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MACROMYCETES OF THE ALPINE BELT: MYCOCOENOLOGICAL INVESTIGATIONS IN THE WESTERN ITALIAN ALPS BY MULTIVARIATE METHODS

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Abstract. Mycological and plant surveys were conducted on 32 areas in the Piedmont Alps and the Aosta Valley, representing an extensive sector of the Western Italian Alps. The results were syntaxonomically interpreted. Nine types of vegetation were identified by cluster analysis. The distribution of saprophytic and ectomycorrhizal macromycetes is studied in connection with these vegetation types and correlations between vegetation, environment and fungal communities are discussed.

Introduction

The first significant assessments of the relationships between macromycetes and the environment, with particular reference to vegetation, date back to the 19th century (Henning, 1888; Brinkmann, 1897). Studies specifically concerned with the Alps have a long history: Studer (1891), Boudier (1895), Heim (1922, 1928), Scaramella (1930, 1932), Peyronel (1930), Hofler (1937), Modess (1941), Lange (1948), Favre (1948, 1955, 1960), Gulden & 1976b, 1977a, 1977b, 1977c, 1978, 1981, 1983), Kuhner & Lamoure (1970, 1971a, 1971b, 1972), Lamoure (1971, 1972, 1973, 1974, 1975, 1977a, 1977b, 1978, 1980, 1984), Eynard (1977), Gillman & Miller (1977), Senn-Irlet (1986, 1987, 1988a, 1988b), and Debaud (1987).

The studies of Hofler, Lange and Favre can be regarded as fundamental. Hofler (1937) formulated a rather complex method for evaluating fungus distribution in various biotypes and the possible influence of vegetation. Lange (1948) studied the relationship between plant associations and the distribution of fungus flora in peatbogs. Favre (1955) remarked that the fungus flora of the basic alpine environments: swards, dwarf shrub heaths, fens and snow patch swards is particularly influenced by the soil reaction. Surveys of literature on fungal sociology and ecology were published by Cooke (1948, 1953).

A concise, but exhaustive historical review of mycocoenological research forms the introduction to Arnolds' study (1981) of the ecology and mycocoenology of the macrofungi of plant communities in grasslands and moist heathlands in the Drenthian district, The Netherlands. The International Arctic and Alpine Mycology Symposia have also served to stimulate a considerable interest in these surveys over the last ten years.

The aim of the present work is to find the correlations between the environment, vegetation and macromycetes in representative grassland areas of the Western Italian Alps. For this purpose, substantial vegetation surveys have been carried out on both calcareous and siliceous soils in Alpine valleys in Piedmont and the Aosta Valley, namely Valsavarenche, Valnontey and the Orco, Dora Riparia, Chisone, Po and Maira Valleys.

The ecological space was analysed indirectly on the assumption of a close correlation between ecological factors and the structure of the plant communities. This approach is based on the postulations that the sample space given by species as axes can be used to investigate the effects of ecological factors on plant communities (Orlóci, 1978, 1979; Feoli *et al.*, 1981).

Geology and climate of the Western Italian Alps

The geology of the Western Alps is marked by an alternation of lithologies. On the external border, the structure is determined by the autochtonous Helvetian complex, whose peripheral sedimentary limestone cover forms the prealpine massifs extending from Switzerland to Provence, as well as the sequence of crystalline bodies that form the central massif. Internally, the Pennine complex is composed of numerous nappes that overlie the preceding sector and it displays compression zones at the Pennine-Helvetian contact. In the Piedmontese Alps it is reached by a lobe of the Austro-Alpine complex that dominates nearly the whole of the Eastern Alps. Glaciers and watercourses have contributed to create an endless alternation of calcareous and siliceous terrains through their formation of moraines and alluvial deposits.

The various mountain barriers from south to north make the total annual precipitation irregularly distributed in the

territory by breaking the northward flow of moist air from the Mediterranean basin (Fig. 1). A dry zone occurs in the Maira Valley under the lee of the Maritime Alps, another dry zone is in the Susa Valley, as consequence of to the Monviso and Orsiera-Rocciavrè barriers, and a third one is in the Aosta Valley, bounded by the Gran Paradiso massif to the south and by Mont Blanc, the Matterhorn and Monte Rosa to the north. Furthermore, the E-W orientation of these valleys and the low altitudes of their passes expose them to the dry air from the French Alps.

Piedmont constitutes a transitional zone between Mediterranean climate with summer minimum, winter maximum precipitation, and Continental climate with summer maximum, winter minimum precipitation. Thus, it has both a spring and an autumn maximum, together with a summer and a winter minimum. The Mediterranean influence diminishes from the south to the north. Montacchini (1990) considers the watershed between the Maira and Varaita Valleys as the boundary of its effect on the plant populations. As a consequence, the floristic frontier between the Northern and Southern Alps can be discerned at the Colle del Monginevro, while the vegetation frontier can be identified at the Orco and Aosta Valleys (see Montacchini, 1990 and Fig. 1).

Post-glacial vegetation repopulation of the Western Alps was given by arctic species from the north, and by Euro-Siberian and Central European species from the east. The former share the higher altitudes with Alpine species, the latter predominate in the xerophilous populations of the drier valleys and the mesophiles bordering the Alps as a whole, which have been mostly subject to human influence.

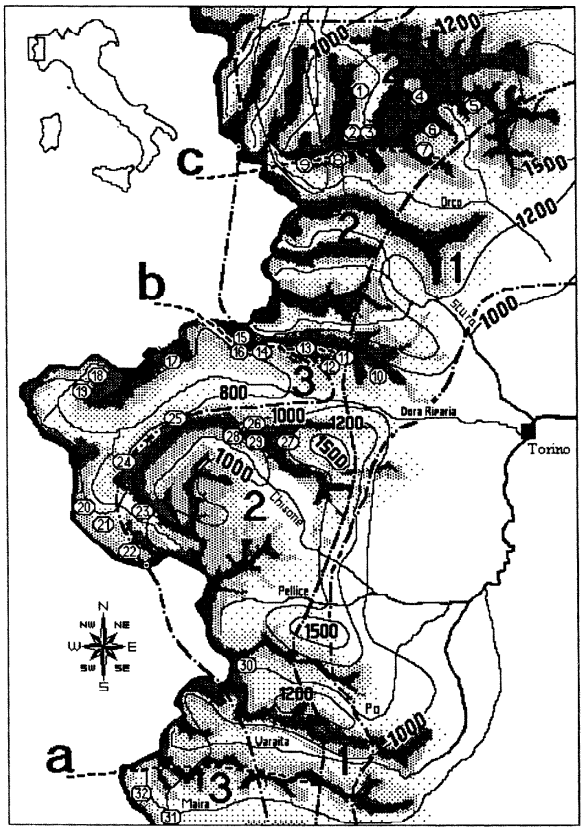


Figure 1. Isohyets and vegetation sectors: 1 - Prealpine; 2 - Alpine; 3 - Inner Alps. Phytogeographic limits of the Western Italian Alps: (a) limit of the Mediterranean influence on vegetation; (b) floristic limit between Northern and Southern Alps; (c) vegetation limit between Northern and Southern Alps. Circles indicate sites where vegetation relevés were conducted and fruit bodies collected (see Appendix A).

Methods

1. Study area, sampling method and evaluation of ecological factors

Mycological and vegetational surveys were carried out from 1975 to 1979 in 32 Piedmont and Aosta Valley alpine sward areas (Fig. 1). A total of 116 vegetation relevés (Appendix A) were taken out when fruit bodies were found.

Only the presence value was given to the fungal species irrespective of the number of their fruit bodies. The presence of *Cenococcum geophilum*, an imperfect fungus, was evaluated by looking for its sclerotia in the soil.

Vegetation stands, on the other hand, were described both by species and by their corresponding cover-abundance values according to the Braun-Blanquet scale (Westhoff & Van der Maarel, 1978).

The soil pH is the only primary factor for which field values were recorded in each relevé. The secondary factors were altitude, aspect and slope. Other primary factors were determined indirectly with Landolt's ecological indicators (1977).

The response of a plant species to the environment was evaluated by cover values.

Pignatti's nomenclature (1982) was used for plants, while for fungi the nomenclature follows the list in Appendix B.

2. Classification of vegetation

2.1 Definition of vegetation types. The Braun-Blanquet cover values were transformed according to van der Maarel's scale (1979).

Average linkage clustering within groups (Anderberg, 1973), based on the similarity ratio (Westhoff & van der Maarel, 1973), was applied to vegetation relevés by the program package of Lagonegro & Feoli (1984).

The NESTOFL program (Feoli *et al.*, 1984a, Lagonegro & Feoli 1984) was used to identify the hierarchical classification levels giving optimum class separation.

The groups of relevés with the highest separation level were used to define the vegetation types (Dale & Webb, 1975; Feoli, 1984).

2.2 Syntaxonomical interpretation of vegetation types. A structured table (Appendix C) was obtained by Intersection Analysis (IA) of relevés. The intersection was measured by the Jaccard coefficient, as suggested by Feoli (1979), using the MLTAX1 program (Feoli & Lagonegro, 1979). This table allowed both syntaxonomical interpretation of individual vegetation types and identification of their differential species.

2.3 Definition of plant species groups and fungal species groups. The species groups both for differential plants and fungi have also been obtained by IA. The tables for plant species-vegetation types (Appendix D) and fungal species-vegetation types (Appendix E) were structured accordingly.

3. Ordination of vegetation types in the ecological space

The purpose of relevé classification was to relate the vegetation to environmental factors and to study the fungus distribution. However, the classification methods do not give the mutual position of vegetation types in the ecological space. Three types of spaces are considered here:

a) space given by the species (indirect ordination);

b) space given by direct observation of environmental factors (direct ordination);

c) space given by the ecological indicator values of Landolt.

Ordinations of vegetation types were obtained by:

i) *Discriminant analysis* of measured environmental factors. The ecological factors used are altitude (m), aspect, slope (sexagesimal degrees), soil pH, and the total herbaceous cover (%) as a parameter expressing the influence of all environmental factors including those not explicitly measured. The aspect values (a.v.) proposed are shown in Fig. 2.

The stepwise method (Klecka 1975, 1984) was used to determine the most important variables for separating the types. The program used is included in the SPSS package.

ii) *Analysis of Concentration* (AOC) (Feoli & Orlóci, 1979) based on the standardised and normalised mean of the environmental parameters used in discriminant analysis, both considering and disregarding the herbaceous cover.

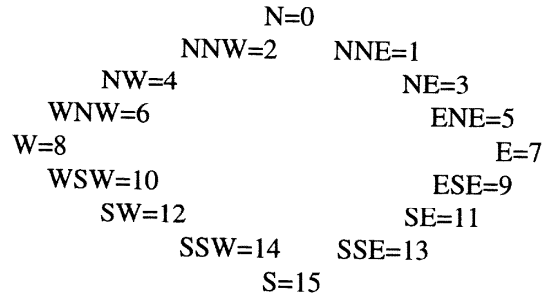


Figure 2. Aspect values (a.v.).

iii) *AOC applied to vegetation types* described by the mean value of Landolt's ecological indicators computed by considering only the frequency values of the differential species. The factors considered by Landolt are: soil humidity (F), soil reaction (R), soil nutrient richness (N), soil humus richness (H), soil dispersion (D), light requirement (L), mean vegetative period temperature (T), and continentality (K). Redundancy, specific variability and correlation coefficients of the Landolt indicators were also evaluated. These analyses were performed with the SOSRANK, ORTOFUN, CHICORSOM and PROBR programs (Lagonegro & Feoli, 1984).

iv) *AOC applied to the contingency table* containing the concentration values of differential species groups (given by IA) in vegetation types. This analysis gives a simultaneous ordination of vegetation types and species groups.

AOC analyses were performed with the ANADECO1, LATTICE and SCGRAM programs (Lagonegro & Feoli, 1984) after adjustment of the frequency values according to Orlóci & Kenkel (1984).

4. Relationships between vegetation types and ectomycorrhizal plants

AOC was also applied to the matrix of symbiotic plants-vegetation types (Appendix F) to study their mutual relationships.

5. Relationships between vegetation types and fungi

To study the relationships between fungal species and vegetation types (Appendix E), AOC was applied to the following 3 matrices:

1) Fungal species groups - vegetation types, considering all fungi species.

2) Fungal species groups - vegetation types, considering only saprophytes.

3) Fungal species groups - vegetation types, considering only ectomycorrhizal fungi.

6.Canonical correlation analyses between different ordinations

Canonical correlation analyses (CC; Gittins, 1979) between the canonical variables of AOC, and between these and the canonical discriminant functions showing at least one significant correlation with the environmental variables were performed with the CORRECAN program (Lagonegro & Feoli, 1984).

The analyses were performed in the following combinations:

1) CC between the measured environmental variables and Landolt's ecological indicators.

2) CC between the measured environmental variables and the differential plants.

3) CC between the ecological indicator values and the differential plants.

4) CC between the measured environmental variables and the ectomycorrhizal plants.

5) CC between the ecological indicator values and the ectomycorrhizal plants.

6) CC between the differential plants and the ectomycorrhizal plants.

7) CC between the measured environmental variables and the fungi.

8) CC between the ecological indicator values and fungi.

9) CC between the differential plants and fungi.

10) CC between the measured environmental variables and the saprophytic fungi.

11) CC between the Landolt's ecological indicators and the saprophytic fungi.

12) CC between the differential plants and the saprophytic fungi.

13) CC between the measured environmental variables and the ectomycorrhizal fungi.

14) CC between the Landolt's ecological indicator values and the ectomycorrhizal fungi.

15) CC between the differential plants and the ectomycorrhizal fungi.

16) CC between the ectomycorrhizal fungi and the ectomycorrhizal plants.

17) CC between the saprophytic fungi and the ectomycorrhizal plants.

18) CC between the ectomycorrhizal fungi and the saprophytic fungi.

7. General classification and ordination

To summarise the correlation pattern between environmental variables, saprophytic fungus groups, ectomycorrhizal fungus groups, symbiotic plant species and vegetation types, Principal Components Analysis (R-PCA) based on correlation coefficient has been applied to the table in Appendix E (Orlóci, 1978). The row and column scores of R-PCA have been used to classify simultaneously the variables and vegetation types by Sum of Squares Clustering (Orlóci, 1978). The same scores have also been used in order to get a simultaneous ordination of vegetation types and all the other variates by another R-PCA. This kind of analysis proves to give a more efficient ordination and a higher resolving power in the scatter graphs (Banyikwa, 1989) than the "primary" PCA.

Results

1. Vegetation types

The highest degree of separation of the groups of relevés defined by cluster analysis occurs at the three- and nine-cluster levels. Fig. 3 illustrates aggregation at the nine-cluster level. Each cluster corresponds to a type of vegetation, as appears from the interpretation of the differential species.

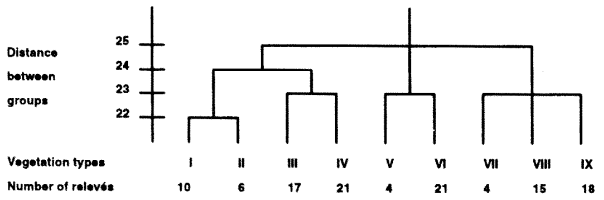


Figure 3. Hierarchical relationship among the nine vegetation types. The unit of measurement is rescaled between 0 and 25.

Means and standard deviations of the environmental variables in the v. t. are given in Table 1. Prevalent aspect (P.a.) was calculated according to the following formula:

$$P.a.=\frac{\sum av}{15N}$$

The mean values of the Landolt's indicators for the differential species of the nine v. t. are given in Table 2.

Since alpine plant communities are involved, the lowest and highest means are obviously those of temperature and light intensity values, respectively. Medium to low nutrient content values are indicative of poor soils, while the humidity and reaction means point to dry soils ranging from subacid to more or less leached calcareous. The humus and soil dispersion values, on the other hand, are mostly above-average, pointing to permeable, well-ventillated soils. The continentality and the heat requirement indicators are those of alpine environments bordering continental regions.

2. Syntaxonomical interpretation of the vegetation types and distribution of macromycetes

The structured phytosociological table of the 116 relevés and 366 plant species is given in Appendix C.

2.1. Vegetation type I. The relevés of this vegetation type are from the Valsoera Valley, the Orco Valley and the Dora Riparia Valley. The dendrogram is shown in Fig. 4.

Table 1. Means and standard deviations of the environmental variables.

Vegetation types	Altitude (m)	Aspect (P.a.)	Slope (deg.)	Soil pH	Herb.cov. (%)
I	2114 ± 167	0.78 ± 0.28	12 ± 12	4.5 ± 0.3	72 ± 19
II	2114 ± 167	0.34 ± 0.38	8 ± 70	4.6 ± 0.3	97 ± 08
III	1941 ± 274	0.70 ± 0.22	15 ± 12	4.7 ± 0.3	95 ± 08
IV	2240 ± 200	0.74 ± 0.28	21 ± 16	4.5 ± 0.5	84 ± 17
V	2043 ± 190	0.56 ± 0.00	26 ± 07	5.9 ± 0.8	90 ± 12
VI	2312 ± 434	0.29 ± 0.30	25 ± 14	6.0 ± 1.0	73 ± 21
VII	2227 ± 380	0.17 ± 0.23	17 ± 11	6.2 ± 1.0	64 ± 16
VIII	2559 ± 171	0.66 ± 0.33	7 ± 50	4.3 ± 0.3	49 ± 22
IX	2310 ± 310	0.74 ± 0.39	11 ± 20	4.9 ± 0.5	78 ± 26
Average	2240 ± 210	0.55 ± 0.27	16 ± 11	5.0 ± 0.5	78 ± 16

Table 2. Means of Landolt's indicator values of the vegetation types (v.t.). Minimum and maximum values are indicated respectively by "m" and "M".

Landolt's indicators		Vegetation types								
		I	II	III	IV	V	VI	VII	VIII	IX
d	F	2.71	2.92	2.41m	2.84	2.43	2.59	2.64	2.97	3.31M
l	R	2.47	2.78	2.82	2.53	3.12	3.27M	3.03	2.38	2.36m
s	N	2.23	2.91M	2.49	2.58	2.12m	2.16	2.32	2.28	2.35
i	H	3.31	3.18	3.18	3.25	3.02	2.99m	3.06	3.37	3.43M
d	D	3.53	3.78M	3.54	3.67	2.96	2.91m	3.32	3.59	3.78M
i	L	4.17	3.89m	3.90	4.00	4.16	4.37	4.42M	4.42M	4.26
a	T	1.57	1.94	2.27M	1.80	2.04	1.75	1.71	1.46m	1.54
t	K	3.36M	2.95	3.21	2.97	3.22	3.24	3.22	2.96	2.75m
o										
r										
s										

Table 3. Fungi and symbiotic plants of the first vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés									
	20	21	22	19	18	23	50	51	16	73
AGARICALES										
Cortinarius albonigrellus (*)	+									
Cortinarius minutulus (*)	+									
Hebeloma crustuliniforme (*)				+						
Hygrocybe pseudoconica					+					
Inocybe dulcamara (*)	+					+				
Inocybe dulcamara var *malençoni (*)*			+							
Inocybe leucoblema (*)			+							
Laccaria laccata (*)	+		+							
Naucoria scolecina						+				
RUSSULALES										
Russula nana (*)	+	+					+	+	+	+
GASTEROMYCETIDAE										
Bovista nigrescens			+							
Bovista plumbea							+	+		
ASCOMYCETES										
Cenococcum gophilum (*)	+	+	+	+		+	+	+	+	+
SYMBIOTIC PLANTS										
Polygonum viviparum	5	5	7	5		5	3	5	5	3
Salix herbacea		2	2						2	5

This type is marked by the presence of humus-requiring differential plants, a relatively high mean altitude (2414 m), the south aspect (P.a. = 0.78), and the maximum continentality observed (K = 3.36). The high humus content (H = 3.31) may be a consequence of the abundance of *Polygonum viviparum*. Microscopic examinations of the root apparatus of this plant regularly revealed the presence of the ectomycorrhizae of *Cenococcum geophilum*, not only on the well-developed plants, but also on the initial rootlets from germinating bulbils in summer. A significant correlation between *C. geophilum* sclerotia abundance in the soil and humus content was reported some time ago by Jensen (1974).

This type is characterized by *Bellardiocloa violacea, Astrantia minor, Pedicularis kerneri, Primula pedemontana* and by a significant presence of *Carex capillaris, Carex frigida, Potentilla aurea, Erigeron uniflorus, Campanula scheuchzeri, Leontodon helveticus, Silene acaulis* ssp. *excapa* and *Trifolium alpinum*. These species indicate that this type can be considered a transition between *Caricetum curvulae* and *Festucetum halleri*. The *Elyno-Seslerietea* contingent is scanty: only *Agrostis alpina* and *Festuca violacea* are relatively constant and abundant.

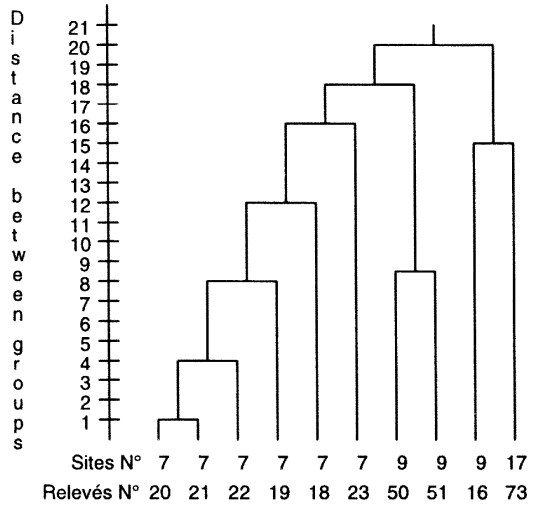


Figure 4. Cluster analysis of relevés of the first vegetation type.

Festucetum halleri is well represented in correspondence with the Northern-Southern Alps vegetation boundary which is reached, albeit marginally, by precipitation brought by the Atlantic currents that sweep over Central Europe when a tropical anticyclone forms over the Mediterranean area. In these alpine valleys the annual precipitation figures exceed 1000 mm and the influence of the Central European climate on the vegetation is reflected by the maximum of Landolt's continentality value displayed by this herbaceous population. The wider distribution of precipitation and the good prevailing aspect of the sites where this association was found may also have encouraged humification, despite their relatively high mean altitude. *Festucetum halleri* is known to have a particularly high light requirement, so that it benefits from glacier-reflected light. In addition to continentality of this association, its Landolt's indicators also show that it has one of the lowest heat and nutrient requirements.

Excluding *Cenococcum geophilum*, in this vegetation type 12 fungal species (f) have been found, 8 symbionts (sy) and 4 saprophytes (sa). The averages of species for a relevé are respectively: S(f) = 1.9; S(sy) = 1.5; S(sa) = 0.4. The ratio S(sy)/S(sa) is 3.75.

Cortinarius albonigrellus, Cortinarius minutulus, Russula nana, Inocybe dulcamara, Hebeloma crustuliniforme and *Laccaria laccata* are associated with *Polygonum viviparum* (Rel. no. 19 & 20). *Inocybe dulcamara* var. *malençoni* and *Inocybe leucoblema* appear only once when *Salix herbacea* accompanies *Polygonum viviparum* (Rel. no. 22).

2.2. Vegetation type II. The relevés of this vegetation type are from the Soana Valley, the Orco Valley and the Dora Riparia Valley. The dendrogram is shown in Fig. 5.

This type has the lowest altitude average (2116 m), northern aspect, and moderate slope. Its differential plants are the most demanding in terms of nutrients (N = 2.91), and

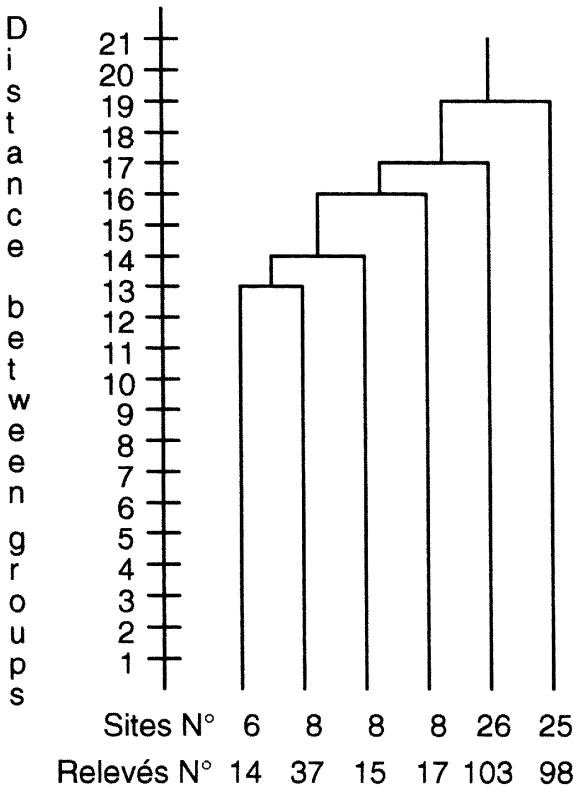


Figure 5. Cluster analysis of relevés of the second vegetation type.

occur on more or less well-ventillated ground (D = 3.78). It shows the greatest herbaceous cover, a very slight slope, and high soil humidity, exceeded solely by that of types VIII (*Salix herbacea* snow patch transitions) and IX (*Salix herbacea* snow patches and fens), together with a high soil dispersion and middle humus content.

Landolt's indicator values also show that type II occupies areas unaffected by the continental climate, or at most particularly favoured zones within areas thus affected. It combines a high heat requirement with the minimum light requirement. The abundance of *Arrhenatheretea* species,

Table 4. Fungi and symbiotic plants of the second vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés					
	14	37	15	17	103	98
AGARICALES						
Calocybe georgii						+
Clitocybe gibba						+
Laccaria proxima (*)				+		
Melanoleuca grammopodia					+	
Gerronema aff. reclinis					+	
Stropharia semiglobata	+					
RUSSULALES						
Russula nana (*)		+	+			
ASCOMYCETES						
Cenococcum geophilum (*)	+	+	+	+	+	+
Octospora rubens	+					
SYMBIOTIC PLANTS						
Polygonum viviparum	5	7	7	5	5	7
Salix herbacea	5					

such as *Poa alpina, Lotus alpinus, Anthoxanthum odoratum, Crocus vernus* and *Gymnadenia conopsea*, and of synanthropic species (e.g. *Taraxacum officinale*), and of *Elyno-Seslerietea* species (e.g. *Lotus alpinus*), and *Caricetea curvulae* species, such as *Cerastium arvense, Euphrasia minima* and *Leontodon helveticus*, suggest to include this type in the *Poion alpinae* alliance which comprehends rich pastures of the upper and lower alpine plateaux considered by Oberdorfer (1983) in a particular position within *Arrhenatheretea* and by Braun-Blanquet (1926) in *Caricion ferrugineae.*

The distribution of symbiotic phanerogams (Table 4) shows the constant and representative presence of *Polygonum viviparum* associated with the ectomycorrhizal fungi *Russula nana* and *Laccaria proxima.*

Excluding *Cenococcum geophilum* present in all the relevés, in this vegetation type only 8 fungal species have been found, 2 symbionts and 6 saprophytes. The averages of species for a relevé are respectively: S(f) = 1.5; S(sy) = 0.5; S(sa) = 1. The ratio S(sy)/S(sa) is 0.5 .

2.3. Vegetation type III. Relevés No. 10, 11 and 12 are from the Soana Valley, the rest from the Dora Riparia Valley. The dendrogram is shown in Fig. 6. This type has the lowest mean altitude (1941 m), south aspect (P.a. = 0.7), and the highest temperature (T = 2.27).

The first five relevés correspond to overgrazed pastures that originally were mowed, manured and irrigated. They belong to a transition between *Festucetum spadiceae austro-occidentale* (Fsao) and *Nardus stricta* facies of *Ranunculo-*

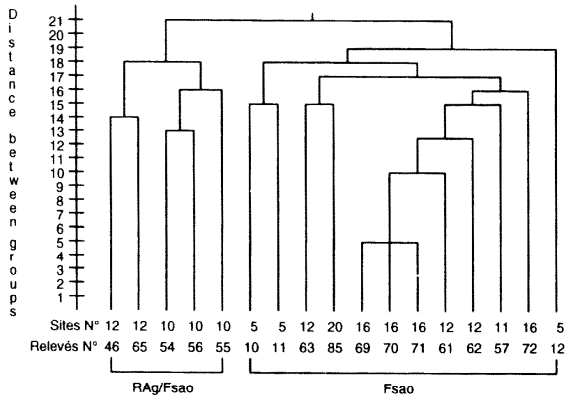


Figure 6. Cluster analysis of relevés of the third vegetation type.

Alopecuretum gerardii (RAg) The remaining twelve relevés refer to Fsao. This plant community is characterized by *Centaurea uniflora, Festuca paniculata* ssp. *spadicea* and *Potentilla grandiflora. Nardus stricta* is often very abundant and accompanied by a contingent of species characteristic of the *Caricetea curvulae* class, such as *Trifolium alpinum, Antennaria dioica, Campanula barbata* and *Arnica montana*, the *Elyno-Seslerietea* class, such as *Helianthemum nummularium, Plantago maritima* ssp. *serpentina, Bupleurum ranunculoides, Sesleria varia*, and the *Arrhenatheretea* class, such as *Anthoxanthum odoratum, Trifolium pratense* var. *frigidum, Rhinanthus alectorolophus* and *Alchemilla xanthochlora.*

The distribution of symbiotic plants (Table 5) shows the discontinuous presence of *Polygonum viviparum*, while *Helianthemum nummularium* is concentrated in the central relevés displaying the most typical Fsao forms.

Excluding *Cenococcum geophilum*, in this vegetation type 30 fungal species have been found, 12 symbionts and 18 saprophytes. The averages of species for relevé are respectively: S(f) = 2.2; S(sy) = 0.9; S(sa) = 1.3. The ratio S(sy)/S(sa) is 0.7 .

Cortinarius phaeochrous alone is distinctly associable with *Helianthemum nummularium.* All the other ectomycorrhizal fungi were observed in the co-presence of *Polygonum viviparum.*

2.4. Vegetation type IV. The relevés of this vegetation type are from the Cogne Valley, the Dora Riparia Valley, the Chisone Valley and a few from the Soana Valley and the Orco Valley. The average altitude is 2240 m. The dendrogram of the clusters is shown in Fig. 7.

This type characterizes slopes where the over-pasturing has favoured the spread of *Nardus stricta.* Its differential plants point to an average humus and nutrient content (H = 3.25; N = 2.58), together with a well-ventillated ground (D = 3.67). The Landolt's indicator discriminating type IV from

Table 5. Fungi and symbiotic plants of the third vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés															
	6 4	6 5	5 4	5 6	5 5	1 0	1 1	6 3	8 5	6 9	7 0	7 1	6 1	6 2	5 7	7 2	1 2
AGARICALES																	
Calocybe georgii							+										
Clitocybe alexandri																	+
Clitocybe gibba		+															
Clitocybe rivulosa		+															
Collybia dryophila															+		
Cortinarius anomalus (*)													+				
Cortinarius bicolor (*)								+					+				
Cortinarius fasciatus (*)														+			
Cortinarius hinnuleus (*)											+	+		+			
Cortinarius phaeochrous (*)					+												
Cortinarius subferrugineus (*)														+			
Entoloma juncinum			+	+													
Hebeloma crustuliniforme (*)														+			
Hygrocybe coccinea													+				
Hygrocybe punicea														+			
Hygrocybe subradiata									+								
Laccaria laccata(*)													+				
Laccaria pumila (*)																+	
Laccaria proxima (*)														+			
Laccaria tortilis (*)													+				
Lepista luscina												+					
Marasmius scorodonius					+												
Panaeolus fimicola															+		
Panaeolus retirugis								+									
Panaeolus rickenii								+									
RUSSULALES																	
Russula nana (*)								+									
GASTEROMYCETIDAE																	
Bovista nigrescens	+	+			+						+						
Lycoperdon pyriforme					+												
Vascellum pratense										+							
ASCOMYCETES																	
Cenococcum geophilum (*)	+	+				+		+				+	+	+			
Scutellinia scutellata																+	
SYMBIOTIC PLANTS																	2
Dryas octopetala																	
Helianth.nummularium	3	2			7	3	5	5	7	5	3	5	5	5	5	3	
H.nummularium ssp.*grandiflorum*													5				
H.oelandicum ssp.*italicum*																5	
Juniperus nana									2	2	2	2					
Kobresia myosuroides																	3
Polygonum viviparum	5	2				2		3		2	2	2	2	2	2		2
Salix reticulata																	2
Salix retusa																	3

type III is soil humidity. In type IV it is relatively high, i.e. between type I and type II whereas type III's drier conditions are reflected in its presentation of the minimum F value.

