Understorey species compositional dynamics in a boreal coniferous forest in SE Norway: does past logging matter?

Ragnhild Heimstad

Master of Science thesis

2007

Botanical Museum

Natural History Museums and Botanical Garden

University of Oslo

FORORD

Denne masteroppgaven er en reanalyse av et prosjekt som ble startet i 1997-98 av NIJOS (nå del av Norsk institutt for skog og landskap) i samarbeid med Botanisk hage og museum, Universitetet i Oslo (nå Naturhistorisk museum, Seksjon for botanikk), som del av MiS-programmet (Miljøregistreringer i skog) finansiert av Landbruksdepartementet. Takk til Tonje Økland, Knut Rydgren, Rune H. Økland, Ken Olaf Storaunet og Jørund Rolstad for å stille grunnlagsdata til disposisjon for masteroppgaven.

Først og fremst vil jeg takke veilederen min, Rune H. Økland for den måten han har veiledet meg gjennom hele master-studiet; vært vennlig og imøtekommende, gitt lynkjappe tilbakemeldinger, og vært til stor inspirasjon gjennom sitt veldige engasjement for fagfeltet. Jeg vil også rette en spesielt varm takk til Anette Edvardsen, som har hjulpet meg med alt fra tekniske problemer i R når min egen tålmodighet var i ferd med å renne ut, til å ta meg med på helt andre ting når jeg trengte noe annet å tenke på. Vegar Bakkestuen har også vært til veldig stor hjelp særlig i skrivefasen med faglige innspill og med evnen til å hanke meg inn igjen når skogsdynamikken, i mine øyne, tok uforklarlige veier. Takk også til Marianne Evju og Hai-Ying Liu for gode råd og utlån av script, Wenche på biblioteket for god hjelp i litteratur-jungelen, Odd Stabbetorp på NINA og ellers alle medstudenter og ansatte på Botanisk museum for ei hyggelig tid.

Feltarbeidet sommeren 2005 var en fantastisk opplevelse, og jeg takker alle som bidro til å gjøre det gjennomførbart: Løvenskiold Skog for kjøretillatelse; Gunvor Greni for leie av stabburet på idylliske Heggeliseter; Leif Koch for formidling av hytteleie; Alf Roald Folvik for lån av bil; Eva og Kjetil for hjelp til lokalisering av feltene (som er vanskeligere enn man skulle tro); og Guri for å avslutte sin solo-tur i Nordmarka for å holde meg med selskap (og litt whisky) de dagene regnet høljet ned som verst!

Min tidlige interesse for natur og biologi må jeg tilegne pappa, som helt siden jeg var liten har tatt meg med ut på tur og gjort meg nysgjerrig på naturen; fugler som blomster. På samme måte vil jeg takke mamma for videreføring av språkinteresse og leseglede, og til slutt begge to for økonomisk bistand i trange tider.

Sist men ikke minst, en ekstra takk til deg, Kjetil, for din evne til å roe meg ned når stress-nivået innimellom går i taket og for din upåklagelige tålmodighet og støtte i alt jeg gjør.

Ragnhild Heimstad   Oslo, mai 2007

CONTENTS

ABSTRACT

Understorey vegetation changes between 1997 and 2005 were studied using 100 permanent plots (1 m^2) in four boreal spruce forest stands situated within a National Nature Reserve in SE Norway. The stands differed with respect to former forest management performed 70–80 years prior to the study: natural old-growth forest, minor selectively cut forest, major selectively cut forest and clear cut forest. Based on repeated recording of species composition (vegetation gradients acquired by ordination axes) and tree-stand properties, as well as several environmental variables recorded in 1997, my aim was to assess if previous logging affected the understorey species composition and/or species abundance.

No general patterns in species abundance change across stands were observed that could be directly ascribed to former management. Most of the change in abundance was interpreted as stochastic inter-annual fluctuations. Previous logging was a poor predictor of change in species composition, and the average positions of plots from a given stand along the tree influence gradient in species composition did not reflect average tree influence at stand scale. This was interpreted as an indication that the influence of trees on understorey species composition is local, at the scale of individual trees rather than stand-scale tree stand properties (including logging history). The vegetation in the major selectively cut stand (highly significant), the clear cut and the natural stand had, however, changed in direction of one typical of more open and moist forest in spite of the forest becoming generally denser. This was attributed to increased amounts of precipitation in the period prior to 2005 compared to the years preceding 1997, which favours spread of species typical of moist microsites and between trees towards tree bases.

Some convergence in species composition changes towards that of the old-growth forest was observed for all formerly managed stands, along the two first ordination axes. This exemplifies the long-term nature of forest floor-successions, which evidently last for many decades after logging. A slight time-lag was also found (though, not significant) in the response of vegetation to tree influence, *and* in the response of species composition in 2005 to its' surrounding environment relative to the species composition in 1997 and the environmental variables recorded the same year.

Apparently, previous logging does not directly influence today's species abundances or species composition *per se*, although indirect effects via tree-layer properties seem to be traceable. Further insight into the complex dynamics of understorey vegetation in boreal post-logged forest require continued long-term monitoring of permanent plots.

INTRODUCTION

Through centuries of timber harvesting by changing technologies, the areas of boreal old-growth forest (i.e. with no signs of logging disturbances; Kuuluvainen 2002a) have been severely reduced (Linder and Östlund 1992, Östlund 1993) and today only scattered small patches of old-growth forest remain (Storaunet et al. 2006). Important characteristics of old-growth forest are frequent canopy gaps and structural complexity with an abundance of older large trees, snags and fallen logs (Linder and Östlund 1992, Östlund 1993), all of which help contribute to a unique microenvironment (Kuuluvainen 2002b) that many cryptogams as well as insects and fungi depend on (Jonsell et al. 1998, Nilsson et al. 2001, Ehnström 2001, Siitonen 2001, Larsson and Danell 2001). In fact, dead wood may amount to more than half of the standing volume of living trees in old-growth forests (T. Økland et al. 2003). Long-term impact of logging is considered to be a major cause of decline for a large number of species typical of these forests (Söderström 1981, 1988a, b, Gustafsson and Hallingbäck 1988, Andersson and Hytteborn 1991); one fifth of all species on the Norwegian Red-List are considered to be threatened by forest management (Kålås et al. 2006). National and international measures have been implemented to counteract this development, such as the Convention of Biological biodiversity (1992), Parliamentary Report no. 42 (Anonymous 2001) and the Parliamentary White Papers no. 8 (1999–2000) and 21 (2004–2005).

Extensive logging brings about drastic and immediate changes of boreal understorey conditions, reflected as changes in radiation, soil moisture, soil temperature (Bjor 1965) and to some extent, soil chemistry (Likens et al. 1978, Piirainen et al. 2004). Little is however known about the consequences of previous logging on understorey vegetation, although there are indications that the effects may not be severe (Atlegrim and Sjöberg 1996, Esseen et al. 1997). The main reason for this is the general lack of tradition in working with long-term vegetation studies that allow re-analysis of permanent plots. In the period 1988–1992 three long-term studies were introduced in Norway: a survey of the dynamics in boreal coniferous forest in the Solhomfjell area as reference for airborne pollutants (R. Økland and Eilertsen 1993); a national monitoring project with ten reference-areas of *Picea*-type forest distributed all over Norway, carried out by NIJOS (Norwegian Institute of Land Inventory; now Norwegian Forest and Landscape Institute) (T. Økland 1996); and the Terrestrial monitoring programme by the Directorate for Nature Management of *Betula*-type forest (Bakkestuen et al. 1999ab, 2000, 2001, 2002, in press). However, none of these projects deal with the influence of *forest management* on understorey vegetation, and most studies on this subject

have used sites that represent different successional stages at one point in time (e.g. Brumelis and Carleton 1989, Frisvoll and Prestø 1997). Such chronosequences offer acceptable alternatives when replicated experiments are not attainable (Foster and Tilman 2000), still the approach by which the analysis is temporally replicated is generally viewed as more reliable (Bakker et al. 1996) because it allows direct comparison of the species composition e.g. before and after a disturbance event.

Understanding fundamental processes in understorey dynamics is facilitated by access to forest reserves that can serve as proper references to which managed forests may be compared (Östlund et al. 1997). In this respect, Oppkuven (Ringerike, SE Norway) is a well suited area for studying how long-term effects of previous logging are reflected in vegetation change. The area is one of few locations in Norway still containing patches of old-growth forest displaying no signs of previous logging activities (T. Økland et al. 2003, Storaunet et al. 2005, 2006), exemplified for instance by the presence of one of the oldest living *Picea abies* trees in Norway; 461 years old (Storaunet et al. 2006). At the same time, areas near Oppkuven have been subjected to selective and later also clear cutting. According to Gjerde and Baumann (2002), the clear-cut at Oppkuven dated 1937 is likely to represent one of the first sites in Norway where clear cutting was put into practice. Oppkuven can thus be considered a true reference area for both old-growth and early clear-cut stands.

Rydgren et al. (1999) and T. Økland et al. (2003) compared and interpreted the understorey vegetation in Oppkuven within four stands representing different extent of previous forest management (natural, minor selectively cut, major selectively cut and clear cut) according to the chronosequence approach. These studies was part of a programme funded by the Norwegian government, initiated to promote development of appropriate tools for monitoring and registering of species and the environmental factors with which they interact, in order to ensure an ecological sustainable forest management policy. My study is a reanalysis and a direct continuation of the studies by Rydgren et al. (1999) and T. Økland et al. (2003). By adding a temporal aspect, my aim is to provide further insights into relationships between the understorey vegetation and previous logging, as opened for by T. Økland et al. (2003). This aim is approached by comparing already identified compositional gradients (coenoclines) with the quantified change in species abundance and species composition for each of the four stands, *and* by relating these changes to new recordings of tree influence as well as natural forest dynamics and, most importantly, previous forest management.

MATERIALS AND METHODS

Investigation area

The study area lies within the Oppkuven National Nature Reserve in Ringerike municipality, Buskerud County (Fig. 1), 40 km North of Oslo in SE Norway (60° 07´N, 10° 32´E). Oppkuven is situated 550-700 m.a.s.l. and is part of the Krokskogen lava area. This area represents the northern region of the Oslo rift, which is made up by igneous bedrock; consisting of both extrusives (mostly feltsites) and intrusives (Larsen 1978). The topography in the area is steep and broken, with sloping hills as well as cliffs and valleys, densely forested and dominated entirely by Norwegian spruce (*Picea abies*). Patches of old-growth intersperse with forest influenced to various extents by previous forestry activities. The climate is relatively humid with annual precipitation and mean temperature estimated to 1200 mm (Aune 1993) and 2.9°C (Førland 1993), respectively (data from 1960-1990 at 650 m.a.s.l.; corrected for altitude). Data on average annual precipitation and temperature (Tab. 1) was based on measurements from the Norwegian Meteorological Institute (2007), made at the stations as close as possible to the study area (Precipitation: Bjørnholt station, 360 m.a.s.l.; Temperature: Blindern station, 94 m.a.s.l.). Annual average values were calculated both on basis of the whole year (January-December), and the growth season (April-November) relative to the annual averages from 1960-1990. All years after 1997 (except for 2003) displayed considerably higher precipitation and somewhat higher temperature both compared to the years prior to 1997 and compared to the 1960-1990 averages (Fig. 2).

As indicated by charcoal and pollen analyses (Ohlson and Tryterud 1999), Oppkuven has not been struck by forest fire for the last 1700 years. The study area lies in the middle boreal vegetation zone and in the weakly oceanic section (Moen 1998).

The field work was carried out as described by T. Økland et al. (2003), and further details on selection of stands and tree stand history, placement of plots and recording of vegetation is given there.

Selection of stands and tree stand characteristics

Rydgren et al. (1999) and T. Økland et al. (2003) explored both southerly- and northerly-exposed stands in Oppkuven. The present study provides a reanalysis of permanent plots of T. Økland et al. (2003) from south-facing stands.
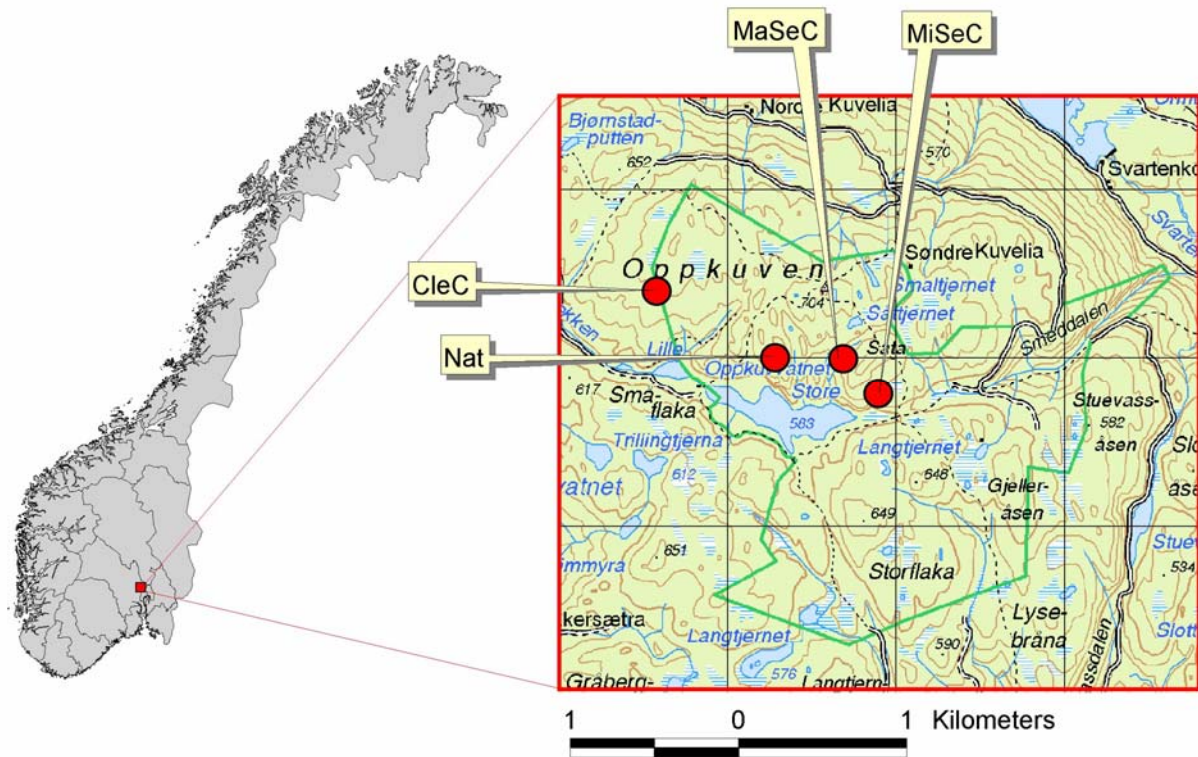
Figure 1. Map showing Oppkuven in SE Norway. Area within the green line represents the National Nature Reserve.
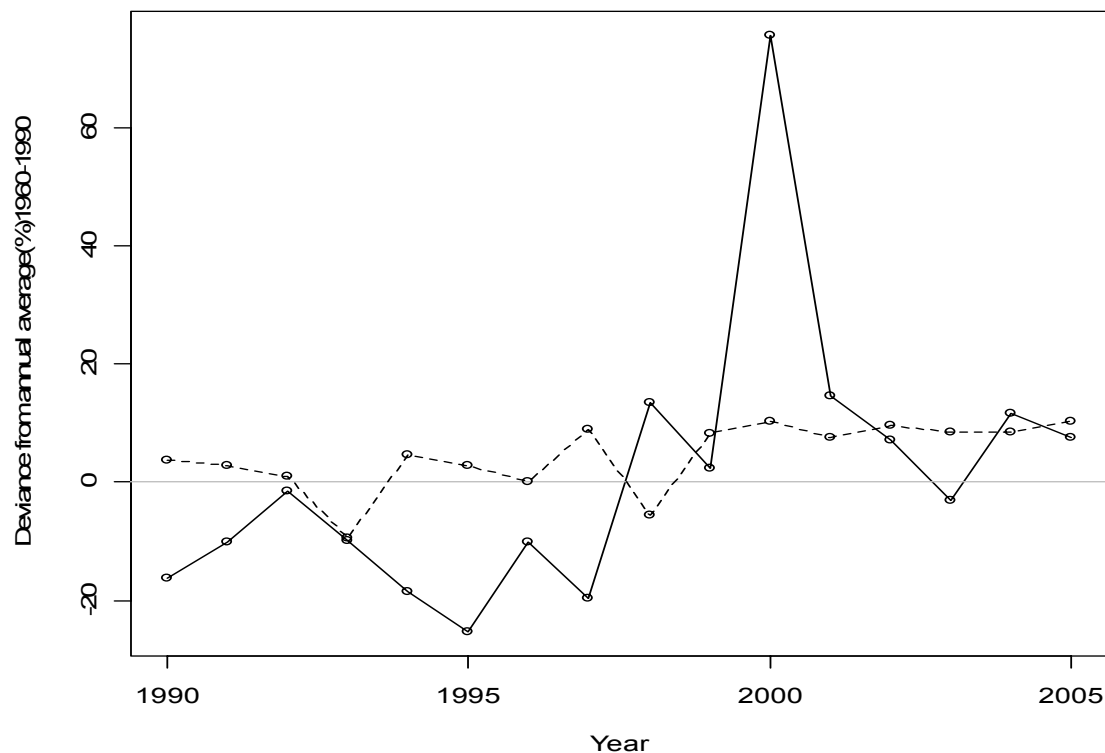
Figure 2. Deviance in precipitation (solid line) and temperature (punctuated line) for each year from 1990 to 2005 relative to the annual average from 1960-1990 (%). Average for each year is calculated from monthly average values from April to November (representing growth season).

