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Egil Ingvar Aune

FOREST VEGETATION IN HEMNE SØR-TRØNDELAG, WESTERN CENTRAL NORWAY

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FOREST VEGETATION IN HEMNE, SÖR-TRÖNDELAG, WESTERN CENTRAL NORWAY

by

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ABSTRACT

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In this phytosociological work six forest associations are recognized: *Vaccinio uliginosi-Pinetum* Kleist 29, *Bazzanio-Pinetum* K.-Lund 67, *Corno-Betuletum* ass. nov., *Melico-Betuletum* ass. nov., *Alno-Prunetum* K.-Lund 71, and *Ulmo-Tilietum* K.-Lund ex. Seibert 69. The associations are divided into several subunits. Principal components analysis and discriminant analysis applied on ten measured edaphic factors show significant differences among the main communities. The relations to vicarious communities in Eastern and Southern Norway are discussed.

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CONTENTS

The purpose of this study is to describe the floristic composition and ecological conditions of the forest vegetation in Hemne, Western Central Norway. Phytosociological investigations of the forest vegetation west of the spruce distribution limit in this part of Norway have not been published before. This work is based upon my cand.real. thesis at the University of Oslo 1970. The field work was carried out during the summers 1968 and 1969.

THE INVESTIGATION AREA

Geographical location (map, Fig. 1): The investigated area is situated in Hemne commune at the south western boundary of Sör-Tröndelag county in Central Norway. I have concentrated on an area called "Hollamarka" south and west of the Hemnefjord from about 63°16' to 63°19'N and from 9°6' to 9°15'E. A few vegetation analyses are also performed in the valley Sövassdalen about 10 km southwards.

Geology and topography. The area belongs to the Centrale Caledonides. The rock formations east of the area were mapped by Ramberg (s.a.), while Kirksæther (1969) has bescribed and mapped the rock formations west of Hemnefjorden. The rocks in the area are mostly hard and acidic, such as different gneisses, and some quartsitic schist. The gneisses may be hornblende-bearing and there are also small bands of biotic schist. Both biotite and hornblende are known to weather readily and may give rise to a favourable soil (cfr. Stålfelt 1965, p. 165).

In the low-lying areas there are quarternary and holocene deposits. These deposits consist of late-glacial and post-glacial marine clays, outwash sediments and morainal debris (Lasca 1970). The clays are mostly restricted to the areas below 70-80 m a.s.l., most of which are cultivated.

The topography is rather broken. Two streams, Hagaelva and Hollaelva, cross the area from south to north and west. The former

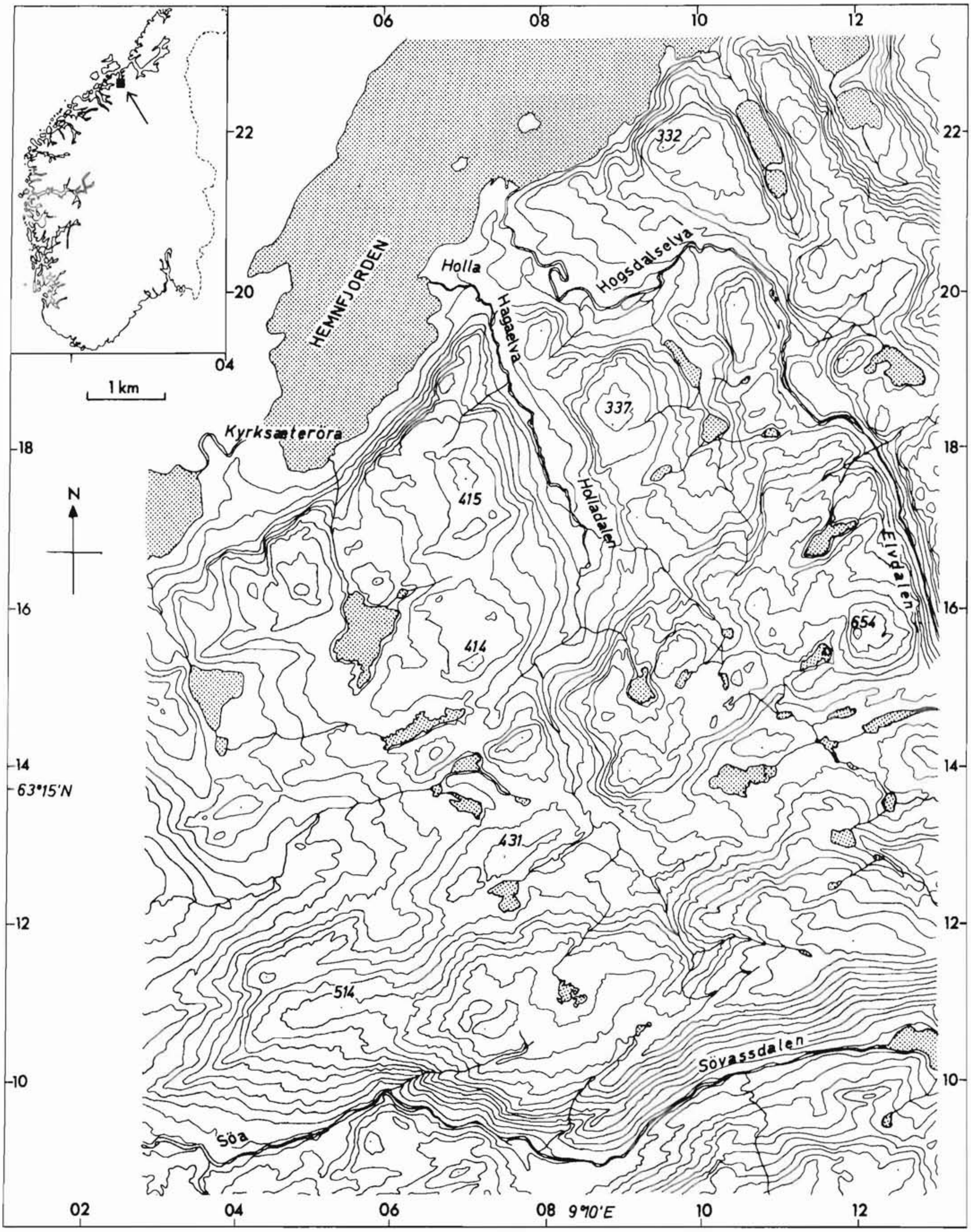


Fig. 1. Map of the investigation area. Redrawn from the sheets 1421 I, 1421 II, 1521 III, and 1521 IV of the Geographical Survey of Norway (NGO). Contour intervals 40 m. The figures along the margin gives the references of the UTM grid, zone 32 V, 100,000 m square NR.

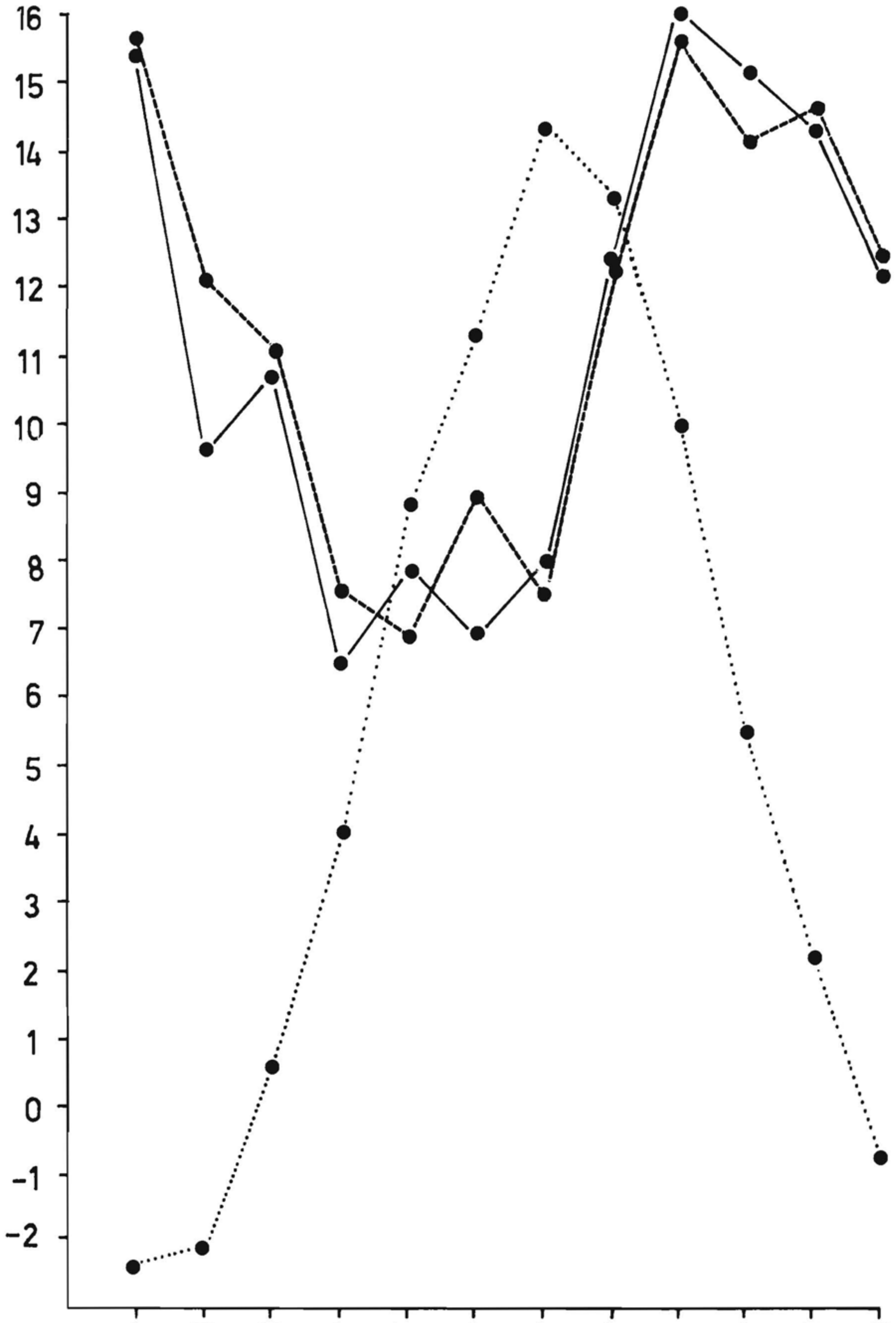


Fig. 2. Mean values of temperature (degrees Celcius) and precipitation (cm). Dotted lines: temperature at Vinjeöra; solid lines: precipitation at Vinjeöra; stippled lines: precipitation at Hemne.

flows through a broad U-shaped valley, whereas the latter runs through a narrow V-shaped valley which ultimately broadens into the inhabited and cultivated part of the area. Outside and between the valleys the landscape reaches altitudes between 300 and 400 m.

Climate. The area has a weakly oceanic climate, and the flora therefore contains many species which are regarded "sub-oceanic" (Aune 1969). The two official meteorological stations, Hemne and Vinjeöra, are situated slightly west of the investigation area. Both of them seem to be representative for the macro-climate of the area. Fig. 2 shows mean values of precipitation and temperature according to Nedbören i Norge (Precipitation in Norway), and Bruun (1962). The precipitation frequency is high, with measurable precipitation ($\geq$ 0.1 mm) 175-200 days a year. Fog and mist are common during the summer nights. The index of humidity (Martonne 1926) is 88 for station Vinjeöra. This is a high value. According to Dahl (1950, p. 32) most of Scandinavia has an index below 60. The index of hygrothermy (Amann 1929) is 47. Lye (1970, p. 32) has shown that what he calls oceanic hygrophytes (e.g. hepatics) require an index of at least 70. For the sub-oceanic ones, however, the limit is around the index value 20.

METHODS AND TERMINOLOGY

Field work. I have analysed the forest vegetation according to a method corresponding to the principles of the Central European Zürich-Montpellier School (Ellenberg 1956, Scamoni 1963, Braun-Blanquet 1964). This classification method has proved useful in several recent Norwegian phytosociological works (Kielland-Lund 1962, 1967, Marker 1969, Björnstad 1971).

The plots for analysis were selected in stands which I regarded floristic, physiognomic, and ecological homogeneous. For every plot the following data are recorded: map reference (UTM-system, cfr. Ouren 1966), date, area (at least 20 sq. m), altitude, slope, and aspect. The vegetation cover is divided into four strata: A - the tree layer (i.e. woody plants more than 2 m tall), B - the shrub layer (wood plants 0.3-2.0 m tall), C - the field layer (woody plants not taller than 0.3 m, and herbs, sedges, grasses, and ferns without regard to their tallness), D - the bottom layer (bryophytes and lichens). The total cover of each stratum is estimated in tenths (denoted TA, TB, TC, and TD in the vegetation tables). The cover and abundance of each species is given in accordance with the 11-point scale of Domin (Krajina 1933, p. 778, Dahl 1957, p. 44). Results obtained with the Domin scale may readily be compared with results obtained by the scales of Hult-Sernander or Braun-Blanquet (Dahl 1957, p. 44, Kershaw 1964, p. 14).

At most of the vegetation plots samples were taken of the humus layer, and the soil profile studied. The following abbreviations for the various types of soil profiles are employed in the tables: ps = podsol in general, ihp = iron humus podsol, ip = iron podsol, hp = humus podsol, pr = podsol ranker, sp = semipodsol (transition to brown soil), bs = brown soil. An arrow between two abbreviations indicates intermediary profiles.

Tabellary work. Throughout this work I use the term (plant) stand (German: "Pflanzenbestand") for the concrete phytocenose found in nature, whereas the terms community (German: "Pflanzengesellschaft") and association are confined to abstract vegetation units. This terminology is in accordance with that of Ellenberg (1956, p. 15). In the vegetation tables I have grouped analyses from similar stands together into communities. The communities are characterized and differentiated on floristic grounds. Characteristic and differential species are defined according to Braun-Blanquet (1964, p. 19). Besides the presence or absence of species the classification employed also takes into consideration dominance and total species composition. For ranking the communities in the phytosociological hierarchy the traditional principles are followed (Tüxen 1937, Scamoni 1963, Braun-Blanquet 1964). The communities are named in concordance with the recommendations of Bach et al. (1962), Rauschert (1963), and Moravec (1968, 1969).

In the tables every species are referred to a life form (Lf) as defined by Raunkiær (1907): Ph = phanerophytes, Ch = chamaephytes, H = hemicryptophytes, G = geophytes, and Th = therophytes. Fruticose lichenes, mosses, and liverworts with stem and leaves are referred to the chamaephytes. Thalloide liverworts and foliose lichens are regarded hemicryptophytes (Braun-Blanquet 1964, p. 146 ff.).

A column marked P in the tables indicates to which class of presence the species in question belong. The five classes of presence are defined as the "Stetigkeitsklassen" of Central European phytosociologists (Ellenberg 1956, p. 60). Another column gives the mean cover (C).

Soil analyses. The soil samples were air-dried at a low temperature ($< 30^{\circ}C$) in a well ventilated room. The dry soil was sieved through a sieve of 2 mm mesh width, and all further analyses were performed on the finer fraction.

I measured the pH in a suspension of 10 ml soil in 25 ml distilled water. The suspension was shaken three times during the following 24 hours, and the measurements were made immediately after the last shaking. A pH-meter with glass electrode was utilized ("Radiometer Titrator," type TTT 1a).

The amount of organic matter (humus) was determined as percentage loss on ignition. The ignition at 550-600°C lasted for 18 hours. pH and loss on ignition were measured for all soil samples collected. On 59 selected humus samples more complete chemical analyses were executed by the staff at the soil laboratory of the Norwegian Forest Research Institute, Ås.

Nitrogen content was determined by a semi-micro Kjeldahl method. Exchangeable hydrogen and metallic cations were measured after extraction with neutral 1 N ammonium acetate. The hydrogen ion concentration was determined by titration ("Radiometer Titrator"). Sodium and potassium were determined by flame photometry ("Zeiss flame photometer"), and calcium, magnesium, and manganese by atomic absorption flame photometry ("Zeiss atomic absorption flame photometer"). The soil density was simply determined by weighing a fixed volume of soil.

Taxonomic nomenclature. The nomenclature of the Pteridophyta, Gymnospermae, and Dicotyledones is in accordance with the "Flora Europaea" (Tutin et al. (ed.) 1964-1972). The nomenclature of the Monocotylodones follows Hylander (1953, 1966). The cryptogame nomenclature follows the following works: Musci (Nyholm 1954-1969), Hepaticae (Arnell 1956), and Lichenes (Poelt 1969).

DESCRIPTION OF THE FOREST COMMUNITIES

Synopsis of the communities

The figures and abbreviations for the communities introduced in this synopsis are used throughout this work in illustrations and tables.

Class Vaccinio-Piceetea
 Order Cladonio-Vaccinietalia
  Alliance Phyllodoco-Vaccinion
   Association Vaccinio uliginosi-Pinetum (VuP)
    (1) Variant with Sphagnum nemoreum (VuPSne)
    (2) Variant with Sphagnum russowii (VuPSru)
   Association Bazzanio-Pinetum (BzP)
    (3) Sub-association sphagnetosum (BzPsp)
      Sub-association hylocomietosum (BzPhy)
    (4) Typical variant (BzPhyt)
    (5) Dry variant (BzPhyd)
    (6) Variant with Racomitrium (BzPRa)
 Order Vaccinio-Piceetalia
  Alliance Vaccinio-Piceion
   Association Corno-Betuletum (CoB)
    (7) Sub-association myrtilletosum (CoBmy)
      Sub-association dryopteridetosum (CoBdr)
    (8) Immature variant (CoBdrim)
    (9) Mature variant (CoBdrma)
    (10) Sub-association thelypteridetosum limbospermae (CoBth)
    (11) Sub-association athyrietosum (CoBat)
   Association Melico-Betuletum (MeB)
    (12) Sub-association cornetosum (MeBcorn)
    (13) Sub-association coryletosum (MeBcory)
    (14) Sub-association athyrietosum (MeBat)
Class Querco-Fagetea
 Order Fagetalia sylvaticae
  Alliance Alno-Padion
    (15) Association Alno-Prunetum (AlPr)
  Alliance Tilio-Acerion
    (16) Association Ulmo-Tilietum (UlTi)

Class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939 p. 2.

Most of the forests in the area belongs to the *Vaccinio-Piceetea*. I have included both pine- and birch- forest communities in this class. Characteristic species are, in accordance with Dahl et al. (1967) and Kielland-Lund (1971):

Vaccinium myrtillus	*Hylocomium splendens*
Vaccinium vitis-idaea	*Pleurozium schreberi*
Linnaea borealis	*Barbilophozia lycopodioides*
Dicranum scoparium	

In addition the two species, *Cornus suecica* and *Ptilium crista-castrensis*, seems to be local characteristic species of the class. In eastern Norway these species are more or less limited to the spruce forests (Kielland-Lund 1962, 1971).

Order *Cladonio-Vaccinietalia* K.-Lund 1967 p. 139.

