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Bryophyte communities in herb-rich forests in Koli, eastern Finland: comparison of forest classifications based on bryophytes and vascular plants

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The structure of the bryophyte communities of herb-rich forests has been studied relatively little in northern Europe. In this study, the bryophyte flora of herb-rich forests in eastern Finland was analysed and classified. Altogether 101 sample plots were studied. The species and sample plots were classified with TWINSPAN and ordinated with Detrended Correspondence Analysis (DCA) by using (1) bryophytes (n = 100), (2) vascular plants and bryophytes (n = 265) and (3) vascular plants (n = 165). The results indicated that bryophytes reflected different environmental factors than vascular plants. When classification was based on bryophytes, TWINSPAN clusters corresponded better to topography and stand structure than to 'a priori' site types. When classification was based on vascular plants and bryophytes or on vascular plants, TWINSPAN clusters corresponded quite well to 'a priori' site types. In all classifications, paludified herb-rich forests formed an own group, which might present a transition type between moist fern-rich forests and eutrophic paludified spruce forests. Bryophytes seemed to play a minor role in the classification of herb-rich forests. However, bryophytes improved the classification providing additional information of the site. The most accurate classification was obtained when both vascular plants and bryophytes were used to distinguish different vegetation types simultaneously.

Key words: bottom layer, Detrended Correspondence Analysis (DCA), indicator species, liverworts, mosses, ordination, TWINSPAN, vegetation types

Introduction

In Scandinavia and the Baltic area, classification of boreal forests is traditionally based on the vegetation composition of understorey (Cajander 1909, 1926, Frey 1978, Trass & Malmer 1978), because the canopy layer is often simple and poor in species, while the ground layer contains diverse vegetation (Kuusipalo 1985). Vascular plants in the ground layer are usually used for classifying forests; but other groups, such as bryophytes, may also be useful in the classifications, especially in boreal areas (Cajander 1926, La Roi & Stringer 1976). One reason why bryophytes and lichens have seldom been included in surveys of terrestrial vegetation might be that they are taxonomically challenging (Cox & Larson 1991). However, bryophytes and lichens play an important role in the function of boreal forest ecosystems (La Roi & Stringer 1976, Bonan & Shugart 1989, Longton 1992, Økland & Eilertsen 1993, Økland 1994). They are also regarded as good indicators of site quality (Cajander 1926, Ulvinen *et al*. 2002) and environmental changes (Vellak *et al*. 2002, Mäkipää & Heikkinen 2003).

According to Cajander (1909, 1926), boreal grass–herb forests are characterised by an abundance of herbs and grasses. The tree stand can be composed of deciduous trees, spruce (*Picea abies*) or sometimes pine (*Pinus sylvestris*) (Alanen *et al*. 1996, Kuusipalo 1996). The moss carpet is normally sparser than in boreal heath forests, despite the great diversity of bryophyte species (Kaakinen 1992). The most typical bryophytes for the Finnish herb-rich forest are, e.g. *Atrichum undulatum*, *Brachythecium* spp., *Plagiomnium* spp., *Plagiothecium* spp., *Rhodobryum roseum* and *Rhytidiadelphus triquetrus* (Koponen 1967, Kuusipalo 1996, Ulvinen *et al*. 2002). Most of these are large-sized mosses, which cover the substrates as dense mats or have an erect growth habit. Grass–herb forests have a fertile and neutral brown soil with a mull layer, whereas heath forests have an acid podzol soil with a grey leached horizon (Kaakinen 1992, Kuusipalo 1996). Grass–herb forests cover 1.4% of the total forest area in southern Finland, while the coverage of herb-rich heath forests is 23% (Kuusipalo 1996).

Conventional classification of the Finnish herb-rich forests is based mainly on vascular plant species (Kaakinen 1974, Alanen *et al*. 1996, Kuusipalo 1996). In Finland, such forests have not been studied to the same extent as heath forests (Koponen 1967), and their ecology and flora are still poorly known (Kaakinen 1992). In particular, detailed descriptions of the bryophyte communities are rare (Kaakinen 1974), even though bryophytes might be important components of vegetation in herb-rich forests. First, bryophytes might indicate other environmental factors than vascular plants (Carleton 1990, Ulvinen *et al*. 2002, Ingerpuu *et al*. 2003). Second, bryophytes are important for classifying heath forest and peatland vegetation as well as for distinguishing boreal herb-rich forests from herb-rich paludified forests (Kuusipalo 1985,1996, Eurola *et al*. 1984, Laine & Vasander 1998).

The main aims of this study are: (1) description of the bryophyte vegetation in the ground layers of different herb-rich forest site types in Koli, eastern Finland, and (2) evaluation of usefulness of bryophytes in classification of herb-rich forests. Evaluation is done by comparing TWINSPAN and DCA results using three different data sets: (1) bryophytes, (2) vascular plants and bryophytes, and (3) vascular plants. This study is a continuation of a previous investigation, in which vascular plant communities in the same area were studied (Hokkanen 2003).

Material and methods

Study area and characteristics of its vegetation

The study area is located in Koli, North Karelia, eastern Finland at the transition between the southern and middle boreal zones (Ahti *et al*. 1968). The area is situated between the Pre-Karelian granite-gneiss area and Karelian schist zone (Simonen 1964, Kalliola 1973). The Karelian schist zone consists mainly of durable quartzite, sedimentary conglomerate and metadiabase, which occur in intrusive bodies between metamorphous quartzite (Simonen 1964, Grönlund & Hakalisto 1998). The mineral soils are mainly glacial moraine (Lyytikäinen 1991).

The climate is continental with cold winters and warm summers (Kalliola 1973, Bonan & Shugart 1989). The mean annual temperature is 2 °C (Finnish Meteorological Institute 1991). The length of the thermal growing period is 150–155 days; and frost can occur at any time, even during the summer (Heino & Hellsten 1983). The sum of degree-days (threshold +5 °C) ranges from 1000 to 1100 (Atlas of Finland 1987). The mean annual precipitation is 600 mm and winter snowfall 60 to 70 cm (Heino & Hellsten 1983, Finnish Meteorological Institute 1991).

The study area is famous for the luxuriant vegetation and the occurrence of eastern plant species. The vascular plant communities, in particular, have been carefully surveyed (Hakalisto 1987, Lyytikäinen 1991, Kärkkäinen 1994, Hokkanen 2003). However, the bryophytes of these forests have not previously been carefully assessed.

The dominant tree species are Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*). Deciduous trees, such as *Betula pendula*, *B. pubescens* and *Alnus incana*, are dominant in the areas affected by slash-and-burn cultivation or cattle raising, which were common in the Koli area until the 1940s (Lyytikäinen 1991, Antikainen 1993). Nowadays, deciduous forests cover many of the old meadows and hay pastures. Heath forest types mentioned here, *Myrtillus* and *Oxalis–Myrtillus* types are the most common forest types in the area (Antikainen 1993). The bottom layer consists mainly of common boreal mosses, such as *Dicranum polysetum*, *Hylocomium splendens*, *Pleurozium schreberi* and *Polytrichum commune*, and lichens, e.g. *Cladina rangiferina* and *C. arbuscula* (Hokkanen *et al*. 2003).

Herb-rich forests are often situated on eastern slopes or next to brooks (Kärkkäinen 1994). Studied forests included eleven 'a priori' site types (*see* also Hokkanen 2003 and Table 1): (1) *Oxalis–Maianthemum* site type (OMaT), usually dominated by *Oxalis acetosella*, *Maianthemum bifolium* and *Gymnocarpium dryopteris*, (2) *Oxalis–Rubus* site type (ORT), characterised by *Oxalis acetosella*, *Rubus saxatilis* and *Viola mirabilis*, (3) *Geranium–Oxalis–Rubus* site type (GORT), characterised by *Oxalis acetosella*, *Rubus saxatilis*, *Geranium sylvaticum and Fragaria vesca,* (4) *Pulmonaria obscura–Viola mirabilis* site type (PuViT), characterised by *Dryopteris filix-mas*, *Convallaria majalis*, *Actaea spicata* and *Viola mirabilis*, (5) *Athyrium–Assimilis* (AthAssT) site type, dominated by *Dryopteris expansa* and *Athyrium filix-femina*, (6) *Athyrium filix-femina* site type (AthT), characterised by *Athyrium filix-femina*, *Crepis paludosa* and *Filipendula ulmaria,* (7) *Diplazium sibiricum* site type (DiplT), dominated by *Diplazium sibiricum*, (8) *Matteuccia struthiopteris* site type (MatT), characterised by *Matteuccia struthiopteris* and *Athyrium filix-femina,* (9) *Oxalis–Filipendula* site type (OFiT), characterised by *Filipendula ulmaria*, *Oxalis acetosella* and *Urtica dioica*,

Table 1. Herb-rich forest site types according to Kaakinen (1974), Alanen *et al.* (1996) and Kuusipalo (1996). Abbreviations for the site types: VRT = *Vaccinium (vitis-idaea)–Rubus (saxatilis)*, GVT = *Geranium (sylvaticum)–Vaccinium (vitis-idaea)*, OMaT = *Oxalis (acetosella)–Maianthemum (bifolium)*, GOMaT = *Geranium (sylvaticum)–Oxalis (acetosella)–Maianthemum (bifolium)*, GDT = *Geranium (sylvaticum)–(Gymnocarpium) dryopteris*, PuViT = *Pulmonaria (obscura)–Viola mirabilis*, ORT = *Oxalis (acetosella)–Rubus (saxatilis)*, OPaT = *Oxalis (acetosella)–Paris (quadrifolia)*, GORT= *Geranium (sylvaticum)–Oxalis (acetosella)–Rubus (saxatilis)*, GOPaT = *Geranium (sylvaticum)–Oxalis (acetosella)–Paris (quadrifolia)*, GT = *Geranium (sylvaticum)*, AthOT = *Athyrium (filix-femina)–Oxalis (acetosella)*, AthAssT = *Athyrium (filix-femina)–Assimilis (Dryopteris expansa)*, CiT (LaAthT) = *Cicerbita alpina–(Athyrium filix-femina)*, OFiT = *Oxalis (acetosella)–Filipendula (ulmaria)*, MatT = *Matteuccia (struthiopteris)*, AthT = *Athyrium (filix-femina)*, AT = *Aconitum lycoctonum*, GOFiT = *Geranium (sylvaticum)–Oxalis (acetosella)–Filipendula (ulmaria)*, GFiT = *Geranium (sylvaticum)–Filipendula (ulmaria)* and DiplT = *Diplazium (sibiricum)*.

Vegetation zone	Subdry medium fertile	Mesic		Moist	
		medium fertile	(very) fertile	medium fertile	(very) fertile
Southern boreal	VRT	OMaT	PuViT ORT OPaT	AthOT AthAssT	OFiT MatT AthT AT
Middle boreal	VRT GVT	GOMaT	GORT GOPaT	AthAssT	GOFiT MatT AthT
Northern boreal	VRT GVT	GDT	GT	AthAssT CiT (LaAthT)	GFiT DiplT MatT AthT

(10) *Geranium–Oxalis–Filipendula* site type (GOFiT), characterised by *Filipendula ulmaria, Geranium sylvaticum* and *Oxalis acetosella*, and (11) *Geranium–Filipendula* site type (GFiT), characterised by *Filipendula ulmaria*, *Geranium sylvaticum* and *Anthriscus sylvestris*.

Field inventories

The fieldwork for this study was carried out during the summers of 1996, 1997, 2000 and 2001. The studied stands included 101 herb-rich forest stands, which represent the most common herb-rich forest site types in the area (Hokkanen 2003). Vegetation was determined from circular sample plots (100 m^2), and the coverage (0%–100%) was estimated from three sample squares, each 2 m^2 in size (*see* Hokkanen 2003). Species outside the square, but inside the circular plot received a percentage coverage of 0.1. Because the forest floor was often covered by small stones (height < 15 cm) and fine woody debris (d < 5 cm), all bryophytes and lichens growing on ground litter, humus, mineral soil, small stones and fine woody debris were studied.

Stand characteristics were determined from the circular sample plot. For each tree species, basal area (ba) was measured. Age of the stand was determined by using a tree of medium diameter at the breast height ($dbh_{1.3}$). Classification in the field was based mainly on Alanen *et al.* (1996) and Kuusipalo (1996) (Table 1). The herb-rich forest types used in this study are described in Results. The nomenclature of vascular plants follows Hämet-Ahti *et al.* (1998), that of bryophytes follows Ulvinen *et al.* (2002) and that of lichens follows Vitikainen *et al.* (1997). For identification and verification of bryophytes and lichens, samples were taken into paper bags and determined later with microscope. Voucher specimens are kept at Mekrijärvi Research Station, University of Joensuu (samples taken in 2000–2001).

Numerical analysis

The PC-ORD 4 program package was used for multivariate analysis (McCune & Mefford 1999). The sample plots (m = 101) and species were analysed by using bryophytes (n = 100), all vegetation data (n = 265) and vascular plants (n = 165). The sample plots and species were classified by TWINSPAN (Two-Way Indicator Species Analysis; Hill 1979). The cut levels for the pseudospecies were set at 0, 0.5, 1, 2, 4, 8, 16, 32 and 64. The octave scale was preferred to the default scale, which was used in the previous work on vascular plants (Hokkanen 2003), because the octave cut levels take into account the small coverage more accurately than the default values do (Hotanen 1990, Pitkänen 1997). In this study, each bryophyte species had a relatively low coverage, while vascular plant species sometimes had a great coverage. The minimum group size for division was three, and the maximum number of species in the final table was 300. In other options, the default settings of the programme were used.

Detrended Correspondence Analysis, DCA (Hill 1979, Hill & Gauch 1979), was applied for ordinating the sample plots and species (*see* Hokkanen 2003). The most common and most abundant species were calculated by the data summarisation of the PC-ORD. Bryophyte species richness and a diversity index for the bottom layer were determined for all sample plots. Shannon-Weaver's entropy index, H', was used as the species diversity index (Økland 1990).

Results

General features of the bryophyte vegetation

In the herb-rich forests studied erratic boulders were common and most stands were situated on slopes. More than half of the slope stands were old 'slash-and-burn' areas. The most common and most abundant species in the bottom layers were *Brachythecium reflexum* and *B. oedipodium* (Table 2). *Brachythecium reflexum* was mainly found on small stones and sometimes on fine woody debris and humus, while *B. oedipodium* usually grew on humus or litter and sometimes on fine woody debris. Other regularly occurring, but not abundant species were e.g., *Plagiomnium cuspidatum* and *Plagiothecium laetum*. The following species were more common in coniferous stands than in deciduous forests:

Dicranum scoparium, *Hylocomium splendens*, *Plagiomnium cuspidatum*, *Pleurozium schreberi*, *Rhytidiadelphus triquetrus* and *Lophozia ventricosa*. The percentage coverage of the bryophyte layers varied considerably between the site type groups and the stands; the greatest mean coverage (35.1%) was recorded for the OR group, while the lowest mean coverage (18.0%) was recorded for the PuV group (Table 3). The greatest mean number of bryophyte species (13.6) was recorded for the AAs group and the lowest mean (7.5) was recorded for the PuV group.

Bryophyte composition of the ecological site type groups

The ecological site type groups used here were based on the previous study about vascular plants (*see* Hokkanen 2003), except for that the OFiT sites formed the southerly OFi group, and the GOFiT and GFiT formed together the northerly GFi group. 'Dominant' bryophytes were recorded for the most abundant species in bottom layers. 'Characteristic' bryophytes had a strong presence (recorded for 40% or more stands) and coverage of over one percent in a site type group. 'Constant' bryophytes for a group had a moderately strong presence (recorded for 40% or more stands), but a low coverage (≤ 1%). 'Differential' bryophytes had a strong presence (recorded for 50% or more stands) and they were 'characteristic' or 'constant' in four or less site type groups.

Sites classified in the field into the OMaT or OMaT-VRT formed the *Oxalis acetosella* –*Maianthemum bifolium* group (OMa, m = 19). The herb-rich forests studied occurred most characteristically on spruce-dominated stony slopes.

Table 2. The most common bryophyte species in the herb-rich forest plots studied. Frequencies (Freq.) and abundance (coverage) in all stands, coniferous and deciduous stands. Most bryophytes are more common and abundant in coniferous than deciduous stands.

Species	Total			Coniferous stands			Deciduous stands		
	Freq. (%)	Coverage (%)		Freq. (%)	Coverage (%)		Freq. (%)	Coverage (%)	
		Mean	S.D.		Mean	S.D.		Mean	S.D.
Brachythecium reflexum	90	4.1	6.5	92	4.7	6.8	88	3.6	6.1
Brachythecium oedipodium	80	4.1	7.1	78	4.8	5.7	81	3.4	8.2
Plagiomnium cuspidatum	69	1.6	2.8	80	2.2	3.3	58	1.1	2.2
Brachythecium salebrosum	59	0.7	1.8	63	0.9	2.3	56	0.5	1.1
Dicranum scoparium	58	0.8	3.0	76	1.4	4.1	42	0.2	0.8
Plagiothecium laetum	56	0.2	0.7	61	0.4	0.9	52	0.1	0.2
Pleurozium schreberi	54	1.1	2.2	71	1.7	2.6	38	0.6	1.6
Hylocomium splendens	52	1.2	3.4	63	2.0	4.2	37	0.4	2.2
Plagiomnium ellipticum	52	0.7	2.0	57	0.7	1.9	46	0.7	2.1
Plagiomnium medium	49	1.3	5.1	41	1.0	3.6	56	1.5	6.1
Rhizomnium punctatum	41	1.0	3.3	37	1.1	2.8	44	0.9	3.6
Rhodobryum roseum	37	0.3	0.8	45	0.5	1.1	29	0.1	0.2
Lophocolea heterophylla	36	0.1	0.4	35	0.0	0.2	36	0.0	0.1
Rhytidiadelphus triquetrus	35	0.8	1.9	47	1.4	2.4	23	0.3	1.2
Brachythecium rutabulum	30	0.8	2.4	31	1.3	3.0	29	0.3	1.5
Climacium dendroides	30	0.3	0.8	27	0.3	0.8	33	0.3	0.8
Cirriphyllum piliferum	26	0.8	3.2	33	1.5	4.5	19	0.2	0.7
Sanionia uncinata	22	0.1	0.2	29	0.1	0.2	21	0.1	0.2
Plagiothecium denticulatum	21	0.2	0.6	10	0.1	0.4	10	0.2	0.7
Pseudobryum cinclidioides	18	0.7	2.8	14	0.8	2.9	21	0.7	2.8
Rhytidiadelphus subpinnatus	17	0.3	1.8	20	0.5	2.5	13	0.1	0.7
Plagiochila asplenioides	17	0.3	1.1	22	0.5	1.6	12	0.0	0.2
Lophozia ventricosa	16	0.1	0.3	29	0.1	0.4	4	0.0	0.0
Plagiothecium curvifolium	15	0.1	0.4	12	0.1	0.5	17	0.1	0.4
Dicranum fuscescens	15	0.1	0.2	20	0.1	0.2	10	0.0	0.1

The bottom layers were usually quite sparse and moderately rich in species, but the coverage varied from very sparse to well-covered (Table 3). The most common dominant species in the bottom layers were e.g. *Brachythecium oedipodium*, *B. reflexum* and *Hylocomium splendens* (Appendix 1). Other 'characteristic' species included e.g. *Dicranum scoparium*, *Plagiomnium cuspidatum*, *Pleurozium schreberi* and *Rhytidiadelphus triquetrus* and the 'constants' e.g. *Brachythecium rutabulum*, *B. salebrosum*, *Plagiomnium ellipticum*, *Plagiothecium laetum* and *Rhodobryum roseum*.

The GORT, ORT and ORT-OMaT sites dominated by *Oxalis acetosella* and *Rubus saxatilis* formed a group of their own (OR, *m* = 7). The stands were chiefly mature forests on stony gentle slopes. The forest floor was usually well covered by bryophytes and moderately rich in bryophyte species (Table 3). However, the coverage of bryophytes varied considerably. The 'differential' bryophyte for the OR was *Rhytidiadelphus triquetrus* (Appendix 1). The ground layers were generally dominated by *Brachythecium reflexum*, *Plagiomnium cuspidatum* and *Plereurozium schreberi*. Other 'characteristic' mosses were e.g. *Brachythecium oedipodium*, *B. salebrosum*, *Hylocomium splendens* and *Rhizomnium punctatum*, and the 'constants' e.g. *Dicranum scoparium*, *Plagiomnium medium*, *Plagiothecium laetum* and *Sanionia uncinata*.

Sites classified in the field into the PuViT, PuViT-Ath and PuViT-OFiT formed the *Dryopteris filix-mas–Viola mirabilis* group (PuV, *m* = 4) named after the most descriptive species. This group included deciduous forests on very stony slopes. The bottom layers were often sparsely covered by bryophytes, but the coverage varied considerably (Table 3). The stands were poor in bryophyte species. The 'differential' bryophytes were e.g. *Brachythecium rutabulum*, *Dicranum fuscescens* and *Rhytidiadelphus triquetrus* (Appendix 1). The most common 'dominant' species included e.g. *Brachythecium reflexum* and *Plagiomnium cuspidatum*, and the 'constants' e.g. *Brachythecium oedipodium*, *B. rutabulum B. salebrosum*, *Dicranum scoparium*, *Hylocomium splendens* and *Plagiothecium laetum*.

The AthAssT, AthAssT-OMaT and AthAssT-OPaT sites formed the *Athyrium filix-femina–Dryopteris expansa* group (AAs), named after the dominant vascular plants. Most stands were situated on stony slopes along brooks or ditches. The forest floor was often sparsely covered by bryophytes and moderately rich in bryophyte species (Table 3). The coverage, however, varied considerably. The 'differential' bryophytes for the group were e.g. *Plagiothecium denticulatum* and *Lophocolea heterophylla* (Appendix 1). *Brachythecium oedipodium* and *B. reflexum* were usually dominant in the bottom layer. The 'characteristic' species included e.g. *Plagiomnium cuspidatum* and *P. medium,* and the 'constants' e.g. *Brachythecium salebrosum*, *Cirriphyllum piliferum*, *Dicranum scoparium*, *Plagiomnium ellipticum*, *Plagiothecium laetum*, *Pleurozium*

Table 3. Number of sample plots in each site type group. Bryophyte species richness, Shannon's diversity index for the bottom layers and % coverage of *Sphagnum* mosses, other mosses, liverworts and lichens (mean, standard deviation) are calculated for each group.

Group	Plots	Species		*H*′		Sphagnums		Other mosses		Liverworts		Lichens	
		mean	S.D.	mean	S.D.	mean	S.D	mean	S.D.	mean	S.D.	mean	S.D.
OMa	19	12.5	4.5	1.566	0.461	0.0	0.0	22.5	13.2	0.9	1.7	0.1	0.2
OR	7	12.9	5.1	1.688	0.591	0.0	0.0	34.5	27.6	0.4	0.4	0.3	0.8
PuV	4	7.5	8.5	1.182	0.567	0.0	0.0	17.9	16.2	0.1	0.1	0.0	0.0
AAs	18	13.6	4.5	1.765	0.400	0.9	2.8	22.5	21.1	0.8	1.3	0.0	0.0
Ath	14	12.5	3.6	1.873	0.333	0.0	0.0	22.2	16.6	0.8	1.3	0.0	0.1
Dip	10	12.9	3.7	1.518	0.525	0.0	0.1	28.9	19.2	1.6	2.9	0.0	0.0
Mat	10	13.0	5.8	1.546	0.422	5.7	18.0	19.4	8.8	0.8	1.4	0.0	0.0
OFi	8	10.8	6.3	1.452	0.433	0.6	1.7	23.8	20.9	0.2	0.2	0.0	0.0
GFi	11	13.6	6.3	1.754	0.595	1.8	5.4	20.3	15.3	0.9	1.8	0.0	0.1
TOTAL	101	12.6	4.9	1.642	0.476	1.0	6.0	23.3	17.5	0.8	1.6	0.0	0.2

schreberi, *Rhizomnium punctatum* and *Rhytidiadelphus triquetrus*.

