea (Scop.:Fr.) Pers. ex Schw.					2						2
Differential species of heathlands											
CBHydnum repandum L.:Fr. var album (Quél.) Rea						2	4	4			
CBAmanita citrina (Schaeff.) S.P. Gray var. alba Price						1	+	2			
CBCortinarius hoeftii Weinm. ap. Fr.						2	+	1			
B Ramaria aurea (Schaeff.:Fr.) Quél.						2	+	4			
C Tricholoma flavovirens (Pers.:Fr.) Lund. & Nannf.						2	1				
CBTricholoma aurantium (Schaeff.:Fr.) Rick.						1	+				
B Cantharellus cinereus Fr.							2	1			
B Ramaria flava (Fr.) Quél.							1	3			
C Tricholoma focale (Fr.) Rick.							2				
B Russula luteotacta Rea						+			2	1	
C Russula sardonia Fr. em. Romell							+		5	5	
C Cortinarius fulvescens Fr. ss. Favre							2		3	3	
B Lactarius violascens (Otto) Fr.							2		1	+	
C Tricholoma pessundatum (Fr.) Quél.						1				4	
CBPaxillus involutus (Batsch) Fr.								1		1	
C Cantharellus lutescens Fr.						6	6	5	6	5	1
C Suillus bovinus (L.:Fr.) O. Kuntze						5	5	6	5	7	5
CBScleroderma citrinum Pers.						+	3	3	3	3	2
CBCortinarius purpurascens Fr.						1	2	+	+	2	1
C Cortinarius spilomeus (Fr.:Fr.) Fr.						3	3	1		4	1
C Gomphidius roseus (L.) Fr.						1	+		+	1	+
CBInocybe similis Bres.						1			1		2
C Tricholoma stans (Fr.) Sacc.						1	2				+
C Suillus granulatus (L.:Fr.) O. Kuntze							+				2
C Hydnellum aurantiacum (Batsch:Fr.) P. Karst.						2					1
C Lactarius deliciosus Fr.										4	1
C Chroogomphus rutilus (Schaeff.:Fr.) O.K. Miller.									+	1	
CBLaccaria proxima (Boud.) Pat.									3	2	2
C Rhizopogon luteolus Fr.										3	1

Other taxa ocurring in one plot only: Ril.1: **B**-Amanita alba Gill. (1), **CB**-A. phalloides (Vaill.:Fr.)Secr.(1), **B**-Boletus erythropus (Fr.:Fr.) Pers. (+), **CB**-Cantharellus friesii Quél.(1), **CB**-Cortinarius cephalixus (Secr.) Fr. (1), **B**-C. crassus Fr. (1), **B**-C. fulvoincarnatus Joach. (+), **B**-C. orellanus (Fr.) Fr.(1), **CB**-C. pumilus (Fr.) Lge.(1), **B**-C. sodagnitus R. Hry. (+), **B**-C. trivialis Lge var. subolivascens R. Hry.(1), **B**-Hygrophorus nemoreus (Lasch) Fr. (1), **B**-Lactarius pterosporus Rom. (1), **B**-Russula romellii R. Mre. (1), **CB**-R. atropurpurea Krbh. (+), **CB**-R. emetica Fr. (1), **B**-R. virescens (Schaeff. ex Zant.) Fr. (+); **Ril.2:** **B**-Cortinarius delibutus Fr. (+), **B**-C. rufoolivaceus Fr. (+), **CB**-C. trivialis Lge. var. squamosipes H. Rry. (+), **CB**-C. venetus (Fr.: Fr.) Fr.(1), **B**-C. xanthophyllus Cke.(1), **B**-Lactarius atlanticus Bon (1); **Ril.3:** **B**-Entoloma sinuatum (Bull.:Fr.) Kumm.(+); **Ril.4:** **B**-Cortinarius amoenolens R. Hry.(+), **CB**-Tricholoma argyraceum (Bull.:Fr.) Sacc. (+); **Ril.5:** **B**-Boletus fechtneri Vel. (1), **C**-Cortinarius dibaphus Fr. (+), **B**-Tricholoma bresadolianum Clç. (+), **CB**-Xerocomus chrysentheron (Bull. ex St-Am.) Quél. (+), **CB**-X. subtomentosum (L.:Fr.) Quél. (+); **Ril.6:** **B**-Cortinarius anomalus (Fr.:Fr.) Fr. (+), **C**-C. collinitus Fr. (+), **CB**-Dermocybe cinnamomea (L.:Fr.) Wünsche (+), **C**-Hygrophorus agathosmus (Fr.:Secr.) Fr. (+), **C**-Suillus boudieri (QuéL) Watl. (+), **C**-Tricholoma colossum (Fr.) Quél. (+); **Ril.7:** **C**-Amanita umbrinolutea Secr. (+), **B**-Cortinarius decipiens Fr. (+), **C**-C. multiformis (Fr.) Fr. var. coniferarum Mos. (+), **B**-C. pseudosalor Lge. (+), **C**-Hygrophorus chrysodon (Batsch) Fr. (+); **Ril.8.:** **B**-Leccinum crocipodium (Letl.) Watl.(+); **Ril.9:** **CB**-Russula sanguinea (Bull. ex St-Am.) Fr. (+); **Ril.10:** **CB**-Amanita spissa (Fr.) Kumm. (+), **CB**-Hebeloma mesophaeum (Pers.:Fr.) Quél. (+); **Ril.11:** **CB**-Amanita muscaria (L.:Fr.) Hooker (+).