Braun-Blanquet et al. (1939) included only one order, the *Vaccinio-Piceetalia*, in the class *Vaccinio-Piceetea*. Kielland-Lund (1967) divided the conifer forests and related communities in two orders. The *Cladonio-Vaccinietalia* comprises oligotrophic pine forests and mountain heaths, while the rest of the class, the mesotrophic and eutrophic elements, are retained in the order *Vaccinio-Piceetalia* s.str.

In the Hemne-area the following seven species may be regarded as characteristic species of *Cladonio-Vaccinietalia* (cfr. Dahl et al. 1967, Kielland-Lund 1967).

Pinus sylvestris	*Sphagnum nemoreum*
Empetrum hermaphroditum	*Cladonia arbuscula*
E. nigrum	*C. rangiferina*
Vaccinium uliginosum	

In western Norway the two suboceanic hepatics *Anastrepta orcadensis* and *Bazzania trilobata* are possibly regional characteristic species of the order.

Differential species against *Vaccinio-Piceetalia* are *Calluna vulgaris* and *Ptilidium ciliare*.

Alliance *Phyllodoco-Vaccinion (myrtilli)* Nordh. 1936 p. 71.
Synonyms: See Dahl 1957 p. 116.

Nordhagen (1936) originally included oligotrophic, alpine heaths, and subalpine birch forests with *Vaccinium myrtillus* and *Deschampsia flexuosa* in his alliance *Phyllodoco-Vaccinion*. Kielland-Lund (1967, 1971) has referred most of the Scandinavian pine forest associations to this alliance, only the most eastern and southern pine associations of Scandinavia are left in the *Dicrano-Pinion* Libb. 1933.

Kielland-Lund (1967, Table 2) has given characteristic species of the *Phyllodoco-Vaccinion* as well as differential species against *Dicrano-Pinion*. I have grouped the pine forests of Hemne in two associations. They are the *Vaccinio uliginosi-Pinetum* (VuP) on boggy ground and the *Bazzanio-Pinetum* (BzP) on firm ground. Both associations are characterized by having some *Phyllodoco-Vaccinion*-species, but none of the *Dicrano-Pinion*-species. Table I gives the presence and middle cover for the species of *Phyllodoco-Vaccinion*.

Table I. Characteristic species and differential species of *Phyllodoco-Vaccinion* in the pine forests of Hemne. O = characteristic species of the order, Ph = characteristic species of *Phyllodoco-Vaccinion*, d = differential species against *Dicrano-Pinion*

		VuP	BzP
Ph	Orthocaulis attenuatus	II^1	I^2
Ph	O. floerkei	II^3	I^2
Ph	Cladonia bellidiflora	.	I^1
O, d	Empetrum hermaphroditum	II^4	(II)
O, d	Vaccinium uliginosum	V^5	IV^5
d	Betula pubescens (A+B+C)	III	III
d	B. nana	I^3	.
d	Cornus suecica	IV^3	V^4
d	Trientalis europaea	II^3	IV^2
d	Pohlia nutans	I^1	.
d	Polytrichum commune	II^3	IV^5

Association *Vaccinio uliginosi-Pinetum (sylvestris)* Kleist 1929 p. 54
(corr. Matuszkiewicz 1962. Basionym: *Pineto-vaccinietum uliginosi*)
Synonyms: see Matuszkiewicz 1962 p. 175.

This community is found on chiefly ombrotrophic peatland. On larger ombrotrophic bogs it is confined to the bog margins.

Floristic composition (Table II): Typical of this community is a mixture of species from conifer forests and bog species. The tree layer is composed of slow-growing pines, normally about 6-10 metres tall, although they may reach a height of 12 metres. Dominating species in the field layer are *Calluna vulgaris, Vaccinium uliginosum,* and *Empetrum nigrum*. Another striking, and sometimes co-dominant, species are *Eriophorum vaginatum* and *Rubus chamaemorus*. The bottom layer is somewhat heterogenous. Forest mosses such as *Hylocomium splendens* and *Pleurozium schreberi* are found around the pine trunks and below the crowns. Farther away from the trunks the bog mosses become more dominating.

Variation. I have recognized two variants of the association in Hemne. They are a variant with *Sphagnum nemoreum* and a variant with *Sphagnum russowii*.

The variant with *Sphagnum nemoreum* is found on the typical, level wooded bogs. Differential species against the variant with *Sphagnum russowii* are:

Drosera rotundifolia
Polytrichum juniperinum var. *gracilius*
Sphagnum magellanicum
Sphagnum fuscum
Lophozia ventricosa coll.

The variant with *Sphagnum russowii* is found on more or less inclined peatland. It is most common on shady valleysides subjected to a particular humid local climate, with much fog and high precipitation frequency. In this variant *Sphagnum nemoreum* is absent. The dominating *Sphagnum* species is *S. russowii*. Differential species against the variant with *S. nemoreum* are:

Plagiothecium undulatum
Polytrichum commune
Sphagnum centrale

Table III. Chemical analyses of soil samples (peat) from *Vaccinio uliginosi-Pinetum*

Reference number	Nitrogen in per cent of loss on ignition	Milliequivalents per 100 g dry substance								
		H	K	Na	Ca	Mg	Mn	Cation capasity	Base saturation, per cent	Density kg/l
5	1.299	177.94	1.23	1.16	10.52	14.43	0.23	145.52	18.96	0.200
17	1.655	98.89	0.65	1.09	5.61	9.27	0.00	115.53	14.40	0.289
26	1.152	114.74	1.19	1.01	8.95	11.78	0.01	137.67	16.66	0.119
32	1.111	120.09	1.25	1.17	9.57	14.41	0.01	146.51	18.03	0.123
42	1.026	115.61	1.55	1.37	9.06	15.88	0.15	143.63	19.50	0.170
54	1.175	94.58	2.34	1.38	6.66	12.79	0.16	117.91	19.79	0.160
94	0.992	100.63	1.60	1.35	9.73	12.90	0.01	126.20	20.27	0.121
114	0.986	118.58	1.04	1.36	7.45	12.82	0.01	141.26	16.06	0.081
60	1.166	104.79	2.19	1.46	10.32	13.44	0.16	132.36	20.83	0.159
110	1.052	102.54	1.49	1.60	11.83	13.79	0.14	131.39	21.96	0.072

Edaphic conditions. In Hemne the *Vaccinio uliginosi-Pinetum* is found on deep peat. The peat layer is at least 50 cm thick, usually more. This is a relatively dry type of bog with much heather and comparatively well aerated upper layers of the peat, and brown "hummock-peat." In the deeper layers there are sometimes spots with yellowish-brown reducing peat (cfr. Malmer 1962 p. 193).

Loss on ignition and pH-values are given in the vegetation tables. The results from a more detailed chemical analysis of ten samples are shown in Table III.

Association *Bazzanio-Pinetum* K.-Lund 1967 p. 133

Floristic composition (Table IV): Most of the pine forests on firm ground in the area belongs to this association. In the rather sparsely stocked tree layer the Scots pine (*Pinus sylvestris*) is the only species of any importance. *Juniperus communis* is a constant species in the shrub layer. The field layer is dominated of vigorously developed ericaceous species. The dominants are *Vaccinium myrtillus*, *Calluna*, and *Empetrum*. In moist stands *Vaccinium uliginosum* may be dominating. Locally species like *Cornus suecica* or *Blechnum spicant* may obtain co-dominance.

In the bottom layer *Hylocomium splendens* and *Pleurozium schreberi* are almost always among the dominants. Especially in the moister stands *Polytrichum commune* and *Sphagnum quinquefarium* are important species.

The *Bazzanio-Pinetum* contain no really good characteristic species. The two mosses *Polytrichum commune* and *Sphagnum quinquefarium* have a slight optimum in this association and they might have been regarded local characteristic species (Table V).

Table V. Presence and mean cover for *Sphagnum quinquefarium* and *Polytrichum commune* in the associations. Association names are abbreviated according the synposis on p. 13.

	VuP	BzP	CoB	MeB	AlPr	UlTi
Sphagnum quinquefarium	III^4	IV^5	I^3	.	.	.
Polytrichum commune	II^3	III^5	II^4	.	.	.

Variation. I have divided the *Bazzanio-Pinetum* in two sub-associations, a *sphagnetosum* and a *hylocomietosum*.

The *sphagnetosum* is common on shady valleysides. This is recognized by *Sphagnum quinquefarium* being predominant in the bottom layer. Differential species against the *hylocomietosum* are *Dactylorhiza maculata, Listera cordata, Plagiothecium undulatum, Obtusifolium obtusum,* and *Tritomaria quinquedentata.*

The *hylocomietosum* is found on places more exposed to the sun, and it lacks the moisture demanding differential species of the *sphagnetosum*. *Sphagnum quinquefarium* and *S. nemorum* may be present. They are, however, never dominants.

In the table I have divided the analysed stands of the *hylocomietosum* on two variants, a "typical" variant and a "dry" variant. The dry variant has fewer species than the typical variant. Especially the bottom layer is poorly developed. *Sphagna* and most of the hepatics are lacking.

At the end of Table IV I have put two analyses from an extremely poor community with *Racomitrium lanuginosum* and *Dicranum fuscescens* in the bottom layer. *Bazzania trilobata* probably has its optimum in this community. More material is necessary to decide whether this constitutes a sub-association of its own or not.

Edaphic conditions. The *Bazzanio-Pinetum* is found on poor and often shallow soils. The soil profiles show either a podsol or a podsol ranker (in the sense of Fitzpatrick 1964).

The podsol ranker is the more common profile type. Iron humus podsols are developed when the soil is deeper. This is usually the case in the drier stands. Both profile types have a litter layer (A_{00}) of about 2-3 cm, followed by 10-15 cm raw humus (A_0). Below the raw humus layer there is a horizon of bleached soil (A_2). This horizon has a thickness of 6-10 cm in the ranker profiles and rests directly on the rock surface. In the podsol profiles the A_2-layer is 3-8 cm and followed by a 20-40 cm deposition layer (B) below. Usually this deposition layer may be divided into an upper, darker B_1-layer and a lower lighter B_2-layer. The subsoil may be of variable nature.

The variant with *Racomitrium* is rather rare in the area and is found only on very shallow soils, often on large, freely lying blocks

Table VI. Chemical analyses of soil samples (A_0-layer) from *Bazzanio-Pinetum hylocomietosum*

Reference number	Nitrogen in per cent of loss on ignition	Milliequivalents per 100 g dry substance								
		H	K	Na	Ca	Mg	Mn	Cation capacity	Base saturation, per cent	Density kg/l
22	1.452	101.74	1.17	1.29	9.18	11.88	0.00	125.26	18.78	0.285
25	1.056	98.25	1.29	1.20	8.23	7.89	0.08	116.95	15.99	0.250
27	1.171	99.52	2.12	2.17	10.87	10.33	0.35	125.36	20.61	0.175
93	1.340	88.34	1.97	0.96	11.15	8.15	0.12	110.70	20.20	0.171
99	1.040	79.41	1.87	0.98	3.42	7.38	0.08	93.14	17.74	0.255
102	1.229	72.53	1.62	0.75	3.41	3.63	0.07	82.00	11.55	0.304
112	1.673	66.21	1.50	0.61	3.66	4.73	0.08	76.80	13.78	0.266
120	1.374	117.41	1.95	1.00	12.24	4.88	0.09	137.59	14.66	0.232
12[x]	1.768	101.52	1.69	1.18	12.34	15.31	0.01	132.05	23.12	0.164
I-7[x]	0.780	55.10	1.93	1.14	5.51	2.23	0.11	66.02	16.54	0.189

[x] Additional samples taken from sites with a vegetation clearly belonging to this variant, but not analysed in detail.

of rock.

Loss on ignition and pH-values of the A_0-layer are shown in the vegetation tables. More detailed chemical analyses are performed only on samples from typical *hylocomietosum* (Table VI).

Order *Vaccinio-Piceetalia* Br.-Bl. in Br.-Bl. et al. 1939 p. 4, emend.
K.-Lund 1967 p. 139
Alliance *Vaccinio-Piceion* Br.-Bl. (1938 n.n.) in Br.-Bl. et al. 1930
p. 10
Synonyms: see Braun-Blanquet et al. 1939 p. 10

In Scandinavia only the alliance *Vaccinio-Piceion* exists in the order *Vaccinio-Piceetalia* s.str. (Kielland-Lund 1967, 1972). As characteristic species of the order and the alliance I have found the following species suitable in Hemne:

Blechnum spicant
Lycopodium annotinum
Orthilia secunda
Trientalis europaea
Dicranum majus
Hylocomium umbratum
Plagiothecium undulatum
Rhytidiadelphus loreus
Plagiochila major

This list is in agreement with the characteristic species given for eastern Norway by Dahl et al. (1967) and Kielland-Lund (1971). The two species *Plagiothecium undulatum* and *Rhytidiadelphus loreus* have a sub-oceanic distribution in Norway (Størmer 1969). They are found only in special moist variants in eastern Norway (Kielland-Lund 1962), but are common in many of the *Vaccinio-Piceion* communities in Hemne. The same is true for *Blechnum.*

As differential species against *Cladonio-Vaccinietalia* I have used (cfr. Dahl et al. 1967):

Agrostis tenuis
Anemone nemorosa
Gymnocarpium dryopteris
Luzula pilosa
Maianthemum bifolium
Oxalis acetosella
Thelypteris phegopteris
Cirriphyllum piliferum
Lophocolea bidentata
Rhytidiadelphus triquetrus

Some of the characteristic and differential species mentioned may be found in the pine communities of *Cladonio-Vaccinietalia*. However, the characteristic species show optimal presence and coverage in their appropriate order, and there is no problem in differentiating the two orders.

I have used some of the characteristic species of the order and alliance as local characteristic species of associations and sometimes even as differential species between syntaxa of lower rank.

Association *Corno-Betuletum* ass. nov.

(Synonym: *Corno-Pinetum* K.-Lund 1971 n.n.)

In this association I have included the poorest birch forests and closely allied pine-birch forests. The tree layer is rather densely stocked with a mean cover of 6/10. The *Corno-Betuletum* is commonly found on shady valleysides.

Floristic composition (Table VII): Local characteristic species of the association are:

Dryopteris assimilis
Lycopodium annotinum
Plagiothecium undulatum

Differential species against the next association (*Melico-Betuletum*) are the following, mostly hygrophilous species:

Empetrum hermaphroditum
(usually poorly developed)
Luzula sylvatica
Obtusifolium obtusum
Polytrichum commune
Polytrichum formosum
Sphagnum girgensohnii
Sphagnum quinquefarium
Tritomaria quinquedentata

In the field layer the dominating species are either *Vaccinium myrtillus* or different ferns. The bottom layer is often dominated by *Hylocomium splendens*, but *Rhytidiadelphus loreus*, *R. triquetrus*, and *Pleurozium schreberi* are important species too.

Variation. I have divided the *Corno-Betuletum* into four subassociations: *myrtilletosum*, *dryopteridetosum*, *athyrietosum*, and *thelypteridetosum* (*limbospermae*).

The *myrtilletosum* often has pine dominating the tree layer. This is a much denser pine forest than the *Bazzanio-Pinetum*. In the field layer *Vaccinium myrtillus* is dominant and has high cover values. This sub-association is poor in species. It has no positive differential species and is recognized from the other sub-associations by the lack of several species.

The *dryopteridetosum* is richer in species than the *myrtilletosum*. Differential species against the *myrtilletosum* are:

Gymnocarpium dryopteris
Oxalis acetosella
Thelypteris phegopteris
Hylocomium umbratum
Lophocolea bidentata
Cirriphyllum piliferum

The field layer is dominated by a characteristic mixture of *Vaccinium myrtillus* and the two small ferns *Gymnocarpium dryopteris* and *Thelypteris phegopteris*.

I have divided this sub-association into two variants, an "immature" variant and a "mature" variant. The former is found on overgrown boulders, while the latter exists on more normal soil conditions. In the immature variant the field layer is rather poor. *Lycopodium annotinum* is optimally developed here. The bottom layer consists of an abundantly growing mat of mosses of the genera *Hylocomium* and *Rhytidiadelphus*.

The mature variant has a richer field layer and may be separated by the following differential species:

Agrostis tenuis
Anemone nemorosa
Blechnum spicant
Luzula sylvatica
Orthilia secunda

The two remaining sub-associations, the *athyrietosum* and the *thelypteridetosum* are dominated by large fern species, and they share the following group of differential species:

Anthoxanthum odoratum
Athyrium distentifolium
A. filix-femina
Deschampsia caespitosa
Geranium sylvaticum
Rhytidiadelphus squarrosus

The *athyrietosum* is dominated by *Athyrium filix-femina*. Other differential species are:

Carex vaginata	*Mnium affine*
Solidago virgaurea	

The *thelypteridetosum* is named after *Thelypteris limbosperma* which often plays a major role in the stands. This sub-association is richer in species than the *athyrietosum* and it shows some affinity to the following association, *Melico-Betuletum*. This is indicated by species such as *Fragaria vesca*, *Veronica officinalis*, and *Viola riviniana*. Differential species against the other sub-associations of *Corno-Betuletum* are:

Alchemilla glabra	*Rumex acetosa*
Circaea alpina	*Atrichum undulatum*
Ranunculus acris	*Hypnum callichroum*
Rubus idaeus	*Mnium punctatum*

Edaphic conditions. All five *myrtilletosum* stands represented in Table VII have a podsol profile. The litter layer (A_{00}) is 2-3 cm. Below follows a raw humus layer (A_0) 10-15 cm thick. It is relatively well humified in the lower part. The bleached soil layer (A_2) is sharply separated from the raw humus, and it is about 5 cm thick. The transition to the deposition layer (B) is rather unsharp. The B-horizon may be developed like an iron podsol, iron-humus podsol or a humus podsol. The thickness of this layer is at least 30-40 cm.

The mature variant of the *dryopteridetosum* has a podsol profile or a related profile in which the bleached soil horizon (A_2) is poorly developed or absent ("semipodsol"). The litter layer is thin (0.5-2 cm). It basically contains decaying birch leaves. The raw humus is of a relatively active type with a slightly fibrous to almost granular structure. This A_0-layer is commonly only 5-6 cm thick with a 1-2 cm thick dark humus layer (A_1) beneath. The bleached layer (A_2) is, if present, seldom more than 1-2 cm. The layer of deposition has in most cases a redish brown colour (iron podsol) and is about 30-40 cm thick. Iron-humus podsol and even a humus podsol may also be found here (see Table VII). The soil usually contains an abundance of stones.