Sites classified in the field into the AthT, AthT-OFiT, AthT-OPaT and AthT-GORT formed the *Athyrium filix-femina* group (Ath). The group included sites which were primarily located along brooks or ditches. The bryophyte layers were often quite sparse and moderately rich in species (Table 3). The 'differential' bryophyte for the Ath was *Climacium dendroides* (Appendix 1). The 'dominant' bryophytes included e.g. *Brachythecium oedipodium*, *B. reflexum* and *Plagiomnium cuspidatum*, the 'characteristic' bryophytes e.g. *Brachythecium rutabulum*, *B. salebrosum* and *Dicranum scoparium* and the 'constants' e.g. *Hylocomium splendens*, *Plagiomnium ellipticum*, *P. medium*, *Plagiothecium laetum, Pleurozium schreberi* and *Rhizomnium punctatum*.

The DiplT and DiplT-AthAssT sites dominated by *Diplazium sibiricum* formed the *Diplazium sibiricum* group (Dip). These sites usually occurred on gentle slopes along mountain brooks. The forest floor was often moderately well covered by bryophytes, but the coverage varied considerably (Table 3). The number of bryophyte species was moderately great. The 'differential' bryophytes for the Dip were *Cirriphyllum piliferum*, *Plagiothecium denticulatum* and *Rhodobryum roseum* (Appendix 1). The bottom layers were dominated most commonly by e.g. *Brachythecium reflexum*, *B. oedipodium* and *Rhizomnium punctatum*. The 'constants' included e.g. *Brachythecium salebrosum*, *Climacium dendroides*, *Dicranum scoparium*, *Hylocomium splendens*, *Plagiomnium cuspidatum*, *P. ellipticum*, *P. medium*, *Plagiothecium laetum* and *Lophocolea heterophylla*.

Sites classified in the field into the MatT, MatT-OFiT and MatT-AthAssT formed the *Matteuccia struthiopteris* group (Mat). The ground was wet with seeping water, poorly drained and covered by stones and rocks. The bryophyte layers were generally sparse and moderately rich in species (Table 3). The 'dominant' bryophytes included e.g. *Brachythecium reflexum* and *B. oedipodium,* and the 'constants' e.g. *Brachythecium salebrosum*, *Climacium dendroides*, *Dicranum scoparium*, *Plagiomnium cuspidatum*, *P. ellipticum*, *P. medium*, *Plagiothecium laetum*, *Rhizomnium punctatum*, *Rhodobryum roseum* and *Lophocolea heterophylla* (Appendix 1).

The *Oxalis acetosella–Filipendula ulmaria* group (OFi) included sites that were classified in the field into the OFiT, OFiT-AthT and OFiT-AthAssT. The forest floor was often moist or wet, and almost free of stones. The stands were usually young deciduous forests, which occurred along ditches or brooks. The bryophyte layers were mostly quite sparse and poor in species (Table 3). However, the coverage varied considerably. The 'dominant' bryophytes included e.g. *Plagiomnium ellipticum* and *Pseudobryum cinclidioides*, the 'characteristic' bryophytes e.g. *Brachythecium reflexum* and *B. oedipodium* and the 'constants' e.g. *Plagiomnium cuspidatum* and *P. medium* (Appendix 1).

Sites classified in the field into the GOFiT, GFiT, GOFiT- AthT and GFiT-AthT formed the *Geranium sylvaticum–Filipendula ulmaria* group (GFiT). Stands were often young deciduous forests, which occurred on shores or along brooks or ditches. The bottom layers were quite sparse and moderately rich in species (Table 3). The 'differential' bryophytes were e.g. *Climacium dendroides* and *Rhodobryum roseum* and the 'dominants' e.g. *Plagiomnium ellipticum*, *P. medium and Pseudobryum cinclidioides* (Appendix 1). The 'constants' included e.g. *Brachythecium oedipodium*, *B. reflexum*, *Plagiomnium cuspidatum*, *Plagiothecium laetum*, *Pleurozium schreberi* and *Rhizomnium punctatum*.

Multivariate analyses

TWINSPAN classifications for sample plots

The first four levels of the TWINSPAN hierarchical classification are summarised in Figs. 1 (bryophytes), 2 (vascular plants and bryophytes) and 3 (vascular plants). Species are listed in two-way ordered tables in Appendix 2. Indicator species for each division are shown in decreasing order of importance. The classification based on vascular plants corresponded well to that of based on vascular plants and bryophytes, whereas the classification based on bryophytes only was considerably different.

At the first level, all divisions were similar to each other. Here the sample plots (*m* = 101)

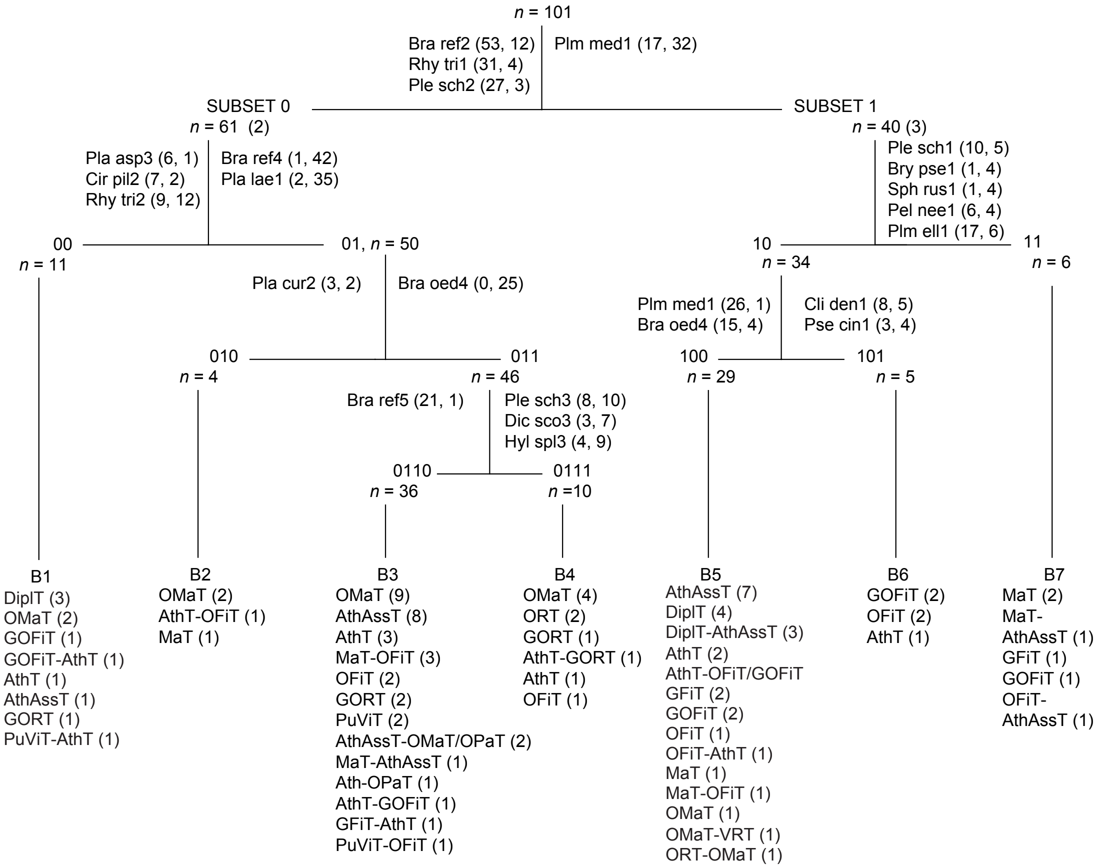

Fig. 1. TWINSPAN classification for the 101 sample plots and 100 bryophyte species. The number after the species (for abbreviations *see* Appendix 1) gives cover classes for indicator species/pseudospecies (1 = 0.1%–0.5%, 2 = 0.51%–1.00%, 3 = 1.01%–2.00%, 4 = 2.01%–4.00%, 5 = 4.01%–8.00%, 6 = 8.01%–16.00%, 7 = 16.01%–32.00%, 8 = 32.01%–64.00% and 9 > 64.00%). Frequencies are inside the brackets. Groups are named after indicator or 'characteristic' bryophytes (*see* "TWINSPAN classifications for sample plots"). B1: *Rhytidiadelphus triquetrus–Cirriphyllum piliferum*, B2: *Brachythecium reflexum–Plagiothecium curvifolium*, B3: *Brachythecium reflexum–Plagiomnium cuspidatum*, B4: *Pleurozium schreberi–Dicranum scoparium*, B5: *Plagiomnium medium–Brachythecium oedipodium*, B6: *Climacium dendroides–Pseudobryum cinclidioides*, and B7: *Plagiomnium ellipticum–Sphagnum russowii*.

were divided into mesic (subset 0) and moist (subset 1) sites. The moist sites were segregated from the mesic sites; *Brachythecium reflexum* was an indicator species for the mesic sites and *Plagiomnium medium* for the moist sites (Fig. 1). When the classification was based on all data or vascular plants, *Filipendula ulmaria,* with more than 2.0% coverage (Fig. 2) or more than 0.5% coverage (Fig. 3), was an indicator species for the moist herb-rich forests.

TWINSPAN clusters

When the classification was based on bryophytes ($m = 101, n = 101$), seven clusters (B1–B7), named after the indicator or the descriptive bryophytes, were received (Fig. 1). The first was the *Rhytidiadelphus triquetrus–Cirriphyllum piliferum* cluster (B1, m = 11), which included spruce-dominated shady slope forests along mountain brooks. Cluster B1 corresponded best to the Ath, except for that e.g. *Cirriphyllum piliferum*, *Brachythecium rutabulum* and *Plagiochila asplenioides* were more often among the dominant bryophytes in cluster B1 than in the Ath. The second (B2, m = 4), named after *Brachythecium reflexum* and *Plagiothecium curvifolium,* included half-shadow hill-side forests on mesic and moist grounds. The species composition resembled that of the

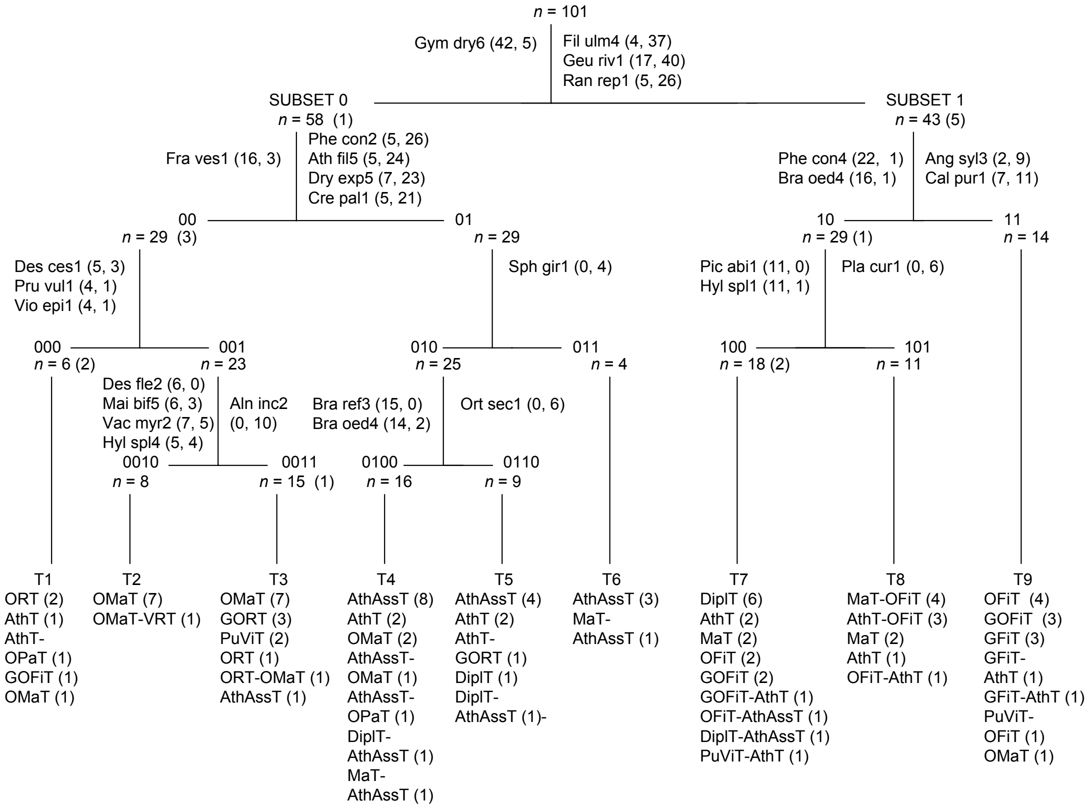

Fig. 2. TWINSPAN classification for the 101 sample plots and 265 vascular plant and bryophyte species. For explanations *see* Fig. 1. Groups are named after the dominant, 'differential' or other 'characteristic' species (*see* "TWINSPAN classifications for sample plots"). T1: *Oxalis acetosella–Deschampsia cespitosa*, T2: *Gymnocarpium dryopteris–Vaccinium myrtillus*, T3: *Oxalis acetosella–Rubus saxatilis*, T4: *Dryopteris expansa–Oxalis acetosella*, T5: *Athyrium filix-femina–Phegopteris connectilis*, T6: *Dryopteris expansa–Sphagnum girgensohnii*, T7: *Geranium sylvaticum–Athyrium filix-femina*, T8: *Athyrium filix-femina–Filipendula ulmaria*, and T9: *Geum rivale–Angelica sylvestris*.

OMa; except for that e.g. *Rhizomnium magnifolium* and *Sphagnum squarrosum* were absent from the OMa. In addition, cluster B2 resembled the Ath, but e.g. *Plagiomnium medium* did not occur on any sites of cluster. The *Brachythecium reflexum–Plagiomnium cuspidatum* cluster (B3, *m* = 36), which resembled both the OMa and AAs, included half-shadow spruce- or alder-dominated mixed forests on stony slopes. Nevertheless, e.g. *Dicranum scoparium*, *Hylocomium splendens* and *Pleurozium schreberi* were not as often 'dominants' as in the OMa, and e.g. *Plagiomnium denticulatum*, *Plagiomnium medium* and *Rhizomnium punctatum* were not as common as in the AAs. Stands of the fourth cluster (B4, *m* = 10), named after *Pleurozium schreberi* and *Dicranum scoparium*, were usually mature spruce-dominated forests on quite sunny and stony slopes. Cluster B4 had a lot of similar features to the OR and OMa, although the sites were often dryer than that of the OMa, but moister than that of the OR. Sites of the fifth and sixth clusters occurred most characteristically in the flat and flooded areas along brooks or ditches. The fifth was the *Plagiomnium medium–Brachythecium oedipodium* cluster (B5, *m* = 29) that included deciduous forests along brooks or ditches. This cluster had a lot of similar features to the Dip, even though it was more often characterised by *Athyrium filix-femina* than *Diplazium sibiricum*, and e.g. *Cirriphyllum piliferum* was not among the 'dominant' bryophytes. Sites of the sixth and seventh clusters often occurred in the flat and flooded areas along brooks or ditches. The *Climacium dendroides–Pseudobryum cinclidioides* cluster (B6, *m* = 5) included half-shadow deciduous forests. It corresponded best to the

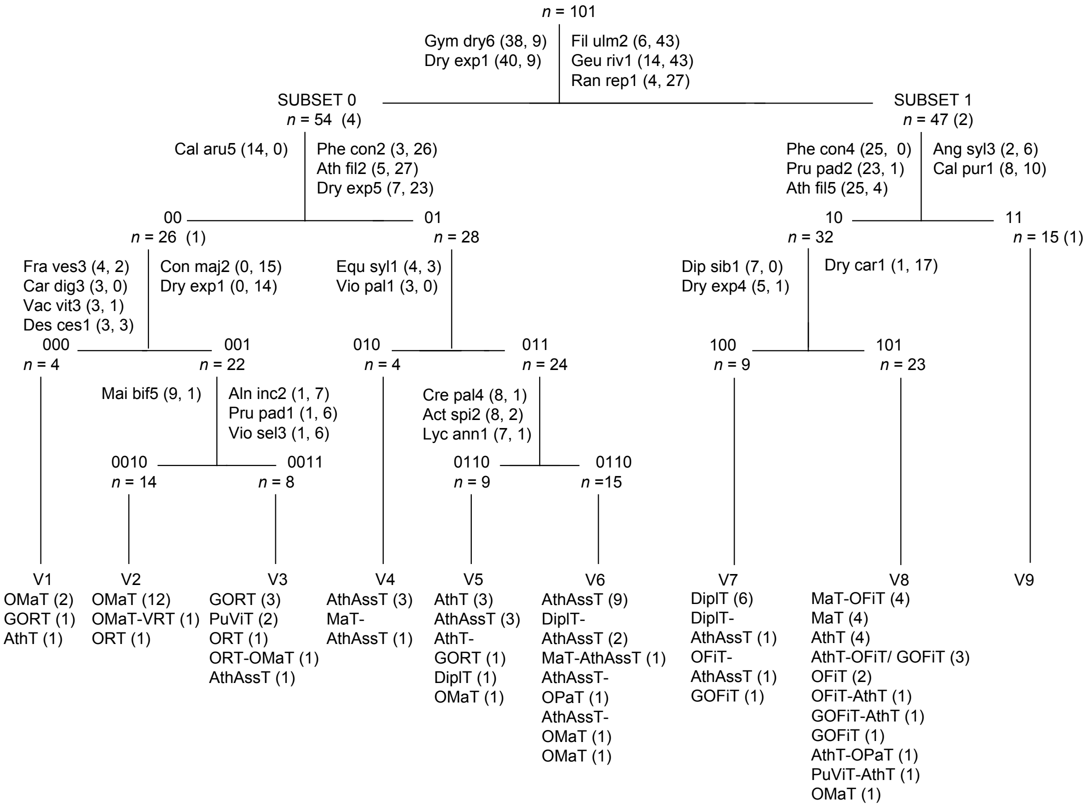

Fig. 3. TWINSPAN classification for the 101 sample plots and 165 vascular plant species. For explanations *see* Fig. 1. Groups are named after the dominant, 'differential' or other 'characteristic' species (*see* "TWINSPAN classifications for sample plots"). V1: *Oxalis acetosella–Fragaria vesca*, V2: *Maianthemum bifolium–Gymnocarpium dryopteris*, V3: *Oxalis acetosella–Rubus saxatilis*, V4: *Dryopteris expansa–Equisetum sylvaticum*, V5: *Athyrium filix-femina–Actaea spicata*, V6: *Dryopteris expansa–Athyrium filix-femina*, V7: *Diplazium sibiricum–Geranium sylvaticum* V8: *Filipendula ulmaria–Oxalis acetosella*, and V9: *Filipendula ulmaria–Angelica sylvestris*.

GFi and OFi, except for that e.g. *Plagiomnium medium* was more common in cluster B6. The stands of the *Plagiomnium ellipticum–Sphagnum russowii* cluster (B7, *n* = 6) were often shady and paludified coniferous forests. Cluster B7 was quite similar to the Mat, but e.g. *Rhizomnium pseudopunctatum* and *Sphagnum russowii* were more common and more abundant in cluster than in the Mat.

Nine clusters (T1–T9) named after the dominant or other characteristic species (Fig. 2) were received when the classification was based on both bryophytes and vascular plants (*m* = 101, *n* = 265). Stands of the first and second clusters were mainly mature spruce-dominated slope forests. The first (T1, *m* = 6), named after *Oxalis acetosella* and *Deschampsia cespitosa*, corresponded well to the OR, except for that e.g. *Viola epipsila* was absent from the OR and *Plagiomnium medium* from cluster. However, sites of cluster T1 were moister than that of the OR. Furthermore, the bryophyte composition had a lot of similarities to the Ath. The *Gymnocarpium dryopteris–Vaccinium myrtillus* cluster (T2, *m* = 8) was similar to the OMa. The third (T3, *m* = 15), named after *Oxalis acetosella and Rubus saxatilis*, resembled both the OMa and OR, but the vascular plant composition was closer to the OR. The sites were often more stony and more fertile than sites of cluster T2. The fourth was the *Dryopteris expansa–Oxalis acetosella* (T4, *m* = 16) cluster, which was very similar to the AAs. The stands were mainly over 40-year-old coniferous forests. The fifth was the *Athyrium filix-femina–Phegopteris connectilis* cluster (T5, *m* = 9) that corresponded well to the Ath. However, the stands were mostly dense deciduous hill-side forests. The sixth cluster (T6, *m* = 4), named after *Dryopteris expansa* and *Sphagnum girgensohnii* (T6, *m* = 4), included swampy coniferous forests. Cluster T6 resembled the AAs, but e.g. *Sphagnums* were more abundant in cluster, and e.g. *Cirriphyllum piliferum*, *Plagiomnium cuspidatum*, *Plagiothecium laetum* and *Rhytidiadelphus triquetrus* were absent from the cluster. The seventh cluster (T7, *m* = 18), named after *Geranium sylvaticum* and *Athyrium filix-femina*, was similar to the Dip, although *Diplazium sibiricum* did not grow on all sites of cluster. The stands were mainly hill-side forests, which occurred along mountain brooks. Most stands of the eighth, *Athyrium filix-femina–Filipendula ulmaria* cluster (T8, *m* = 11), were young deciduous forests along flooded brooks or ditches. Cluster T8 corresponded best to the Mat, except for that e.g. *Matteuccia struthiopteris* was not found in all forests, and *Plagiothecium curvifolium* was strongly present in cluster. The ninth was the *Geum rivale–Angelica sylvestris* cluster (T9, *m* = 14), which included young deciduous shore and brook-side forests of the flat and flooded areas. It resembled both the GFi and OFi, although the species composition corresponded a little bit better to the GFi than to the OFi.

When classification was based on vascular plant species only (*m* = 101, *n* = 165), nine clusters named after the most descriptive species, were received (Fig. 3). The first was the *Oxalis acetosella–Fragaria vesca* cluster (V1, *m* = 4). The species composition corresponded quite well to that of the OR and very well to that of cluster T1. The second (V2, *m* = 14), named after *Maianthemum bifolium* and *Gymnocarpium dryopteris,* was similar to the OMa and cluster T2. The third was the *Oxalis acetosella–Rubus saxatilis* cluster (V3, *m* = 8), which resembled the OR, except for that stands were more often dominated by deciduous trees. In addition, the species composition corresponded well to that of cluster T3. The fourth was the *Dryopteris expansa–Equisetum sylvaticum* cluster (V4, *m* = 4), which included paludified coniferous forests and it was almost identical with cluster T6. The fifth cluster, (V5, *m* = 9), named after *Athyrium filix-femina* and *Actaea spicata,* was similar to cluster T5. It also corresponded well to the Ath, even though e.g. *Actaea spicata* and *Dryopteris expansa* were more common and more abundant than in the Ath. The sixth was the *Dryopteris expansa–Athyrium filix-femina* cluster (V6, *m* = 15), which was almost identical with cluster T4, and it also corresponded well to the AAs. The species composition of the seventh cluster (V7, *m* = 9), named after *Diplazium sibiricum* and *Geranium sylvaticum*, was similar to that of the Dip and cluster T7. The eighth was the *Filipendula ulmaria–Oxalis acetosella* cluster (V8, *m* = 23), which corresponded very well to cluster T8 and well to the Mat. The ninth (V9, *m* = 15), named after *Filipendula ulmaria* and *Angelica sylvestris*, was almost identical with cluster T9, and it also resembled both the GFi and OFi.