The vegetation type is characterized by the constant and accentuated presence of *Geum montanum, Nardus stricta* and *Carex sempervirens.*

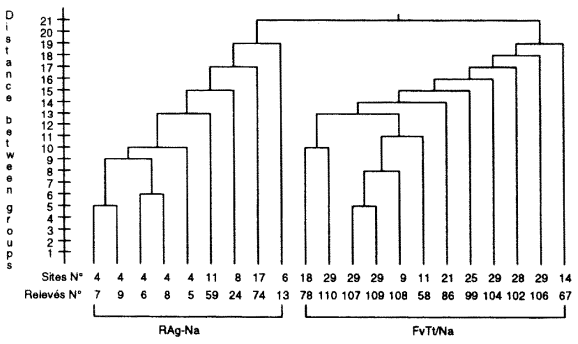


Figure 7. Cluster analysis of relevés of the fourth vegetation type.

Table 6. Fungi and symbiotic plants of the fourth vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés																					
	7	9	6	8	5	9	5	2	4	4	7	3	1	7	8	0	1	0	7	9	0	0	5	8	6	9	1	4	0	2	0	6	6	7
AGARICALES																																		
Clitocybe rivulosa																																		+
Galerina vittaeformis																								+										
Hebeloma alpinum (*)																												+						
Hygrocybe persistens																								+										
Hygrocybe reai var. *insipida*																																	+	
Inocybe dulcamara (*)									+																									
Inocybe fastigiata var. *alpina (*)*	+																																	
Inocybe friesii (*)																												+						
Inocybe lacera var. *heterospora (*)*									+																									
Lepista saeva																																	+	
Melanoleuca subalpina												+																						
Mycena erubescens			+																															
Naucoria alnetorum	+	+			+	+																												
Panaeolus fimicola																											+							
Panaeolus foenisecii																										+								
Panaeolus rickenii																											+							
Tubaria pellucida		+	+	+																														
RUSSULALES																																		
Russula nana (*)									+		+			+	+	+	+	+																
LYCOPERDALES																																		
Bovista plumbea									+																									
Calvatia utriformis																														+				
ASCOMYCETES																																		
Cenococcum geophilum (*)	+			+			+	+	+		+	+	+	+	+	+	+	+	+	+	+	+												+
SYMBIOTIC PLANTS																																		
Salix herbacea	2			5			5				2	5																						
Polygonum viviparum						2	2	2			5	5	2	2	2	2	3	3	5			2												
Salix retusa															2																			
Helianthemum nummularium																			5		7													

The relevés are distinctly divided into two groups notwithstanding they have many species of *Salicetea herbaceae* in common. The first group comprises relevés on acid soils, the second those of neutral soils.

In the first group (see Fig. 7), there is a significant presence of *Salicion herbaceae* species, such as *Alchemilla pentaphyllea, Sibbaldia procumbens* and *Plantago alpina*, but the high cover of *Geum montanum* and *Nardus stricta* and the relevant presence of *Gnaphalium supinum, Leontodon helveticus, Alchemilla xanthochlora* and *Anthoxanthum odoratum* suggest that this group of relevés could be interpreted as an advanced phase of transition of *Ranunculo-Alopecuretum gerardi* (RAg) to *Nardetum alpigenum* (Na). In the second group *Salicion herbaceae* species are present, with species of *Caricion ferrugineae*, such as *Festuca violacea, Phleum alpinum* and *Myosotis alpestris* together with species characteristic of *Arrhenatheretea*, such as *Poa alpina, Campanula scheuchzeri* and *Trifolium pratense* var. *frigidum*. This group can be interpreted as a transitional phase between *Festuco (violaceae)-Trifolietum thalii* (FvTt) and *Nardetum alpigenum*.

Excluding *Cenococcum geophilum*, 20 fungal species have been found in this vegetation type, 6 symbionts and 14 saprophytes. The averages of species per relevé are respectively S(f) = 1.5; S(sy) = 0.6; S(sa) = 0.9. The ratio S(sy)/S(sa) is 0.7 The fungus distribution (Table 6) shows the frequent occurrence of *Naucoria alnetorum* and *Tubaria pellucida* in the relevés (5 to 9) of the *Ranunculo-Alopecuretum gerardii* and a greater variety of saprophytic species in the *Festuco (violaceae)-Trifolietum thalii*.

Apart from *Russula nana*, which occurs when *Polygonum viviparum* is present, the symbiotic fungi are sporadic: *Inocybe lacera* var. *heterospora* and *Inocybe dulcamara* occur when the cover of *Salix herbacea* is high (Rel. 24). *Inocybe friesii* and *Hebeloma alpinum* seem to be associated here with *Helianthemum nummularium* (Rel. 104).

2.5. Vegetation type V. The first two relevés of this vegetation type are from the Maira Valley, the other two from the Dora Riparia Valley. The average altitude is 2043 m. This type shows the lowest mean nutrient requirement (N = 2.12), a relatively high soil reaction (R = 3.12) and include many calciphilous species. It also has the steepest mean slope (26°), and hence is subjected to rainwater washing off the organic matters. All the relevés may be attributed to the *Elyno-Seslerietea* class. The hierarchical classification is shown in Fig. 8.

This type shows an abundance of species characteristic of the *Seslerion variae* alliance, such as *Sesleria varia*, and it may be attributed to *Seslerio-Caricetum sempervirentis* despite the frequency of *Arrhenatheretea* species, such as *Achillea millefolium, Leontodon hispidus* and *Poa alpina*. The constant and high abundance of *Plantago alpina* underlines the protracted snow cover of these swards.

The cluster is divided into two groups: the first (Rel. 113, 114) is differentiated by the presence of *Gentiana verna, Potentilla crantii, Phyteuma orbiculare, Globularia cordifolia, Leontodon hispidus* and *Thymus pulegioides*, the second (Rel. 100, 101) by the presence of *Pedicularis kerneri, Polygonum viviparum, Primula farinosa* and the sporadic appearance of *Salix retusa* and *S. reticulata*.

The distribution of the symbiotic plants (Table 7) clearly confirms the two groups distinguished by the cluster analysis. In the first, only *Helianthemum* species are present, in the second *Polygonum viviparum* and dwarf willows.

Excluding *Cenococcum geophilum*, in this vegetation type only 7 fungi species have been found, 4 symbionts and 3 saprophytes. The averages of species for relevé are respectively S(f) = 2.3; S(sy) = 1; S(sa) = 1.3. The ratio S(sy)/S(sa) is 0.8.

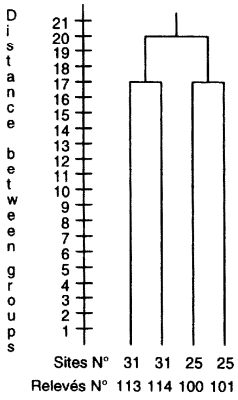


Figure 8. Cluster analysis of relevés of the fifth vegetation type.

Table 7. Fungi and symbiotic plants of the fifth vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés			
	1	1	1	1
	1	1	0	0
	3	4	0	1
AGARICALES				
Clitocybe gibba			+	
Collybia butyracea			+	
Cortinarius glandicolor f. exilis (*)				+
Cortinarius hoeftii (*)		+		
Entoloma griseocyaneum	+			
Inocybe fastigiata var. alpina (*)				+
Inocybe friesii f. epixantha (*)				+
ASCOMYCETES				
Cenococcum geophilum (*)			+	+
SYMBIOTIC PLANTS				
Helianthemum oelandicum ssp. italicum	5	5		
Helianthemum nummularium		3		
Polygonum viviparum			5	7
Salix breviserrata			3	
Salix reticulata			2	
Salix retusa			2	

The first group is poor in fungi. Here *Cortinarius hoeftii* is associated with *Helianthemum* species (Rel. 114). The second group presents a greater variety both of saprophyte and ectomycorrhizal macromycetes, though the latter are solely associated with *Polygonum viviparum* (Rel. 101).

2.6. Vegetation type VI. The relevés of this vegetation type are principally from the Dora Riparia Valley, a few from the Cogne, the Orco, the Po and the Maira valleys. The dendrogram is shown in Fig. 9.

This type is influenced by the same factors as type V, though its mean altitude (2312 m) is greater and its differential plants have a lower heat requirement (T = 1.75). The relevés show a northwards aspect (P.a.= 0.29).

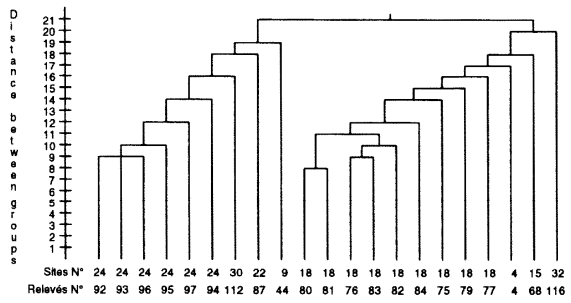


Figure 9. Cluster analysis of relevés of the sixth vegetation type.

This type is characterized by the abundance of *Salix reticulata, S. retusa, Dryas octopetala* and *Oxytropis gaudinii* and it is referable to *Salicetum retuso-reticulatae* transitions. It can be divided into two groups. The first is characterized by *Salix herbacea, Festuca violacea* and *Saxifraga exarata* in addition to the species already mentioned. It may be interpreted as a transition between *Salicetum retuso-reticulatae* and *Festuco (violaceae)-Trifolietum thalii. Bartia alpina, Saxifraga aizoides, Anemone baldensis* and *Sesleria albicans* are abundant in the second group, which may be interpreted as a transition between *Salicetum retuso-reticulatae* and *Elynetum.*

Excluding *Cenococcum geophilum*, present in all the relevés, in this vegetation type 38 fungi species (f) have been found, 17 symbionts (sy) and 21 saprophytes (sa). Their frequencies are respectively: S(f) = 2.4; S(sy) = 1.1; S(sa) = 1.3.The ratio S(sy)/S(sa) is 0.8 .

Only the distribution of saprophytes agrees with the division of the cluster into two groups. The second one (from Rel. 80, see Table 8a) is characterized by the distribution of *Marasmius epidryas* which occurs only on dead lignified parts of *Dryas octopetala.*

The more abundant ectomycorrhizal plants (Table 8b) are *S. retusa, S. reticulata* and *Polygonum viviparum. Dryas octopetala* and *Kobresia myosuroides* (Fontana 1963b) are also frequent. The others are sporadic.

In the first four relevés (n. 92, 93, 96, 95) almost all the ecto plants are present. Their ecto fungi are *Cortinarius decipiens, C. minutulus, C. phaeochrous, Inocybe dulcamara, I. piricystis* and *Laccaria laccata.* The saprophytic ones are *Melanoleuca melaleuca, Bovista tomentosa, B. nigrescens, Clitocybe alexandrii, Entoloma sericeum* f. *nanum, Naucoria subconspersa*, and *Omphalina umbratilis.* The next relevés (97, 94, 112, 87, 44) are characterized by the progressive reduction of ecto plant species. The ecto fungi in this relevé group are: *Laccaria laccata, Cortinarius helvelloides, Inocybe lanuginella* and *Russula nana.* The saprophytes are *Entoloma sericeum* f. *nanum, Clitocybe rivulosa, Camarophyllus pratensis, Hygrocybe conica, Omphalina umbratilis* and *Panaeolus fimicola.*

Relevés 80, 81, 76 and 83 are characterized by a high cover of *Dryas octopetala, Salix reticulata* and *S. retusa. Polygonum viviparum, Kobresia myosuroides* and *Helianthemum oelandicum* ssp. *italicum* are sporadic. This group of relevés is very poor in fungi: *Cortinarius minutulus* is the only symbiotic species. Of the few saprophytic species, *Marasmius epidryas* predominates, whereas *Entoloma sericeum* appears only once.

Ectomycorrhizal fungi are particularly well represented in the last relevés (82, 84, 75, 79, 77, 4, 68, 116): *Hebeloma alpinum, H. versipelle, H. sarcophyllum, Cortinarius favrei, C. orellanus* and *Inocybe fastigiata* f. *alpestris.* Saprophytoc species are well represented only in the relevé 116: *Entoloma incanum, E. papillatum, Hygrocybe cystidiata, H. lepida, H. reai* var. *insipida, Panaeolus guttulatus* and *Tubaria pellucida.*

Table 8a. Fungi of the sixth vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés																								
	9	9	9	9	9	9	1	1	8	4	8	8	7	8	8	8	7	7	7		6	1
	2	3	6	5	7	4	2	7	4	0	1	6	3	2	4	5	9	7	4	8	6	
AGARICALES																						
Camarophyllus pratensis								+														
Clitocybe alexandri	+																					
Clitocybe rivulosa						+																
Cortinarius favrei (*)														+								
Cortinarius decipiens (*)		+		+																		
Cortinarius helvelloides (*)						+																
Cortinarius minutulus (*)			+										+									
Cortinarius orellanus (*)															+							
Cortinarius phaeochrous (*)			+																			
Entoloma incanum																					+	
Entoloma papillatum																					+	
Entoloma sericeum													+									
Entoloma sericeum f. nanum				+	+																	
Hebeloma alpinum (*)														+		+	+	+				
Hebeloma sarcophyllum (*)																	+	+				
Hebeloma versipelle (*)																+						
Hygrocybe conica					+																	
Hygrocybe cystidiata																						
Hygrocybe lepida																					+	
Hygrocybe reai var. insipida																					+	
Inocybe decipiens (*)																					+	
Inocybe dulcamara (*)			+																			
Inocybe fastigiata f.albestris (*)																						
Inocybe humilis (*)																			+			
Inocybe lanuginella (*)						+															+	
Inocybe piricystis (*)			+																			
Laccaria laccata (*)		+					+															
Marasmius epidrys											+	+	+	+			+					
Melanoleuca melaleuca	+																					
Naucoria subconspersa		+																				
Naucoria tantilla																						
Omphalina umbratilis				+				+												+		
Panaeolus fimicola							+															
Panaeolus guttulatus																						
Tubaria pellucida																					+	
RUSSULALES																			+		+	
Russula nana (*)						+	+															
LYCOPERDALES																						
Bovista nigrescens				+																		
Bovista tomentosa			+																			
ASCOMYCETES																						
Cenococcum geophilum (*)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		

Table 8b. Symbiotic plants of the sixth vegetation type.

	Relevés																								
	9	9	9	9	9	9	1	1	8	4	8	8	7	8	8	8	7	7	7		6	1
	2	3	6	5	7	4	2	7	4	0	1	6	3	2	4	5	9	7	4	8	6	
SYMBIOTIC PLANTS																						
Dryas octopetala	5	7	2	2					3	3	7	3	5	2	2							
Helian.oelandicum ssp.italicum			2	2		2					2	2		2	2		2					2
Helian.oelandicum ssp.alpestre																			2			
Kobresia myosuroides	3	3				3		2	7			2		3	3	3		2				
Polygonum viviparum	5	5	3	5	3	2	5	3			2	2	2	3	3	2	2	5	2			
Salix breviserrata																5						
Salix herbacea	5	2		5	7		3											2				
Salix reticulata	5	5	5	5	5				8	5	7	5	3	8	5	5	2					
Salix retusa	5	5	5	5	5	7			2	5	5	3	3	5	2	5	2	5	7			
Salix serpyllifolia				2				2						2					2			

2.7. Vegetation type VII. Three relevés of this type are from the Dora Riparia Valley, and one from the Cogne Valley. The average altitude is 2227 m. The aspect reaches its minimum (P.a.= 0.17) in this type VII. Its discriminant species are mainly neutrophilous (pH 6.2), and show full light and low heat requirement (T = 1.71). The dendrogram of relevés is shown in Fig. 10.

The main feature of this type is the constant and abundant presence of *Salix serpyllifolia*. Other well-represented species are *Cerastium arvense* ssp. *strictum* and *Leucanthemum atratum*. This type may be interpreted as a transition between *Thlaspietea* and *Salicetea*. *Salix serpyllifolia*, *S. herbacea* and *Polygonum viviparum* are the sole ectomycorrhizal plants. Only symbiotic fungi (sy) are present (Table 9).

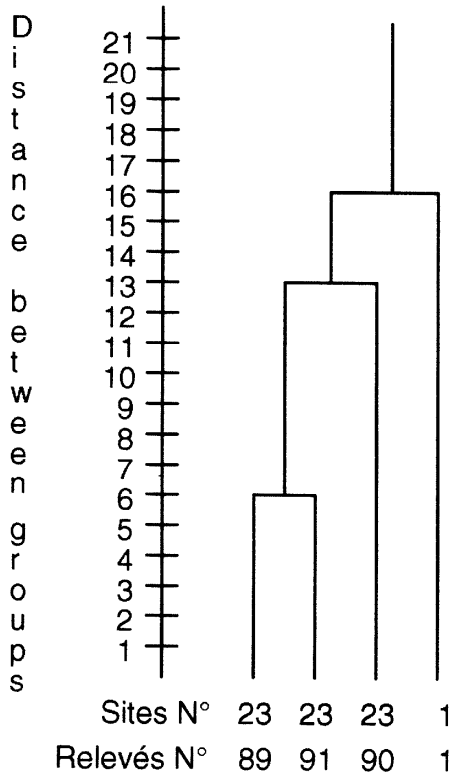


Figure 10. Cluster analysis of relevés of the seventh vegetation type.

Excluding *Cenococcum geophilum*, present in all the relevés, they are represented by 4 species. The average of species for relevé is S(sy) = 1.25.

Inocybe dulcamara and *Cortinarius glandicolor* f. *exilis* seem to be associated with *Salix serpyllifolia*.

2.8. Vegetation type VIII. The relevés of this vegetation type are mainly from the Orco Valley, few from the Cogne, Dora Riparia and Chisone valleys. The dendrogram is shown in Fig. 11.

This type comprises the highest relevés (mean 2559 m). It shares with type VII the lowest mean slope (7°), the lowest mean soil reaction (pH 4.3), and the lowest mean herbaceous cover (49%). In this case, a shallower mean slope (7°) has favoured surficial leaching. Its predominantly Arcto-Alpine differential plants have the lowest heat requirement (T = 1.46), and middle values of soil humidity and humus content.

All the last three vegetation types comprise populations with the lowest heat requirements: type VII is characterized

Table 9. Fungi and symbiotic plants of the seventh vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés			
	8 9 1	9 1	0	1
AGARICALES				
Cortinarius glandicolor f. exilis (*)				+
Hebeloma mesophaeum (*)	+			
Inocybe dulcamara (*)	+		+	
Inocybe friesii (*)		+		
ASCOMYCETES				
Cenococcum geophilum (*)	+	+	+	+
SYMBIOTIC PLANTS				
Salix serpyllifolia	7	5	5	8
Salix herbacea	5	3		
Polygonum viviparum	3	5		

Table 10. Fungi and symbiotic plants of the eighth vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*).

	Relevés																			
							1													
	4	4	3	4	8	4	0		5	5	4	4	4	4	3					
	2	3	9	0	8	1	5	2	2	3	5	7	8	6	8					
AGARICALES																				
Hebeloma marginatulum (*)					+								+							
Inocybe dulcamara (*)						+														
Inocybe lacera ssp. heterocystis (*)	+	+	+																	
Laccaria laccata (*)			+	+		+						+			+					
Naucoria tantilla												+								
Omphalina umbratilis						+					+			+						
RUSSULALES																				
Russula nana (*)							+													
Russula oreina								+	+	+										
ASCOMYCETES																				
Cenococcum geophilum (*)	+	+	+	+	+	+	+	+		+	+	+	+	+	+					
Scutellinia trechispora						+														
SYMBIOTIC PLANTS																				
Polygonum vivparum					2		3							5	3					
Salix herbacea	7	7	5	7	8	3	3		7	7	7	7	5	3						
Salix retusa					5															
Salix breviserrata						2														
Salix helvetica								3												

by pioneer populations, VIII and XI comprise vegetation found in snow patches and fens whose gentle slopes and high altitude encourage leaching and persistent snow coverage.

Type VIII is characterized by *Salix herbacea, Carex curvula, Gnaphalium supinum, Sedum atratum, Carex ovalis, Cerastium alpinum* and *Hutchinsia alpina*. Two groups of relevés can be distinguished (Fig. 11). One is characterized by *Luzula alpinopilosa* and *Poa alpina*. It may be interpreted as a transition between *Salicetum herbaceae* (She) and *Luzuletum alpinopilosae* (Lap). The second is characterized by *Pedicularis kerneri, Leontodon pyrenaicus, Senecio halleri, Cardamine resedifolia, Carex curvula* and *Alchemilla*

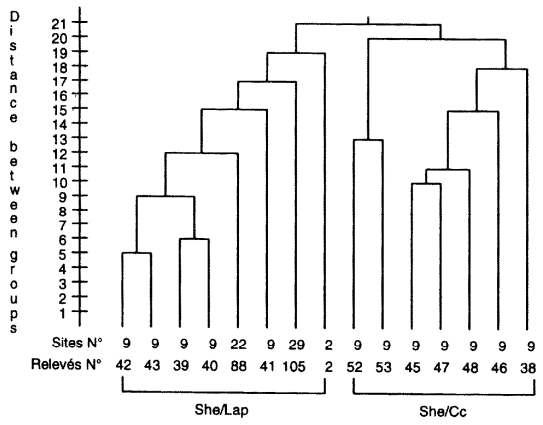


Figure 11. Cluster analysis of relevés of the eighth vegetation type.

pentaphyllea. It may be interpreted as a transition of *Salicetum herbaceae* to *Caricion curvulae* (Cc). *Salix herbacea* is almost constant and other dwarf willows (*S. retusa, S. breviserrata and S. helvetica*) are sporadic in the first group only (Table 10). The predominance of *Salix herbacea* tends to unify the distribution of the ectomycorrhizal fungi.

Excluding *Cenococcum geophilum*, present in all the relevés, in this vegetation type 9 fungi species (f) have been found, 6 symbionts (sy) and 3 saprophytes (sa). The averages of species per relevé are S(f) = 1.3; S(sy) = 1.0; S(sa) = 0.3 . The ratio S(sy)/S(sa) is 3.0 .

Inocybe lacera ssp. *heterocystis, Laccaria laccata, Hebeloma marginatulum* and *Russula oreina* are associated with *Salix herbacea* in relevés where it is the only symbiont. *R. oreina* is also associated with *Salix helvetica* in Rel. 2.

Russula nana appears when *Polygonum viviparum* is also present.

2.9. Vegetation type IX. The relevés of this vegetation type are principally from the Orco Valley, some from the Dora Riparia Valley and a few from the Cogne and Maira valleys. The dendrogram is shown in Fig. 12.

This type shows ecological pattern similar to type VIII, though its herbaceous cover is greater (78%). Its differential plants occupy humid soils (F = 3.31) with the highest humus content (H = 3.43), and average ventilation (D =3.78). Southwards aspect (P.a.= 0.74) and a gentle mean slope (11°) have favoured species with the lowest continentality value (K = 2.75), while the high mean altitude (2310± 310 m) has favoured Arcto-Alpine species with a low mean heat requirement (T = 1.54).

Two distinct groups can be distinguished, including three and fifteen relevés, respectively. The first group can be interpreted as belonging to *Scheuchzerio-Caricetea fuscae* (SCf).

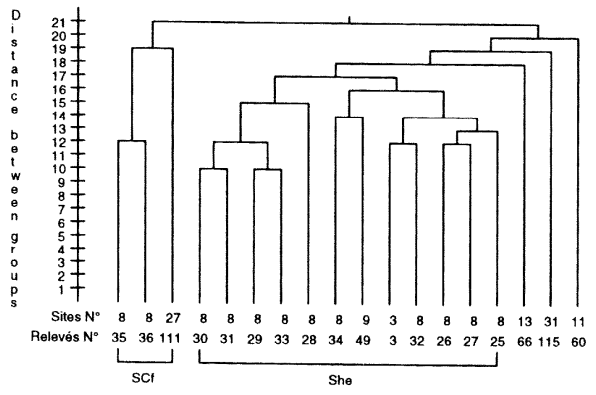


Figure 12. Cluster analysis of relevés of the ninth vegetation type.

Table 11. Fungi and symbiotic plants of the ninth vegetation type. Ectomycorrhizal fungi are indicated by an asterisk (*)

	Relevés																			
			1																	1
	3	3	1	3	3	2	3	2	3	4		3	2	2	2	6	1	6
	5	6	1	0	1	9	3	8	4	9	3	2	6	7	5	6	5	0
AGARICALES																		
Agaricus semotus			+															
Camarophyllus pratensis (f. nanus)										+								
Cortinarius albonigrellus (*)				+														
Cortinarius glandicolor (*)																	+	
Cortinarius helvelloides (*)		+																
Cortinarius hinnuleus var. minutalis(*)					+													
Cortinarius inconspicuus (*)																		+
Cortinarius minutulus (*)		+		+	+	+								+				
Galerina hypnorum				+														
Gerronema reclinis	+																	
Hebeloma maesophaeum (*)																	+	
Hebeloma marginatulum (*)				+														
Hemimycena cucullata																	+	
Inocybe canescens (*)																		+
Inocybe decipiens (*)		+				+												
Inocybe dulcamara (*)			+			+												
Inocybe lanuginella (*)		+																
Inocybe piricystis (*)							+											
Laccaria laccata (*)							+	+								+		
Laccaria proxima (*)		+		+		+			+					+				
Mycena sp.			+															
Naucoria scolecina	+		+															
Naucoria subconspersa			+			+												
Omphalina umbratilis		+																
RUSSULALES																		
Russula nana (*)				+				+	+		+	+	+			+		
LYCOPERDALES																		
Bovista nigrescens			+															
PHRAGMOBASIDIOMYCETIDAE																		
Exidia sp.	+																	
ASCOMYCETES																		
Cenococcum geophilum (*)	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Scutellinia hirtella	+																	
Scutellinia trechispora			+															
SYMBIOTIC PLANTS																		
Polygonum viviparum	2	2	3	3	3				5	5		5	5	3		3	2	3
Salix herbacea	2	5	5	5	7	7	7	7	5	5		7	5	7	5	5	2	
Helianthemum nummularium																		3
Helianthemum oelandicum ssp. italicum																		3
Salix reticulata			2															
Salix breviserrata			5														2	
Alnus viridis																	2	

The clear dominance of species such as *Carex atrata* and *C. lachenalii* relates the first two relevés to *Caricetalia fuscae* associations: no. 35 to *Eriophoretum scheuchzeri* and no. 36 to *Caricetum fuscae*. The third relevé (no. 111) is clearly differentiated by the presence of *Parnassia palustris, Selaginella selaginoides, Dactylorrhiza maculata, Primula farinosa, Eriophorum latifolium, Tofielda calyculata, Pinguicula vulgaris, Carex davalliana, C. flacca, Juncus alpinus* ssp. *articulatus* and *J. triglumis*, as well as *C. atrata*. This may belong to *Caricetum davallianae*.

The constant presence of *Salix herbacea, Alchemilla pentaphyllea, Omalotheca supina* and *Nardus stricta* suggests that the first twelve relevés of the second group could belong to *Salicetum herbaceae* (She). *Campanula scheuchzeri, Soldanella alpina, Sibbaldia procumbens, Poa alpina, Veronica alpina* and *Carex foetida* are also occasionally present in this group. Relevés 66 and 115 show a lower abundance of *Salicetum herbaceae* species in connection with a high presence of *Elyno-Seslerietea* species, such as *Alchemilla alpina, Sesleria albicans, Helianthemum nummularium, Plantago serpentina* and *Potentilla grandiflora*.

The dominance of *Campanula elatines* could suggest that relevé 60 may be assigned to *Campanulo-Primuletum pedemontanae* of the *Androsacion vandelii* (Montacchini *et al.*, 1982).

The most frequent and abundant ectomycorrhizal plants of this vegetation type are *Polygonum viviparum* and *Salix herbacea* (Table 11).

Excluding *Cenococcum geophilum*, in this type 29 fungal species (f) have been found, 16 symbionts (sy) and 13 saprophytes (sa). The averages of species per relevé are respectively: S(f) = 2.6; S(sy) = 1.9; S(sa) = 0.6. The ratio S(sy)/S(sa) is 1.2.

The two groups of this vegetation type are clearly distinguished by the distribution of the ectomycorrhizal and saprophytic species. The former are particularly concentrated in the second group. *Salix herbacea* is the only symbiotic species in relevés 29, 33 and 27 and is associated with several ectomycorrhizal fungi: *Laccaria proxima, L. laccata, Cortinarius minutulus, Inocybe piricystis, I. dulcamara* and *I. decipiens*. *Russula nana* is always accompanied by *Polygonum viviparum*. *Inocybe canescens* and *Cortinarius inconspicuus* occur in relevé 60 where symbiotic plants were not detected.

3. Ordination of vegetation types (v.t.) in the ecological spaces

3.1. Ordination of v.t. by discriminant analysis based on environmental variables. Significance tests for the equality of group means for each environmental variable are shown in Table 12. The F values show that there are significant differences between v.t.

The variables were introduced in the following order by the stepwise procedure: soil pH, herbaceous cover, altitude, aspect, slope. Their individual contributions to group separation are shown in Table 13.

Their contribution to the discriminant functions of the environmental variables is given by the correlation coefficients in Table 14.

The canonical discriminant functions of the v.t. evaluated at group means are given in Table 15. According to the ordination in Fig. 13, v.t. VI and VII are related with

Table 12. Wilks' lambda (U-statistic) and univariate F-ratio with 8 and 107 degrees of freedom.

	Altitude	Aspect	Slope	Soil pH	Herbaceous cover
Wilk's lambda	0.69724	0.66082	0.82270	0.46319	0.66751
Variance ratio (F)	5.80800	6.86500	2.88100	15.50100	6.66200
Significance	0.00000	0.00000	0.00610	0.00000	0.00000

Table 13. Summary table of stepwise variable selection.

Step	Variable entered	Vars. in	Wilks' lambda	Significance
1	Soil pH	1	0.463191	0.0000
2	Herbaceous cover	2	0.308014	0.0000
3	Altitude	3	0.232727	0.0000
4	Aspect	4	0.164264	0.0000
5	Slope	5	0.138696	0.0061

Table 14. Standardized canonical discriminant function coefficients (correlation coefficients between original variables and discriminant functions).

Function	Soil pH	Herb. cov.	Slope	Aspect	Altitude
1	* 0.77717	-0.16094	0.17620	-0.49463	0.00868
2	0.32232	* 0.64870	0.25230	-0.04452	-0.62387
3	0.15832	-0.17343	* 0.62543	* 0.59927	0.32799
4	-0.50865	0.38555	0.36804	-0.48850	0.30291
5	0.09124	0.61201	-0.61537	0.39446	* 0.64138

Table 15. Canonical discriminant functions evaluated on the group means.

Group	Func. 1	Func. 2	Func. 3	Func. 4	Func. 5
I	-0.54862	-0.59717	0.45386	0.12672	0.07034
II	-0.27309	0.57518	-1.28184	0.65223	0.17230
III	-1.12206	1.33696	-0.32318	-0.25047	-0.13464
IV	-0.84238	0.26149	0.42611	0.28729	-0.04326
V	0.55409	1.44769	0.66372	-0.32000	0.06258
VI	2.24022	0.22336	0.12249	0.08564	-0.04099
VII	2.64307	-0.38831	-0.66778	-0.37627	-0.01339
VII	-0.53785	-2.01565	-0.22529	-0.07643	-0.12985
IX	-0.43754	-0.24402	0.02898	-0.26793	0.22621

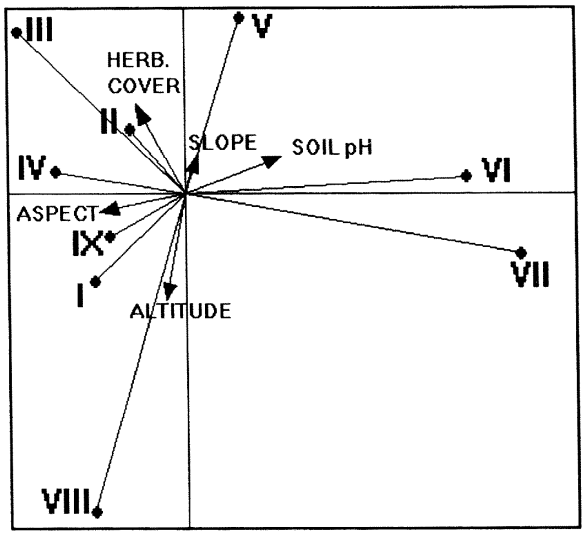


Figure 13. Ordination of v.t. (full circles) and environmental variables (arrows) according to the first two canonical discriminant functions (see Tables 14 - 15).

soil pH, v.t. VIII with altitude, v.t. I and IX with aspect, v.t. II, III and IV with herbaceous cover and v.t. V with slope.

The classification obtained by discriminant analysis is summarized in Table 16. The main diagonal elements are the numbers of relevés correctly classified on the basis of the measured environmental variables (46%).