In the immature variant of this sub-association there is a 5-15 cm thick layer of raw humus below the moss mat. The raw humus is

Table VIII. Chemical analyses of soil samples (A_0-layer) from *Corno-Betuletum*

	Reference number	Nitrogen in per cent of loss on ignition	Milliequivalents per 100 g dry substance H	K	Na	Ca	Mg	Mn	Cation capasity	Base saturation, per cent	Density kg/l
dryopteridetosum	14	2.202	121.63	1.90	1.33	12.70	9.61	0.06	147.24	17.39	0.328
	18	2.315	40.94	1.11	0.55	7.62	5.37	0.10	55.68	26.48	0.414
	30	2.245	77.38	0.85	0.45	1.43	1.88	0.70	82.68	6.42	0.360
	43	2.458	93.70	1.35	0.87	2.89	4.78	0.06	103.64	9.59	0.361
	48	2.201	64.96	1.10	0.48	9.16	5.95	0.06	81.72	20.51	0.313
	58	1.968	21.52	0.61	0.21	3.61	2.18	0.10	28.34	23.71	0.565
	61	2.591	77.53	2.95	0.51	5.30	5.48	0.07	91.85	15.60	0.278
	90	2.278	109.38	0.97	1.07	6.86	12.91	0.00	131.20	16.63	0.242
	97	2.516	44.54	0.91	0.35	1.65	2.34	0.05	49.84	10.63	0.391
	118	1.707	76.28	1.27	0.61	8.25	8.81	0.11	95.32	19.98	0.190
athyrietosum	62	2.460	49.92	1.21	0.38	2.24	0.97	0.00	54.73	8.77	0.429
	108	2.804	21.30	0.27	0.15	0.50	0.67	0.06	22.95	7.19	0.683
thelypteridetosum	127	2.701	24.42	0.32	0.23	4.15	2.73	0.20	32.05	23.80	0.574
	133	3.503	20.14	0.49	0.11	4.20	1.21	0.60	26.75	24.71	0.704
	134	2.959	15.93	0.36	0.14	4.76	3.35	0.39	24.93	36.10	0.667

of nearly the same type as in the mature variant, but the structure is more fibrous. This A_0-layer rests directly on large blocks of rock.

The sub-associations *athyrietosum* and *thelypteridetosum* are found on richer soils influenced by seepage water. The soil profile resembles a sort of shallow brown soil. The upper 5-10 cm consists of a dark mull-like humus layer. Below this comes a horizon with gradually decreasing humus deposition. Gleization may occur, due to insufficient drainage.

Loss on ignition per cent and pH-values are given in the vegetation tables. Further chemical analyses are performed on samples from *dryopteridetosum*, *athyrietosum*, and *thelypteridetosum* (Table VIII).

Association *Melico-Betuletum* ass. nov.

This association comprises the most species-rich birch forests. In the tree and shrub layers one may find some pine, grey alder, hazel or aspen. Herbs and grasses are important in the field layer.

Floristic composition (Table IX). Local characteristic species of the association are:

Hieracium sylvaticum coll.
Melampyrum sylvaticum
Pyrola rotundifolia
Rubus saxatilis

Differential species against the *Corno-Betuletum* are the following eutrophic species:

Carex pallescens
C. pilulifera
Fragaria vesca
Melica nutans
Veronica chamaedrys
V. officinalis
Viola riviniana
Barbilophozia barbata

In addition the following group of species is more common in the *Melico-Betuletum* than in the *Corno-Betuletum*, except the large fern sub-associations of the last mentioned association:

Anthoxanthum odoratum
Deschampsia caespitosa
Geranium sylvaticum
Solidago virgaurea
Rhytidiadelphus squarrosus

All the species in the latter differential group as well as most of those in the former, are known to occur more frequently and abundantly as a result of grazing pressure.

Variation. I have divided this association into three sub-associations, *cornetosum, coryletosum,* and *athyrietosum*. The two former are low-herb types, while the latter is a tall herb community.

The *cornetosum* is found on somewhat moister and cooler localities than the other sub-associations. The following moisture demanding species differentiates it from *coryletosum* and *athyrietosum*:

Cornus suecica
Hylocomium umbratum
Polytrichum formosum
Ptilium crista-castrensis

In the field layer *Vaccinium myrtillus* has highest coverage. In most of the herb- and grass-rich sites, the quantity of *Vaccinium myrtillus* is much reduced. Small ferns such as *Blechnum, Gymnocarpium dryopteris,* and *Thelypteris phegopteris* are often important. *Anemone nemorosa* dominates the spring aspect.

The bottom layer is most often dominated by *Hylocomium splendens*, but in some stands *Rhytidiadelphus loreus* or *R. triquetrus* may dominate.

The *coryletosum* is a rich low-herb type which is recognized by hazel, *Corylus avellana*, in the tree layer. The community is found on steep, and warm valley-sides with stony and somewhat unstable soil. This gives the field and bottom layers a low coverage.

In the field layer there is a mixture of several species, none predominating. Quantitatively the most important species in the bottom layer are *Hylocomium splendens* and *Rhytidiadelphus triquetrus*.

Differential species of the sub-association are:

Corylus avellana
Campanula rotundifolia
Epilobium montanum
Luzula multiflora
Hypnum cupressiforme
Isothecium myurum
Radula complanata

The *athyrietosum* comprises luxuriant, sunexposed stands with large ferns and tall herbs. The field layer is dense, 80-100 cm tall with a high cover value. Dominating species are *Athyrium filix-femina, Thelypteris limbosperma,* and *T. phegopteris*.

The bottom layer suffers from light deficiency and has low cover with relatively few species. *Rhytidiadelphus triquetrus* often has the highest coverage.

Differential species of the sub-association are:

Aconitum septentrionale
Athyrium filix-femina
Calamagrostis purpurea
Carex vaginata
Cirsium heterophyllum
Dryopteris filix-mas
Filipendula ulmaria
Hypericum maculatum
Phalaris arundinacea
Pteridium aquilinum
Rubus idaeus
Thelypteris limbosperma
Viola palustris
Mnium affine

Edaphic conditions: The *cornetosum* has what have been called "oligotrphic brown soil" (cfr. Fitzpatrick 1964 p. 48). Sometimes there is only a few (2-3) cm thick mull-like humus layer at the top of the profile. Below this there is a rust-red or yellowish B-layer. Some stands had a more distinct mull-layer about 10-12 cm thick.

The *coryletosum* is usually found on scree soil, often under steep cliffs of rock. It has a brown mull with granular structure. I have, in many instances, found a B-layer of a similar type as that of the *cornetosum*.

The *athyrietosum* has a brown soil profile. More often than not the soil is moister and not as rich in stones as in the *coryletosum*. The mull is dark and usually well aggregated.

Loss on ignition and pH-data are found in the vegetation tables. Table X gives the results of the chemical analyses.

Class *Querco-Fagetea* Br.-Bl. & Vlieger 1937 (in Vlieger 1937 p. 349)
Order *Fagetalia sylvaticae* Pawlowski 1928 p. 19

I have referred two communities to this class and order. It is a warmth demanding forest type with *Ulmus glabra* on scree slopes, and an *Alnus incana* community along streamsides. The former I have referred to the association *Ulmo-Tilietum* in the alliance *Tilio-Acerion*, and the latter to the *Alno-Prunetum* in *Alno-Padion*.

Table X. Chemical analyses of soil samples (A_1 layer) from *Melico-Betuletum*

	Reference number	Nitrogen in per cent of loss on ignition	Milliequivalents per 100 g substance H	K	Na	Ca	Mg	Mn	Cation capasity	Base saturation per cent	Density kg/l
cornetosum	23	2.770	8.59	0.09	0.05	0.50	0.33	0.04	9.59	10.47	1.070
	40	2.805	17.03	10.53	0.33	5.31	3.70	0.13	27.02	36.98	0.800
	65	2.497	42.42	0.60	0.35	4.16	2.76	0.69	50.98	16.79	0.584
	104	2.448	20.48	0.63	0.17	3.65	2.29	0.79	28.08	26.92	0.581
coryletosum	19	3.439	10.96	0.78	0.19	3.98	2.53	0.12	18.55	40.92	0.876
	66	2.940	14.69	0.54	0.21	2.62	1.55	0.25	19.86	26.03	0.776
	81	2.975	34.94	0.58	0.18	3.51	2.27	0.14	41.64	16.08	0.555
	83	3.313	12.58	0.40	0.19	2.03	1.44	0.18	16.82	25.21	0.854
	84	2.979	21.77	0.74	0.24	2.61	1.87	0.11	27.33	20.37	0.712
	85	2.634	12.47	0.81	0.30	5.72	2.80	0.10	22.20	43.84	0.803
athyrietosum	49	2.854	45.66	0.63	0.37	3.82	2.09	0.89	53.45	14.57	0.423
	68	2.900	36.74	0.44	0.30	6.63	4.38	0.13	48.61	24.43	0.592
	74	2.969	38.94	0.71	0.17	2.79	3.80	0.08	46.49	16.25	0.488
	75	3.217	23.80	0.68	0.24	5.70	3.70	0.31	34.42	30.86	0.695
	76	3.068	28.84	0.69	0.14	4.14	3.01	0.24	37.06	22.17	0.550

The temperate broadleaved forests were first described from their optimal areas in Middle Europe. Lists of characteristic species of the class and of the order are given by many Middle European authors, for instance Tüxen (1937), Klika (1955), Oberdorfer (1957), Moor (1960 p. 290), and Ellenberg (1963 p. 98). I have mainly followed the two last mentioned. These species are mostly southern and thermophilous in Norway. In Hemne I have found many of them in the *Ulmus* community, while there are rather few of them in the *Alnus* community. I have listed the characteristic species present in the description of each community below.

Alliance *Alno-Padion* Knapp 1942 em. Mat. & Bor. 1957 p. 723
Association *Alno incanae-Prunetum* K.-Lund 1971 p. 30

This association comprises *Alnus incana* stands on fertile sediments along streams.

Floristic composition (Table XI): Characteristic species of the class (Cl) and the order (O) found in this community are:

O *Cardamine flexuosa*
O *Impatiens noli-tangere*
O *Paris quadrifolia*
Cl *Poa nemoralis*
O? *Prunus padus*
O? *Stellaria nemorum*
O *Atrichum undulatum*
O *Thuidium tamariscinum*

Prunus padus and *Stellaria nemorum* are usually regarded characteristic species of *Alno-Padion*, but in Hemne they are equally abundant in *Tilio-Acerion*. *Anemone nemorosa* is also an important species in this community, but it can hardly be called a characteristic species of the class as in Middle Europe.

Because I recognize only one association in the alliance in Hemne, the characteristic species of the alliance also becomes local characteristic species of the association. These are (cfr. Ellenberg 1963 p. 100, Matuszkiewicz & Borowik 1957 p. 723 ff.):

Alnus incana
Antriscus sylvestris
Equisetum pratense
Ranunculus auricomus
Mnium undulatum

Several hygrophilous species differentiates against the alliance *Tilio-Acerion*. The most frequent are:

Angelica sylvestris	*Filipendula ulmaria*
Crepis paludosa	*Viola palustris*
Deschampsia caespitosa	*Cirriphyllum piliferum*

Alnus incana may be found, especially as a pioneer species, in many other communities on moist and wet land. However, it clearly thrives and grows best in the *Alno-Prunetum*.

The field layer is dense and rich in tall herbs. Common dominants are *Filipendula ulmaria* and *Rubus idaeus*.

Other important species are *Deschampsia caespitosa*, *Geum rivale*, *Athyrium filix-femina*, *Geranium sylvaticum*, *Aconitum septentrionale*, and *Cicerbita alpina*.

The bottom layer is sparse. The most prominent species are *Cirriphyllum piliferum*, *Mnium undulatum*, *Rhytidiadelphus triquetrus*, and *Thuidium tamariscinum*.

Zonation and dynamics: On the banks along the lower part of the Hollaelva strem we find the following zones of vegetation.

Nearest the stream there is a pioneer vegetation of *Salix* brushes and *Myricaria germanica*. Various herbs such as *Galium boreale*, *Oxyria digynea*, *Saxifraga aizoides*, *Saussurea alpina*, and *Solidago virgaurea* grow scattered. In this *Myricaria* zone the bottom layer is dominated by *Racomitrium canescens*. Farther away from the stream the brushes of *Myricaria* are overgrown by a dense scrub of *Alnus* which gradually merges into a typical *Alno-Prunetum*. *Racomitrium canescens* is soon replaced by shade tolerate species.

The *Myricaria* zone is submerged every year by the spring and autumn floods, sometimes even in the midsummer. The ice drift in the spring also prevents the establishment of *Alnus* forest in the outermost zone.

Flooding often occur also in the *Alnus* stands, but not necessarily every spring and autumn.

Edaphic conditions: The soil of the *Alno-Prunetum* is clearly influenced by the periodic flooding. On level ground I usually found a thin (2-5 cm) humus layer (A_1) with a gradual, transition to the gravel

and sand below. The community is also found on rising ground with clay in the subsoil. Here the flooding is more infrequent and the A_1-layer is deeper, about 15 cm. Chemical data are shown in Table XII.

Alliance *Tilio-Acerion* Klika 1955 p. 322 em. Seibert 1969 p. 165 ff.
Association *Ulmo-Tilietum* K.-Lund ex. Seibert 1969 p. 170

This is a thermophilous community, and in Hemne it is found only on the richest and warmest localities, such as the upper part and the edges of steep sun-faced screes. Often there are only small areas with suitable ecological conditions. Therefore the association is mostly somewhat fragmentary developed.

Floristic composition: Characteristic species of the order (O) and the class (Cl) found in this community in Hemne are:

Cl *Corylus avellana*
O *Dryopteris filix-mas*
O *Epilobium montanum*
O *Galium odoratum*
O *Geum urbanum*
O *Lathyrus vernus*
Cl *Melica nutans*
O *Milium effusum*
Cl *Moerhingia trinervia*
O *Mycelis muralis*
O *Paris quadrifolia*
Cl *Poa nemoralis*
O? *Prunus padus*
O *Roegneria canina*
O *Stachys sylvatica*
O? *Stellaria nemorum*
O *Atrichum undulatum*
O *Eurhynchium striatum*

As characteristic species of the alliance and local characteristic species of the association I have used (cfr. Seibert 1969, Kielland-Lund 1971):

Actaea spicata
Campanula latifolia
Polystichum braunii
Ulmus glabra

Several species differentiate against the *Alno-Padion*. Most of them are nitrophilous and thermophilous species characteristic of marginal communities:

Geranium robertianum
Hypericum hirsutum
Urtica dioica
Vicia sylvatica

Mnium cuspidatum
Porella platyphylla
Rhodobryum roseum

The tree and shrub layers show a mixture of species. Besides *Ulmus glabra* and *Prunus padus*, there are *Betula pubescens*, *Populus tremula* and *Sorbus aucuparia*.

The field layer is sparse in the most stony and driest stands, containing only a few scattered individuals. In the moister stands there is a dense field layer with large ferns such as *Dryopteris filix-mas* and *Athyrium filix-femina*. *Galium odoratum* has its optimum in this association. If the soil is not too stony and unstable *Anemone nemorosa* is found in masses during the spring. Other spring geophytes which may be present in this community are *Corydalis intermedia* and *Ranunculus ficaria*. Both were completely wilted when the vegetation analyses were performed in the summer.

The bottom layer is always poorly developed. *Rhytidiadelphus triquetrus* is a constant species. However, the previously mentioned species are frequent.

Variation. The five stands represented in Table XI indicates a considerable variation. If more analyses were available I think it would be possible to divide the stands into at least two different sub-associations. Larger areas with related vegetation are situated in the neighbouring parishes Vinje and Snillfjord.

Edaphic conditions. The soil is rich in stones, but between the stones there is a dark, coarse-grained mull. Results of chemical analyses are given in Table XII.

Table XII. Chemical analyses of soil samples (A_1 layer) from *Alno-Prunetum* and *Ulmo-Tilietum*

	Reference number	Nitrogen in per cent of loss on ignition	Milliequivalents per 100 g dry substance H	K	Na	Ca	Mg	Mn	Cation capasity	Base saturation per cent	Density kg/l
Alno-Prunetum	1	3.801	9.32	0.16	0.19	5.35	1.63	0.33	16.98	45.11	0.949
	69	3.301	10.20	0.21	0.27	14.46	2.56	0.30	28.00	63.59	0.886
	71	3.977	14.73	0.22	0.10	2.25	1.56	0.14	19.00	22.45	0.904
	72	4.020	9.60	0.21	0.16	4.45	1.22	0.09	15.73	38.97	0.976
	73	3.951	14.02	0.30	0.16	7.40	1.96	0.57	24.41	42.57	0.795
Ulmo-Tilietum	56	3.665	8.19	0.30	0.19	12.19	6.51	0.23	27.61	70.36	0.820
	67	3.272	24.83	0.80	0.26	11.62	5.93	0.12	43.55	42.99	0.617
	135	3.269	9.32	0.60	0.23	18.02	6.42	0.45	35.04	72.36	0.802
	136	3.007	13.87	0.98	0.25	12.98	5.62	0.16	33.87	59.05	0.771

HOMOTONEITY

Presence diagrams

The term homotoneity was defined by Nordhagen (1943 p. 45). It means the homogeneity within a community (syntaxon), or more concrete, the similarity between the individual analysed stands in the community table.

A measure of the homotoneity is the relationship between the number of species in each of the five classes of presence. If analyses belonging to the same community are grouped together, and the sample areas were homogenous and larger than the minimal area, then the number of species in each class of presence usually will conform Raunkiær's law of frequencies (Raunkiær 1918 p. 21, Dahl 1957 p. 40):

$$V > IV \gtrless III < II < I$$

Especially it is said to be an important criterion that the number of species in class V exceeds that in class IV (Dahl 1957 p. 53).

Presence diagrams of the communities of lowest rank from which at least five analyses were available, are shown in Fig. 3.

Fig. 3 illustrates that in all communities, except *Ulmo-Tilietum*, the number of species is larger in class V than in class IV. The presence diagram of *Ulmo-Tilietum* thus supports the view that the analysed stands belong to two or more subassociations. About one half of the diagrams conform the law of Raunkiær. Most of the deviations may be explained from the number of analyses available. For instance in *Bazzanio-Pinetum sphagnetosum* (Fig. 3, 1) there are more species in class II than in class I. From this community eight analyses were available. This results from species being present in one analysis only are placed into class I, while species present in two or three analyses are placed into class II. The probability of a species falling into class II is therefore relatively larger than that of falling into class I. Similar considerations will explain most of the remaining deviations from the law of frequencies.