DCA ordinations for sample plots

Ordinations for the 101 sample plots are shown in Figs. 4 (bryophytes), 5 (vascular plants and bryophytes) and 6 (vascular plants). Abbreviations represent herb-rich forest types, and numbers indicate TWINSPAN clusters. The ordination agreed well with TWINSPAN clusters. When only bryophytes were taken into account, TWINSPAN clusters corresponded better to the topography and stand structure than to the ‘ecological groups’ or ‘a priori’ site types. Whereas ordinations made by using vascular plants and both vascular plants and bryophytes corresponded well to the ‘ecological groups’ and ‘a priori’ site types.

Moist and flooded forests, which occurred in the flat lands along brooks (sites of cluster B7), received the greatest values for the first ordination axis (*see* Fig. 4). These forests were mainly spruce-dominated, and some sites were also paludified. Deciduous ‘lowland’ forests on shores or on downer parts of the slopes (GFi and Ath sites of cluster B5) had the lowest DCA 1 values. Wet and quite sunny forests affected by standing water (the OFi and GOFi sites of cluster B6) received the highest values for the second ordination axis, whereas shaded and very fertile coniferous forests along mountain brooks (PuV-Ath and Dip sites of cluster B1) had the lowest DCA 2 values.

Sites dominated by *Diplazium sibiricum* (Dip) received the highest values for the first

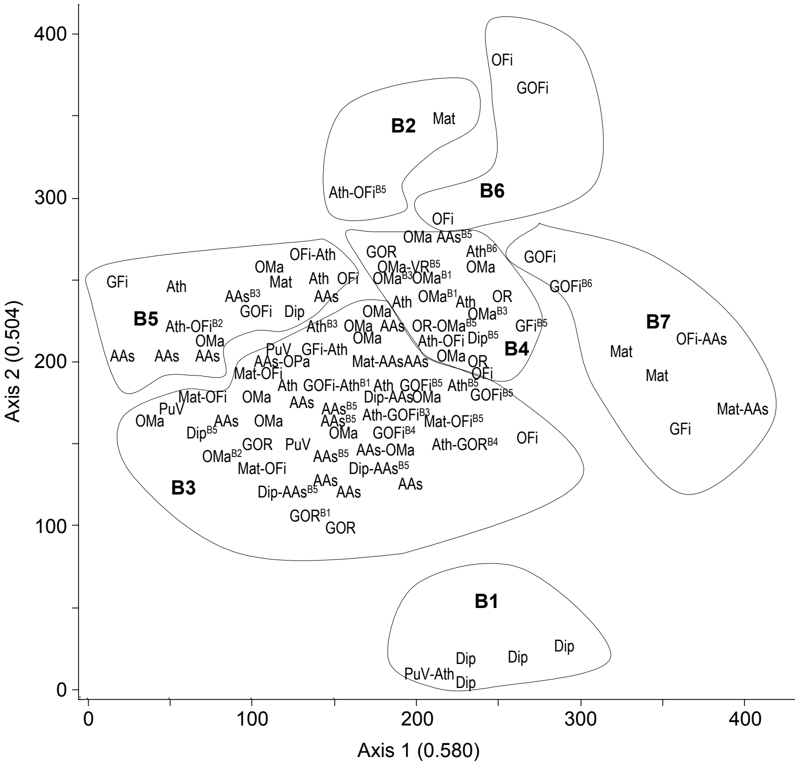

Fig. 4. DCA ordination for the sample plots (total variance 6.584) using bryophytes alone. B1–B7 indicate TWINSPAN clusters (*see* Fig. 1) and abbreviations herb-rich forest types (*see* also Table 1). Abbreviations: AAs = AthAssT, Ath = AthT, GFi = GFiT, GOFi = GOFiT, GOR = GORT, Mat = MaT, OMa = OMaT, OPa = OPaT, OR = ORT and PuV = PuViT.

ordination axis (*see* Figs. 5 and 6). Furthermore, other fern-rich sites (AAs, Ath and Mat) had relatively high DCA 1 values. When only vascular plants were used, sub-dry sites (GOR, OMa-VR) received the lowest DCA 1 values, whereas when vascular plants and bryophytes were used, both sub-dry (OMa-VR) and moist herb-dominated sites (GFi, GOFi, OFi) received the lowest DCA 1 values. Sub-dry and mesic sites (OMa-VR, OMa) with an abundance of *Vaccinium myrtillus* or *Dryopteris expansa* received the greatest values for the second ordination axis, while moist and flooded sites dominated by *Matteuccia struthiopteris* (Mat, Mat-OFi) or *Filipendula ulmaria* (OFi, OFi-Ath) received the lowest values (*see* Fig. 5). Moist and flooded sites received the highest DCA 2 values and mesic and sub-dry sites had the lowest values for the second ordination axis (*see* Fig. 6).

TWINSPAN groups and DCA ordinations for species

TWINSPAN classified bryophytes ($n = 100$) into seven groups (Table 4) and all species ($n = 265$) into ten groups (Table 5) named after the most characteristic features. The first two axes are presented in Fig. 7 (only bryophytes) and 8 (all data sets). In these figures bryophytes with low frequency ($n < 3$) are ignored. Vascular plants with coverage of over four percentages in a site type group are also shown in Fig. 8. DCA ordinations for vascular plants are described in Hokkanen (2003: fig. 5).

Species preferring wet sites, e.g. *Aulacomnium palustre*, *Rhizomnium pseudopunctatum*, *Sphagnum girgensohnii* and *S. russowii*, received the greatest DCA 1 values (*see* Fig. 7). *Plagiomnium medium*, *Calypogeia neesiana*, *Brachythecium populeum*, *Rhizomnium magellanicum* and *Plagiothecium curvifolium* had the lowest values for the first ordination axis. These species, except for *C. neesiana*, had the greatest coverage in half-shadow deciduous forests of under 80 years. Species preferring half-open moist and wet sites, e.g. *Calliergon cordifolium*, *Rhytidiadelphus squarrosus, Pseudobryum cinclidioides* and *Polytrichum commune*, received the greatest DCA 2 values. *S*pecies occurring most

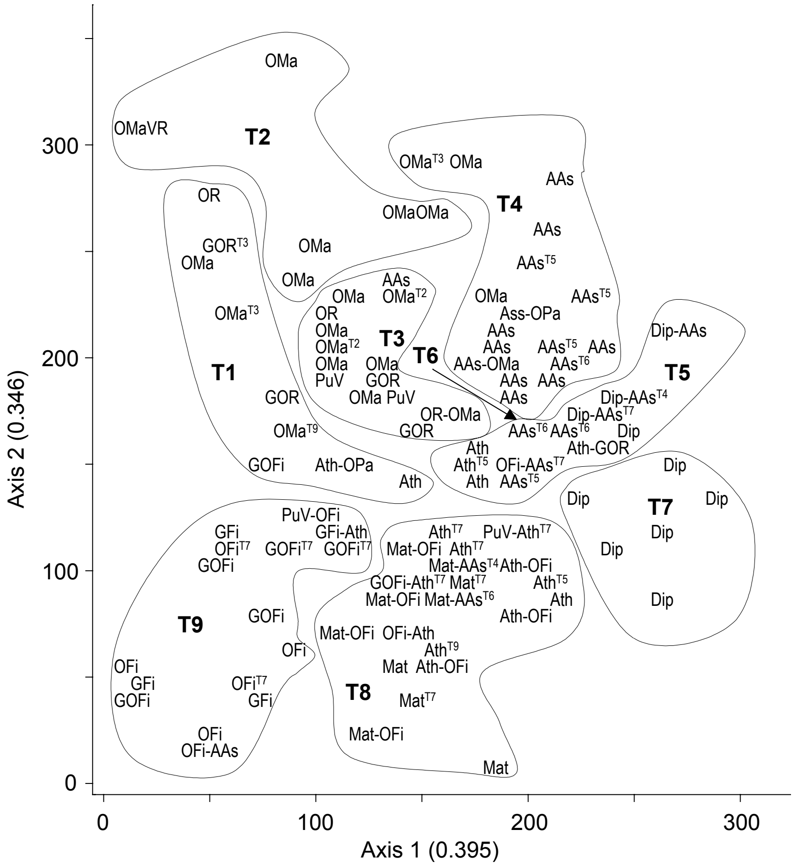

Fig. 5. DCA ordination for the sample plots (total variance 4.425) using both vascular plants and bryophytes. T1-T9 are indicating TWINSPAN clusters (*see* Fig. 2) and abbreviations herb-rich forest types (*see* Fig. 1).

abundantly in shadow brook-side forests or on other fertile sites, e.g. *Cirriphyllum piliferum*, *Rhytidiadelphus subpinnatus* and *Hylocomiastrum pyrenaicum*, received the lowest values for the second ordination axis. Soil moisture or paludification seemed to increase along the first axis, while shading seemed to decrease along the second axis.

Species of the group 7b preferring fertile brook-side forests, e.g. *Diplazium sibiricum*, *Cirriphyllum piliferum*, *Rhizomnium punctatum* and *Crepis paludosa*, received the highest DCA 1 values (*see* Fig. 8). Furthermore, *Plagiothecium denticulatum* and *Rhytidiadelphus subpinnatus*, which prefer shady forests (Ulvinen *et al*. 2002), had relatively high DCA 1 values. Species of the group 8b, especially *Rhytidiadelphus squarrosus* and *Calliergon cordifolium* received the lowest DCA 1 values. Most species of this group had both low frequency and coverage, and they prefer moist or wet, half-open sites, which have been previously cut, burnt, drained or used as forest pasture or field. Species of the 'sub-dry' group, e.g. *Vaccinium myrtillus*, *Calypogeia muelleriana*, *Hylocomium splendens*, *Mnium stellare* and *Cladonia cornuta*, also had relatively low DCA 1 values. However, *M. stellare* and *C. muelleriana* preferred mesic and shady forests on slopes or below cliffs. Species preferring mesic, moderately fertile spruce-dominated slopes received the greatest DCA 2 values. These species included e.g. *Vaccinium myrtillus, Ptilium crista-castrensis*, *Barbilophozia lycopodioides*, *Polytrichum juniperinum* and *Dicranum polysetum*. Species preferring moist or wet flooded sites, e.g. *Aulacomnium palustre*, *C. cordifolium*, *Bryum weigelii* and *Matteuccia struthiopteris* received the lowest values for the second DCA axis. Fertility and shading seemed to increase along the first ordination axes, while moisture and fertility seemed to decrease along the second axis.

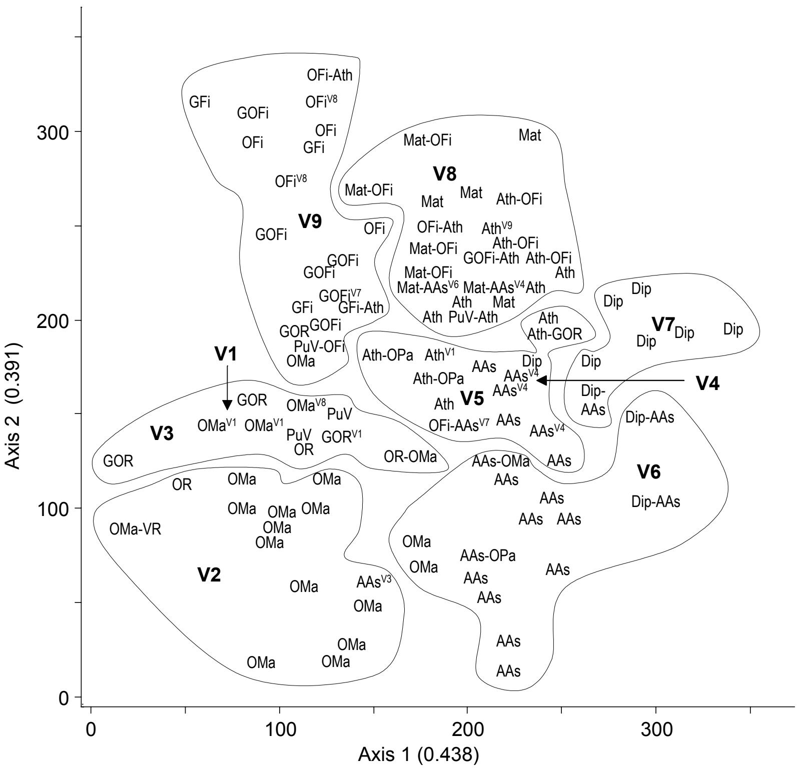

Fig. 6. DCA ordination for the sample plots (total variance 3.932) using vascular plants alone. V1–V9 indicate TWINSPAN clusters (*see* Fig. 3a) and abbreviations herb-rich forest types (*see* Fig. 1).

Fig. 7. Species ordination (DCA) for bryophytes (total variance 6.584) using bryophyte data. Ordination is done for all bryophytes (n = 100), but species with low frequency (< 3) are ignored. For species groups (1a–5a) *see* Table 4 and for abbreviations *see* Appendix 1.

Discussion

Bryophyte flora

The species diversity of the studied bottom layers was relatively high, but the bottom layers were usually sparsely covered by bryophytes. According to Kujala (1979), Kaakinen (1992) and Kuusipalo (1996) these features are typical for the bottom layers of the herb–grass forests. Bryophytes typical for the boreal heath forests, e.g. *Dicranum polysetum*, *Polytrichum commune* and *Ptilium crista-castrensis* (Kujala 1965, Kuusipalo 1985) had low coverage on the studied sites. Whereas bryophytes known to prefer herb-rich forests, herb-rich heath forests or eutrophic paludified spruce forests, e.g. *Brachythecium oedipodium*, *B. reflexum*, *Plagiomnium cuspidatum*, *P. ellipticum*, *P. medium*, *Rhizomnium punctatum* and *Rhytidiadelphus triquetrus* (Kujala 1979, Eurola *et al*. 1992, Kuusipalo 1996), were among the most abundant bryophytes in the studied sites. 'Terricolous' lichens e.g. *Cladina arbuscula*, *C. rangiferina* and *C. stellaris*, which are usually abundant in the sub-xeric, xeric and barren heath forests (Kujala 1965, 1979, Kuusipalo 1985, 1996), were absent from the studied plots or had both low frequency and coverage in the studied herb-rich forests.

Bryophytes and ecological gradients

The results of this study indicated that bryophyte composition reflected probably other environmental factors than the vascular plants did. Bryophyte composition seemed to reflect atmospheric humidity and conditions on the soil sur-

Table 4. Species groups from TWINSPAN classification using bryophyte data (*m* = 101, *n* = 100). Groups (1a–7a) are named after the most typical habitat. Asterisk (*) indicates that species occurred mainly in other kinds of habitat.

Group name and species composition
1a. A group of species growing in mesic, mesic-moist and/or moist forests *Barbilophozia hatcheri**, *B. kunzeana*, *B. lycopodioides*, *Brachythecium populeum*, *Breidleria pratensis*, *Cladina rangiferina**, *Cladonia* sp., *Campylophyllum sommerfeltii*, *Hylocomiastrum pyrenaicum*, *H. umbratum*, *Jungermannia leiantha*, *Lophozia longiflora, Metzgeria furcata*, *Nephroma arcticum*, *Plagiothecium succulentum*, *Pohlia nutans**, *Polytrichum strictum*, *Rhizomnium magnifolium*, *Thuidium recognitum*, *Sphagnum fimbriatum*, *Stereocaulon* sp.*
2a. A group of species preferring mesic coniferous heath forests *Atrichum undulatum**, *Campylium stellatum**, *Cladonia cornuta*, *Dicranum fuscescens*, *D. scoparium*, *Hylocomium splendens*, *Pleurozium schreberi*, *Ptilium crista-castrensis*
3a. A group of species preferring fertile brook-side forests *Barbilophozia barbata**, *Brachythecium rivulare*, *Cirriphyllum piliferum*, *Mnium stellare*, *Plagiochila asplenioides*, *Plagiomnium cuspidatum**, *Rhytidiadelphus subpinnatus*, *R. triquetrus**
4a. A group of 'oligo- and mesotrophic' species growing mainly on silicate-rich stones or on moist humus *Blepharostoma trichophyllum**, *Brachythecium reflexum*, *B. rutabulum*, *B. salebrosum*, *Calypogeia neesiana**, *Chiloscyphus polyanthos*, *Hypogymnia physodes*, *Fissidens adianthoides**, *Lophozia ventricosa*, *Plagiochila porelloides*, *Plagiothecium laetum*, *P. ruthei*, *Polytrichastrum longisetum*, *Polytrichum commune*, *P. juniperinum*, *Rhodobryum roseum*, *Sanionia uncinata*, *Sphagnum angustifolium*
5a. A group of species preferring mesic and moist shady coniferous and mixed forests *Barbilophozia floerkei*, *Brachythecium oedipodium*, *Calypogeia muelleriana**, *Dicranum polysetum*, *Plagiomnium ellipticum*, *Plagiothecium curvifolium*, *P. denticulatum**, *Ptilidium ciliare*, *Sphagnum squarrosum*
6a. A group of species preferring fertile moist and wet sites affected by ground or surface water *Bryum psedotriquetrum*, *Cephalozia bicuspidata**, *Climacium dendroides*, *Dicranum majus**, *Lophocolea heterophylla**, *Plagiomnium medium*, *Pseudobryum cinclidioides*, *Rhizomnium punctatum*, *Rhytidiadelphus squarrosus**
7a. A group of species preferring wet (and moist) sites *Aulacomnium palustre*, *Brachythecium starkei**, *Bryum weigelii*, *Calliergon cordifolium*, *C. lindbergii*, *Calypogeia fissa*, *Cephalozia lunulifolia*, *Cladonia coccifera**, *Cladopodiella fluitans*, *Fontinalis antipyretica*, *Harpanthus flotovianus*, *Mnium* spp., *Paraleucobryum longifolium**, *Pellia neesiana*, *Peltigera apthosa**, *Plagiomnium elatum*, *Scapania undulata*, *Rhizomnium pseudopunctatum*, *Riccardia latifrons*, *Sphagnum centrale*, *S. girgensohnii*, *S. riparium*, *S. russowii*, *S. teres*, *Tetraphis pellucida**, *Tritomaria quinquedentata**, *Warnstorfia fluitans*

Table 5. Species groups from TWINSPAN classification using all data set (*m* = 101, *n* = 265). Groups (1b–9b) are named after the most describing habitat. Asterisk (*) indicates that species occurred mainly in other kinds of habitat.

Group name and species composition
1b. A group of species preferring 'unmanaged' paludified shady forests *Barbilophozia hatcheri**, *Calypogeia fissa*, *Cephalozia lunulifolia*, *Cladopodiella fluitans*, *Dicranum majus*, *Harpanthus flotovianus*, *Hylocomiastrum umbratum*, *Paraleucobryum longifolium**, *Peltigera apthosa**, *Polytrichum strictum*, *Sphagnum centrale*, *S. fimbriatum*, *S. girgensohnii*, *S. teres*, *Stereocaulon* spp.*, (*Agrostis stolonifera)*
2b. A group of species preferring half-shadow slope forests *Barbilophozia lycopodioides*, *Brachythecium populeum*, *Cladina rangiferina*, *Cladonia* sp., *C. coccifera*, *Metzgeria furcata**, *Nephroma arcticum*, *Plagiothecium ruthei**, *Polytrichum juniperinum*, *Ptilidium ciliare*, *Ptilium crista-castrensis*, *Thuidium recognitum**, *(Botrychium lunaria*, *Cypripedium calceolus*, *Deschampsia flexuosa*, *Epipogium aphyllum**, *Festuca ovina*, *Hieracium pilosella*, *H. sylvatica*, *Lycopodium clavatum*, *Melampyrum pratense*, *Mentha arvense*, *Poa* sp.*, *Solidago virgaurea)*
3b. A group of species preferring shady coniferous forests *Brachythecium rivulare**, *Dicranum polysetum*, *Lophozia ventricosa*, *Polytrichastrum longisetum**, *Sphagnum squarrosum*, *(Actaea spicata*, *Dryopteris expansa*, *Hieracium vulgata*, *Milium effusum**, *Populus tremula*)*
4b. The 'sub-dry' group *Calypogeia muelleriana**, *Cladonia cornuta, Brachythecium rivulare, Dicranum scoparium*, *Hylocomium splendens*, *Mnium stellare**, *Pleurozium schreberi*, *Rhytidiadelphus triquetrus*, *(Calamagrostis arundinacea*, *Fragaria vesca*, *Juniperus communis*, *Linnea borealis**, *Melampyrum sylvaticum*, *Moneses uniflora**, *Platanthera bifoliata*, *Rubus saxatilis*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Viola riviniana)*
5b. A group of species preferring 'managed' mesic sites *Atrichum undulatum*, *Barbilophozia floerkei*, *Blepharostoma trichophyllum**, *Hypogymnia physodes*, *Lophozia longiflora*, *Sanionia uncinata*, *(Betula pubescens*, *Carex digitata*, *C. pallescens*, *Convallaria majalis*, *Dryopteris carthusiana**, *D. filix-mas*, *Epipactis helleborine*, *Huperzia selago**, *Melica nutans*, *Pyrola minor*, *Rhamnus frangula**, *Scutellaria galericulata**, *Veronica officinalis*, *Viola mirabilis)*
6b. A group of 'constant' herb-rich forest species preferring mesic and moist sites *Barbilophozia barbata**, *B. kunzeana**, *Brachythecium oedipodium*, *B. reflexum*, *B. rutabulum*, *B. salebrosum*, *Calypogeia neesiana**, *Cephalozia bicuspidata**, *Dicranum fuscescens**, *Hylocomiastrum pyrenaicum*, *Lophocolea heterophylla*, *Plagiochila asplenioides*, *Plagiothecium curvifolium*, *P. denticulatum*, *P. laetum*, *Plagiomnium cuspidatum*, *Rhodobryum roseum*, *Rhytidiadelphus subpinnatus*, *Sphagnum angustifolium*, *(Alnus incana*, *Athyrium filix-femina*, *Dactylorhiza maculata**, *Galium triflorum*, *Geranium sylvaticum*, *Gymnocarpium dryopteris*, *Lonicera xylosteum*, *Luzula pilosa*, *Maianthemum bifolium*, *Sorbus aucuparia*, *Trientalis europaea*, *Viola selkirkii*, *Orthilia secunda*, *Oxalis acetosella*, *Phegopteris connectilis*, *Rubus idaeus*, *Stellaria media)*
7b. A group of species preferring fertile brook-side forests *Breidleria pratensis*, *Cirriphyllum piliferum*, *Plagiochila porelloides*, *Plagiomnium medium*, *Polytrichum commune**, *Rhizomnium punctatum*, *Sphagnum russowii**, *(Calamagrostis purpurea*, *Carex* sp.*, *Cirsium helenioides*, *Crepis paludosa*, *Daphne mezereum*, *Deschampsia cespitosa**, *Diplazium sibiricum*, *Equisetum pratense, Galium uliginosum*, *Lycopodium annonitum**, *Paris quadrifolia**, *Picea abies**, *Prunus padus*, *Ribes spicatum*, *Rosa acicularis*, *Salix phylicifolia*, *Tussilago farfara*, *Viburnum opulus*, *Viola palustre*)*
8b. A group of pioneer and culture-favoring hydrophilous species *Aulacomnium palustre*, *Calliergon cordifolium**, *Calliergonella lindbergii*, *Climacium dendroides*, *Plagiomnium elatum**, *Rhytidiadelphus squarrosum*, *Sphagnum riparium*, *(Aegopodium podagraria*, *Angelica sylvestris*, *Agrostis capillaris*, *Alchemilla* sp., *Andromeda polifolia*, *Anthoxanthum odoratum*, *Anthriscus sylvestris*, *Caltha palustris*, *Campanula glomerata*, *C. rotundifolia*, *Carex cespitosa*, *C. flava**, *Corallorhiza trifida*, *Dactylis glomerata*, *Dryopteris cristata*, *Elymus caninus**, *Epilobium angustifolium*, *Equisetum arvense*, *E. palustre*, *E. fluviatile*, *E. sylvaticum*, Galeopsis bifida*, *Galium boreale**, *Hypericum maculatum*, *Lathyrus pratensis*, *Listera ovata*, *Lysimachia thyrsiflora*, *L. vulgaris*, *Lythrum salicaria*, *Menyanthes trifoliata*, *Moehringia trinerva**, *Peucedanum palustre*, *Parnassia palustris*, *Pinus sylvestris**, *Potentilla erecta*, *P. palustris*, *Pteridium aquilinum*, *Pyrola rotundifolia**, *Ranunculus auricomus*, *Rubus arcticus*, *Rumex acetosa*, *Salix caprea**, *S. pentandra*, *Salix* sp., *Silene dioca*, *Urtica dioica*, *Vicia sepium*, *Veronica chamaedrys**, *Viola canina*, *V. epipsila)*
9b. A group of species preferring fertile and flooded sites *Brachythecium starkei*, *Bryum psedotriquetrum*, *B. weigelii*, *Campylium stellatum*, *Chiloscyphus polyanthos*, *Fissidens adianthoides*, *Fontinalis antipyretica*, *Jungermannia leiantha**, *Mnium* spp.*, *Plagiomnium ellipticum, Plagiothecium succulentum*, Pellia neesiana, Pohlia nutans*, Pseudobryum cinclidioides, Rhizomnium magnifolium, R. pseudopunctatum, Riccardia latifrons, Scapania undulata*, Tetraphis pellucida, Tritomaria quinquedentata*, Warnstorfia fluitans*, (Alchemilla vulgaris, Barbarea stricta, Calamagrostis canescens, Calla palustris, Carex buxbaumii, C. canescens, C. echinata, C. elongata, C. loliacea, C. rhynchophysa, C. vaginata, Circaea alpina, Cirsium palustre, Epilobium montanum*, Filipendula ulmaria, Galium palustre, G. trifidum, Geum rivale, Glyceria lithuanica, Impatiens glandulifera, Matteuccia struthiopteris, Mycelis muralis, Poa palustris*, Poa nemoralis, Poa remota, P. trivialis, Ranunculus acris*, R. repens, Prunella vulgaris, Ribes rubrum*, Rosa majalis*, Scirpus sylvaticus, Scrophularia nodosa, Stachys sylvatica, Valeriana sambucifolia*, Viola rupestris)*