hizal species are present only in the chestnut woods and most of them are fungi with a wide ecological range, found in the Tuscan woodlands studied so far (De Dominicis & Barluzzi, 1983, Perini et al., 1989), for instance *Lactarius uvidus, L. zonarius, Tricholoma atrosquamosum, Russula vesca* and others. About 70% of the differential species of chestnut coppices are associated with broad leaved trees (e.g. *Russula chamaeleontina, Lactarius pergamenus* and *Cortinarius torvus*). In the group of 39 mycorrhizal species common to the two vegetation types, we observe a decrease in species in more recently burnt heathlands. Only four species *(Laccaria laccata, Cortinarius acutus, Russula fragilis, Boletus edulis)* were collected in all relevé groups. 62% of the common fungi do not have specific host. The presence of the conifer symbionts *Cortinarius dibaphus* in plot 5, *Dermocybe cinnamomeofulva* and *D. semisanguinea* in plot 1, is probably due to sporadic pine trees, even if growing at some distance from the plots. 45 mycorrhizal species are present only in the heathlands. Some species are only found in the more or less recently burnt plots: *Amanita muscaria, A. spissa, Chroogomphus rutilus, Laccaria proxima, Lactarius deliciosus,* and *Rhizopogon luteolus*. 49% of the differential species of heathlands are obviously associated with conifers; e.g. *Cantharellus lutescens, Cortinarius spilomeus, Suillus bovinus, Gomphidius roseus.*

In Table 3 the parasitic fungi and the saprophytes on humus, litter and wood are listed. 62 species are exclusive of chestnut coppices, 20 are common and 36 are exclusive of heathlands. *Mycena inclinata* and *Fistulina hepatica,* mainly linked to chestnut trees, have never been observed in the heathlands though scattered *Castanea sativa* are present in five plots out of six. Only *Mycena galopoda* and *Lycoperdon pyriforme* are present in all the relevé groups. Only two litter species are found among the differential fungi of heathlands: *Clitocybe suaveolens* and *Mycena vulgaris*; this latter is linked to coniferous needles. The saprophytes linked to dead woods of conifers are: *Gymnopilus penetrans, Mycena seynii* (on cones), *Galerina marginata* and *Tricholomopsis rutilans*.

In Table 4 numbers of species and approximate numbers of carpophores of mycorrhizal, saprophytic and parasitic fungi are reported for each relevé. A decrease in number of species and an increase in number of carpophores is generally observed in the succession from chestnut woods to unburnt and burnt heathlands: in the chestnut coppices (group I) on the average 82 species and 900 carpophores; in the heathlands not recently burnt (group II) on the average 59 species and 1091 carpophores; in the burnt heathlands (group III+IV), on the average 43 species and 1389 carpophores. However, the lowest number of fruit bodies is present in the most recently burnt plot 11 (group IV).

Ectomycorrhizal fungi have a relatively low number of species and a high

(Continuation next page 191)

Table 3 - Mycocoenological relevés of saprophytic and facultative parasitic fungi. H = saprophytes on humus; L = saprophytes on litter; W = saprophytes on wood; P = facultative parasites. Relevé groups: I = chestnut coppices; II =