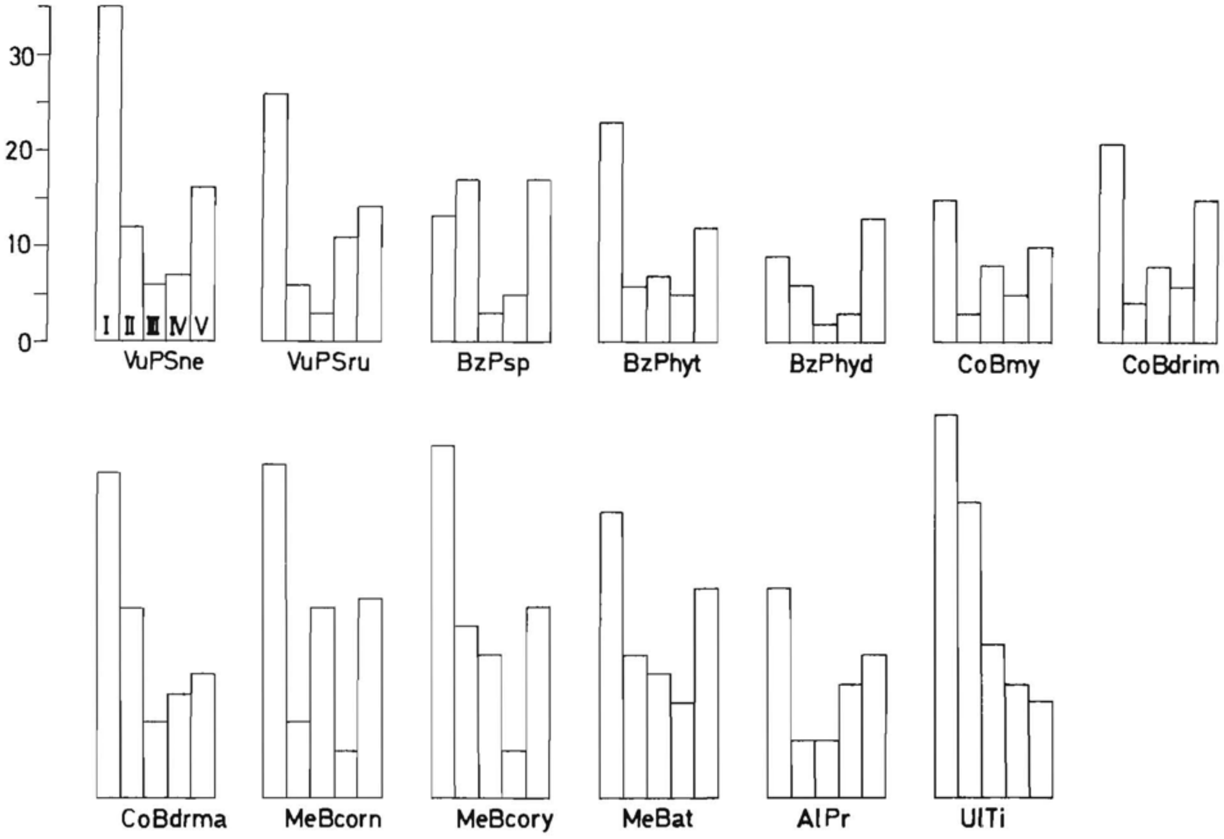


Fig. 3. Presence diagrams for the communitites of lowest rank. Abbreviations as in the synposis on p. 13.

Indices of uniformity and diversity

Dahl (1960) has introduced an index of uniformity which is a measure of the homotoneity. This index assumes that the species-area curve fits a lognormal distribution. This assumption is discussed by Dahl (1957). I have calculated the index, called S_1/α, according to the instructions of Dahl (1960 p. 807). A high value of the index means a high degree of homotoneity. Only when S_1/α is at least 1.2 we may expect the number of species in presence class V to exceed that of class IV.

Table XIII gives the index of uniformity for the investigated communities. With the exception of *Ulmo-Tilietum*, all have an index higher than 1.2. Most of the communities with an irregular presence diagram have comparatively high values. The table also shows that S_1/α increases when the associations are split into sub-units, indicating that the splitting is reasonably done, since it results in more homotoneous syntaxa.

Table XIII. Indices of uniformity and diversity for the communities investigated. n = number of analyses, S_n = number of species in n analyses, S_1 = mean number of species, S_1/α = index of uniformity, α = index of diversity

	n	S_n	S_1	S_n/S_1	S_1/α	α
Bazz.-Pin. sphagnetosum	8	56	27.8	2.01	2.0	13.9
Bazz.-Pin. hylocom. typ.	10	53	25.6	2.07	2.1	12.2
Bazz.-Pin. hylocom. dry	5	34	21.0	1.62	2.1	10.0
Bazz.-Pin. whole ass.	23	72	25.4	2.83	1.6	15.9
Vacc.ulig.-Pin. Sph. nem.	10	76	34.2	2.22	1.7	20.1
Vacc.ulig.-Pin. Sph. russ.	5	60	32.8	1.83	1.7	19.3
Vacc.ulig.-Pin. whole ass.	15	85	33.7	2.52	1.6	21.1
Corno-Bet. myrtilletosum	5	41	23.0	1.78	1.8	12.8
Corno-Bet. dryopt. immat.	12	54	26.8	2.01	2.3	11.7
Corno-Bet. dryopt. mature	19	86	32.9	2.61	1.7	19.4
Corno-Bet. athyrietosum	4	63	36.5	1.72	(1.9)	(19.1)
Corno-Bet. thelypt.	4	70	42.8	1.65	(2.2)	(19.6)
Corno-Bet. whole ass.	44	113	31.3	3.61	1.3	24.1
Melico-Bet. cornetosum	7	79	40.4	1.96	2.1	19.2
Melico-Bet. coryletosum	11	95	39.7	2.39	1.6	24.8
Melico-Bet. athyrietosum	6	90	44.5	2.02	1.6	27.8
Melico-Bet. whole ass.	24	139	41.1	3.38	1.2	34.3
Alno-Prunetum	6	61	30.5	2.00	1.6	19.1
Ulmo-Tilietum	5	109	49.4	2.20	1.1	44.9

The index of diversity (α in Table XIII) is an indicator of the richness of the community in question. If the associations are arranged with respect to increasing diversity we obtain the following order, *Bazzanio-Pinetum*, *Alno-Prunetum*, *Vaccinio uliginosi-Pinetum*, *Corno-Betuletum*, *Melico-Betuletum*, and *Ulmo-Tilietum*. Except for the *Alno-Prunetum*, which has a surprisingly low α value, this sequence conforms to the general impression of richness and soil fertility of the communities. The low diversity of *Alno-Prunetum* confirms the statement that communities in unstable environments have a relatively low diversity (Odum 1971 p. 149). However, the environment of the *Ulmo-Tilietum* seems equally unstable.

FLORISTIC COMPARISONS BETWEEN THE COMMUNITIES

Synoptic table

Table XIV is a synposis showing presence and mean cover of the dicriminating species of the classes, orders, alliances, and associations. These characteristic and differential species are discussed in connection with the descriptions of the communities and in the chapter of the synsystematic discussion. Characteristic species, which according to this table, are exclusive of their proper syntaxon in the forest vegetation of Hemne, are marked by a plus sign (+).

Similarity indices

As a measure of the floristic community between the communities I have calculated what Sörensen (1948 p. 6) called the quotient of similarity:

$$QS = \frac{2c}{a + b} \cdot 100$$

c is the number of species common to the two communities, a is the number

(text continues on p. 49)

Table XIV. Synoptic table of the classes, orders, alliances, and associations

	VuP	BzP	CoB	MeB	AlPr	UlTi
Class Vaccinio-Piceetea:						
Ch: Vaccinium myrtillus	V^3	V^5	V^6	V^5	.	I^1
V. vitis-idaea	V^4	V^5	V^4	V^3	.	I^1
$^+$Cornus suecica	IV^3	V^4	III^3	II^3	.	.
$^+$Linnaea borealis	I^2	IV^3	V^3	II^2	.	.
Dicranum scoparium	II^3	IV^3	II^2	II^2	.	I^1
Hylocomium splendens	V^5	V^6	V^7	V^5	.	IV^4
Pleurozium schreberi	V^5	V^6	V^4	IV^4	.	I^2
$^+$Ptilium crista-castrensis	V^3	V^4	III^3	I^2	.	.
$^+$Barbilophozia lycopodioides	I^1	I^1	II^3	I^2	.	.
Order Cladonio-Vaccinietalia:						
Ch: Pinus sylvestris	V^5	V^6	III^5	II^4	.	.
Empetrum nigrum coll.	V^4	V^5	II^3	.	.	.
$^+$Vaccinium uliginosum	V^5	V^5	.	.	.	.
$^+$Sphagnum nemoreum	IV^6	II^3	.	.	.	.
$^+$Anastrepta orcadensis	I^1	I^2	.	.	.	.
$^+$Bazzania trilobata	I^3	I^3	.	.	.	.
$^+$Cladonia arbuscula	IV^2	II^4	.	.	.	.
$^+$C. rangiferina	III^2	III^3	.	.	.	.
Df: Calluna vulgaris	V^7	V^5	I^1	.	.	.
Ptilidium ciliare	IV^2	III^2	I^3	.	.	.
Alliance Phyllodoco-Vaccinion:						
Ch: $^+$Orthocaulis attenuatus	II^2	I^2	.	.	.	.
O. floerkei	I^3	I^2	I^2	.	.	.
$^+$Cladonia bellidiflora	.	I^3	.	.	.	.
Df: Betula nana	I^3	.	.	.	.	.
Pohlia nutans	I^1	.	.	I^1	.	.
Polytrichum commune	II^3	III^5	II^4	.	.	.

cont.

Table XIV. Cont.

	VuP	BzP	CoB	MeB	AlPr	UlTi
Association Vaccinio uliginosi-Pinetum:						
Dr: Andromeda polifolia	V^3	III^3	.	.	.	.
Eriophorum vaginatum	V^4	.	.	.	.	.
Rubus chamaemorus	V^4	I^2	.	.	.	.
Drosera rotundifolia	III^2	.	.	.	.	.
Vaccinium microcarpum	V^3	I^1	.	.	.	.
Aulacomnium palustre	V^2	.	.	.	.	.
Pohlia sphagnicola	III^1	I^1	.	.	.	.
+Polytrichum juniperinum gracilius	III^2	.	.	.	.	.
Sphagnum angustifolium	III^5	I^3	.	.	.	.
S. russowii	III^5	I^1	.	.	.	.
Calypogeia sphagnicola	V^2	II^2	.	.	.	.
Mylia anomala	III^2	.	.	.	.	.
Cephalozia spp.	III^2	.	I^1	.	.	.
Order Vaccinio-Piceetalia, alliance Vaccinio-Piceion:						
Ch: Blechnum spicant	I^+	II^4	III^3	II^4	.	.
Orthilia secunda	.	I^1	II^2	II^2	.	.
Trientalis europaea	II^3	III^1	V^3	IV^3	III^2	II^2
Dicranum majus	II^3	III^2	V^3	III^2	.	I^1
+Hylocomium umbratum	.	.	III^3	I^3	.	.
Rhytidiadelphus loreus	III^2	II^3	V^5	III^4	.	I^3
Plagiochila major	.	.	IV^3	III^3	III^3	II^1
Df: Agrostis tenuis	.	.	II^2	IV^3	.	II^3
Anemone nemorosa	.	I^+	III^5	V^3	V^3	V^3
Gymnocarpium dryopteris	.	I^1	V^5	IV^4	.	II^2
Luzula pilosa	I^1	I^1	V^2	V^2	.	II^2
Maianthemum bifolium	.	I^2	IV^3	II^3	III^2	I^2
Oxalis acetosella	.	.	IV^3	IV^3	V^3	V^3
Thelypteris phegopteris	.	.	IV^4	IV^5	.	III^3
Cirriphyllum piliferum	.	.	II^3	IV^3	V^3	I^1
Lophocolea bidentata	.	I^1	III^3	II^3	.	.
Rhytidiadelphus triquetrus	.	.	IV^5	V^5	V^5	IV^4

cont.

Table XIV. Cont.

	VuP	BzP	CoB	MeB	AlPr	UlTi
Association Corno-Betuletum:						
Ch: Dryopteris assimilis	.	.	II^{4}	I^{+}	.	I^{2}
Lycopodium annotinum	I^{2}	I^{2}	III^{3}	I^{3}	.	.
Plagiothecium undulatum	II^{2}	II^{3}	IV^{3}	I^{1}	.	.
Df: Obtusifolium obtusum	I^{1}	I^{2}	II^{1}	.	.	.
Polytrichum formosum	.	.	III^{2}	I^{2}	II^{2}	I^{2}
Tritomaria quinquedentata	.	I^{2}	II^{2}	I^{1}		
Association Melico-Betuletum:						
Ch: $^{+}$Hieracium sylvaticum coll.	.	.	.	IV^{2}	.	.
Melampyrum sylvaticum	.	.	I^{1}	II^{3}	.	II^{2}
Pyrola rotundifolia	.	.	I^{1}	II^{2}	.	.
Rubus saxatilis	.	.	.	IV^{2}	.	II^{3}
Df: Carex pallescens	.	.	.	IV^{2}	.	.
C. pilulifera	.	.	I^{2}	III^{2}	.	.
Fragaria vesca	.	.	I^{3}	IV^{2}	II^{2}	V^{3}
Veronica chamaedrys	.	.	I^{1}	II^{2}	.	III^{2}
V. officinalis	.	.	I^{2}	V^{2}	.	III^{2}
Viola riviniana	.	.	II^{2}	V^{3}	III^{2}	V^{3}
Isothecium myurum	.	.	.	III^{2}	.	II^{1}
Class Querco-Fagetea, order Fagetalia sylvaticae:						
Ch: Agropyron caninum	.	.	.	I^{2}	.	II^{3}
$^{+}$Cardamine flexuosa	.	.	.	.	I^{1}	.
Corylus avellana	.	.	.	III^{5}	.	I^{7}
Dryopteris filix-mas	.	.	I^{+}	II^{1}	.	IV^{5}
Epilobium montanum	.	.	.	I^{1}	.	IV^{2}
Galium odoratum	.	.	.	I^{3}	.	IV^{5}
$^{+}$Geum urbanum	.	.	.	.	.	III^{2}
$^{+}$Impatiens noli-tangere	.	.	.	.	I^{2}	.
$^{+}$Lathyrus vernus	.	.	.	.	.	II^{2}
Melica nutans	.	.	.	IV^{3}	.	III^{3}
$^{+}$Milium effusum	.	.	.	.	.	I^{2}

cont.

Table XIV. Cont.

	VuP	BzP	CoB	MeB	AlPr	UlTi
+Moerhingia trinervia	.	.	.	.	.	II^3
+Mycelis muralis	.	.	.	.	.	I^1
Paris quadrifolia	.	.	.	I^1	V^3	II^2
Poa nemoralis	.	.	I^1	I^2	I^3	IV^3
Prunus padus	.	.	.	I^4	IV^3	V^5
+Stachys sylvatica	.	.	.	.	.	IV^2
+Stellaria nemoreum	.	.	.	.	III^3	V^3
Atrichum undulatum	.	.	I^1	I^2	I^3	II^3
+Eurhynchium striatum	.	.	.	.	.	II^3
Thuidium tamariscinum	.	.	.	I^3	V^4	.
Alliance Alno-Padion, association Alno-Prunetum:						
Ch: Alnus incana	.	.	I^4	III^5	V^9	.
+Anthriscus sylvestris	.	.	.	.	IV^1	.
+Ranunculus auricomus coll.	.	.	.	.	IV^2	.
+Equisetum pratense	.	.	.	.	II^2	.
+Mnium undulatum	.	.	.	.	V^3	.
Df: Filipendula ulmaria	.	.	I^+	II^2	V^5	I^2
Viola palustris	.	.	I^1	I^3	V^2	.
Angelica sylvatica	.	.	.	.	IV^1	I^1
Cicerbita alpina	.	.	.	.	IV^5	.
Crepis paludosa	.	.	.	I^1	IV^4	.
Alliance Tilio-Acerion, association Ulmo-Tilietum:						
Ch: +Ulmus glabra	.	.	.	.	.	IV^5
+Actaea spicata	.	.	.	.	.	II^1
+Campanula latifolia	.	.	.	.	.	II^3
+Polystichum braunii	.	.	.	.	.	II^2
Df: Geranium robertianum	.	.	.	.	.	IV^2
Urtica dioica	.	.	.	.	.	III^2
Vicia sylvatica	.	.	.	.	.	III^2
Hypericum hirsutum	.	.	.	.	.	II^2
Mnium cuspidatum	.	.	I^1	.	.	III^2
Porella platyphylla	.	.	.	I^1	I^2	IV^2
Rhodobryum roseum	.	.	I^2	I^2	I^1	III^1

cont.

Table XIV. Cont.

	VuP	BzP	CoB	MeB	AlPr	UlTi
Other species:						
Betula pubescens	III^2	II^2	V^7	V^7	I^5	IV^5
Juniperus communis	I^1	IV^4	III^4	III^4	.	III^2
Populus tremula	.	.	I^2	III^4	.	III^7
Sorbus aucuparia	II^2	IV^2	IV^5	V^3	IV^5	V^5
Anthoxanthum odoratum	.	.	I^3	IV^3	.	II^2
Athyrium filix-femina	.	.	II^4	III^5	IV^5	III^5
Circaea alpina	.	.	I^3	I^1	I^2	IV^4
Deschampsia caespitosa	.	.	II^3	IV^3	V^4	.
D. flexuosa	IV^2	V^3	V^3	V^4	I^1	III^3
Galeopsis bifida	.	.	.	I^1	III^1	III^2
Geranium sylvaticum	.	.	I^3	IV^3	V^3	V^3
Geum rivale	.	.	I^3	I^1	V^5	II^3
Hypericum maculatum	.	.	.	III^2	.	III^1
Melampyrum pratense	III^2	V^3	II^2	III^3	.	.
Potentilla erecta	I^1	I^2	III^3	V^3	.	.
Ranunculus acris	.	.	I^2	I^1	IV^2	I^2
Rubus idaeus	.	.	I^2	III^2	V^5	V^2
Rumex acetosa	.	.	I^3	I^1	V^1	III^2
Solidago virgaurea	.	.	II^2	III^2	I^1	II^3
Valeriana sambucifolia	.	.	.	.	IV^3	V^2
Barbilophozia barbata	I^2	III^2	I^2	III^2	.	II^2
Mnium affine	.	.	I^2	I^2	IV^2	II^2
Rhytidiadelphus squarrosus	.	.	II^3	III^3	IV^4	.
Sphagnum quinquefarium	III^4	IV^5	I^3	.	.	.

of species within the one community, and b is the number of species within the other community. This index may vary between 0 (no species common) and 100 (identical species content).

Sörensen (1948) originally used his index to compare single populations (stands). When comparing communities made up of analyses from a varying number of stands, an index including only the species in the upper classes of presence, will be a more realistic reflection of the floristic similarity (Dahl 1957 p. 65, Marker 1969 p. 18, Björnstad 1971 p. 204). I have therefore calculated the indices based on the species of presence classes III, IV, and V. In the two cases (*Corno-Betuletum athyrietosum* and *thelypteridetosum*) where only four analyses were available I have included merely the species present in at least three analyses. The similarity indices are shown in Tabel XV, at the upper right.

Sörensen (1948) introduced a method for construction of a schematic dendrogram based on the similarity indices. Fig. 4 is a corresponding dendrogram for the forest communities of Hemne. This figure illustrates the floristic relationship between the communities. Sörensen (1948) united related stands in groups at fixed limits of QS. In Fig. 4 I have united the communities at their actual QS values of Table XV. In other respects the procedure is analogous to that of Sörensen. Björnstad (1971 p. 204) gives an almost similar dendrogram for the deciduous forest in Sögne, referring to Sokal & Sneath (1963).

Fig. 4 mostly verifies the phytosociological classification applied. The only exception is that the sub-association *thelypteridetosum limbospermae* shows a slightly greater affinity to the *Melico-Betuletum* than to the *Corno-Betuletum* in which I have classified it. The intermediate position of this community is also evident from Tabel XV. However, it is important to remember that this is one of the communities with only four analyses. Mathematically, the comparison of the QS values are therefore quite dubious.

Another way of illustrating a similarity matrix is the geometrical ordination proposed by Bray & Curtis (1957). The similarity indices are transformed to "floristic distance indices" by subtracting the actual QS values from the maximum value of QS (in Table XV, $QS_{max} = 90$). These floristic distances are given in Table XV, at the lower left.