Table 1. Average values for precipitation and temperature both for the whole year (January to December) and from April to November (representing the growth season) from 1990 to 2005. Measurements recorded at Bjørnholt (precipitation) and Blindern (temperature) meteorological stations. %: Percentage of annual average from 1960-1990.

	Precipitation				Temperature			
	Jan-Dec		Apr-Nov		Jan-Dec		Apr-Nov	
Year	mm	%	mm	%	°C	%	°C	%
1990	185.4	18.1	84.3	-16.2	7.5	20.1	10.4	3.7
1991	157.6	-12.0	97.6	-10.1	6.4	9.8	10.3	2.8
1992	168.4	-5.3	103.9	-1.5	6.8	13.9	10.1	1.0
1993	158.7	-13.6	98.3	-9.9	5.9	3.3	9.2	-9.5
1994	160.8	-3.9	81.5	-18.6	6.0	4.7	10.5	4.6
1995	154.4	-1.8	75.4	-25.3	6.1	6.1	10.2	2.8
1996	153.4	-17.3	98.4	-10.1	5.3	-8.2	10.0	0.0
1997	145.7	-17.0	86.9	-19.7	7.1	16.4	11.1	9.0
1998	175.7	2.8	112.4	13.4	6.3	8.7	9.5	-5.6
1999	206.0	23.8	104.6	2.3	6.8	14.0	11.0	8.3
2000	280.1	48.0	192.1	75.7	7.7	20.6	11.3	10.3
2001	185.1	6.3	116.9	14.7	6.1	6.1	10.9	7.7
2002	176.2	3.6	109.4	7.2	6.9	15.8	11.2	9.7
2003	165.1	0.9	94.6	-3.0	6.9	14.8	11.0	8.4
2004	195.1	10.1	118.1	11.8	7.1	16.6	11.0	8.4
2005	97.6	-0.3	111.9	7.6	7.4	19.5	11.3	10.3

The selection of stands in 1997 was based on detailed field recording in the Oppkuven area by Storaunet et al. (2005; unpublished data at the time of stand selection) of: dead wood and stumps, assigned to appropriate classes of decay and size; age and size measurements for living trees (diameter at breast height (dbh) and age coring); and of productivity index and basal area for the tree stands. This information on tree stand properties made it possible to select stands that were maximally comparable in terms of environmental characteristics and at the same time representing different forest management history. The four south-facing stands chosen were: natural forest (Nat), minor selectively cut (MiSeC), major selectively cut (MaSeC) and clear cut (CleC) stands. The criteria for stand selection were: tree-stand age of at least 60 years; mean inclination 8-22°; similar forest management history over a rectangular area (of at least 20 m width and 0.1 ha); no extensive (at most signs of) natural disturbances such as tree fall during the last 80 years; situated close to 650 m.a.s.l.; tree-layer dominated by *Picea abies*; and lack of species indicating high soil nutrient content. These criteria of placement had to be relaxed for Nat, however, because the area found to be most suitable was situated in a narrow gorge, resulting in both an extended length of the area and a lower mean inclination compared to the other three stands.

The natural forest stand had the lowest number of living trees (dbh >8 cm) per daa (53 trees) and the highest mean age of living trees (136 years; Tab. 2). This was an area

11

apparently not affected by any forest management activity, reflected by the absence of cut stumps and high amounts of dead wood (volume of dead wood 68% of the volume of living trees). In 1997 this stand was a mosaic of patches in the ageing, decay and regeneration phases. This was still the case in 2005 when, in addition, a number of relatively recent windfalls were evident. The MiSeC stand had a mean tree-age of 85 years, and trees up to 200 years of age were present. There were relatively few logs and snags and the estimated volume of dead wood was 18% of the volume of living trees. The area was selectively cut in 1927 when one fifth of the volume of living trees was removed. Logs were in intermediate stages of decay in 1997, whereas the stand in general was in early decay phases without large gaps and with low regeneration. In 2005, a few windfalls and an increased number of snags were observed. The MaSeC stand was subjected to extensive selective cutting in 1927 when 34% of its living volume was removed. The percentage of dead wood in 1997 was slightly less than in MiSeC (5.2 m^3/daa compared to 6.1 m^3/daa) and most trees were 60 to 70 years of age. There were few logs and snags and otherwise the stand was densely forested, without larger gaps and regenerating poorly.

Table 2. Tree-layer characteristics of the Natural (Nat), Minor selectively cut (MiSeC), Major selectively cut (MaSeC) and Clear cut (CleC)stands in Oppkuven, SE Norway (Storaunet et al. 2005). dbh = diameter at breast height.

Characteristics (units of measurement)	Nat	MiSeC	MaSeC	CleC
Dated tree harvests (±2 years)	None	1927	1927	1937
Tree stand; trees alive in 1997				
Number of trees, dbh > 8 cm (daa^{-1})	53	58	108	133
Estimated volume of living trees (m^3/daa)	30.6	33.1	42.7	27.5
Mean age of trees, dbh > 8 cm (years)	126	85	67	…
Dead wood				
Number of logs, dbh > 8 cm (daa^{-1})	36	13	12	…
Number of snags, dbh > 8 cm (daa^{-1})	12	2	11	19
Estimated volume of logs > 8 cm (m^3/daa)	14.1	4.3	0.7	< 1
Estimated volume of snags > 8 cm (m^3/daa)	6.8	1.8	4.5	1.1
Dead wood volume, % of volume of living trees	68	18	12	< 10
Cut stumps				
Number of cut stumps (daa^{-1})	0	26	36	55
Estimated volume removed by cutting (m^3/daa)	0	6.7	14.5	18.7
Removed volume, % of volume of living trees	0	20	34	68

The CleC stand was clear cut in 1937 when 68% of all the living trees were removed; some young trees and saplings were left uncut. Less than 10 % was recorded as dead wood volume

in 1997 and the stand was in the growth phase with scattered gaps (see Tab. 2 for further details for all stands).

Placement of plots

A centreline of 39–54 m (136 m in Nat) was demarcated in the field along the long axis of each rectangular stand area. Each centreline was divided into five (10 in Nat) equal segments. Within the core of each segment (the remaining part after the 3 m near the border of each segment had been excluded), a random position along the centreline was selected for the crossing of a transverse line (at right angle to the centreline) with length 20 m (9–14 m in Nat). A *transverse area* of 20 × 2 m was symmetrically placed around the transverse line. For recording of trees, an *extended transverse area* of 20 × 6 m was symmetrically placed around the transverse area.

Twenty-five plots (1 m^2) were placed in each of the four stands (five in each transverse area); fifteen at random and ten according to following criteria: 1) underneath the largest tree; 2) at the crown perimeter of the largest tree; 3) in the largest gap; 4) at the most distinct terrain concavity; 5) at the most distinct terrain convexity. Furthermore, plot positions were rejected and replaced if including more than 25 % of for instance mire, brook or other non-forest elements and if including trees taller than 2 m or stumps and logs with diameter larger than 0.2 m.

Recording of vegetation

All the one hundred permanently marked 1m^2 plots first analysed in 1997 by T. Økland et al. (2003) were reanalysed in July–September 2005. Each plot was divided into a 4×4 grid; creating 16 subplots each of which measured 0.0625 m^2. Presence/absence of all vascular plant, bryophyte and lichen species was recorded in each subplot (see appendix 1 and 2 for species-plot matrix). A species was defined as present in a subplot if living tissue covered part of the subplot. Vascular plant species > 80 cm of height were not recorded. Most of the work was done *in situ*, but numerous (small) collections were made whenever necessary for determination *ex situ*. Subplot frequency in each plot was used as a measure of species abundance (cf. R. Økland 1990a). Nomenclature follows Lid and Lid (2005), Frisvoll et al. (1995) and Krog et al. (1994) except for: *Dryopteris expansa* agg., that may also include *D. dilatata* (Hoffm.) A.Gray and *D. carthusiana* (Vill.) Fuchs.; *Dicranum fuscescens* agg., that may also include *D. flexicaule* Brid.; the genus *Polytrichastrum* G. L. Sm., which is not recognized as distinct from *Polytrichum* Hedw.; *Lophozia ventricosa* agg., that includes *L.*

silvicola Buch and may also include *L. longiflora* (Nees) Schiffn.; and *Cladonia chlorophaea* agg., that may also include *C. cryptochlorophaea* Asah., *C. grayi* Merr. ex Sandst., *C. fimbriata* (L.) Fr., *C. merochlorophaea* Asah. and *C. pyxidata* (L.) Hoffm.

Recording of environmental variables

The sixteen explanatory variables recorded at each plot from data collected in 1997, used in the study by T. Økland et al. (2003) were applied for description of the basic environmental conditions (topography, soil etc.) at each plot also in the present study (see Tab. 2 for an account of these variables and the methods used for recording them). This was justified by the constancy of topographic variables and the slow change (R. Økland and Eilertsen 1996), high within-year variability (Skyllberg 1991) and high spatial variability (Nykvist and Skyllberg 1989) of soil properties. In September 2005, all living trees (height > 2.0 m) in each stand were measured with respect to diameter at breast height (1.30 m above normal stump height) and tree maps for the area were updated in regards to logs, snags and wind-falls, thus, tree influence was the only environmental variable that was re-recorded in 2005. New values for the tree influence index (R. Økland et al. 1999), comparable with 1997 values reported by T. Økland et al. (2003) were calculated. In retrospect, two of the tree-measurements from 2005 included in the calculation of the tree influence index were apparently erroneous. Choosing a conservative approach, the diameter at breast height of these two measurements was set equal to the measurements in 1997. In 1997 the number of trees measured was 661, whereas in 2005 the number of trees had decreased to 628.

Statistical analyses

All statistical analyses were done using R software, Version 2.2.0 (R Development Core Team 2005). Packages vegan, stats, mva *and* MASS *were used for ordinations and* geoR, MASS *and* splancs *for geostatistical methods. Editing and transforming of data was performed in Microsoft Office Excel (Anonymous 2003).*

Environmental variables

Transformation and standardisation

All 17 variables were transformed to zero skewness by the 'zero-skewness transformation' (R. Økland et al. 2001) prior to analyses to reduce skewness in distributions and, hence, to improve homoscedasticity. Depending on whether a variable (x) was skewed to the left or right, it was transformed as follows:

x right-skewed: $y = \ln(x + c)$

x left-skewed: $y = e^{cx}$

By manual iteration the value for c that corresponded to the skewness minimum was found for each variable. Three of the variables were treated for left-skewness, while the remaining 14 were treated for right-skewness, resulting in |standardised skewness| < 10e–04 for all variables (except LossOI where |standardised skewness| < 10e–03 had to be accepted). After transformation all variables were ranged to a standard 0–1 scale by the formula:

$$z = \frac{(y - y_{min})}{(y_{max} - y_{min})}$$

See Tab. 3 for summary statistics and transformation properties for all environmental variables and appendix 3 and 4 for untransformed and transformed values of all variables, respectively.

Analysing relationships between environmental variables
Principal Component Analysis (PCA) ordination (Pearson 1901; ter Braak and Prentice 1988) was used to extract structure in the matrix of centred and standardised, zero skewness transformed explanatory variables. Conjugated variables (Ponge and Ferdy 1997) were also included in the ordination to make interpretation of grouping along axes more visual. Correlation biplot scaling was preferred to best preserve the correlations among the response variables (ter Braak 1994, Legendre and Legendre 1998), and vector length in PCA-units was calculated for each of the variables. Kendall's non-parametric correlation coefficient (Kendall 1938) was calculated for all pairs of environmental variables as a measure of strength of relationships.

Ordination of vegetation
The full vegetation data matrix consisted of 200 plots (100 permanent plots × 2 times – 1997 and 2005) with subplot frequency recorded for a total of 90 species (appendix 1 and 2). Ordination methods representing the two main families of ordination techniques; geometric and multivariate statistical, were applied to extract gradient structure of the species-plot data matrix. Global Non-metric Multidimensional Scaling (GNMDS) is a geometrical method that

15

optimises the rank-order correspondence between sample-plot distances in the ordination and the floristic between-plot dissimilarities. Detrended Correspondence Analysis (DCA), is based on metric ordinations and is a multivariate method by which gradients in species composition are extracted that maximise the fit of species abundances to a specific species response model to underlying (hypothetical) environmental gradients. These two methods are considered complementary because of their innate differences, thus similar results by the two should indicate that a reliable gradient structure has been found (R. Økland 1990a, 1996).