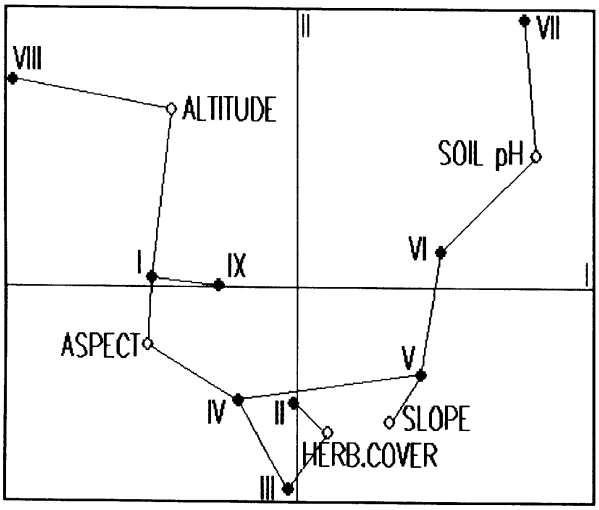
3.2. Ordination of v.t. by AOC based on environmental variables. The ordination of the v.t. according to the first two canonical variates obtained by AOC of the environmental variables recorded in the field, including the herbaceous cover, is given in Fig. 14. Lines indicate MST connections using the first three variates, which account for 97.3% of the total χ^2. The MST shows that the relationships between v.t. and environmental variables are very similar to that obtained by discriminant analysis (see Fig. 13), namely v.t. VI and VII with soil pH, v.t. VIII with altitude, v.t. I, IV and IX with aspect, v.t. II and III with herbaceous cover, and V v.t. with slope. The herbaceous cover is considered here as the parameter expressing the influence of all environmental factors including those not explicitly measured. If this is not taken into account, the C value and χ^2 change very little. This means that there is a strong correlation between herbaceous cover and the other measured environmental variables.

3.3. Ordination of v.t. by AOC based on Landolt's Ecological Indicator values. Redundancy and specific variance analysis were applied to interpret the ecological factors and their influence. The results for the mean Landolt's indicators in the nine types are shown in Table 17.

Soil dispersion and mean temperature are the most redundant factors and together accounted for 80% of the total

Table 16. Classification results.

Veg. Types	No. of Relevés	Predicted group membership I	II	III	IV	V	VI	VII	VIII	IX
I	10	3	1		2				2	2
		30.0%	*10.0%*		*20.0%*				*20.0%*	*20.0%*
II	6		5	1						
			83.3%	*16.7%*						
III	17		5	10	3	1				1
			11.8%	*58.8%*	*17.6%*	*5.9%*				*5.9%*
IV	21	4	3	4	4	2			1	3
		19.0%	*14.3%*	*19.0%*	*19.0%*	*9.5%*			*4.8%*	*14.3%*
V	4				1	3				
					25.0%	*75.0%*				
VI	21		1	1		2	10	5	1	1
			4.8%	*4.8%*		*9.5%*	*47.6%*	*23.8%*	*4.8%*	*4.8%*
VII	4						1	3		
							25.0%	*75.0%*		
VIII	15	2							10	3
		13.3%							*66.7%*	*20.0%*
XI	18	2	3		4		1		3	5
		11.1%	*16.7%*		*22.2%*		*5.6%*		*16.7%*	*27.8%*



Canonical variates and influence levels for the environmental variables and the herbaceous cover evaluated according to their means in the nine v.t.:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.46137	5.015	51.23	51.23
2	.37334	3.284	33.55	84.78
3	.22811	1.226	12.52	97.30
4	.10569	.263	2.70	100.10

$\chi^2 = 9.79$ df = 32 C = 0.104

Figure 14. Ordination of v.t. (full circles) on the basis of the measured environmental variables and the herbaceous cover (empty circles) according to the first two canonical variables. The MST relations are evaluated from the first three canonical variates.

Table 17. Redundancy and specific variance analysis of mean Landolt's indicators for the differential plants in the v.t.

Variable	Specif. sum of squares	Rank	Share (%)	Cumulative (%)	Specific variance	Rank
Dispersion (D)	3.972416	1	49.65	49.65	0.000409	5
Temperature (T)	2.423659	2	30.30	79.95	0.000313	6
Continentality (K)	0.744906	3	9.31	89.26	0.000781	4
Humus (H)	0.566269	4	7.08	96.34	0.000865	2
Light (L)	0.204342	5	2.55	98.89	0.000830	3
Humidity (F)	0.050414	6	0.63	99.52	0.000297	7
Nutrients (N)	0.036424	7	0.45	99.97	0.001011	1
Soil pH (R)	0.001664	8	0.03	100.00	0.000208	8

species variance in the nine types. Table 17 also gives the specific variances of each indicator. Nutrient content, humus content and light have the highest specific variance showing that they are less correlated with the other factors. The specific variance of all eight factors is low, however, and a strong correlation between them is to be expected. The corresponding matrix of correlation coefficients is shown in Table 18.

There are positive correlations between humidity, humus content and soil dispersion, i.e. an increase in one of these factors tends to lead to the increase in the other two. There is also a positive correlation between nutrients and dispersion, whereas the correlation between nutrients and humus is indifferent as is between temperature and continentality. The light is negatively correlated with both temperature and nutrient content, suggesting that at high altitudes less favourable environments are colonised by plant species capable of high light saturation for photosynthesis and highly

Table 18. Correlation coefficients for ecological factors calculated from the mean Landolt indicator values for the nine v.t. Correlations above the 0.05 significance level are indicated by an asterisk. The number of positive and negative significant correlations and non-significant correlations for each indicator is listed in the three right-hand columns.

Variable	pH	Nutr.	Humus	Disp.	Light	Temp.	Cont.	+	−	0
Humidity	-.725*	.285	.774*	.689*	.164	-.686*	-.855*	2	3	2
Soil pH		-.234	-.982*	-.834*	.095	.522	.569	0	3	4
Nutrients			.193	.698*	-.720*	.304	-.457	1	1	5
Humus				.817*	-.038	-.540	-.616	2	1	4
Dispersion					-.416	-.210	-.655	3	1	3
Light						-.704*	.084	0	2	5
Temperature							.296	0	2	5
Continentality								0	1	6
							Totals	8	14	34

efficient CO_2 absorption. For species of this kind, high light intensity is much more important than temperature (Scott *et al.*, 1970; Moser W., 1980; Korner, 1982; Korner & Diemer, 1978; Korner *et al.* 1988). Their pioneering character is further emphasised by the negative correlation observed between their need for high light radiation and their low nutrient requirement.

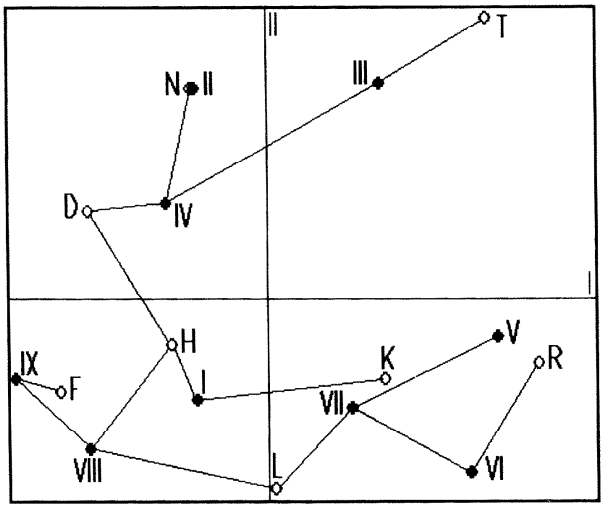
The ordination of the ecological indicators and v.t. is illustrated in Fig. 15. The first two canonical variates used to construct the biplot account for about 88% of the total χ^2.

3.4. Ordination of v.t. by AOC based on the plant species groups. For this analysis only the groups of differential plants have been considered (Appendix D). The ordination is given in Fig. 16. The two canonical variates account for 46% of the total χ^2. The MST shows a very high correspondence between differential plant groups and the corresponding v.t.

By superimposing the environmental variables to v.t. (see Tables 1 - 2) it appears that MST puts in evidence two vegetation series one on acid soil from v.t. III to VIII and the other on neutral or basic soil from v.t. V to VII. Along the lines connecting the v.t. there is an altitude gradient from the top to the bottom (see Table 1). The maximum value of the third variate corresponds to v.t. I. The MST links this acidophilous type directly to the calciphilous type VI. Both types share species such as *Ligusticum mutellinoides* on their windy ridges where there is a relatively high continentality.

4. Relationships between vegetation types and ectomycorrhizal plants

Thirteen ectomycorrhizal plants species and subspecies were identified. They were mostly suffruticose chamaephytes: *Helianthemum nummularium, H. nummularium* ssp. *grandiflorum, H. oelandicum* ssp. *italicum, H. oelandicum* ssp. *alpestre, Salix herbacea* and fruticose chamaephytes: *Salix breviserrata, S. retusa, S. reticulata* and *S. serpyllifolia*, together with a reptant chamaephyte (*Dryas octopetala*), a cespitose hemicryptophyte (*Kobresia myosuroides*), a nanophanerophyte (*Salix helvetica*), and a rhizomatose geophyte (*Polygonum viviparum*), which was the most widespread and found in all nine types. The ordination of v.t.s by AOC based on the ecto plants is shown in Fig. 17.

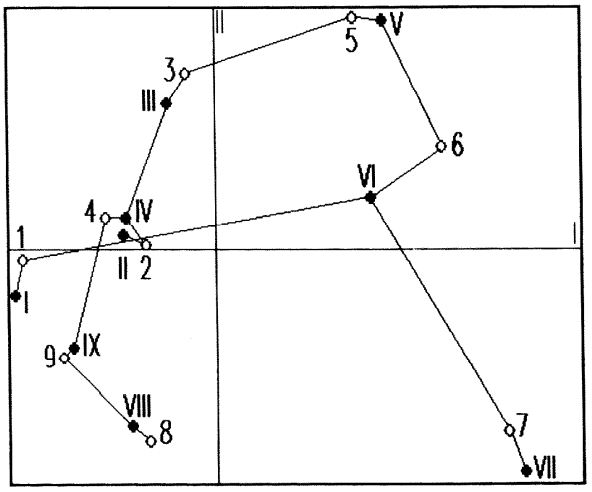


Canonical variates and influence levels for the ecological factors evaluated on the basis of Landolt's Indicators in the nine v.t.:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.06598	.9253	60.85	60.85
2	.04420	.4153	27.31	88.16
3	.02335	.1159	7.62	95.78
4	.01542	.0505	3.32	99.10

$\chi^2 = 1.50$ df = 56 C = 0.001

Figure 15. Ordination of the nine v.t. (full circles) on the basis of the Landolt's indicators (empty circles) according to the first two canonical variates. The MST relations are evaluated from the first three canonical variates and illustrate the link between the indicators and v.t.

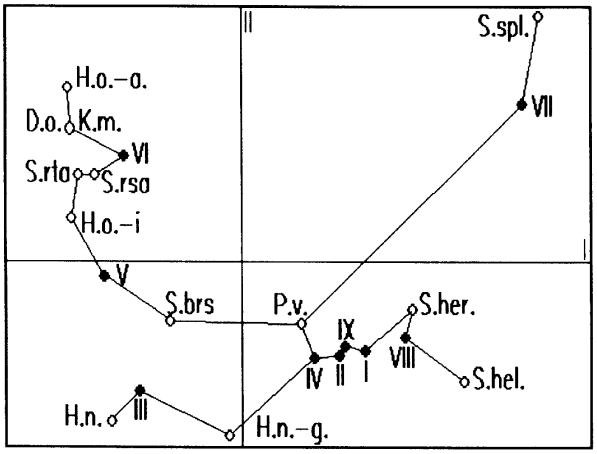


Canonical variates and influence levels for vascular species groups in the nine v.t.:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.61288	489.8	24.19	24.19
2	.58732	449.8	22.22	46.41
3	.49971	325.6	16.09	62.50
4	.47636	295.9	14.62	77.12
5	.38121	189.5	9.36	86.48
6	.33435	145.8	7.20	93.68
7	.24199	76.4	3.77	97.45
8	.19867	51.5	2.54	99.99

$\chi^2 = 2024$ df = 64 C = 0.19

Figure 16. Ordination of the v.t. (full circles) on the basis of the groups of differential plants (empty circles) according to the first two canonical variates. The MST relations are evaluated from the first three canonical variates.



SYMBIOTIC PLANTS

D.o.: *Dryas octopetala*

K.m.: *Kobresia myosuroides*

H.n.: *Helianthemum nummularium*

H.n.-g: *H. numm.* ssp. *grandiflorum*

H.o.-i: *H. oelandicum* ssp. *italicum*

H.o.-a: *H. oelandicum* ssp. *alpestre*

P.v.: *Polygonum viviparum*

S.brs.: *Salix breviserrata*

S.hel.: *Salix helvetica*

S.her.: *Salix herbacea*

S.rsa: *Salix retusa*

S.rta: *Salix reticulata*

S.spl.: *Salix serpyllifolia*

Canonical variates and influence levels for ectomycorrhizal plants in the nine v.t.s:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.70686	111.42	35.68	35.68
2	.62190	86.25	27.62	63.30
3	.54870	67.14	21.50	84.80
4	.37084	30.67	9.82	94.62
5	.22646	11.44	3.66	98.28
6	.14761	4.86	1.56	99.84

$\chi^2 = 312$ df = 88 C = 0.17

Figure 17. Ordination of ectomycorrhizal plants (empty circles) in the nine v.t.s (full circles) according to the first two canonical variates. The MST relations are evaluated on the basis of the first three canonical variates.

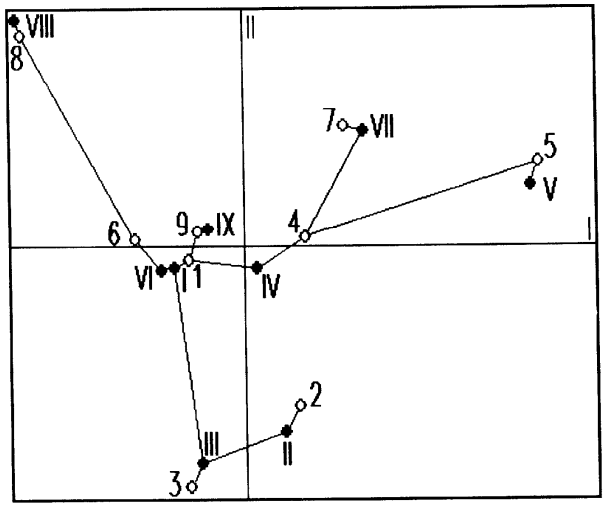
The wide distribution of *Polygonum viviparum* lowered the relative divergence (C = 0.17). This species is particularly frequent in v.t.s I, II, VI and IX. *Salix herbacea* is associated with snow patches, fens and spring swamps (VIII, IX), and is well represented in other types. The largest number of ecto plant species is located near type VI. They are all calciphilous as *Dryas octopetala, Kobresia myosuroides, Helianthemum oelandicum* ssp. *italicum* and *alpestre, Salix retusa* and *S. reticulata,* or indifferent as *Polygonum viviparum. Helianthemum nummularium* is associated with v.t. III. The other species are sporadic.

5. Relationships between vegetation types and fungi

5.1 Ordination of v.t.s by AOC based on the fungi species groups. This ordination (Fig. 18) shows a strict relationship between fungi species groups and veg.types (Appendix E), as suggested by Table 19.

The efficiency is rather high since the contingency table is tendencially disjoint owing to the high relationships between the groups of fungi and the types. The low similarity between the fungal species groups underlines the high correspondence between v.t.s and fungal composition.

5.2. Ordination of v.t.s by AOC based on the saprophytic fungi. The saprophyte groups (Appendix E) are well related to the v.t.s (Fig. 19). No saprophytes were observed in the relevés of type VII. The MST relations illustrate the link between the saprophyte groups of the more anthropized pas-



Canonical variates and influence levels for fungi species groups in the nine v.t.s:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.86536	170.7	21.64	21.64
2	.77840	138.1	17.52	39.16
3	.75043	128.3	16.27	55.43
4	.69580	119.3	14.00	69.43
5	.60521	83.5	10.59	80.02
6	.54727	68.3	8.65	88.67
7	.51033	59.4	7.53	96.20
8	.36225	29.9	3.80	100.00

$\chi^2 = 788.76$ df = 64 C = 0.43

Figure 18. Reciprocal ordination of fungus species groups (empty circles) and v.t.s (full circles) according to the first two canonical variates. The MST relations are evaluated from the first three canonical variates.

Table 19. Similarity ratio matrix between v.t.s based on fungus species groups and the Jaccard index.

Vegetation types	I	II	III	IV	V	VI	VII	VIII	IX
I	1.000	0.052	0.105	0.103	0.000	0.111	0.066	0.166	0.206
II		1.000	0.117	0.037	0.071	0.022	0.000	0.062	0.088
III			1.000	0.087	0.027	0.114	0.000	0.054	0.072
IV				1.000	0.038	0.137	0.090	0.074	0.042
V					1.000	0.000	0.100	0.000	0.000
VI						1.000	0.024	0.119	0.196
VII							1.000	0.083	0.064
VIII								1.000	0.187
IX									1.000

tures, from those still manured (II) to those abandoned and exhausted (III & IV). V.t.s VIII & IX of snow patches, fens and spring swaps are close together.

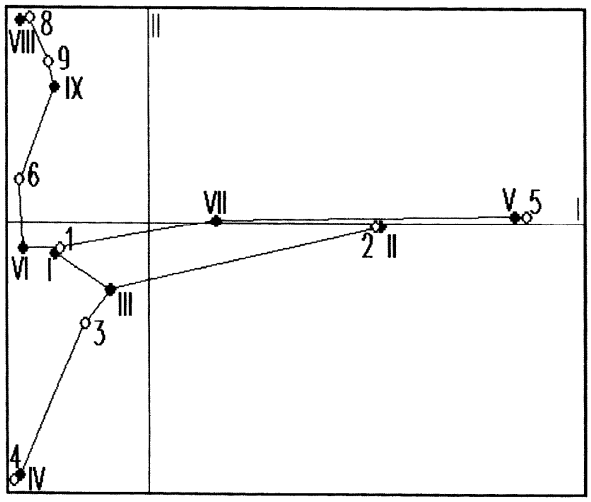
5.3 Ordination of v.t.s by AOC based on the ectomycorrhizal fungi. Ordination of the symbiotic fungi (Appendix E) results in a clear distinction between only a few groups (Fig. 20). Groups 1, 6 & 9 are close to the origin. Groups 3, 5 & 8 are the best described.

6. Canonical correlation analyses between different ordinations.

Canonical correlation analysis (CCA) was used to determine the correlations between the environmental variables and the frequency of the vegetal and fungal species in the nine veg. types. This method directly measures the predictivity of a set of ordination axes with respect to another set. Because of its limitations (Gittins, 1979), CCAs were not carried out on the original data sets, but on the canonical variates obtained by AOC of the measured environmental variables, Landolt's indicator values, and plant and fungus frequency.

6.1 Correlation between the measured environmental variables and Landolt's indicators. The correlation between the environmental variables, including herbaceous cover, and Landolt's indicators of the differential plants is illustrated in Fig. 21.

The variance common to the two sets of data is 60%. Bartlett's test on the first CC shows that the probability of their independence is about 5%. If the herbaceous cover is not taken into account the common variance decreases to 51% and the probability of independence increases to 10%.

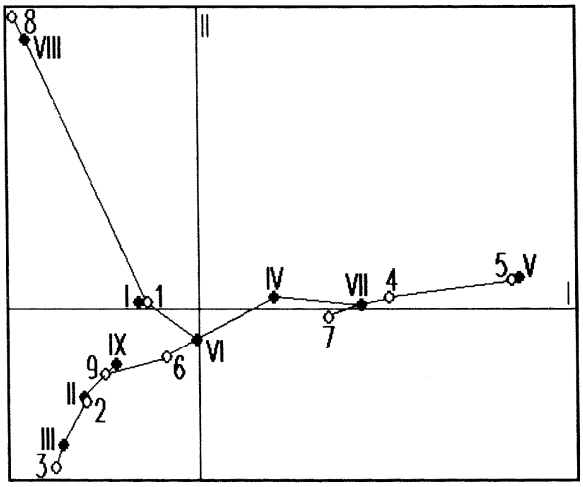


Canonical variates and influence levels for saprophyte fungi species groups in the nine v.t.s:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.96449	94.88	25.57	25.57
2	.83796	71.62	19.31	44.88
3	:80745	66.50	17.92	62.80
4	.74794	57.06	15.38	78.18
5	.62609	39.98	10.77	88.96
6	.48025	23.52	6.34	95.30
7	.41353	17.44	4.70	100.00

$\chi^2 = 371$ df = 49 C = 0.52

Figure 19. Reciprocal ordination of saprophytic groups (empty circles) and v.t.s (full circles) according to the first two canonical variates. The MST relations are evaluated from the first three canonical variates.



Canonical variates and influence levels for the ectomycorrhizal fungi groups in the nine v.t.s:

Can. var.	r(x,y)	Level	% Lev.	% Cum.
1	.89344	99.77	26.43	26.43
2	.81941	83.93	22.23	48.66
3	.66580	55.41	14.67	63.33
4	.61325	47.01	12.45	75.78
5	.58983	43.49	11.52	87.30
6	.50603	32.01	8.48	95.78
7	.29482	10.86	2.88	98.66
8	.20132	5.06	1.34	100.00

$\chi^2 = 377$ df = 64 C = 0.37

Figure 20. Reciprocal ordination of symbiotic fungus groups (empty circles) and v.t.s (full circles) according to the first two canonical variates. The MST relations are evaluated from the first three canonical variates.

6.2 Correlation between the environmental variables and the differential plant groups. A linear relationship between the environmental variables, including herbaceous cover, and the differential plants groups is shown by their correlation diagram (Fig. 22).

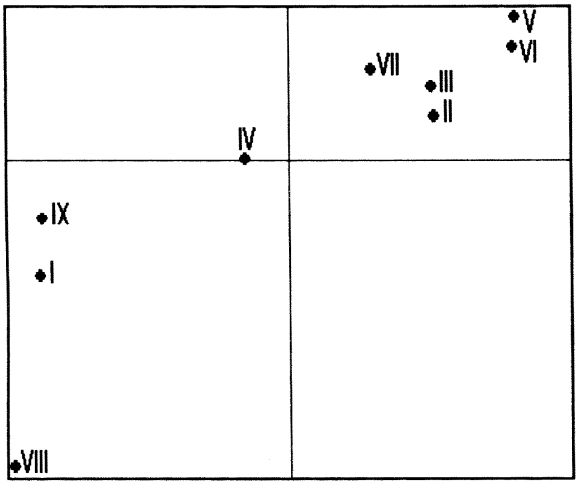
The common variance is 68.7% and Bartlett's test shows that the first canonical variates are highly interdependent (p is about 0.002%). If the herbaceous cover is not taken into account the common variance decreases to 61.5% and the probability of independence increases to 2.7%.

The most hygrophilous v.t.s and those with a particularly long snow cover are the least influenced by the environmental variables (and hence near the origin). The close proximity of type I (*Festucetum halleri*) and type V (*Elyno-Seslerietea* humid environments) suggests that their species are influenced more by humidity than pH. As in Fig. 21, it can be seen that hygrophilous vegetation includes species with a wider distribution, whereas those of drier pastures, whether warm and insolated (type III: *Festucetum spadiceae austro-occidentale*) or cold and with northwards aspect (type VII: pioneer populations between *Thlaspietea* and *Salicetea*) are more dependent on the soil pH.

6.3 Correlation between Landolt's indicators and the differential plants groups. The diagram in Fig. 23 shows the correlation between the differential plant groups and their Landolt's indicators. The common variance is 68.8% and the probability of independence of the first CC is about 0.4%. The main feature of the ordination is a soil dispersion gradient.

Well-ventillated soils, acid and rich in both humus and nutrient, carry the types of vegetation located at the bottom left, whereas those of subalkaline, humus and nutrient-poor soils appear at the top right. Types near the origin are those with species least influenced by soil dispersion and primarily dependent on temperature (heat requirement or continentality).

6.4 Correlation between the environmental variables and the ectomycorrhizal plants. The correlation between the environmental variables, including herbaceous cover, and the ectomycorrhizal plants is illustrated in Fig. 24. The common variance is about 70% and the probability of independence of the first CC is about 0.03%. If the herbaceous cover is not taken into account the common variance increases to 83.4% and the probability of independence is 0.056%.



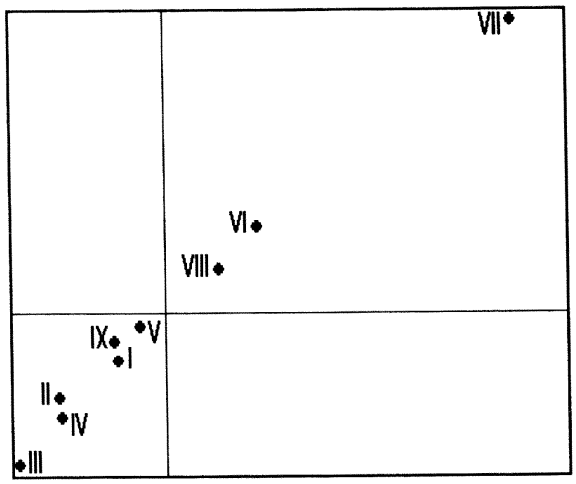
Can. var.	r^2	r	r%	cum. %
1	.86152	.92818	47.8	47.8
2	.79090	.88932	43.9	91.7
3	.14900	.38601	8.3	100.0

Variance common to the two sets = 60.0%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	16.66510	9	5.42289
2	7.76836	4	10.04690
3	.72608	1	39.39565

Figure 21. Correlation between the first canonical variates of AOC on the basis of environmental variables and the herbaceous cover (Y axis) and on the basis of Landolt's indicators (X axis).



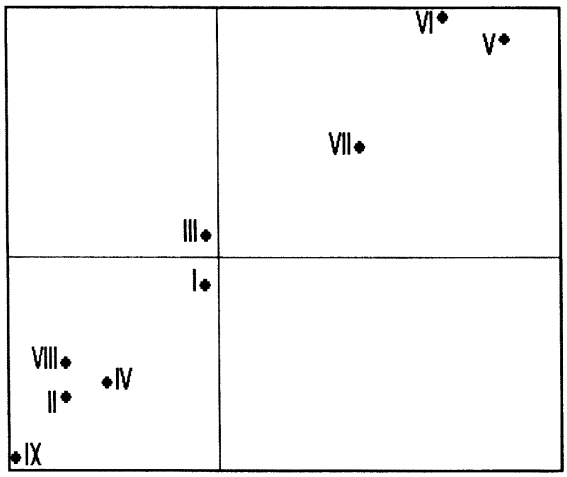
Can. var.	r^2	r	r%	cum. %
1	1.00000	1.00000	48.6	48.6
2	.80787	.89882	39.2	87.8
3	.25157	.50156	12.2	100.0

Variance common to the two sets = 68.7%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	37.62555	9	0.00198
2	8.72725	4	6.81316
3	1.30399	1	25.32723

Figure 22. Correlation between the first canonical variates of AOC on the basis of the environmental variables and the herbaceous cover (Y axis) and on the basis of the differential plant groups (X axis).



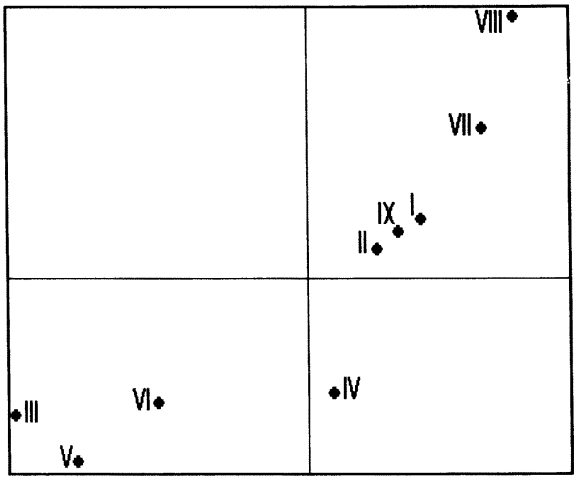
Can. var.	r^2	r	r%	cum. %
1	.97324	.98653	48.8	47.2
2	.74375	.86241	36.0	83.2
3	.34673	.58884	16.8	100.0

Variance common to the two sets = 68.8%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	24.33708	9	0.37988
2	8.04327	4	9.00330
3	1.91596	1	16.60888

Figure 23. Correlation between the first canonical variates of AOC on the basis of the Landolt's indicators (Y axis) and on the basis of the differential plants groups (X axis).



Can. var.	r^2	r	r%	cum. %
1	1.00000	1.00000	47.7	47.7
2	.82333	.90738	38.9	86.6
3	.28234	.53136	13.4	100.0

Variance common to the two sets = 70.4%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	31.20820	9	0.02722
2	9.29369	4	5.41892
3	1.49296	1	22.15463

Figure 24. Correlation between the first canonical variates of AOC on the basis of the environmental variables and the herbaceous cover (Y axis) and of the ectomycorrhizal plants (X axis).

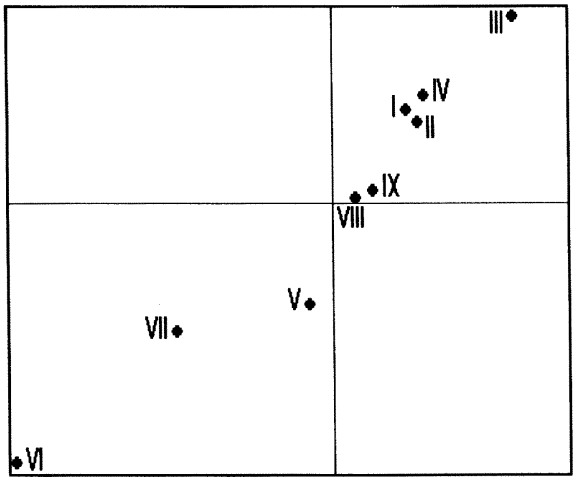
There is an apparent altitudinal gradient in this ordination. A closer analysis, however, reveals the gradient of a factor, namely the duration of the snow cover, that was not directly measured in this study. Type VIII (*Salicetum herbaceae* snow patch transitions), in fact, is clearly isolated at one extreme from type III (low-altitude dry pastures with *Helianthemum nummularium* as the most abundant symbiont) at the other. Despite their higher mean altitudes, types V & VI, too, are hosts to thermophilous ecto plants, such as *H. oelandicum* ssp. *italicum*. The distribution of *Polygonum viviparum* and *Salix serpyllifolia*, which predominate in v.t.s near the origin, is primarily influenced by soil humidity.

6.5 Correlation between the Landolt indicators and the ectomycorrhizal plants. The diagram in Fig. 25 shows the correlation between the Landolt's indicators of the differential plants and the frequency of ectomycorrhizal plants. The common variance is 94.7% and the probability of independence of the first CC is about 0.07%.

There is a soil pH gradient (bottom left to top right). Host plants most sensitive to this factor are those predominant in dry grasslands: *Helianthemum nummularium* in type III vegetation (acidophilous, *Festucetum spadiceae austro-occidentale*) at the top right, and *Salix retusa, S. reticulata, Dryas octopetala* and *Kobresia myosuroides* in type VI (calcareous, *Festuco (violaceae) - Trifolietum thalii* and *Elynetum*) at the bottom left. V.t.s with species more dependent on humidity than pH, such as *Salix herbacea*, are located near the origin of the axes.

6.6 Correlation between the differential plant groups and the ectomycorrhizal plants. The correlation between the ectomycorrhizal plants and the groups of the differential plants is shown in Fig. 26. The common variance is 63.7% and the probability of independence of the first CC is about 0.7%.

This ordination displays a pH gradient. V.t.s hosting ecto plant species preferring humid environments are located at each extremity: types VIII (*Salix herbacea* snow patches transitions) and IX (*S. herbacea* snow patches, fens and spring swamps) and type I (*Festucetum halleri*) at the top right, and types V (humid facies of *Elyno-seslerietea*) and VI (*Salicetum retuso-reticulatae* and its transitions) at the bottom left. The drier types (IV & VII) host symbionts are less affected by the soil reaction and lie closer to the origin of the axes.



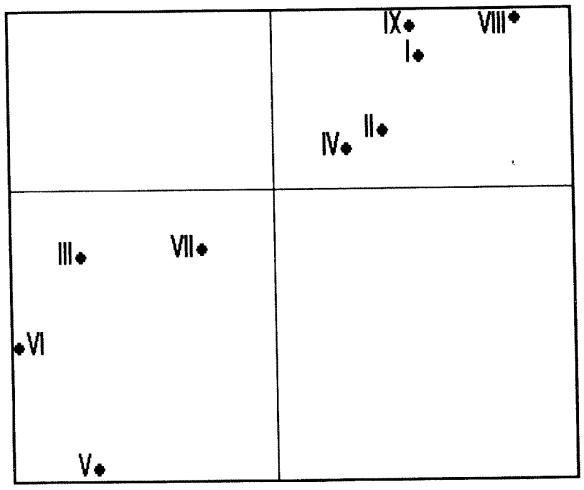
Can. var.	r^2	r	r%	cum. %
1	1.00000	1.00000	55.1	55.1
2	.84980	.92184	44.9	100.0

Variance common to the two sets = 94.68%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	22.59895	9	0.71627
2	8.53123	4	7.39715

Figure 25. Correlation between the second canonical variates of AOC on the basis of the Landolt's indicators (Y axis) and of the ectomycorrhizal plants (X axis).