Table XV. Upper right: similarity indices (QS) based on species in presence classes III, IV, and V. Lower left: floristic distance (QS_{max} - QS). The figures for the communities are according to the synopsis on p. 13

	1	2	3	4	5	7	8	9	11	10	12	13	14	15	16
1		75	47	56	50	42	37	33	21	15	26	17	16	0	9
2	15		63	64	60	54	45	39	32	21	32	23	16	0	9
3	43	27		90	79	71	56	56	39	19	45	31	23	7	13
4	34	26	0		81	68	53	50	35	20	43	31	23	7	13
5	40	30	11	9		78	60	56	38	26	44	35	28	8	18
7	48	36	19	22	12		81	76	60	43	58	44	35	14	20
8	53	45	34	37	30	9		85	71	52	61	41	35	19	21
9	58	51	34	40	34	14	5		71	61	69	47	42	25	29
11	69	58	51	55	52	30	19	19		53	58	45	42	30	25
10	75	69	71	70	64	47	38	29	37		63	57	51	34	37
12	64	58	45	47	46	32	29	21	32	27		72	68	33	31
13	73	67	59	59	55	46	49	43	45	33	18		64	27	41
14	74	74	67	67	62	55	55	48	48	39	22	26		44	41
15	90	90	83	83	82	76	71	65	60	56	57	63	46		37
16	81	81	77	77	72	70	69	61	65	53	59	49	49	53	

At the x axis it is reasonable to select reference communities with great floristic distance. Table XV gives two pairs showing maximum distance. Both between 1 and 15 and between 2 and 15 the distance equals 90. The ordination was performed with both pairs, and the final x axis positions of the communities were determined as the median postition of each community.

Reference communities at the y axis construction should be communities with close distance on the x axis, but which are to be farther separated according to Table XV. The reference pairs were selected by the test suggested by Bray & Curtis (1957 p. 333). The difference between floristic distance and the separation on the x axis ought to be as great as possible. Four pairs of communities (14, 16), (11, 16), (10,

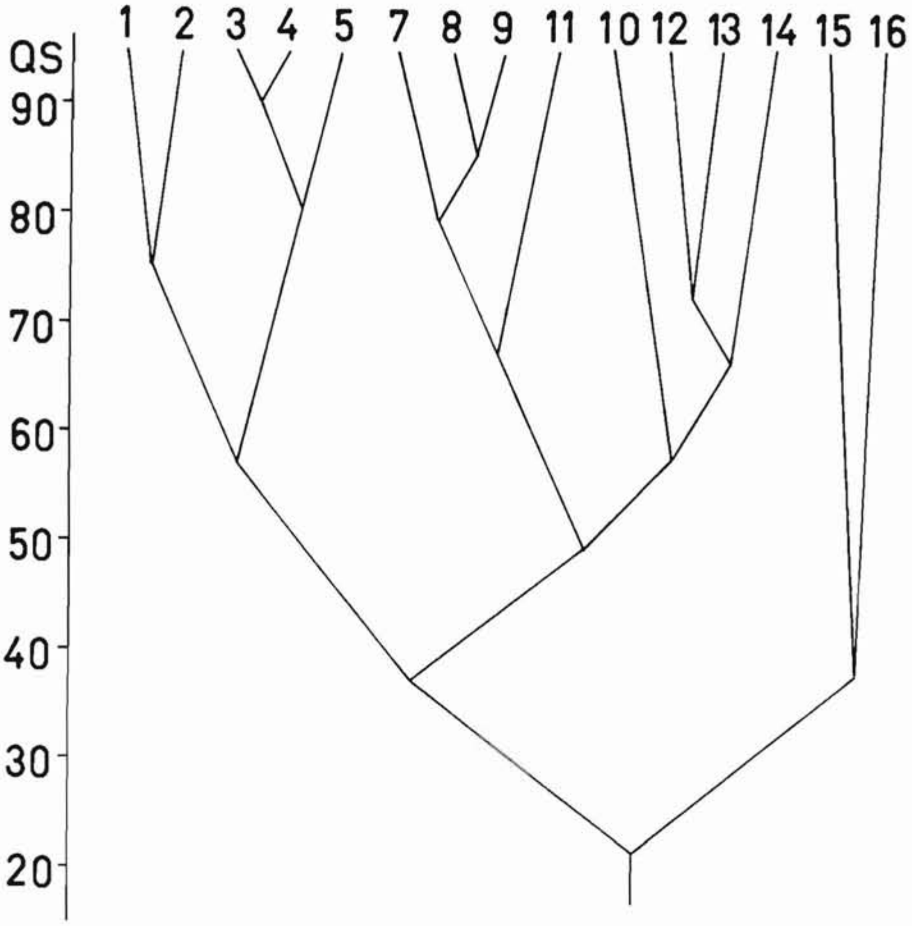


Fig. 4. Affinity dendrogram of the communities based on indices of floristic similarity (QS). The figures for the communities are according to the synopsis on p.

16), and (11, 13) gave especially high test values. The y axis ordination was performed with these four pairs as references in turn. The mean values of the four ordinations were considered the final locations on the y axis.

The result of this two dimensional ordination is given in Table XVI and Fig. 5. Fig. 5 shows again the affinity of *thelypteridetosum limbospermae* (no 10) to *Melico-Betuletum*. If we omit this irregularity, the result of the ordination conforms well with the applied classification and the general impression of the realtionship between the communities.

Table XVI. Geometrical ordination on the two axes using different reference communities, and the mean coordinates

Community	x-axis			y-axis				
	Refer. pairs		Mean	Reference pairs				Mean
no	(1,15)	(2,15)	value	(14,16)	(11,16)	10,16)	11,13)	value
1	0.0	1.5	0.75	13.5	18.5	16.5	16.5	16.25
2	1.5	0.0	0.75	13.5	8.0	9.0	10.0	10.13
3	16.5	11.0	13.75	10.0	6.5	18.0	13.5	12.0
4	19.0	10.5	14.75	10.0	10.0	16.0	18.0	13.5
5	16.5	13.0	14.75	10.5	13.0	16.0	19.0	14.63
7	26.0	20.0	23.0	4.5	1.0	1.0	9.0	3.88
8	32.5	28.5	30.5	6.0	-2.0	-4.5	0.0	-0.13
9	40.0	36.0	38.0	10.5	6.0	-1.0	5.0	5.13
10	58.5	54.0	56.25	12.0	21.0	0.0	25.5	14.63
11	51.0	43.5	47.25	5.0	0.0	-2.0	0.0	0.75
12	50.0	46.0	48.0	-6.5	13.5	0.0	30.0	9.25
13	52.5	48.0	50.25	6.5	29.0	14.0	45.0	23.63
14	63.5	64.0	63.75	0.0	31.5	18.0	40.5	22.5
15	90.0	90.0	90.0	17.5	38.0	29.5	18.0	25.75
16	66.0	66.0	66.0	49.0	65.0	53.0	42.0	52.25

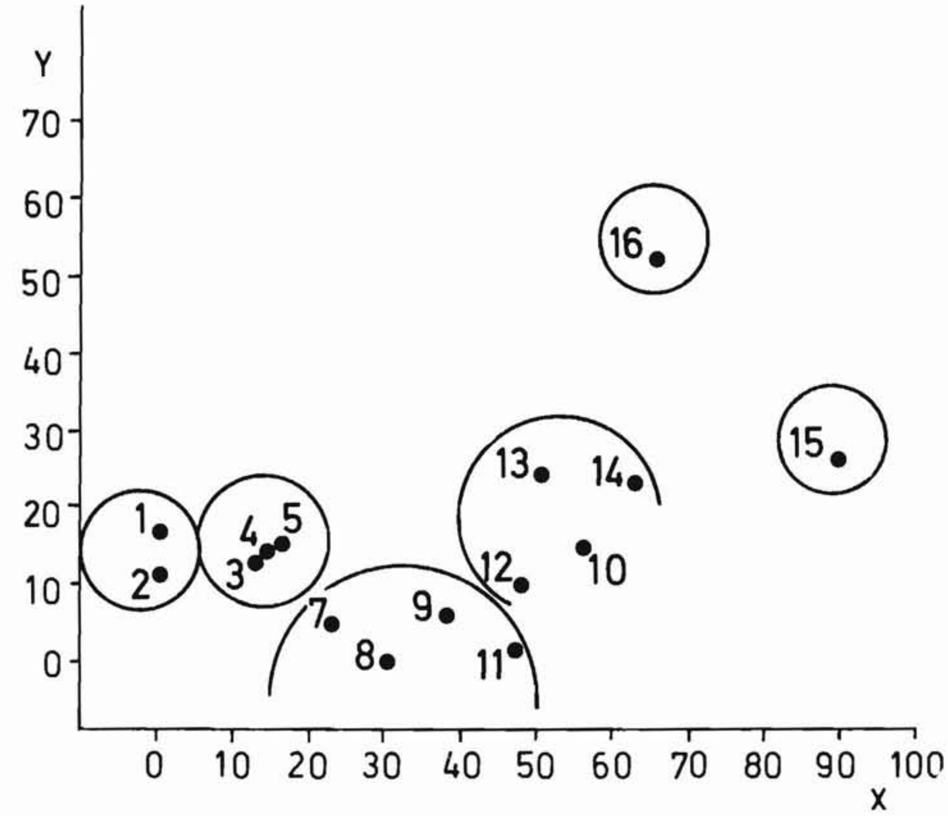


Fig. 5. Geometrical ordination of the communities based on floristic distance ($QS_{max} - QS$).

Life form spectra

Fig. 6 shows the distribution of the life forms of Raunkiær within the plant communities. The figure gives the life forms in per cent of cover.

Fig. 7 illustrates the life form distribution at the association level. The most oligotrophic associations are situated on the left and the more eutrophic at the right. The percentages of hemicryptophytes, phanerophytes, and geophytes show an increasing tendency with increasing fertility. The proportion of chamaephytes decreases correspondingly. This trend is probably quite common in forests at our latitudes (cfr. Björnstad 1971 p. 205).

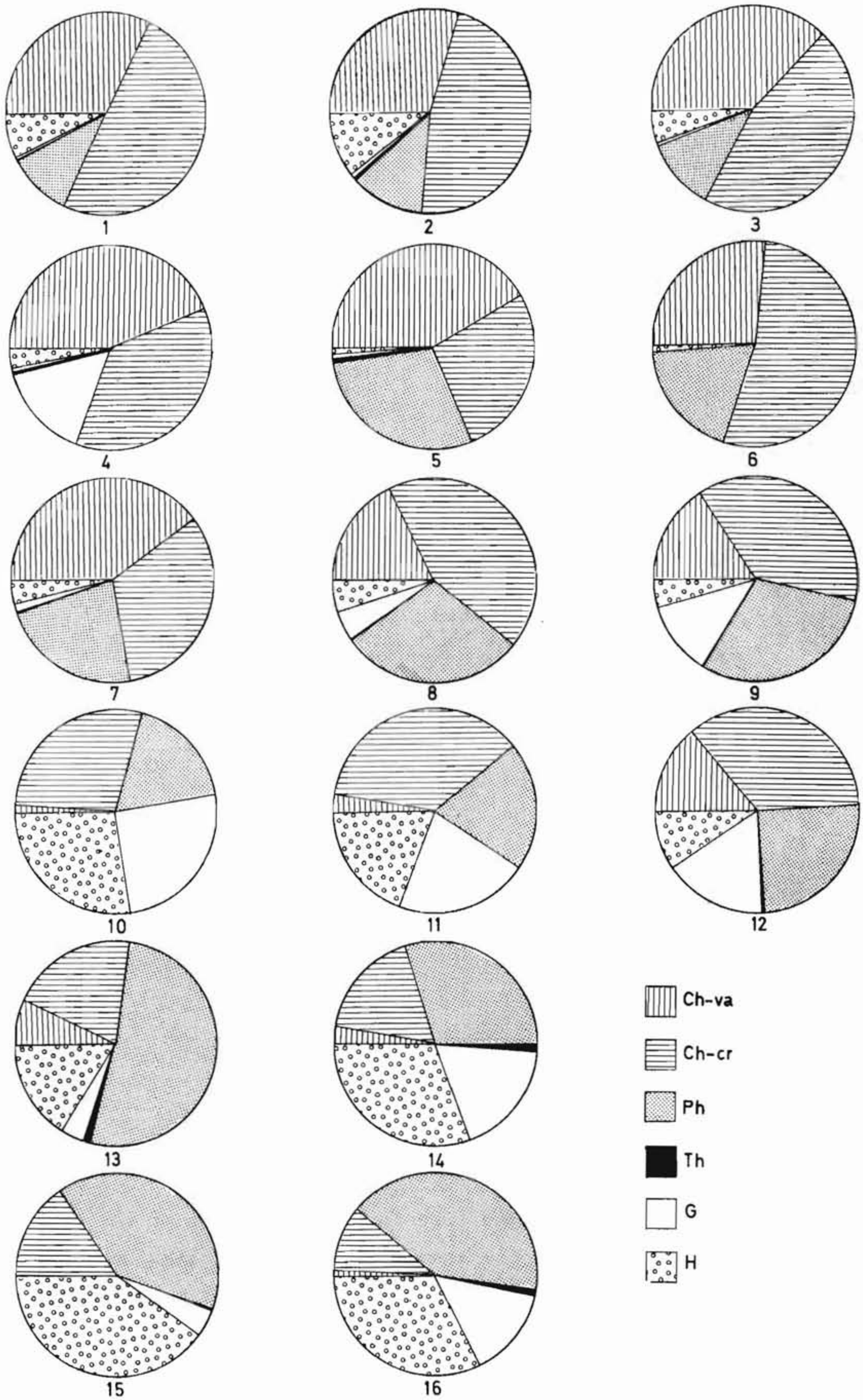


Fig. 6. Life form spectra of the communities of lowest rank (cfr. synopsis on p. 13). Ch-va: chamaephytes - vascular plants, Ch-cr: chamaephytes - cryptograms, Ph: phanerophytes, Th: therophytes, G: geophytes, H: hemicryptophytes.

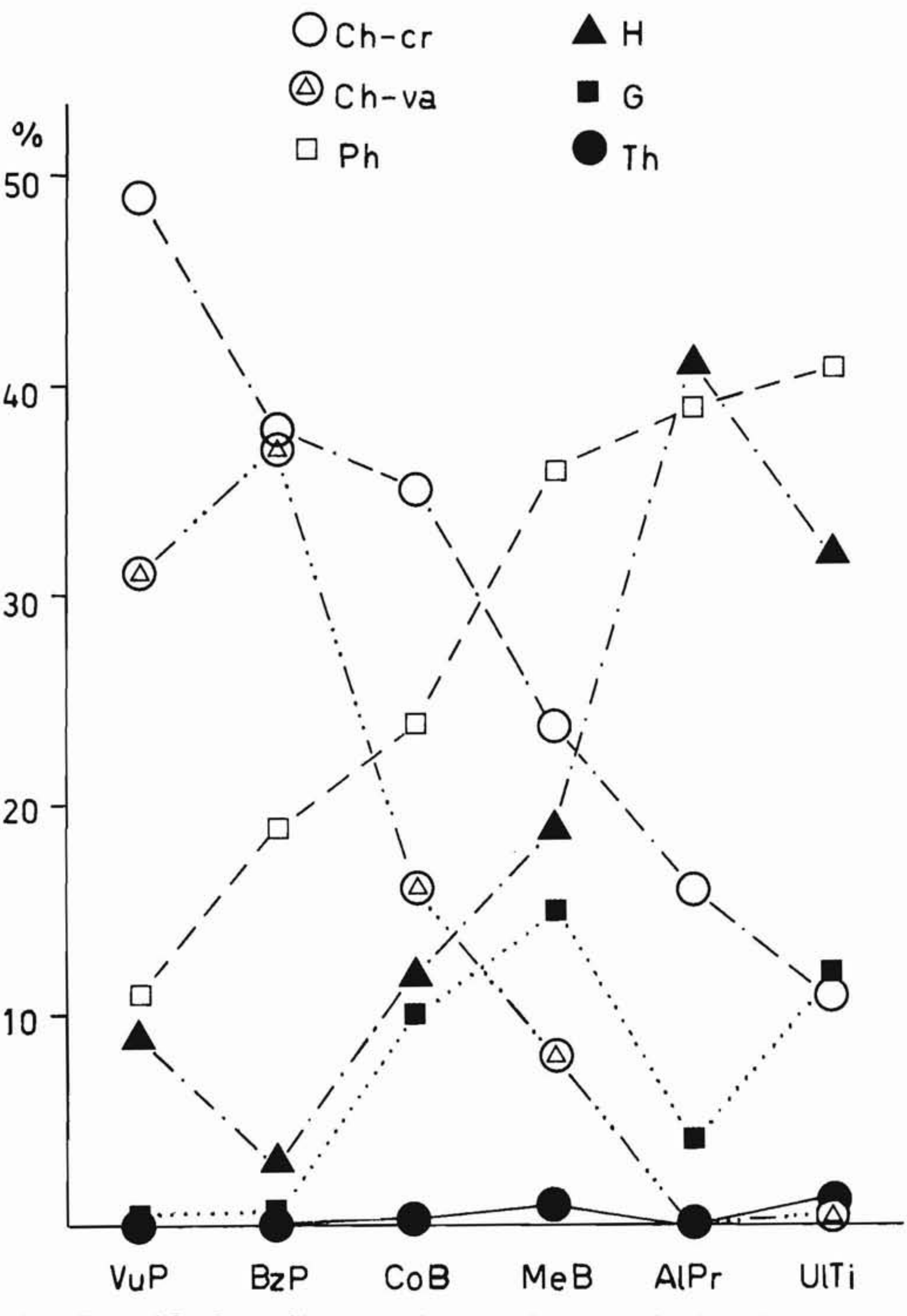


Fig. 7. Life form distribution at the association level. Life forms abbreviated as in Fig. 6.

ECOLOGICAL FACTORS

Topography

Fig. 8 summarizes the data of aspect, slope, and altitude. Some of the communities show a clear preference for shady northfaced slopes. This concerns *Vaccinio uliginosi-Pinetum Sphagnum russowii*-variant, *Bazzanio-Pinetum sphagnetosum*, and *Corno-Betuletum thelypteridetosum* and *athyrietosum*. *Corno-Betuletum dryopteridetosum* has a similar tendency, too.

The communities mentioned above contain many hygrophilous species which would suffer from drought and warmth in the more sunny slopes.

Bazzanio-Pinetum hylocomietosum, *Melico-Betuletum coryletosum* and *athyrietosum*, and *Ulmo-Tilietum* clearly prefer localities exposed to the sun. There is no doubt that *Ulmo-Tilietum* and *Melico-Betuletum coryletosum* are the two most thermophilous communities. Both of them are found on steep localities with a high content of stones in the soil. Stony soils are known to have a considerably higher temperature than stoneless soils (Troedsson 1956). These communities are often found below rocky walls. The rock can store the heat from the sun and keep the surrounding air warm even after sunset (Stålfelt 1965 p. 208).