Comparing ordination methods (DCA and GNMDS)
Kendall's correlation coefficient was calculated for pair-wise DCA- and GNMDS-axes 1 to 4. In addition, Procrustes rotation (Mardia et al. 1979; Peres-Neto and Jackson 2001) as implemented in the R package, library vegan (procedure *procrustes*), was used to assess the degree of correspondence between the two ordinations (the minimum squared differences between the ordinations, to be specific). Procrustes rotation is a non-symmetric method and was thus applied twice to each set of two ordinations to be compared; once with GNMDS and once with DCA as the reference configuration. The averaged sum of squares (SS) from the two rotations was used as a measure of concordance. Furthermore, a PCA was run with ordination axes (DCA and GNMDS sampling unit scores) as variables to visualise the axial relationships.

Results showed that all four axes of the four-dimensional GNMDS were correlated with at least one of the four DCA-axes and vice versa. In addition a lack of increase in procrustes sum of squares with increasing dimensionality motivated for interpretation of four-dimensional ordinations (see results for further details).

Global Non-metric Multi-Dimensional Scaling
GNMDS (Kruskal 1964ab) was run with the following options: two, three and four dimensions, Bray-Curtis distance, initial configurations = 100, maximum iterations = 200 and stress tolerance = 10e–07. Axes were linearly scaled in half change units (HC) so that one unit equalled on average half of the floristic similarity, ranged from 0 to maximum gradient length. To test whether the stands significantly differed along the axes, ANOVA was performed with normal distribution of error and identity-link (package vegan; procedure *lm*) for each of the axes in the four-dimensional solution.

Table 3. Summary statistics and transformation properties for all environmental variables. C-value correspond to degree of skewness.

Code	Variable names	Unit	Range	Treatment	C-value	Recording of variable and comments
						Topography and soil depth variables:
Inclin	Inclination	°	4–48	ln(c+x)	16.32	Measured by a clinometer (400° scale); representative for the sample plot
HeatI	Heat index		–0.52–0.90	e^cx	0.24	Index of insulation (Parker 1988), calculated as HeatI = tan a1*cos a2, where a1 is the inclination and a2 the absolute value of the difference between the plot's aspect and SSW (225°), considered to be the most favourable aspect (Heikkinen 1991)
RoughMe	Median terrain	cm	0.5–18.5	ln(c+x)	1.91	Calculated from the average lengths of six chains, placed on the ground along the borders between subplots (25 cm apart, three chains in each direction), from which the theoretical minimum length of 100 cm was subtracted (Nellemann and Thomsen 1994)
InclMax	Maximum inclination	°	18–100	ln(c+x)	53.14	Measured by a clinometer (400° scale) as the maximum slope between two points in the sample plot, situated 10 cm apart
SoilDMe	Median soil depth	cm	2.0–55.5	ln(c+x)	105.26	The median of eight measurements of the distance a steel rod could be driven into the soil in fixed positions, 25 cm outside the sample plot borders
						Tree influence variables:
BasalA	Basal area		8–40	ln(c+x)	15.71	A measure of tree density, measured at breast heigth by a relascope using relascope factor 1 (Fitje and Strand 1973)
GapAvg	Average gap	%	0.0–36.9	ln(c+x)	0.15	Gaps over the sample plot were measured by a convex, spherical densiometer (Lemmon 1956; Forestry Supplier Inc.) as the percentage of visible sky. Measurements made from the mid-points of the four plot edges, with the meter directed towards the plot, were averaged to derive the variables
TI1	Tree influence (1997)		0.00–0.95	ln(c+x)	2.32	Using the tree influence model (R. Økland et al. 1999), the influence I_i for each plot of tree i was calculated as $I_i = 0.0825\,dbh^{0.6}\,exp(-0.248s^{2.2}\,dbh^{-1.52})$, where s (in dm) is the distance from the plot center to the center of the stem of tree i and dbh is diameter at breast height of tree i.
TI2	Tree influence (2005)		0.00–0.91	ln(c+x)	22.60	The I_i values for all n trees that influence a particular plot are combined to a tree influence index by $TI = 1-\prod_{i=1,..,n}[1-I_i]$
Litter	Litter index		0–1234	ln(c+x)	42.08	Calculated according to Økland (1990a, 1996) and Økland and Eilertsen (1993) as $LitterI_i = \sum_{i=1,..n}(d_i/cr'_i)cc_i ca_i ch_i$, where d_i is the distance from the crown periphery to the proximal sample plot border (i.e. the side facing the stem) along the line through the plot centre and the stem centre for tree i, cr'_i is the crown radius of tree i, measured through the plot centre, cc_i is the crown cover of tree i, ca_i is the crown area of tree i within the 1 m² plot, and ch_i is the length along the stem from top to the point of emergence of the lowest-situated green branch whorl (in m), respectively

						Soil moisture variables:
Mois	Soil moisture, median	vol. %	48.4–81.3	e^cx	0.05	The samples were collected on 19 September 1997, after a period with ample precipitation followed by two rain-free days, weighed, dried at 110°C to constant weight, and weighed. Measurements were interpreted as median soil moisture (cf. Økland 1990a; Økland and Eilertsen 1993)
						Soil chemical and physical variables:
LossOI	Loss on ignition	%	61.0–97.1	e^cx	0.37	Determined by ashing ca. 1g of sample at 550°C in a muffle furnace
pH	pH		3.6–4.6	ln(c+x)	-3.33	Measured in aqueous solution; one part of sample mixed with 2.5 parts of distilled water
Ca	Exchangeable Ca	ppm	284–4305	ln(c+x)	18640	Determined in the Jarrell Ash instrument after adding 50 cm^3 of 1 M NH_4NO_3 solution to 10 g dried soil, leaving the solution overnight, filtering and washing the sediment with 1 M NH_4NO_3 until the extract volume amounted to 250 cm^3. Element concentrations were recalculated as ppm of organic matter (from mg/kg dry sample to mg/kg organic matter, by multiplication with 100 per loss OI), as recommended by T. Økland (1988)
Mg	Exchangeable Mg	ppm	102–518	ln(c+x)	355	
N	Total N	%	1.67–2.66	ln(c+x)	-1.34	Determined by digestion of the dried sample with H_2SO_4 in the presence of a Se catalyst in a Tecator FIA system: recorded as wt. % of organic matter
P.Al	Total P	ppm	68.6–256.3	ln(c+x)	-43.79	Determined by the ammonium lactate-method; one part dried sample was mixed with 20 parts of a solution 0.1 M with respect to ammonium lactate and 0.4 M with respect to acetic acid, pH was adjusted to 3.75, and P determined in the extract by a Jarrell Ash model 1100 ICP instrument

Detrended Correspondence Analysis

DCA (Hill 1979, Hill and Gauch 1980), always providing four axes, was run with detrending by segments and non-linear rescaling as standard options. No down-weighting of rare species was performed.

Comparing GNMDS-axes to LNMDS-axes of the original study by T .Økland et al. (2003)

The vegetation data matrix from T. Økland et al. (2003) consisted of 100 plots and 87 species, and was originally analysed by a four-dimensional LNMDS with the following options: dissimilarity measure = percentage dissimilarity; species abundance standardised by division with species maximum (Faith et al. 1987); minimum number of starting configurations = 100; maximum number of iterations = 1000; stress reduction ratio for stopping the iteration procedure = 0.99999. Several studies (e.g. H. Liu, pers. comm., Pitkänen 1997) have shown that Global NMDS and Local NMDS most often give similar results in terms of vegetation

gradients and correlations with environmental variables, and that they can be considered as equally good alternatives.

Kendall's correlation coefficient was used to compare the GNMDS ordination axes obtained for 200 plots (100 plots first analysed in 1997 and reanalysed in 2005) with the LNMDS ordination axes obtained for the 100 plots analysed in 1997 by T. Økland et al. (2003). Correlation coefficients were calculated between GNMDS scores for the 100 plots analysed in 1997 from the total dataset (GNMDS-axes 1 to 4) of 200 plots and LNMDS scores (axes 1–4) for the same plots according to T. Økland et al. (2003).

Results indicated that essentially the same vegetation gradients were identified by DCA and GNMDS for the 200 plots. However, the DCA ordination showed a weak tongue-effect (R. Økland 1990a) along axis 2, which could indicate that the data structure had been distorted by the detrending procedure. Furthermore, the GNMDS-axes turned out to be more readily interpretable in environmental terms than the DCA-axes, and were strongly related to the corresponding LNMDS-axes found by T. Økland et al. (2003). Consequently, GNMDS was preferred for further in-depth analyses of gradient relationships and vegetation change (see "Results" for further information).

Ecological interpretation of ordinations
Correlation and analysis of variance
The strength of relationships between the sixteen environmental variables (all except the tree influence index from 2005 (TI2) which was not considered relevantly linked to the species composition of 1997) and both the DCA- and GNMDS-axes obtained for 100 plots analysed in 1997 (drawn from the total dataset of 200 plots) was explored by calculating Kendall's non-parametric correlation coefficients. This was done for two reasons: i) to evaluate how well the DCA- and GNMDS-axes corresponded to the environmental variables as support for choice of ordination method; ii) and for using the τ-values for correlating environmental variables to axes of the preferred ordination method in the environmental interpretation of the ordination. The τ-values were, however, used only to indicate the strength of the relationships, as the standard test of the null hypothesis of no relationship does not take nestedness of sampling designs into account, hence will tend to overemphasize the reliability of the data with danger of Type I error, i.e. that the null hypothesis is rejected too often (pseudoreplication; Hurlbert 1984, Legendre 1993, R. Økland in press).

Statistically valid environmental interpretation of ordination axes was instead obtained by a procedure where the nested sampling, consequently the variation, was assigned to two different levels (stand and plot level). Split-plot GLM (package vegan; procedure *aov*) with normal error distribution and identity-link was performed on transformed and ranged environmental values separately for each of the four GNMDS-axes with the null hypotheses of no difference in means between the stands and no relationship between the variable and plot ordination at within-stand scale.

Spatial structure

Ecological variables are often autocorrelated to a certain degree, especially in nested experiment designs such as this (Legendre 1993). Consequently, spatial structure should be considered also when interpreting ordinations (e.g. Palmer 1988). All four GNMDS-axes and all the environmental variables (with UTM grid references used to describe positions in space) were subjected to semivariance analysis (procedure *variog* of library geoR) to obtain a description of spatial dependence and autocorrelation. Semivariance values were standardised by division with sample variance (Rossi et al. 1992). Distances in space were grouped into 9 metric lags (<4, 8, 16, 32, 64, 128, 256, 512, 1024), each lag containing at least 45 observation pairs. Semi-variograms were obtained by plotting standardised semi-variance (y) against distance, given on a log-2 scale with each lag class represented by the 2-logarithm of the geometric mean of the minimum and maximum limits for each lag (x). Within-stand and between-stand variation was separated by grey lines in the semi-variograms. Because of the natural stand being of much greater length than the three other stands (136m vs. 39–54m, respectively); a continuous line was used to represent within-stand variation in MiSeC, MaSeC and CleC whereas a punctuated line represented within-stand variation in Nat.

Testing of change from 1997 to 2005

Species abundance

The hypothesis of no change in abundance from 1997 to 2005 was tested on 41 species (for which abundance change was observed in five or more plots against the two-sided alternative hypothesis of change, by use of the paired Wilcoxon signed rank one-sample test. Seedlings of *Picea abies*, *Betula pubescens* and *Sorbus aucuparia* were not included because of high inter-annual variability (R. Økland 1995). This was done both for total change in subplot frequency for each species, and for change between pairs of stands for each species; a total of 190 tests. A conservative interpretation was used for tests of total change (R. Økland in

press.) although the fine-scaled vegetation mosaic revealed by ordination and the weak spatial structure of ordination axes suggest the danger of Type I errors is small in the present case.

Exact tests based on binomial distributions were constructed for the hypothesis that significant abundance change was observed for no more species than expected by chance, against the one-tailed alternative hypothesis that the observed number of successes (number of species with significant change in abundance) was higher than expected by chance. Tests were made for the total material as well as separately for each stand.

Species composition

Plot score positions along GNMDS 1 to 4 from 1997 vs. 2005 were compared (see appendix 5 for GNMDS plot scores from 1997 and 2005), and displacements along axes 1 to 4 (represented both by actual differences in plot scores and vector lengths along axes 1 & 2, 1 & 3, 1 & 4 and for the total 4-dimensional solution) were calculated as measures of change in species composition (R. Økland and Eilertsen 1996). Mean plot displacements (total and for each stand) along GNMDS-axes 1 to 4 from 1997 to 2005 were used as variables for analysis of species compositional change (along these environmentally interpreted compositional gradients). The hypothesis of zero displacement was tested against the two-tailed alternative by a paired one-sample t-test. Separate tests were made for the total material and for each of the four stands.

Linear models for change in species composition (based on plot scores from 100 plots in 1997 and 2005 drawn from the total dataset of 200 plots) as a response variable for the species composition along GNMDS-axis 1 (based on plot scores from 100 plots in 1997 drawn from the total dataset) were tested for all the stands separately. Average change in plot scores from GNMDS 1 in 1997 to GNMDS1 in 2005 was calculated.

Tree influence

The relationship between total tree influence (as measured by the tree influence index; TI) for all plots calculated from 1997 (TI1) and 2005 (TI2) was expressed in a paired t-test (H_0: mean of differences equals zero). All four stands were also tested separately with the paired t-test. Furthermore, the distribution of variation on different levels was explored using split-plot GLM with normal error and identity link and stand as factor variable on TI1 and TI2. Change in tree influence index from 1997 to 2005 was analysed in histograms, and in addition, tested against TI1 in linear models for all the stands separately.

Relationship between environmental variables and species composition

Tree influence

In order to test for a possible delay in the response of understorey species composition to tree-layer change, a split-plot GLM was performed on GNMDS-axes (all four dimensionalities) with each of the years 1997 and 2005 as response variables, and the tree influence indices from 1997 and 2005 as predictor variables. GLMs with identity-link and normal error structure were thus run for 12 combinations of 8 GNMDS axes (GNMDS 1–4 1997 against TI1 and GNMDS 1–4 2005 against TI1 *and* TI2); the relationship between 1997 species composition and 2005 tree indices was not meaningful and hence not tested. Kendall's τ was also calculated for each of the 12 combinations.

Correlation between environmental variables and species composition over time

Kendall's correlation coefficient was calculated between environmental variables (except TI2; see above) and scores for 2005-analyses of plots along GNMDS-axes 1 to 4 (in addition to the scores for 1997-analyses calculated for environmental interpretation), to explore change in the relationships between environmental variables and species composition over time. Exact binomial tests for number of successes (increase in τ-value from 1997 to 2005) compared to tests along each of the four GNMDS-axes and to total number of tests, were performed.