Can. var.	r^2	r	r%	cum. %
1	96821	.98398	50.6	50.6
2	.75597	.86946	39.5	90.1
3	.18832	.43396	9.9	100.0

Variance common to the two sets = 63.7%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	22.80606	9	.66469
2	7.28612	4	12.15465
3	.93893	1	33.23483

Figure 26. Correlation between the first canonical variates of AOC on the basis of the differential plant groups (Y axis) and on the basis of the ectomycorrhizal plants (X axis).

6.7 Correlation between the environmental variables and the fungi species groups. The diagram (Fig. 27) shows the correlation obtained by the second canonical variates of the ordinations of environmental variables, including the herbaceous cover, and of the frequency of all the fungi species. The common variance is 52.7%.

The linear relationship shows an unequivocal herbaceous cover gradient, i.e. the parameter expressing the influence of all environmental factors including those not explicitly measured. Cultivated pastures, namely v.t.s II (*Poion alpinae*) and III (*Festucetum spadiceae austro-occidentale*), are at one end, and type VIII (*Salix herbacea* snow patch transitions) at the other. If the herbaceous cover is not taken into account the common variance decreases to 36.7% and the probability of independence increases to 57%.

6.8 Correlation between the Landolt indicator values and the fungal species groups. The correlation obtained by the first canonical variates of the ordinations of the Landolt's indicators and fungal species groups is very low. The common variance is 53.6% and the probability of independence of the first CC is about 44.5%.

6.9 Correlation between the differential plant groups and the fungi species groups. The correlation obtained by the first canonical variates of the ordinations of the differential plant groups and fungi species groups is very low. The common variance is 40% and the probability of independence of the first CC is about 48%.

6.10 Correlation between the environmental variables and the saprophyte fungal groups. The diagram in Fig. 28 shows the correlation between the measured environmental variables, including the herbaceous cover, and the saprophyte groups. The common variance is 53.5% and the probability of independence of the first CC is 11.6%. Acidophilous slope pastures (types I, III, IV), at the bottom left, and flatter meadows and pastures (type II: *Poion alpinae*) display an anthropization gradient. The *Elyno-seslerietea* steep pastures (V) deviate to the right and the *Salicetum retuso-reticulatae* pioneer populations (VI) deviate upwards.

If the herbaceous cover is not taken into account the common variance decreases to 45.2% and the probability of independence increases to 17.2%.

6.11 Correlation between the Landolt's indicators and the saprophyte fungus groups. The correlation obtained by the

first canonical variates of the ordinations of the mean Landolt's indicators and the groups of saprophytes is decidedly low. The common variance is 38.6% and the probability of independence of the first CC is about 72.5%

6.12 Correlation between the differential plant groups and the saprophyte fungus groups. The correlation obtained by the canonical variates of the ordinations of the differential plant groups and the saprophyte groups is decidedly low. The common variance is 42.1% and the probability of independence of the first CC is about 62%.

6.13 Correlation between the environmental variables and the symbiotic fungi groups. The measured environmental variables, including the herbaceous cover, and the ectomycorrhizal fungi groups (Fig. 29) show a common variance of 50.2% and an independence probability of 10% of the first CC. If the herbaceous cover is not taken into account (Fig. 30) the common variance increases to 76.4% and the probability of independence decreases to 1.78%.

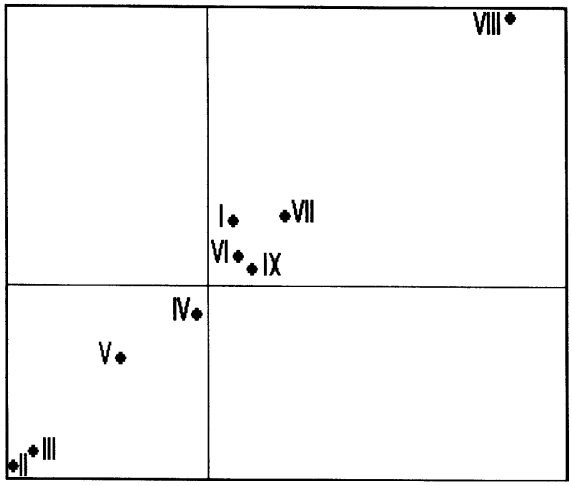
6.14 Correlation between the Landolt indicators and the symbiotic fungus groups. The correlation obtained by the canonical variates of the ordinations of the Landolt's indicators and ectomycorrhizal fungi groups is decidedly low. The common variance is 42% and the probability of independence of the first CC is 44%.

6.15 Correlation between the differential plant groups and the symbiotic fungi groups. The correlation obtained by the canonical variates of the ordinations of the differential plants and ectomycorrhizal fungi groups is decidedly low. The common variance is 39.5% and the probability of independence of the first CC is 43%.

6.16 Correlation between the symbiotic fungus groups and the ectomycorrhizal plants. The correlation between the ectomycorrhizal fungi and symbiotic plant groups is shown in Fig. 31. The common variance is 43.1%.

The third variates were used on this diagram. Greater specificity is displayed by types found in drier environments, such as type III (*Festucetum spadiceae austro-occidentale*) and where the snow cover remains longer, i.e. type VIII (*Salix herbacea* snow patch transitions).

The diagram reveals a distribution very similar to that offered by the correlation between the symbiotic fungal groups and the environmental variables when the herbaceous cover is not taken into account (see Fig. 30).



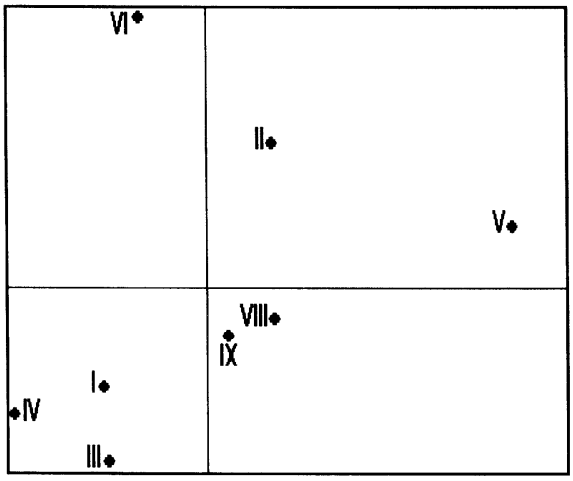
Can. var.	r^2	r	r%	cum. %
1	.99057	.99527	62.6	62.6
2	.58879	.76732	37.2	99.8
3	.00327	.05225	0.2	100.0

Variance common to the two sets = 52.7%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	25.00391	9	0.2966
2	4.01369	4	40.4184
3	0.01476	1	> 80

Figure 27. Correlation between the second canonical variates of AOC on the basis of the environmental variables and the herbaceous cover (Y axis) and on the basis of the fungal species groups (X axis).



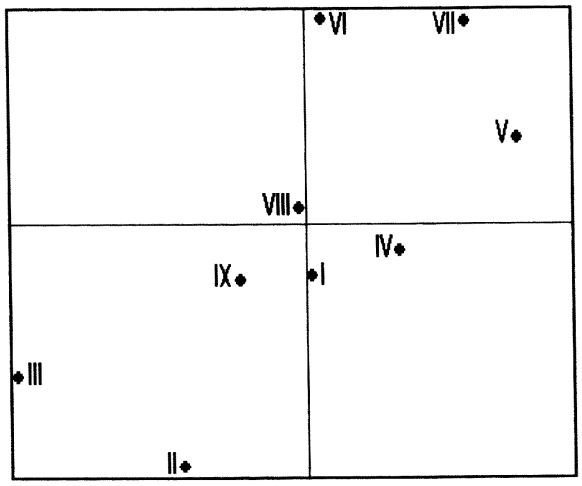
Can. var.	r^2	r	r%	cum. %
1	.95652	.97801	59.6	59.6
2	.56337	.75058	35.1	94.7
3	.08495	.29147	5.3	100.0

Variance common to the two sets = 53.49%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	14.18540	9	11.58863
2	3.21108	4	52.31740
3	.31075	1	57.70384

Figure 28. Correlation between the first canonical variates of AOC on the basis of the measured environmental variables and the herbaceous cover (X axis) and on the basis of the saprophyte groups (Y axis).



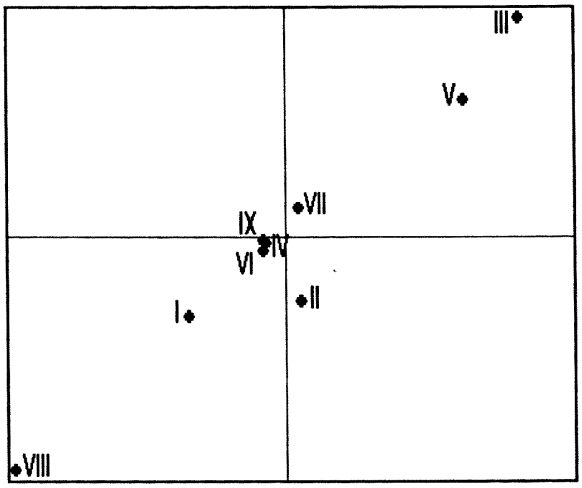
Can. var.	r^2	r	r%	cum. %
1	.91657	.95738	60.9	60.9
2	.48713	.69795	32.3	93.2
3	.10172	.31893	6.8	100.0

Variance common to the two sets = 50.18%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	14.66467	9	10.05723
2	3.48753	4	47.98088
3	.48272	1	48.69930

Figure 29. Correlation between the first canonical variates of AOC on the basis of the environmental variables and the herbaceous cover (X axis) and on the basis of the symbiotic fungi groups (Y axis).



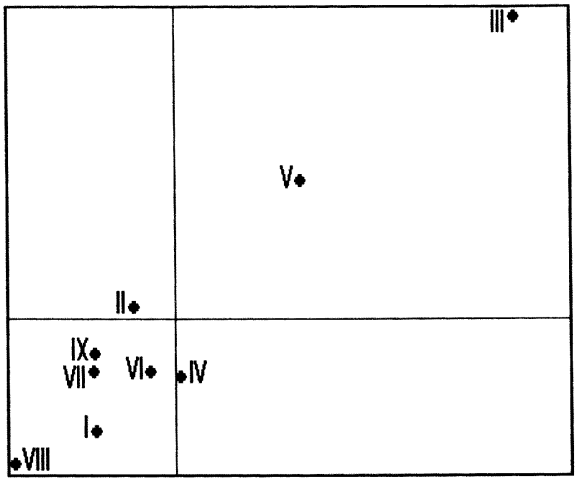
Can. var.	r^2	r	r%	cum. %
1	.97377	.98680	63.7	63.7
2	.55390	.74424	36.3	100.0

Variance common to the two sets = 76.38%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	20.01674	9	1.78096
2	3.63243	4	45.80599

Figure 30. Correlation between the first canonical variates of AOC on the basis of the environmental variables (X axis) and on the basis of the symbiotic fungus groups (Y axis).



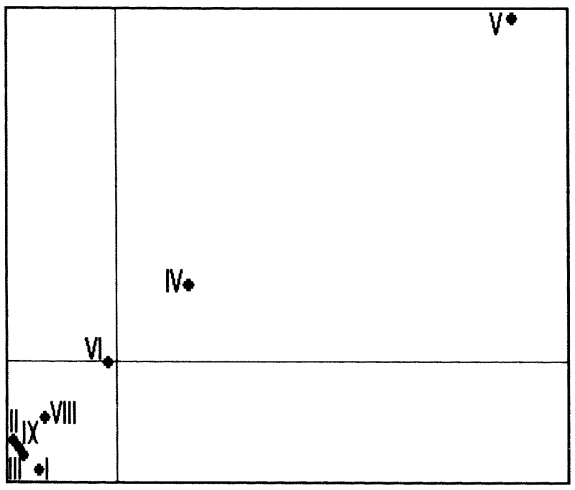
Can. var.	r^2	r	r%	cum. %
1	.91229	.95514	70.5	70.5
2	.35021	.59178	27.1	97.6
3	.03062	.17499	2.4	100.0

Variance common to the two sets = 43.1%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	13.03193	9	16.11721
2	2.07998	4	72.10891
3	.13995	1	70.82447

Figure 31. Correlation between the third canonical variates of AOC on the basis of the symbiotic fungus groups (X axis) and on the basis of the symbiotic plants (Y axis).



Can. var.	r^2	r	r%	cum. %
1	.99143	.99570	57.8	57.8
2	.50438	.71019	29.4	87.2
3	.21919	.46818	12.8	100.0

Variance common to the two sets = 57.16%

Bartlett's test for the independence of X and Y (Ho hypoth.):

Can. var.	χ^2	df	cum.%
1	19.98338	9	1.80160
2	3.32281	4	50.53561
3	.86600	1	35.18588

Figure 32. Correlation between the first canonical variates of AOC on the basis of the ectomycorrhizal fungi groups (X axis) and on the basis of the saprophyte fungi groups (Y axis).

6.17 Correlation between the saprophyte fungus groups and the ectomycorrhizal plants. The correlation between the saprophytic fungi and ectomycorrhizal plants is decidedly low. The common variance is 64.5% and the probability of independence of the first CC is 12.93%.

6.18 Correlation between the symbiotic fungus groups and the saprophyte fungus groups. The correlation between the ectomycorrhizal and saprophytic fungi is shown in Fig. 32. The common variance is 57.2% and the probability of independence of the first CC is 1.8%.

6.19. Summary of canonical correlation analyses. Table 20 gives a summary on CCA from what it appears that the vegetation types and the distribution of the ectomycorrhizal plants of the Alpine belt are better described by the environmental variables if the herbaceous cover is taken into account. Clearly this parameter summarizes other ecological factors not measured here, but partially shown by the Landolt's indicators. In fact the correlation between the last ones and the environmental variables is higher when the herbaceous cover is considered.

Table 20. Levels of the common variance (%) and the probability of independence values of correlate pair of canonical variates.

		Env.var. +her.c.	Envir. var.	Land. Indic.	Differ. plants	Symbio. plants	All fungi	Symb. fungi	Sapro. fungi
Env.	Comm.var.%		74.44	60.04	68.70	70.44	52.75	50.18	53.49
var.	Ho c.var.1		0.002	5.42	0.002	0.027	0.29	10.05	11.58
+	Ho c.var.2		0.18	10.04	6.83	5.41	40.41	47.98	52.31
h.cov.	Ho c.var.3		31.93	39.39	25.32	22.15	>80.00	48.69	57.70
	Comm.var.%	74.44		50.88	61.52	83.45	36.76	76.38	45.23
Env.	Ho c.var.1	0.002		10.23	2.69	0.08	56.99	1.78	17.19
var.	Ho c.var.2	0.18		38.30	7.65	0.71	67.17	45.80	78.01
	Ho c.var.3	31.93		>80.00	44.80	2.21	>80.00	>80.00	>80.00
	Comm.var.%	60.04	50.88		68.79	94.68	53.56	42.01	38.06
Land.	Ho c.var.1	5.42	10.23		0.37	0.71	44.52	44.19	72.54
Indic.	Ho c.var.2	10.04	38.30		9.00	7.39	>80.00	60.29	77.69
	Ho c.var.3	39.39	>80.00		16.60	>80.00	>80.00	37.46	55.98
	Comm.var.%	68.70	61.52	68.79		63.75	39.93	39.46	42.09
Dif.	Ho c.var.1	0.002	2.69	0.37		0.66	48.48	43.28	62.09
plants	Ho c.var.2	6.83	7.65	9.00		12.15	55.89	66.69	67.06
	Ho c.var.3	25.32	44.80	16.60		33.23	>80.00	>80.00	64.61
	Comm.var.%	70.44	83.45	94.68	63.75		46.36	43.10	64.53
Symb.	Ho c.var.1	0.027	0.08	0.71	0.66		29.61	16.11	12.93
plants	Ho c.var.2	5.41	0.71	7.39	12.15		71.71	72.10	>80.00
	Ho c.var.3	22.15	2.21	>80.00	33.23		64.16	70.82	>80.00
	Comm.var.%	52.75	36.76	53.56	39.93	46.36		73.64	90.41
All	Ho c.var.1	0.29	56.99	44.52	48.48	29.61		0.16	0.02
fungi	Ho c.var.2	40.41	67.17	>80.00	55.89	71.71		9.68	0.35
	Ho c.var.3	>80.00	>80.00	>80.00	>80.00	64.16		27.35	2.29
	Comm.var.%	50.18	76.38	42.01	39.46	43.10	73.64		57.16
Symb.	Ho c.var.1	10.05	1.78	44.19	43.28	16.11	0.16		1.80
fungi	Ho c.var.2	47.98	45.80	60.29	66.69	72.10	9.68		50.53
	Ho c.var.3	48.69	>80.00	37.46	>80.00	70.82	27.35		35.18
	Comm.var.%	53.49	45.23	38.06	42.09	64.53	90.41	57.16	
Sapro.	Ho c.var.1	11.58	17.19	72.54	62.09	12.93	0.02	1.80	
fungi	Ho c.var.2	52.31	78.01	77.69	67.06	>80.00	0.35	50.53	
	Ho c.var.3	57.70	>80.00	55.98	64.61	>80.00	2.29	35.18	

Also the fungus distribution is strongly correlated with the environmental variables when the herbaceous cover is taken into account, but only when they are considered all together, and it results very few correlated when saprophyte and symbionts are considered separately.

The symbiotic fungus groups are well correlated with the environmental variables only when the herbaceous cover is not taken into account. The saprophyte fungus groups are highly correlated only with the symbiotic fungi.

The significant interdependence between saprophytic and symbiotic fungi underscores the complementary nature of their specific contribution to the evolution of alpine grounds, though that of the ectomycorrhizal fungi seems greater in the colonisation of extreme environments where *Cenococcum geophilum* is almost constantly present in keeping with its leading role in the process of humification, as in the high-altitude *Salix herbacea* snow patches. Their decidedly acid grounds have a low nutrient content, but are rich in humus. Here the main hosts of ecto fungi are *Salix herbacea* and *Polygonum viviparum*, whereas *Helianthemum nummularium, H. oelandicum ssp. italicum, Salix breviserrata* and *S. reticulata* are very sporadic. CCA revealed a close correlation between these plants with both the soil reaction and the duration of the snow cover.

7. General classification and ordination

The general ordination of vegetation types, saprophyte and ecto fungi groups, symbiotic plants, Landolt's indicators and environmental variables is presented in Fig. 34. The MST and the results of classification presented in Fig. 33 are reported on the ordination scattergram. The two figures show the pattern of links between vegetation types, environmental variables and fungus groups. From these figures it comes out that same vegetation types are strictly related with environmental variables, such as II, III, IV, V, VIII and IX. Others are less related such as I, VI and VII.

By considering the sequence of vegetation types according to the MST and by following the variation of the environmental variables (or ecological factors) it appears that only the soil reaction (measured by Landolt's indicator) shows a monotonic gradient while the herbaceous cover shows a bell-shaped response (Fig. 35). This means that the environmental factors have a synergetic action on the vegetation variation. Table 21 gives a synthetic view of the variation pattern of the environmental variables in the transition between vegetation types along the MST pathways. It can also explain the variation between the different fungal groups.

Discussion

Vegetation analysis has often provided evidence of the effect of Man's presence in the valleys covered by this study. The Western Alps, in fact, were the scene of human settlements in prehistoric times and their passes have ever since formed part of trade and communication routes trodden in turn by semi-nomad hunters, Celts, Romans, Burgundians, Franks, Vandals, Goths and Lombards. The approach roads were gradually widened and consolidated. Morainic amphitheatres were occupied by settled populations, initially housed in palafitte villages, and then in powerful abbeys, seignories and communes. A thick web of mule tracks and paths soon reached out to every accessible piece of land, while extensive irrigation works enabled the areas thus occupied to be used to the best advantage. Human pressure in these valleys reached its peak in the 18th and 19th centuries. Since then, the population has shrunk and the less accessible or exhausted pasturelands have been abandoned. This depopulation has touched most of the uplands and even some valley floors, while in more recent times further disturbances to the equilibrium of the environment have been provoked by the installation of skiing facilities.

The types of vegetation identified by cluster analysis, however, are primarily determined by the soil reaction and its degree of evolution, as it is clear from the three broad blocks of relevés at the top of the dendrogram (see Fig. 3).

The first one embraces four types which are acidophilous or neutrophilous, the second comprises two types found on calcareous substrata, and the third three types with minimal heat requirements on calcareous or siliceous grounds in early stages of evolution.

The number of fungal species in the vegetation types is related to the number of relevés (Tab. 22) since the relevés have been done when and where fungal species were found.

The first of the four acidophilous types includes *Caricion curvulae* associations: *Caricetum curvulae* and *Festucetum halleri*. Few saprophytes are associated with it, such as *Bovista nigrescens* and *B. plumbea*, common in alpine grasslands. *Hygrocybe pseudoconica* was found with this type only, and *Naucoria scolecina*, which also appears in type IX, very probably as a result of the common conditions of greater humidity and humus. Ectomycorrhizal fungi are associated only with *Polygonum viviparum* and *Salix herbacea*. They include *Cortinarius albonigrellus* on siliceous soils in accordance to what was previously observed by Favre (1955). The distribution of *C. minutulus* also fits to Favre's observation concerning its presence on *Salix* retusa and *S. reticulata* as well as on *Salix herbacea*. In this study, in fact, it was found in type VI (*Salicetum retuso-reticulatae*) on calcareous soils, as well as on the acid soils of type I and IX. A similar diffusion was observed by Favre for *Hebeloma crustuliniforme*. However, in this study, it looks confined to type I and III. *Inocybe dulcamara* var. *malençoni* looks associated only with *Festucetum halleri*, whereas Favre found it both on calcareous soils (in association with *Dryas octopetala*), and on acid soils (in association with *Salix herbacea*). *Inocybe dulcamara* was found on acid and subacid soils (types I, IV, VIII, IX), and on calcareous soils (types VI & VII). Senn-Irlet (1988) found it in *Salicetum retuso-reticulatae* snow beds. *Inocybe leucoblema*, observed by Favre on *Dryas* carpets, is found here only in *Caricion curvulae*.

The other two species found in type I (*Laccaria laccata* and *Russula nana*) are the most common species, they are absent only in type V and VII. They can thus be regarded as hygro-acidophilous. *Russula nana* was observed in association with *Polygonum viviparum* (Fontana, 1977), that may be considered its preferential or sole host.

The ecological distribution of some ecto species, such as *Cenococcum geophilum*, may coincide with that of their hosts, whereas others are restricted to more clearly defined niches. The ecological range of *Russula nana* seems undoubtedly smaller than that of *Polygonum viviparum*. Like *Laccaria laccata* it requires acid or subacid soils, and fairly constant soil humidity. The presence of both *Russula nana* and *Laccaria laccata* in the calcareous soil of type VI (*Salicetum retuso-reticulatae*) vegetation was limited to heavily leached areas, as shown by the co-occurrence of *Luzula spicata* in releves 94 & 112. Other *Russula* and *Laccaria* species found in this study, too, were substantially hygro-acidophilous, whereas *Inocybe*, *Cortinarius* and *Hebeloma* species are less sensitive to the soil pH.

Type II, that represents *Poion alpinae*, was found at lower altitudes on subalpine plateaux where the snowcover enhances soil humidity and nutrient content. Some of the saprophytes identified in this v.t. were also collected from other types with a high herbaceous cover. *Calocybe georgii* and *Clitocybe gibba*, for example, were found in type III

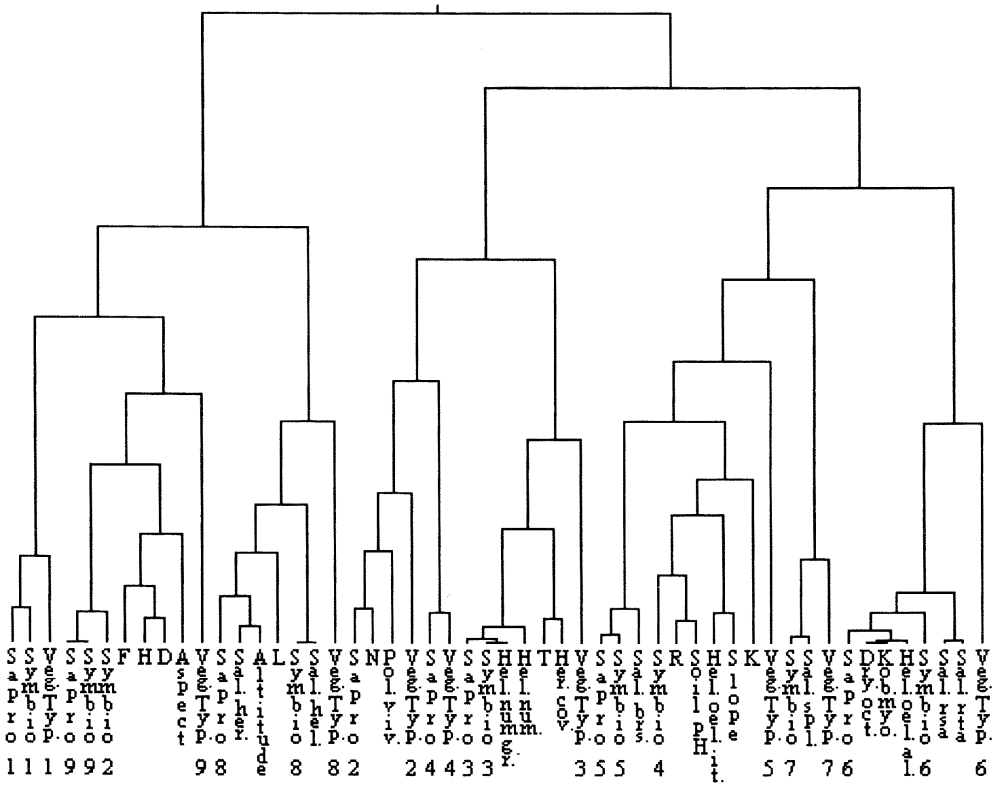


Figure 33. Cluster analysis of the vegetation types, saprophytic and ecto fungi groups, symbiotic plants, environmental variables and Landolt's indicators on the basis of their Euclidean distance.

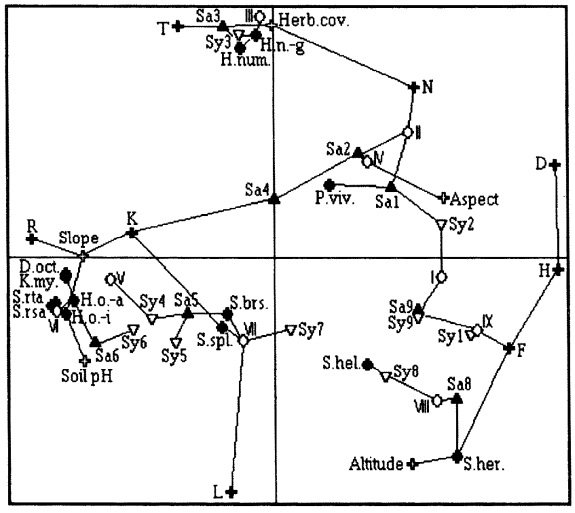


Figure 34. Ordination of the vegetation types, saprophyte and ecto fungi groups, symbiotic plants, environmental variables and Landolt's indicators on the basis of R-PCA scores.

Table 21. Summary of environmental variations along the MST.

			VI	⇒	V	⇒	III	⇒	IV	⇒	I	⇒	IX	⇒	VIII
L	i	F	–		–		+		–		+		–		
a	n	R	–		–		–		–		–		+		
n	d	N	–		+		+		–		+		–		
d	i	H	+		+		+		+		+		–		
o	c	D	+		+		+		–		+		–		
l	a	L	–		–		+		+		+		+		
t'	t.	T	+		+		–		–		–		–		
s		K	–		=		–		+		–		+		
E	v	Altitude	–		–		+		+		–		+		
n	a	Aspect	+		+		+		+		–		–		
v	r	Slope	+		–		+		–		–		–		
i	s	Soil pH	–		–		–		=		+		–		
r.		Herb.cov.	+		+		–		–		+		–		

⇓

			VII	⇐	II	⇐	IV
L	i	F			–		+
a	n	R			+		+
n	d	N			–		+
d	i	H			–		–
o	c	D			–		+
l	a	L			+		–
t'	t.	T			–		+
s		K			+		–
E	v	Altitude			+		–
n	a	Aspect			–		–
v	r	Slope			+		–
i	s	Soil pH			+		+
r.		Herb.cov.			–		+

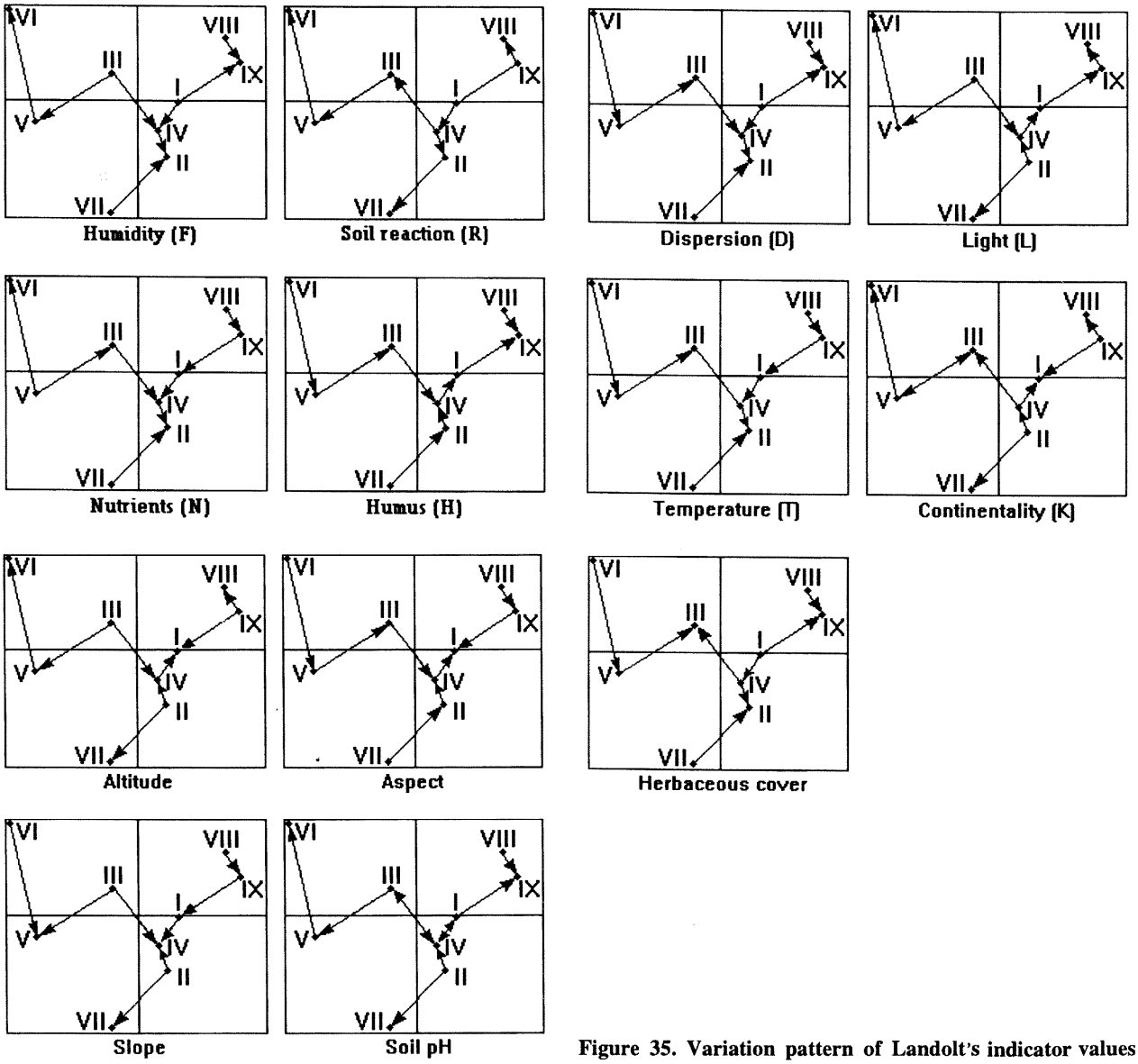


Figure 35. Variation pattern of Landolt's indicator values and environmental variables in the transition between the vegetation types.

(substantially *Festucetum spadiceae austro-occidentale*), and *Clitocybe gibba* was equally present on the calcareous type V (*Seslerio-Caricetum sempervirentis*).