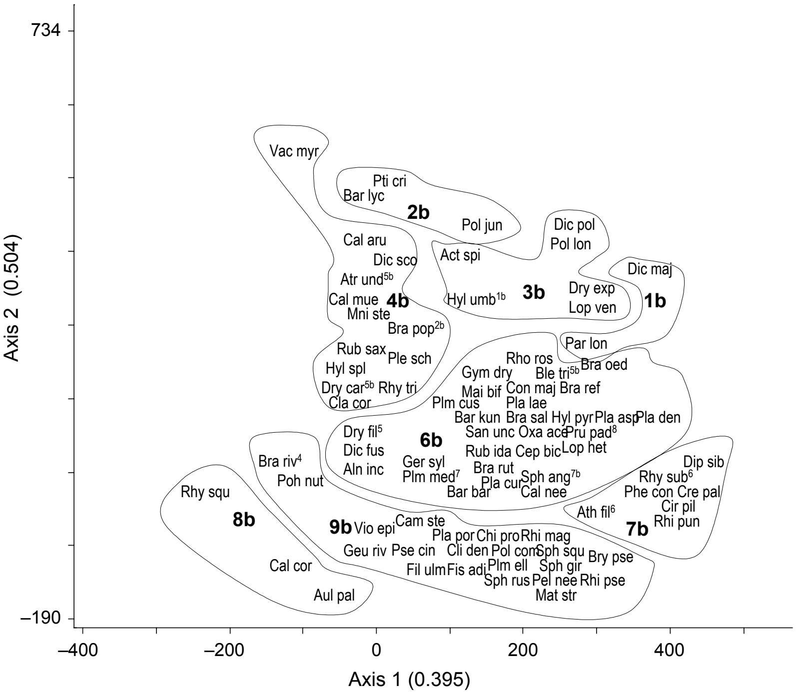

Fig. 8. Species ordination (DCA) for bryophytes and 'abundant' vascular plant species (total variance 4.425) using vascular plant and bryophyte data. Ordination is done for all species (n = 265), but only bryophytes with frequency > 3 and vascular plant with coverage > 4% are shown. For species groups (1b–9b) *see* Table 4 and for abbreviations *see* Appendix 1.

face e.g. soil moisture, accumulation of organic matter and total content of nitrogen. This pattern was revealed when ordination was based on the bryophyte flora. When bryophytes grow on the ground, they are known to obtain nutrients from a soil surface rather than from a subsoil volume, because they are rootless and grow directly on substrate e.g. on litter, humus or mineral soil (Smith 1982, Carleton 1990, Ingerpuu *et al.* 2003). Vascular plants reflect mainly site moisture (hydrology), fertility (pH, content of base cations) and shading (Hokkanen 2003). When both vascular plants and bryophytes were considered, the interpretations for ordination axes were quite similar to that of vascular plants. Bryophytes covered 20% of the forest floor in the herb-rich forests studied, while vascular plants sometimes covered more than 100% of the ground (*see* also Hokkanen 2003); and thus their common ordination may largely reflect the patterns of the vascular plants.

An interpretation for the first axis in the bryophyte ordination might be soil moisture and accumulation of organic matter (paludification). Species preferring moist and wet sites often received greater values for the first axis than species preferring mesic sites (Table 5 and Fig. 7). However, e.g. *Calypogeia neesiana*, *Plagiomnium medium* and *Rhizomnium magnifolium*, which are known to prefer fertile moist and wet sites (Ulvinen *et al.* 2002), received the lowest values for the first axis. In this study, these species had the greatest coverage on half-shadow, fertile and moist sites along flooded brooks or ditches. One reason why these species received lower values than the other species preferring wet sites might be that they were infrequent on paludified sites and seldom grew together with *Sphagnum* spp. Another reason could be that they often grew on soils, which had a little litter or low organic matter content. The soil organic matter and accumulation of litter correlate positively with total content of nitrogen, because both are important sources of nitrogen (Tamm 1991). Thus the first axis might also reflect the content of total nitrogen in the soil surface layers.

The interpretation for the second ordination axis was not so clear. It might reflect shading, which seemed to decrease along the second axis. The number of species preferring shady brook-side forests decreased and the number of species preferring half-shadow moist and wet sites increased along the second axis. However, e.g. *Hylocomium splendens, Ptilium crista-cas-*

trensis and *Rhizomnium magnifolium*, which are known to prefer shading (Mäkipää 2001d, 2001f, Ulvinen *et al*. 2002), received relatively high values for the second ordination axis. In this study, these species often occurred in shady spruce-dominated forests. Both tree and vascular plant cover effected on shading, therefore many shade-demanding bryophytes were able to grow on moist and open (sunny) sites under well -covered field layer. On the other hand, some species preferring openness were able to grow in relatively shady forests under sparse field layer. Thus the second ordination axis might also reflect coverage of the field layer.

Role of bryophytes in classification

In the field, classification was mainly based on vascular plants, but bryophytes were useful for determining parallel site types. For instance, if vascular plants only were considered, the moist-wet herb-rich forests dominated by *Filipendula ulmaria* formed a quite homogeneous group (Hokkanen 2003). After bryophytes were taken into account, it was possible to distinguish three subtypes within the *Filipendula ulmaria* group: the southerly *Oxalis–Filipendula* subtype (OFiT) and the northerly *Geranium–Oxalis–Filipendula* (GOFiT) and *Geranium–Filipendula* (GFiT) subtypes. The 'differential' species were e.g. *Brachythecium rutabulum* for the GOFiT, *Oxalis acetosella* and *Hylocomium splendens* for the OFiT and GOFiT, *Rhodobryum roseum* for the GOFiT and GFiT, and *Anthriscus sylvestris* for the GFiT. *Geranium sylvaticum* occurred in all subtypes, but it was more abundant in the GOFiT and GFiT than in the OFiT. The southerly subtype formed the *Oxalis acetosella–Filipendula ulmaria* group (OFi) and the northerly subtypes the *Geranium sylvaticum–Filipendula ulmaria* group (GFi). In addition, based on vascular plants and bryophytes, the OR group was divided into the southern *Oxalis–Rubus* subtype (ORT) and the northern *Geranium–Oxalis–Rubus* subtype (GORT). The 'differential' species were e.g., *Atrichum undulatum* and *Brachythecium populeum* for the GORT, and e.g. *Viola mirabilis* and *Dicranum polysetum* for the ORT. *Geranium sylvaticum* occurred in both subtypes, but it was more abundant in the GORT than in the ORT. However, the differences between the ORT and the GORT were not remarkable, so the OR included both subtypes. Bryophytes known to prefer or tolerate human activities, e.g. *Atrichum undulatum*, *Brachythecium populeum*, *B. salebrosum*, *Climacium dendroides* and *Rhytidiadelphus squarrosus* (Mäkipää 2001a, 2001b, 2001h, Ulvinen *et al*. 2002), were more abundant in the northern than in the southern subtypes.

Based on TWINSPAN classifications (Figs. 1–3), bryophytes seemed to be less informative for classifying herb-rich forests than vascular plants were, because they did not form clearly separated groups. Thus bryophytes alone were not useful enough for classification; but combined with vascular plants the classification became very detailed. Nevertheless, the classifications based on all vegetation data and on vascular plants did not differ essentially from each other's. The classification based on bryophytes alone was considerably different from the other classifications.

Comparison of the bottom layers to those of previously studied

Sub-dry vegetation types

The bryophyte composition of the *Oxalis acetosella–Rubus saxatilis* group (OR), the *Oxalis acetosella–Rubus saxatilis* (T3) and *Pleurozium schreberi–Dicranum scoparium* (B4) clusters resembled both dry and mesic moderately fertile herb-rich forests (Kujala 1979, Kuusipalo 1996). On most sites, species typical of the southern boreal *Vaccinium-Rubus* site type (VRT), e.g. *Hylocomium splendens*, *Pleurozium schreberi* and *Rhytidiadelphus triquetrus* (Kujala 1979, Heikkinen 1991, Kuusipalo 1996) were predominant. Nevertheless, e.g. *Brachythecium* species were absent from the VRT (Kujala 1979, Heikkinen 1991), and *Dicranum polysetum* occurred occasionally in the herb-rich forests studied. These vegetation types were also quite similar to the GOMaT sites studied previously in Kainuu (Kaakinen 1974), although e.g. *Hylocomiastrum pyrenaicum* and *Polytrichum commune* did not occur on the studied sites. Based on bryophyte composition, the sub-dry vegetation types studied seem to be moister and more fertile than the VRT, but dryer than the GOFiT. It is known that *Brachythecium* species are abundant only on fertile sites, while *D. polysetum* prefers barren sites (Carleton 1990, Mäkipää 2001a, 2001c). Moreover, both *H. pyrenaicum* and *P. commune* thrive better on moist than on sub-dry sites (Korpela 2001, Ulvinen *et al*. 2002).

The *Dryopteris filix-mas–Viola mirabilis* group (PuV) did not correspond well to any group or cluster, but it had some features of the dry (VRT, MelaT) and mesic (OMaT) herb-rich forests studied in southern Finland (Kujala 1979, Heikkinen 1991, Kuusipalo 1996). When bryophyte composition was considered, the PuV group seemed to correspond better to the MelaT than to the VRT or OMaT. Nevertheless, the following bryophytes were absent from the PuV: *Dicranum polysetum*, a characteristic moss for the VRT and the MelaT, *Barbilophozia barbata*, a characteristic hepatic for the MelaT (Heikkinen 1991), and *Atrichum undulatum*, *Rhodobryum roseum* and *Plagiochila asplenioides*, characteristic bryophytes for the OMaT (Kujala 1979, Kuusipalo 1996). The studied stands were probably too young for *D. polysetum*, which is known to prefer mature forests (Mäkipää 2001c), too sunny for the 'shade-favouring' *B. barbata* (Ulvinen *et al*. 2002), and too dry for species preferring mesic sites, such as *A. undulatum*, *P. asplenioides* and *R. roseum* (Kujala 1979, Mäkipää 2001g).

Mesic vegetation types

The *Oxalis acetosella–Maianthemum bifolium* group (OMa), the *Gymnocarpium dryopteris–Vaccinium myrtillus* (T2) and *Brachythecium reflexum–Plagiothecium curvifolium* (B2) clusters had more similarities to the mesic than to the dry herb-rich forests (Kaakinen 1974, Kujala 1979, Heikkinen 1991, Kuusipalo 1996). The bryophyte composition of the OMa and cluster T2 corresponded quite well to that of the OT (Kujala 1979) and OMaT (Heikkinen 1991) described previously in southern Finland. Nevertheless, a characteristic bryophyte for the OT, *Rhytidiadelphus subpinnatus,* and a predominant moss for the OMaT, *D. polysetum*, occurred occasionally on the studied sites. Absence of *R. subpinnatus* might be due to the fact that the studied sites were too dry for it, since it is known to prefer moist sites (Ulvinen *et al*. 2002). However, the studied sites were probably too moist and fertile for *D. polysetum,* which prefers sub-xeric heath forests (Mäkipää 2001c). However, cluster B2 had similarities to the GOPaT and GOMaT studied previously in Kainuu in the middle boreal zone (Kaakinen 1974). Nevertheless, e.g. *Cirriphyllum piliferum, Plagiomnium medium*, *Rhizomnium punctatum* and *Rhytidiadelphus triquetrus* were absent from the studied plots. Sites of cluster B2 might be too sunny and too open for *C. piliferum* and *R. punctatum*, too nutrient-poor for *P. medium* and too moist for *R. triquetrus*. In the study area, *C. piliferum* seemed to be most abundant in moderately shady mature coniferous forests, while *P. medium* preferred fertile occasionally flooded deciduous forests. *Rhizomnium punctatum* is known to prefer shady sites (Ulvinen *et al*. 2002), while *R. triquetrus* often grows in sub-dry and mesic herb-rich forests (Kujala 1979).

The *Oxalis acetosella–Deschampsia cespitosa* cluster (T1) was moister than the mesic vegetation site types described above. The bryophyte composition resembled a lot of that of the fertile mesic *Hepatica–Oxalis* (HeOT) site type studied previously in Häme (Heikkinen 1991), except for that e.g. *Cirriphyllum piliferum*, *Pleurozium schreberi* and *Rhytidiadelphus subpinnatus* were absent from the HeOT. Based on the bryophyte composition, sites of Cluster T1 seemed to be more sunny and moister than sites of the HeOT. Abundance of *C. piliferum* and *R. subpinnatus* might reflect both relatively high fertility and moisture on the soil surface, while abundance of *P. schreberi* might reflect lack of shading or dominance of coniferous trees. It is known that *C. piliferum* and *R. subpinnatus* prefer e.g. fertile and moist brook-side forests (Ulvinen *et al*. 2002), while *P. schreberi* thrives best in sunny or half-shaded mature coniferous forests (Kujala 1965, Carleton 1990, Mäkipää 2001e).

Mesic-moist vegetation types

The *Athyrium filix-femina–Dryopteris expansa* group (AAs) as well as the *Brachythecium* *reflexum–Plagiomnium cuspidatum* (B3) and *Dryopteris expansa–Oxalis acetosella* (T4) clusters were moister than those described above, and they had features similar to those of the medium fertile herb- and fern-rich forests (Kaakinen 1974, Kujala 1979, Alanen *et al*. 1996, Kuusipalo 1996). These vegetation types seemed to be moister than the OT, and e.g. *Plagiomnium* and *Rhizomnium* species, which were characteristic for the studied types, were absent from the OT (Kujala 1979). Studied types were, however, dryer than the *Filices* type (FT) described in southern Finland (Kujala 1979). For example, species known to prefer dry and mesic sites, such as *Dicranum scoparium, Hylocomium splendens* and *Rhytidiadelphus triquetrus* (Mäkipää 2001c, 2001d, 2001h), were abundant on the studied sites, but absent from the FT. The AAs and clusters B3 and T4 corresponded very well to the AthAssT studied in Kainuu (Kainuu 1974). However, characteristic species for the mesic sites, e.g. *Atrichum undulatum* and *Ptilium crista-castrensis* (Kujala 1979, Mäkipää 2001f, Ulvinen *et al*. 2002) were absent from the AthAssT. Occurrence of *A. undulatum* and *P. crista-castrensis* might be due to the fact that the studied sites were not very moist.

The *Athyrium filix-femina* group (Ath) as well as the *Athyrium filix-femina–Phegopteris connectilis* (T5) and *Rhytidiadelphus triquetrus–Cirriphyllum piliferum* (B1) clusters resembled both mesic and moist herb-rich forests (Kujala 1979). Their bryophyte composition resembled that of the AthAssT and GOPaT studied previously in Kainuu (Kaakinen 1974), even though e.g. *Polytrichum commune* and *Syntrichia ruralis* did not occur on the studied plots. Studied sites were probably too ‘mesic’ for *P. commune*, which prefers early stages of paludification (Kujala 1965, Korpela 2001). Soil surface layers of the studied sites, mull or humus, were probably unsuitable substrates for *S. ruralis*, which mostly grows on bare rock or sandy soil (Ulvinen *et al*. 2002).

Moist vegetation types

In terms of bryophyte composition, the *Diplazium sibiricum* group (Dip), the *Geranium sylvaticum–Athyrium filix-femina* (T7) and *Plagiomnium medium–Brachythecium oedipodium* (B5) clusters were more moist than mesic, although they had many characteristic species of the mesic sites. The Dip and cluster T7 had a lot of northern features. These two vegetation types corresponded quite well to the LaAthT studied previously in Kuusamo in the northern boreal zone (Kaakinen 1974), except for that e.g. *Calliergonella cuspidata* was absent from the studied sites and *Cirriphyllum piliferum* from the LaAthT. The Dip and both clusters (T7 and B5) resembled the GOFiT and AthAssT of Kainuu (Kaakinen 1974), even though e.g. *Calliergonella lindbergii* was absent from the studied plots. Studied types seemed to be dryer than the LaAthT, GOFiT and AthAssT. Thus e.g. *C. cuspidata* and *C. lindbergii*, which are known to prefer wet sites (Ulvinen *et al*. 2002), were absent from the studied sites.

The *Matteuccia struthiopteris* group (Mat) and the *Athyrium filix-femina–Filipendula ulmaria* cluster (T8) resembled moist grass–herb forests described in the southern and middle boreal zones (Kaakinen 1974, Kujala 1979). The bryophyte composition corresponded quite well to both the AthAssT and GOFiT of Kainuu (Kaakinen 1974), except for that e.g. *Rhytidiadelphus triquetrus* was absent from the studied sites and *Cirriphyllum piliferum* occurred occasionally. The stands were situated in occasionally flooded areas and thus they might be (in part of the year) too wet for *R. triquetrus* and *C. piliferum*, which are known to thrive better on mesic sites (Ulvinen *et al*. 2002). Furthermore, the Mat and cluster T8 had a lot of similarities to the FT described by Kujala (1979), although e.g. *Hylocomiastrum umbratum* did not occur on the studied plots. The Mat forests as well as sites of cluster T8 were probably too sunny for the ‘shade-favouring’ *H. umbratum* (Ulvinen *et al*. 2002).

Moist-wet vegetation types

The *Oxalis acetosella–Filipendula ulmaria* group (OFi) and the *Climacium dendroides–Pseudobryum cinclidioides* cluster (B6) had more similarities to the moist than mesic sites (Kujala 1979). The bryophyte composition had a lot of similarities to that of the FT described in southern Finland (Kujala 1979), except for that e.g. *Hylocomiastrum umbratum* was absent from the studied sites and *Cirriphyllum piliferum* occurred occasionally in the moist-wet vegetation types (Appendix 1). *Hylocomiastrum umbratum* and *C. piliferum* did not thrive well on the studied sites, because the studied sites were probably too sunny and too moist for these species (*see* also Ulvinen *et al*. 2002). In addition, the OFi and cluster B6 resembled the GOFiT of Kainuu (Kaakinen 1974), although e.g. *Calliergonella lindbergii*, *Hylocomiastrum pyrenaicum* and *Sphagnum girgensohnii* were absent from the vegetation types studied. Absence of *C. lindbergii*, *H. pyrenaicum* and *S. girgensohnii* might reflect the fact that the studied sites were not as wet and fertile as the GOFiT. These species are known to prefer eutrophic paludified forests, and *H. pyrenaicum* is also known to prefer calciferous soils (Hotanen 2001, Ulvinen *et al*. 2002).

The *Geranium sylvaticum–Filipendula ulmaria* group (GFi) and the *Geum rivale–Angelica sylvestris* (T9) cluster resembled the moist grass-herb forests described previously in the middle and northern boreal zones (Kaakinen 1974, Kujala 1979). The bryophyte composition corresponded quite well to that of the GFi and GOFiT, except for that e.g. *Hylocomiastrum pyrenaicum*, *Sphagnum girgensohnii*, *S. warnstorfii* and *Barbilophozia lycopodioides* did not occur on the studied plots. The studied sites were often affected by standing water. Thus they were probably both too poor in oxygen and too acid for *H. pyrenaicum* and *S. warstorfii,* and too sunny for *S. girgensohnii* and *B. lycopodioides*. *Hylocomiastrum pyrenaicum* prefers calciferous soils and *S. warnstorfii* wet sites affected by ground water (Ulvinen *et al*. 2002) and the running water is known to have 'a calcium-like' effect (Pesola 1928). *Barbilophozia lycopodioides* and *S. girgensohnii* prefer shady coniferous forests and demand relatively high atmospheric humidity (Kujala 1964, Hotanen 2001).

Paludified vegetation types

The *Dryopteris expansa–Sphagnum girgensohnii* (T6) and *Plagiomnium ellipticum–Sphagnum russowii* (B7) clusters were characterised by mire species and differed from all other groups or clusters. Although, they had the same features as the eutrophic paludified forests (LhK) (Laine & Vasander 1998), their bottom layers resembled more that of the moist grass-herb forests studied in Kainuu (Kaakinen 1974). Both clusters had many similarities to the AthAssT and GOFiT forests of Kainuu (Kaakinen 1974), except for that e.g. *Hylocomiastrum pyrenaicum* and *Rhytidiadelphus triquetrus* were absent from clusters. The studied plots were probably too paludified for *R. triquetrus* and too acid for *H. pyrenaicum* (*see* Mäkipää 2001h and Ulvinen *et al*. 2002).

Conclusions and future prospects

The multivariate methods used here complemented each other. The 'ecological groups' were based on 'a priori' typification. By using vascular plants as well as vascular plants and bryophytes, TWINSPAN classifications corresponded well to the 'ecological groups' and 'a priori 'site types. When bryophytes only were used, the classification did not correspond clearly to the 'ecological groups' or 'a priori' site types. Bryophytes seemed to classify the sites according to topography, stand structure and exposition. In all the classifications, TWINSPAN separated paludified vegetation types to own clusters. The paludified herb-rich forests formed a new herb-rich forest site type, which might be a transition type between moist fern-rich forests and eutrophic paludified forests.

The results of this study might indicate that bryophytes respond more to conditions on the soil surface (e.g. moisture, accumulation of organic matter and total content of nitrogen), shading, stand structure and atmospheric humidity than to soil fertility. In herb-rich forests, vascular plants seemed to predict soil nutrient status better than bryophytes. When the classification is needed for practical forestry to predict wood production, it would be better to use vascular plants than bryophytes. However, for detailed vegetation ecological classifications, both vascular plants and bryophytes should be included in the analysis. In addition, bryophytes could be useful for studying, e.g. forest succession and land use history. Bryophytes are also useful for distinguishing herb-rich forests from eutrophic paludified spruce forests and, on the other hand, for distinguishing sub-dry herb-rich forests from herb-rich heath forests.