RESULTS

Relationship among environmental variables

The first four PCA-axes explained 62 % of the total variation in the matrix of environmental variables and the eigenvalues for axes 1–4 were 0.241, 0.162, 0.123 and 0.095, respectively. The sixteen variables grouped somewhat along the first and second axes (Fig. 3). For instance some of the variables relating to tree influence (Litter, GapAvg and TI1; see Tab. 3 for explanations on abbreviations) were highly correlated (Tab. 4) making up one group along the first axis. All variables representing topography (Inclin, InclMax and RoughMe) also grouped together and were strongly positively correlated to each other. Median soil moisture was strongly correlated both to the group of soil chemical-related variables (pH, Ca and to a lesser extent Mg), and to the tree influence variables (TI1 and Litter) along the second axis. Loss on ignition and nitrogen concentrations also grouped together along PCA1.

All variables mentioned above were represented by relatively long vectors, indicating strong relationships with the axes (Tab. 5). Only three (SoilDMe, P.Al and HeatI) of the seventeen explanatory variables had very short vector components along PCA 1 and 2, indicating weak associations with the axes.

Ordination

Comparison of ordination methods

Pair-wise correlation coefficients between 2-, 3- and 4-dimensional GNMDS-axes and DCA (Tabs 6a-c), demonstrate significant correspondence ($p < 0.0001$) between many axes, but not strong relationships in terms of high τ-values for all. The first axes of all GNMDS-ordinations corresponded strongly to the first DCA-axis; all $\tau > 0.6$. Axes 1 and 2 of the two-dimensional GNMDS- and DCA-axes 1 and 2 were significantly correlated in all pairs, indicating that the two-dimensional GNMDS- and DCA-axes 1 and 2 captured much of the same compositional variation (Tab. 6a). Mainly the same applied to the three-dimensional GNMDS- compared to DCA-axes 1–3 (Tab. 6b) and the four-dimensional GNMDS compared to DCA-axes 1–4 (Tab. 6c); all axes obtained by one method were correlated with at least one axis obtained by the other method with $\tau > 0.34$. This indicated that the variation expressed on GNMDS- and DCA-axes in the same number of dimensions was much the same, but sorted differently on the axes.

Table 4. Pairwise correlations (Kendall) between all environmental variables. τ-values on the left lower-side, and p-values on the right upper-side. For explanations of the abbreviations, see Tab. 3. $p < 0.05$, $|\tau| > 0.3$

T / P	Mois	Litter	BasalA	Inclin	HeatI	SoilDMe	RoughMe	InclMax	GapAvg	LossOl	pH	Ca	Mg	TotN	P.Al	TI1
Mois		**<0.001**	0.312	0.091	0.368	0.239	0.447	0.943	**0.002**	0.203	**<0.0001**	**<0.0001**	**0.004**	0.284	0.640	**<0.0001**
Litter	-0.240		0.199	0.090	0.360	0.073	0.260	**0.039**	**<0.0001**	0.052	0.097	**0.040**	**0.019**	**0.002**	0.535	**<0.0001**
BasalA	0.070	0.089		**0.004**	0.417	0.884	**0.031**	0.055	**0.001**	0.108	0.389	0.117	**<0.001**	0.816	0.151	**0.010**
Inclin	-0.117	-0.118	-0.204		**<0.0001**	0.919	**0.001**	**<0.0001**	0.711	0.098	0.174	**0.035**	**0.003**	0.123	0.067	0.263
HeatI	-0.061	0.063	0.056	0.461		0.476	0.129	**0.008**	**0.043**	**0.039**	0.845	0.430	0.249	**0.018**	0.277	0.112
SoilDMe	0.080	-0.123	-0.010	0.007	-0.049		0.549	0.297	0.141	**0.010**	0.500	0.826	0.184	0.161	0.151	0.634
RoughMe	-0.053	-0.079	-0.153	0.228	0.106	0.042		**<0.0001**	**0.019**	0.060	0.597	0.442	0.157	0.282	0.053	0.097
InclMax	0.005	-0.143	-0.158	**0.369**	0.183	-0.073	**0.417**		0.102	0.075	0.900	0.306	0.080	**0.028**	**0.016**	0.058
GapAvg	0.218	-0.414	-0.232	0.026	-0.142	0.104	0.169	0.117		0.341	0.267	0.057	**0.003**	0.075	0.105	**<0.0001**
LossOl	0.087	0.134	-0.112	-0.115	-0.142	0.178	-0.133	-0.124	-0.067		**0.036**	0.919	0.644	**<0.0001**	0.941	**0.009**
pH	**0.322**	-0.124	0.065	-0.103	-0.015	-0.050	-0.040	0.010	0.085	-0.157		**0.001**	**<0.001**	**0.001**	0.389	**0.019**
Ca	**-0.379**	0.140	-0.108	0.146	0.054	0.015	0.054	0.071	-0.133	0.007	-0.242		**<0.0001**	0.117	0.060	**0.004**
Mg	-0.194	-0.160	-0.262	0.207	-0.078	0.091	0.099	0.121	0.210	-0.032	-0.266	**0.416**		0.936	0.151	**0.034**
TotN	0.073	-0.210	-0.016	0.107	0.161	-0.096	0.075	0.152	0.125	**-0.369**	0.243	-0.107	-0.005		0.657	**<0.0001**
P.Al	-0.032	0.042	0.099	-0.127	-0.074	-0.098	-0.136	-0.168	-0.114	0.005	-0.064	0.128	0.098	0.030		0.347
TI1	-0.295	**0.555**	0.178	-0.078	0.108	-0.033	-0.116	-0.131	**-0.387**	0.179	-0.174	0.194	-0.144	-0.284	-0.064	
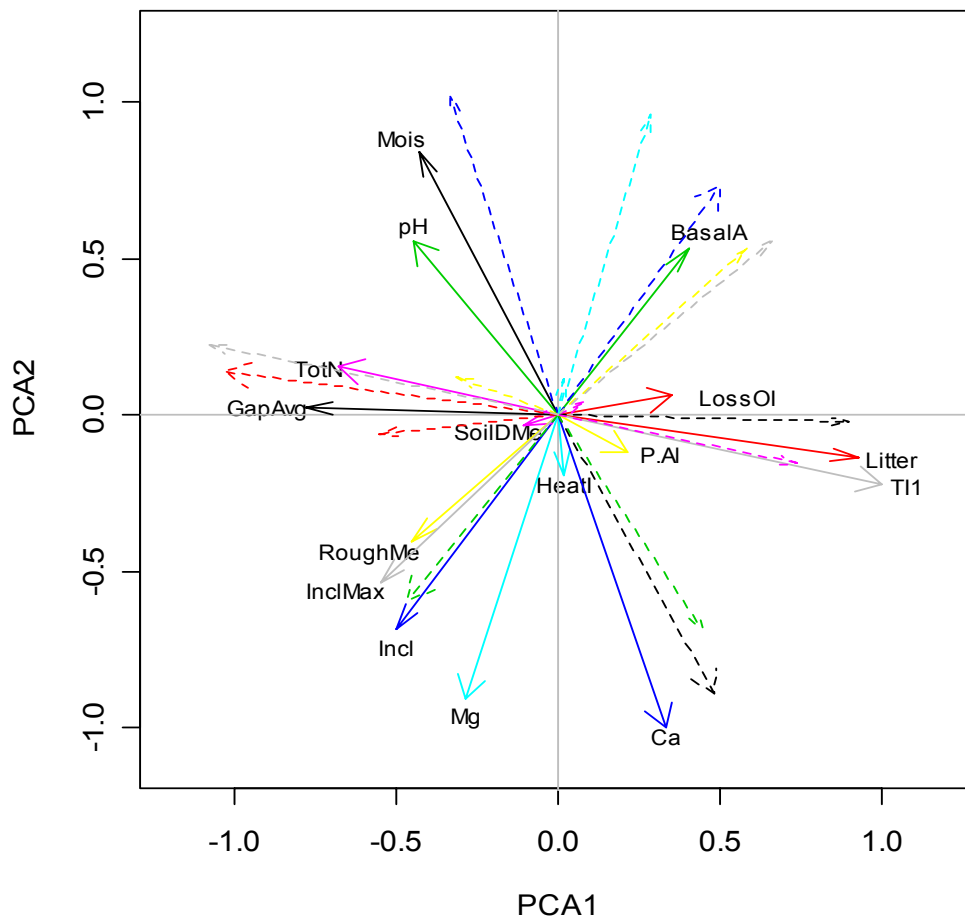
Figure 3. PCA ordination plot axes 1 and 2 of environmental variables. (Punctuated lines represent conjugated axes.)

Table 5. Vector length (in PCA units) along PCA 1 and 2 for all environmental variables sorted by increasing length.

	Vector length
SoilDMe	0.096
HeatI	0.115
P.Al	0.339
LossOl	0.557
BasalA	0.753
TotN	0.758
RoughMe	0.790
pH	0.821
InclMax	0.863
Inclin	0.888
GapAvg	0.902
Mg	1.002
Mois	1.014
Litter	1.039
Ca	1.074
Tl1	1.104

Table 6a. Kendall's correlation test of the two-dimensional GNMDS against the first two axes of DCA. Pairs of axes corresponding the strongest.

τ	GNMDS1	GNMDS2
DCA1	**0.650**	-0.261
DCA2	0.358	**0.344**
P		
DCA1	<0.0001	<0.0001
DCA2	<0.0001	<0.0001

Table 6b. Kendall's correlation test of the three-dimensional GNMDS against the first three axes of DCA. Pairs of axes corresponding the strongest.

τ	GNMDS1	GNMDS2	GNMDS3
DCA1	**0.648**	-0.260	0.273
DCA2	0.358	0.174	**0.341**
DCA3	0.113	**0.463**	0.326
P			
DCA1	<0.0001	<0.0001	<0.0001
DCA2	<0.0001	<0.001	<0.0001
DCA3	0.017	<0.0001	<0.0001

Table 6c. Kendall's correlation test of the four-dimensional GNMDS against the first four axes of DCA. Pairs of axes corresponding the strongest.

τ	GNMDS1	GNMDS2	GNMDS3	GNMDS4
DCA1	**0.641**	**0.359**	-0.080	-0.147
DCA2	0.273	-0.248	**0.422**	0.038
DCA3	0.261	-0.296	-0.359	-0.259
DCA4	0.165	-0.041	-0.226	**0.444**
P				
DCA1	<0.0001	<0.0001	0.092	0.002
DCA2	<0.0001	<0.0001	<0.0001	0.421
DCA3	<0.0001	<0.0001	<0.0001	<0.0001
DCA4	<0.001	0.387	<0.0001	<0.0001

The PCA ordination (with eigenvalues 0.232, 0.212, 0.203 and 0.031 for PCA 1−4, respectively) of ordination axes (four-dimensional solution of GNMDS and DCA 1 to 4) confirmed the strong relationship between DCA1 and GNMDS 1 along the first PCA-axis (Fig. 4a) ($\tau = 0.563$ and 0.658, respectively). GNMDS 2 and GNMDS 3 were not most strongly related to their DCA-equivalents; GNMDS 2 correlated most strongly to DCA 1 along PCA 3 ($\tau = 0.635$ and 0.336, respectively), and GNMDS 3 most strongly to DCA 2 along the second PCA-axes ($\tau = 0.603$ and 0.650, respectively). The fourth pair of axes (DCA 4 and GNMDS 4) were most strongly related with the third PCA-axis ($\tau = 0.377$ and 0.605, respectively) (Fig. 4b).
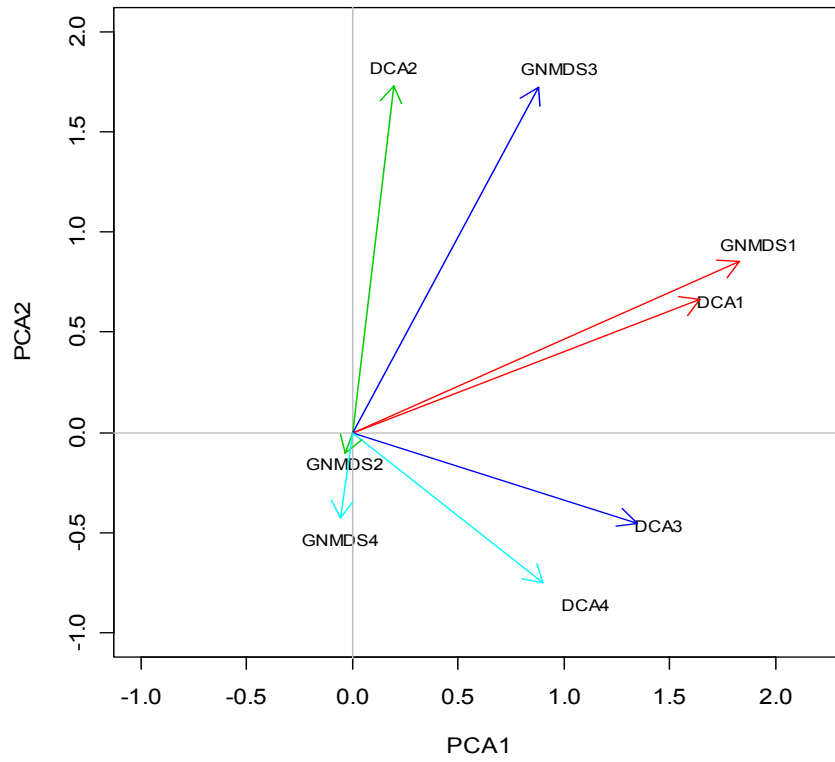
Figure 2a. PCA 1 and 2 on all DCA- and GNMDS-axes.
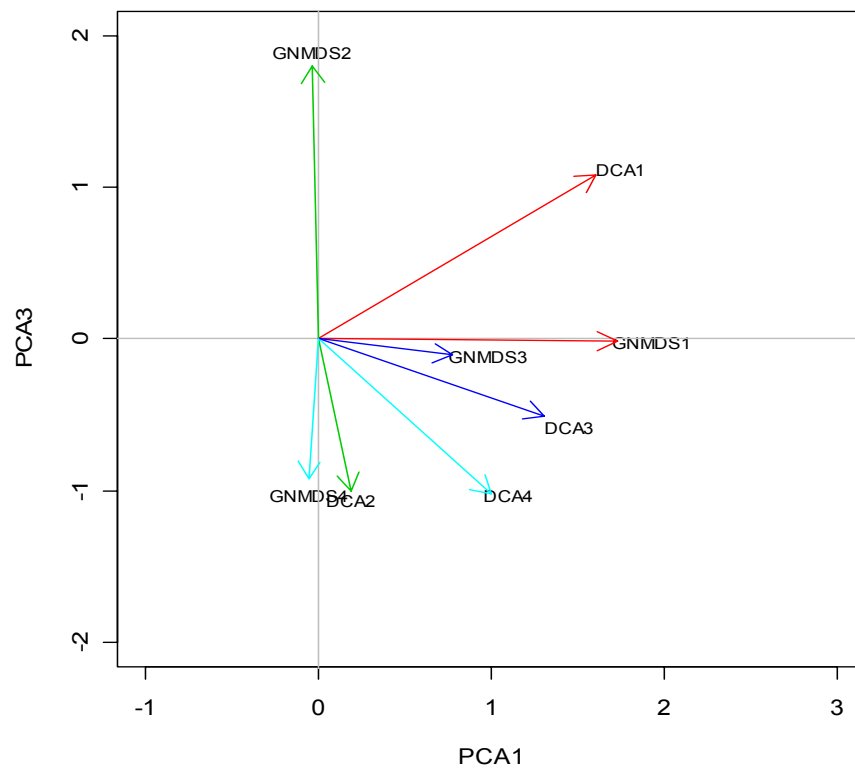
Figure 2b. PCA 1 and 3 on all DCA- and GNMDS-axes.