In the acidophilous grasslands of the drier valleys (type III and IV), *Ranunculo-Alopecuretum gerardii* is predominant at lower altitudes. Over-grazed pastures of these types show high presence of *Nardus stricta*, while other abandoned pastures represent a transition to *Festucetum spadiceae austro-occidentale.* In these types there is the widest variety of saprophyte and symbiotic species observed on the acidophilous grasslands. *Cenococcum geophilum* is not always present. It is particularly associated with *Polygonum viviparum*, all the dwarf willows, *Dryas octopetala* and *Kobresia myosuroides*. Eleven saprophytes were found only in type III: *Collybia dryophila, Entoloma juncinum, Hygrocybe coccinea, H. punicea, H. subradiata, Lepista luscina, Marasmius scorodonius, Panaeolus retirugis, Lycoperdon pyriforme, Scutellinia scutellata* and *Vascellum pratense*. *Panaeolus rickenii* was found in type III and in the more neutrophilous type IV, while *Clitocybe alexandrii, C. rivulosa* and *Panaeolus fimicola* were all also present in type VI (*Salicetum retuso-reticulatae* and its transitions). Of the ecto species, those of the *Cortinarius* genus were particularly well represented in types with abundance of *Helianthemum*, especially *H. nummularium*, as in type III (*Festucetum spadiceae austro-occidentale*). *Cortinarius anomalus, C. bicolor, C. fasciatus, C. hinnuleus* and *C. subferrugineus*, in fact, were found solely in type III, whereas *Cortinarius phaeochrous* was also present in type VI. The ectomycorrhizal plant species are numerous, though mostly

Table 22. Number of fungi species and symbiotic plants in the nine vegetation types.

	Syntaxa	Relevés	Fungus species: Saprio	Fungus species: Symbio	Fungus species: Total	Ecto plant species
I	*Caricetum curvulae & Festucetum halleri*	10	4	8	12	2
II	*Poion alpinae*	6	6	2	8	2
III	*Festucetum spadiceae austro-occidentale*	17	18	12	30	9
IV	transitions to *Nardetum alpigenum*	21	14	6	20	4
V	*Seslerio-Caricetum sempervirentis*	4	3	4	7	6
VI	*Salicetum retuso-reticulatae*	21	21	17	38	10
VII	transition of *Thlaspietea* to *Salicetea*	4	0	4	4	3
VIII	transitions of *Salicetum herbaceae*	15	3	6	9	5
IX	*Salicetum herbaceae & Scheuchzerio-Caricetea fuscae*	18	13	16	29	6

sporadic. Only *Helianthemum nummularium* and *Polygonum viviparum* are well represented. The calciphilous species appear only in the last two relevés.

The type IV vegetation encountered at higher altitudes consisted of acidophilous *Ranunculo-Alopecuretum gerardii* and neutrophilous *Festuco (violaceae)-Trifolietum thalii* transitions to *Nardetum alpigenum* on slopes often subjected to over-grazing, followed by the establishment of *Nardus stricta*. Eight saprophyte species are found in this type only: *Calvatia utriformis, Galerina vittaeformis, Hygrocybe persistens, Lepista saeva, Melanoleuca subalpina, Mycena erubescens, Naucoria alnetorum* and *Panaeolus foenisecii. Bovista plumbea, Clitocybe rivulosa, Panaeolus fimicola* and *P. rickenii* are shared with the acidophilous pastures of type III, while *Hygrocybe reai* var. *insipida* and *Tubaria pellucida* also appear in calciphilous type VI (*Salicetum retuso-reticulatae* transitions). No ectomycorrhizal plant was present in the relevé containing *Melanoleuca subalpina*. This suggests that the *Melanoleuca* genus does not include ecto species contrary to the views of Miller (1982). *Inocybe lacera* var. *heterospora* was the only ectomycorrhizal species found solely on the slope pastures of type IV. The other symbionts (also observed in other types of are well distributed on acid or subacid soils, and *Hebeloma alpinum*, also present in type VI. The most frequent host is *Polygonum viviparum*, followed by *Salix herbacea. S. retusa* and *Helianthemum nummularium* are sporadic.

In type V, found clearly isolated woth type VI by the cluster analysis (see Fig. 3) as a consequence of its calcareous soils, *Sesleria varia* is abundant and species of *Seslerion variae* and *Arrhenatheretea* are fairly common (*Taraxacum erythrospermum, Alchemilla xanthochlora, Poa alpina, Achillea millefolium* and *Leontodon hispidus*). The saprophyte species found only in type V are *Entoloma griseocyaneum* and *Collybia butyracea*. Favre (1955) observed this last species only on calcareous soils. The other species found in type V (*Clitocybe gibba*) is also present in the acidophilous plant communities corresponding to types II and III. The two ectomycorrhizal species observed solely in type V were *Cortinarius hoeftii* (associated with *H. oelandicum* ssp. *italicum*) and *Inocybe friesii* f. *epixantha* (associated with *P. viviparum*). While *Cortinarius glandicolor* f. *exilis*, here associated with *Polygonum viviparum*, in type VII is associated with *S. serpyllifolia. Inocybe fastigiata* var. *alpina*, generally associated with dwarf willows, as reported by Favre (1955), is associated here with *Polygonum viviparum* (Rel. 101), whereas in type IV it was found in absence of a potential symbiont.

Type VI is mainly distributed in the Inner Alps sector beyond the boundary of Mediterranean influence. This type is one of the richest in saprophytes and in symbiotic species even more so. Notwhistanding it comprises some *S. retuso-reticulatae* transitions; its saprophyte and symbiotic fungus distribution is fairly uniform. *Hebeloma* species are found in relevés where *Dryas octopetala* is associated with species of *Thlaspietea rotundifolii* (e.g. Rochemolles Valley). Twelve saprophytes appear only in this type of vegetation: *Camarophyllus pratensis, Bovista tomentosa, Entoloma incanum, E. papillatum, E. sericeum, E. sericeum f. nanum, Hygrocybe conica, H. cystidiata, H. lepida, Melanoleuca melaleuca, Marasmius epidryas* and *Panaeolus guttulatus*. Other six species are shared with the acidophilous grassland communities (*Bovista nigrescens, Clitocybe alexandrii, C. rivulosa, Panaeolus fimicola, Hygrocybe reai* var. *insipida* and *Tubaria pellucida*), and three with types VIII and IX (*Omphalina umbratilis, Naucoria tantilla* and *N. subconspersa*). The symbiotic fungi confined to type VI are: *Cortinarius favrei, C. decipiens, C. orellanus, Hebeloma versipelle, H. sarcophyllum, Inocybe fastigiata* f. *alpestris* and *I. humilis*. Apart from *Cenococcum geophilum*, further four species are shared with other types: *Inocybe dulcamara, I. friesii, Cortinarius glandicolor* f. *exilis* and *Hebeloma mesophaeum*. Their hosts are also fairly evenly distributed. The most frequent are *Polygonum viviparum* (more abundant at higher altitudes), *Dryas octopetala, Salix reticulata* and *S. retusa*, whereas *Helianthemum oelandicum* ssp. *italicum* and *Kobresia myosuroides* are less common, and *H. nummularium, S. breviserrata,* S. *herbacea* and *S. serpyllifolia* are sporadic. The general co-occurrence of several hosts, however, makes it impossible to point to specific symbioses, apart from the association of *Inocybe humilis* with *Helianthemum oelandicum* ssp. *italicum* in the last relevé.

Type VII (*Thlaspietea* to *Salicetea* transitions) is accompanied by ectomycorrhizal fungi: *Inocybe dulcamara* and *I. friesii* (shared with the acidophilous plants communities), *Cortinarius glandicolor* f. *exilis* (shared with calciphilous type VI), and *Hebeloma mesophaeum* (also observed in type IX in an abnormal relevé with a wide contingent of *Elyno-Seslerietea*). *Salix serpyllifolia* is the constant and abundant host in association with both *Cortinarius glandicolor* f. *exilis* and *Inocybe dulcamara*. The first two releves also include many S. *herbacea* and *Polygonum viviparum.*

Type VIII embraces high-altitude *Salix herbacea* snow patch transitions to *Luzuletum alpino-pilosae* and to *Cur-*

vuletum. It has the highest mean altitude and the smallest herbaceous cover.

There are few saprophytes: *Naucoria tantilla* and *Omphalina umbratilis* (shared with type VI), *Scutellinia trechispora* (shared with type IX). The ectomycorrhizal fungi include *Inocybe lacera* var. *heterocystis* and *Russula oreina* (not found in the other types), *Hebeloma marginatulum* (shared with type IX), and *Inocybe dulcamara*, *Russula nana* and *Laccaria laccata* (shared with several v.t.). *Cenococcum geophilum* is always present. *Salix herbacea* is the typically abundant host, whereas *Polygonum viviparum*, *Salix breviserrata*, *S. helvetica* and *S. retusa* are sporadic and their limited co-occurrence permits identification of associations between S. *herbacea* and *Hebeloma marginatulum*, *Inocybe lacera* var. *heterocystis*, *Laccaria laccata* and *Russula oreina*, which is also associated with *Salix helvetica*.

Type IX comprises *Salix herbacea* snow patches, fens and spring-swamp communities and shows a broad spectrum of both saprophyte and symbiotic fungi. The exclusive saprophyte contingent here observed consists of *Agaricus semotus*, *Camarophyllus pratensis*, *Scutellinia hirtella*, *Galerina hypnorum* and *Hemimycena cucullata*, an *Exidia* species and a *Mycena* species (both unidentified). *Bovista nigrescens*, *Naucoria scolecina*, *N. subconspersa*, *Omphalina umbratilis*, *Gerronema reclinis* and *Scutellinia trechispora* are shared with other types. Four ectomycorrhizal species (*Cortinarius glandicolor*, *C. inconspicuus*, *C. hinnuleus* var. *minutalis* and *Inocybe canescens*) are found only in type IX. Eleven (*Cortinarius albonigrellus*, *C. minutulus*, *C. helvelloides*, *Hebeloma mesophaeum*, *H. marginatulum*, *Inocybe dulcamara*, *I. decipiens*, *I. lanuginella*, *I. pyricistis*, *Laccaria laccata* and *Russula nana*) are shared with other types. It confirmed the statement of Senn-Irlet (1988) that "fungi with a wide ecological range and a large distribution dominate in *Salicetum herbaceae* while fungi with specified ecological demands dominate in *Salicetum retuso-reticulatae*." The main hosts are *Salix herbacea* and *Polygonum viviparum*, whereas *Helianthemum nummularium*, *H. oelandicum* ssp. *italicum*, *Salix breviserrata* and *S. reticulata* are very sporadic. *Alnus viridis* was also present in one relevé. It was not observed in any other type of vegetation. Many ectomycorrhizal plants found in this investigation are circumboreal Arcto-Alpine, such as *Dryas octopetala*, *Kobresia myosuroides*, *Polygonum viviparum*, *Salix breviserrata*, S. *herbacea* and *S. reticulata*. Others, e.g. *Helianthemum oelandicum* ssp. *italicum* and H. *oelandicum* ssp. *alpinum*, *Salix serpyllifolia* and *S. retusa*, are European orophytes. Endemic Alpine or Europeo-Caucasian species such as *S. helvetica* and *Helianthemum nummularium* are exceptional.

Conclusions

This work is not based on a traditional sampling design. Vegetational relevés and some environmental variables have been recorded where fungal species were encountered during five years of excursions in the Western Alps. In this approach the vegetational relevé plays the sole role of environmental indicators by assuming that similar species compositions are reflecting similar environmental situations (see Westhoff and van der Maarel, 1978). Fungal species are grouped into clusters on the basis of their presence in vegetation types obtained by numerical methods. The comparison of the list of fungi found in different vegetation types shows that the similarity between them is very low. This suggests that the correspondence between mycocoenoses and vegetation types is very high. However, the correlations between the environmental variables and the other biotic variables in Table 21 decrease if the herbaceous cover is not taken into consideration. This suggests that the herbaceous cover is taking into account for a complex of environmental factors that complement those measured here. These factors, such as the composition of the soil microbial flora and its involvement in the processes of humification and mineralization, play a role of major importance in the distribution of fungal species. Furthermore the significant interdependence between saprophyte and symbiotic fungi proves that the two fungal components behave in a correlated way in the environment under study. However the correlation with environment is higher for saprophyte than for symbiotic species only if the herbaceous cover is taken into account. This proves that the saprophyte component of fungal communities is less sensitive to the chemical-physical environment than the symbiont component wich is more related to living plants.

The importance of fungi in humification and plant nutrition has long been known, though it is only in recent years that ecological studies (Skirgiello, 1961; Winterhoff, 1978 a, b) have laid stress on the importance of preserving the fungal taxa and their habitat for the protection of nature itself. Some ecologists hold the view that the protection of particular plant communities automatically ensures the conservation of their fungi. The analyses conducted in this study, however, suggest that the latter are in some respects dependent on other ecological factors and require particular measures for the protection and preservation of their habitats. Arnols (1976, 1980) emphasizes that "Areas which are very interesting for fungi are not necessarily interesting for phanerogams and vice versa".

Knowledge of their geographical distribution, spatial frequency and fundamental ecological requirements is indispensable in ensuring their protection, since measures appropriate for the management and conservation of their habitats must necessarily be based on ecological knowledge.

Furthermore, since the drastic changes now taking place in the environment may considerably alter the future composition of mycocoenoses, there is an urgent need to acquire a detailed understanding of the qualitative and quantitative mycofloral complements of all the main biocoenoses. Decomposition processes and mycorrhizal relationships are of vital importance for the ecosystems and marked variations could jeopardise their correct functioning.

In addition to its particular suitability as an illustration of the fundamental ecological requirements of fungi so as to aid in their conservation in natural environments, the especially disadvantaged ecosystem represented by the alpine

grasslands can offer useful points of reference for the identification of symbiotic and saprophytic fungi that could be used in re-establishment of the ecological equilibrium in areas degraded by both natural and anthropic phenomena.

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References

Ammirati J. F. & G. A. Laursen. 1982. *Cortinarii* in Alaskan Arctic Tundra. Arctic and Alpine Mycology. Proc. First Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A. & J. F. Ammirati (eds). Washington Univ. Press, pp. 282-315.

Anderberg, M. R. 1973. Cluster analysis for applications. Academic Press, N. Y., pp. 359.

Antibus, R. K. 1980. Mechanisms of acclimation to lowered growth temperature in isolates of arctic and temperate ectomycorrhizal fungi. Ph. D. dissertation. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Antibus, R. K., J. G. Croxdale, O. K. Miller & A. E. Linkins. 1981. Ectomycorrhizal fungi of *Salix rotundifolia* III. Resynthesized mycorrhizal complexes and their surface phosphatase activities Can. J. Bot. 59: 2458-2465.

Antibus, R. K. & A. E. Linkins 1981. Ectomycorrhizal fungi of *Salix rotundifolia* Trautv. I. Impact of surface applied Prudhoe Bay crude oil on mycorrhizal structure and composition. Arctic 31: 366-380.

Arnolds, E. 1974. Taxonomie en Floristiek van *Hygrophorus* subgenera *Hygrotrama*, *Cuphophyllus* en *Hygrocybe* in Neederland. Rijksherbarium, Leiden, pp. 236.

Arnolds, E. 1981. Ecology and coenology of macrofungi in grasslans and moist heathlands in Drente, the Netherlands. Part 1. Introduction and Synecology. Bibl. mycol. 83. J. Cramer, Vaduz, pp. 407.

Arnolds, E. 1982. Ecology and coenology of macrofungi in grasslands and moist heathlands in Drente, the Netherlands. Vol. 2. Part 2. Autecology. Part 3. Taxonomy. Bibl. mycol. 90. J. Cramer, Vaduz, pp. 501, Pl. 1-8.

Arnolds, E. 1985. Notes on *Hygrophorus* - IV. New species and new combinations in *Hygrophoraceae*. Persoonia 12(4): 475-478.

Arnolds, E. 1986a. Notes on *Hygrophoraceae* - VI. Observations on some new taxa in Hygrocybe. Persoonia 13(1): 57-68.

Arnolds, E. 1986b. Notes on *Hygrophoraceae* - VII. On taxonomy and nomenclature of some species of *Hygrophorus*. Persoonia 13(1): 69-76.

Arnolds, E. 1986c. Notes on *Hygrophoraceae* - VIII. Taxonomic and nomenclatural notes of some taxa of Hygrocybe. Persoonia 13(2): 137-160.

Banyikwa, F. F. 1989. Species-habitat relationships in the Serengeti short grasslands, Tanzania. Coenoses 4(3): 149-152.

Boekhout, T. 1988. *Notulae ad floram agaricinam neerlandicam* - XVI. New taxa, new combinations in *Melanoleuca* Pat. and notes on rare species in the Netherlands. Persoonia 13(4): 397-431.

Bon, M. 1970. Flore héliophile de la zone maritime picarde. Bull. trim. Soc. mycol. Fr. 861: 79-213.

Bon, M. 1974. Tricholomes de France et d'Europe Occidentale (Tome I: Généralités.) Docum. mycol. 312: 1-53.

Bon, M. 1974. Tricholomes de France et d'Europe occidentale (Tome II: Partie descriptive.) Docum. mycol. 414: 55-110.

Bon, M. 1975. Tricholomes de France (3ème tome: sections *Atrosquamosa* et *Equestria*. Docum. mycol. 518: 111-164.

Bon, M. 1976a. Tricholomes de France et d'Europe occidentale (4ème Partie). Docum. mycol. 6(22-23): 165-304.

Bon, M. 1976b. Clé monographique des *Hygrophoraceae* Roze. Docum. mycol. 7(25): 1-24.

Bon, M. 1977. Clé analitique des *Hygrophoraceae* (suite). Le genre *Hygrophorus* Fr. Docum. mycol. 7(27-28): 25-53.

Bon, M. 1978. *Tricholomataceae* de France et d'Europe occidentale (Sousfamille *Leucopaxilloideae* (Singer). Bon). Docum. mycol. 9(33): 1-79.

Boudier, E. 1895. Description de quelques nouvelles espèces de champignons récoltées dans les regions élevées des Alpes du Valais, en août 1894. Bull. Soc. mycol. Fr. 11: 27-30.

Boudier, E. 1907. Discomycetes d'Europe. Klincksieck, Paris, pp. 223.

Bresadola, G. 1929-1933. *Iconographia mycologica*. 1-26. Milano.

Braun-Blanquet, J. 1961. Die Inneralpine Trockenvegetation. G. Fischer, Stuttgart.

Brinkmann, W. 1897. Vorarbeiten zu einer Pilzflora Westfalens. Jahresb. Westf. Prov. Ver. 25: 195-207.

Bruchet, G. 1970. Contribution à l'étude du genre *Hebeloma* (Fr.) Kumm.; partie spéciale. Bull. mens. Soc. Linn. Lyon 39, suppl. 6: 1-132.

Bruchet, G. 1973. Contribution a l'étude du genre *Hebeloma* (Fr.) Kumm.; essai taxonomique et écologique. These de doctorat d'-Etat. Univ. Lyon.

Bruchet, G. 1974. Recherches sur l'écologie des *Hebeloma* artico-alpins; étude spéciale de l'aptitude ectomycorhizogene des espèces. Travaux mycologiques dediès a R. Kühner, n°. special du Bull. Soc. Linn. Lyon. pp. 85-96.

Cappelli, A. 1984. Agaricus L.: Fr. (Psalliota Fr.). Biella, Saronno (Va), Italy, pp. 558.

Casorati, M. 1981. I funghi dei pascoli. Simbiosi micorriziche in *Dryas octopetala* L. Tesi di Laurea. Univ. Torino, Italy.

Colombo, E. 1982. I funghi dei pascoli. Simbiosi micorriziche in *Salix herbacea* L., *S. reticulata* L., *S. retusa* L. Tesi di Laurea. Univ. Torino, Italy.

Cooke, W. B. 1948. A survey of literature on fungus sociology and ecology. Ecology 29: 376-382.

Cooke, W. B. 1953. A survey of literature on fungus sociology and ecology II. Ecology 34: 211-222.

Dale, M. B. & L. J. Webb. 1975. Numerical methods for the establishment of associations. Vegetatio 30(2): 77-87.

Darimont, F. 1973. Recherches mycologiques dans les forêts de Haute Belgique. Mem. Inst. Roy. Sc. nat. Belg. N 170. pp. 220, Pls. XXXIV, Tabs. 68.

Debaud, J. C. 1975. Influence de la temperature sur la croissance des myceliums de Clitocybes alpins (*Basidiomycetes-Agaricales*). Trav. Scient. Parc Nationale Vanoise 6: 167-174.

Debaud, J. C. 1980. Ecophysiologie des champignons alpins associés a *Dryas octopetala* (Rosacées.) Bull. Soc. Ecophysiol. 5: 139-144.

Debaud, J. C. 1984. Ecophysiological studies on alpine macromycetes: saprophytic *Clitocybe* and mycorrhizal *Hebeloma* associated with *Dryas octopetala*. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 47-60.

Debaud, J. C., R. Pepin & G. Bruchet. 1981a. Étude des ectomycorhizes de *Dryas octopetala*. Obtention de synthèses mycorhiziennes et de carpophores d'*Hebeloma alpinum* et *H. marginatulum*. Can. J. Bot. 59: 1014-1020.

Debaud, J. C., R. Pepin & G. Bruchet. 1981b. Ultrastructure des ectomycorhizes synthetiques à *Hebeloma alpinum* et *Hebeloma marginatulum* de *Dryas octopetala*. Can. J. Bot. 59: 2160-2166.

Dennis, R. W. G. 1953. Les *Agaricales* de l'Ile de la Trinite: *Rhodosporae-Ochrosporae*. Bull. Soc. mycol. Fr. 69: 145-198.

Dennis, R. W. G. 1978. British Ascomycetes. Cramer, Vaduz, pp. 585, Pls. 44.

Dissing, G. 1982. Operculate Discomycetes From Greenland. Arctic and Alpine Mycology. Proc. First Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A. & J. F. Ammirati (eds). Washington Univ. Press., pp. 56-81.

Eynard, M. 1977. Contribution a l'étude ecologique des *Agaricales* des groupements a *Salix herbacea*. These. Univ. Claude-Bernard, Lyon.

Favre, J. 1948. Les associations fongiques des hauts-marais jurassiens et de quelque régions voisines. Materiaux Fl. crypt. Suisse 10(3), pp. 228, Pls. 6.

Favre, J. 1955. Les champignons supérieurs de la zone alpine du Parck National Suisse. Ergebn. wiss. Unters. Schweiz. Nat. Park, Liestal. 5 (N. F.). 33: 1-212.

Favre, J. 1960. Catalogue descriptif des champignons supérieurs de la zone sub-alpine du Parck National Suisse. Ergebn. wiss. Unters. Schweiz. Nat. Park, Liestal. 6 (N. F.). 42: 321-610.

Fellner, R. & J. Biber. 1988. *Helianthemum* and some *Agaricales*: unusual case of ectomycorrhizal symbiosis. Abstracts of 2nd European Symposium on Mycorrhizae. Prague, pp. 33-34.

Feoli, E. 1976. Correlation between single ecological variables and vegetation by means of cluster analysis. Not. Fitosoc. Ital. 12:77-82.

Feoli, E. 1977a. A criterion for monothetic classification of phytosociological entities on the basis of the species ordination. Vegetatio 33(2-3): 147-152.

Feoli, E. 1977b. On the resolving power of principal component analysis in plant community ordination. Vegetatio 33(2-3): 119-125.

Feoli, E. 1979. La classificazione automatica nell'analisi degli ecosistemi. Analisi e gestione dei sistemi ambientali. Gragsa, Milano, pp. 205-210.

Feoli, E. 1983. Predictive use of ordination and classification methods in plant community ecology. A summary with examples. Le comunità vegetali come indicatori ambientali. C. Ferrari, S. Gentile, S. Pignatti, E. Poli Marchese (eds). Regione Emilia Romagna, Studi e Documentazioni 30: 83-108.

Feoli, E. 1984. Some aspects of classification and ordination of vegetation data in perspective. Studia Geobotanica 4: 7-21.

Feoli, E., F. Biondani & M. Lagonegro. 1981. Individuazione di cenoclini nell'analisi indiretta di gradienti. Atti del Primo Con. Naz. della Soc. It. di Ecol. Salsomaggiore.

Feoli, E. & L. Feoli Chiappella. 1979. Ranking relevés based on a sum of squares criterion. Vegetatio 39: 123-125.

Feoli, E. & M. Lagonegro. 1979. Intersection analysis in phytosociology: computer program and application. Vegetatio 40: 55-59.

Feoli, E. & D. Lausi. 1980. Hierarchical levels in Syntaxonomy based on information functions. Vegetatio 42: 113-115.

Feoli, E. & D. Lausi. 1981. The logical basis of syntaxonomy in vegetation science. Syntaxonomie. H. Dierschke. pp. 35-42.

Feoli, E., M. Lagonegro & A. Zampar. 1982. Classificazione e ordinamento della vegetazione. C. N. R. AQ/5/35, Roma, Italia, pp. 199.

Feoli, E., M. Lagonegro & L. Orlóci. 1984 Information analysis in Vegetation research. Tasks for Vegetation Science 10. Junk, The Hague, Boston, pp. 143.

Feoli, E. & L. Orlóci. 1979. Analysis of concentration and detection of underlying factors in structured tables. Vegetatio 40: 49-54.

Feoli, E., L. Orlóci & M. Scimone. 1984. Comparison of ordinations of some Appennine forest communities based on different characters and methods. Studia Geobotanica 4: 137-145.

Feoli, E. & M. Speranza. 1974. Confronto tra gli spettri biologici di alcuni Seslerieti alpini e prealpini. Not. Fitosoc. Ital. 8: 1-13.

Ferdinandsen, C. & O. Winge. 1925. *Cenococcum* Fr. A monographic study. Arsskr. K. Vet. -Landbohojsk. pp. 332-382.

Fontana, A. 1963a. Simbiosi micorrizica di *Hebeloma hiemale* Bres. con un salice e con un pioppo. Allionia 9: 113-118.

Fontana, A. 1963b. Micorrize ectotrofiche in una ciperacea: *Kobresia bellardi* Degl. Gior. Bot. Ital. 70: 639-641.

Fontana, A. 1977. Ectomycorrhizae in *Polygonum viviparum* L. Abstracts of Third N.A.CO.M. Athens, Georgia, U.S.A., p. 53.

Gillman, L. S. & O. K. Miller 1977. A study of the boreal, alpine and arctic species of *Melanoleuca*. Mycologia 69: 927-951.

Gittins, R. 1979. Ecological applications of canonical analysis. Multivariate methods in ecological work. L. Orlóci, W. M. Rao & W. M. Stiteler (eds). Int. Coop. Publishing House, Burtonsville, Maryland.

Goodall, D. W. 1966. Classification, prediction and utility. Nature 221: 53-54.

Guinochet, M. 1938. Études sur la végétation de l'étage alpin dans le bassin supérieur de la Tinée (Alpes-Maritimes). pp. 460, Bosc Frères M. & L. Riou, Lyon.

Gulden, G. & M. Lange. 1971. Studies in the Macromycete Flora of Jotunheimen, the Central Mountain Massif of South Norway. Norw. J. Bot. 181: 1-46.

Gulden, G. 1980. Alpine Galerinas (*Basidiomycetes, Agaricales*) with special reference to their occurrence in South Norway at Finse on Hardangervidda. Norw. J. Bot. 27: 219-253.

Gulden, G. 1984. The genus *Galerina* on Svalbard. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 177-204.

Gulden, G. 1988. Studies in the Agarics of Svalbard. 1. New species and combinations (*Tricholomataceae*). Sydowia 40: 51-59.

Hacskaylo, E. & G. Bruchet. 1972. *Hebeloma*s as mycorrhizal fungi. Bull. Torrey Bot. Club 99: 17-20.

Haller, R. 1955. Contribution à l'étude du genre *Hygrocybe*. Schweiz. Z. Pilzk. 33: 169-172.

Haselwandter, K. & D. J. Read. 1980. Fungal association of roots of dominant and sub-dominant plants in high-alpine vegetation systems with special reference to mycorrhiza. Oecologia 45: 57-62.

Harmaja, H. 1969. The genus *Clitocybe* (*Agaricales*) in Fennoscandia. Karstenia 10: 5-168.

Heim, R. 1922. Notes sur les zones de végétation fongique dans les Alpes. Bull. Soc. Bot. Fr. 69: 464-469.

Heim, R. 1928. Les Champignons des Alpes. Mem. de la Soc. de Biogeogr., II. Contrib. a l'étud e du peuplement des hautes montagnes. Lechevalier, Paris. pp. 230-251.

Henning, E. 1888. Vaxtfysiognomiska antechningar fran vestra Härjedalen, med särskild hansyn till Hymenomycetenas förekomst inom olika växtformationer. Bih. K. Svenska Vetensk. -Akad. Handl. 13: 1-26.

Hesselman, H. 1900. Om mykorrhizabildningar hos arktiska växter. Bih. K. Svenska Vetensk.-Akad. Handl. 26: 1-46.

Hofler, K. 1937. Pilzsoziologie. Ber. Deutsch. Bot. Ges. 55: 606-622.

Horak, E. 1963. Pilzökologische Untersuchungen in der subalpinen Stufe (*Piceetum subalpinum* u. *Rhodoreto-Vaccinietum*) der Ratischen Alpen (Dischmatal, Graubunden). Mitt. Schweiz. Anst. f. d. Forstl. Versuchsw. 391: 1-111.

Horak, E. 1984. *Astrosporina* in the alpine zone of Swiss National Park (SNP) and adjacent regions. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A.

& J. F. Ammirati, S. A. Redhead (eds). Plenum Press, N. Y., pp. 205-234.

Horak, E. 1987. Revision der von J. Favre 1955) aus der Region des Schweizer Nationalparks beschriebenen alpinen Arten von *Cortinarius* subgen. *Telamonia* (*Agaricales*). Candollea 42: 771-803.

Irlet, B. I. 1984. Ein Beitrag zur Discomycetenflora der alpine Stufe der Schweizer Alpen. Mycol. Helvetica 1(3): 129-143.

Jensen, H. A. 1974. *Cenococcum geophilum* Fr. in arable soil in Denmark. Friesia 10(4-5): 300-314.

Julich, W. 1984. Die Nichtblätterpilze, Gallertpilze und Bauchpilze: (*Aphyllophorales, Heterobasidiomycetes, Gasteromycetes*). G. Fischer, Stuttgart, N. Y. pp. 626.

Katenin, A. E. 1964. Mycorrhiza of arctic plants. Probl. Sev. (Moscow) 8: 148-154.

Klercka, W. R. 1975. Discriminant analysis. SPSS: Statistical Package for the Social Sciences. N. Nie *et al.* (eds). McGraw-Hill, N. Y., pp. 434-467.

Klercka, W. R. 1984. Discriminant analysis. Qualitative Applications in the Social Sciences, Sage Publications, Beverly Hills, California, pp. 71.

Knudsen, H. & T. Borgen. 1982. *Russulaceae* in Greenland. Arctic and Alpine Mycology. Proc. First Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A. & J. F. Ammirati (eds). Washington Univ. Press., pp. 216-244.

Knudsen, H. & T. Borgen. 1984. *Agaricaceae, Amanitaceae, Boletaceae, Gomphidiaceae, Paxillaceae* and *Pluteaceae* in Greenland. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 235-253.

Kobayasi, Y., N. Hiratsuka, Y. Otani, K. Tubaki, S. Udagawa, J. Sugiyama & K. Konno 1971. Mycological studies of the Angmagssalik region of Greenland. Bull. Natl. Sci. Mus. (Tokyo), 14: 1-96.

Korner, Ch. 1982. Carbon dioxide exchange in the alpine sedge *Carex curvula* influenced by canopy structure, light and temperature. Oecologia 53: 98-104.

Korner, Ch. & M. Diemer. 1987. *In situ* photosynthetic responses to light, temperature and carbon dioxide in herbaceous plants from low and high altitude. Functional Ecology 1: 179-194.

Korner, Ch., G. D. Farquhar & Z. Roksandic. 1988. A global survey of carbon isotope discrimination in plants from high altitude. Oecologia 74: 623-632.

Kühner, R. 1935. Le genre *Galera*. Encyclopedie mycologique, 7: 1-240. P. Lechevalier, Paris.

Kühner, R. & H. 1953. Flore analitique des champignons supérieurs. Masson & Cie, Paris, pp. 556.

Kühner, R. & D. 1971a. *Agaricales* de la zone alpine. Rhodophyllacées. Caractères generaux et grandes lignes de classification. Bull. Soc. mycol. Fr. 871: 9-13.

Kühner, R. 1972a. *Agaricales* de la Zone Alpine, Genre *Galerina* Earle. Bull. Soc. mycol. Fr. 88: 41-118.

Kühner, R. 1972b. *Agaricales* de la Zone Alpine, Genres *Galerina* Earle et *Phaeogalera* gen. nov. Bull. Soc. mycol. Fr. 88: 119-153.

Kühner, R. 1974. *Agaricales* de la zone Alpine. Genre *Agaricus* L. ex Fr., Trav. scien. Parc National Vanoise 5: 131-147.