Boreal herb-rich forests are important ecosystems for maintaining diverse bryophyte flora in Finnish forests. Despite the sparse bottom layers, the studied herb-rich forests had relatively diverse bryophyte flora. According to Kuusipalo (1996) such forests have more diverse bryophyte flora than the heath forests.

Different kinds of herb-rich forest types are essential for maintaining regional plant diversity in Finnish forests. It is essential to include different herb-rich vegetation types and subtypes in the conservation network. Herb-rich forests are also important habitats for several other taxonomic groups (Rassi *et al*. 2001). For example, herb-rich forests harbour dozens of threatened invertebrates (especially beetles and moths) and fungi. It is currently unclear how useful forest classifications based on vascular plants and/or bryophytes are for separating the patterns of occurrence of other groups. This remains a challenging conservation problem, but the classifications proposed in this study and in other plant studies should provide a useful starting point for exploring patterns in the inter-taxonomic biodiversity covariation of herb-rich forests.

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Appendix 1. Summary table of the forest site type groups. Mean percentage cover (+ = cover < 0.5%) and frequency (%) of each species in the site type groups is given. Abbreviations of species names used in Figures are given in parenthesis. For abbreviations of the site type groups (*see* 'Bryophyte composition of the ecological site type groups'). For bryophytes, habitat is given in superscripts: G = mineral soil or humus, S = small stones, W = fine woody debris and R = rock.

Site type group Number of plots	OMa 19	OR 7	PuV 4	AAs 18	Ath 14	Dip 10	Mat 10	OFi 8	GFi 11
Mean percentage coverage									
Alnus incana (Aln inc)	0.5/58	8/86	0.5/100	0.6/67	1/71	0.9/60	0.8/60	+/50	6/64
Betula pubescens (Bet pub)	+/11	0.7/14	–	–	+/7	–	+/10	–	–
Daphne mezereum (Dap mez)	+/21	+/43	+/75	+/6	+/43	+/60	+/10	+/25	+/36
Juniperus communis (Jun com)	+/16	–	–	+/6	–	–	–	–	–
Lonicera xylosteum (Lon xy)	+/16	0.7/43	+/50	+/11	+/21	+/10	+/10	+/13	–
Picea abies (Pic ab)	+/37	+/43	+/75	+/33	–	+/50	+/30	+/50	1/73
Pinus sylvestris (Pin sy)	–	–	–	–	–	–	–	–	+/9
Populus tremula (Pop tre)	+/21	+/14	+/25	+/17	–	–	–	–	–
Prunus padus (Pru pad)	+/21	5/57	1/50	+/50	1/64	1/70	1/60	0.8/75	1/73
Rhamnus frangula (Rha fra)	+/11	+/14	–	+/11	+/7	–	–	–	–
Ribes rubrum (Rib rub)	–	–	–	–	+/7	+/10	–	–	–
Ribes spicatum (Rib sp)	–	3/14	0.6/50	+/6	+/7	+/10	+/20	+/13	–
Rosa acicularis (Ros ac)	+/16	+/14	+/25	+/11	+/29	+/40	+/10	+/13	0.4/27
Rosa majalis (Ros ma)	–	–	–	–	–	–	+/10	–	–
Rubus idaeus (Rub ida)	4/79	4/71	15/75	5/83	3/79	3/90	2/80	3/88	–
Salix caprea (Sal cap)	+/5	–	–	+/6	+/7	–	+/10	+/13	+/9
Salix pentandra (Sal pen)	–	–	–	–	–	–	–	–	+/9
Salix phylicifolia (Sal phy)	–	–	–	+/11	–	+/20	–	–	+/18
Salix sp. (Sal sp.)	–	–	–	+/6	–	–	–	–	+/18
Sorbus aucuparia (Sor auc)	2/90	+/29	1/75	1/78	+/43	0.9/60	+/40	0.7/63	2/64
Viburnum opulus (Vib opu)	+/5	+/14	–	–	–	+/10	+/20	+/13	+/9
Andromeda polifolia (And po)	–	–	–	–	–	–	–	–	+/9
Huperzia selago (Hup se)	–	+/14	+/25	–	–	–	–	–	–

continued

Appendix 1. Continued.

Site type group Number of plots	OMa 19	OR 7	PuV 4	AAs 18	Ath 14	Dip 10	Mat 10	OFi 8	GFi 11
Linnea borealis (Lin bor)	+/21	–	–	+/6	–	+/10	+/20	+/13	+/9
Lycopodium annonitum (Lyc ann)	+/21	+/14	–	+/33	+/35	+/30	+/20	+/13	+/27
Lycopodium clavatum (Lyc cla)	–	–	+/25	–	–	–	–	–	–
Vaccinium myrtillus (Vac myr)	6/90	2/71	+/50	+/83	+/50	+/50	+/30	+/25	0.6/55
Vaccinium vitis-idaea (Vac vit)	0.6/42	+/57	+/25	+/33	+/29	+/20	+/20	+/13	+/36
Agrostis capillaris (Agr cap)	+/5	–	–	+/6	–	+/10	–	+/38	+/36
Agrostis stolonifera (Agr sto)	–	–	–	+/11	–	–	–	–	–
Anthoxanthum odoratum (Ant odo)	–	–	–	–	–	–	–	–	+/9
Calamagrostis arundinacea (Cal ar)	5/74	9/86	2/50	0.5/72	0.8/71	0.5/50	+/20	+/25	+/27
Calamagrostis canescens (Cal can)	–	–	+/25	–	+/21	–	–	+/25	+/27
Calamagrostis purpurea (Cal pur)	+/11	–	+/25	+/28	+/29	+/10	+/30	+/50	+/55
Carex buxbaumii (Car bux)	–	–	–	–	–	–	–	–	+/9
Carex canescens (Car can)	+/11	–	–	–	–	–	–	+/25	+/46
Carex cespitosa (Car ces)	–	–	–	–	–	–	–	–	+/9
Carex digitata (Car dig)	+/42	+/86	–	+/22	+/29	+/30	–	+/25	+/18
Carex echinata (Car ech)	–	–	–	+/6	–	–	–	–	+/18
Carex elongata (Car elo)	–	–	–	–	–	–	–	+/13	+/9
Carex flava (Car fla)	–	+/14	–	–	–	+/10	–	–	+/18
Carex loliacea (Car lol)	–	–	–	+/6	–	+/10	+/20	+/13	+/18
Carex pallescens (Car pal)	+/5	+/43	–	+/6	+/7	–	–	–	+/18
Carex rhynchophysa (Car rhy)	–	–	–	–	–	–	+/10	–	–
Carex sp. (Car sp.)	–	–	–	+/6	–	–	–	–	+/9
Carex vaginata (Car vag)	–	–	–	–	–	–	–	+/13	–
Dactylis glomerata (Dac glo)	–	–	–	–	–	–	–	+/13	+/9
Deschampsia cespitosa (Des ces)	+/5	0.7/57	–	+/22	+/50	+/20	+/30	+/63	1/100
Deschampsia flexuosa (Des fle)	1/37	+/43	+/25	+/22	+/14	–	+/10	+/25	+/18
Elymus caninus (Ely can)	–	+/29	2.5/50	+/6	0.9/36	+/50	0.8/50	+/13	2/27
Festuca ovina (Fes ov)	–	+/14	–	–	–	–	–	–	–
Glyceria lithuanica (Gly lit)	–	–	–	–	–	+/10	+/10	–	–
Luzula pilosa (Luz pil)	+/58	+/57	+/50	+/61	+/50	+/30	–	+/50	+/73
Melica nutans (Mel nut)	0.9/84	1/86	0.8/75	+/67	+/93	+/70	0.9/60	+/50	1/82
Milium effusum (Mil eff)	1.0/42	–	+/50	0.9/56	+/21	+/20	0.8/30	+/13	+/9
Poa nemoralis (Poa nem)	–	–	–	–	–	+/20	–	–	+/9
Poa palustris (Poa pa)	–	–	–	–	–	–	–	–	+/18
Poa remota (Poa rem)	–	–	–	–	–	–	+/10	–	–
Poa sp. (Poa sp.)	+/5	–	–	–	–	–	–	–	–
Poa trivialis (Poa tr)	–	–	–	–	+/7	+/10	–	–	–
Scirpus sylvaticus (Sci sy)	–	–	–	–	+/7	–	–	–	–
Actaea spicata (Act sp)	5/47	3/43	+/50	3/33	0.9/36	0.5/80	0.7/20	–	–
Aegopodium podagraria (Aeg pod)	–	–	–	–	–	–	–	–	+/9
Alchemilla sp. (Alc sp.)	–	–	–	–	–	–	–	–	+/27
Alchemilla vulgaris (Alc vu)	–	–	–	–	–	+/10	+/10	+/13	+/27
Angelica sylvestris (Ang sy)	+/63	+/71	+/50	+/33	+/64	+/60	0.6/60	2/88	2/82
Anthriscus sylvestris (Ant sy)	+/16	–	–	–	+/14	+/20	+/30	+/13	2/46
Athyrium filix-femina (Ath fi)	0.9/37	1/43	20/50	26/100	49/100	15/100	22/100	13/63	8/82
Barbarea stricta (Bar str)	–	–	–	–	–	–	+/10	–	+/18
Botrychium lunaria (Bot lun)	–	+/14	–	–	–	–	–	–	–
Calla palustris (Cll pa)	–	–	–	–	+/7	–	–	–	–
Caltha palustris (Clt pa)	–	–	–	–	–	–	+/30	+/25	+/27
Campanula glomerata (Cam glo)	–	–	–	–	–	–	–	–	+/9
Campanula rotundifolia (Cam rot)	–	–	–	–	–	–	–	–	+/9
Circaea alpina (Cir alp)	+/5	0.6/14	–	+/6	+/21	+/10	+/20	+/13	+/9
Cirsium helenioides (Cir he)	–	–	–	+/6	–	+/10	–	+/38	+/18
Cirsium palustre (Cir pa)	–	+/14	–	+/6	+/7	–	–	+/25	+/27
Convallaria majalis (Con ma)	3/74	3/43	6/75	1/44	+/21	+/40	+/30	–	2/64
Corallorhiza trifida (Cor tr)	–	–	–	–	–	–	–	+/13	–
Crepis paludosa (Cre pa)	+/16	–	+/25	2/61	5/93	7/100	6/100	2/75	4/82
Cypripedium calceolus (Cyp ca)	+/5	+/14	–	–	–	–	–	–	–
Dactylorhiza maculata (Dac mac)	+/5	–	–	–	–	+/10	–	–	+/9
Diplazium sibiricum (Dip sib)	–	–	–	–	–	56/100	–	–	–

continued

Appendix 1. Continued.

Site type group Number of plots	OMa 19	OR 7	PuV 4	AAs 18	Ath 14	Dip 10	Mat 10	OFi 8	GFi 11
Dryopteris carthusiana (Dry car)	5/58	2/43	3/100	+/22	3/79	+/10	2/50	1/75	1/64
Dryopteris cristata (Dry cr)	–	–	–	–	–	–	–	+/13	+/9
Dryopteris expansa (Dry exp)	10/58	1/43	+/50	34/100	+/36	9/50	3/30	+/13	+/9
Dryopteris filix-mas (Dry fi)	+/32	1/43	11/75	+/17	+/21	–	–	+/25	–
Epilobium angustifolium (Epi ang)	+/5	+/14	+/25	+/11	+/14	+/20	+/30	+/13	+/27
Epilobium montanum (Epi mon)	–	–	–	–	–	+/10	–	–	+/9
Epipactis helleborine (Epi he)	–	–	–	–	–	–	–	–	+/9
Epipogium aphyllum (Epi aph)	–	+/14	–	–	–	–	–	–	–
Equisetum arvense (Equ arv)	–	+/14	–	–	+/7	–	–	+/13	+/9
Equisetum fluviatile (Equ flu)	–	–	–	–	–	–	–	–	+/9
Equisetum palustre (Equ pa)	+/5	–	–	–	–	–	–	+/13	+/36
Equisetum pratense (Equ pra)	+/16	+/14	+/25	+/22	0.7/29	0.8/60	0.6/50	+/50	0.8/46
Equisetum sylvaticum (Equ sy)	+/11	–	–	+/33	0.8/50	+/50	0.8/50	+/50	3/64
Filipendula ulmaria (Fil ulm)	+/5	2/43	4/50	0.8/28	5/79	3/90	12/80	25/100	18/100
Fragaria vesca (Fra ves)	+/32	3/86	+/25	+/6	+/36	+/30	+/10	+/13	0.9/46
Galeopsis bifida (Gal bif)	+/11	–	+/25	+/17	+/7	–	+/20	+/25	+/18
Galium boreale (Gal bor)	–	–	–	–	–	–	–	–	+/9
Galium palustre (Gal pa)	–	–	–	–	+/7	–	–	+/13	+/9
Galium trifidum (Gal tf)	–	–	–	–	+/7	+/40	+/10	+/25	+/27
Galium triflorum (Gal tlo)	+/5	+/14	–	+/11	0.8/50	+/40	+/30	–	+/9
Galium uliginosum (Gal ul)	–	–	–	–	–	–	–	–	+/18
Geranium sylvaticum (Ger sy)	2/63	4/86	*+/75*	1/83	1/93	2/90	1/80	1/75	7/100
Geum rivale (Geu riv)	+/16	+/57	0.5/25	+/22	1/79	0.8/80	2/70	8/100	5/100
Gymnocarpium dryopteris (Gym dry)	17/100	11/71	10/100	12/100	8/93	5/90	6/100	3/75	6/91
Hieracium pilosella-coll. (Hie pil)	–	+/14	–	–	–	–	–	–	–
Hieracium sylvatica-coll. (Hie sy)	+/16	+/29	–	–	–	–	–	–	+/18
Hieracium vulgata-coll. (Hie vu)	+/5	+/14	–	+/6	–	–	–	+/13	–
Hypericum maculatum (Hyp mac)	+/5	+/14	+/25	+/6	+/14	–	–	+/38	+/18
Impatiens glandulifera (Imp gla)	–	–	–	–	–	–	+/10	–	–
Lathyrus pratensis (Lat pra)	–	–	–	–	–	–	–	–	+/9
Listera ovata (Lis ova)	+/5	–	1.3/25	–	–	–	+/10	+/38	+/27
Lysimachia thyrsiflora (Lys thy)	–	–	–	–	+/14	–	–	+/13	+/9
Lysimachia vulgaris (Lys vul)	–	–	–	–	–	+/10	+/10	+/13	+/27
Lythrum salicaria (Lyt sal)	–	–	–	–	–	–	–	–	+/9
Maianthemum bifolium (Mai bif)	5/100	4/100	6/100	3/100	3/100	2/100	2/100	1/88	4/91
Matteuccia struthiopteris (Mat str)	–	–	–	–	–	+/10	29/100	–	–
Melampyrum pratense (Mel pra)	+/21	+/14	–	+/17	–	–	–	+/13	–
Melampyrum sylvaticum (Mel syl)	+/63	+/57	–	+/11	+/21	–	+/20	+/25	+/36
Mentha arvensis (Men arv)	–	–	–	+/6	–	–	–	–	–
Menyanthes trifoliata (Men tri)	–	–	–	–	–	–	–	–	+/9
Moehringia trinervia (Moe tri)	–	–	+/25	–	–	–	–	–	–
Moneses uniflora (Mon uni)	+/5	+/14	–	–	–	+/10	–	+/13	–
Mycelis muralis (Myc mur)	–	–	+/25	–	–	–	–	–	–
Orthilia secunda (Ort sec)	+/42	+/14	–	+/28	+/43	+/30	+/10	+/13	+/27
Oxalis acetosella (Oxa ace)	13/95	17/100	19/100	8/100	8/100	9/100	11/100	6/100	6/64
Paris quadrifolia (Par qua)	+/63	+/57	+/50	+/61	+/93	+/80	+/80	+/25	0.6/100
Parnassia palustris (Par pal)	–	–	–	–	–	–	–	–	+/9
Peucedanum palustre (Peu pal)	–	–	–	–	–	–	–	–	+/9
Phegopteris connectilis (Phe con)	0.6/21	3/14	+/25	11/100	11/100	9/90	7/90	2/75	2/64
Platanthera bifolia (Pla bif)	+/5	+/14	–	+/6	–	–	–	–	+/9
Potentilla erecta (Pot ere)	–	+/14	–	+/6	+/14	–	–	–	+/27
Potentilla palustris (Pot pal)	–	–	–	–	–	–	–	+/13	–
Prunella vulgaris (Pru vul)	–	+/29	–	–	+/21	+/20	–	+/25	+/9
Pteridium aquilinum (Pte aqu)	+/5	+/14	–	+/6	2/21	+/20	–	+/25	+/9
Pyrola minor (Pyr min)	+/21	+/29	–	+/11	+/21	+/30	–	+/13	+/27
Pyrola rotundifolia (Pyr rot)	–	–	–	+/6	–	+/10	–	+/13	+/27
Ranunculus acris (Ran acr)	–	–	–	–	–	–	+/10	–	–
Ranunculus auricomus (Ran aur)	–	+/14	–	–	+/7	–	+/10	+/13	+/36
Ranunculus repens (Ran rep)	+/5	+/29	28/50	+/6	+/21	+/20	+/70	0.6/88	+/55
Rubus arcticus (Rub arc)	+/5	–	–	–	–	–	–	+/13	+/18

continued

Appendix 1. Continued.

Site type group Number of plots	OMa 19	OR 7	PuV 4	AAs 18	Ath 14	Dip 10	Mat 10	OFi 8	GFi 11
Rubus saxatilis (Rub sax)	3/84	8/100	1/75	0.7/78	2/71	0.5/40	+/50	1/63	3/82
Rumex acetosa (Rum ace)	–	–	–	–	–	–	–	–	+/9
Scrophularia nodosa (Scr nod)	–	–	–	–	–	+/10	–	–	–
Scutellaria galericulata (Scu gal)	–	+/14	–	–	+/7	–	–	–	+/9
Silene dioica (Sil dio)	–	–	–	–	–	–	–	+/13	+/9
Solidago virgaurea (Sol vir)	2/84	+/43	0.6/25	0.6/50	+/29	+/30	+/20	+/13	+/36
Stachys sylvatica (Sta syl)	–	+/29	2/50	–	+/7	+/20	1/40	+/13	–
Stellaria media (Stel med)	+/5	–	–	–	+/7	–	–	–	–
Trientalis europaea (Tri eur)	1/100	1/100	0.9/100	1/100	0.7/93	+/90	0.6/90	+/63	0.6/100
Tussilago farfara (Tus far)	–	+/29	+/25	+/6	–	+/20	–	+/13	+/9
Urtica dioica (Urt dio)	+/5	–	–	+/6	+/7	+/10	+/10	2/50	+/18
Valeriana sambucifolia (Val sam)	–	–	–	–	–	–	–	–	+/9
Veronica chamaedrys (Ver cha)	+/11	+/14	–	–	–	–	–	–	+/36
Veronica officinalis (Ver off)	+/11	+/57	+/25	+/11	+/7	+/10	–	+/13	+/18
Vicia sepium (Vic sep)	–	–	+/25	–	–	–	+/10	+/25	+/9
Viola canina (Vio can)	–	–	–	–	–	–	–	–	+/9
Viola epipsila (Vio epi)	+/16	–	–	+/17	3/64	+/20	2/60	4/75	3/82
Viola mirabilis (Vio mir)	0.7/21	+/57	2/50	+/11	+/36	+/20	–	0.8/38	+/9
Viola palustris (Vio pal)	–	–	–	+/17	+/21	–	+/10	+/13	1/46
Viola riviniana (Vio riv)	+/58	+/71	–	+/11	+/29	+/30	+/20	–	+/36
Viola rupestris (Vio rup)	–	–	–	–	+/7	–	–	+/9	–
Viola selkirkii (Vio sel)	+/58	0.9/86	1/50	+/33	0.8/71	+/80	0.6/40	3/88	+/36
Cladina rangiferina (Cla ran)^{G}	+/5	–	–	–	–	–	–	–	–
Cladonia coccifera (Cla coc)^{GW}	+/5	–	–	–	–	–	–	–	–
Cladonia cornuta (Cla cor)^{W}	+/5	+/14	–	–	+/7	–	–	–	+/9
Cladonia sp. (Cla sp.)^{W}	+/5	+/14	–	–	–	–	–	–	–
Hypogymnia physodes (Hyp psy)^{W}	+/11	–	–	–	–	–	–	–	+/9
Nephroma arcticum (Nep arc)^{G}	+/11	–	–	–	–	–	–	–	–
Peltigera aphthosa (Pel aph)^{G}	–	–	–	–	–	–	+/10	–	–
Stereocaulon sp. (Ste sp.)^{S}	–	–	–	–	+/7	–	–	–	–
Atrichum undulatum (Atr und)^{G}	+/11	0.6/29	–	+/6	+/7	+/10	–	–	–
Aulacomnium palustre (Aul pal)^{G}	–	–	–	+/6	+/7	–	–	–	+/9
Brachythecium oedipodium (Bra oed)^{GW}	5/79	2/57	0.6/25	8/89	2/79	7/80	4/100	2/63	0.9/91
Brachythecium populeum (Bra pop)^{WS}	+/16	+/29	–	–	+/7	–	–	–	–
Brachythecium reflexum (Bra ref)^{SGW}	4/90	12/100	4/100	4/94	4/100	6/80	4/90	2/75	+/82
Brachythecium rivulare (Bra riv)^{G}	–	–	–	–	–	–	+/10	–	0.5/18
Brachythecium rutabulum (Bra rut)^{GS}	0.5/42	1/29	+/50	+/28	2/43	0.7/20	+/10	1/13	1/36
Brachythecium salebrosum (Bra sal)^{GS}	0.7/58	2/43	+/25	0.5/67	2/64	+/50	0.8/80	+/38	+/36
Brachythecium starkei (Bra sta)^{G,S}	–	–	–	–	–	–	+/20	–	–
Breidleria pratensis (Hyp pra)^{G}	–	–	–	+/6	–	–	–	0.5/13	–
Bryum pseudotriquetrum (Bry pse)^{G}	+/5	–	–	–	–	+/20	+/10	+/13	+/18
Bryum weigelii (Bry wei)^{G}	–	–	–	–	–	–	–	+/13	+/9
Calliergon cordifolium (Cal cor)^{G}	–	–	–	+/6	–	–	+/10	+/25	+/9
Calliergonella lindbergii (Cal lind)^{G}	–	–	–	–	–	–	–	–	+/9
Campylophyllum sommerfeltii (Cam som)^{WS}	–	–	–	–	+/7	–	–	–	–
Campylium stellatum (Cam ste)^{G}	–	–	–	–	+/7	–		–	+/18
Cirrifyllum piliferum (Cir pil)^{G}	+/11	1/29	4/25	0.5/44	+/21	5/50	+/10	+/13	+/27
Climacium dendroides (Cli den)^{G}	+/11	+/14	–	+/6	0.7/50	+/40	+/40		1/73
Dicranum fuscescens (Dic fus)^{GS}	+/11	–	+/50	+/17	+/36	–	+/10	+/13	+/9
Dicranum majus (Dic maj)^{G}	+/16	–	–	+/17	–	+/20	–	–	–
Dicranum polysetum (Dic pol)^{WG}	+/11	+/29	–	+/11	+/7	+/10	+/10	–	–
Dicranum scoparium (Dic sco)^{SGW}	2/84	0.8/71	+/75	+/67	1/50	+/40	0.5/60	+/25	+/36
Fissidens adianthoides (Fis adi)^{GR}	–	–	–	–	–	+/10	+/20	+/13	–
Fontinalis antipyretica (Fon ant)^{S}	–	–	–	–	–	+/10	–	–	–
Hylocomiasrum pyrenaicum (Hyl pyr)^{GS}	+/5	–	4/25	0.7/22	+/14	–	+/20	–	–
Hylocomiastrum umbratum (Hyl umb)^{G}	+/16	0.9/14	–	0.5/11	–	–	–	–	–
Hylocomium splendens (Hyl spl)^{GS}	3/74	3/71	+/50	+/39	0.5/50	+/60	+/30	+/13	0.8/36
Mnium spp. (Mni spp.)^{WG}	–	–	–	–	–	–	+/10	–	+/9
Mnium stellare (Mni ste)^{G}	+/16	+/14	–	+/11	–	–	–	–	+/18
Paraleucobryum longifolium (Par lon)^{SW}	–	–	–	+/17	–	–	–	–	–

continued

Appendix 1. Continued.