27

Procrustes rotation showed that the overall similarity (differences in sum of squares) were quite similar among ordinations with dimensionalities 2, 3 and 4 (averaged SS-values were 27.33, 26.45 and 28.14, respectively).

GNMDS

The gradient lengths of the axes (in the four-dimensional GNMDS) were 2.53, 1.79, 1.79 and 1.40, respectively. The plots were distributed quite evenly along the first axis (Fig. 5a), although they clustered somewhat for high values along axis 1. Along the second axis plot number 197 made up a weak outlier, situated about one half HC unit from the nearest plot in the lower left corner of Fig. 5a; otherwise the plots spread evenly in the ordination. Apart from plot number 189 situated about 0.75 units apart from the others in the upper left corner along axis three (Fig. 5b); the plot scores were also relatively evenly distributed along GNMDS 3 and GNMDS 4 (Fig. 5c). The different stands separated significantly ($p = 0.006$) along GNMDS 1 (Tab. 7), making out two groups of stands that were significantly ($0.05 < p < 0.001$) related to each other; Nat and MiSeC to MaSeC and CleC. Stands differed highly significantly ($p < 0.0001$) along axes number two, three and four. Nat and MaSeC separated significantly from MiSeC and CleC along GNMDS 2; the relationship among stands was the same along GNMDS 3 as along GNMDS 1 (mentioned above); and CleC was highly significantly different from all the other stands along GNMDS 4.

Table 7. One-way ANOVA for GNMDS axes as response variables, with stand as predictor. df: degrees of freedom attributed to total number of plots and stands, respectively. Var.exp. = fraction of variation in plot score along the axis that is explained by stand affiliation F: *F*-statistic testing the nullhypothesis of no difference between stands with corresponding p-values. Also showing pairwise comparisons between stands based on linear models testing t-statistic of stand median different from 0. a/b: different letters indicate significant difference between stands. Cor. var: Corresponding variables to PCA-axes as indicated by Kendall's non-parametric test.

	ANOVA-table GNMDSx ~ Stand df =196 + 3			Pairwise comparisons					
Axis	Var.exp.	F	P	Nat	MiSeC	MaSeC	CleC	Cor.var.	τ
GNMDS 1	0.557	4.265	0.006	a	a	b	b	TI1	0.492
GNMDS 2	0.722	7.599	<0.0001	a	b	a	b	InclMax	0.309
GNMDS 3	0.738	7.835	<0.0001	a	a	b	b	Mois	0.377
GNMDS 4	0.800	26.510	<0.0001	a	a	a	b	P.Al	0.283
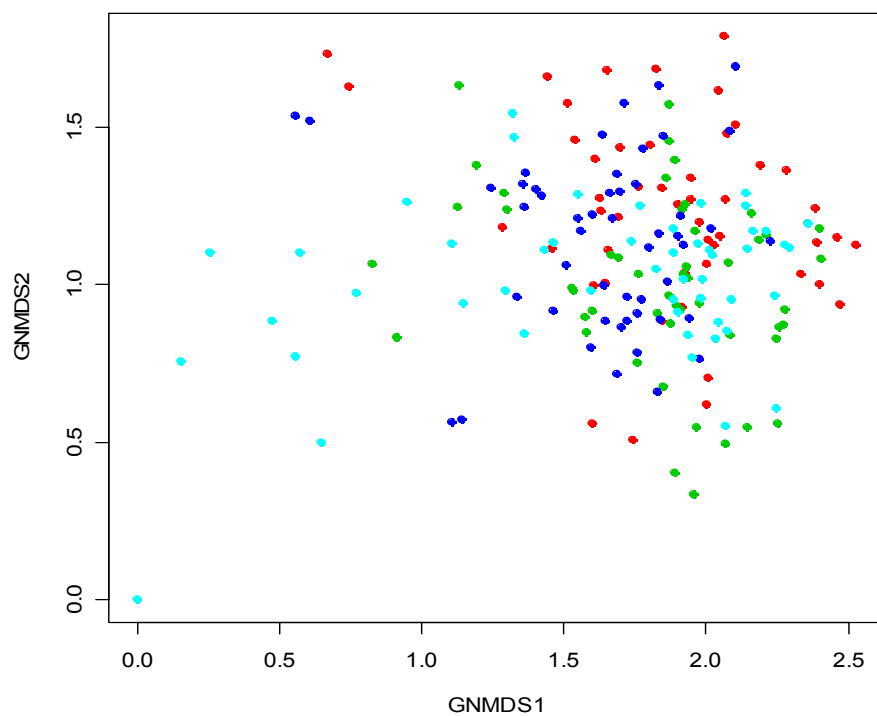
Figure 5a.GNMDS ordination of the total dataset (200 plots), axes 1 and 2.
(Nat, MiSeC, MaSeC and CleC.)
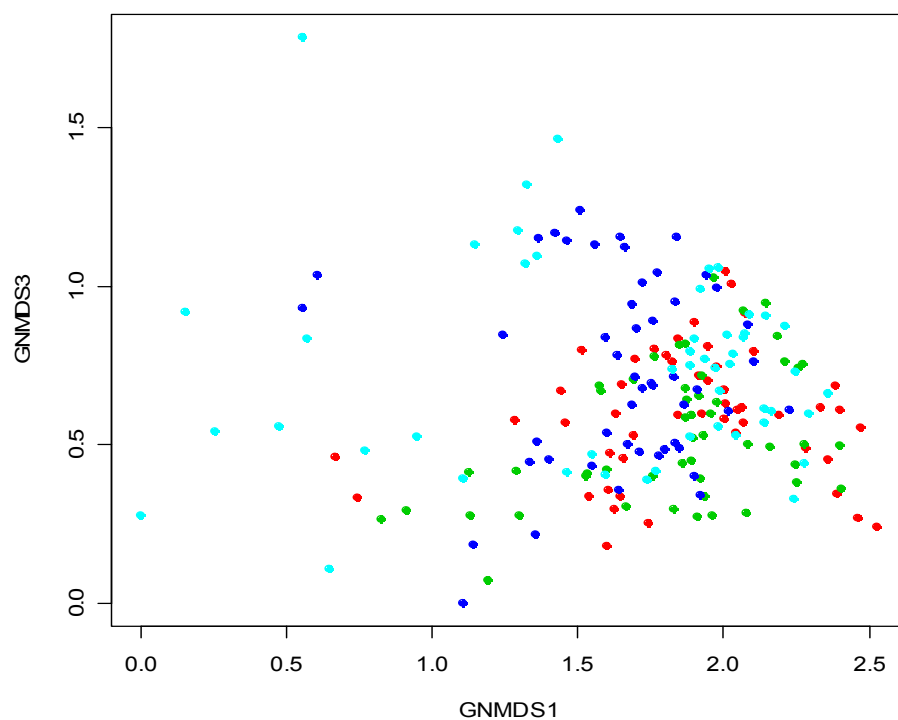
Figure 5b. GNMDS ordination of the total dataset (200 plots), axes 1 and 3.
(Nat, MiSeC, MaSeC and CleC.)
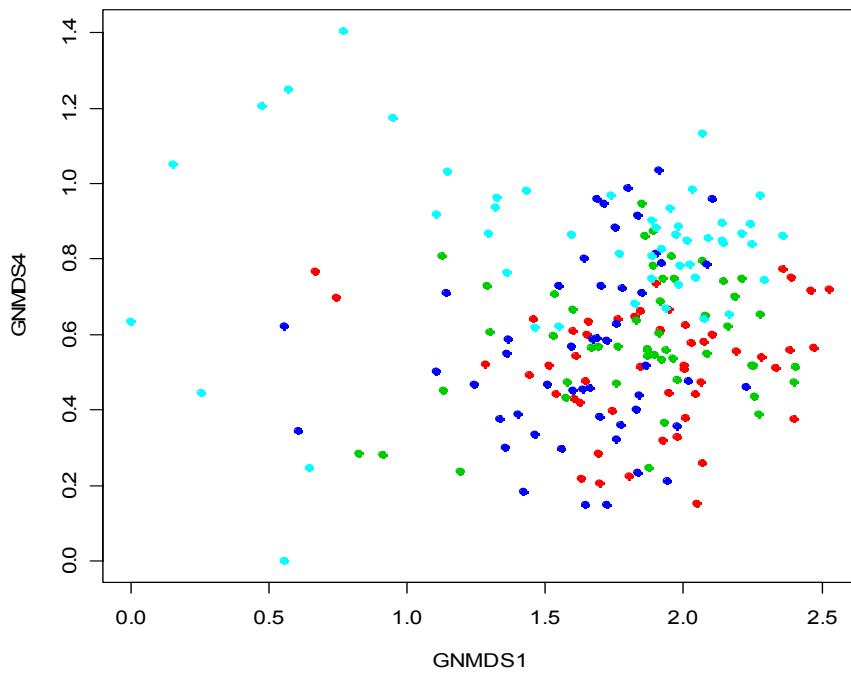
Figure 5c. GNMDS ordination of the total dataset (200 plots), axes 1 and 4.
(Nat, MiSeC, MaSeC and CleC.)
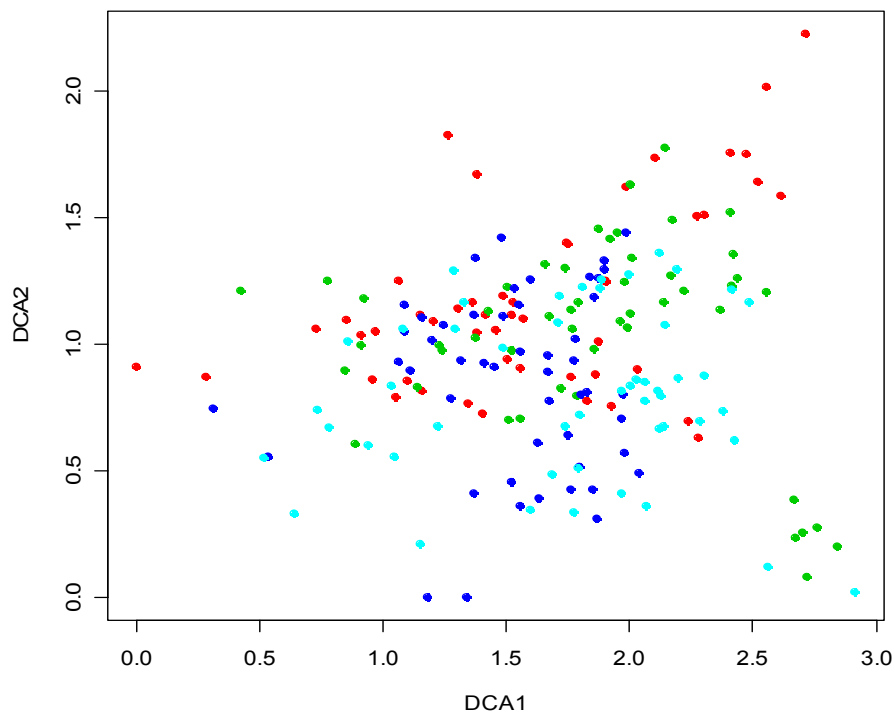
Figure 6a. DCA ordination of the total dataset (200 plots), axes 1 and 2.
(Nat, MiSeC, MaSeC and CleC stand.)
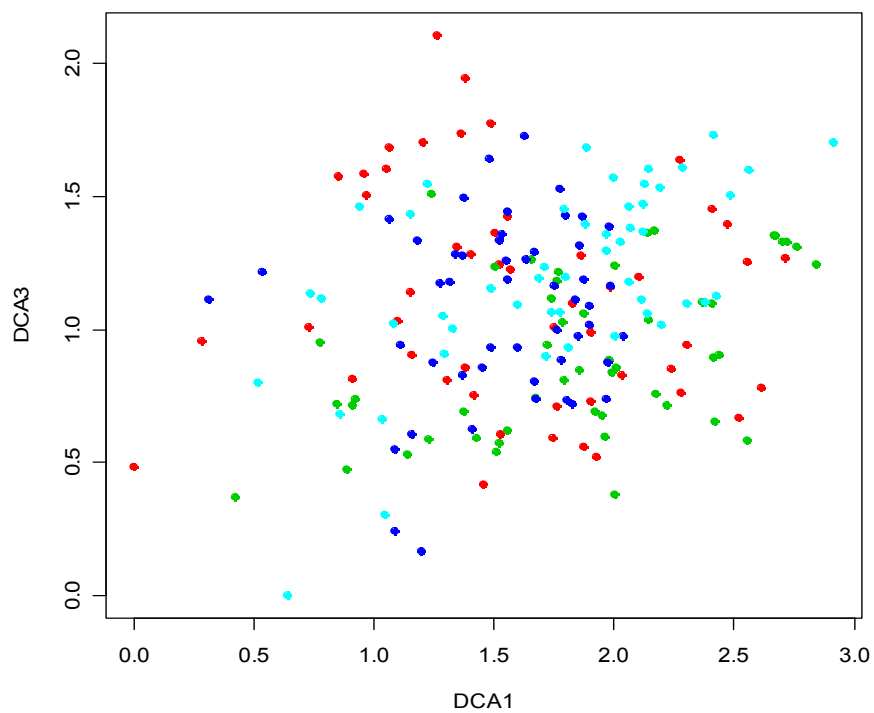
Figure 6b. DCA ordination of the total dataset (200 plots), axes 1 and 3.
(Nat, MiSeC, MaSeC and CleC stand.)
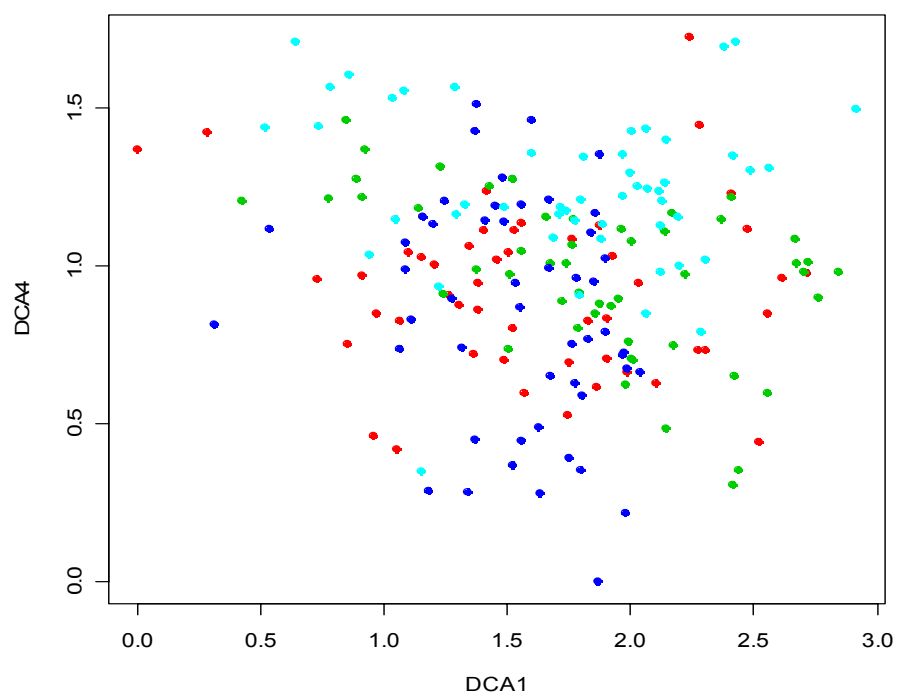
Figure 6c. DCA ordination of the total dataset (200 plots), axes 1 and 4.
(Nat, MiSeC, MaSeC and CleC stand.)