Relevé groups	I					II			III		IV
Plot number	1	2	3	4	5	6	7	8	9	10	11
Differential species of chestnuts coppices											
W Mycena inclinata (Fr.) Quél.	2	5	3	4	4						
P Fistulina hepatica Schaeff.:Fr.	1	+	1	1	1						
L Mycena polygramma (Bull.:Fr.) S.F. Gray	1	1	1	+	+						
L Mycena sanguinolenta (A.& S.:Fr.) Kumm.	+	1	+	1	1						
H Macrolepiota mastoidea (Fr.) Sing.	1	+	+	+							
W Crepidotus variabilis (Pers.:Fr.) Kumm.	2	2	4	1							
L Clitocybe odora (Bull.:Fr.) Kumm.	+	2	4	2							
W Trametes pubescens (Schum.:Fr.) Pil.	1		2	2	2						
H Coprinus plicatilis (Curt.:Fr.) Fr.		1	1	+	1						
H Leotia lubrica Pers.		2	1	1	1						
W Oudemansiella longipes (Bull. ex St-Am.) Mos.		+	+	+	+						
L Marasmius cohaerens (Pers.:Fr.) Fr.	2	2		+							
H Mycena rosea (Bull.) Sacc.	+	2		1							
W Marasmius rotula (Scop.:Fr.) Fr.	1	3			1						
H Lycoperdon perlatum Pers. ex Pers.	1	1			2						
W Psilocybe crobula (Fr.) M.Lge. ex Sing.		1	+	2							
W Marasmiellus ramealis (Bull.:Fr.) Sing.		2	2		1						
W Psathyrella hydrophila (Bull. ex Merat) R. Mre.		1		1	2						
L Mycena metata (Fr.) Kumm.		1		3	2						
L Mycena vitilis (Fr.) Quél.			+	1	+						
H Lepista nuda (Bull.:Fr.) Cke.	2		2								
H Lepiota clypeolaria (Bull.:Fr.) Kumm.	+		+								
W Mycena alcalina (Fr.) Kumm.	2			1							
L Clitocybe costata Kühn. & Rom.		+	+								
L Marasmius androsaceus (L.:Fr.) Fr.		1		2							
W Mycena xantholeuca Kühn.			4	2							
H Cystolepiota sistrata (Fr.) Sing.			1	+							
P Omphalotus olearius (D.C.:Fr.) Sing.			3		1						
L Rutstroemia firma (Pers.) Karst.			+		1						
W Dasyscyphus niveus (Hedwig:Fr.) Sacc.	4										
W Crepidotus pubescens Bres.	3										
L Collybia peronata (Bolt.:Fr.) Sing.		5									
W Trametes hirsuta (Wulf.:Fr.) Pil.		3									
L Cyathus striatus Huds. ex Pers.		3									
L Marasmius epiphyllus (Pers.:Fr.) Fr.		3									
W Mycena maculata Karst.		2									
P Armillariella tabescens (Scop.:Fr.) Sing.		2									
W Panellus stypticus (Bull.:Fr.) Karst.				2							
Common species											
L Mycena galopoda (Pers.:Fr.) Kumm.	3	2	3	3	1	1	1	4	1	1	3
W Stereum hirsutum (Wild.:Fr.) S.F. Gray	5	4	5	5	3	1		1		2	
L Rickenella fibula (Bull.:Fr.) Raith.	2	1	2	2	+	1	+				1
W Lycoperdon pyriforme Schaeff. ex Pers.		3	3	2		+	+			1	+
H Lyophyllum infumatum (Bres.) Kühn.	2		+	+	1	1	1				
L Marasmius splachnoides Fr.	2	5	4	4					2	3	
W Mycena galericulata (Scop.:Fr.) S.F. Gray			+	3	+		1		2		
W Hypholoma fasciculare (Huds.:Fr.) Kumm.					1			2	1	4	
W Trametes versicolor (L.:Fr.) Pil.	1		3							2	1
H Mycena pura (Pers.:Fr.) Kumm.		4		1					+		
L Mycena epipterygia (Scop.:Fr.) S.F. Gray		1	+					3			
L Mycena filopes (Bull.:Fr.) Kumm.	1							1			
H Entoloma sericellum (Bull.:Fr.) Kumm.	+										1
H Collybia butyracea (Bull.:Fr.) Quél.		+				+					

not recently burnt heathlands; III = heathlands burnt 10 and 5 years before the study; IV = heathland burnt the previous year.