Kühner, R. 1975a. *Agaricales* de la Zone Alpine. Genre *Lactarius* D. C. ex S. F. Gray. Bull. Soc. mycol. Fr. 91: 5-69.

Kühner, R. 1975b. *Agaricales* de la Zone Alpine. Genre *Russula* Pers. ex S. F. Gray Bull. Soc. mycol. Fr. 91: 313-390.

Kühner, R. 1976a. *Agaricales* de la zone Alpine. Lepistées. Bull. Soc. mycol. Fr. 92(1): 5-32.

Kühner, R. 1976b. *Agaricales* de la Zone Alpine. Genre *Hygrocybe* (Fries) Kummer. Bull. Soc. mycol. Fr. 92: 455-515.

Kühner, R. 1977a. *Agaricales* de la Zone Alpine. Genre *Hygrocybe* (Fries) Kummer (suite et fin). Bull. Soc. mycol. Fr. 93: 53-115.

Kühner, R. 1977b. *Agaricales* de la Zone Alpine. Hygrophoracées. Généralités. Bull. Soc. mycol. Fr. 93: 117-144.

Kühner, R. 1977c. *Agaricales* de la Zone Alpine. Genre *Rhodophyllus* Quélet., Bull. Soc. mycol. Fr. 93(4): 445-562.

Kühner, R. 1978. *Agaricales* de la zone Alpine. Genre *Melanoleuca* Pat., Bull. Soc. Linn. Lyon 471: 12-52.

Kühner, R. 1981. *Agaricales* de la zone Alpine. Genre *Alnicola* Küuhner. Trav. scien. Parc National Vanoise 11: 113-134.

Kühner, R. 1983. *Agaricales* de la zone Alpine. Genre *Lepiota* (Pers. :Fr.) Gray, Crypto. Mycol. 4: 61-69.

Kühner, R. & D. Lamoure. 1970. *Agaricales* de la zone alpine. Bull. Soc. mycol. Fr. 86(4): 875-880.

Kühner, R. & D. Lamoure. 1971b. *Agaricales* de la Zone Alpine. Genre *Rhodocybe* R. Maire. Bull. Soc. mycol. Fr. 87: 15-23.

Kühner, R. & D. Lamoure. 1972. *Agaricales* de la Zone Alpine: Pleurotacées. Le Botaniste 55: 7-37.

Lagonegro M. & Feoli 1979. IAHOPA: a useful overlay program for systematics and ecology. Quaderni del Centro di Calcolo N 12. Univ. Trieste, Italy.

Lagonegro M. & E. Feoli 1980. COCHIS: a program for a similarity function based on probability. Quaderni del Centro di Calcolo N 13. Univ. Trieste, Italy..

Lagonegro M. & E. Feoli 1981. SINFUN: a program for information analysis in ecology. Quaderni del Centro di Calcolo N 16. Univ. Trieste, Italy.

Lagonegro M. & E. Feoli. 1984. THREE-PAckages for classification and ordination of multivariate data. Libreria Goliardica, Trieste, Italy, pp. 114.

Lagonegro M. & E. Feoli. 1985. Analisi multivariata di dati. Manuale l'uso di programmi BASIC per personal computers. Libreria Goliardica, Trieste, Italy, pp. 184.

Lamoure, D. 1971. *Agaricales* de la zone Alpine. *Rhodocybe borealis* Lange & Skifte et sa position systematique. Svensk Bot. Tidsk. 65: 278-282.

Lamoure, D. 1972. *Agaricales* de la zone alpine. Genre *Clitocybe*. Trav. scient. Parc National Vanoise 2: 107-152.

Lamoure, D. 1973. *Agaricales* de la Zone Alpine. *Mycena ochrogaleata* Favre. Le Botaniste 56: 55-88.

Lamoure, D. 1974. *Agaricales* de la Zone Alpine. Genre *Omphalina* (1ére partie). Trav. scient. Parc National Vanoise 5: 149-164.

Lamoure, D. 1975. *Agaricales* de la Zone Alpine. Genre *Omphalina* (2éme partie). Trav. scient. Parc National Vanoise 6: 153-166.

Lamoure, D. 1977a. *Agaricales* de la zone Alpine. *Psillocybe chionophila* sp. nov. Bull. Soc. Linn. Lyon 46(7): 213-217.

Lamoure, D. 1977b. *Agaricales* de la zone Alpine. Genre *Cortinarius*, Sous-genre *Telamonia*, (1ère partie). Trav. scient. Parc National Vanoise 8: 115-146.

Lamoure, D. 1978. *Agaricales* de la zone Alpine. Genre *Cortinarius*, Sous-genre *Telamonia*, (2ème partie). Trav. scient. Parc National Vanoise 9: 77-101.

Lamoure, D. 1980. Alpine and circumpolar *Omphalina* species. Arctic and Alpine Mycology. Proceedings of First International Symposium on Arcto-Alpine Mycology. Laursen, G. A. & J. F. Ammirati (eds). Washington Univ. Press., pp. 201-215.

Lamoure, D. 1983. A propos de *Clytocybe rivulosa* (Pers. :Fr.) Kummer. Crypto. Mycol. 4: 99-104.

Lamoure, D. 1984. *Agaricales* de la zone Alpine. Genre *Cortinarius* Fr. Sous-genre *Dermocybe* Fr. ss Fayod., Trav. scient. Parc National Vanoise 15: 55-59.

Lamoure, D. 1987. *Agaricales* de la zone Alpine: genus *Cortinarius* Fr., subgenus *Telamonia* (Fr.) Loud, Part III. Arctic and Alpine Mycology II, Proc. 2nd Int. Symp. on Arctic and Alpine Mycology. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 255-259.

Lamoure, D. & R. Kühner. 1971. *Agaricales* de la zone Alpine. Genre *Rhodocybe* R. Maire. Bull. Soc. mycol. Fr. 87: 15-23.

Lamoure, D. & R. Kühner. 1972. *Agaricales* de la zone Alpine. *Pleurotacees*. Le Botaniste 55: 7-37.

Lamoure, D. & R. Kühner. 1986. Catalogue des *Agaricales* (Basidiomycetes) de la zone Alpine du Parc National de la Vanoise et des regions limitrophes. Trav. scien. Parc National Vanoise 15: 103-187.

Landolt, E. 1977. Ökologische Zeigerwerte zur Schweizer Flora. Veröff. Geobot. Inst. ETH, Stiftung Rubel, Zürich, 64: 64-208.

Lange, J. E. 1935-1940. Flora Agaricina Danica, Voll. I-V. Copenhagen.

Lange, M. 1945. Macromycetes. Part I. The Gasteromycetes of Greenland. Medd. Gronl. 147(4): 1-32.

Lange, M. 1948. The agarics of Maglemose. Dansk. bot. Ark. 13: 1-141.

Lange, M. 1955. Macromycetes. Part II. 1. Greenland *Agaricales*. (*Pleurotaceae, Hygrophoraceae, Tricholomataceae, Amanitaceae, Agaricaceae, Coprinaceae*, and *Strophariaceae*). Medd. Gronl. 147(11): 1-69.

Lange, M. 1957. Macromycetes. Part III. 1. Greenland *Agaricales* (Pars) *Macromycetes caeteri II*. Ecological and Plant Geographical studies. Medd. Gronl. 148(2): 1-125.

Lange, M. 1984. Arctic Gasteromycetes. The Genus *Bovista* in Greenland and Svalbard. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 261-271.

Laursen, G. A. 1975. Higher fungi in soils of coastal arctic tundra plant communities. Ph. D. dissertation. Virginia Polytechnic Institute & State University, Blacksburg, VA.

Laursen, G. A., J. F. Ammirati & D. F. Farr. 1984. *Hygrophoraceae* from arctic and alpine tundra in Alaska. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 273-286.

Lesica, P. & R. K. Antibus. 1986. Mykorrhizae of alpine fell-field communities on soils derived from crystalline and calcareous parent materials. Can. J. Bot. 64: 1691-1697.

Lo Bue, G. 1975. Contributo allo studio degli influssi antropici sulla vegetazione subalpina ed alpina della Bassa Valle della Dora Riparia. Tesi di Laurea. Univ. Torino, Italy.

Maarel van der E. 1979. Transformation of cover-abundance values in phytosociology and its effects on community similarity. Vegetatio 39: 97-114.

Malloch, D. & B. Malloch. 1981. The mycorrhizal status of boreal plants: species from north-eastern Ontario. Can. J. Bot. 59: 2167-2172.

Malloch, D. & R. G. Thorn. 1985. The occurrence of ectomycorrhizae in some species of *Cistaceae* in North America. Can. J. Bot. 63: 872-875.

Martin, F., G. R. Stewart, I. Genetet & F. Le Tacon. 1986. Assimilation of $^{15}N_{4+}$ by beech (*Fagus sylvatica* L.) ectomycorrhizas. New Phytol. 102: 85-94.

Mikola, P. 1948. On the physiology and ecology of *Cenococcum graniforme* especially as a mycorrhizal fungus of birch. Inst. Forest. Fenn. Commun. 36(3): 1-104.

Miller, O. K. 1982a. Taxonomy of ecto- and ectendomycorrhizal fungi. Methods and Principles of Mycorrhizal Research. N. C. Schenck (ed.). Americ. Phytopathol. Soc., Saint Paul, Minnesota, pp. 91-101.

Miller, O. K. 1982b. Ectomycorrhizae in the *Agaricales* and Gasteromycetes. Can. J. Bot. 61: 909-916.

Miller, O. K. 1984. Higher fungi in tundra and subalpine tundra from the Yukon Territory and Alaska. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 287-297.

Miller, O. K., G. A. Laursen & B. M. Murray 1973. Arctic and alpine Agarics from Alaska and Canada. Can. J. Bot. 51: 43-49.

Miller, O. K. & G. A. Laursen. 1978. Ecto- and endomycorrhyzae of arctic plants at Barrow, Alaska. Vegetation and production ecology of an Alaskan arctic tundra. L. Tieszen (ed.). Springer-Verlag, Berlin, pp. 229-237.

Modess, O. 1941. Zur Kenntnis der Mykorrhizabildner von Kiefer und Fichte. Symb. Bot. Upsal. 5: 1-147.

Moeller, F. H. 1945. Fungi of the Faeroes. Part I. *Basidiomycetes*. E. Munksgaard, Copenhagen, pp. 295, Pls. 3.

Moeller, F. H. 1958. Fungi of the Faeroes. Part II. *Myxomycetes, Archimycetes, Phycomycetes, Ascomycetes* and *Fungi imperfecti*. E. Munksgaard, Copenhagen, pp. 286. Pl. 1.

Montacchini, F. 1976. Settori floristicie settori ecologico-vegetazionali del Piemonte. Allionia 21: 83-95.

Montacchini, F. 1986-87. Tipi di vegetazione naturali ed antropici sul territorio piemontese. Ann. Accad. Agric. Torino 129: 167-191.

Montacchini, F. 1990. Problemi fitogeografici del Piemonte. Interpretare una Regione, Geografia del Piemonte che cambia. C. Lanza Dematteis (ed.). Cortina, Torino.

Montacchini, F., R. Caramiello-Lomagno, G. Forneris & R. Piervittori 1982. Carta della vegetazione della valle di Susa ed evidenziazione dell'influsso antropico. C. N. R. AQ/1/120, Roma, Italia, pp. 114, Tav. 10.

Moser, M. 1978. Kleine Kryptogamenflora. Band IIb/2: Die Rohrlinge und Blattenpilze. 4. Aufl., G. Fischer, Stuttgart, N. Y., pp. 532.

Moser, M. 1980. Guida alla determinazione dei funghi. Saturnia, Trento, pp. 565.

Moser, M. 1982. Mycoflora of the transitional zone from subalpine forests to alpine tundra. Arctic and Alpine Mycology. Proc. First Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A. & J. F. Ammirati (eds). Washington Univ. Press., pp. 371-389.

Moser, M. & K. H. McKnight. 1984. Fungi (*Agaricales, Russulales*) from the alpine zone of Yellowstone National Park and the Beartooth Mountains with special emphasis on *Cortinarius*. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 299-317.

Moser, W. 1980. Ökophysyologie Untersuchungen an Nivalpflanzen. Mitteilungen der Ostalpin-Dinarischen. Gesellschaft für Vegetationskunde 11: 121-134.

Noordelos, M. E. 1979. Type studies on entolomatoid species in the Velenovsky herbarium - I. Species described in the genera *Nolanea, Leptonia* and *Telamonia*. Persoonia 10(2): 245-265.

Noordelos, M. E. 1980a. *Entoloma* subgenus *Nolanea* in the Netherlands and adjacent regions with a reconnaissance of its remaining taxa in Europe. Persoonia 10(4): 427-534.

Noordelos, M. E. 1980b. Type studies on entolomatoid species in the Velenovsky herbarium - II. Species described in the genera *Entoloma, Eccilia* and *Clitocybe*. Persoonia 11(1): 81-86.

Noordelos, M. E. 1981a. Introduction to the taxonomy of the Genus *Entoloma* sensu lato (*Agaricales*). Persoonia 11(2): 121-151.

Noordelos, M. E. 1981b. *Entoloma* subgenera *Entoloma* and *Allocybe* in the Netherlands and adjacent regions with a reconnaissance of their remaining taxa in Europe. Persoonia 11(2): 153-256.

Noordelos, M. E. 1982. *Entoloma* subgenus *Leptonia* in northwestern Europe - I. Introduction and a revision of its section Leptonia. Persoonia 11(4): 51-471.

Noordelos, M. E. 1984. *Entolomataceae* in Greenland - I. The genus *Entoloma*. Persoonia 12(3): 263-305.

Norusis M. J. 1985. S. P. S. S. -X advanced statistics guide. McGraw-Hill, N. Y., pp. 505.

Oberdorfer, E. 1977. Süddeutsche Pflanzengesellschaften. Teil I, G. Fischer, Stuttgart, N. Y., pp. 311.

Oberdorfer, E. 1978. Süddeutsche Pflanzengesellschaften. Teil II, G. Fischer, Stuttgart, N. Y., pp. 355.

Oberdorfer, E. 1983. Süddeutsche Pflanzengesellschaften. Teil III, G. Fischer, Stuttgart, N. Y., pp. 455.

Ohenoja, E. 1971. The larger fungi of Svalbard and their ecology. Rep. Kevo Subarctic Res. Stn. 8: 122-147.

Orlóci, L. 1969. Information analysis of structure in biological collection. Nature 223: 483-484.

Orlóci, L. 1976. Ranking species by an information criterion. J. Ecol. 64: 417-419.

Orlóci, L. 1978. Multivariate analysis in vegetation research. 2nd. edition. Junk, The Hague.

Orlóci, L. 1979. Non-linear data structures and their description. Int. Statistic Ecol. Program., Parma 1978.

Orlóci, L. & J. M. Bowles. 1982. Numerical methods in ecology and systematics. UWO Plant Sciences 503. Univ. Western Ontario, London.

Orlóci, L. & N. C. Kenkel. 1984. Introduction to data analysis with applications in populations and community biology. UWO Biology 244a, 252b. Univ. Western Ontario, London.

Ozenda, P. 1985. La végétation de la chaine alpine dans l'espace montagnard européen. Masson, Paris, pp. 344.

Parker-Rhodes, A. F. 1951. The *Basidomycetes* of Skokholm Island; some floristic and ecological calculations. New Phytol. 50: 227-243.

Parker-Rhodes, A. F. 1955. The Basidomycetes of Skokholm Island. XIII. Correlation with the chief plant associations. New Phytol. 54: 259-256.

Peretti, L. 1978. Simbiosi micorrizica fra *Polygonum viviparum* L. e *Cenococcum graniforme* (Sow.) Ferd. et Winge. Tesi di Laurea. Univ. Torino, Italy.

Petersen, P. M. 1977. Investigations on the Ecology and Phenology of the Macromycetes in the Arctic. Medd. Gronl. 199(5): 1-72.

Petrini, O. 1984. Endophytic fungi of alpine *Ericaceae*. The endophytes of *Loiseleuria procumbens*. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 71-77.

Peyronel, B. 1930. Simbiosi micorrizica tra piante alpine e Basidiomiceti. Nuovo Gior. Bot. Ital. 37(3), 655-663.

Peyronel, B. 1937. Osservazioni e considerazioni sul fenomeno della micorrizia al Piccolo San Bernardo. Nuovo Gior. Bot. Ital. 44(3): 587-594.

Pignatti, S. 1979. I piani di vegetazione in Italia. G. Bot. Ital. 113: 411-428.

Pignatti, S. 1982. Flora d'Italia. Voll. I-III. Edagricole, Bologna, Italia.

Phillips, R. 1985. Mushrooms and other fungi in Great Britain & Europe, 288 pp., 3rd. pr., Pan Books, London, pp. 288.

Premoli, M. 1981. I funghi dei pascoli. Relazioni fra miceti e associazioni fanerogamiche. Tesi di Laurea. Univ. Torino, Italy.

Read, D. J. & K. Haselwandter. 1981. Observations on the mycorrhizal status of some alpine plant communities. New Phytol. 88: 341-352.

Read, D. J., H. Kianmehr & A. Malibari. 1977. The biology of Mycorrhiza in *Helianthemum* Mill. New Phytol. 78, 305-312.

Reale, A. M. 1977. Micorrizia in *Polygonum viviparum* L. Tesi di Laurea. Univ. Torino, Italy.

Redhead, S. A. & Th. W. Kuyper. 1984. Lichenized Agarics: taxonomic and nomenclatural riddles. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 319-348.

Rehder, H. 1976a. Nutrient turnover studies in alpine ecosystems. I. Phytomass and nutrient relations in four mat communities of the Northern Calcareous Alps. Oecologia 22: 411-423.

Rehder, H. 1976b. Nutrient turnover studies in alpine ecosystems. II. Phytomass and nutrient relations in the *Caricetum firmae*. Oecologia 23: 49-52.

Rehder, H. & A. Schäfer. 1978. Nutrient turnover studies in alpine ecosystems. IV. Communities of the Central Alps and comparative survey. Oecologia 34: 309-327.

Romagnesi, H. 1967. Les Russules d'Europe et d'Afrique du Nord. Bodras, Paris, pp. 998.

Scaramella, P. 1930. Appunti sull'ecologia dei funghi alpini nella zona del Piccolo San Bernardo. Nuovo Gior. Bot. Ital. 37: 448-451.

Scaramella, P. 1932. Contributo alla flora micologica del Piccolo S. Bernardo (Valle d'Aosta). Ann. Chanoussia 2: 27-52.

Scott, D., R. D. Hillier & W. D. Billings. 1970. Correlation of CO_2 exchange with moisture regime and light in some Wyoming subalpine meadow species. Ecology 51: 701-702.

Senn-Irlet, B. I. 1986. Okologie, Soziologie und Taxonomie alpiner Makromyzeten (*Agaricales, Basidiomycetes*) der Schweizer Zentralalpen. Gnagi's Druck-Egge, Bern, pp. 252 + X, Pls. 36.

Senn-Irlet, B. I. 1987. Pilze aus der alpinen stufe des Val d'Anniviers (Wallis). Bull. Murithienne 105: 87-105.

Senn-Irlet, B. I. 1988a. Macromycetes in alpine snow-bed communities - mycocoenological investigations. Acta Bot. Neerl. 37(2): 251-263.

Senn-Irlet, B. I. 1988b. The higher fungi (*Basidiomycetes, Ascomycetes*) of the Oberaar Natural Reserve [Switzerland]. KLN-Object 3. 45

Shermakhanova, N. M. 1956. *Hebeloma crustuliniforme* (Bull.) Fr. mycorrhiza former with oak. Mikrobiologiya 25(1): 57-60.

Singer, R. 1932. Monographie der Gattung *Russula*. Beih. Bot. Centralbl. 49(II): 205-380.

Singer, R. 1935. Supplemente zu meiner Monographie der Gattung *Russula*. Ann. Mycol. 33: 297-352.

Singer, R. 1938. Contribution a l'étud e des Russules III. Quelques Russules americanes et asiatiques. Bull. Soc. mycol. Fr. 54: 132-177.

Singer, R. 1986. The *Agaricales* in Modern Taxonomy. 4d ed., Koeltz, Koeningstein, F. R. G., pp. 981, Pls. 88.

Skirgiello, A. 1961. De la nécessité de la protection des champignons et des terrains respectif. Ceska Mykol. 15: 153-158.

Smith, A. H. & R. Singer. 1964. A monograph on the Genus *Galerina* Earle. 384 pp., Haefner Publ., N. Y., London.

Studer, D. jun. 1891. Beitrage zur Kenntnis der schweizerischen Pilze. a) Wallis. Mittheil. Naturforsch. Ges. Bern, 1890. pp. 16-22.

Trappe, J. M. 1962. Fungus associates of ectotrophic mycorrhizae. Bot. Rev. 28: 538-606.

Trappe, J. M. 1964. Mycorrhizal hosts and distribution of *Cenococcum graniforme*. Lloydia 27: 100-105.

Trappe, J. M. 1987. Banquet address: lesson from alpine mycorrhizae. Proc. of 7th N.A.CO.M., Gainesville, Florida, U.S.A., pp. 338-340.

Tutin, T. G. et al. 1964-1977. Flora Europaea, Voll. I-VI. Cambridge.

Watling, R. 1984. Larger arctic-alpine fungi in Scotland. Arctic and Alpine Mycology II. Proc. Second Int. Symp. on Arcto-Alpine Mycol. Laursen, G. A., J. F. Ammirati & S. A. Redhead (eds). Plenum Press, N. Y., pp. 17-45.

Westhoff, V. & E. Van der Maarel 1978. The Braun-Blanquet approach. In: R. H. Whittaker (ed.), Classification of plant communities. 2nd. ed. Junk, The Hague, pp. 227-399.

Whittaker, R. H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. Ecol. Monogr. 30: 279-338.

Whittaker, R. H. 1967. Gradient analysis of vegetation. Biol. Rev. 49: 201-264.

Whittaker, R. H. 1972. Convergences of ordination and classification. In: Grundfragen und Methoden der Pflanzensoziologie. E. van der Maarel & R. Tuxen (eds). Ber. Int. Symp. Rinteln 1970: 39-57.

Whittaker, R. H. 1972b. Evolution and measurement of species diversity. Taxon 21: 213-251.

Whittaker, R. H. 1978. Ordination of plant communities. 2nd. Junk, The Hague.

Winterhoff, W. 1978a. Bemerkenswerte Pilze in Trockenrasen des nordlichen Oberrheingebietes. Hessische floristische Briefe 27(1): 2-8; 27(3): 41-47.

Winterhoff, W. 1978b. Gefährdung und Schultz von Pilzen. Veröff. Naturschutz Landschaftspflege Bad. -Württ. 11: 161-167.

Zerova, M. Y. & H. L. Rozhenko. 1966. *Entoloma erophilum* (Fr.) Karst. and *E. sericeum* (Bull.) Quél. - mycorrhizal symbionts of the oak. Ukr. Bot. Zh. 23(4): 87-90. R. A. M. 46:569.

Appendix A

Detailed geographical data for relevés (see Fig. 1)

C2 - Sector to the N of the Northern-Southern Alps vegetation boundary

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
COGNE VALLEY								
a) Vallone di Valnontey								
1. Grange Lauson	03.10.79	VII	1	2280	1	3	75	4.8
2. Bivacco "C.Pol"	25.08.79	VIII	2	2190	8	10	30	4.7
3.Grange di Money	10.08.79	IX	3	2350	5	5	100	4.8
b) Vallone di Bardoney								
4. Bardoney	04.10.79	VI	4	2235	16	35	45	7.0
	04.10.79	IV	5	2255	9	2	80	4.5
	04.10.79	IV	6	2255	7	5	100	4.2
	04.10.79	IV	7	2255	9	5	100	4.2
	04.10.79	IV	8	2255	9	17	70	4.2
	04.10.79	IV	9	2260	11	10	100	4.8
SOANA VALLEY								
a)Vallone di Campiglia								
5. San Besso	05.07.78	III	10	1860	14	40	100	5.0
	05.07.78	III	11	1865	14	42	100	4.8
	26.07.78	III	12	2075	10	5	90	4.5
b) Vallone di Forzo								
6. Pian Lavina	13.07.77	IV	13	1830	12	25	95	4.8
Alpe Muanda	21.07.77	II	14	2275	15	2	100	4.8

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BC2 - Sector between the Northern-Southern Alps flora and vegetation boundaries

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
ORCO VALLEY								
7. Motta Lake	22.07.76	I	18	2400	13	10	60	4.5
	22.07.76	I	19	2400	13	10	90	4.5
	22.07.76	I	20	2400	13	10	60	4.5
	22.07.76	I	21	2400	13	10	50	4.5
	22.07.76	I	22	2400	13	10	40	4.5
	22.07.76	I	23	2400	13	10	70	4.5
8. Gran Piano hunting lodge	22.07.77	II	15	2010	1	18	100	4.7
"Vittoria"	22.07.77	I	16	2010	1	18	80	4.0
	22.07.77	II	17	2010	1	5	100	4.0
Alpe Breuil	04.08.76	IV	24	2380	16	3	90	4.4
	04.08.76	IX	25	2380	16	3	90	4.4
	04.08.76	IX	26	2400	9	3	85	4.4
	04.08.76	IX	27	2400	13	2	100	5.0
Chamousseretto Lake	05.08.76	IX	28	2510	16	10	70	4.8
	05.08.76	IX	29	2510	16	10	50	4.8
	05.08.76	IX	30	2510	16	10	95	4.7
	05.08.76	IX	3	2510	16	10	70	5.0
	05.08.76	IX	32	2510	15	10	65	4.6
	05.08.76	IX	33	2510	15	10	50	5.0
	05.08.76	IX	34	2390	16	5	100	4.2
	05.08.76	IX	35	2390	16	5	70	4.8
	05.08.76	IX	36	2390	16	5	70	4.8
9. Bastalon Hut	27.07.76	VIII	38	2600	3	3	50	4.5
Colle della Terra	28.07.76	VIII	39	2590	13	2	35	4.0
Colle della Terra	28.07.76	VIII	40	2590	13	2	40	4.0
Colle della Terra	28.07.76	VIII	41	2590	13	2	10	4.0
Colle della Terra	28.07.76	VIII	42	2590	13	2	40	4.0
Colle della Terra	28.07.76	VIII	43	2590	13	2	60	4.0
Gias del Beuf Lake	29.07.76	VI	44	2790	13	5	70	4.0
above Bastalon Hut	29.07.76	VIII	48	2650	16	10	50	4.5
Bastalon Hut	03.08.78	VIII	52	2500	16	2	80	4.5
Bastalon Hut	03.08.78	VIII	53	2500	1	10	35	4.5
Gias del Beuf Lake	29.07.76	VIII	45	2790	16	10	90	4.2
Gias del Beuf Lake	29.07.76	VIII	46	2790	4	10	50	4.2
Gias del Beuf Lake	29.07.76	VIII	47	2790	8	15	70	4.5
below Gias Beuf Lake	30.07.76	IX	49	2565	16	10	100	4.5
below Gias Beuf Lake	30.07.76	I	50	2610	16	20	85	4.8
below Gias Beuf Lake	30.07.76	I	51	2610	16	20	100	4.8

AB1 - Prealpine sector to the N of the limit of Mediterranean influence

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
DORA RIPARIA VALLEY								
10. Monte Pelà	30.09.75	III	54	1444	12	5	100	4.0
	30.09.75	III	55	1444	16	5	100	4.0
	30.09.75	III	56	1444	8	5	90	4.0

AB2 - Sector between the limit of Mediterranean influence and the Northern-Southern Alps flora boundary

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
DORA RIPARIA VALLEY								
11. Alpe della Portia	12.09.75	III	57	2160	12	20	70	4.5
	12.09.75	IV	58	2100	8	25	100	4.5
	12.09.75	IV	59	2000	16	5	100	4.5
Alpe Crosatto	07.09.79	IX	60	1355	1	90	5	5.5
12. Alpe Formica	26.09.75	III	61	1905	16	15	100	5.0
	26.09.75	III	62	1955	12	10	95	5.0
	26.09.75	III	63	1960	16	0	100	5.0
	11.09.77	III	64	1920	13	15	100	4.7
	11.09.77	III	65	1920	4	5	100	4.5
13. Colle delle Coupe	05.09.75	IX	66	2050	2	5	80	5.5
23. Passo dell Capra	19.09.79	VIII	88	2200	8	10	70	5.0
(Vallone dell'Argentiera)	19.09.79	VII	89	2200	8	5	70	7.0
	19.09.79	VII	90	2230	1	10	40	6.8
	19.09.79	VII	91	2200	1	10	70	6.0
CHISONE VALLEY								
28. above Prà Catinat	07.07.76	IV	102	1830	13	5	100	4.5
29. Colle del Sabbione	07.10.75	IV	104	2223	14	15	60	5.0
	07.10.75	VIII	105	2420	14	10	30	4.2
	07.10.75	IV	106	2490	14	30	50	4.0
	07.10.75	IV	107	2505	16	45	85	4.2
	07.10.75	IV	108	2505	16	45	60	4.2
	07.10.75	IV	109	2505	16	45	80	4.2
	07.10.75	IV	110	2510	16	5	75	4.0
PO VALLEY								
30. Pian del Re	27.07.79	VI	112	2135	9	12	70	4.5

AB3 - Inner alpine sector between the limit of Mediterranean influence and the Northern-Southern Alps boundary

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
DORA RIPARIA VALLEY								
14. Combe	22.09.75	IV	67	1850	6	30	100	5.0
15. Ca' da'Asti	20.08.76	VI	68	2960	12	15	45	7.2
16. La Riposa	18.09.75	III	69	2200	10	20	100	5.0
	18.09.75	III	70	2200	10	25	100	5.0
	18.09.75	III	71	2205	10	20	100	5.0
	18.09.75	III	72	2230	8	5	90	5.0
17. Monache Lake	31.08.79	I	73	2510	14	5	85	4.2
	31.08.79	IV	74	2500	8	25	45	4.5
18. Vallone di Rochemolles	13.09.79	VI	75	2145	5	40	80	6.8
	13.09.79	VI	76	2150	5	40	100	5.5
	13.09.79	VI	77	2150	5	40	60	6.8
	13.09.79	IV	78	2150	1	40	80	4.5
	13.09.79	VI	79	2160	1	20	40	5.5
	13.09.79	VI	80	2140	1	35	80	7.0
	13.09.79	VI	81	2140	1	10	35	7.0
	13.09.79	VI	82	2185	3	15	60	6.3
	13.09.79	VI	83	2185	1	30	70	7.2
19. Valle Fredda	21.08.79	VI	84	2365	1	10	95	5.8
20. Colle Gimont	10.10.75	III	85	2210	8	20	85	5.0
21. Colle Bousson	01.08.78	IV	86	2225	15	40	95	5.8
22. Vallone di Thuras	10.08.78	VI	87	2420	5	10	100	5.5
24. Colle Basset	24.08.76	VI	92	2450	2	15	100	5.8
	24.08.76	VI	93	2455	2	15	70	6.2
	24.08.76	VI	94	2445	2	45	100	5.0
	24.08.76	VI	95	2445	2	45	85	5.0
	24.08.76	VI	96	2445	2	45	60	6.0
	24.08.76	VI	97	2445	2	45	100	5.0
25. Rifugio Montenero	08.08.78	II	98	2110	6	10	100	4.8
	08.08.78	IV	99	2170	9	10	100	5.5
	08.08.78	V	100	2170	9	30	100	6.0
	08.08.78	V	101	2240	9	15	100	5.5
26. Rifugio Balmerotto	23.06.76	II	103	2070	1	15	80	5.0
27. Pian delle Cavalle	24.09.75	IX	111	1980	7	2	100	6.5

A< Inner alpine sector within the Mediterranean influence limit

Sites	Date	Veget. Type	Relev én°	Altit. (m)	Aspect (Ipe)	Slope s.d.	Her.cov. %	Soil pH
MAIRA VALLEY								
31. Vallone Unerzio	01.10.79	V	113	1895	9	30	85	5.8
	01.10.79	V	114	1870	9	30	75	6.3
	01.10.79	IX	115	1870	1	8	100	5.0
32. Visaisa Lake	12.07.76	VI	116	1675	9	15	70	7.2

Appendix B

Taxonomical references and list of macromycetes

List of the macromycetes

Ectomycorrhizal fungi are indicated by an asterisk (*)