DCA

The eigenvalues of the first four axes were 0.208, 0.157, 0.126 and 0.103, respectively, and their gradient lengths were 2.91, 2.23, 2.10 and 1.72. The distribution of plots in the DCA axes 1 and 2 diagram (Fig. 6a) indicated a weak tongue-effect; a higher spread of plots along DCA 2 for high values along DCA 1. There was no clear segregation of the four stands along the first two axes; all plots seemed to spread evenly. Along the third and fourth axes (Fig. 6b-c) the distribution of the plots was very similar; spreading along full axes-lengths.

Comparing GNMDS-axes to LNMDS-axes of the study by T .Økland et al. (2003)

Kendall's correlation coefficients between pairs of 1997 plots along the GNMDS of 200 plots in the present study and along the LNMDS-axes of T. Økland et al. (2003) were high (all τ > 0.75) in all pairs (Tab. 8), indicating that the same gradients in species composition were obtained in both studies.

Table 8. Kendall's correlation test on LNMDS-axes 1−4 from T. Økland et al. (2003) against GNMDS-axes 1−4 from 1997 (scores drawn from the total GNMDS of 200 plots). **τ > 0.75**

T	GNMDS1.97	GNMDS2.97	GNMDS3.97	GNMDS4.97
LNMDS1	**0.920**	-0.085	0.081	0.110
LNMDS2	-0.026	**0.778**	0.159	-0.037
LNMDS3	-0.016	-0.145	**0.753**	0.101
LNMDS4	-0.050	0.119	-0.024	**0.852**
P				
LNMDS1	<0.0001	0.215	0.241	0.109
LNMDS2	0.704	<0.0001	0.021	0.592
LNMDS3	0.818	0.035	<0.0001	0.145
LNMDS4	0.470	0.084	0.727	<0.0001

Ecological interpretation of ordinations

Correlating DCA and GNMDS with environmental variables

Kendall's correlation coefficient between the explanatory variables and both GNMDS- and DCA-axes (Tab. 9) showed that both methods produced axes that were clearly related to the environmental variables, however the GNMDS ordination presented a more clearly interpretable set of axes. Both GNMDS 1 and DCA 1 were related the most to tree influence, although more for GNMDS 1 than for DCA 1 (τ= −0.492 and −0.330, respectively). In fact, all the variables included in the tree influence-group (Litter, BasalA, GapAvg and TI) had τ-values > 0.3 along GNMDS 1. The remaining GNMDS-axes showed the strongest correlations to InclMax (τ = 0.309), Mois (τ = 0.377) and P.Al (τ = 0.283) for axes 2, 3 and 4, respectively. In comparison, DCA 2 correlated strongly to Mg (τ = 0.378), DCA 3 to TI1

($\tau = -0.418$) and DCA 4 to P.Al ($\tau = -0.270$).

Results from the comparison of the two ordination techniques and from split-plot GLM on environmental variables for each of the GNMDS-axes motivated for choice of the four-dimensional solution in further interpretation.

Table 9. Kendall's correlation test on environmental variables against GNMDS- and DCA-axes from 1997 (scores withdrawn from the total ordinations of 200 plots). $|\tau| > \mathbf{0.3}$

τ	GNMDS1	GNMDS2	GNMDS3	GNMDS4	DCA1	DCA2	DCA3	DCA4
Mois	0.244	-0.100	**0.377**	0.198	0.272	-0.216	**0.312**	0.017
Litter	**-0.336**	-0.186	-0.203	-0.084	-0.177	-0.090	**-0.388**	-0.174
BasalA	**-0.323**	-0.086	0.215	0.095	-0.161	**-0.302**	0.041	-0.040
Inclin	0.025	0.220	-0.071	-0.062	-0.089	0.137	-0.006	0.114
HeatI	-0.182	0.128	-0.039	0.038	-0.206	-0.045	-0.045	-0.002
SoilDMe	0.039	-0.023	0.099	-0.031	0.046	-0.042	0.030	0.077
RoughMe	0.120	0.193	0.001	-0.110	-0.038	0.097	0.095	0.119
InclMax	0.072	**0.309**	0.084	-0.086	-0.099	0.100	0.214	0.254
GapAvg	**0.419**	0.072	0.054	-0.004	0.272	0.110	0.288	0.144
LossOI	-0.117	-0.157	-0.068	-0.010	0.010	-0.101	-0.164	-0.137
pH	0.092	-0.083	0.246	0.131	0.115	-0.169	0.223	0.053
Ca	-0.239	0.128	**-0.360**	-0.075	**-0.301**	0.269	-0.229	-0.084
Mg	0.118	0.177	-0.261	-0.043	-0.008	**0.378**	-0.063	0.013
TotN	0.192	0.121	0.097	0.056	0.092	0.109	0.191	0.109
P.Al	0.004	-0.049	-0.116	0.283	0.081	0.086	0.030	-0.270
TI1	**-0.492**	-0.163	-0.199	-0.165	**-0.330**	-0.123	**-0.418**	-0.089

Interpretation of GNMDS-axes by split-plot GLM and correlation analysis

The total sum of squares (total variation in plot positions along the GNMDS-axes) estimated by split-plot GLM on the four GNMDS-axes were 21.657, 9.686, 8.034 and 6.003, respectively. (For SS_{stand}, SS_{plot}, fraction of variance explained on within- and between-stand level as well as $SS_{exp}/SS_{stand/plot}$: see Tab. 10a-d). The first GNMDS-axis (Tab. 10a) was strongly correlated with tree influence ($\tau = -0.492$) and all other variables related to tree influence (Litter, BasalA and GapAvg; all $|\tau| > 0.32$). This pattern was reflected in the split-plot analysis, where all the tree influence-variables were highly related ($p < 0.0001$) on within-stand level. Tree influence, litter and basal area were all increasing while gap average was decreasing along the first axis. The second GNMDS-axis (Tab. 10b) was highly correlated with InclMax ($\tau = 0.309$; Tab. 10b) as found also in the split-plot analysis on within-stand level ($p < 0.0001$). Median soil depth was weakly related ($0.001 < p < 0.05$) both on plot scale (see Tab. 10b) *and* on between-stand level in the split-plot GLM. GNMDS 3 was strongly correlated with soil moisture ($\tau = 0.377$) and Ca ($\tau = -0.360$; Tab. 10c) as reflected also in the split-plot analyses. On stand scale, pH related moderately

Tables 10a-d. Split-plot GLM (normal error and identity link) on GNMDS-axes 1 to 4 for stand level and plot level. Kendall's correlation test on environmental variables against the respective axes. SS: total variation. SSstand: variation explained on stand scale. SSplot: variation explained on plot scale. FVE: fraction of variation attributed to the given scale. df: degrees of freedom distributed on the different scales and total. Coef: model coefficient. SSexplained/SSstand and plot: fraction of variation explained by the variable at the given scale. F: F statistic for test of the hypothesis that coef = 0 against the two-tailed alternative. P < 0.05 and $|\tau| > 0.3$.

Table 10a. GNMDS 1.

GNMDS1	Stand				Plot within stand				Kendall
SS=21.657	SSstand=1.576 FVE=0.073				SSplot=20.081 FVE=0.927				
df=99	df=3				df=96				
	SSexp/SSstand	Coef.	F	P	SSexp/SSplot	Coef.	F	P	τ
Mois	0.397	-0.897	1.318	0.370	0.193	0.971	22.754	**<0.0001**	0.244
Litter	0.348	-0.945	1.067	0.410	0.194	-0.666	22.876	**<0.0001**	**-0.336**
BasalA	0.839	-0.738	10.391	0.084	0.207	-1.312	24.830	**<0.0001**	**-0.323**
Inclin	0.715	1.119	5.022	0.154	<0.0001	-0.037	0.029	0.865	0.025
HeatI	0.013	-0.711	0.026	0.888	0.081	-0.345	8.342	**0.005**	-0.182
SoilDMe	0.025	0.231	0.052	0.841	0.007	0.197	0.695	0.407	0.039
RoughMe	0.382	0.929	1.235	0.382	0.058	0.674	5.887	**0.017**	0.120
InclMax	0.843	1.140	10.764	0.082	0.010	0.173	0.990	0.322	0.072
GapAvg	0.522	0.740	2.186	0.277	0.332	0.944	47.175	**<0.0001**	**0.419**
LossOl	0.250	1.037	0.668	0.500	0.027	-0.351	2.654	0.107	-0.117
pH	0.867	-2.167	13.069	0.069	0.033	0.504	3.209	0.076	0.092
Ca	0.677	2.092	4.186	0.177	0.178	-1.105	20.577	**<0.0001**	-0.239
Mg	0.535	1.014	2.297	0.269	0.008	0.264	0.810	0.371	0.118
TotN	0.005	0.343	0.010	0.930	0.055	0.543	5.535	**0.027**	0.192
P.Al	0.203	-0.582	0.508	0.550	0.001	0.086	0.065	0.799	0.004
TI1	0.081	-0.510	0.175	0.716	0.444	-1.139	75.845	**<0.0001**	**-0.492**

Table 10b. GNMDS 2.

GNMDS2	Stand				Plot within stand				Kendall
SS=9.686	SSstand=1.138 FVE=0.117				SSplot=8.547 FVE=0.882				
df=99	df=3				df=96				
	SSexp/SSstand	Coef.	F	P	SSexp/SSplot	Coef.	F	P	τ
Mois	0.037	-0.233	0.077	0.808	0.014	-0.172	1.368	0.245	-0.100
Litter	0.702	-1.140	4.704	0.162	0.044	-0.208	4.407	**0.038**	-0.186
BasalA	0.187	-0.296	0.459	0.568	0.005	-0.133	0.481	0.490	-0.086
Inclin	0.411	0.721	1.396	0.359	0.055	0.324	5.570	**0.020**	0.220
HeatI	0.060	-1.326	0.129	0.754	0.050	0.486	5.011	0.028	0.128
SoilDMe	0.930	1.190	26.669	**0.036**	0.006	-0.113	0.536	0.466	-0.023
RoughMe	0.196	0.566	0.489	0.557	0.104	0.587	11.026	0.001	0.193
InclMax	0.426	0.689	1.484	0.347	0.165	0.451	18.804	**<0.0001**	**0.309**
GapAvg	0.776	0.767	6.906	0.119	0.002	-0.043	0.157	0.693	0.072
LossOl	0.169	0.724	0.406	0.589	0.078	-0.387	8.015	**0.006**	-0.157
pH	0.079	-0.557	0.172	0.718	0.003	-0.097	0.270	0.604	-0.083
Ca	0.420	1.399	1.445	0.352	0.007	0.147	0.707	0.403	0.128
Mg	0.712	0.995	4.948	0.156	0.002	0.091	0.223	0.638	0.177
TotN	0.028	-0.696	0.058	0.833	0.032	0.271	3.165	0.078	0.121
P.Al	0.640	-0.878	3.548	0.200	0.013	0.244	1.252	0.266	-0.049
TI1	0.121	-0.531	0.276	0.652	0.039	-0.222	3.901	0.051	-0.163

Table 10c. GNMDS 3.

GNMDS3	Stand				Plot within stand				Kendall
SS=8.034	SSstand=0.771 FVE=0.0960				SSplot=7.264 FVE=0.904				
df=99	df=3				df=96				
	SSexp/SSstand	Coef.	F	P	SSexp/SSplot	Coef.	F	P	τ
Mois	0.744	0.859	5.807	0.138	0.120	0.461	13.000	**<0.001**	**0.377**
Litter	0.127	0.398	0.290	0.644	0.072	-0.244	7.345	**0.008**	-0.203
BasalA	0.510	0.403	2.079	0.286	0.090	0.520	9.396	**0.003**	0.215
Inclin	0.797	-0.827	7.878	0.107	0.002	-0.063	0.234	0.630	-0.071
Heatl	0.063	-1.111	0.134	0.750	<0.0001	-0.037	0.032	0.858	-0.039
SoilDMe	0.026	-0.162	0.052	0.840	0.018	0.188	1.773	0.186	0.099
RoughMe	0.675	-0.864	4.158	0.178	<0.0001	0.021	0.015	0.915	0.001
InclMax	0.767	-0.761	6.591	0.124	0.040	0.205	3.954	0.050	0.084
GapAvg	0.355	-0.427	1.103	0.404	0.001	0.026	0.069	0.794	0.054
LossOl	0.026	-0.232	0.053	0.840	0.004	-0.085	0.424	0.517	-0.068
pH	0.998	1.625	919.650	**0.001**	0.046	0.358	4.552	**0.035**	0.246
Ca	0.362	-1.069	1.133	0.399	0.153	-0.617	17.212	**<0.0001**	**-0.360**
Mg	0.314	-0.544	0.917	0.439	0.110	-0.573	11.725	**0.001**	-0.261
TotN	0.178	-1.444	0.434	0.578	0.006	0.110	0.598	0.441	0.097
P.Al	0.330	0.519	0.986	0.425	0.076	-0.544	7.851	**0.006**	-0.116
Tl1	0.006	-0.095	0.012	0.924	0.046	-0.221	4.603	**0.034**	-0.199

Table 10d. GNMDS 4.