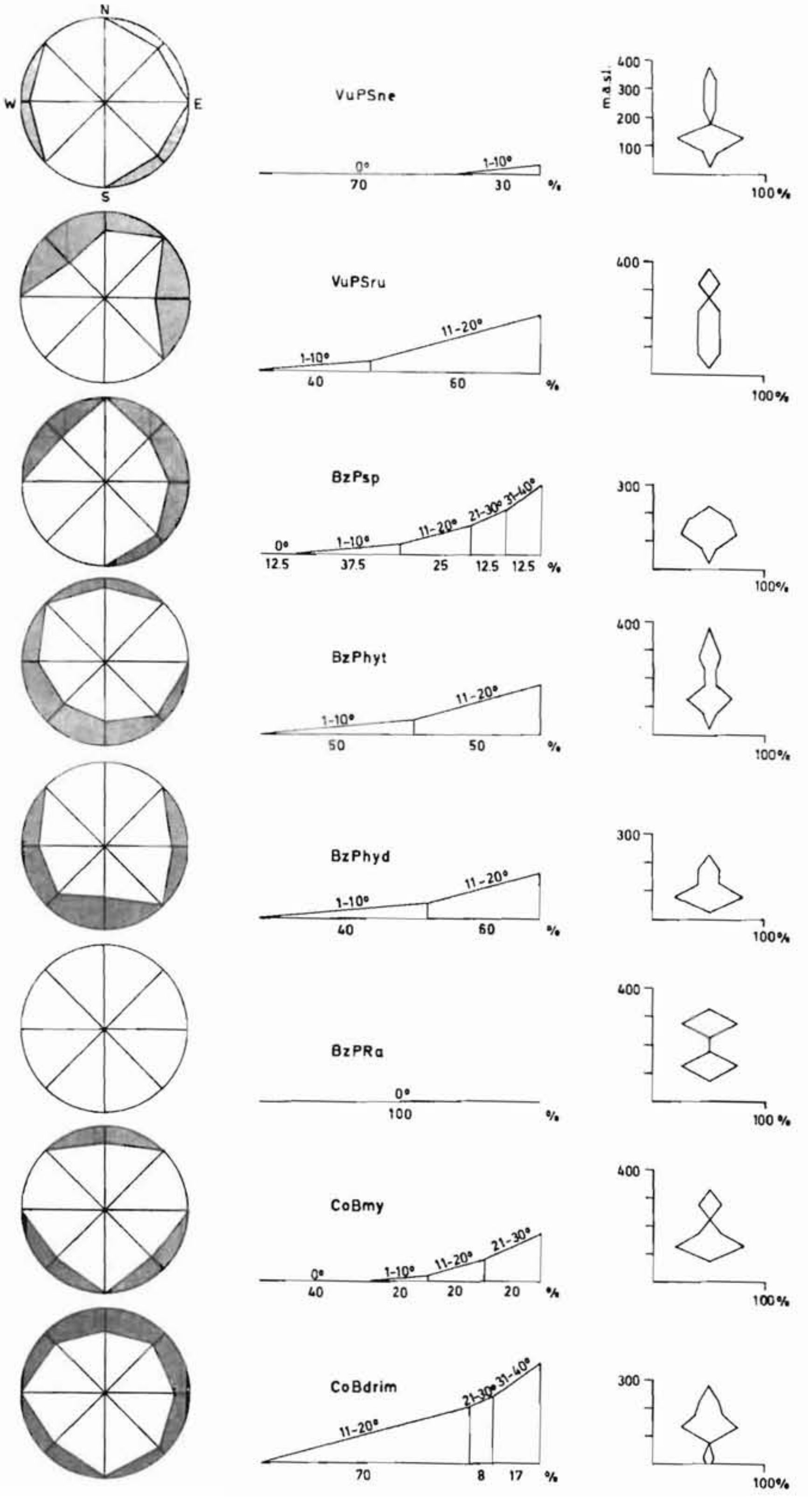
In most communities the analyses are fairly evenly distributed among the levels of altitude. I have carried out most analyses between 100 and 300 m a.s.l. Fig. 8 confirms that *Alno-Prunetum* is an extreme low-land community. *Melico-Betuletum athyrietosum* seems to be most common at altitudes above 200 m.

Edaphic factors

Table XVII shows the mean values of the measured physical and chemical properties of the soil. The values of acidity (pH), nitrogen-content, manganese, base saturation, and density increase when we go from the floristic poorer to the floristic richer communities. There is a simultaneous decrease in loss on ignition, hydrogen, and base capacity.

Table XVII. Mean values of the edaphic factors. Loss on ignition is expressed in per cent of weight. Nitrogen content is given as weight per cent of loss on ignition. The consentrations of cations are given as me/loo g dry soil as well as g/l dry soil. The latter values are made use of in the statistical calculations. Note that the figures given for the cation concentrations are linear values corresponding to the logarithmic means

Community	Nos of anal.	pH	Loss on ig- nition	Nitro- gen	Milliequivalents per 100 g dry matter							Base sat. (%)	g/l dry soil					Density kg/l
					H	K	Na	Ca	Mg	Mn	Capa- sity		K	Na	Ca	Mg	Mn	
VuP	10	4.11	96.31	1.161	108.50	1.37	1.28	8.77	13.03	0.04	133.40	18.64	0.068	0.037	0.225	0.203	0.001	0.150
BzPhyt	10	4.07	84.78	1.288	85.96	1.68	1.07	7.10	6.64	0.06	103.60	17.00	0.138	0.052	0.298	0.200	0.003	0.229
CoBdrma	10	4.13	58.45	2.248	65.54	1.18	0.57	4.80	4.94	0.07	78.86	16.69	0.144	0.040	0.299	0.187	0.006	0.344
CoBat	2	4.85	35.18	2.632	32.60	0.57	0.24	1.06	0.81	0.03	35.44	7.98	0.116	0.029	0.110	0.051	0.002	0.556
CoBth	3	5.10	20.25	3.054	19.86	0.38	0.15	4.36	2.23	0.36	27.75	28.21	0.095	0.022	0.550	0.171	0.062	0.649
MeBcorn	4	4.93	23.13	2.630	18.88	0.37	0.18	2.52	1.66	0.23	24.67	22.78	0.101	0.029	0.355	0.143	0.045	0.759
MeBcory	6	5.12	17.91	3.047	16.36	0.62	0.22	3.22	2.02	0.14	23.22	28.74	0.178	0.037	0.473	0.180	0.029	0.763
MeBat	5	4.80	34.21	3.001	33.90	0.62	0.23	4.41	3.29	0.23	43.41	21.66	0.125	0.027	0.455	0.207	0.033	0.550
AlPr	5	4.94	10.60	3.810	11.32	0.22	0.17	5.65	1.73	0.37	20.32	42.54	0.075	0.034	1.004	0.188	0.058	0.902
UlTi	4	5.75	18.88	3.303	12.77	0.61	0.23	13.49	6.11	0.21	34.55	61.44	0.174	0.039	1.962	0.540	0.042	0.753
Totalt	59	4.58	51.29	2.330	53.82	0.96	0.59	6.03	5.74	0.14	67.93	24.65	0.116	0.037	0.393	0.188	0.010	0.477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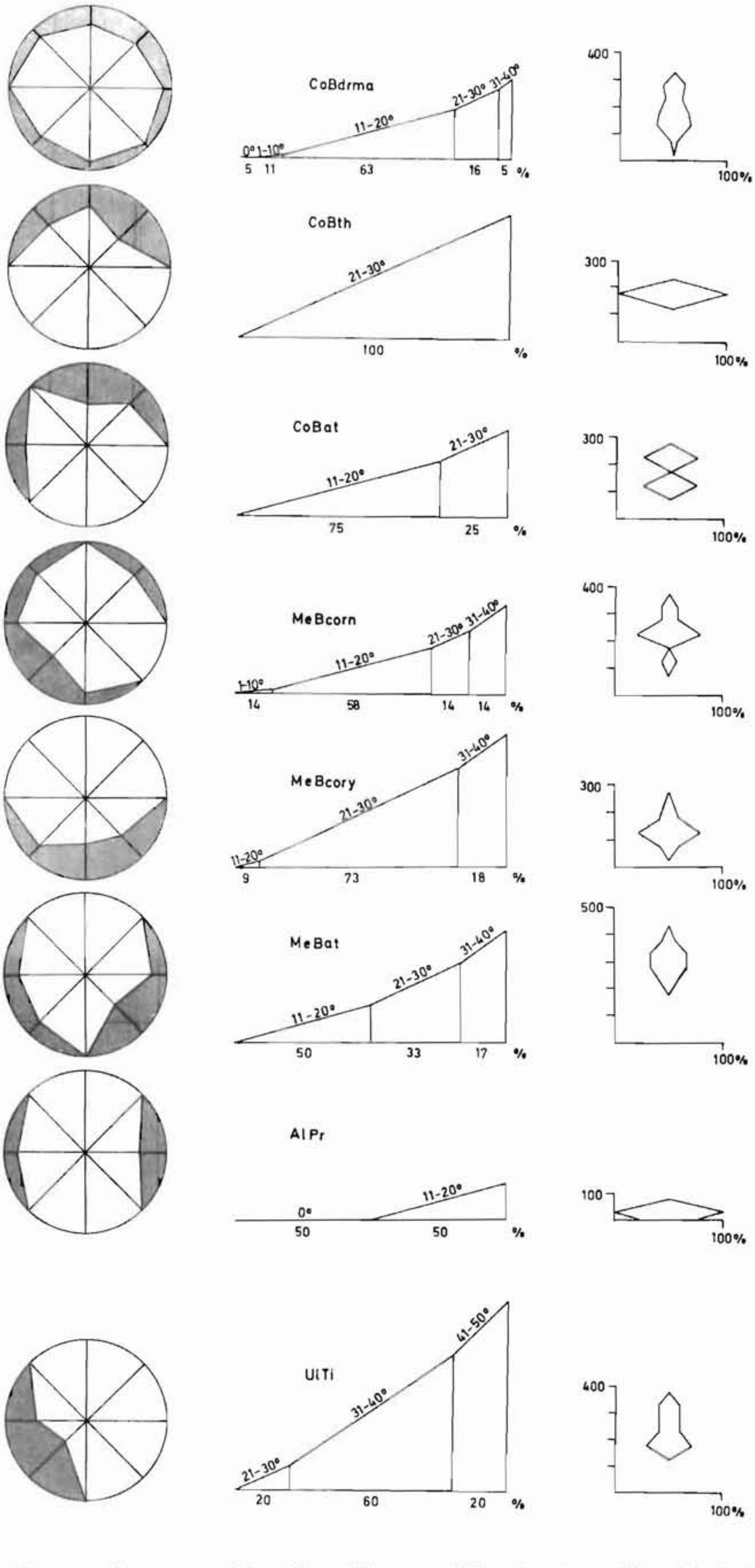

Fig. 8. For each community the figure illustrates the distribution of the vegetation analyses on various aspects (at left), degrees of slope (in the middle), and altitude (at right). In the diagrams of aspect the radius equals 100 per cent (count from the perimeter to the center).

The concentrations of calcium, sodium, potassium, and magnesium are highest in the most oligotrophic and in the most eutrophic communities, while they are lowest in the mesotrophic communities. Similar gradients of soil factors in relation to floristic richness are described and discussed by Dahl et al. (1967) and Björnstad (1971).

In order to see if the differences in the mean values are valid, and if so, to what extent the edaphic differences conform with the floristic classification, some statistical calculations were carried out. The following variables were included in the calculations:

1. degree of acidity (pH)
2. loss on ignition (I%)
3. nitrogen as per cent of loss in ignition (N%)
4. logarithmic value of potassium concentrations (K)
5. " " " sodium " (Na)
6. " " " calcium " (Ca)
7. " " " magnesium " (Mg)
8. " " " manganese " (Mn)
9. base saturation percentage (B%)
10. density (De)

The cation concentrations (expressed as g/l) were transformed to logarithmic values (base 10) to obtain variables with an approximate normal distribution (cfr. Dahl et al. 1967 p. 517).

Principal component analysis. The correlation matrix (Table XVIII) shows many significant correlations between the variables. It was therefore decided to carry out a principal component analysis in order to see if the number of variables could be reduced. Principal component analysis are described in many textbooks of statistics (Kendall 1957, Anderson 1958, Hope 1968). Mathematically the principal components are equal to the latent vectors of the correlation matrix (see for instance Searle 1965).

In this case the principal components were computed by means of an iterative method.

The purpose of the computation is to find new uncorrelated variables which explain as much as possible the variation in the original variables. Table XIX shows that nearly 85 per cent of the variation within the material may be explained by three variables only.

In Fig. 9 I have plotted the mean values for each community along these three principal axes. This ordination shows that the two pine communities (VuP and BzP) are relatively closely related with regard to soil factors. The three sub-associations of *Melico-Betuletum* also form a cluster of their own. Regarding *Corno-Betuletum*, however, we see that the three sub-associations under consideration are rather widely separated. *Dryopteridetosum* and *athyrietosum* have an intermediate position between both the *Melico-Betuletum* and the pine communities. This is in agreement with the floristic classification. *Thelypteridetosum* has an isolated position distant from the remainder of its association. With respect to the soil factors measured, it seems to belong somewhere between *Melico-Betuletum* and *Querco-Fagetea* communities.

Comparing Fig. 5 and Fig. 9, it is interesting to note that *thelypteridetosum* has a position closer to *Melico-Betuletum* than to *Corno-Betuletum* both with regard to the principal axes ordination based on soil factors and the geometrical ordination based on floristic similarity. This indicates that this community possibly should be reclassified as a shadow variant of the tall herb sub-association of *Melico-Betuletum*. The material is sparse, with only four vegetation analyses and three soil samples, and I therefore leave this question open.

Alno-Prunetum and *Ulmo-Tilietum* both have locations on the graphs which are in accordance with the floristic classification.

We may now ask what these three principal components mean in terms of the original edaphic factors. The first component (co 1) is clearly a "soil fertility component", reflecting the relatively high positive correlations between pH, N%, Ca, Mn, B%, and De. These factors are negatively correlated with the loss on ignition (see Tables XVIII and XIX). The second component (co 2) appears to be a component of "concentrations of bases" (K, Na, Ca, and Mg). The interpretation of the third component (co 3) is more dubious, but it appears to reflect the high positive correlation between the bivalent cations of calcium and magnesium on one side and the base saturation on the other side. Furthermore this component measures the ratio between the bivalent ions (Ca and Mg) and the univalent ions (K and Na).

Table XVIII. Upper right: Correlation matrix for the soil factors. Lower left: Significance of the correlations. The significance levels are: *** 0.1%, ** 1%, * 5%, n.s. not significant

	pH	I%	N%	K	Na	Ca	Mg	Mn	B%	De
pH	1.000	-0.744	0.706	0.107	-0.230	0.534	0.164	0.644	0.697	0.775
I%	***	1.000	-0.898	-0.179	0.402	-0.483	-0.015	-0.712	-0.535	-0.944
N%	***	***	1.000	0.164	-0.322	0.544	0.122	0.665	0.529	0.893
K	n.s.	n.s.	n.s.	1.000	0.376	0.315	0.270	0.268	0.140	0.116
Na	n.s.	**	*	**	1.000	0.242	0.454	-0.208	0.079	-0.270
Ca	***	***	***	*	n.s.	1.000	0.702	0.480	0.874	0.524
Mg	n.s.	n.s.	n.s.	*	***	***	1.000	0.066	0.604	0.054
Mn	***	***	***	*	n.s.	***	n.s.	1.000	0.470	0.696
B%	***	***	***	n.s.	n.s.	***	***	***	1.000	0.577
De	***	***	***	n.s.	*	***	n.s.	***	***	1.000

Table XIX. Principal components (latent vectors) computed from the matrix in Table XVIII

Root no	Latent root	Principal component (= latent vector)										Per cent variation explained
		pH	I%	N%	K	Na	Ca	Mg	Mn	B%	De	
1	5.187	0.376	-0.395	0.390	0.114	-0.080	0.334	0.143	0.344	0.348	0.399	51.9
2	2.271	-0.079	0.218	-0.156	0.301	0.545	0.364	0.543	-0.102	0.259	-0.173	22.7
3	1.005	0.105	0.114	-0.068	-0.798	-0.214	0.165	0.265	-0.260	0.349	-0.049	10.0
											Sum	84.6

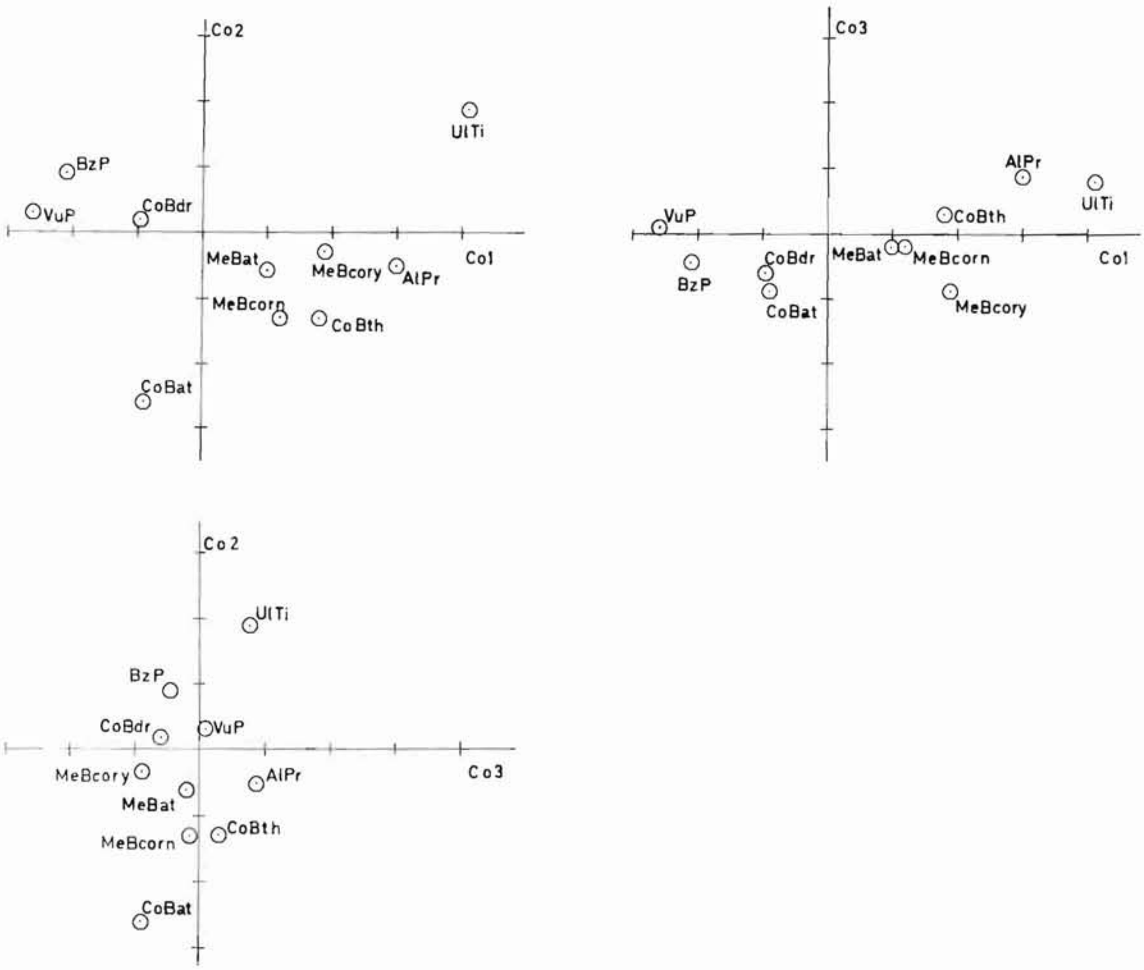

Fig. 9. A three-axes ordination of the communities based on a principal components analysis of edaphic factors.