1 - *Agaricus semotus* Fr.
2 - *Calocybe georgii* (Clus. ex Fr.) Kuhn., ss. Sing.
3 - *Camarophyllus pratensis* (Pers. ex Fr.) Kumm.
4 - *Camarophyllus pratensis* Kumm. (f. nanus ss. Favre)
5 - *Clitocybe alexandri* (Gill.) Konr.
6 - *Clitocybe gibba* (Pers. ex Fr.) Kumm.
7 - *Clitocybe rivulosa* (Pers. ex Fr.) Kumm.
8 - *Collybia butyracea* (Bull. ex Fr.) Quel.
9 - *Collybia dryophila* (Bull. ex Fr.) Kumm.
10 - *Cortinarius albonigrellus* Favre (*)
11 - *Cortinarius favrei* Mos. ex. Henderson (*)
12 - *Cortinarius anomalus* (Fr. ex Fr.) Fr. (*)
13 - *Cortinarius bicolor* Lange (*)
14 - *Cortinarius decipiens* (Pers. ex Fr.) Fr. (*)
15 - *Cortinarius fasciatus* (Scop. ex Fr.) Fr. (*)
16 - *Cortinarius glandicolor* (Fr.) Fr. (*)
17 - *Cortinarius glandicolor* var. *exilis* Favre (*)
18 - *Cortinarius helvelloides* (Fr.) Fr. (*)
19 - *Cortinarius hinnuleus* Fr. ss. Lange (*)
20 - *Cortinarius hinnuleus* var. *minutalis* Favre (*)
21 - *Cortinarius hoeftii* (Weinm.) Fr. (*)
22 - *Cortinarius incospicuus* Favre (*)
23 - *Cortinarius minutulus* Favre (*)
24 - *Cortinarius orellanus* (Fr.) Fr. (*)
25 - *Cortinarius phaeochrous* Favre (*)
26 - *Cortinarius subferrugineus* (Batsch ex Fr.) Fr., ss. Konr. (*)
27 - *Entoloma griseocyaneum* (Fr.) Kumm.
28 - *Entoloma incanum* (Fr.) Hesler
29 - *Entoloma juncinum* (Khun. & Romagn.) Noordel. sensu Noordel.
30 - *Entoloma papillatum* (Bres.) Dennis
31 - *Entoloma sericeum* (Bull. ex Merat) Quel.
32 - *Entoloma sericeum* f. *nanum* Favre
33 - *Galerina hypnorum* (Schrank ex Fr.) Kuhn.
34 - *Galerina vittaeformis* (Fr.) Sing.
35 - *Hebeloma alpinum* (Favre) Bruchet (*)
36 - *Hebeloma crustuliniforme* (Bull. ex St. Amans) Quel. (*)
37 - *Hebeloma marginatulum* (Favre) Bruchet (*)
38 - *Hebeloma mesophaeum* (Pers. ex Fr.) Quel. (*)
39 - *Hebeloma sarcophyllum* (Peck.) Sacc.
40 - *Hebeloma versipelle* (Fr.) Gill. (*)
41 - *Hemimycena cucullata* (Pers. ex Fr.) Sing.
42 - *Hygrocybe coccinea* (Schaeff. ex Fr.) Kumm.
43 - *Hygrocybe conica* (Scop. ex Fr.) Kumm.
44 - *Hygrocybe cystidiata* Arnods
45 - *Hygrocybe lepida* Arnolds
46 - *Hygrocybe persistens* (Britz.) Sing.
47 - *Hygrocybe pseudoconica* Lange
48 - *Hygrocybe punicea* (Fr.) Kumm.
49 - *Hygrocybe reai* (Maire) Lange var. *insipida* Lange
50 - *Hygrocybe subradiata* (Schum.) Ort.-Watl.
51 - *Inocybe canescens* Favre (*)
52 - *Inocybe decipiens* Bres. (*)
53 - *Inocybe dulcamara* (A. & S. ex Pers.) Kumm. (*)
54 - *Inocybe dulcamara* var. *malenoni* Heim (*)
55 - *Inocybe fastigiata* f. *alpestris* Heim (*)

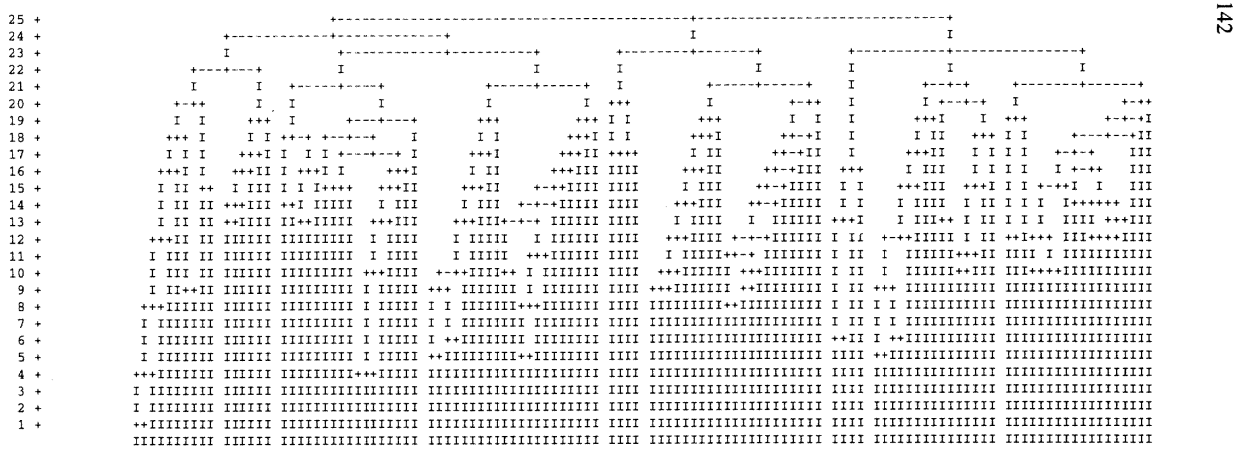
56 - *Inocybe fastigiata* var. *alpina* Heim (*)
57 - *Inocybe friesii* Heim (*)
58 - *Inocybe friesii* f. *epixantha* Kuhn. (*)
59 - *Inocybe humilis* Favre (*)
60 - *Inocybe lacera* var. *heterocystis* Favre (*)
61 - *Inocybe lacera* (Fr.) Kumm. f. *heterospora*, ss. Favre (*)
62 - *Inocybe lanuginella* (Schroet. ap. Cohn.) Konr.& Maubl.(*)
63 - *Inocybe leucoblema* Kuhn. (*)
64 - *Inocybe piricystis* Favre (*)
65 - *Laccaria laccata* (Scop. ex Fr.) Berk. & Br. (*)
66 - *Laccaria laccata* var. *pumila* Fayod (*)
67 - *Laccaria proxima* (Boud.) Pat. (*)
68 - *Laccaria tortilis* (Bolt.) S.F. Gray (*)
69 - *Lepista luscina* (Fr. ex Fr.) Sing.
70 - *Lepista saeva* (Fr.) Orton
71 - *Marasmius epidryas* Kuhn.
72 - *Marasmius scorodonius* (Fr.) Fr.
73 - *Melanoleuca grammopodia* (Bull. ex Fr.) Pat.
74 - *Melanoleuca melaleuca* (Pers. ex Fr.) Murr.
75 - *Melanoleuca subalpina* (Britz.) Brsky & Stangl.
76 - *Mycena erubescens* von Hoehn.
77 - *Mycena* sp.
78 - *Naucoria alnetorum* R.Maire
79 - *Naucoria scolecina* (Fr.) Quel.
80 - *Naucoria subconspersa* Kuhn.
81 - *Naucoria tantilla* Favre
82 - *Omphalina obscurata* Reid
83 - *Omphalina umbratilis* (Fr.) Quel.
84 - *Panaeolus fimicola* (Fr.) Gill.
85 - *Panaeolina foenisecii* (Pers. ex Fr.) Maire
86 - *Panaeolus guttulatus* Bres.
87 - *Panaeolus retirugis* (Fr.) Quel.
88 - *Panaeolus rickenii* Hora
89 - *Stropharia semiglobata* (Batsch. ex Fr.) Quel.
90 - *Tubaria pellucida* (Bull. ex Fr.) Gill.
91 - *Russula nana* Killerm. (*)
92 - *Russula oreina* Sing. (*)
93 - *Bovista nigrescens* Pers. ex Pers.
94 - *Bovista plumbea* Pers. ex Pers.
95 - *Bovista tomentosa* (Vitt.) Quel.
96 - *Calvatia utriformis* (Bull. ex Pers.) Jaap
97 - *Lycoperdon pyriforme* Schaeff. ex Pers.
98 - *Vascellum pratense* (Pers.) Kreisel
99 - *Exidia* sp.
100 - *Cenococcum geophilum* Fr.
101 - *Octospora rubens* (Boud.) Moser
102 - *Scutellinia hirtella* (Rehm) O.Kuntze
103 - *Scutellinia scutellata* (L. ex St. Amans) Lamb.
104 - *Scutellinia trechispora* (Berk. & Br.) Lamb.

Appendix C

Cluster analysis of relevés and rearranged data table

Differential species are indicated by an asterisk

(see following 6 pages)



		1				1111	111	1111	1	1	1	1	1
		2221125517	131019	66555116867766571	527171000589006			1100	9999991848878887777	61	899	4434840	5544443	3313323234	3222616
	Relevés N.	0129830163	475378	45465013590112722	79685944380798869426 7			3401	23657427401632459748 6	9101	2390815223578 68			5610193849326756 50	
*	1 - Pedicularis kerneri Dalla Torre	32325522..	.....	.....	.....2.....			..25	.....	....	.....222..22			...33..2.2.....	
*	2 - Astrantia minor L.	23232..3..	....2.	2	.....			....	.....	....	.....			.....	
*	3 - Bellardiochloa violacea (Bellardi) Chiov.	332553....	.....	7.....2.....	.....			....	.....3.....	....	.....			.....	
*	4 - Primula pedemontana Thomas	22222.53..	.....	2	.....			....	.....	....	.....			.....	
*	5 - Agrostis alpina Scop.	55555..7..	2	.....52...5....	..355...5.3.....5...			....	.....	....	.....			.....	
	6 - Polygonum viviparum L.	5575.53553	577557	52...2.3.22222.2.	.....222.55222335...2			..27	55353253..222332252..	35..	....2.3.....53			22333..55.553.323.	
	7 - Silene acaulis (L.) Jacq. ssp. excapa (All.) J.Braun	2222.....2	.....	.....52.	.....22.....			....	22.....2.....2.....	....	..22..2.....32			....2..52..22.....	
	8 - Leontodon helveticus Meérat	532..2..53	353...	22.....2..	55322.53.222.3.....			...2	....2..22.....22.....	..2.	.....2222..2			..2..2..322255.22.	
*	9 - Trifolium alpinum L.	553...552.	.....	22.....5.233322.7	..2..22.....3....3.			....	.....	....	.....			.....5.....	
	10 - Vaccinium uliginosum L.	353.....57	.....	2.2.....2	.....2.2...			....	7377..5.....	....	.....2.....5			.3.22.....	
*	11 - Carex sempervirens Vill.	232.....5	.....	.....7835355.7553	.5555533.3755575.225.			3...	3.....2....5223..53..	....	.....			.....	
	12 - Senecio halleri Dandy	222.....	.....	.....	.....			....	.....2.....	....	.....322..22			.....2.2.....	
	13 - Euphrasia minima Jacq.	22.22.32.2	.2..2.	.....2.2...	.2222.22..22.2.....2.			....	.....2..2..2..	....	3.....2.....2			.3.5.5.5333.22....	
	14 - Hieracium glanduliferum Hoppe	52.2..22..	...2..	.....2.....	.....			....	2222...22.....2....	....	.....			.....222....	
*	15 - Rhodiola rosea L.	22...2....	.....	.....	.....			....	.....	....	.....			.....	
	16 - Valeriana celtica L.	32.....	.....	.....	.....			....	.....	....	.....			.....	
*	17 - Pulsatilla alpina (L.) Delarbre ssp. apiifolia (Scop.) Nyman	22.....	.....	.....	.....			....	.....	....	.....			.....	
	18 - Draba fladnizensis Wulfen	2..3.....	.....	.....	.....2.			2...	..2.....2	....	.....2.....			.....	
	19 - Cardamine resedifolia L.	2..2.....	.....	.....	.....			....	.....	....	.....22.2.2			.....	
	20 - Phyteuma hemisphaericum L.	2.....2.2.	..2...	2	.....2.....			....	.....2.....	....	.....22.....			.....2.....	
	21 - Loiseleuria procumbens (L.) Desv.	2.....	.....	.....	.....			....	2.....	....	.....2.....			.....	
*	22 - Festuca violacea Schleicher	.225..55..	5	.....3...2.3...2.	.....5..55535.2.5.			....	355552375.....	....	..2.223.....2.			.2.....52.....5..	
*	23 - Salix herbacea L.	.22.....23	5.....	.....	2..5..5..25.....			....	52.57.3.....2...	53..	7757833..777753			255577755.757552..	
	24 - Cetraria islandica (L.) Ach.	.2....2...	.....	.....2....2...	.....32.....2...			....	2.2.....3.....7.....2	....	.....53.....			.....22.....	
*	25 - Ranunculus montanus Willd.	.2.....	555523	...22....2..2..32	....2....2....2...3.2			....	.....2.....	....	.....			.....2..2.....	
*	26 - Juncus trifidus L.	..3..2....	.....	72...2.5.3552325.	.....2.....5.			....	.....	....	.....2.....			.....	
	27 - Phyteuma humile Schleicher	..2.....	.....	.....	.....2.....			....	.....	....	2			.....2.2...	
	28 - Minuartia sedoides (L.) Hiern	...23.33.2	.....	.....	.....2.....2.....2.			....	222..3.....2.....	....	.....2.53...2.			.....22.....	
*	29 - Carex curvula All.	...2.....	.....	.....	.....7..2.....			....	.332...25.....	....	.....75.5.73			.....3.....	
	30 - Sedum sexangulare L.	...2.....	.....	.....	.....			....	.....	....	.....			.....2.....	
*	31 - Ligusticum mutellinoides (Crantz) Vill.	....2.22.2	.....	.....	.....			....	.2.....	....	.....			.....	
*	32 - Taraxacum officinale Weber	....2.....	.2227.	.....	.....2..			....	.....	....	...2.....			.....	
*	33 - Silene acaulis (L.) Jacq.	....3.....	.....	.....	.....			3..2	.....2.....	....	.....			.....	
	34 - Androsace obtusifolia All.	....2.....	.....	.....	.....			....	.....2.....	....	2			.....	
	35 - Luzula alpinopilosa (Chaix) Breistr.	.....3....	.2....	.....	.....3.....			....	.....	....	3133.....			22.25.22..2.....	
*	36 - Helictotrichon sedenense (DC.) J.Holub	.....2....	2	32.....	.....			....	.....2.2.....2...2...	....	.....			.....	
*	37 - Plantago alpina L.	.....5....	.....	.....2.3.	....53.355.....3552..			5575	....2..5.....2.2..	..2.	.....			.....5...	
	38 - Avena pubescens Hudson	.....7....	.....	.....	.....			....	3	....	.....			.....	

Relevés N.									
		1		1111 111	1111	1 1		1	1 1
	2221125517	131019	66555116867766571	5271710005890006	1100	99999918488788777 61	899	4434840 5544443	3313323234 3222616
	0129830163	475378	45465013590112722	796859443807988694267	3401	236574274016324597486	9101	239081522357868	561019384932675650
* 39 - Eriophorum scheuchzeri Hoppe	.....2....	......	....	....	....	....	....	....	3..22.3...........
40 - Athamanta cretensis L.	.....7....	......	....	....	....	....	....	....	....
41 - Carex sp.	.....5....	......	....	....	....	....	....	....	....
42 - Scirpus cespitosus L.	.....3....	......	....	....	....	....	....	....	....
43 - Campanula scheuchzeri Vill.	......22.2	.2....	...22..2.....2..	....2..2.2..22.22...2	....	2..2322...22.....2...	....	....	.......2.2222.....
44 - Phyteuma globulariifolium Sternb.& Hoppe ssp. pedemontanum Becherer	......22.2	......	....	..........22.........	....	........2............	....	......2......2.	..........2.......
45 - Potentilla aurea L.	......22..	.3....	.......2.....2..	......2....2...2.....	...3	...2.32..............	...2	........5......	.........3........
46 - Erigeron uniflorus L.	......22..	......	.............2..	....	....	.2...2.............2.	....	........2......	....
47 - Taraxacum erythrospermum Andrz.	......22..	......	....	..2......2...........	2..5	....2....2......2....	..2.	..2.......2....	...2...2..22......
* 48 - Carex capillaris L.	......87..	......	....	....	..5.	....	....	....	......2.322..33...
49 - Saxifraga stellaris L.	......32..	......	....	....	...2	....	....	....	....
* 50 - Carex frigida All.	......22..	......	....	....	....	....	....	....	2..2..32.....2....
* 51 - Agrostis rupestris All.	......5.32	2.2.5.	....	......23.............	....	.....23..22..........	...5	.2.2.......3.3	23.2.33532.5.55...
52 - Avena versicolor (Vill.) Lainz	......2..2	......	....	..........2..........	....	2.......3..2..2......	....	....	....
* 53 - Geum montanum L.	......2...	22.2..	.2......2322..5.	.22.2332.75555327222.	....	....2................	....	........2.2....	....2...5555.52...
* 54 - Nardus stricta L.	......5...	25....	5887525..5557553.	8757285.25575557552..	....	...................2.	....	....	..72352575555572.
55 - Luzula spicata (L.) DC.	......2...	......	....	....2..........2.2..	...2	....2222.............	....	....	.........32.......
56 - Gentiana brachyphylla Vill.	......2...	......	....	....	....	....................2.	....	....	....
57 - Pinguicula alpina L.	......2...	......	....	....	....	....	....	....	....
58 - Poa laxa Haenke	......2...	......	....	....	....	....	....	....	....
* 59 - Alchemilla xanthochlora Rothm.	.......2..	.3.3.3	.2.....2..22.2.52	32222..2.2...2.2522.2	...2	2...2..2.............	....	....	...3...52.232...2.
60 - Gentianella campestris (L.) Borner	.......2..	......	2...2.2......2.	............2.....22	2...	..2..................	....	....	.........2........
* 61 - Cerastium arvense L. ssp. strictum Goudin	.......3..	......	.........2....22.	........2...........	...2	...2..2.........2..	2222	..3...........2	.................2.
62 - Luzula nutans (Vill.) Duval-Jouve	.......2..	......	....	..............2......	....	....	....	....	....
* 63 - Anthoxantum odoratum L.	22	2325..	23...752.5253.75.	23225.2.3.....5.5....	....	.......3.......2.....	..2.	.......3.......	...53.....53.25...
* 64 - Festuca gr. halleri (F.alpina Suter & F.halleri All.)	53	....3.	3	.......3.............	....	......5.........5....	335.	....3...55.....	..........3.......
* 65 - Carex fusca All. (=C.nigra Reichard; = C.goodenowii J.Gay)	........2.	2...2.	....	....	....	.......2.............	....	....	8572..............
66 - Soldanella alpina L.	........3.	.352.2	.........2.....2.	23...232.3.23...2....	.2..	...25.25..222.32.3...	....	....	...53..2...3332.2.
67 - Homogine alpina (L.) Cass.	........5.	..22..	.2.......2....3..	22...25..2...........	....	.......2...2.........	....	....	..............22...
68 - Festuca nigrescens Lam.	........2.	..3...	....	....	....	....	....	....	....
69 - Hieracium x floribundum Wimmer & Grab.	........2.	....2.	....	....	....	....	....	....	.........2........
70 - Carex curta Good.	........2.	......	....	....	....	....	....	....	....
* 71 - Poa alpina L.	2	.5272.	........3...55257	2.2...2252355.333282.	.325	32232333.225222.52222	2222	22322.332.322.2	.........5..75522.
* 72 - Biscutella laevigata L.	2	...3..	.......2..222...2.	....	....	...............2.....	....	....	....
73 - Carex atrata L.	2	......	...............2.	....	....	2....................	....	....	....
74 - Pedicularis rosea Wulfen	2	......	....	2....................	....	...........2.2.2.....	....	....	...........2......
* 75 - Lotus alpinus (DC.) Schleicher	....	752225	........2.3..2222	22..22.2522.222.2.523	.3..	...55752...22..223..2	2...	2..22.3.22.....	..........2522....
76 - Poa alpina L. ssp. vivipara (L.) Arcangeli	....	222.22	....	....	....	....	..2.	.2223..........	..22...352.32.....
77 - Ligusticum mutellina (L.) Crantz	....	3.2...	....	....	....	......3..........2..	....	....	....
* 78 - Alchemilla pentaphyllea L.	....	.22.7.	....	..332.2.252..........	....	......2..............	....	...........8733.	.2.532322553552...
* 79 - Phleum alpinum L.	....	.2...2	.2.........2.2..	...2....222.25..222.	....	....	....	....	........22........
* 80 - Cerastium arvense L.	....	.3...2	...........2...2	..........22.3...2222	....	....	....	...3...........	....
* 81 - Festuca ovina L.	....	.3....	5555..7..........	..................7.5	33.2	...........223...52..	....	5	....
* 82 - Trifolium pratense L. var. frigidum Gaudin	....	.2....	..2..2..2222..22.	........3.....25.2..2	....	2	....	....	....
* 83 - Sibbaldia procumbens L.	....	.2....	....	2.2.2222.22.22.....2.	....	....	....	......2.2..2...	.......32.32......
* 84 - Veronica alpina L.	....	.2....	....	.2222.2...2.22.......	....	....	....	..........2.2..	...2.2.3...222....
* 85 - Leucanthemopsis alpina (L.) Heyw.	....	.2....	....	....2.2..............	....	.2.2..............2.	....	2222.2.5523....	.2.22222322332...
86 - Gymnadenia conopsea (L.) R.Br.	....	.2....	....	....	....	....	....	....	....
87 - Parnassia palustris L.	....	..5.2.	2......2....2.2.	.2...2..............2	...2	....	.2..	....	..3.......5.......
88 - Selaginella selaginoides (L.) Link	....	..2.3.	....	.2.222...............	...2	2..........2..22.2...	....	....	..2...............
89 - Campanula excisa Schleicher	....	..2.2.	....	....	....	....	....	....	....
90 - Silene rupestris L.	....	..2...	....	........2............	....	....	....	....	....
91 - Viola biflora L.	....	...32.	....	........2............	....	....	....	....	....
92 - Myosotis alpestris F.W.Schmidt	....	...2.2	....	........2...2..2..2..	....	.2...2.2.............	....	..........2....	....
93 - Leontodon hirtus L.	....	...2.2	....	2	....	....	....	....	....
94 - Rumex scutatus L.	....	...2..	.......2...2....	....	....	................2...	....	.......2.......	.......5...2......
* 95 - Gentiana verna Ll	....	...2..	............2...	...............2.2..	22..	22.222.2........2....	....	........2......	....
96 - Luzula lutea (All.) DC.	....	...2..	2	...........32.....3.	....	3....................	....	......3..2...3	.2................
97 - Crocus vernus (L.) Hill	....	...5..	2	..............2......	....	....	....	....	....
* 98 - Trifolium thalii Vill.	....	...2..	....	57555...............3..	....	......2.........2....	2225	....2..........	....
99 - Tussilago farfara L.	....	...5..	....	....	.2..	....	....	....	....
100 - Ranunculus pyreneus L.	....	...2..	....	....	....	....	....	....	....
101 - Thlaspi alpestre L.	....	...2..	....	....	....	....	....	....	....
102 - Veratrum album L.	....	...2..	....	....	....	....	....	....	....
* 103 - Deschampsia flexuosa (L.) Trin.	....	....3.	...5..5755.35553	.....2..5.........2...	....	....................2.	....	......3........	................5..
104 - Veronica fruticulosa L.	....	....2.	....	........2............	....	....	....	....	....

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		2221125517	131019	66555116867766571	5271710005890006	1100	99999918488788777	61 899	4434840	5544443	3313323234	3222616
	Relevés N.	0129830163	475378	45465013590112722	79685944380798869426 7	3401	23657427401632459748 6	9101	239081522357868	561019384932675650
* 105	- Centaurea uniflora Turra	.....	2	2.....222....3	.....3.....	....	.....	....	.....	.....
* 106	- Achillea millefolium L.	.....	2	.2222222..2222...	.....2.....3.3.2	.2..	2	....	.....	.....2.
* 107	- Carlina acaulis L.	.....	2	..2.2.....22.22..	.....2.....2..2..2	22..	2	....	.....	.....
* 108	- Sesleria varia (Jacq.) Wettst.	.....	2	.....3.3..2..3.3.	5	3573	.....2.22.22.5...	....	.....	..2.....2.
109	- Polygonum bistorta L.	.....	2	......2..2..2....	.....2..3.....	....	.....	....	.....	.....
* 110	- Trifolium pallescens Schreb.	.....	2	.....2..2.	.....3.....5..2.	2533	....55.....2.....	....	.....2.....	.....2....55.
111	- Trollius europaeus L.	.....	5	.....2....	.....	....	.....	....	.....	.....
112	- Carduus nutans L.	.....	2	.....	.....2.....2	....	.....	....	.....	.....
113	- Onobrychis viciifolia Scop.	.....	3	.....	.....5..	....	.....	....	.....	.....
114	- Astragalus alpinus L.	.....	2	.....	.....	....	.2.....	....	.....	.....
115	- Crepis aurea (L.) Cass.	.....	2	.....	.....	....	....2.....	....	.....	.....2.....
116	- Poa cenisia All.	.....	5	.....	.....	....	.....2...5...	....	.....	.....
117	- Aster bellidiastrum (L.) Scop.	.....	2	.....	.....	....	.....2...	....	.....	..3.....
* 118	- Agrostis capillaris L.	.....	.....	25552....32..2.3.	.....	....	.....	....	..2.	3.....	.....5.
* 119	- Trifolium repens L.	.....	.....	325.2..222...2...	2	....	.....	....	...2	.....
* 120	- Helianthemum nummularium (L.) Miller	.....	.....	32..73557535553..	.....5.7...	.3..	.....	....	.....	.....3.
121	- Luzula multiflora (Ehrh.) Lej. ssp. congesta	.....	.....	22...2.....2....	..2.2.....	....	.....	....	.....	.....
* 122	- Anemone narcissiflora L.	.....	.....	52.....2....2....	.....	....	.....	....	.....	.....
123	- Teucrium chamaedrys L.	.....	.....	22.....	.....	....	.....	....	.....	.....
* 124	- Plantago maritima L. ssp. serpentina Arcangeli	.....	.....	2.22.525....23...	2	....	2	....	.....	.....3.
* 125	- Rhinanthus alectorolophus (Scop.) Pollich	.....	.....	2.22.32....2...2.	2	....	.....	....	.....	.....
* 126	- Arnica montana L.	.....	.....	2..3...3.33322..3	.....2.....2.....	....	.....	....	.....	.....
* 127	- Potentilla grandiflora L.	.....	.....	2....22332232.325	.....2.2.532322	....	.....	....	.....	.....2.
128	- Bartsia alpina L.	.....	.....	2....2...222...2.	.....3.....2....2	....	.....2.3.233.2...	....	.....	..2.....
* 129	- Festuca paniculata Sch.& Tell. ssp. spadicea	.....	.....	2.....5557....	.....	....	.....	....	.....	.....
130	- Pulsatilla halleri (All.) Willd.	.....	.....	2.....	.....	....	.....	....	...2	.....
131	- Coeloglossum viride (L.) Hartman	.....	.....	2.....	.....	..2.	.....	....	.....	.....
132	- Genista tinctoria L.	.....	.....	2.....	.....	....	.....	....	.....	.....
133	- Hypericum perforatum L.	.....	.....	2.....	.....	....	.....	....	.....	.....
134	- Phyteuma ovatum Honckeny	.....	.....	2.....	.....	....	.....	....	.....	.....
135	- Potentilla erecta (L.) Rauschel	.....	.....	.2322.....2....	.....3.....52....2	....	.....	....	.....	.....
136	- Festuca arvenensis Auquier	.....	.....	.2.....2..2.....	2	....	2.2.....	....	...5	.....
137	- Viola calcarata L.	.....	.....	.2.....2222....	.....222..222..	22..	.....3.....	....	.....	.....
138	- Campanula rotundifolia L.	.....	.....	.2.....2..	.....2.....	....	.....2.....	....	.....	.....
139	- Lathyrus montanus Bernh.	.....	.....	.2.....	.....	....	.....	....	.....	.....
140	- Thymus pulegioides L.	.....	.....	..2322.35.....32.	.....2..2..2...2.5222	52..	.....2.....	....	...2 .....2.....	.....
141	- Hieracium pilosella L.	.....	.....	..322.2222.2223..	.....22.22.2.22	....	.....	....	.....	.....
* 142	- Bupleurum ranunculoides L.	.....	.....	..222.2..322.2.2.	..2.....	.2..	.....2.2	....	.....	.....
143	- Calluna vulgaris (L.) Hull.	.....	.....	..252.....2...	.....	....	.....	....	.....	.....
144	- Polygala chamaebuxus L.	.....	.....	..223.....	2	....	.....	....	.....	.....
145	- Chamacytisus supinus (L.) Link	.....	.....	..32.....	.....	....	.....	....	.....	.....
146	- Galium verum L.	.....	.....	..2.2....2.3.....	2	....	.....	....	.....	.....
147	- Dianthus seguieri Vill.	.....	.....	..2.2.....	2	....	.....	....	.....	.....
148	- Carex caryophyllea La Tourr.	.....	.....	..3.3.....	.....	....	.....	....	.....	.....
149	- Festuca valesiaca Schleicher	.....	.....	..2.5.....	.....	....	.....	....	.....	.....
150	- Cerastium fontanum Baumg. ssp. triviale (Link) Jalas	.....	.....	..2.....	.....2.....	....	.....	....	.....	.....
151	- Prunella vulgaris L.	.....	.....	..2.....	5	....	.....	....	.....	.....
152	- Plantago media L.	.....	.....	..2.....	.....2..	....	.....	....	.....	.....2..
153	- Hypericum tetrapterum Fries	.....	.....	..2.....	.....	....	.....	....	.....	.....
154	- Veronica officinalis L.	.....	.....	..2.....	.....	....	.....	....	.....	.....
155	- Gentiana acaulis L.	.....	.....	...33..2.2...22..	.....2.....2..2.23	....	2	....	.....	.....
156	- Vaccinium myrtillus L.	.....	.....	...22....2.2.....	.....	....	.....	....	.....	.....
157	- Genista germanica L.	.....	.....	...22.....	2	....	.....	....	.....	.....
158	- Lotus corniculatus L.	.....	.....	...2.23....2.....	.....	....	.....	....	.....	.....32.
* 159	- Antennaria dioica (L.) Gaertner	.....	.....	...2...252...322.	.....2....222.....5.	3222	2.....2.....2.....	....	.....2.....	.....
160	- Thesium alpinum L.	.....	.....	...2.....222.....	.....	2...	.....	....	.....	.....
* 161	- Luzula campestris (L.) DC.	.....	.....	...2.....2....2..	.....2.	....	.....	....	.....	.....2.5.2.253....
162	- Cirsium acaule Scop.	.....	.....	...2.....2.....	.....2.2..2	....	2	....	.....	.....3.
163	- Alchemilla alpina L.	.....	.....	...2.....33.	.....5.2....2.....	....	.....7.....	....	.....	..2.....2.....5.2
164	- Carex montana L.	.....	.....	...5.....	.....2.....	....	2	....	.....	.....
165	- Brachypodium pinnatum (L.) Beauv.	.....	.....	...2.....	.....	....	5	....	.....	.....
166	- Danthonia decumbens (L.) DC.	.....	.....	...2.....	.....	....	.....	....	.....	.....
167	- Viola hirta L.	.....	.....	...2.....	.....	....	.....2...	....	.....	.....
168	- Leontodon hispidus L.	.....	.....	....23.....2...	.....2.....	23..	.....	..2.	.....	..2.....2.
169	- Leucanthemum adustum (Koch) Gremli	.....	.....	....22.....	.....2.....	....	.....	....	.....	.....
170	- Viola canina L.	.....	.....	....2.....	.....	....	.....	....	.....	.....