Relevé groups	I					II			III		IV
Plot number	1	2	3	4	5	6	7	8	9	10	11
L Mycena oortiana Kühn. ex Hora		1				+					
H Clitocybe gibba (Pers.:Fr.) Kumm.		5								+	
H Bovista plumbea Pers. ex Pers.			+			+					
H Clitocybe hydrogramma (Bull.:Fr.) Kumm.				2		1					
P Ganoderma lucidum (W.Curt.:Fr.) Karst.					+					1	
W Tremella foliacea (Pers. ex S.F. Gray) Pers.					+						1
Differential species of heathlands											
W Gymnopilus penetrans (Fr.:Fr.) Murr.						1	3	2	1	3	
W Mycena seynii Quél.						1	1	1	2	1	
H Lyophyllum loricatum (Fr.) Kühn.							2	2	2	+	+
W Galerina marginata (Fr.) Kühn.						1	3	1		1	
H Lyophyllum semitale (Fr.) Kühn.						2		1		1	
W Tremella mesenterica Retz.:Fr.						+	+				1
W Tricholomopsis rutilans (Schaeff.:Fr.) Sing.							+	1			1
W Schizophyllum commune Fr.:Fr.								3		3	2
H Rhodophyllus hirtipes (Schum.:Fr.) Mos.								1		2	2
H Collybia maculata (A. & S.:Fr.) Quél.						2		+			
H Conocybe tenera (Schaeff.:Fr.) Kühn.						2			+		
L Clitocybe suaveolens (Schum.:Fr.) Kumm.						2					2
W Tremella lutescens Pers.:Fr.						+	+				
H Lyophyllum decastes (Fr.) Sing.							4		4		
H Hygrocybe nigrescens (Quél.) Kühn.								+	+		
H Leucopaxillus gentianeus (Quél.) Kotl.								2			
L Mycena vulgaris (Pers.:Fr.) Quél.									3		
H Pseudoclitocybe obbata (Fr:) Sing.											3
H Hygrocybe coccinea (Schaeff.:Fr.) Kumm.											2
W Trichaptum fusco-violaceum (Ehrenb.:Fr.) Ryv.											2

Other species occurring in one plot only: Ril.1: H-Camarophyllus niveus (Scop.:Fr.) Wünsche (+), L-Galerina mniophila (Lasch) Kühn.(1), L-Hygrocybe cantharellus (Schw.) Murr.(+), L-Marasmius bulliardii Quél. (1), H-Mycena pura (Pers.:Fr.) Kumm. f. alba Gill. (1), W-Oudemansiella radicata (Relhan:Fr.) Sing. (+) W-Xylaria hypoxylon (L. ex Hook:) Grev. (1). **Ril.2:** H-Agaricus silvicola (Vitt.) Sacc.(1), W-Collybia fusipes (Bull.:Fr.) Quél. (1), W-Coprinus micaceus (Bull.:Fr.) Fr. (+), W-Hypholoma sublateritium (Fr.) Quél. (+) H-Lycoperdon atropurpureum Vitt. (1), L-Marasmius tremulae Vel. (1), L-Mycena galopoda (Pers.:Fr.) Kumm. var. nigra (Fl.Dan.) (1), L-Mycena pelianthina (Fr.) Quél.(+), L-Rutstroemia echinophila (Bull ex Mérat) Höhn. (1) H-Peziza varia (Hedwig) Fr. (1); **Ril.3:** W-Mycena alba Bres. (1); **Ril.4:** H-Clitocybe brumalis (Fr.:Fr.) Kumm.(1), L-Entoloma incanum (Fr.) Hesler (+), H-Helvella crispa Scop.:Fr. (+), P-Phellinus torulosus (Pers.) Bourd. & Galz. (+), H-Stropharia coronilla (Bull.:Fr.) Quél. (1); **Ril.5:** H-Clavaria vermicularis Sow.:Fr. var. gracilis Bourd. & Galz. (1); **Ril. 6:** H-Thelephora anthocephala Bull.: Fr. (1); **Ril.7:** L-Entoloma conferendum (Britz.) Noord. (+); **Ril.8:** H-Clitocybe dealbata (Sow.:Fr.) Kumm.(+), W-Gymnopilus spectabilis (Fr.) Sing.(1), H-Macrolepiota procera (Scop.:Fr.) Sing. (+), W-Marasmius chordalis Fr. (1); **Ril.9:** L-Entoloma minutum (Karst.) Noord. (1); **Ril.10:** H-Calvatia excipuliformis (Scop. ex Pers.) Perdeck (+), L-Collybia dryophila (Bull.:Fr.) Kumm. (+), H-Geastrum fimbriatum Fr.(+), H-Hygrophoropsis aurantiaca (Wulf.:Fr.) R.Mre. (+), W-Mycena excisa (Lasch) Gill. (1), L-Omphalina rustica (Fr.) Quél. (1), W-Paxillus atrotomentosus (Batsch) Fr. (1); **Ril.11:** W -Hirneola auricula-judae (Bull. ex St-Am.) Berk. (1), W-Gloeoporus dichrous (Fr.) Bres. (+), L-Mycena capillaripes Peck. (+), W-Polyporus arcularius (Batsch) Fr.(+), L-Xeromphalina caulicinalis (With.:Fr.) Kühn. & Mre. (+).