Discriminant analysis. The principal axes analysis is no statistical test, and it tells nothing about the significance of the differences between the communities. Therefore, a stepwise discriminant analysis was carried out. This kind of statistical analysis was employed by Dahl et al. (1967) and Björnstad (1971). The theory of discriminant analysis is described in general in several textbooks of multivariate statistics (Rao 1952, Kendall 1957, Hope 1968). Dahl et al. (1967) and Björnstad (1971) used the original edaphic factors as variables in the discriminant analyses, 8 and 9 variables respectively. I have used only 3 variables, namely the three former principal components of the soil factors.

For all possible pairs of communities the discriminant function, D^2 ("distance of Mahalonobi"), is computed. D^2 is a function of the differences between the variables, i.e.

$$D^2 = k_1 d_1 + k_2 d_2 + k_3 d_3,$$

where d_1, d_2, d_3 are the mean differences between the communities for each of the three variables (components). The coefficients k_1, k_2, k_3 are determined in such a way that the significance of D^2 maximizes.

In order to ascertain the significance of the discrimination, a test statistic called F, was calculated. Percentage points of this F-distribution are given in most sets of statistical tables (e.g. Table 7 in Lindley & Miller 1966). The F-value has n_v and $n_a+n_b-n_v-1$ degrees of freedom. Here n_v equals the number of variables, while n_a and n_b are the numbers of samples from communities a and b respectively.

The analysis was said to be stepwise. This means that first the discriminant function is determined with aid of all three variables. Then the variable that contributes least to the D^2 value is omitted, and a new discriminant function is computed for the two remaining variables. Again the least important variable is omitted, and D^2 is found for the last variable. At all three steps of the analysis there are also calculated test statistics for each variable. These statistics have F-distributions with 1 and $n_a+n_b-n_v-1$ degrees of freedom. An example of the stepwise analysis in comparison of two spruce communities is given by Dahl et al. (1967 p. 520).

Table XX. Results of the discriminant analysis. Upper right: D^2-values with degrees of freedom in brackets. Lower left: The corresponding F-values and their significance. *** means significance at the 0.1 per cent level, ** significance at the 1 per cent level, * significance at the 5 per cent level, and n.s. means not significant

	VuP	BzP hy	CoB dr	CoB at	CoB th	MeB corn	MeB cory	MeB at	Al Pr	Ul Ti
VuP		(3,16) 0.208	(3,16) 0.502	(3,8) 8.29	(3,9) 20.9	(3,10) 12.7	(3,12) 10.5	(3,11) 9.51	(3,11) 48.8	(3,10) 15.2
BzP hy	** 5.54		(3,16) 0.262	(3,8) 1.40	(3,9) 13.9	(3,10) 9.46	(3,12) 4.94	(3,11) 5.56	(3,11) 19.5	(3,10) 11.4
CoB dr	*** 13.39	** 6.99		(3,8) 0.405	(3,9) 2.09	(3,10) 1.15	(3,12) 1.02	(3,11) 0.784	(3,11) 3.23	(3,10) 3.62
CoB at	*** 36.85	* 6.24	n.s. 1.80		(3,1) 15.8	(3,2) 2.11	(3,4) 1.57	(3,3) 1.96	(3,3) 8.09	(3,2) 15.7
CoB th	*** 144.97	*** 96.03	*** 14.48	n.s. 6.32		(3,3) 0.464	(3,5) 2.09	(3,4) 3.93	(3,4) 1.43	(3,3) 6,94
MeB corn	*** 121.29	*** 90.09	** 10.94	n.s. 1.88	n.s. 0.80		(3,6) 0.470	(3,5) 0.084	(3,5) 2.10	(3,4) 1.72
MeB cory	*** 158.00	*** 74.07	*** 15.23	n.s. 3.14	* 6.97	n.s. 2.26		(3,7) 0.450	(3,7) 4.14	(3,6) 2.26
MeB at	*** 116.19	*** 67.95	** 9.58	n.s. 2.80	* 9.82	n.s. 0.31	n.s. 2.86		(3,6) 9.48	(3,5) 1.93
Al Pr	*** 596.43	*** 238.71	*** 39.44	* 11.55	n.s. 3.59	* 7.77	*** 26.33	*** 47.39		(3,5) 1.19
Ul Ti	*++ 144.44	*** 108.98	*** 34.49	n.s. 13.95	* 11.90	n.s. 4.60	** 10.83	* 7.14	n.s. 4.40	

Table XX gives the D^2 values at the first step of the discriminant analysis. 20 of the 45 comparisons are significant at the 0.1 per cent level. Between related types the significance is less, or the comparison is insignificant at the 5 per cent level. Especially *Corno-Betuletum athyrietosum* and *thelypteridetosum* give many insignificant comparisons. This is not surprising as the degrees of freedom are few. At step 2 or 3 in the analysis more (39) comparisons become clearly significant. Within the associations *Melico-Betuletum*, however, the edaphic differences seem to be rather slight. *Cornetosum* is not significantly different from either *coryletosum* or *athyrietosum*, neither at step 2 nor at step 3. Other ecological factors than the measured soil properties

Table XXI. Significant variables (components) by the discriminant analysis. By following horizontal rows the table shows in which components one community differs positively from the other. By following vertical columns it indicates in which components the same community differs negatively. Significance levels: ** 1%, *** 0.1%

	VuP	BzP hy	CoB dr	CoB at	CoB th	MeB corn	MeB cory	MeB at	Al Pr	Ul Ti
VuP		$\underline{\text{Co3}}^{***}$		$\underline{\text{Co2}}^{***}$ Co3^{***}	Co2^{**}	Co2^{**}	Co2^{***}	Co2^{***}	Co2^{***}	
BzP hy				Co2^{**}		Co2^{**}				
CoB dr	Co1^{***}	$\underline{\text{Co1}}^{***}$								
CoB at										
CoB th	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$							
MeB corn	$\underline{\text{Co1}}^{***}$	Co1^{***}	$\underline{\text{Co1}}^{***}$							
MeB cory	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$							
MeB at	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$							
Al Pr	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{**}$		$\underline{\text{Co1}}^{**}$	$\underline{\text{Co3}}^{**}$	$\underline{\text{Co1}}^{***}$		
Ul Ti	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{***}$	$\underline{\text{Co1}}^{**}$	$\underline{\text{Co2}}^{***}$	$\underline{\text{Co1}}^{**}$	$\underline{\text{Co2}}^{**}$	$\underline{\text{Co1}}^{**}$	$\underline{\text{Co2}}^{**}$	

are obviously responsible for the floristic differences. The most important ones are probably soil water, aspect and slope.

Dahl et al. (1967 p. 521) point out a significant correlation between "edaphic distance" and "floristic distance" in East-Norwegian coniferous forest communities. "Edaphic distance" may be measured as D^2, or better as D. "Floristic distance" may be expressed by inverting the index of Sörensen, i.e. 100/QS. Regarding the edaphic distances I have omitted D values with less than five "error degrees of freedom." The

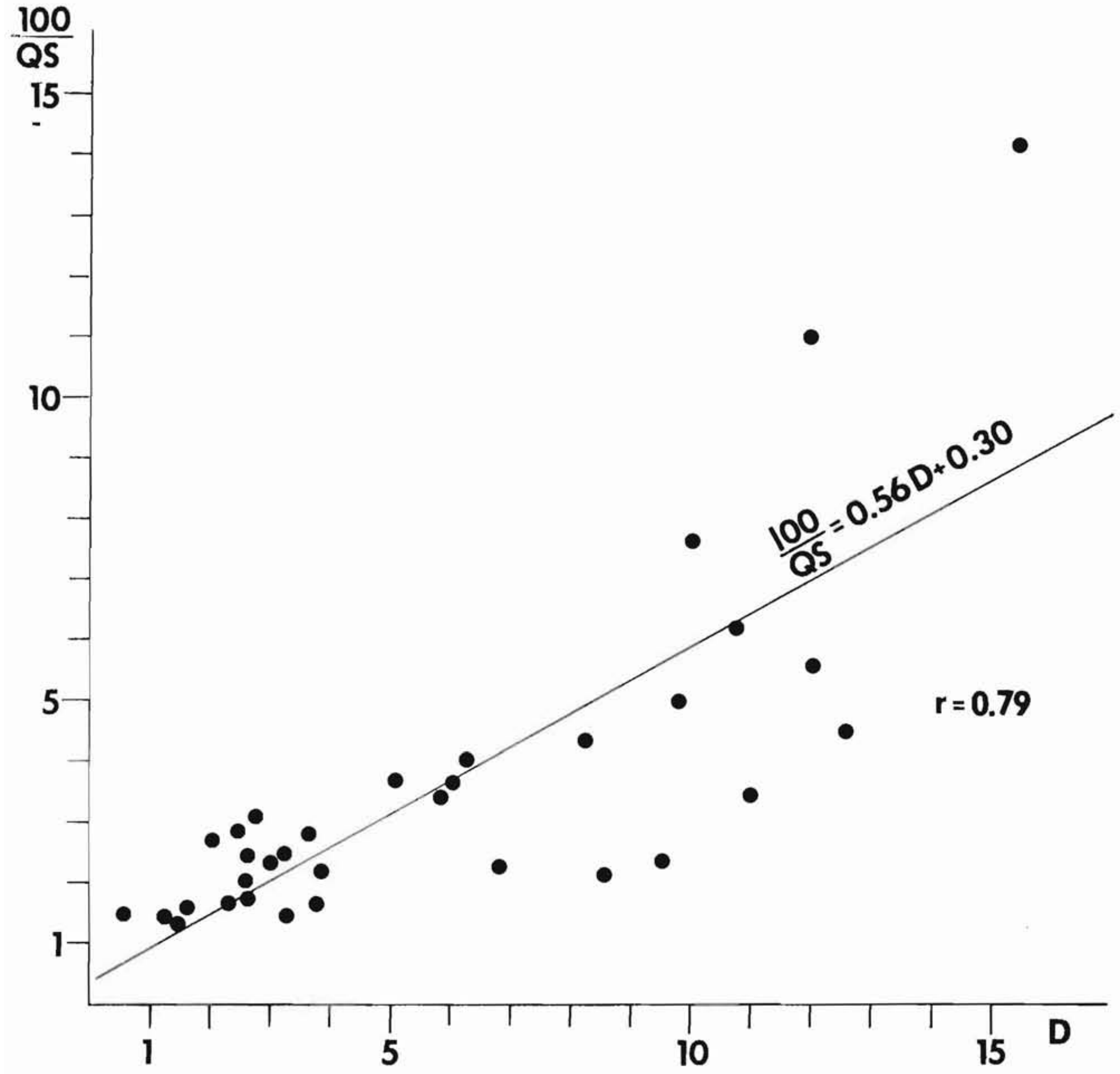

Fig. 10. Relationships between floristic distance (100/QS) and edaphic distance (D).

comparison with QS = 0 is also omitted. The remaining 33 pairs of floristic and edaphic distances are plotted in Fig. 10, together with the calculated regression line. The correlation is fairly good, and the correlation coefficient is equal to 0.79.

Table XXI shows significant variables (principal components) at the discriminant analyses. These variables are mostly found at step 2 or 3. In many cases the most important discriminator is the variable which remains until the last step of analysis. These variables are set underlined in Table XXI.

Component 1, "the general fertility" is a significant discriminator between most of the communities. Component 2, "base capacity", contributes positively to the discrimination for *Vaccinio uliginosi-Pinetum*, and to some extent also for *Bazzanio-Pinetum* and *Ulmo-Tilietum*. The two pine communities have a high content of organic matter (I%) and thereby humus colloids provide a high exchange capacity. Although the base saturation is low the base capacity gets a high value. *Ulmo-Tilietum* has a lower loss on ignition and also a much lower exchange capacity than the pine communities, but the base saturation is high and the base capacity thereby high. Component 3 is a significant discriminator in only three comparisons.

Biotic factors

Every summer there are some domestic animals grazing in the area. Nowadays there are mostly sheep. In the past cattle grazed in the forests, but now there are only a few young animals. At the Asplisetra mountain pasture goats were kept until 1970.

Kielland-Lund (1962 p. 66) and Dahl (1967 p. 142) mention several "grazing indicator species," i.e. species that will increase in frequency and abundance due to grazing. In Table XXII I have listed such species and their presence in the various forest communities in Hemne. I have also tabulated a few species which are believed to be sensitive to grazing (cfr. Kielland-Lund 1962 p. 66, Dahl et al. 1967 p. 514). From the table it is evident that most of the "grazing species" are found in *Melico-Betuletum*. Stands of this association are particularly attractive to the animals because of the high content of grasses and other food plants. In *Corno-Betuletum* the sub-associations *athyrietosum* and especially the *thelypteridetosum* have many grazing indicators. Most of these species are naturally occurring in the forests but become more abundanct because of alterations in the competition conditions caused by the grazing. A few of them, e.g. *Ranunculus acris*, are apparently quite unfamiliar in virgin forest vegetation.

Table XXII. "Grazing indicator species" and species sensitive to grazing in the communities

	VuP			BzP					CoB				MeB		Al	Ul
	Sne	Sru	sp	hyt	hyd	Ra	m	dri	drm	th	at	corn	cory	at	Pr	Ti
"Grazing species":																
Agrostis tenuis	.	.	.	.	.	.	.	.	II^2	3^2	2^2	V^2	III^2	IV^3	.	II^2
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	I^3	3^2	2^3	V^3	V^3	III^2	.	II^2
Carex pallescens	.	.	.	.	.	.	.	.	.	.	.	III^2	V^2	IV^2	.	.
C. vaginata	.	.	.	.	.	.	.	.	.	.	2^1	I^2	I^1	III^2	.	.
Deschampsia caespitosa	.	.	.	.	.	.	.	.	II^3	4^3	2^4	III^2	III^3	V^3	V^4	.
Alchemilla spp.	.	.	.	.	.	.	.	.	.	3^2	.	I^1	II^1	I^1	.	.
Hypericum maculatum	.	.	.	.	.	.	.	.	.	.	.	I^+	II^2	V^3	.	III^1
Potentilla erecta	I^1	I^1	II^2	I^1	II^2	.	II^1	I^1	IV^3	3^3	2^3	V^3	V^2	V^3	.	.
Ranunculus acris	.	.	.	.	.	.	.	.	.	4^2	.	II^1	I^1	.	IV^2	I^2
Solidago virgaurea	.	.	.	.	.	.	.	I^3	II^2	.	3^3	IV^2	II^1	V^2	I^1	II^3
Veronica chamaedrys	.	.	.	.	.	.	.	.	.	1^1	.	II^2	III^2	I^2	.	III^2
V. officinalis	.	.	.	.	.	.	.	.	I^1	2^2	.	IV^2	V^2	V^2	.	III^2
Rhytidiadelphus squarrosus	.	.	.	I^1	.	.	.	.	II^1	1^1	3^4	V^2	II^2	IV^3	IV^4	.
Species sensitive to grazing:																
Calamagrostis purpurea	.	.	.	.	.	.	.	I^1	.	.	.	.	I^2	III^2	.	II^1
Milium effusum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^2
Athyrium filix-femina	.	.	.	.	.	.	.	I^1	III^2	2^4	4^5	II^2	III^1	V^5	IV^5	III^5
Campanula latifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^3
Cicerbita alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^5	.

The investigated stands of *Alno-Prunetum* were utilized both for hay fields and grazing until about thirty years ago. Since then the vegetation has regenerated rather rapidly, and a sensitive species like *Cicerbita alpina* has become reestablished. But of course there remains evidence of the cultural influence.

Hay-cutting has influenced the forest vegetation in the lowlands only slightly, in that it has mostly been restricted to fens and birch forests in the sub-alpine zone (except that on cultivated land) (cfr. Moen 1969, 1970). The influence of forestry seems also to have been unimportant. Selection cutting and natural regeneration have been the usual silviculture.

SYNSYSTEMATIC DISCUSSION AND COMPARISON WITH EARLIER WORKS

The concept of vicarious communities

The concept of vicarious communities is discussed by several authors (Fukarek 1964 p. 85, Hartmann & Jahn 1967 p. 4, Kielland-Lund 1971 p. 14, Björnstad 1971 p. 211). The main idea of the notion "vicarious" is to describe geographical variations due to macroclimatic and/or historical reasons. Vicarious communities thus are "parallel" communities occurring at similar edaphic conditions in different vegetational regions. The regional differences are caused by climate or vegetation history. The basic unit of classification, the association, may be devided into two or more geographical vicarious races. If the differences are still greater, one talks about vicarious associations (vicarious alliances, orders etc.). Variants at different altitudes within a vegetational region are called elevation forms (Kielland-Lund 1971 p. 14).

Regarding Norwegian forest vegetation, we recognize at least four main vegetation regions with differences in climate and history. These regions are the eastern Norway, the southernmost Norway, the western Norway, and the northern Norway. In eastern Norway the climax vegetation is spruce forests with pine forests as "para-climax" on shallow soils (Kielland-Lund 1962, 1970). The southernmost Norway has broadleaved deciduous forests, especially oak forests (Björnstad 1971). In the oceanic climate of western Norway pine, birch, and several broadleaved deciduous trees occur, but spruce is normally absent. In the colder climate of northern Norway pine and especially birch become the most important forest trees.

The synsystematic relations of the individual associations

Vaccinio uliginosi-Pinetum. Kielland-Lund has in Dahl et al. (1967, Table 1) published six analyses from pine bogs in eastern Norway. The floristic similarity between his analyses and mine from Hemne is evident, especially for the *Sphagnum nemoreum* variant (QS = 72). Kielland-Lund (1971 p. 23) recognizes four vicarious communities of this association in Scandinavia. My analyses from Hemne are probably intermediate to the western and the boreal races mentioned by Kielland-Lund. Western species such as *Cornus suecica* and *Rhytididadelphus loreus* differentiates against the boreal race described by Dahl et al. (1967). *Dicranum polysetum*, several *Cladonia* species, *Vaccinium oxycoccus*, and *Picea abies* are never found in the community in Hemne, but are frequent in that of eastern Norway. Kielland-Lund (1971) claims that *Erica tetralix* is characteristic of the western pine bogs, but I have never seen this species in the wooded bogs in Hemne although it is quite common on treeless mires.