GNMDS4	Stand				Plot within stand				Kendall
SS=6.003	SSstand=1.667 FVE=0.278				SSplot=4.336 FVE=0.722				
df=99	df=3				df=96				
	SSexp/SSstand	Coef.	F	P	SSexp/SSplot	Coef.	F	P	τ
Mois	0.702	1.227	4.707	0.162	0.010	0.105	0.997	0.321	0.198
Litter	0.174	0.688	0.422	0.583	0.039	-0.140	3.899	0.051	-0.084
BasalA	0.118	0.284	0.267	0.657	<0.0001	0.016	0.013	0.908	0.095
Inclin	0.825	-1.237	9.433	0.092	0.013	0.110	1.219	0.272	-0.062
Heatl	0.193	-2.864	0.477	0.561	0.007	0.134	0.717	0.399	0.038
SoilDMe	0.546	-1.103	2.401	0.261	0.047	0.232	4.659	0.033	-0.031
RoughMe	0.910	-1.475	20.136	**0.046**	<0.0001	0.009	0.004	0.948	-0.110
InclMax	0.618	-1.004	3.229	0.214	<0.0001	0.003	0.002	0.968	-0.086
GapAvg	0.494	-0.740	1.948	0.298	0.029	0.129	2.794	0.098	-0.004
LossOl	0.012	0.235	0.025	0.890	0.006	0.074	0.538	0.465	-0.010
pH	0.541	1.761	2.359	0.264	0.001	-0.036	0.075	0.785	0.131
Ca	0.172	-1.084	0.415	0.586	<0.0001	-0.019	0.024	0.878	-0.075
Mg	0.361	-0.858	1.131	0.399	0.018	0.179	1.730	0.192	-0.043
TotN	0.309	-2.797	0.894	0.444	0.026	0.173	2.532	0.115	0.056
P.Al	0.961	1.302	48.486	**0.020**	0.052	0.348	5.252	**0.024**	0.283
Tl1	0.082	-0.528	0.178	0.714	0.045	-0.169	4.521	0.036	-0.165

strong (p = 0.001, $SS_{explained}/SS_{stand}$ = 0.998) along the third axis. GNMDS 4 (Tab. 10d) had no τ-values > 0.3; P.Al had the highest correlation coefficient value of 0.283. The split-plot analysis showed the same weakly significant main gradient both on plot- *and* stand-scale. RoughMe was also significantly (p = 0.046) related (negatively) to GNMDS 4 on stand level.

Spatial structure

The standardised semi-variograms for all ordination axes demonstrated that there was no strong spatial structure in species composition, as shown in T. Økland et al. (2003). All axes showed some increase in semivariance as function of distance (lag class) up to ranges of 32, 16, 8 and 16 m along GNMDS 1 to 4, respectively, but the increase was weak in all cases and even lower semi-variances than obtained for lag class 1 (< 4 m) were in all cases obtained for at least one lag class above the range (Figs 7a-d). Distance < 54 m for MiSeC, MaSeC and CleC (grey line) and distance < 136 m for Nat represented within-stand variation and were in most cases weak. On between-stand level (distance > 54 m), the semi-variance varied irregularly. The semi-variance almost always peaked in the area between the two grey lines (representing variation on within-stand level for MiSeC, MaSeC and CleC vs. Nat) probably due to the low number of observation-pairs in this lag class, representing the difference between the upper and the lower part of the Nat stand rather than a generally valid relationship.
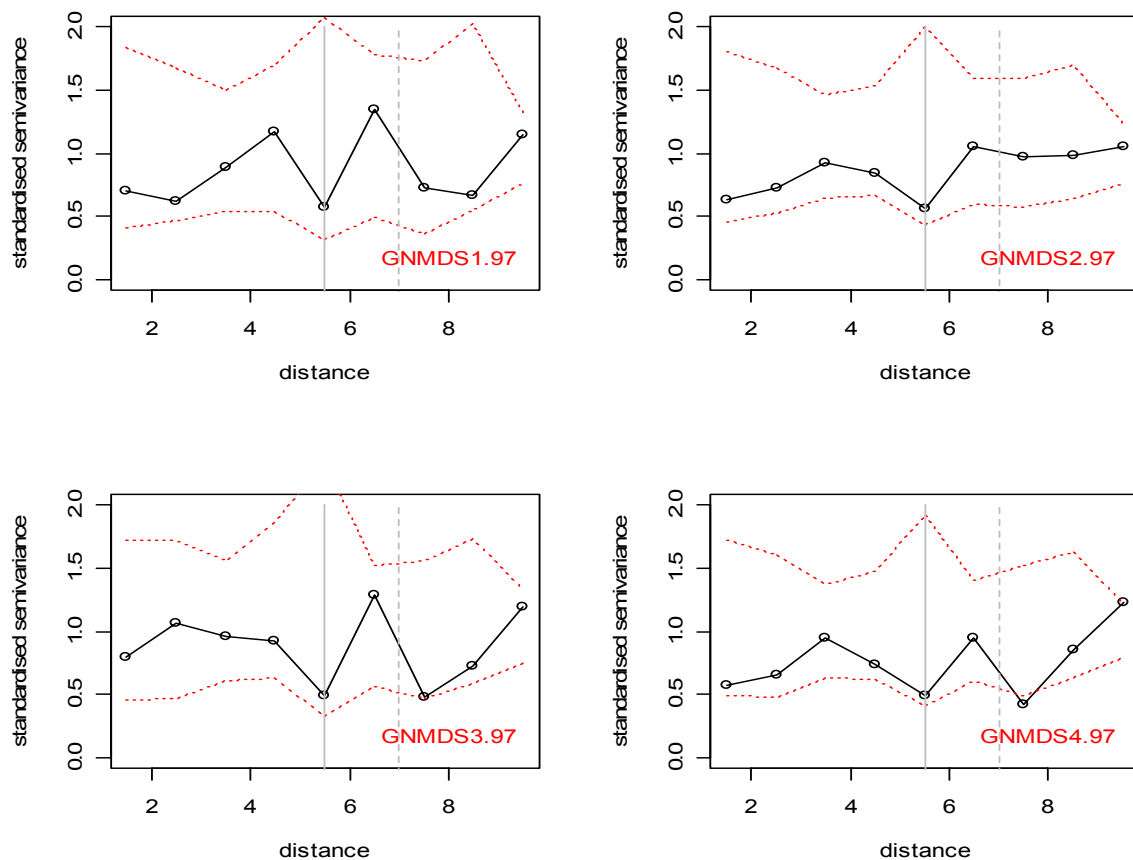
Fig. 5a-d Variograms on GNMDS 1-4 from 1997 (drawn from the total 200 plots), with standardised semivariance plotted against distance (1 to 9 representing geometric mean of lag classes: 4, 8, 16, 32, 64, 128, 256, 512, 1024 m). Punctuated lines represent envelope (95 % confidence intervals).

Most variables showed a bimodal pattern of spatial structure. The tree influence variable had a range of 32 m (Fig. 8a) with an irregular within-stand pattern. Small differences within stands but considerable differences between stands were indicated for maximum inclination (Fig. 8b), with a range of c. 350 m. Moisture showed a quite irregular spatial pattern on between-stand level (Fig. 8c), and indicated a within-stand range of c. 20 m. Phosphorus (Fig. 8d) showed similar irregular within-stand pattern as moisture and similar between-stand pattern with a range of c.100 m.
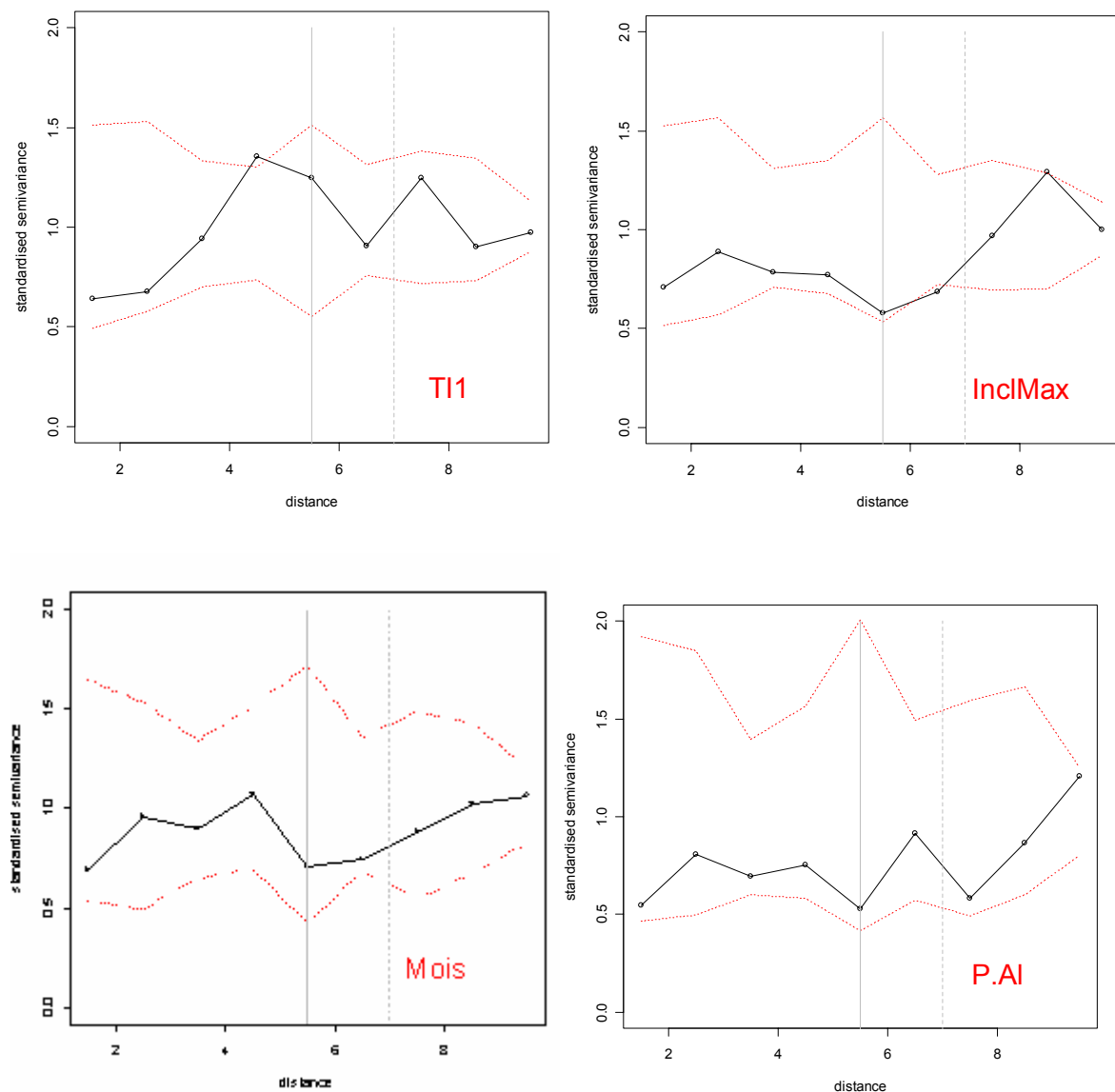
Figure 8 a-d. Standardised semi-variograms of the environmental variables correlating the strongest to the four GNMDS-axes. Punctuated lines represent envelope (95 % confidence intervals). TI1: tree influence in 1997. InclMax: maximum inclination. Mois: soil moisture. P.Al.: amount of phosphorus in the soil.

Testing change 1997–2005

Species abundance

Thirty-nine tests out of a total 190 tests of changes in abundance from 1997 to 2005 were significant at the $\alpha = 0.05$ level; either in the total material or at least one stand (Tab. 11). The 21 species for which at least one test was significant represented 7 vascular plants, 7 mosses, 6 hepatics and 1 lichen species.

Vaccinium myrtillus, V. vitis-idaea, Dryopteris expansa agg., *Maianthemum bifolium, Trientalis europaea, Dicranum fuscescens, Hylocomatrium umbratum* and *Pohlia nutans* all changed significantly in the natural stand (Nat); all of them decreasing (except *Vaccinium myrtillus*) . In the minor selectively cut stand; nine species differed significantly in abundance; *Vaccinium myrtillus, Dicranum fuscescens, Plagiothecium laetum* and *Pleurozium schreberi* increased, while the five hepatics (*Barbilophozia floerkei, B. lycopodioides, Calypogeia integristipula, Cephalozia lunulifolia* and *Lophozia ventricosa* agg.) decreased in abundance. In the major selectively cut stand, a significant increase in abundance was observed for nine species (*Vaccinium vitis-idaea, Deschampsia flexuosa, Dicranum scoparium, Pleurozium schreberi, Polytrichum formosum, Barbilophozia floerkei, Chiloscyphus profondus* and *Lophozia ventricosa* agg.). Only five species changed significantly in abundance in the clear cut stand; *Dryopteris expansa* agg., *Plagiothecium laetum* and *Cephalozia lunulifolia* increasing and *Trientalis europaea* and *Dicranum fuscescens* decreasing.

Nine species showed significant *total* change in abundance. *Trientalis europaea, Pohlia nutans, Calypogeia integristipula* and *Cladonia coniocraea* decreased significantly, whereas *Vaccinium myrtillus, Linnaea borealis, Dicranum montanum, Pleurozium schreberi* and *Chiloscyphus profondus* increased significantly.

The exact binomial total test indicated that the observed number of species with significant total change (9 significant events of abundance change out of 41 tests) was indeed higher than expected by chance ($p < 0.0001$). For abundance change within each stand, the results were as follows: Nat (8 out of 38) $p < 0.0001$; MiSeC (9 out of 36) $p < 0.0001$; MaSeC (8 out of 38) $p < 0.0001$; and CleC (5 out of 37) $p = 0.003$. The 39 significant tests total, was higher than expected ($p < 0.0001$) out of the 190 tests.

Table 11. Species abundance change from 1997 to 2005. n-: number of plots with decreasing subplot frequency. n+: number of plots with increasing subplot frequency. P-values significantly (p < 0.05) increasing (*) or decreasing (**) in subplot frequency, tested by Wilcoxon signed rank one-sample test with the null hypothesis of no change. NA: not applicable.