Site type group Number of plots	OMa 19	OR 7	PuV 4	AAs 18	Ath 14	Dip 10	Mat 10	OFi 8	GFi 11
Plagiomnium cuspidatum (Plm cus)[SGW]	2/84	3/100	3/75	1/56	3/64	0.8/80	0.9/60	1/75	0.5/55
Plagiomnium elatum (Plm ela)[G]	–	–	–	+/6	–	–	–	–	0.6/9
Plagiomnium ellipticum (Plm ell)[G]	+/42	+/29	+/25	+/44	0.7/43	+/70	1/60	4/75	2/73
Plagiomnium medium (Plm med)[G]	+/21	+/43	+/25	2/61	1/50	0.9/70	0.5/60	+/50	5/46
Plagiothecium curvifolium (Pla cur)[GW]	+/21	+/14	–	+/6	+/22	–	+/20	+/13	+/9
Plagiothecium denticulatum (Pla den)[SWG]	+/5	+/14	–	+/50	+/14	0.6/50	+/10	+/13	+/9
Plagiothecium laetum (Pla lae)[SWG]	+/63	+/71	+/50	+/50	0.6/71	+/50	+/60	+/38	+/46
Plagiothecium ruthei (Pla rut)[GW]	–	–	–	+/6	+/7	–	–	–	–
Plagiothecium succulentum (Pla sug)[G]	–	–	–	–	+/7	–	–	–	–
Pleurozium schreberi (Ple sch)[GWS]	2/68	4/100	+/25	0.8/44	0.8/64	+/30	+/30	1/38	1/64
Pohlia nutans (Poh nut)[GSW]	–	–	–	+/6	+/7	–	+/10	+/13	–
Polytrichastrum longisetum (Pol lon)[G]	+/5	–	–	+/17	–	–	+/10	–	–
Polytrichum commune (Pol com)[G]	–	–	–	+/6	–	–	+/20	–	–
Polytrichum juniperinum (Pol jun)[S]	+/16	–	–	–	–	+/10	–	–	–
Polytrichum strictum (Pol str)[G]	–	–	–	+/6	–	–	–	–	–
Pseudobryum cinclidioides (Pse cin)[G]	–	–	–	+/17	–	+/10	2/30	3/38	2/36
Ptilium crista-castrensis (Pti cri)[G]	+/16	+/14	–	+/6	–	+/10	+/10	–	–
Rhizomnium magnifolium (Rhi mag)[G]	–	–	–	+/6	+/7	–	+/10	–	–
Rhizomnium pseudopunctatum (Rhi pse)[G]	–	–	+/25	+/11	–	+/10	3/30	3/13	–
Rhizomnium punctatum (Rhi pun)[G]	+/11	2/57	–	+/44	0.7/50	5/90	+/40	0.9/13	0.7/46
Rhodobryum roseum (Rho ros)[GS]	0.8/42	+/14	–	+/33	+/29	+/60	+/40	+/13	+/64
Rhytidiadelphus squarrosus (Rhy squ)[G]	–	–	–	+/6	–	–	–	+/13	1/27
Rhytidiadelphus subpinnatus (Rhy sub)[G]	+/5	+/29	–	+/17	+/21	2/20	+/10	+/25	0.5/27
Rhytidiadelphus triquetrus (Rhy tri)[G]	1/42	2/86	+/50	0.8/44	1/36	+/30	–	0.8/13	0.5/18
Sanionia uncinata (San unc)[S]	+/32	+/43	–	+/6	+/14	+/30	+/10	–	+/36
Sphagnum angustifolium (Sph ang)[G]	–	–	–	+/6	–	+/10	–	+/13	+/27
Sphagnum centrale (Sph cen)[G]	–	–	–	+/6	–	–	–	–	–
Sphagnum fimbriatum (Sph fim)[G]	–	–	–	+/6	–	–	–	–	–
Sphagnum girgensohnii (Sph gir)[G]	–	–	–	+/17	–	–	1/10	–	–
Sphagnum riparium (Sph rip)[G]	–	–	–	–	–	–	–	+/13	–
Sphagnum russowii (Sph rus)[G]	+/5	–	–	–	–	–	3/10	0.5/13	2/18
Sphagnum squarrosum (Sph squ)[G]	–	–	–	+/11	+/7	–	2/20	–	+/9
Sphagnum teres (Sph ter)[G]	–	–	–	+/6	–	–	–	–	–
Tetraphis pellucida (Tet pel)[G]	–	–	–	–	–	–	–	+/13	+/9
Thuidium recognitum (Thu rec)[G]	–	–	–	–	–	–	–	–	+/9
Warnstorfia fluitans (War flu)[G]	–	–	–	–	–	–	–	–	+/9
Barbilophozia barbata (Bar bar)[SG]	+/11	–	–	+/6	+/7	–	–	–	+/18
Barbilophozia floerkei (Bar flo)[R]	+/5	–	–	–	–	–	–	+/13	–
Barbilophozia hatcheri (Bar hat)[G]	–	–	–	+/6	–	–	–	–	–
Barbilophozia kunzeana (Bar kun)[W]	+/5	+/14	–	+/11	–	–	+/10	–	–
Barbilophozia lycopodioides (Bar lyc)[GS]	+/21	+/29	–	+/11	–	–	+/10	+/13	–
Blepharostoma trichophyllum (Bel tri)[WS]	+/16	+/29	–	+/6	+/7	+/10	–	–	+/9
Calypogeia fissa (Cal fis)[G]	–	–	–	+/6	–	–	–	–	–
Calypogeia müelleriana (Cal müe)[G]	+/11	–	–	+/11	–	–	–	+/13	–
Calypogeia neesiana (Cal nee)[G]	+/5	+/14	–	–	+/14	–	–	–	–
Cephalozia bicuspidata (Cep bic)[G]	–	+/14	–	+/17	+/7	–	–	–	+/9
Cephalozia lunulifolia (Cep lun)[G]	–	–	–	+/11	–	–	–	–	–
Chiloscyphus polyanthos (Chi pol)[G]	+/5	–	+/25	–	+/7	–	+/10	–	–
Cladopodiella fluitans (Cla flu)[G]	–	–	–	–	–	–	+/10	–	–
Harpanthus flotovianus (Har flo)[S]	–	–	–	+/6	–	–	–	–	–
Jungermannia leiantha (Jun lei)[GW]	+/5	–	–	–	–	+/10	–	–	–
Lophocolea heterophylla (Chi pro)[WG]	+/32	+/29	+/25	+/50	+/29	+/40	–	+/38	+/9
Lophozia longiflora (Lop lon)[G]	+/5	–	–	–	–	+/10	–	–	–
Lophozia ventricosa (Lop ven)[S]	+/26	+/14	–	+/22	+/14	+/20	–	+/13	+/9
Metzgeria furcata (Met fur)[S]	+/5	–	–	–	+/7	–	–	–	–
Pellia neesiana (Pel nee)[G]	–	–	–	+/6	+/14	+/10	+/30	+/13	+/9
Plagiochila asplenioides (Pla asp)[G]	+/16	–	–	+/17	–	1/30	+/20	+/25	0.7/36
Plagiochila porelloides (Pla por)[WG]	–	–	–	–	+/14	–	+/10	–	–
Ptilidium ciliare (Pti cil)[G]	+/5	–	–	–	–	–	+/10	–	–
Riccardia latifrons (Ric lat)[G]	–	–	–	–	–	–	–	–	+/9
Scapania undulata (Sca und)[S]	–	–	–	–	–	+/10	–	–	–
Tritomaria quinquedentata (Tri qui)[G]	–	+/14	–	–	+/7	+/10	–	+/13	–

Appendix 2. Two-way ordered tables. Sample plots (n = 101) and species from TWINSPAN classification based on (1) bryophytes (m = 100), (2) bryophytes and vascular plants (m = 265) and (3) vascular plants (m = 165). For clusters B1–B7 *see* Fig. 1, for clusters T1–T9 *see* Fig. 2 and for clusters V1–V9 *see* Fig. 3. Abbreviations are in Appendix 1.

(1)	B1	B2	B3	B4	B5	B6	B7
					1	1	
	38954556633	44	1266 11112222232567 123444457788812	1347 33645	67 1123755568889088899997799	9903	466757
	57418350423	3649	974675016801368994808476014595858992	5461109226	52472357402712346001613786702	25911	739389
Thu rec	----------4	----	------------------------------------	----------	-----------------------------	-----	------
Jun lei	------4----	----	----1-------------------------------	----------	-----------------------------	-----	------
Lop lon	------1--1-	----	------------------------------------	----------	-----------------------------	-----	------
Nep arc	---------1-	----	---------------2--------------------	----------	-----------------------------	-----	------
Hyl pyr	---7-------	----	455---1-1-----3-------12-----------3	----------	-----------------------------	-----	------
Bra pop	-----------	--3-	----1------31-----------3-----------	------1---	-----------------------------	-----	------
Pla sug	-----------	----	------------1-----------------------	----------	-----------------------------	-----	------
Pol str	-----------	----	----------------------------------1-	----------	-----------------------------	-----	------
Rhi mag	-----------	-4-5	-2----------------------------------	----------	-----------------------------	-----	------
Bar kun	-----------	-3--	--1-------------2----------------1-1	----------	-----------------------------	-----	------
Sph fim	-----------	----	-------------------1----------------	----------	-----------------------------	-----	------
Cla ran	-----------	----	--------------------1---------------	----------	-----------------------------	-----	------
Cam som	-----------	----	------------------------------------	1---------	-----------------------------	-----	------
Hyl umb	-----------	----	--------1-------------------------55	-----45--1	-----------------------------	-----	------
Hyp pra	-----------	----	-1--------------------------------2-	--4-------	-----------------------------	-----	------
Poh nut	-----------	----	---------1-------------------11-----	--4-------	-----------------------------	-----	------
Bar lyc	-----------	----	---2-----2-----2------------1-1-----	---3-431-1	-----------------------------	-----	--1---
Met fur	-----------	----	--------------------------------2---	-2--------	-----------------------------	-----	------
Ste sp.	-----------	----	------------------------------------	1---------	-----------------------------	-----	------
Cla cor	-----------	----	------------------------------------	11----1---	-----------------------------	----1	------
Atr und	-----------	---2	--------1--1------------2--------4-1	----------	----------2------------------	-----	------
Cam ste	-----------	-1--	-----1---1--------------------------	----2-----	-----------------------------	----1	------
Dic fus	-1---------	---1	--11------------1----2-----1--1-2---	123-------	------1----------------------	----1	----1-
Dic sco	---1112--11	551-	111-221-21-1-251111112-5----11-1--13	3512374143	-1--1---11-1111---1------1---	11---	--3111
Hyl spl	441--111275	-3--	-1--2----2-3-12544111111------2--1-2	37754474-4	1-----1-1---11------1----2-11	2111-	--1-21
Ple sch	22--51--345	-1--	11-46---1-----2-211111-455--113-1234	5543443565	------1-1---1-------1--111--1	-1--1	1-4144
Pti cri	-------1-1-	----	---1--------------1-----------------	-----4-1--	-----------------------------	-----	----2-
Plm cus	4--5153-113	123-	441-213-21411331361-6-465145146154-4	55436-51--	--34-111343-2--2-1--1----1111	11-1-	--1--3
Bra riv	----------5	-1--	------------------------------------	----------	--1--------------------------	-----	------
Mni ste	---------3-	----	-2--1----------3--------------1-----	-------1--	-----------------------------	----1	-----1
Rhy tri	3633-323155	----	-6515--------1--532---14-----12-131-	---141551-	------------1-2----------1---	---5-	------
Bar bar	1------1--1	---3	-----------1--------1---------------	----------	---------------------------1-	-----	------
Cir pil	---756667-2	----	----------3-1--11-----11------11---1	1------2--	-----------133------1--------	-----	211--1
Rhy sub	------3-7-5	----	-------------------3--11----1-----5-	2-----1---	--1---1----------------1-1---	--1--	-21---
Pla asp	3-----43635	-2--	--2---------------2-----------1-----	-----4----	--------------1--------1-----	---1-	--1-12
Fis adi	-------2---	----	------------------------------------	--5-------	---1-------------------------	-----	---1--
Chi pol	---1-------	----	------------------------------------	---1----1-	-----------------------------	-----	1-----
Sph ang	-------1--2	----	----------4-------------------------	----------	-----------------------------	2----	--1--1
Hyp phy	---------1-	----	------------------------------------	-----1----	-----------------------------	1----	------
Pol com	-----------	-4--	------------------------------------	----------	-1---------------------------	-----	----1-
San unc	--------1--	----	----1---21111--1----1--1------1-----	-12---21--	--------2-------1--------11--	1----	3----1
Pol lon	-----------	----	---2--------------1-----------1-----	----------	-1---------------------------	-----	---1--
Rho ros	4------13-1	-4--	-11--2--4-3-3-145-3---1---------1---	-3-2----1-	---1-----2-311-111--1111----1	----2	-1--11
Ble tri	-----1-----	----	----1------------11----------1------	-------1--	1------------1---------------	-----	-----1
Bra ref	21-2-831441	5-67	454414765554346565544655754364425655	1543422244	5213335157-51-761-111-1111111	111-1	-1121-
Bra rut	55-3--5--1-	2-3-	--1---------11221-----16--6------6-4	-----2---5	--3-3-54------11---------1-1-	1---2	------
Bra sal	-----6-1-54	34-5	3333311131312222-111----11--111-6-13	1--114-1--	-114-23131-121----111---1----	1---3	1-11-1
Lop ven	-----1-11--	----	---41-----1---1-111-------1-1-1-----	----------	2-----1----------------------	1----	------
Pla lae	11---------	-1--	25-121121221-11111---11121--111111--	31--5111-3	--1-1-1-1111--1--1111----11-1	1-1--	--12-1
Pla rut	-----------	----	-----------------------4------------	----------	---------------------------1-	-----	------
Pol jun	-----------	----	----------------------------1-------	---------4	--------1-------------------1	-----	------
Cal nee	-----------	---2	------------------------------------	-------1--	-----------------------------	-1---	------
Pla por	-----------	-4--	--------------------------------3---	----------	----2------------------------	-----	------
Dic pol	-----------	----	---3------------------------1-------	----1--1--	1--------------1---------1--1	-----	----1-
Pla cur	-----------	3-22	--4---1-1-----------1---------------	2---------	---3134------------------1--1	1----	------
Pla den	----1--11--	----	-1----------1-----21----1-1--2----44	----------	23------5--111-2-------------	1----	----1-
Bra oed	4-1-76--43-	31--	274653646667444464642-36-----4----45	53661233--	4434445546764187251111111131-	31122	342111
Bar flo	-----------	----	----1-------------------------------	----------	-----------------------------	-----	--1---
Pti cil	-----------	----	----------------------------1-------	----------	-----------------------------	-----	----1-
Sph squ	-----------	-1-1	----------5--------1----------------	----------	-----------------------------	1----	----6-
Plm ell	32----1-111	-1-1	21111--13---21-11113---2116---------	--515--1--	1-4-4---12-111----1111-11-1--	--1-5	536511
Cal mue	-----------	--1-	------------------------------------	-2--------	-1---------1-----------------	-----	--1---
Cli den	451---1---1	---1	-----1-2--1------------3---------1--	1---4-----	--5--2133-1--1---1-----------	21121	4--112
Lop het	-----1-----	----	----11---1-------21--1------111---22	---1---1--	14--212-11111-1---111-------1	--1--	111111
Pse cin	----------4	-7--	--1---------1-----------------------	----4-----	-2-1533------1----1----------	6-753	----16
Bry pse	------1----	----	----1-------------------------------	----------	-------------1---------------	-----	111--1
Rhi pun	----566-2-1	----	---11-11----------2----1-2---11-321-	5-5----1--	-11-2-3-155-1711----1----111-	-1--1	5--344
Bry wei	-----------	----	------------------------------------	----------	-----1-----------------------	-----	1-----
Mni spp.	-----------	----	------------------------------------	----------	---1-------------------------	1----	------
Pel nee	-----------	----	------------------------------------	----------	-1--4---1--------------------	-111-	13-11-
Bra sta	-----------	----	1-----------------------------------	----------	---3-------------------------	-----	------
Fon ant	-----------	----	------------------------------------	----------	--------1--------------------	-----	------
Plm ela	-----------	----	--1---------------------------------	----------	-----------------------------	5----	------
Cal fis	-----------	--------	------------------------------------	-------1--	-------------------------	-----	------

continued

```
(1)      B1          B2   B3                                    B4         B5                            B6     B7
                                                                                          1               1
         38954556633   44  1266 11112222232567 123444457788812 1347 33645 67  1123755568889088899997799  9903 466757
         57418350423 3649 974675016801368994808476014595858992 5461109226 52472357402712346001613786702 25911 739389
Cep lun  ----------- ---- ------------------------------------ ---------- 11--------------------------- ----- ------
Har flot ----------- ---- ------------------------------------ ---------- -1--------------------------- ----- ------
Sca und  ----------- ---- ------------------------------------ ---------- --------1-------------------- ----- ------
Tri qui  ----------- ---- ------------------------------------ ---------- ---------------1------1--1--- ----- --1---
Sph cen  ----------- ---- ------------------------------------ ---------- -4--------------------------- ----- ------
Sph rip  ----------- ---- ------------------------------------ ---------- ----------------------------- ---1- ------
Sph ter  ----------- ---- ------------------------------------ ---------- -5--------------------------- ----- ------
Cla coc  ----------- ---- ------------------------------------ ---------- ----------------------------1 ----- ------
Par lon  ----------- ---- ------------------------------1----- ---------- 11--------------------------- ----- ------
Cal cor  ----------- ---- -------------------1---------------- ---------- ----------------------------- --4-- --1-1-
Tet pel  ----------- ---- ------------------------------------ ---------- ----------------------------- ----1 --1--1
Aul pal  ----------- ---- ------------------------------------ ---------- -1--------------------1------ ----- 5-----
Sph gir  ----------- ---- -------------------1---------------- ---------- 13--------------------------- ----- ----6-
Cal lin  ----------- ---- ------------------------------------ ---------- ----------------------------- ----- 1-----
Rhi pse  ---3------- ---- ------------------------------------ ---------- 11-----11-------------------- ----- -77-5-
War flu  ----------- ---- ------------------------------------ ---------- ----------------------------- ----- -----1
Cla flu  ----------- ---- ------------------------------------ ---------- ----------------------------- ----- ----1-
Ric lat  ----------- ---- ------------------------------------ ---------- ----------------------------- ----- -----1
Sph rus  ----------- ---- ------------------------------------ ---------- ----------------------------1 ----- 7-5-71
Pel aph  ----------- ---- ------------------------------------ ---------- ----------------------------- ----- ----1-
```

```
(2)      T1     T2       T3              T4               T5        T6   T7                 T8          T9
                                                                                                         1        1
         343389 35923367 3 225567758 144 1246111222556882 678889961 5677 4  367745778883556 1122 36 114 90  9 99990444
         326974 06292871 481649268393403 9286678047078388 170150505 8502 616193912452465154 23357739019 91251463780457
Cam som  ------ -------- --------------- ---------------- --------1 ---- ------------------ ----------- --------------
Pol str  ------ -------- --------------- 1--------------- --------- ---- ------------------ ----------- --------------
Bar hatc ------ -------- --------------- ---3------------ --------- ---- ------------------ ----------- --------------
Agr stol ------ -------- --------------- ---------------- --------- --11 ------------------ ----------- --------------
Par lon  ------ -------- --------1------ ---------------- --------- -1-1 ------------------ ----------- --------------
Cal fis  ------ -------- --------------- ---------------- --------- ---1 ------------------ ----------- --------------
Cep lun  ------ -------- --------------- ---------------- --------- -1-1 ------------------ ----------- --------------
Cla flu  ------ -------- --------------- ---------------- --------- 1--- ------------------ ----------- --------------
Har flot ------ -------- --------------- ---------------- --------- ---1 ------------------ ----------- --------------
Sph cen  ------ -------- --------------- ---------------- --------- ---4 ------------------ ----------- --------------
Sph fim  ------ -------- --------------- ---------------- --------- --1- ------------------ ----------- --------------
Sph gir  ------ -------- --------------- ---------------- --------- 6113 ------------------ ----------- --------------
Sph ter  ------ -------- --------------- ---------------- --------- ---5 ------------------ ----------- --------------
Pel aph  ------ -------- --------------- ---------------- --------- 1--- ------------------ ----------- --------------
Dic maj  ------ --1---11 --------------- ---2------------ -----1-1- -2-- -----------1------ ----------- --------------
Hyl umb  ---5-- 41------ --------------- 55--1----------- --------- ---- ------------------ ----------- --------------
Bot lun  ------ -------- ------1-------- ---------------- --------- ---- ------------------ ----------- --------------
Cyp cal  ------ ------1- -------4------- ---------------- --------- ---- ------------------ ----------- --------------
Epi aph  ------ -------- -------1------- ---------------- --------- ---- ------------------ ----------- --------------
Hie pil  ------ -------- -------1------- ---------------- --------- ---- ------------------ ----------- --------------
Lyc cla  ------ -------- ---1----------- ---------------- --------- ---- ------------------ ----------- --------------
Men arv  ------ -------- --------1------ ---------------- --------- ---- ------------------ ----------- --------------
Poa sp.  ------ ------1- --------------- ---------------- --------- ---- ------------------ ----------- --------------
Bra pop  ---1-- ------1- --3----------33 ---------------- --------- ---- ------------------ --1-------- --------------
Pol jun  ------ -41----- -----1--------- ---------------- --------- ---- ---------1-------- ----------- --------------
Cla coc  ------ --1----- --------------- ---------------- --------- ---- ------------------ ----------- --------------
Cla ran  ------ -------- -1------------- ---------------- --------- ---- ------------------ ----------- --------------
Nep arc  ------ ---21--- --------------- ---------------- --------- ---- ------------------ ----------- --------------
Des fle  21-411 6-4-4443 ----------1-1-- 3--2---1-------1 --------- ---1 --1-1------------- ----------- 1-1-----------
Fes ovi  ---1-- -------- --------------- ---------------- --------- ---- ------------------ ----------- --------------
Hie syl  12---- ------3- --1---2-------- ------------1--- --------- ---- ------------------ ----------- -------------1
Pla rut  --4--- -------- --------------- ---------------- -----1--- ---- ------------------ ----------- --------------
Thu rec  4----- -------- --------------- ---------------- --------- ---- ------------------ ----------- --------------
Bar lyc  ---3-- 41-2---3 -----11-1------ ---2--2--------- --------- ---- ----1------------- ----------- --------------
Cla sp.  ---3-- -------- 1-------------- ---------------- --------- ---- ------------------ ----------- --------------
Mel pra  -----3 3-1-1--- -------1------- 4--------------- --------- --11 ------------------ ----------- 1-------------
Sol vir  --1--1 32154143 1-6413333-1---- ---161141---2-1- 1------33 -125 ---111----1---1-11 ----------- ---1-2----1---
Pti cri  ------ 4---1--- ------1-------- ---1--------1--- -------1- 2--- ------------------ ----------- --------------
Met fur  ------ -------- 2-------------- --------------2- --------- ---- ------------------ ----------- --------------
Pti cil  ------ -------- -----1--------- ---------------- --------- 1--- ------------------ ----------- --------------
Dry exp  ------ 87-3-816 --21473-75---1- 888987376777781- 6881885-- 5776 --7-8-6-7-354--1-- ----------2 --------------
Pol lon  ------ -------- --------1------ ---2--------1--- --------- ---1 -----1------------ ----------- --------------
Sph squ  ------ -------- --------------- -------5-------- --------- 6-1- --1--------------- ----------1 --1-----------
Mil eff  ------ ---5--11 --6-13--2--11-- 4--3-441-4-313-1 41------- -1-- --1-----1------1-- -1-2----511 --------5-----
Pop tre  ------ --1----- ----1-1----1--- ---1--------1--- --------1 -1-3 ------------------ ----------- ------------3-
Lop ven  ------ -----11- ----11--11----- ---4---1----1--1 -------1- -2-- -----------------1 ---1------- --1--------1--
Act spi  ------ --4---66 -433276464----- ----775---15645- 5114--43- ---- 1-------411-12-11- --3-3------ --------------
Hie vul  ------ -------- ----1--1------- -------3-------- --------- ---- ----1------------- ----------- --------------
Dic pol  ------ --1----- -----111------- ---3------------ --------- 11-- -1----------1----- ----------- --------------
Jun com  -----5 --1----- ----1---------- ---------------- --3------ ---- ------------------ ----------- -------------2
Mel syl  -4--22 1--11111 1----11--11---- ----4--1-------- 1-----1-- 1--- 1---1-----1------- -------1--- ---2-1---11--1
Vio riv  11--21 --111--1 112----1-21--1- ----2-2---1-112- ---1-1-1- ---- -2------------2-1- -----1----- --1------14---
Bra riv  5----- -------- --------------- ---------------- --------- ---- --1--------------- ----------- -----1--------
Rhy tri  514563 1---5551 ---13-51233---- 1--1-6--51--221- 1------3- ---- -4--------1---3321 ----------- -5------------
Cal aru  351-5- 71-63656 15--4551158263- -3436-111-121-41 1-1111-13 21-3 -1--5---1-----1152 -1-1------1 -----1-1-----3
Fra ves  421443 ----1-1- 4--11-3-162--2- ---------------- ------111 ---- -3-----11---1-5--- -------1--- --12-1----1---
```