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Relevés N.	0129830163	475378	45465013590112722	796859443807988694267	3401	236574274016324597486	9101	239081522357868	561019384932675650
171 - Chamaecytisus hirsutus (L.) Link	....	......	....3............	....	....	....	....	....	....
172 - Teucrium scorodonia L.	....	......	....2............	....	....	....	....	....	....
173 - Hippocrepis comosa L.	....	......	.....2..3.2..2...	................2...2	....	....	.2..	....	....
174 - Polygala vulgaris L.	....	......	.....2.........2.	....	....	2	....	....	....
175 - Hieracium glaciale Reyn.	....	......	.....2..........2	23......2.........2..	....	....	....	........23.....	........2.........
176 - Carduus defloratus L.	....	......	.....2...........	....	....	...2.2...............	....	....	....
177 - Salvia pratensis L.	....	......	.....2...........	....	....	2	....	....	....
178 - Dactylorrhiza maculata (L.) Soo'	....	......	.....2...........	....	....	....	....	....	..2...............
179 - Carex cespitosa L.	....	......	.....2...........	....	....	....	....	....	....
180 - Carex ornithopoda Willd.	....	......	.....3...........	....	....	....	....	....	....
181 - Campanula barbata L.	....	......	......2..3222....	2	....	....	....	....	....
182 - Briza media L.	....	......	......2........2.	..1............1....2	.2..	2	....	....	................2.
183 - Thalictrum foetidum L.	....	......	......2..........	....	....	....	....	....	....
184 - Galium pusillum L.	....	......	......2..........	........2............	2...	....	....	....	....
185 - Chenopodium bonus henricus L.	....	......	......2..........	....	....	....	....	....	....
186 - Helictotrichon parlatorei (J.Woods) Pilger	....	......	......2..........	....	....	....	....	....	....
187 - Paradisea liliastrum (L.) Bertol.	....	......	......2..........	....	....	....	....	....	....
188 - Peucedanum oreoselinum (L.) Moench	....	......	......2..........	....	....	....	....	....	....
189 - Trifolium montanum L.	....	......	......2..........	....	....	....	....	....	....
190 - Festuca gracilior (Hackel) Markgr.-Dannenb. (=F.ovina duriuscula)	....	......	.......75........	...................5.	....	....	....	....	..2...............
191 - Botrychium lunaria (L.) Swartz	....	......	.......2.222.....	..................22.	....	....	....	....	....
192 - Dactylis glomerata L.	....	......	.......2..2......	2	....	....	....	....	....
193 - Erigeron alpinus L.	....	......	.......2.....2...	....	....	......2..............	....	....	................2.
194 - Nigritella nigra (L.) Reichenb. fil.	....	......	.......2.........	....	....	....	....	....	....
195 - Juniperus communis L. ssp. nana Syme	....	......	........2222.....	2	....	....	....	....	....
196 - Dianthus pavonius Tausch.	....	......	........2.....2..	............2....2.2.	....	2..2.................	....	......2........	....
197 - Silene nutans L.	....	......	........2........	........3......2.....	....	....	....	....	....
198 - Vitaliana primuliflora Bertol.	....	......	........3........	...................2.	....	....	....	....	....
199 - Pulsatilla alpina (L.) Delarbre	....	......	.........5523...2	5	....	....	....	....	....
200 - Phyteuma orbiculare L.	....	......	.........222.....	...............2....2	22..	....	....	....	........22........
201 - Stachys monieri (Gouan) P.W.Ball	....	......	.........222.....	.................2...	....	....	....	....	....
202 - Thymus serpyllum L.	....	......	.........2...2...	............23.......	....	2	....	....	....
203 - Veronica allionii Vill.	....	......	.........2.......	............2....522.	....	...2.................	....	....	....
204 - Pedicularis rostratospicata Crantz	....	......	..........22.22..	.....2.......2.......	....	....	....	....	....
205 - Hypocheris uniflora Vill.	....	......	..........2.2....	..............2......	....	....	....	....	....
206 - Cruciata glabra (L.) Ehrend.	....	......	..........2......	2	....	....	....	....	....
* 207 - Oxytropis helvetica Scheele	....	......	...........2.....	....	2...	5.5.52...2.2222.32...	.22.	....2..........	....
208 - Pseudorchys albida (L.) A.& D.Love	....	......	...........2.....	2	....	....	....	....	....
209 - Hieracium sp.	....	......	...........2.....	....	....	2	....	....	....
210 - Acinos alpinus (L.) Moench	....	......	...........2.....	....	....	....	....	....	....
211 - Trisetum flavescens (L.) Beauv.	....	......	............22...	....	....	....	....	....	....
212 - Euphrasia rostkoviana Hayne	....	......	............2....	........2........2..2	....	....	....	....	....
213 - Hypocheris maculata L.	....	......	............2....	2	....	....	....	....	....
214 - Silene otites (L.) Wibel	....	......	............2....	2	....	....	....	....	....
215 - Centaurea montana L.	....	......	............2....	....	....	....	....	....	....
216 - Phyteuma michelii All.	....	......	............2....	....	....	....	....	....	....
217 - Prunella grandiflora (L.) Scholler	....	......	............2....	....	....	....	....	....	....
218 - Helianthemum nummularium (L.) Mill. ssp. grandiflorum Sch.& Thell.	....	......	............5....	....	....	....	....	....	....
219 - Anthyllis vulneraria L.	....	......	.............2.2.	5	....	....	....	....	....
220 - Sempervivum montanum L.	....	......	..............3.2	....	....	........3............	....	...2..........2	........22........
221 - Campanula cochleariifolia Lam.	....	......	..............2..	..........2..........	....	..............2....2.	....	....	....
* 222 - Helianthemum oelandicum (L.) DC. ssp. italicum	....	......	..............3..	....	55..	..22.2.....22.22.2..2	....	....	................3.
223 - Polytrichum alpinum L.	....	......	..............3..	....	....	....	....	5	....
224 - Festuca rubra L.	....	......	..............2..	....	....	....	....	....	....
225 - Rhododendron ferrugineum L.	....	......	...............3.	.....22..............	....	....	....	....	....
* 226 - Leucanthemum atratum (Koch) Gremli	....	......	...............3.	........2.......2....	2..2	222.......2..........	22.2	....2..........	..2...............
* 227 - Salix retusa L.	....	......	...............3.	............3........	..2.	555557...25533525257.	....	....5..........	....
228 - Minuartia recurva (All.) Schinz & Hoppe	....	......	...............2.	...................2.	....	........2............	....	5	....
229 - Primula farinosa L.	....	......	...............2.	....	..32	....	....	....	..2...............
* 230 - Salix reticulata L.	....	......	...............2.	....	..2.	55555....857538552...	....	....	..2...............
231 - Salix breviserrata Flod.	....	......	...............2.	....	..3.	...............5.....	....	.....2.........	..5............2..
* 232 - Dryas octopetala L.	....	......	...............3.	....	....	5722......3373522....	....	....	....
* 233 - Kobresia myosuroides (Vill.) Fiori	....	......	...............3.	....	....	33...3.27..2.333.2...	....	....	....
234 - Saxifraga aizoides L.	....	......	...............2.	....	....	.........22..........	.2..	....	..2...............
235 - Trifolium badium Schreber	....	......	...............2.	....	....	...............2.....	....	....	..........2.......
236 - Juncus trifidus L. ssp. monanthos (Jacq.) Ascherson & Graebner	....	......	3	....	....	........2............	....	....	....

	Relevés N.	2221125517 0129830163	131019 475378	66555116867766571 45465013590112722	5271710005890006 79685944380798869426	1111 1100 7 3401	111 1111	99999918488788877 23657427401632459748	1 6	1 1 899 9101	4434840 2390815223578	5544443 68	3313323234 5610193849326	3222616 75650
237	Callianthemum coriandrifolium Reichenb.	.....	.....	2	.....	....	.....	.....	....	.....	.....	.....	.....	.....
238	Minuartia laricifolia (L.) Schiz & Thell.	.....	.....	2	.....	....	.....	.....	....	.....	.....	.....	.....	.....
239	Sanguisorba minor Scop.	.....	.....	2	.....	....	.....	.....	....	.....	.....	.....	.....	.....
240	Achillea erba rotta All.	.....	.....	.....	2	....	.....	.....	....	.....	3	.....	.....	.....
241	Festuca varia Haenke	.....	.....	.....	2	....	.....	.....	....	.....	.....	.....	2	.....
242	Potentilla crantzii (Crantz) G.Beck	.....	.....	.....	.....	23..	.....	.....	....	.....	.....	.....	.....	.....
243	Sempervivum arachnoideum L.	.....	.....	.....	.....	....	.....	.....2.....	...2	.....	.2.....	.....	.....	.....
244	Astragalus penduliflorus Lam.	.....	.....	.....	.....	....	.....	3	....	.....	.....	.....	.....	.....
245	Euphorbia cyparissias L.	.....	.....	.....	.....	....	.....	.....	...3	.....	.....	.....	.....	.....
246	Ranunculus glacialis L.	.....	.....	.....	2.....	....	.....	.....2.	....	.222	.....	.....	...22.2	.....2....
247	Viola palustris L.	.....	.....	.....	.23.....	....	.....	.....	....	.....	.....	.....	.....	.....
* 248	Gnaphalium supinum L.	.....	.....	.....	..22..22.....	....	.....	...2..2.....2....	..2.	2232	52	..2	...223.222	.222....
249	Gentiana nivalis L.	.....	.....	.....	....2.....	....	.....	.....	.2..	.....	.....	.....	.....	.....
* 250	Polytrichum juniperinum Willd.	.....	.....	.....	.....23.2.22.2.....	....	.....	.....5.....	...2	.....	3.7.....	.....	.....	.....
251	Cladonia furcata (Hudson) Schrad.	.....	.....	.....	.....35.....	....	.....	.....	....	.....	.....2.....	.....	.....2.....	.....
* 252	Carex lachenalii Schkuhr	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	23.5.33.2	.....2...
* 253	Alopecurus gerardi Vill.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	22.....25	.....
254	Eriophorum latifolium Hoppe	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	..2.....	.....
* 255	Sedum atratum L.	.....	.....	.....	.....2.....	....	.....	.....2.	....	2.22..2222.2..	.....	.....	22	.....
256	Rhinanthus minor L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....3.
257	Scabiosa holosericea Bertol.	.....	.....	.....	.....2.....3.....	....	.....	3	...2	.....	.....	.....	.....	.....
258	Armeria alliacea (Cav.) Hoffmanns & Link	.....	.....	.....	.....2.....	....	.....	.....2.....	....	.....	.....	.....	.....	.....
259	Saxifraga bryoides L.	.....	.....	.....	.....2.....	....	.....	.....	....	2.2.....	3	.....	.....3...2	.....
260	Phyteuma betonicifolium Vill.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	2
261	Polypodium vulgare L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	2
262	Chaerophyllum hirsutum L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
263	Cryptogramma crispa (L.) R.B.Br.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
264	Cystopteris fragilis (L.) Bernh.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
265	Gentianella amarella (L.) Borner	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
266	Laserpitium halleri Crantz	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
267	Rumex acetosella L.	.....	.....	.....	.....5.....	....	.....	.....	....	.....	.....	.....	.....	.....
268	Sedum alpestre Vill.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
269	Sempervivum grandiflorum Haw.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
270	Sedum annuum L.	.....	.....	.....	.....2.....	....	.....	2	....	.....	2	2	.....	.....
* 271	Carex foetida All.	.....	.....	.....	.....2.....2.	....	.....	.....	....	..53	5	....	...25.2	..2...7....
272	Senecio incanus L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.2.....
273	Minuartia verna (L.) Hiern	.....	.....	.....	.....2.....	....	.....	.....2.22.	....	.....	.....	.....	2	2
274	Euphrasia alpina Lam.	.....	.....	.....	.....2.....	....	.....	2	....	.....	.....	.....	3	.....
275	Bunium bulbocastanum L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
276	Leontodon autumnalis L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
277	Onobrychis montana DC.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
278	Ajuga pyramidalis L.	.....	.....	.....	.....2.....	....	.....	.....	....	.....	.....	.....	.....	.....
279	Cirsium spinosissimum (L.) Scop.	.....	.....	.....	.....2....	..5.	.....	.....	....	.....	.....	.....	.....5.2	..
280	Carex firma Host	.....	.....	.....	.....3....	....	.....	.....	....	.....	.....	.....	.....	.....
281	Alyssum montanum L.	.....	.....	.....	.....2...	....	.....	.....	....	.....	.....	.....	.....	.....
* 282	Juncus jacquini L.	.....	.....	.....	.....5.	....	.....	.....	....	53.....3	.....	.....	3..33	.....5...
283	Hypericum montanum L.	.....	.....	.....	2	....	.....	.....	....	.....	.....	.....	.....	.....
284	Linum trigynum L.	.....	.....	.....	2	....	.....	.....	....	.....	.....	.....	.....	.....
285	Rosa pendulina L.	.....	.....	.....	5	....	.....	.....	....	.....	.....	.....	.....	.....
286	Leontodon hispidus L. ssp. danubialis (Jacq.) Simonakai	.....	.....	.....	2	....	.....	.....	....	.....	.....	.....	.....	.....
287	Carex umbrosa Host ssp. umbrosa	.....	.....	.....	2	....	.....	.....	....	.....	.....	.....	.....	.....
* 288	Globularia cordifolia L.	.....	.....	.....	.....	52..	.....	.....2.7	....	.....	.....	.....	.....	.....
* 289	Equisetum variegatum Schleicher	.....	.....	.....	.....	5...	.....	.....	....	.....	.....	.....	..5	.....
290	Euphrasia salisburgensis Funck	.....	.....	.....	.....	2...	.....	.....	....	.....	.....	.....	.....	.2.
291	Trifolium alpestre L.	.....	.....	.....	.....	2...	.....	.....	....	.....	.....	.....	.....	.....
292	Oxytropis jacquinii Bunge	.....	.....	.....	.....	.2..	2.....	.....	....	.....	.....	.....	.....	.....
293	Alchemilla subsericea Reuter	.....	.....	.....	.....	.5..	.....	.....	....	.....	.....	.....	.....	.3.
294	Leucanthemum atratum (Jacq.) DC. ssp. ceratophylloides Horvatic	.....	.....	.....	.....	.2..	.....	.....	....	.....	.....	.....	.....	.....
295	Tofieldia calyculata (L.) Wahlenb.	.....	.....	.....	.....	..2.	.....	.....	....	.....	.....	.....	..2	.....
296	Thymus glabrescens Willd.	.....	.....	.....	.....	..2.	.....	.....	....	.....	.....	.....	.....	.....
297	Carex ferruginea Scop.	.....	.....	.....	.....	...2	.....	.....	....	.....	.....	33..	..2	.....3..
298	Scirpus pumilus Vahl. [=Trichophorum pumilum (Vahl) Sch. & Th.]	.....	.....	.....	.....	...2	.....	.....	....	.....	.....	.....	.....	.....
* 299	Saxifraga exarata Vill.	.....	.....	.....	.....	....	2222.2	.....	....	.....	.....	.....	.....	.....
* 300	Festuca quadriflora Honckeny	.....	.....	.....	.....	....	32.....	.....2.	....	.....	.....	.....	.....	.....
301	Androsa alpina (L.) Lam.	.....	.....	.....	.....	....	2.....	.....	....	.....	2	.....	.....	.....
* 302	Arenaria ciliata L.	.....	.....	.....	.....	....	.222.22	.....2.....	....	.....	.....	.....	.....	.....

	Relevés N.									
			1		1111 111	1111	1 1		1 1	1 1
		2221125517	131019	66555116867766571	5271710005890006	1100	99999918488788877 7 61	899	4434840 5544443	3313323234 3222616
		0129830163	475378	45465013590112722	796859443807988694267	3401	236574274016324597486	9101	239081522357868	561019384932675650
* 303	Oxytropis campestris (L.) DC.	....	......	....	....	....	.222.2...............	....	....	....
* 304	Saxifraga oppositifolia L.	....	......	....	....	....	.222....23.222.2..3..	....	....	....
* 305	Saxifraga paniculata Miller (= S. aizoon Jacq.)	....	......	....	....	....	.222.................	....	....	....
* 306	Silene acaulis L. ssp. longiscapa Hayek	....	......	....	....	....	..3..23...2..3.5.....	....	....	....
307	Pedicularis cenisia Gaudin	....	......	....	....	....	..2..........2.......	....	......2........	..2...............
308	Veronica bellidioides L.	....	......	....	....	....	...22.22.............	.2..	2.............2	..........2.......
* 309	Salix serpyllifolia Scop.	....	......	....	....	....	...2...2....2.....2..	7558	....	....
310	Androsace carnea L.	....	......	....	....	....	...2............2....	....	....	....
311	Antennaria carpatica (Wahlenb.) Bluff.& Fingerh.	....	......	....	....	....	.......2.............	....	....	....
* 312	Anemone baldensis L.	....	......	....	....	....	.........222....52...	....	....	....
313	Cladonia pixidata (L.) Fr.	....	......	....	....	....	..........2...2......	...2	....	....
314	Epipactis atrorubens (Hoffm.) Besser	....	......	....	....	....	...........2.........	....	....	....
315	Hieracium murorum L.	....	......	....	....	....	............2........	....	....	2
* 316	Achillea atrata L.	....	......	....	....	....	.............2.2.....	....	....	....
317	Cerastium sp.	....	......	....	....	....	.............2.......	....	22.....2.......	....
318	Gypsophyla repens L.	....	......	....	....	....	.................3.2.	....	....	....
319	Anthyllis vulneraria L. ssp. pulchella (Vis.) Bornm.	....	......	....	....	....	.................2...	....	....	....
320	Helianthemum oelandicum (L.) DC. ssp. alpestre (Jacq.) Breistr.	....	......	....	....	....	.................2...	....	....	....
321	Achillea nana L.	....	......	....	....	....	..................3..	....	....	.......2..........
322	Campanula cenisisa L.	....	......	....	....	....	..................2..	....	....	....
323	Geum reptans L.	....	......	....	....	....	..................2..	....	....	....
324	Herniaria incana Lam.	....	......	....	....	....	..................2..	....	....	....
325	Petrocallis pyrenaica (L.) R.Br.	....	......	....	....	....	..................2..	....	....	....
326	Saussurea alpina (L.) DC.	....	......	....	....	....	..................2..	....	....	....
327	Asperula cynanchica L.	....	......	....	....	....	...................2.	....	....	....
328	Astragalus monspessulanus L.	....	......	....	....	....	...................3.	....	....	....
329	Bromus erectus Hudson	....	......	....	....	....	...................2.	....	....	....
330	Carlina vulgaris L.	....	......	....	....	....	...................2.	....	....	....
331	Cytisus sessilifolius L.	....	......	....	....	....	...................2.	....	....	....
332	Koeleria vallesiana (Honckeny) Gaudin	....	......	....	....	....	...................2.	....	....	....
333	Linum catharticum L.	....	......	....	....	....	...................2.	....	....	....
334	Minuartia mutabilis Schinz & thell.	....	......	....	....	....	...................2.	....	....	....
335	Ononis cristata Miller	....	......	....	....	....	...................2.	....	....	....
336	Senecio doronicum L.	....	......	....	....	....	...................2.	....	....	....
337	Teucrium montanum L.	....	......	....	....	....	...................2.	....	....	....
338	Vincetoxicum hirundinaria Medicus	....	......	....	....	....	...................2.	....	....	....
339	Viola rupestris F.W. Schmidt	....	......	....	....	....	...................2.	....	....	....
340	Pinguicula vulgaris L.	....	......	....	....	....	....	.2..	....	..2...............
341	Doronicum grandiflorum Lam.	....	......	....	....	....	....	.2..	....	....
342	Galium album Miller	....	......	....	....	....	....	...2	....	....
* 343	Carex ovalis Good.	....	......	....	....	....	....	....	2533.5.........	....
* 344	Cerastium alpinum L.	....	......	....	....	....	....	....	2222......22...	........2...2.....
345	Oxyria digyna (L.) Hill	....	......	....	....	....	....	....	.2.............	...........2......
346	Carex hallerana Asso	....	......	....	....	....	....	....	..2............	....
347	Sagina procumbens L.	....	......	....	....	....	....	....	...2...........	....
348	Scirpus hudsonianus (Michx) Fernald	....	......	....	....	....	....	....	.....2.........	....
349	Epilobium fleicheri Hochst.	....	......	....	....	....	....	....	.......5.......	....
350	Salix helvetica Vill.	....	......	....	....	....	....	....	.......3.......	....
351	Hieracium amplexicaule L.	....	......	....	....	....	....	....	.......2.......	....
* 352	Hutchinsia alpina (L.) R.Br.	....	......	....	....	....	....	....	........32.....	....
353	Gentiana bavarica L.	....	......	....	....	....	....	....	..........2....	....
354	Saxifraga muscoides All.	....	......	....	....	....	....	....	.............2.	....
355	Epilobium palustre L.	....	......	....	....	....	....	....	....	5.................
356	Agrostis canina L.	....	......	....	....	....	....	....	....	..2...............
357	Carex davalliana Sm.	....	......	....	....	....	....	....	....	..5...............
358	Carex flacca Schreber	....	......	....	....	....	....	....	....	..2...............
359	Deschampsia cespitosa (L.) Beauv.	....	......	....	....	....	....	....	....	..2...............
360	Juncus alpino-articulatus Chaix	....	......	....	....	....	....	....	....	..3...............
361	Juncus triglumis L.	....	......	....	....	....	....	....	....	..2...............
362	Veronica serpyllifolia L.	....	......	....	....	....	....	....	....	.........2........
363	Alnus viridis (Chaix) DC.	....	......	....	....	....	....	....	....	...............2..
364	Asplenium septentrionale (L.) Hoffm.	....	......	....	....	....	....	....	....	2
365	Campanula elatines L.	....	......	....	....	....	....	....	....	3
366	Festuca tenuifolia Sibth.	....	......	....	....	....	....	....	....	3

Appendix D

Table D1. Frequency of differential plant species in the nine vegetation types.

Differential species	Vegetation Types								
	I	II	III	IV	V	VI	VII	VIII	IX
Group 1									
Pedicularis kerneri Dalla Torre	8			1	2			5	4
Astrantia minor L.	7	1	1						
Bellardiochloa violacea (Bellardi) Chiov.	6		2			1			
Primula pedemontana Thomas	7		1						
Agrostis alpina Scop.	6	1	3	6					
Trifolium alpinum L.	6		10	5					1
Rhodiola rosea L.	3								
Pulsatilla alpina Delarbre ssp. *apifolia* Nyman	2								
Festuca violacea Schleicher	5	1	4	8		9		5	4
Ligusticum mutellinoides (Crantz) Vill.	4					1			
Group 2									
Ranunculus montanus Willd.	1	6	6	5		1			2
Taraxacum officinale Weber	1	4		1				1	
Anthoxantum odoratum L.	2	4	11	9		2	1	1	6
Poa alpina L. ssp. *vivipara* (L.) Arcangeli		5					1	4	7
Cerastium arvense L.		5	2	7				1	
Lotus alpinus (DC.) Schleicher		6	6	15	2	11	1	6	4
Group 3									
Juncus trifidus L.	2		11	2				1	
Biscutella laevigata L.	1	1	5			1			
Trifolium pratense L. var. *frigidum* Gaudin		1	8	5		1			
Deschampsia flexuosa (L.) Trin.		1	10	3		1		1	1
Centaurea uniflora Turra		1	5	1	1				
Achillea millefolium L.		1	11	4	1	1			1
Agrostis capillaris L.			9				1	1	1
Trifolium repens L.			8	1			1		
Helianthemum nummularium (L.) Miller				13	2	1			1
Anemone narcissiflora L.			4						
Plantago maritima L. ssp. *serpentina* Arcangeli			8	1			1		1
Rhinanthus alectorolophus (Scop.) Pollich			7	1					
Arnica montana L.			9	2	1				
Potentilla grandiflora L.			12	8	1				1
Festuca paniculata Sch.& Tell. ssp. *spadicea*			5						
Bupleurum ranunculoides L.			9	1	1	2			
Group 4									
Carex sempervirens Vill.	4		11	17	1	8			
Geum montanum L.	1	3	6	17		1		2	7
Nardus stricta L.	1	2	14	18		1			14
Alchemilla xanthochlora Rothm.	1	3	7	13	1	3			7
Phleum alpinum L.		2	3	9					2
Sibbaldia procumbens L.		1		11				3	4
Veronica alpina L.		1		8				2	6
Polytrichum juniperinum Willd.				6		1	1	2	

Group 5									
Silene acaulis (L.) Jacq.	1				2	1			
Plantago alpina L.	1		1	9	4	4	1		1
Festuca ovina L.		1	5	2	3	5		1	
Gentiana verna L.		1	1	2	2	7		1	
Carlina acaulis L.		1	6	4	2	1			
Sesleria varia (Jacq.) Wettst.		1	5	1	4	6			2
Trifolium pallescens Schreb.		1	2	3	4	3		1	3
Antennaria dioica (L.) Gaertner			7	5	4	3		1	
Globularia cordifolia L.					2	2			
Equisetum variegatum Schleicher					1				1
Group 6									
Helictotrichon sedenense (DC.) J.Holub	1	1	2			4			
Oxytropis helvetica Scheele			1		1	11	2	1	
Helianthemum oelandicum (L.) DC. ssp. *italicum*			1		2	9			1
Salix retusa L.			1	1	1	17		1	
Salix reticulata L.			1		1	14			1
Dryas octopetala L.			1			11			
Kobresia myosuroides (Vill.) Fiori			1			10			
Saxifraga exarata Vill.						5			
Festuca quadriflora Honckeny						3			
Arenaria ciliata L.						6			
Oxytropis campestris (L.) DC.						4			
Saxifraga oppositifolia L.						10			
Saxifraga paniculata Miller						3			
Silene acaulis L. ssp. *longiscapa* Hayek						6			
Anemone baldensis L.						5			
Achillea atrata L.						2			
Group 7									
Cerastium arvense L. ssp. *strictum* Goudin	1		3	1	1	3	4	2	1
Festuca halleri All.	2	1	1	1		2	3	3	1
Trifolium thalii Vill.		1		6		2	4	1	
Leucanthemum atratum (Koch) Gremli			1	2	2	4	3	1	1
Salix serpyllifolia Scop.						4	4		
Group 8									
Salix herbacea L.	4	1		5		6	2	13	15
Carex curvula All.	1			2		5		5	1
Gnaphalium supinum (L.) DC.				4		3	1	7	9
Sedum atratum L.				1		1		8	2
Carex ovalis Good.								5	
Cerastium alpinum L.								6	2
Hutchinsia alpina (L.) R.Br.								2	
Group 9									
Eriophorum scheuchzeri Hoppe	1								4
Carex capillaris L.	2				1				6
Carex frigida All.	2								5
Agrostis rupestris All.	3	3		2		4	1	4	11
Carex fusca All.	1	2				1			4
Alchemilla pentaphyllea L.		3		7		1		4	13
Leucanthemopsis alpina (L.) Heyw.		1		2		3		9	13
Luzula campestris (L.) DC.			3	1					6
Carex lachenalii Schkuhr				1					7

Alopecurus gerardi Vill.	1			4
Carex foetida All.	2		3	5
Juncus jacquini L.	1		3	4

Table D2. Total frequency of groups of the differential species in the vegetation types

Groups	Vegetation types								
	I	II	III	IV	V	VI	VII	VIII	IX
1	54	3	21	20	2	11	0	10	9
2	4	27	25	37	2	14	3	13	19
3	3	5	134	31	6	7	2	3	6
4	7	12	41	99	2	14	1	9	40
5	2	5	27	26	28	32	1	4	7
6	1	1	8	1	5	120	2	2	2
7	3	2	5	10	3	15	18	7	3
8	5	1	0	12	0	15	3	46	29
9	9	9	3	17	1	9	1	23	82

Appendix E

Table E1. Frequency of fungus species. Ectomycorrhizal fungi are indicated by an asterisk (*)

Fungi	Vegetation types								
	I	II	III	IV	V	VI	VII	VIII	IX
Group 1									
Bovista nigrescens	1		4			1			1
Bovista plumbea	1		1						
**Cortinarius albonigrellus*	1								1
**Cortinarius minutulus*	1					2			5
**Hebeloma crustuliniforme*	1		1						
Hygrocybe pseudoconica	1								
**Inocybe dulcamara*	2			1		1	2	1	2
**Inocybe dulcamara* var *malenconi*	1								
**Inocybe leucoblema*	1								
**Laccaria laccata*	2		1			2		5	3
Naucoria scolecina	1								2
**Russula nana*	6	2	1	7		1		1	7
Group 2									
Calocybe georgii		1	1						
Clitocybe gibba		1	1		1				
Gerronema reclinis		1							1
**Laccaria proxima*		1	1						5
Melanoleuca grammopodia		1							
Octospora rubens		1							
Stropharia semiglobata		1							
Group 3									
Clitocybe alexandrii			1			1			
Clitocybe rivulosa			1	1		1			
Collybia dryophila			1						

**Cortinarius anomalus*	1			
**Cortinarius bicolor*	2			
**Cortinarius fasciatus*	1			
**Cortinarius hinnuleus*	3			
**Cortinarius phaeochrous*	1		1	
**Cortinarius subferrugineus*	1			
Entoloma juncinum	2			
Hygrocybe coccinea	1			
Hygrocybe punicea	1			
Hygrocybe subradiata	1			
**Laccaria pumila*	1			
**Laccaria tortilis*	1			
Lepista luscina	1			
Lycoperdon pyriforme	1			
Marasmius scorodonius	1			
Panaeolus fimicola	1	1	1	
Panaeolus retirugis	1			
Panaeolus rickenii	1	1		
Scutellinia scutellata	1			
Vascellum pratense	1			
Group 4				
Calvatia utriformis		1		
Galerina vittaeformis		1		
**Hebeloma alpinum*		1	2	
Hygrocybe persistens		1		
Hygrocybe reai var. *insipida*		1	1	
**Inocybe fastigiata* var. *alpina*		1	1	
**Inocybe friesii*		1		1
**Inocybe lacera* f. *heterospora*		1		
Lepista saeva		1		
Melanoleuca subalpina		1		
Mycena erubescens		1		
Naucoria alnetorum		4		
Panaeolus foenisecii		1		
Tubaria pellucida		3	2	
Group 5				
Collybia butyracea			1	
**Cortinarius glandicolor* f. *exilis*			1	1
**Cortinarius hoeftii*			1	
Entoloma griseocyaneum			1	
**Inocybe friesii* f. *epixantha*			1	
Group 6				
Bovista tomentosa			1	
Camarophyllus pratensis			1	
**Cortinarius alpinus*			1	
**Cortinarius decipiens*			2	
**Cortinarius helvelloides*			1	
**Cortinarius orellanus*			1	
Entoloma incanum			1	
Entoloma papillatum			1	
Entoloma sericeum			1	

Entoloma sericeum f. *nanum*	2		
**Hebeloma versipelle*	1		
**Hebeloma sarcophyllum*	2		
Hygrocybe conica	1		
Hygrocybe cystidiata	1		
Hygrocybe lepida	1		
**Inocybe decipiens*	1		2
**Inocybe lanuginella*	1		1
**Inocybe fastigiata* f. *alpestris*	1		
**Inocybe humilis*	1		
**Inocybe piricysti*	1		1
Marasmius epidryas	5		
Melanoleuca melaleuca	1		
Naucoria subconspersa	1		2
Naucoria tantilla	1	1	
Omphalina umbratilis	2	3	1
Panaeolus guttulatus	1		
Group 7			
**Hebeloma mesophaeum*	1		1
Group 8			
**Hebeloma marginatulum*		2	1
**Inocybe lacera* var. *heterocystis*		3	
**Russula oreina*		3	
Scutellinia trechispora		1	1
Group 9			
Agaricus semotus			1
Camarophyllus pratensis (f. *nanus*)			1
**Cortinarius glandicolor*			1
**Cortinarius inconspicuus*			1
**Cortinarius hinnuleus* var. *minutalis*			1
Exidia sp.			1
Galerina hypnorum			1
Hemimycena cucullata			1
**Inocybe canescens*			1
Mycena sp.			1
Scutellinia hirtella			1

Table E2. The sum of frequencies of fungal species of each group in the nine vegetation types

Groups	Vegetation types								
	I	II	III	IV	V	VI	VII	VIII	IX
1	19	2	7	7		7	2	7	21
2		7	3						6
3			27	3		4			
4				19	1	5	1		
5					5		1		
6						35		4	8
7							1		1
8								9	2
9									11

Table E3. The sum of frequencies of the saprophytic fungi of each group in the nine vegetation types

Groups	Vegetation types								
	I	II	III	IV	V	VI	VII	VIII	IX
1	4		4	1		1			3
2		6	2		1				1
3			16	3		3			
4				15		3			
5					2				
6						21		4	3
7									
8								1	1
9									7

Table E4. The sum of frequencies of the symbiotic fungi of each group in the nine vegetation types

Groups	Vegetation types								
	I	II	III	IV	V	VI	VII	VIII	IX
1	15	2	3	8		6	2	7	18
2		1	1						5
3			11			1			
4				4	1	2	1		
5					3		1		
6						13			5
7							1		1
8								8	1
9									4

Appendix F

Table F. Frequency of the ectomycorrhizal plants in the nine vegetation types

	Ectomycorrhizal species	Vegetation types								
		I	II	III	IV	V	VI	VII	VIII	IX
1	*Polygonum viviparum*	9	6	10	12	2	17	2	4	13
2	*Salix herbacea*	4	1		5		6	2	13	15
3	*Helianthemum nummularium*			13	2	1				1
4	*Helianthemum nummularium* ssp. *grandiflorum*			1						
5	*Helianthemum oelandicum* ssp. *italicum*			1		2	9			1
6	*Salix retusa*			1	1	1	17		1	
7	*Salix reticulata*			1		1	14			1
8	*Salix breviserrata*			1		1	1		1	2
9	*Dryas octopetala*			1			11			
10	*Kobresia myosuroides*			1			10			
11	*Salix serpyllifolia*						4	4		
12	*Helianthemum oelandicum* ssp. *alpestre*						1			
13	*Salix helvetica*								1	