Table 4 - Number of species and approximate number of carpophores for each niche groups and sub groups per plot. Relevé groups: I = chestnut coppices; II = not recently burnt heathlands; III = heathlands burnt 10 and 5 years before the study; IV = heathland burnt the previous year.

RELEVE GROUPS		I					II			III + IV		
PLOT NUMBER		1	2	3	4	5	6	7	8	9	10	11
TOTAL FUNGI	sp.n°	105	93	63	73	76	64	59	51	36	50	44
	carp.n°	1287	1441	680	604	489	1005	1132	1138	1208	2594	347
Mycorrhizal fungi												
with broad leaved trees (B)	sp.n°	43	26	16	21	29	8	12	10	4	3	3
	carp.n°	378	273	42	50	242	39	29	83	26	8	13
with conifer trees (C)	sp.n°	2	0	0	0	1	13	14	4	7	11	10
	carp.n°	2	0	0	0	1	801	796	763	961	2374	194
without distinct host (CB)	sp.n°	28	21	15	16	21	24	19	17	12	16	11
	carp.n°	567	163	99	133	128	127	199	162	116	68	63
Total	sp.n°	73	47	31	37	51	45	45	31	23	30	24
	carp.n°	947	436	141	183	371	967	1024	1008	1103	2450	270
Saprophytic fungi												
on humus (H)	sp.n°	9	11	8	11	5	8	3	8	5	5	5
	carp.n°	18	257	12	15	11	22	65	16	65	9	31
on litter (L)	sp.n°	11	19	10	11	7	4	3	3	4	4	5
	carp.n°	42	427	144	115	11	9	2	77	26	22	26
on wood (W)	sp.n°	11	14	12	12	10	7	8	9	4	10	10
	carp.n°	279	315	364	289	93	7	41	37	14	112	20
Total	sp.n°	31	44	30	34	22	19	14	20	13	19	20
	carp.n°	339	999	520	419	115	38	108	130	105	143	77
(Pac.)Parasitic fungi												
on wood (P)	sp.n°	1	2	2	2	3	0	0	0	0	1	0
	carp.n°	1	6	19	2	3	0	0	0	0	1	0

number of carpophores in the heathland plots, except in the one burnt only one year ago. The lowest number of species and carpophores is shown in that vegetation type by fungi associated with broad-leaved trees (B). The abundance of fruit bodies in heathlands is mostly due to the massive fructification of only a few fungi associated with conifers i.e. *Cantharellus lutescens, Russula sardonia* and *Suillus bovinus*.

The numbers of species and carpophores of saprophytes show a strong decrease going from chestnut coppices to heathlands and this is especially evident for the litter-inhabiting fungi. The influence of fire is not so clear. The parasites generally play a minor role. Five facultative parasites were found in the chestnut coppices: *Fistulina hepatica, Armillariella tabescens, Omphalotus olearius, Phellinus torulosus* and *Ganoderma lucidum*. The latter is the only species also found in the heathlands, not as a parasite but as a saprophyte on wood (tab.4).

Conclusions

From the present study it emerges that there is a decrease in the number of species, both of vascular plants and macrofungi, in the retrograde succession from the chestnut coppices to the heathlands. Although burnt in different periods, the heathlands are phytocoenologically more homogeneous than the chestnut woods. The structure of heathland phytocoenoses changes after fire but the floristic composition is rather constant.

The mycocoenological situation, however, is different: the chestnut woods are more homogeneous than the heathlands even if the ecological factors (vegetation, altitude and geological substrate) are more homogeneous in the latter. The heathlands can be divided into three clusters according to the period after burning.

The high number of carpophores found in the heathlands is mainly due to the massive fructification of few ectomycorrhizal species associated to conifers *(Russula sardonia, Suillus bovinus* and *Cantharellus lutescens)*. The number of species and carpophores in all the other ecological groups is scanty.

From the phytocoenological and mycocoenological analysis of different successional stages of one dynamic series, it is possible to conclude that the mycocoenoses show a greater sensitivity to factors determining the degradation of the phytocoenoses, in this case mainly fire. The fruiting of relatively few species is strongly enhanced.

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