continued

(2)	T1	T2	T3	T4	T5	T6	T7	T8	T9
									1 1
	343389	35923367	3 225567758 144	1246111222556882	678889961	5677	4 367745778883556	1122 36 114	90 9 99990444
	326974	06292871	481649268393403	9286678047078388	170150505	8502	616193912452465154	23357739019	91251463780457
Lin bor	------	2-2-1-3-	4-------1------	----------------	-------1-	2---	--1-2---------1---	-----------	--------------
Mon uni	------	------1-	------1--------	----------------	-------1-	----	1-----------------	-----------	--------------
Pla bif	------	---1----	-------1-------	----------------	---------	---1	--------------1---	-----------	--------------
Vac myr	36--47	73716542	1-61311312121--	-31411311--11-31	1-1-11111	3113	-11-1-3----11-1-11	-----------	-11--1-1--1--4
Vac vit	12-3-5	--311-11	5-21--11-------	--1----1--------	------311	11--	-11-1----1----2---	--1--------	--2----------1
Dic sco	1454--	73-11122	51121111-1-52-1	131-211-1-1111-5	1-1-1-1-3	1-11	135-311--111---12-	1------11--	--12----------
Hyl spl	5-1741	44157425	71314-42211-1--	-2---12--1--1--2	1----1113	211-	743-1-1--1-1-14-12	---1-------	112-----------
Mni ste	------	---33-1-	------1-1------	-----2----------	---------	----	---1--1-----------	-----------	--------------
Ple sch	56432-	451-4263	51--1151312-15-	345411------1-12	1-----1-5	4-1-	44114145-11--12--3	---1---1---	--------11---1
Cal mue	------	--------	2-------------1	-----------1----	---------	---1	----1-------------	-----------	--------------
Cla cor	---1--	--------	1--------------	----------------	--------1	----	---1--------------	-----------	--------------
Rub sax	56-331	-1773251	34643265237-341	-211-1151--31-22	1-11-1545	4141	35155162-111--1--3	-31--1-----	--1134-33-3-34
Car dig	21-3-3	----1-21	3---112111---1-	-----2------1-1-	1-----111	--1-	63--1----1----4--2	-----------	--------------
Hup sel	------	--------	----------1----	----------------	---------	----	---------------1--	-----------	--------------
Ver off	-1---1	--1-----	------1-121----	----------------	---------	---1	11----------1--3--	-----------	---1--1-------
Bar flo	------	------1-	---------------	----------------	---------	----	----1-------------	-----------	--------------
Lop lon	------	----1---	---------------	----------------	---------	----	----------------1-	-----------	--------------
Atr und	------	--------	--1-------4--2-	-1--1-----------	---------	----	--------2---------	----------2	--------------
Ble tri	------	------1-	----1-1--1-----	------------1---	---------	-1--	------1---11------	-----------	--------------
Pyr min	------	--1-----	--3-3-42-------	-------1--------	------151	---1	- --2----1-1------	-----------	---1-1-1-11--1
Car pal	-2-1-2	--------	-------------1-	----------------	------1--	---4	------------------	-----------	--------1----6
Rha fra	---2-3	--2-----	---------------	----------------	----2-2--	---1	------------------	-----------	--4--1-------2
Scu gal	---1--	--------	---------------	----------------	------1--	----	------------------	-----------	--1-----------
Hyp phy	------	1---1---	---------------	----------------	---------	----	------------------	-----------	--1-----------
Bet pub	---5-1	4-------	---------------	----------------	---------	2---	----1-----1-------	-----------	--1----------2
Con maj	1-----	-1144-44	164524461-566--	---1513-6-------	1-2----4-	-3-5	---1-4---14--31--1	--541------	---6--1-631-41
Dry fil	--1---	-1--2---	--1-1-1-15--741	-1----------3---	1--------	----	11-------------4--	----------1	-----------56-
Epi hel	3-----	--------	---------------	----------------	---------	----	------------------	-----------	-------------2
Mel nut	431144	13121111	45341-2141511--	-11----34--11121	1-11-1112	--11	2112-11-1111-11111	-112-1-1521	1-1312-1-12-15
Dry car	1-514-	556-55--	55-1---13--6667	--3-1---43----53	--11--7--	----	-42----1--3-5-13--	41-421--61-	124653111-631-
Vio mir	-13---	----5-2-	-1-55-415----1-	----------------	1-----13-	----	5---1--4-12-------	--31-------	--------8---4-
San unc	--12--	---1--1-	111---111------	----2-11--------	-1-------	----	2-----1--2-------1	--1--------	--1---1------3
Aln inc	3-15-4	------11	3141--234851453	4-4-112-12311-51	1--311-41	11-4	-4--236152-3-121--	4-13---1534	-17--47---2432
Ger syl	542153	---74-53	3-31415-317--1-	-21-131313-31341	512111-52	1-41	424514141144134134	-433-423-11	--431765454117
Vio sel	-1224-	--11--23	2123113-433--3-	-----------14111	21131--1-	----	22--1-121-11131-11	-1511--234-	7-1-1--21-134-
Bra rut	--6-5-	25-211--	---1---1--62--3	-4------11---1-2	-----1---	----	---2--------1-535-	3-15-4-----	--1--3-----6--
Pla cur	------	--1-----	-1-----1---3--2	----1---4-------	--------2	----	------------------	13-43---1-2	--1-----------
Rho ros	11----	--14-5-2	3--------------	----41-311233-11	1------1-	1---	--42--1----1114--3	--3-1-1----	---21-111-1---
Bar bar	1-----	--------	-11------------	----------------	-----1-1-	----	--------------1---	----------3	--------------
Cal nee	------	--------	------1--------	----------------	------1--	----	------------------	----------2	--------------
Pla asp	5-----	4---3---	--------1------	--------2---21--	-------3-	1---	--2-1-2-------3-46	-----------	-1------1-----
Gal tlo	--5-3-	--------	------1-13-----	------------41-3	1--1--12-	----	-33--1---12--11--1	----4------	--------------
Lon xyl	---4--	------4-	-4-1--133------	----------1-43-3	---------	----	34-------------3--	--1-4------	--------------
Ort sec	----1-	111-1-2-	1-2--13-2------	----------------	1-1--1112	31--	-3-11-----------11	---1------4	-----11-------
Oxa ace	677755	-5167777	656566756845667	4734566753588574	64353457-	6541	676143534153457886	54656647654	645-36-22-657-
Sor auc	42--31	52224341	2662113-1--1---	163-313534-12-42	1---2--11	2123	41--4-62321--11451	-321----42-	-114-2------21
Bra oed	--63-1	2--43656	32744-31-6-3---	45766766436668-4	4311-11-5	1444	6112211-7441714--4	4445454264-	12331321115--3
Bra ref	14521-	24154613	544456214865676	55-4555545755756	111121111	1542	44-112-5-54-612234	33353114767	1-14-11111-43-
Bra sal	4-----	4--25-31	--12111-16-3-1-	13-333133-111-62	2-11---11	--11	-1431111-311-1----	-22341-3115	--11-1---1---1
Dic fus	----1-	-----1--	2-------1---2--	---1----1-----2-	--------1	1---	3--1--------------	---1------1	------------1-
Pla lae	--111-	1311-12-	1-1111111-1-12-	---11522-111-111	-1111---3	----	-51-1211111--11---	1--1---212-	1-11-1----1---
Plm cus	3-65--	--111323	561361116541-53	-41-2414144-1-53	21--111-5	----	462-1-31334-214531	-11141-43--	-111-3----145-
Bar kun	------	-----2--	----------1----	-1------1-------	---------	----	--3---------------	-----------	--------------
Cep bic	------	--------	---------1-----	-----------1----	---------	-1-1	------1---1-------	-----------	--------------
Lop het	------	--1---11	----211-11--1--	22----1---1111--	1-11-----	11-4	----111-111--1----	21-2--1----	1--1---------1
Gym dry	7-7764	46786776	6877677666-6557	4576677567566567	655788677	6514	-154445-22543565-5	145-4433652	541143-4487653
Luz pil	1--212	1-2-1-21	1---1-11-1----1	211111-2----111-	1--1--111	-111	1--11-1---1-1-11-1	----------1	1---1111-2--22
Mai bif	565547	52655555	135523334444444	4434332434464244	443353442	3365	1546413-1121142444	233421-4464	21-52633215464
Tri eur	112434	21332333	323211-33331212	33-331122-111131	314313131	4144	-32-223-11211313-1	111122-121-	2-232223233231
Ath fil	3-6671	-61-4---	--1---1-41--7-4	8421-77978774888	767966868	7788	-971771-5171888867	87987676818	7417-1197--8--
Dac mac	-----1	--------	---------------	----------------	1--------	----	-----------1------	-----------	-------------1
Rub ida	--1547	--12411-	13--145655-1521	-72274343-561732	63-53465-	1111	-43-231463331431-2	-33243--64-	1421543777768-
Rhy sub	5-11--	--------	-----1-1-------	5--------1------	--------2	--3-	----1-----------37	---1--2----	1----1--1-----
Ste med	------	--------	---------------	----------------	------1--	----	------------------	-----------	----------1---
Phe con	4-6-71	--1-----	--5----71------	6466-6456147576-	564548565	3567	-565665-43664761-7	55774-36666	121311-7---1--
Hyl pyr	--2---	--------	---------------	-3--15--51-----3	---------	----	---------------7--	-------41--	--------------
Pla den	------	--------	-------------1-	441--1-----12---	1------1-	1213	---------5212----1	--1--------	--1--------1--
Sph ang	2-----	--------	---------------	-------4--------	-------1-	----	----1-1-----------	-----------	--2-----------
Cal pur	------	--------	---3-----------	-1--1-----------	--3331---	1-12	----133------1----	5-1---1----	11-111-11211-1
Vio pal	4-----	--------	---------------	-------2--------	---------	--26	---51-------------	3-1--1----1	--54--1-------
Sph rus	------	--1-----	---------------	----------------	---------	7---	----5-1-----------	-----------	-------------7
Par qua	3-1-11	-1--2-13	-111-11111---11	----111111113113	11111-111	----	-21111222213-111-1	--231112-12	-1111131111--3
Pic abi	----5-	3-----1-	2-321-11-1-----	2-21---1--1-2---	------13-	33-3	--332214----1-3223	-----------	-11--1--132126
Plm med	------	------21	----1-1121-----	-7-1-3---2311622	5114-1---	1--1	----111-41244152--	61-33214---	4---12812-3---
Car sp.	------	--------	---------------	----------------	---------	---1	------------------	-----------	---1----------
Cir hel	3-----	--------	---------------	--1-------------	------11-	----	----1-------------	-----------	----1---4--1--
Des ces	3-3512	--------	---------11--1-	-------1------21	--1------	--23	-2-11-131-----2-1-	1----1-1-11	1134111-141--3
Dap mez	23----	---1--3-	-2-1---1-1-----	------------1---	2--2--111	----	------2-33211-121-	--1-1------	--2-2--1---11-
Rib spi	------	--------	-------------7-	----------------	----5-1--	----	-------34------2--	-------1-2-	------------4-
Gal uli	1-----	--------	---------------	----------------	---------	----	--------------1---	-----------	--------------
Lyc ann	-11--1	------11	---------------	-----------11-1-	1-----111	11--	--111-1-------1-12	---5-------	--------------

continued

(2)	T1	T2	T3	T4	T5	T6	T7	T8	T9
									1 1
	343389	35923367	3 225567758 144	1246111222556882	678889961	5677	4 367745778883556	1122 36 114	90 9 99990444
	326974	06292871	481649268393403	9286678047078388	170150505	8502	616193912452465154	23357739019	91251463780457
Cir pil	2-1---	---1-1--	------2-16-----	-15----3-1-1----	3---1--61	----	----1-1----3-1-767	--1---1----	-------------2
Pru pad	2-2--1	--1-----	---4--3-174--5-	-41-----23124-5-	2--43-1--	--1-	245414352443-33451	333-41-32--	--1116-11-1---
Hyp pra	------	--------	---------------	2----1----------	---------	----	4-----------------	-----------	--------------
Rhi pun	1-1---	------1-	------11162----	1-51------5-213-	11---11-5	4--1	5--1-342511711--62	2--3----11-	-----1-------5
Ros aci	4-1-1-	--------	1---1----1-----	------------1---	--4-1--1-	----	---322---1---1132-	--4--------	-------5------
Vib opu	------	--1-----	---------6-----	------1---------	---------	----	----145--1--------	-----------	--------------
Cre pal	3-1--1	--------	--4-----1------	--1-1-11--25-453	753711545	6-14	-45546644117-55347	4466-573114	-43421-41--1-7
Equ pra	--4---	------1-	----1--11------	-----1----1-1--4	1---1----	----	--4-533333-44-44-2	214-131----	--143----2----
Sal phy	------	--------	---------------	----------------	--2------	--1-	------3----1----3-	-----------	-------------3
Pla por	------	--------	---------------	--------------3-	---------	----	--4---------------	2----------	--------------
Dip sib	------	--------	---------------	----------8-----	-8-----9-	----	--------78-999--88	-----------	--------------
Tus far	1--1--	--------	------1--------	----------------	--1------	----	1-------1--4---1--	-----------	--------------
Pol com	------	--------	---------------	----------------	---------	1--1	--4---------------	-----------	--------------
Ang syl	--1--1	--112-1-	24121111111-13-	------3---1-1-11	1111-1---	--11	13-111111-221-1--1	-11141-22--	-12465633453--
Lis ova	------	--------	---5----------1	---------------2	---2-----	----	5--1---1----------	-------1---	------5-4--4--
Equ arv	---3--	--------	---------------	----------------	---------	----	------------------	-----------	-1----12-2----
Gal bif	------	--------	-1------1------	----------------	--1-1-1--	----	------------------	-----1---1-	2---1---121-3-
Hyp mac	---11-	--------	---------------	----------------	---------	---1	1------1----------	-----------	---2-1-1--113-
Pot ere	----1-	--------	----------1----	----------------	------1--	---1	---1--------------	-----------	--1----------6
Ran aur	------	--------	-------------2-	----------------	---------	----	-------1----------	------1----	--11--21-1----
Rub arc	-----1	--------	---------------	----------------	------2--	----	------------------	-----------	-1-3--1-------
Sal sp.	------	--------	---------------	----------------	---------	--2-	------------------	-----------	--2----------2
Ver cha	11---1	--------	---------------	----------------	---------	----	------------------	-----------	---3--1--11---
Epi ang	---3--	--------	------------1--	----------------	----1-1--	1-1-	--31-1--1-1-1-1---	-----------	3-----421-1---
Equ pal	1----1	--------	---------------	----------------	---------	----	---2--------------	-----------	3-----1------3
Equ syl	--3--1	--------	---------------	--1----5-----1-3	--1------	5-11	--13326-1--31---11	1311-31---4	-3-1-5654-52-3
Lys thy	------	--------	---------------	----------------	------1--	----	------------------	2----------	-1----1-------
Vio epi	1-6-25	--------	-1-------------	-------1-----111	--1---1--	2---	43-446------1-4--4	54--3432--1	-55476-71313-4
Cli den	1-3-51	--------	----------1----	-------1--------	------1-1	1---	-4-1-12-13-1--4-1-	-2-1-3---21	1221-5----1--4
Ely can	-1----	--------	-------1-------	--------------6-	1--------	----	-2------111--1-111	----11-1151	---1--137--36-
Pte agu	-1---4	--------	---------------	---------------5	---------	---5	3---1----41---1-3-	-----4---1-	-------7------
Sal cap	------	--------	-----------1---	----------------	---------	1-1-	------------------	----------3	-13-----------
Cal cor	------	--------	---------------	----------------	---------	1-1-	----1-1-----------	-----------	4-------------
Rhy squ	1-----	--------	---------------	---2------------	---------	----	4-----------------	-----------	--6---1-------
Aeg pod	------	--------	---------------	----------------	---------	----	------------------	-----------	---1----------
Agr cap	------	--------	---------------	----------------	---------	--1-	----1----1--------	-----------	1--13-1--11--3
Alc sp	------	--------	---------------	----------------	---------	----	------------------	-----------	------7--1---1
Ant syl	------	--------	--1-----------1	---------------1	---------	----	--------11--------	------131-3	---4155-653---
Cam glo	------	--------	---------------	----------------	---------	----	------------------	-----------	------1-------
Cam rot	------	--------	---------------	----------------	---------	----	------------------	-----------	---------1----
Car ces	------	--------	---------------	----------------	---------	----	------------------	-----1-----	--3-----------
Cor tri	------	--------	---------------	----------------	---------	----	------------------	-----------	1-------------
Dac glo	------	--------	---------------	----------------	---------	----	------------------	-----------	----1-4-------
Dry cri	------	--------	---------------	----------------	---------	----	------------------	-----------	-11-----------
Equ flu	------	--------	---------------	----------------	---------	----	------------------	-----------	--1-----------
Gal bor	------	--------	---------------	----------------	---------	----	------------------	-----------	-----1--------
Lat pra	------	--------	---------------	----------------	---------	----	------------------	-----------	---------1----
Lyt sal	------	--------	---------------	----------------	---------	----	------------------	-----------	---------1----
Moe tri	------	--------	---------------	----------------	---------	----	------------------	-----------	------------3-
Peu pal	------	--------	---------------	----------------	---------	----	------------------	-----------	--1------1----
Pot pal	------	--------	---------------	----------------	---------	----	------------------	-----------	1-------------
Pyr rot	------	--------	---------------	-------1--------	---------	----	1-------1---------	-----------	---3-11-------
Rum ace	------	--------	---------------	----------------	---------	----	------------------	-----------	------1-------
Sal pen	------	--------	---------------	----------------	---------	----	------------------	-----------	------1-------
Sil dio	------	--------	---------------	----------------	---------	----	------------------	-----------	----31--------
Urt dio	------	--------	---------------	---------------1	-1--1----	----	-------11-----1---	------1----	61-------245--
Vic sep	------	--------	---------------	----------------	---------	----	-------1----------	--------1--	---------1-33-
Vio can	------	--------	---------------	----------------	---------	----	------------------	-----------	-----11--1----
Plm ela	------	--------	---------------	--------1-------	---------	----	------------------	-----------	--5-----------
Sph rip	------	--------	---------------	----------------	---------	----	------------------	-----------	-1------------
And pol	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------1
Ant odo	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------1
Car fla	---1--	--------	---------------	----------------	---------	----	---1---------1----	-----------	-------------5
Men tri	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------4
Par pal	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------1
Pin syl	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------1
Aul pal	------	--------	---------------	----------------	---------	---1	------------------	-----------	-------1-----5
Cal lin	------	--------	---------------	----------------	---------	----	------------------	-----------	-------------1
Clt pal	------	--------	---------------	----------------	------1--	----	-----1--------1---	-----21----	-4--33-------1
Lys vul	------	--------	---------------	----------------	---------	----	-----4---1--------	-----------	--3-3-1--2----
Bar str	------	--------	---------------	----------------	---------	----	--------------1---	------1----	-----1--------
Fil ulm	7-3-1-	--------	------5--5---12	--1-------1--21-	6-11---3-	--3-	756666772266116555	77526756786	7874757677-768
Poa pal	------	--------	---------------	----------------	---------	----	--------------1---	-----1-----	-----1--------
Sta syl	------	--------	---------3---1-	----------------	---------	----	--------1------15-	----3--4451	-----------15-
Bry wei	------	--------	---------------	----------------	---------	----	------------------	-1---------	-------------1
Mni sp	------	--------	---------------	----------------	---------	----	------------------	----1------	--1-----------
Car can	------	--1-----	---------------	----------------	---------	---1	---41-1-----------	-----------	113-----111---
Car elo	------	--------	---------------	----------------	---------	----	---1--------------	-----------	1-------------
Cir pal	------	--------	----------1----	--1-------------	---------	----	---3--4-------1---	-----------	-1--2--1-----1
Gal pal	------	--------	---------------	----------------	---------	----	----1-----1-------	-----------	--1-----------
Gal tfi	------	--------	---------------	----------------	-------1-	----	-1---1---1---11--1	-----------	11----1------1

continued

(2)	T1	T2	T3	T4	T5	T6	T7	T8	T9
									1 1
	343389	35923367	3 225567758 144	1246111222556882	678889961	5677	4 367745778883556	1122 36 114	90 9 99990444
	326974	06292871	481649268393403	9286678047078388	170150505	8502	616193912452465154	23357739019	91251463780457
Ran rep	-1----	--------	---1----11-----	---------------1	---------	----	1-1111-24---1-15--	2----213213	41--113-1131--
Bry pse	------	------1-	---------------	----------------	---------	----	----1-1----1----1-	------1----	-------------1
Pse cin	4-----	--------	---------------	--------1-------	--1------	1--2	-473--6----1------	53131------	756-----------
Cal can	----3-	--------	---------------	1------1--------	---------	----	---2---------11---	-11-------3	---3-------1--
Cir alp	---5--	--------	---------------	-3--------1----7	---------	----	------------------	5-2-6--45--	4-1-------11--
Geu riv	3-----	--------	----2--1-33--15	---------21-1231	1-14----2	----	334531155123116-21	4543-515531	8674147114-544
Pel nee	------	--------	---------------	----------------	------1--	1--1	-----1---1--------	4-----3----	11-----------1
Alc vul	--2-1-	--------	---------------	----------------	---------	----	-------2--------1-	-------1-1-	---1----1-----
Pru vul	211-1-	--------	------1--------	----------------	---------	----	-3-11--1----1---1-	-1---------	-1-----------3
Plm ell	1-2-2-	---11111	---11-1------1-	---131--1-211---	1111-----	113-	55156511-1-1-13-11	4-2---32-11	1---14--11-6-5
Tri qui	------	--------	-------1-------	----------------	---------	----	----1-------1-----	-----------	-------1------
Car bux	------	--------	---------------	----------------	---------	----	---1--------------	-----------	--------------
Car vag	------	--------	---------------	----------------	---------	----	----1-------------	-----------	--------------
Car lol	------	--------	---------------	----------------	--1------	1---	---1415----1------	-----------	--------------
Epi mon	------	--------	---------------	----------------	---------	----	------1-1---------	-----------	--------------
Gly lit	------	--------	---------------	----------------	---------	----	-----------3------	------1----	--------------
Myc mur	------	--------	---------------	----------------	---------	----	---------------3--	-----------	--------------
Poa nem	------	--------	---------------	----------------	---------	----	--------1--1------	-----1-----	---1----------
Poa tri	------	--------	---------------	----------------	---------	----	----------11------	-----------	--------------
Scr nod	------	--------	---------------	----------------	---------	----	--------1---------	-----------	--------------
Val sam	------	--------	---------------	----------------	---------	----	---2--------------	-----------	--------------
Cam ste	------	--------	---------------	------1---------	---------	----	-211--------------	-----------	---1----------
Fon ant	------	--------	---------------	----------------	---------	----	---------1--------	-----------	--------------
Tet pel	------	--------	---------------	----------------	---------	----	---11-------------	-----------	--------------
War flu	------	--------	---------------	----------------	---------	----	------1-----------	-----------	--------------
Ric lat	------	--------	---------------	----------------	---------	----	------1-----------	-----------	--------------
Sca und	------	--------	---------------	----------------	---------	----	---------1--------	-----------	--------------
Cal pal	------	--------	---------------	----------------	---------	----	------------------	1----------	--------------
Car rhy	------	--------	---------------	----------------	---------	----	------------------	-----1-----	--------------
Imp gla	------	--------	---------------	----------------	---------	----	------------------	---------1-	--------------
Poa rem	------	--------	---------------	----------------	---------	----	------------------	-----1-----	--------------
Rib rub	------	--------	---------------	----------------	---------	----	------------1-----	----------2	--------------
Ros maj	------	--------	---------------	----------------	---------	----	------------------	-------1---	--------------
Sci syl	------	--------	---------------	----------------	---------	----	------------------	6----------	--------------
Vio rup	------	--------	---------------	----------------	---------	----	------------------	-1-1-------	--------------
Bra sta	------	--------	---------------	----------------	---------	----	------------------	----3--1---	--------------
Pla sug	------	--------	---------------	----------------	---------	----	------------------	--1--------	--------------
Car ech	------	--------	---------------	----------------	---------	---1	---3--------------	-----------	-------------1
Mat str	------	--------	---------------	------8---------	---------	7---	--7--7-----------1	----888565-	--------------
Rhi mag	------	--------	---------------	-----2----------	---------	----	--4---------------	----------5	--------------
Ran acr	------	--------	---------------	----------------	---------	----	------------------	-------1---	--------------
Rhi pse	------	--------	---------------	----------------	---------	51-1	----7----1-----3--	-----17----	--------------
Chi pol	------	-1------	---------------	----------------	---------	----	-1-------------1--	------1----	--------------
Fis adi	------	--------	---------------	----------------	-------2-	----	5----1------------	----1------	--------------
Poh nut	------	--------	--------1------	------1---------	---------	----	4---------1-------	-----------	--------------
Jun lei	------	------1-	---------------	----------------	---------	----	----------------4-	-----------	--------------