Mork & Låg (1959 p. 57) describe related communities (*Vaccinium* swamp forest and *Calluna* swamp forest) with *Carex globularis* from Trysil in easternmost South Norway. Descriptions of a more eastern Scandinavian race with *Ledum palustre* are given by Swedish authors (Malmström 1949, Malmer 1962).

Whether Dahl et al. (1967) and Kielland-Lund (1971) are right or not joining this Scandinavian communities with the Middle European association *Vaccinio uliginosi-Pinetum* is a matter for discussion. Matuszkiewicz (1962 p. 175 ff.) has given a survey of the association in eastern Central Europe. Boreal species such as *Betula nana, Carex globularis, Empetrum* spp.*, Rubus chamaemorus, Vaccinium microcarpum, Dicranum undulatum* ("*bergeri*"), and *Sphagnum fuscum* are absent from or very rare in the material of Matuszkiewicz. He regards the association an element of the alliance *Dicrano-Pinion.*

Neuhäusel (1969) has proposed a revision, reviewing most of the European works on the problem. His conclusion is that boreocontiental pine bogs constitute a separate association *Ledo-Sphagnetum medii* Sukopp 1959 in the class *Oxycocco-Sphagnetea,* while the "traditional" *Vaccinio uliginosi-Pinetum* is retained in the alliance *Dicrano-Pinion* of *Vaccinio-Piceetea.* There is, however, some reason for believing that Neuhäusel's knowledge about the Scandinavian pine bogs might have been insufficient. Further research is clearly required. For the time being I prefer to follow Kielland-Lund (1971) in using the name *Vaccinio uliginosi-Pinetum.* I have decided to place the association among the pine forests in the alliance *Phyllodoco-Vaccinion,* because of the close floristic relationship with the following association *Bazzanio-Pinetum.* I feel, however, that Central European phytosociologists will have good reasons for disagreement for my including their *Vaccinio uliginosi-Pinetum* in *Phyllodoco-Vaccinion.*

Bazzanio-Pinetum. Kielland-Lund (1967) has given a survey of the Norwegian pine forest associations on firm ground. In this paper he describes the west Norwegian association *Bazzanio-Pinetum,* which he regards vicarious of the east Norwegian association *Barbilophozio-Pinetum.* As differential species of *Bazzanio-Pinetum* Kielland-Lund (1967, Table 2) lists, *Cladonia impexa, Pteridium aquilinum, Bazzania trilobata, Sphagnum quinquefarium, Racomitrium lanuginosum, Barbilophozia barbata, Rhytidiadelphus loreus, Molinia coerulea,* and *Blechnum spicant.* These species differentiate against other Scandinavian pine forests, but most of them are found in other communities in Western Norway. Table IV shows that many of these species are present also in the community in Hemne. Kielland-Lund based his description of the association on 11 analyses from Förde in Sogn (260 km SW of Hemne) and 15 analyses from the Bergen area (100 km S of Förde). The analyses from Förde are especially similar to my own analyses from Hemne. McVean & Ratcliffe (1962) have described two related communities, *Pinetum Vaccineto-Callunetum* and *Pinetum Hylocomieto-Vaccinetum,* from Scotland. According to Kielland-Lund (pers.comm.) they constitute another western vicarious association.

Malme (1971 p. 15) describes a "*Bazzanio-Pinetum hylocomietosum*" from the island Fræna (120 km SW of Hemne). In my opinion, this must be a misclassification. Species such as *Convallaria majalis, Luzula pilosa, Oxalis acetosella, Rubus saxatilis,* and *Viola riviniana* indicate a much richer community than the true *Bazzanio-Pinetum* K.-Lund 1967.

Similarity indices between the variants of *Bazzanio-Pinetum* from Hemne, and related communities from Norway and Scotland, are given in Table XXIII.

Table XXIII. Similarity indices of three variants of *Bazzanio-Pinetum* from Hemne and related communities in Norway and in Scotland. 1: *Barbilophozio-Pinetum* from eastern Norway (Dahl et al. 1967). 2-5: *Bazzanio-Pinetum* (Kielland-Lund 1967); 2, *Cladonia* variant from Förde, 3, *Sphagnum* variant from Förde, 4, *Cladonia* variant from Bergen area, 5, *Sphagnum* variant from Bergen area. 6-7: Scottish pine forests (McVean & Ratcliffe 1962), 6, *Pinetum Vaccineto-Callunetum*, 7, *Pinetum Hylocomieto-Vaccinetum*.

	Eastern Norway	Western Norway				Scotland	
	1	2	3	4	5	6	7
BzPsp (Hemne)	44	62	69	42	56	65	54
BzPhyt "	49	68	67	47	57	54	50
BzPhyd "	55	69	67	49	56	52	59

Kielland-Lund (1967) included *Bazzanio-Pinetum* in *Phyllodoco-Vaccinion*. At our present state of knowledge about Norwegian vegetation I see no reason to propose a reclassification. I feel, however, that future research will show that some improvements will be necessary. Concerning the alliances *Phyllodoco-Vaccinion* and *Vaccinio-Piceion* there are some disagreements between phytosociologists working with alpine vegetation and those working with forest vegetation (compare, Dahl, Kalliola, Marker & Persson 1971 p. 10 with Kielland-Lund 1971 p. 19 ff).

Corno-Betuletum. I regard this association a western vicarious community of the eastern spruce community *Eu-Piceetum* (Caj. 1921) K.-Lund 1962. Kielland-Lund (1971 p. 74) recognizes three main sub-associations of *Eu-Piceetum*, a *Myrtillus*, a *Dryopteris*, and a *Athyrium filix-femina* sub-association. These are ecological parallels to the *myrtilletosum*, *dryopteridetosum*, and *athyrietosum* of *Corno-Betuletum*. Kielland-Lund (1971) also mentions vicarious birch-pine forests, "*Corno-Pinetum*", in West Norway, but so far he has not published any vegetational analyses of this western community. The name *Corno-Pinetum* is probably more descriptive than my *Corno-Betuletum*. There is some evidence that stands with *Betula* are over-represented in my vegetation tables. The *Myrtillo-Betuletum luzuletosum silvaticae* (prov.) described by Malme (1971 p. 13) probably belongs to this association. Kielland-Lund (1967 p. 130, 1971 p. 25) reports that the meso-trophic birch forests of the sub-alpine zone are elevation forms of *Eu-Piceetum*.

Beside the different tree layers the floristic difference between *Corno-Betuletum* and *Eu-Piceetum* is an element of sub-oceanic species in *Corno-Betuletum*, i.e. *Cornus suecica*, *Plagiothecium undulatum*, *Rhytidiadelphus loreus*, *Lophocolea bidentata*, and *Tritomaria quinquedentata*. Some of these species may be present in particularly humid variants of *Eu-Piceetum*, for instance the *Cornus* variant and the *Phegopteris* variant from Hurdal (60 km N of Oslo) described by Kielland-Lund (1962 p. 45).

Björnstad (1971) points out that the southern *Populo-Quercetum* Tx. 1951 and the eastern *Eu-Piceetum* are vicarious communities. *Populo-Quercetum pinetosum* corresponds to *Eu-Piceetum Myrtillus* sub-association, and *Populo-Quercetum oxalidetosum* corresponds to *Eu-Piceetum Dryopteris* sub-association.

Table XXIV gives similarity indices between the variants of *Corno-Betuletum* and vicarious communities in eastern and southern Norway. I have also included two variants of the sub-alpine birch forests (*Betuletum myrtillo-hylocomiosum* Nordh. 1943) namely a "continental facies" (Nordhagen 1943, Table 19) and a "sub-oceanic facies" with *Cornus* (Nordhagen 1928). It was unexpected that the description of the variant

Table XXIV. Similarity indices of five variants of *Corno-Betuletum* from Hemne and related communities from other parts of Norway. 1-5: *Eu-Piceetum* (Kielland-Lund 1962), 1, *Myrtillus* sub-ass. typical var., 2, *Myrtillus* sub-ass. *Cornus* var., 3, *Dryopteris* sub-ass. *Linnaeana* var., 4, *Phegopteris* var., 5, *Athyrium* sub-ass. (*Aconito-Piceetum* with *Athyrium alpestre* (*distentifolium*)). 6-7: *Betuletum myrtillo-hylocomiosum*, 6, continental facies (Nordhagen 1943), 7, sub-oceanic facies with *Cornus* (Nordhagen 1928). 8-9: *Myrtillo-Quercetum* (Björnstad 1971), 8, *pinetosum*, 9, *oxalidetosum*

	Eastern Norway					Sub-alp. zone		Southern Norway	
	1	2	3	4	5	6	7	8	9
CoBmy	60	55	53	41	42	48	47	51	50
CoBdrim	65	68	69	60	55	43	42	45	52
CoBdrma	57	57	62	54	55	37	40	46	56
CoBth	26	23	41	41	52	38	37	26	35
CoBat	45	47	53	59	53	37	44	27	42

with *Cornus* did not give higher similarity indices than the continental variant.

Melico-Betuletum. Although the characteristic species of the coniferous forests are only slightly abundant in many of the stands referred to *Melico-Betuletum*, I see no reason for not classifying this association in *Vaccinio-Piceion*. The association is characterized by a group of eutrophous species also characteristic of the deciduous forests (*Querco-Fagetea*), but it would be rather meaningless to include *Melico-Betuletum* in *Querco-Fagetea*. The sub-association *coryletosum* is the community which is most closely related to *Querco-Fagetea*. Hånde (1969 p. 55) describes a rather similar community, *Asperulo-Coryletum myrtilletosum*, from Eikesdalen (100 km SW of Hemne). He refers this community to the order *Fagetalia*. The main difference between *Melico-Betuletum coryletosum* and this "*Coryletum*" is that species such as *Galium odoratum*, *Ulmus glabra* (seedlings and saplings), *Dryopteris* *filix-mas*, and *Paris quadrifolia* are more abundant in the latter. The similarity index equals 68. This illustrates that it may be difficult to differentiate between *Vaccinio-Piceetalia* communities with *Corylus* and *Corylus* communities of *Fagetalia*.

A reasonable proposal could be to classify the tall herb community, *athyrietosum*, among the sub-alpine tall herb meadows of the class *Betulo-Adenostyletea*. Kielland-Lund (1962) referred some special tall herb communities of the coniferous forest zone to this class. I do not think this is a solution for *Melico-Betuletum athyrietosum*. The characteristic species of *Betulo-Adenostyletea* are too sparse.

The vicarious association of *Melico-Betuletum* in the eastern spruce forests is *Melico-Piceetum* (Caj. 1921) K.-Lund 1962. In the oak forests of southern Norway the vicarious community is *Melico-Quercetum* Björnst. 1971. *Melico-Piceetum* is divided into sub-units which more or less correspond to the three sub-associations of *Melico-Betuletum*. Dahl et al. (1967) and Kielland-Lund (1971) recognizes a typical low herb sub-association (*typicum*) and a tall herb sub-association (*athyrietosum*). The low herb sub-association is divided into a poorer typical variant and a richer one with *Corylus* (Kielland-Lund 1965 a). Table XXV shows similarity indices of the *Melico-Betuletum* communities and the vicarious communities in eastern and southern Norway. A sub-alpine herb rich birch forest (from Nordhagen 1943) is also included for comparison.

Table XXV. Similarity indices of three variants of *Melico-Betuletum* from Hemne and related communities from other parts of Norway. 1-3: *Melico-Piceetum* from eastern Norway, 1, typical sub-ass. (Kielland-Lund 1962), 2, variant with *Corylus* (Kielland-Lund 1965 a), 3, *Athyrium* sub-ass. (Dahl et al. 1967). 4: *Melico-Quercetum* from Southern Norway (Björnstad 1971). 5: sub-alpine *Betuletum geraniosum* (Nordhagen 1943)

	Eastern Norway			Southern Norway	Sub-alpine zone
	1	2	3	4	5
MeBcorn	62	47	63	48	34
MeBcory	53	44	53	51	28
MeBat	50	53	59	43	39

Alno-Prunetum. The classification of the broadleaved forests along streams and rivers ("Auenwälder") has been greatly disputed among European phytosociologists (Oberdorfer 1953, Matuszkiewicz & Borowik 1957, Moor 1960, Ellenberg 1963, Medwecka-Kornas et al. 1966, Oberdorfer 1967). Kielland-Lund (1971 p. 30) gives a survey of the corresponding Scandinavian forest communities which he refers to the alliance *Alno-Padion.* He describes the association *Alno-Prunetum* by providing a list of the dominating and differential species. The only characteristic species mentioned is *Ribes spicatum.* I have not found this species in Hemne, but nevertheless I am convinced that the *Alnus* forests along the stream Hollaelva belong to this association.

Several authors report various forests with *Alnus incana* from western Norway (Knaben 1952, Ve 1968, Hånde 1969, Malme 1971). These forests share many species with *Alno-Prunetum*, but some of them are probably pioneer stands with many apophytic species due to grazing and human activities.

Ulmo-Tilietum. Phytosociological investigations of the thermophilous deciduous forests of Norway are insufficient. The original description of *Ulmo-Tilietum* is based on 18 analyses from the Oslofjord and Mjösa area carried out by J. Kielland-Lund. They are published by Seibert (1969, Table II). These analyses are divided into two sub-associations, one with *Lathyrus vernus* and another with *Prunus padus.* The former is reminiscent of the drier stands in Hemne. The latter has more in common with the moister stands.

Björnstad (1971, Table V) has published 20 analyses from Sögne (southern Norway). He recognizes two sub-associations, *typicum* and *eurhynchietosum.* The latter moss-rich and moister sub-association is the one which shares most species with the analyses from Hemne.

Related communities are found along the west coast of Norway north to Beiarn at 67°N and at favourable localities in the interior eastern Norway (Nordhagen 1954, Rönning 1954, Kielland-Lund 1965 b, 1971, Hånde 1969, Aas 1970 a, 1970 b). More research is needed to decide how to classify these communities. They probably must be devided into two or more regional associations or races. For the moment I prefer to refer my analyses from Hemne to a north-western race of *Ulmo-Tilietum.* Many of the species mentioned by Seibert (1969) and Björnstad (1971) are not found in Hemne, for instance *Acer platanoides*, *Carex digitata*, *Dentaria bulbifera*, *Fraxinus excelsior*, *Hepatica nobilis*, *Lonicera xylosteum*, *Prunus avium*, *Quercus robur*, and *Tilia cordata*. This results in relatively low similarity indices (Table XXVI).

Table XXVI. Similarity indices of the north-western race of *Ulmo-Tilietum* from Hemne and races from other parts of Norway. 1-2: south-eastern race (Seibert 1969), 1, sub-ass. with *Lathyrus vernus* (Oslofjord area), 2, sub-ass. with *Prunus padus* (Oslofjord and Mjösa area). 3-4: southern race from Sögne (Björnstad 1971), 3, *typicum*, 4, *eurhynchietosum*

	South-eastern		Southern	
	1	2	3	4
UlTi (Hemne)	29	36	41	44

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SUMMARY

This work is a phytosociological investigation of the forest vegetation in Hemne, an area with a "sub-oceanic" climate (Fig. 2). Six associations are discussed:

1. *Vaccinio uliginosi-Pinetum* Kleist 29 (Table II) comprises oligotrophic pine bogs with *Calluna, Empetrum, Vaccinium uliginosum, Eriophorum vaginatum,* and *Rubus chamaemorus.* On level ground there is a variant with *Sphagnum nemoreum* and on sloping ground a variant with *S. russowii.* The substratum consists of thick peat.

2. *Bazzanio-Pinetum* K.-Lund 67 (Table IV) also comprises oligotrophic pine forests, but on firm ground without bog species. The subassociation *sphagnetosum* with *Sphagnum quinquefarium* is found on moist shady slopes, while the *hylocomietosum* is found on drier places. The soils are commonly shallow with a "podsol-ranker."

3. *Corno-Betuletum* ass. nov. (Table VII) is mesotrophic birch forests with some pine. Characteristic and differential species are, among others; *Dryopteris assimilis, Lycopodium annotinum, Trientalis europaea, Lusula pilosa, Maianthemum bifolium, Plagiothecium undulatum, Lophocolea bidentata, Rhytidiadelphus loreus,* and *R. triquetrus.*

The *myrtilletosum* is dominated by *Vaccinum myrtillus* in the field layer. The *dryopteridetosum* is recognized by the occurence of the small ferns *Gymnocarpium dryopteris* and *Thelypteris phegopteris.* The sub-associations *athyrietosum* and *thelypteridetosum* have more exacting field layers dominated by the large ferns *Athyrium filix-femina* and *Thelypteris limbosperma.*

The soil profile is commonly a podsol with mesotrophic raw humus. The large fern communities are influenced by seepage water and have a more mull-like humus.

4. *Melico-Betuletum* ass. nov. (Table IX) comprises species-rich birch forests with species such as: *Fragaria vesca, Hieracium sylvaticum* coll., *Rubus saxatilis, Melica nutans, Veronica officinalis,* and *Viola riviniana.*

The sub-association *cornetosum* is a moisture demanding community with *Cornus suecica, Hylocomium umbratum,* and *Polytrichum formosum.* The *coryletosum* is found on steep warm localities with *Corylus avellana.*

The *athyrietosum* is a tall herb community with *Aconitum septentrionale, Athyrium filix-femina, Calamagrostis purpurea, Dryopteris filix-mas, Filipendula, Phalaris arundinacea, Pteridium aquilinum,* and other species.

The soil profiles in the *Melico-Betuletum* stands are more or less typical brown soils.

5. The *Alno-Prunetum* K.-Lund 71 (Table XI) comprises *Alnus incana* stands on fertile sediments along streams in the low-land. The field layer is dense with *Filipendula ulmaria, Deschampsia caespitosa, Athyrium, Geranium sylvaticum, Rubus idaeus, Aconitum,* and *Cicerbita.* Frequent mosses are *Cirriphyllum piliferum, Mnium undulatum,* and *Thuidium tamariscinum.*

6. A thermophilous community found on steep sun-faced screes is referred to the *Ulmo-Tilietum* K.-Lund ex. Seibert 69. It is recognized by species such as: *Ulmus glabra, Actaea spicata, Campanula latifolia, Corydalis intermedia, Galium odoratum, Lathyrus vernus, Polystichum braunii, Eurhynchium striatum,* and *Porella platyphylla* (Table XI).

A similarity dendrogram (Fig. 4) and a geometrical ordination (Fig. 5) based on the Sörensen's quotient of similarity both mostly verify the phytosociological classifications given in the synposis on page 13.

Table XVII shows mean values for the measured soil factors. A principal components analysis based on these edaphic factors gives an "edaphic ordination" (Fig. 9) which mostly is in accordance with the floristic classification.

A discriminant analysis (Tables XX and XXI) based on the three former principal components of the soil factors gives significant differences between the main communities (associations). Within the associations, the sub-associations are probably correlated with factors that were not measured (e.g. soil moisture).

The communities here described from a "sub-oceanic" part of Norway have vicarious communities in the more continental Eastern Norway. *Bazzanio-Pinetum* corresponds to *Barbilophozio-Pinetum* K.-Lund 67, *Corno-Betuletum* to *Eu-Piceetum* (Caj. 21) K.-Lund 62, and *Melico-Betuletum* to *Melico-Piceetum* (Caj. 21) K.-Lund 62.

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