(3)	V1	V2	V3	V4	V5	V6	V7	V8	V9
									11
	3389	339 135722564	26771458	2577	169885668	111222456695788	56857688	6367122337 114124 3544	9 990099449 34
	4974	08238629119472	62684039	0802	505187183	789247865600705	592442468	47333355657901328913116	645180137459217
Men arv	----	--------------	---1----	----	---------	---------------	---------	-----------------------	---------------
Lyc cla	----	--------------	1-------	----	---------	---------------	---------	-----------------------	---------------
Hie pil	----	--------------	--1-----	----	---------	---------------	---------	-----------------------	---------------
Fes ovi	-1--	--------------	--------	----	---------	---------------	---------	-----------------------	---------------
Epi aph	----	--------------	--1-----	----	---------	---------------	---------	-----------------------	---------------
Cyp cal	----	------------1-	--4-----	----	---------	---------------	---------	-----------------------	---------------
Bot lun	----	--------------	-1------	----	---------	---------------	---------	-----------------------	---------------
Poa sp.	----	------------1-	--------	----	---------	---------------	---------	-----------------------	---------------
Sol vir	1--1	311--64336514-	4333---1	4-25	33--1-12-	11--1--211-----	11---1---	---1---111-------------	-21--1-------1-
Mel pra	---3	3-1---1-------	--1-----	--11	---------	--4------------	---------	-----------------------	-----------1---
Act spi	----	--4-47-763-26-	3646--4-	----	-34455564	75---------111-	1--41--12	-----3---13---------1-1	---------------
Hie syl	----	---------1--32	-2------	----	-------1-	---------------	---------	-------------------1---	--------------1
Des fle	-411	644---4-3---41	----1--1	1--1	---------	--3------2-----	-1-------	-411644---4-3---41----1	-----------11--
Vio riv	1-21	--1-121-121--1	--1--121-	---	-1-12--11	-2--------11---	1--------	-1-----2----------21---	----14------1--
Vac vit	53-5	--3---1-121-12	111-----	11--	113------	------1-1------	-1--1----	1----1-2----------11---	------------2-1
Vac myr	1-47	7572-161261346	11311-21	1313	111-3111-	13-31-13141--11	113--111-	1------1--------1-13---	-1---111----1-4
Pyr min	----	--1------3-3--	-42-----	1--1	151------	---------------	-2--1-1--	-----------------------	-11-11-1------1
Pla bif	----	----------1---	--1-----	---1	---------	---------------	---------	-------1---------------	---------------
Mon uni	----	------------1-	-1------	----	-1-------	---------------	---------	----------------------1	---------------
Mel syl	1-22	11---4111-1-14	-1----11	11--	--1---1--	---------------	-1-------	---------1-1----------1	-11-11-1------1
Lin bor	4---	2-2---1-----3-	---1----	-2--	-1-------	---------------	-2-------	1------1---------------	---------------
Con maj	1---	--16654444424-	54616--5	---5	-4----1--	13--6--131---2-	----11--3	---4-541-41--------1---	1-6-31--6-4--11
Cal aru	1-5-	76-256356-6455	-5116358	12-3	31-14211-	-1-31-411311-11	55-1-2---	----1-111-------11131--	-1-----1------3
Bet pub	-5-1	4-------------	--------	-2--	---------	---------------	-1-------	---------1-------------	------------1-2
Rub sax	3331	-27-4-32167356	46523437	5441	54512311-	11-21-11111--1-	-56-131--	11-131-1-1----1-2-55-23	-413-3-33-3-154
Scu gal	-1--	--------------	--------	----	--1------	---------------	---------	-----------------------	---------------
Pop tre	----	--11-------1--	-1------	---3	1------1-	--------11-----	---------	-----------------------	----------3----
Jun com	---5	--1--------1--	--------	----	---------	-------------3-	---------	-----------------------	--------------2
Mil eff	----	---1---316511-	---21---	1---	-----3413	444--4--13--1--	---1-----	1---1-2-----51--11--1--	--------5------
Hie vul	----	-----------1--	--1-----	3---	---------	---------------	-1-------	-----------------------	---------------

continued

```
(3)     V1   V2             V3       V4   V5        V6              V7        V8                      V9
                                                                                                          11
        3389 339  135722564 26771458 2577 169885668 111222456695788 56857688  6367122337  114124 3544 9  990099449 34
        4974 08238629119472 62684039 0802 505187183 789247865600705 592442468 47333355657901328913116 645180137459217
Dry exp ---- 88---8-762341- 13-7-15- 7576 --5117678 738867877987888 -867--54- 7--------3-------2--1-- ---------------
Agr sto ---- -------------- -------- --11 --------- --------------- --------- ----------------------- ---------------
Vio mir ---- ----1-5----521 5415-1-- ---- -31---1-- --------------- -1--1---- -----31-32-----------45 --------8-4----
Ver off ---1 --1----------1 -1-1--21 ---1 --------- --------------- -------1- ------------------1-3-1 1-1------------
Hup sel ---- -------------- -------1 ---- --------- --------------- --------- --------------------1-- ---------------
Dry fil ---- ------2--1-1-- -1-1745- ---- ------13- ---1---1------- --------- --------1-----1--11-4-1 ---------56----
Lon xyl -4-- ----4-------4- 1133---- ---- -------43 -----------1--- --------- ------1----4-----3-4-3- ---------------
Fra ves 4443 ------1----112 13-1-262 ---- 111------ --------------- ---1---1- -------51--1------34-1- -12--1------1--
Car dig 33-3 ------111--121 -211-11- --1- 111-1-11- 2-------------- -1--12--- -------4----------32--6 ---------------
Sor auc 2-31 53216341162142 23-1---- 5223 11--4112- 131634321-----2 546321--1 ----3211-1--42--2-14424 -24---1---2-1-1
Oxa ace 6755 -7155576766677 57566684 7641 -75578685 664753355445433 845416345 66434657756765754476836 -6-3-642257651-
Tri eur 3434 23312321333131 2-332133 2444 131331311 11332--11331141 -23111113 22-21111222121211-313-- 223233-322322-1
Rha fra -2-3 --2----------- -------- ---1 --2------ --------------2 --------- ----------------------- -1----------4-2
Ort sec 1-1- 1-1---11-2--2- -3-2---- -3-- 211---1-- -------11-1--1- 11---1--- ------1----------43---- 11-----------1-
Mel nut 4144 11115-1-132113 42141-15 3-11 211121111 ---14-13--1--1- 1-11111-1 11-1112111-152--11141-2 -23112-1--11125
Mai bif 1547 55643353555256 53344444 4365 244346442 324434323434435 443114114 41-133425224464244554-1 365215132462-64
Luz pil 1212 1-2--11-1--12- -11---1- 2-11 11111-111 1-21--1-11----- -11--1-1- -------1-1----1--1-11-1 11-12--1--21-12
Gym dry 6764 4776866767867- 7766556- 5614 776766665 774567765685558 -45225435 543445-67543657172175-- -31487444655143
Car pal -1-2 -------------2 -----1-- ---4 --1------ --------------- --------- ----------------------- --------1-----6
Rub ida 1547 -1113744--211- -565525- 4111 -56536617 43-73-2-12453-3 -21632314 33-33323134-641-2-4-14- 3415774776812--
Pic abi 2-5- 3--------3-11- 211---1- 13-3 -31----2- --2---2-31-1--- 221--3-1- 3--2---3------------24- -1--321-112-136
Dry car 514- 5566515------- 1-1366-- ---- --715---- ----4335-----1- -------5- 21--1-41532-61743-4131- 1365-62113114--
Dac mac ---1 -------------- -------- ---- ------1-- --------------- ------1-- ----------------------- --------------1
Vio sel 224- --1-1--1321121 33-4-333 ---- -1-311241 ------------111 1111-1113 ----1511211234--1-2--22 ---1-1-213471--
Rib spi ---- -------------- -----7-- ---- --1------ --------------5 ---4----- -----------1-2------23- ----------4----
Ger syl 3153 -----141337454 15-3-117 3141 25-143513 31-2131---1-121 311114413 4424433424-3-1--1125144 673154-5411-457
Aln inc 35-4 ---111--14--1- 12344585 -1-4 14-35111- 124-124-1-13--1 -2652-3-1 ---3-1321--15334144311- 74---21--43-7-2
Phe con --71 --1------5---- --71----53675 655675576 464616-5684644- 654376476 -365776664666-5-6541--- -131--27-1-115-
Ath fil -671 --1---4--1---- -1-47-1-97888 689877487 784782671676766 715171887 67779886776814888938--1 117---4978-711-
Ste med ---- -------------- ------------- -1------- --------------- --------- ----------------------- -----1---------
Sal sp. ---- -------------- ----------2-- --------- --------------- --------- ----------------------- -----1---------
Rub arc ---1 -------------- ------------- -2------- --------------- --------- ----------------------1 1-3---1--------
Car sp. ---- -------------- -----------1- --------- --------------- --------- ----------------------- --1------------
Ang syl 2--1 --1-4-21-1111- 21111311--11- --11-11-- 3--------1111-- 111-121-- 1-1111112422---1-3—1165 6546451333--21-
Par qua --11 ----112131--1- 1111-11- 1--- 111111131 11--11-1---1111 -122213-1 1111-2311112-11-322312- 311111111---113
Lyc ann ---1 --------1---11 -------- -1-- 111-1111- --------1------ 111--2--- 1-----511-------------- -------------1-
Dap mez ---- ----2-----1-33 1-1---1- ---- 1112--21- --------------- 1-233-11- -----1-1-21--------22-- ---2---1-11-2--
Cal pur ---- -----1-------- 3------- -112 ---3----- ---1------1--33 -13-----1 --13-1---------5------- ---2---1-11-2--
Vib opu ---- --1----------- ------6- ---- --------- -1------------- -15-1---- ---4------------------- ---------------
Pru pad ---1 --1----------- 43-1-574 --1- --145224- ---4231----1--3 5132413-3 51-433-324432--3--42452 -611-1-11---14-
Gal tlo --3- -------------- -1-1--3- ---- -211--141 --------------- ----11--1 3--1---1524-----3-3---- ---------------
Cre pal ---1 -----1---4---- ---1---- 1614 5457557-4 -1----1---12531 4464177-5 5576466511-311-4344334- -142--4411--357
Dip sib ---- -------------- -------- ---- -9------- -----------88-- 8--788999 ----------------------- ---------------
Mat str ---- -------------- -------- -7-- --------- -8------------- -----1--- 7887------8565--------- ---------------
Tus far -1-- -------------- -1------ ---- --------- -------------1- ---1--4-- -------------------11-1 ---------------
Car lol ---- -------------- -------- -1-- --------- -------------1- -45---1-- ---1------------------- --1------------
Vio rup ---- -------------- -------- ---- --------- --------------- --------- ----1-1---------------- ---------------
Scr nod ---- -------------- -------- ---- --------- --------------- ---1----- ----------------------- ---------------
Sci syl ---- -------------- -------- ---- --------- --------------- --------- ---------------6------- ---------------
Ros maj ---- -------------- -------- ---- --------- --------------- --------- -----------1----------- ---------------
Rib rub ---- -------------- -------- ---- --------- --------------- -------1- -----------------2----- ---------------
Ran acr ---- -------------- -------- ---- --------- --------------- --------- -----------1----------- ---------------
Poa tri ---- -------------- -------- ---- --------- --------------- -----1--- --------1-------------- ---------------
Poa rem ---- -------------- -------- ---- --------- --------------- --------- -1--------------------- ---------------
Poa nem ---- -------------- -------- ---- --------- --------------- ---1--1-- -1--------------------- --1------------
Myc mur ---- -------------- -------- ---- --------- --------------- --------- --------------------3-- ---------------
Imp gla ---- -------------- -------- ---- --------- --------------- --------- -------------1--------- ---------------
Gly lit ---- -------------- -------- ---- --------- --------------- ------3-- --1-------------------- ---------------
Gal uli ---- -------------- -------- ---- --------- --------------- --------- -------1-----------1--- ---------------
Equ pra ---- -----------11- --11---- ---- ------11- 1----------1--1 -5333244- 431314-44-1----24---43- --432-------1--
Epi mon ---- -------------- -------- ---- --------- --------------- --11----- ----------------------- ---------------
Car rhy ---- -------------- -------- ---- --------- --------------- --------- -1--------------------- ---------------
Car vag ---- -------------- -------- ---- --------- --------------- -1------- ----------------------- ---------------
Cal pal ---- -------------- -------- ---- --------- --------------- --------- ---------------1------- ------------1--
Vio epi --25 ----1--------- -------- 12-- --1-1---1 -------------1- -4---4-1- -4364--46-32---51131--4 -647315713--544
Poa pal ---- -------------- -------- ---- --------- --------------- --------- -1-----1--------------- -1-------------
Bar str ---- -------------- -------- ---- --------- --------------- --------- --1----1--------------- -1-------------
Sta syl ---- -------------- -----13- ---- --------- --------------- 5--1----- ----------3445---1—1--- 31-1131-11-4-1-
Ran rep ---- -------------1 1--1--1- ---- --------- --------------- -1-4---1- 1211---1---321-213--521 31-1131-11-4-1-
Gal tfi ---- -------------- -------- ---- -1------- --------------- ----11--1 ---1---1----------1---- 1-----1----1--1
Gal pal ---- -------------- -------- ---- --------- --------------- -1------- ---------1------------- ------------1--
Fil ulm --1- -------------- -5---15- --3- -3-11-6-2 ------1----1-1- 567225611 6756752636667827-657577 75477-867767768
Epi hel ---- -------------- -------- ---- --------- --------------- --------- ------------------3---- ---------------
Alc vul --1- -------------- -------- ---- --------- --------------- 1-------- --------2--1-1-------2- --1-----1------
Ros aci 1-1- -----------1-- ------1- ---- -1-----1- -------------41 22--1---1 ---2-4-11----------43-- -------5-----3-
Pte agu ---4 -------------1 -------- ---5 --------- --------------- 31--4---- -4-----1-1---1--5-----3 -------7-------
Pru vul --1- -------------1 -1------ ---- --------- --------------- 11-----1- ----1---1---------32-1- ------1------13
Geu riv ---- -----------2-- --1—133- ---2 --43-112- ----2-----1-1-2 315113114 5115436-2-553541133-537 74414-611548754
Cir alp -5-- -------------- -------- ---- --------- ---3-------1--- --------- -----2----645--57------ -----1---1-41--
Cal can --3- -------------- -------- 1--- --------- --1------------ --------- ----11-1---------3--1-- --3------1---2-
Vio pal ---- -------------- -------- 2-26 --------- --------------- -1------- -1---1---------3-1-4--- 1-4---------55-
```

continued

(3)	V1	V2	V3	V4	V5	V6	V7	V8	V9
									11
	3389	339 135722564	26771458	2577	169885668	111222456695788	56857688	6367122337 114124 3544	9 990099449 34
	4974	08238629119472	62684039	0802	505187183	789247865600705	592442468	47333355657901328913116	645180137459217
Sal phy	----	--------------	--------	--1-	---------	-------------2-	3-3---1--	-----------------------	--------------3
Lys thy	----	--------------	--------	----	--1------	---------------	---------	---------------2-------	1-----1--------
Equ syl	---1	--------------	--------	5511	--------1	------1------1-	1361-131-	1312311-3------134-----	651--53542---33
Sal cap	----	---1----------	--------	-11-	---------	---------------	---------	-----------------3-----	------1-----3--
Epi ang	-3--	--------------	----1---	-11-	--1------	--------------1	---1---1-	3--1---1-1-------------	4----1-21--3-1-
Des ces	-512	--------------	-----111	1-23	----2----	-------------1-	1111-----	-1-----23--1-1-11123-3-	1141411-1--1313
Lis ova	----	--------------	5-------	----	---2-----	---------------	---------	-----------1--1-2----15	5-------44---1-
Ely can	----	-------------1	--1-----	----	----6-1--	---------------	1--111--1	-1-------11115---12-1--	1-1----3736----
Cir hel	----	--------------	--------	----	-11------	------1--------	-1-------	-------------------3---	---1----41-----
Ver cha	---1	-------------1	--------	----	---------	---------------	---------	-------------------1---	1-3-11---------
Ran aur	----	--------------	-----2--	----	---------	---------------	---------	--1------------------1-	2-1-1--1----1--
Hyp mac	-11-	--------------	--------	---1	---------	---------------	---------	---------------------11	-12--1-1-13----
Gal bif	----	----1---------	---1----	----	--1------	-------------11	---------	-1-----------1---------	---121--1-32---
Car ech	----	--------------	--------	---1	---------	---------------	---------	-----------------------	-------------31
Pot ere	--1-	--------------	-------1	---1	--1------	---------------	---------	-----------------------	------------116
Lys vul	----	--------------	--------	----	---------	---------------	----1----	---4-------------------	1--32-------3--
Equ arv	-3--	--------------	--------	----	---------	---------------	---------	-----------------------	1---2-12-------
Clt pal	----	--------------	--------	----	--1------	---------------	---------	-211---1---------------	-3-3--4-------1
Ant syl	----	---------1----	--------	----	---------	---------------	---11----	--1--------31-1-13-----	554153--6------
Vio can	----	--------------	--------	----	---------	---------------	---------	-----------------------	11--1----------
Vic sep	----	--------------	--------	----	---------	---------------	---------	------------1--------1-	----1----33----
Val sam	----	--------------	--------	----	---------	---------------	---------	-----------------------	-------------2-
Urt dio	----	--------------	--------	----	---------	------------1-1	---1-----	--1----1--------1----1-	----241--5-6---
Sil dio	----	--------------	--------	----	---------	---------------	---------	-----------------------	-1-3-----------
Sal pen	----	--------------	--------	----	---------	---------------	---------	-----------------------	1--------------
Rum ace	----	--------------	--------	----	---------	---------------	---------	-----------------------	1--------------
Pyr rot	----	--------------	--------	1---	---------	---------------	---1-----	----------------------1	113------------
Pot pal	----	--------------	--------	----	---------	---------------	---------	-----------------------	-----------1---
Pin syl	----	--------------	--------	----	---------	---------------	---------	-----------------------	--------------1
Peu pal	----	--------------	--------	----	---------	---------------	---------	-----------------------	----1-------1--
Par pal	----	--------------	--------	----	---------	---------------	---------	-----------------------	--------------1
Moe tri	----	--------------	--------	----	---------	---------------	---------	-----------------------	----------3----
Men tri	----	--------------	--------	----	---------	---------------	---------	-----------------------	--------------4
Lyt sal	----	--------------	--------	----	---------	---------------	---------	-----------------------	----1----------
Lat pra	----	--------------	--------	----	---------	---------------	---------	-----------------------	----1----------
Gal bor	----	--------------	--------	----	---------	---------------	---------	-----------------------	-1-------------
Equ pal	---1	--------------	--------	----	---------	---------------	---------	-------------------1---	1----------3-23
Equ flu	----	--------------	--------	----	---------	---------------	---------	-----------------------	------------1--
Dry cri	----	--------------	--------	----	---------	---------------	---------	-----------------------	------1-----1--
Dac glo	----	--------------	--------	----	---------	---------------	---------	-----------------------	4--1-----------
Cor tri	----	--------------	--------	----	---------	---------------	---------	-----------------------	-----------1---
Car fla	-1--	--------------	--------	----	---------	---------------	--------1	-----------------------	-------------15
Car elo	----	--------------	--------	----	---------	---------------	---------	-----------------------	-----------1-1-
Car ces	----	--------------	--------	----	---------	---------------	---------	-1---------------------	------------3--
Car can	----	--1-----------	--------	---1	---------	---------------	-11------	-----------------------	----111-1--134-
Car bux	----	--------------	--------	----	---------	---------------	---------	-----------------------	-------------1-
Cam rot	----	--------------	--------	----	---------	---------------	---------	-----------------------	----1----------
Cam glo	----	--------------	--------	----	---------	---------------	---------	-----------------------	1--------------
Ant odo	----	--------------	--------	----	---------	---------------	---------	-----------------------	--------------1
And pol	----	--------------	--------	----	---------	---------------	---------	-----------------------	--------------1
Alc sp.	----	--------------	--------	----	---------	---------------	---------	-----------------------	7---1---------1
Agr cap	----	--------------	--------	--1-	---------	---------------	-1--1----	-----------------------	1-1311-----1--3
Aeg pod	----	--------------	--------	----	---------	---------------	---------	-----------------------	--1------------
Cir pal	----	--------------	-------1	----	---------	------1--------	--4------	-------1---------------	---2--11-----31