Species	Nat				MiSeC				MaSeC				CleC				Total			
	n-	n+	~n	P	n-	n+	~n	P	n-	n+	~n	P	n-	n+	~n	P	n-	n+	~n	P
Vaccinium myrtillus	1	6	5	*0.025	3	6	3	*0.041	6	10	4	0.256	7	6	-1	0.335	17	28	11	*0.014
Vaccinium vitis-idaea	9	4	-5	**0.039	1	4	3	0.085	0	6	6	*0.018	4	2	-2	0.299	14	16	2	0.351
Dryopteris expansa agg.	5	1	-4	**0.045	5	5	0	0.252	5	9	4	0.233	5	12	7	*0.047	20	27	7	0.155
Linnaea borealis	0	1	1	0.500	0	4	4	0.050	0	2	2	0.186	0	0	0	NA	0	7	7	*0.011
Lycopodium annotinum	0	3	3	0.091	2	2	0	0.500	3	10	7	0.124	3	1	-2	0.427	8	16	8	0.078
Maianthemum bifolium	6	0	-6	**0.018	4	4	0	0.472	2	0	-2	0.173	3	5	2	0.153	15	9	-6	0.173
Trientalis europaea	9	3	-6	**0.022	2	5	3	0.074	1	2	1	0.500	10	3	-7	**0.040	22	13	-9	**0.041
Carex brunnescens	0	0	0	NA	1	0	-1	0.500	0	0	0	NA	1	3	2	0.172	2	3	1	0.286
Deschampsia flexuosa	8	8	0	0.388	8	2	-6	0.153	4	16	12	*0.029	3	4	1	0.273	23	30	7	0.470
Luzula pilosa	0	3	3	0.087	1	0	-1	0.500	0	0	0	NA	3	2	-1	0.445	4	5	1	0.201
Brachythecium reflexum	3	4	1	0.198	4	3	-1	0.465	5	1	-4	0.053	3	9	6	0.134	15	17	2	0.269
Brachythecium starkei	0	0	0	NA	0	0	0	NA	0	1	1	0.500	4	2	-2	0.101	4	3	-1	0.150
Dicranum fuscescens	16	3	-13	**0.002	7	12	5	*0.045	13	7	-6	0.244	12	3	-9	**0.029	48	25	-23	0.062
Dicranum majus	8	5	-3	0.444	9	5	-4	0.069	4	5	1	0.453	2	6	4	0.159	23	21	-2	0.238
Dicranum montanum	2	2	0	0.500	0	3	3	0.091	0	2	2	0.186	0	0	0	NA	2	7	5	*0.032
Dicranum scoparium	9	8	-1	0.209	16	6	-10	0.177	4	13	9	*0.012	9	9	0	0.307	38	36	-2	0.336
Hylocomiastrum umbratum	5	1	-4	**0.037	2	3	1	0.500	0	2	2	0.186	1	5	4	0.144	8	11	3	0.366
Hylocomium splendens	2	3	1	0.139	2	4	2	0.336	0	0	0	NA	0	0	0	NA	4	7	3	0.083
Plagiothecium denticulatum	1	0	-1	0.500	1	0	-1	0.500	0	3	3	0.087	2	0	-2	0.173	4	3	-1	0.500
Plagiothecium laetum	16	6	-10	0.116	6	12	6	*0.011	10	13	3	0.421	8	13	5	*0.047	40	44	4	0.064
Pleurozium schreberi	8	6	-2	0.500	4	10	6	*0.024	3	10	7	*0.014	5	9	4	0.120	20	35	15	*0.003
Pohlia nutans	10	1	-9	**0.004	0	0	0	NA	1	0	-1	0.500	0	1	1	0.500	11	2	-9	**0.004
Polytrichum commune	1	0	-1	0.500	1	0	-1	0.500	1	0	-1	0.500	1	1	0	0.500	4	1	-3	0.111
Polytrichum formosum	10	8	-2	0.379	7	5	-2	0.126	1	14	13	*0.005	5	12	7	0.073	23	39	16	0.050
Rhytitiadelphus loreus	1	0	-1	0.500	0	1	1	0.500	0	1	1	0.500	0	2	2	0.173	1	4	3	0.205
Tetraphis pellucida	9	6	-3	0.156	3	0	-3	0.087	7	5	-2	0.186	4	3	-1	0.500	23	14	-9	0.053
Sphagnum girgensohnii	0	1	1	0.500	1	3	2	0.135	4	3	-1	0.399	5	8	3	0.163	10	15	5	0.086
Barbilophozia attenuata	9	5	-4	0.307	5	3	-2	0.444	5	7	2	0.238	2	3	1	0.383	21	18	-3	0.486
Barbilophozia floerkei	3	4	1	0.305	10	1	-9	**0.005	2	6	4	*0.049	5	4	-1	0.312	20	15	-5	0.296
Barbilophozia lycopodioides	7	5	-2	0.152	15	3	-12	**0.023	4	8	4	0.353	7	10	3	0.152	33	26	-7	0.143
Calypogeia integristipula	4	2	-2	0.140	4	0	-4	**0.047	6	1	-5	0.134	2	1	-1	0.293	16	4	-12	**0.006
Calypogeia muelleriana	0	1	1	0.500	0	0	0	NA	3	2	-1	0.342	0	0	0	NA	3	3	0	0.416
Cephalozia bicuspidata	0	0	0	NA	0	0	0	NA	4	2	-2	0.102	0	3	3	0.074	4	5	1	0.291
Cephalozia lunulifolia	4	5	1	0.360	6	1	-5	**0.035	4	4	0	0.472	1	5	4	*0.044	15	15	0	0.314
Chiloscyphus profundus	4	9	5	0.147	6	11	5	0.085	3	16	13	*0.003	9	14	5	0.387	22	50	28	*0.006
Lophozia obtusa	2	0	-2	0.186	0	0	0	NA	1	0	-1	0.500	1	1	0	0.500	4	1	-3	0.293
Lophozia ventricosa agg.	6	8	2	0.364	10	1	-9	**0.004	2	12	10	*0.002	6	5	-1	0.343	24	26	2	0.430
Ptilidium ciliare	1	4	3	0.291	4	1	-3	0.102	0	1	1	0.500	2	1	-1	0.207	7	7	0	0.219
Ptilidium pulcherrimum	4	1	-3	0.245	2	0	-2	0.186	1	2	1	0.500	2	0	-2	0.173	9	3	-6	0.057
Cladonia chlorophaea agg.	10	6	-4	0.317	2	1	-1	0.386	5	4	-1	0.357	3	1	-2	0.135	20	12	-8	0.113
Cladonia coniocraea	8	4	-4	0.134	2	0	-2	0.173	6	2	-4	0.177	2	1	-1	0.386	18	7	-11	**0.046

Three species were new in 2005, i.e. *Solidago virgaurea, Tetraploidon mnioides* and *Rhodobryum roseum*. Fourteen of the species from T. Økland et al. (2003) were not found in 2005, i.e. *Andreae rupestris, Bryum* sp.*, Ceratodon purpureus, Dicranella heteromalla, Isopterygium elegans, Racomitrium heterostichum, Anastrophyllum minutum, Bazzania tricrenata, Plagiochila asplenoides, Scapania scandica, Tritomaria quinquedentata, Cladonia gracilis, C. rangiferina* and *C. squamosa*. All of these species had low occurrences (in one or two plots) at the time of the first registration, and almost all of them were originally found in either the natural or the major selectively cut stand.

Species composition

Change by plot

Average change in plot score positions along all axes from 1997 to 2005 and averaged lengths of displacement vectors for each plot are shown in Tab. 12. (For all plot scores and vector lengths for each individual plot; see appendix 5 and 6.) Nine of the plots (plot numbers 11, 29, 48, 82, 94, 95, 97, 98 and 99) had lengths of displacement vectors longer than 0.3 HC units along GNMDS 1 and 2, and maximum length of displacement vectors was 0.818 HC units (plot number 99; GNMDS-axes 1 and 2). Thus, two thirds of the total number of plots with length of displacement vector > 0.3 HC units, including the plot with the longest vector, were found in CleC. The shortest displacement vector was observed for plot number 32 in MiSeC (0.018). The major selectively cut stand had no plots with vector length > 0.3 S.D. units, and an average absolute displacement of just 0.002 (GNMDS 1) and 0.001 (GNMDS 2). (See Figs 9a-c for displacement plots of GNMDS 1 to 4.) Minor average changes were evident along GNMDS 4 for all stands, whereas along GNMDS 3, all the former managed stands had rather large average displacements. All in all, the clear cut stand changed the most according to the four-dimensional total vector length.

Table 12. Descriptive statistics of displacement given as minimum, maximum and average plot scores along each axis for all stands and total in 1997, 2005 and for values of change from 1997 to 2005. Vector lengths representing pairs of axes and for the total four-dimensional change in the GNMDS.

	GNMDS 1			GNMDS 2			GNMDS 3			GNMDS4			Vector length			
	1997	2005	Change	1997	2005	Change	1997	2005	Change	1997	2005	Change	Axes 1&2	Axes 1&3	Axes 1&4	4-dim
Total																
MIN	0.000	0.253	-0.304	0.000	0.333	-0.401	0.000	0.073	-1.243	0.000	0.148	-0.389	0.018	0.016	0.006	0.054
MAX	2.527	2.463	0.649	1.788	1.683	0.498	1.786	1.177	0.305	1.404	1.249	0.444	0.818	1.280	0.757	1.395
AVG	1.735	1.752	0.017	1.092	1.098	0.005	0.652	0.647	-0.005	0.622	0.626	0.004	0.157	0.149	0.144	0.226
Nat																
MIN	0.668	0.743	-0.146	0.505	0.559	-0.401	0.241	0.181	-0.125	0.151	0.218	-0.198	0.024	0.042	0.033	0.068
MAX	2.527	2.463	0.172	1.788	1.683	0.116	1.047	1.009	0.131	0.773	0.752	0.212	0.401	0.186	0.257	0.432
AVG	1.866	1.885	0.019	1.249	1.209	-0.040	0.594	0.597	0.002	0.522	0.513	-0.008	0.136	0.105	0.113	0.177
MiSeC																
MIN	0.909	0.825	-0.238	0.402	0.333	-0.270	0.273	0.073	-0.234	0.246	0.237	-0.212	0.035	0.016	0.006	0.054
MAX	2.404	2.279	0.117	1.634	1.454	0.339	0.948	1.026	0.212	0.948	0.808	0.148	0.818	0.260	0.281	0.395
AVG	1.854	1.812	-0.043	0.999	1.005	0.006	0.544	0.516	-0.028	0.580	0.595	0.014	0.193	0.122	0.117	0.193
MaSeC																
MIN	0.557	0.607	-0.091	0.563	0.572	-0.273	0.000	0.184	-0.117	0.147	0.148	-0.279	0.018	0.054	0.033	0.076
MAX	2.106	2.228	0.211	1.693	1.632	0.286	1.240	1.156	0.305	0.987	1.034	0.212	0.352	0.329	0.283	0.399
AVG	1.608	1.676	0.067	1.132	1.141	0.009	0.702	0.759	0.057	0.543	0.563	0.020	0.133	0.136	0.154	0.228
CleC																
MIN	0.000	0.253	-0.304	0.000	0.498	-0.168	0.276	0.107	-1.243	0.000	0.246	-0.389	0.039	0.043	0.023	0.074
MAX	2.358	2.295	0.649	1.469	1.544	0.498	1.786	1.177	0.215	1.404	1.249	0.444	0.541	1.280	0.757	1.395
AVG	1.610	1.636	0.026	0.989	1.035	0.046	0.768	0.717	-0.051	0.843	0.833	-0.009	0.167	0.231	0.193	0.306

Change by stand and total

For the two selectively cut stands, significant displacement from 1997 to 2005 (Tab. 13) was observed along GNMDS 1 ($p < 0.05$); representing change in direction of vegetation typical of denser forests and/or plots below trees for MiSeC (to the left in along GNMDS 1; Fig. 10a) and changing towards vegetation typical of more open forests and or plots in gaps between trees for MaSeC (to the right along GNMDS 1; Fig. 10a). The vegetation in the major selectively cut stand also significantly displaced towards that typical of higher soil moisture (towards higher plot scores along GNMDS 3; Fig. 10b). All other displacements along GNMDS-axes 1 to 4 were not significant and were only interpreted as directional indications of displacement (see Tab. 13).

Table 13. Change in plot scores (1997 to 2005) along GNMDS 1 to 4; total and for all stands. n: number of plots. Mean: mean plot score for the group in question for each axes. S.D.: standard deviation. n-: number of plots with negative change. n+: number of plots with positive change. t: *t*-statistic on mean change in plot scores from 1997 to 2005 tested with Wilcoxon signed rank one-sample test: null hypothesis of no change. p: corresponding p-value to t. **p** < 0.05

		Mean plot score		Change in plot score 1997-2005					
	n	1997	2005	Mean	S.D.	n-	n+	t	p
GNMDS1									
Total	100	1.735	1.752	0.017	0.132	41	59	1.324	0.189
Nat	25	1.866	1.885	0.019	0.079	10	15	1.206	0.240
MiSeC	25	1.854	1.812	-0.043	0.098	16	9	-2.172	**0.040**
MaSeC	25	1.608	1.676	0.067	0.074	4	21	4.571	**<0.001**
CleC	25	1.610	1.636	0.026	0.209	11	14	0.622	0.540
GNMDS2									
Total	100	1.092	1.098	0.005	0.145	52	48	-0.375	0.709
Nat	25	1.249	1.209	-0.040	0.114	15	10	1.770	0.089
MiSeC	25	0.999	1.005	0.006	0.145	13	12	-0.216	0.831
MaSeC	25	1.104	1.110	0.009	0.136	11	14	-0.343	0.735
CleC	25	0.989	1.035	0.046	0.176	13	12	-1.317	0.200
GNMDS3									
Total	100	0.652	0.647	-0.005	0.163	44	56	0.305	0.749
Nat	25	0.594	0.597	0.002	0.081	12	13	-0.138	0.891
MiSeC	25	0.544	0.516	-0.028	0.092	16	9	1.529	0.139
MaSeC	25	0.702	0.759	0.057	0.103	6	19	-2.780	**0.010**
CleC	25	0.768	0.717	-0.051	0.278	10	15	0.921	0.366
GNMDS4									
Total	100	0.622	0.626	-1.374	0.225	49	51	-0.321	0.749
Nat	25	0.522	0.513	-1.487	0.164	15	10	0.414	0.683
MiSeC	25	0.580	0.595	-1.405	0.156	9	16	-0.784	0.441
MaSeC	25	0.543	0.563	-1.437	0.222	12	13	-0.734	0.470
CleC	25	0.843	0.833	-1.167	0.211	13	12	0.296	0.770
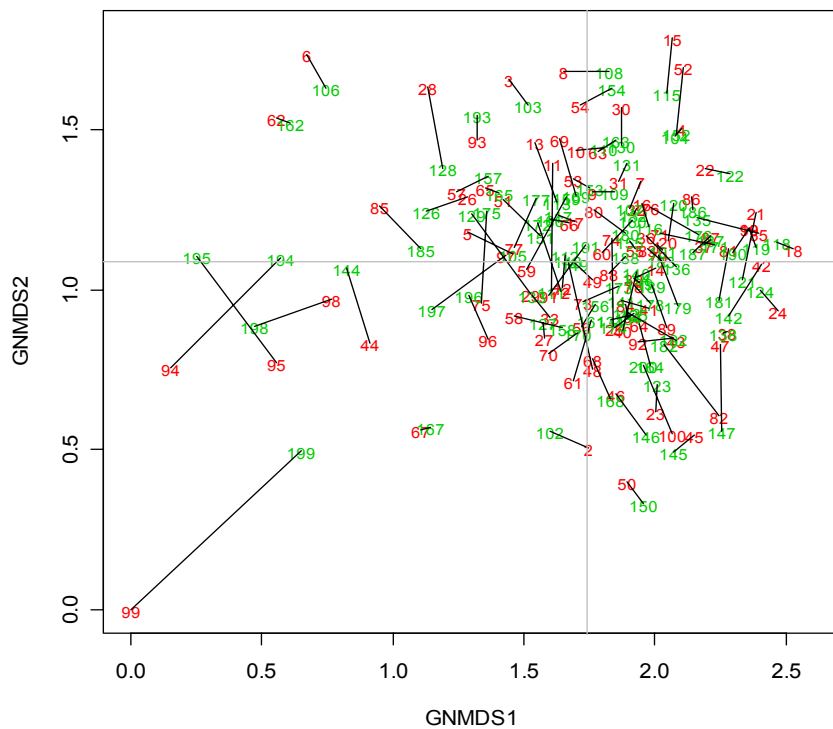
Figure 9a. Displacement along GNMDS 1 and 2 for each plot from the total dataset of 200 plots. Numbers connected represent the same plot in 1997 and 2005.
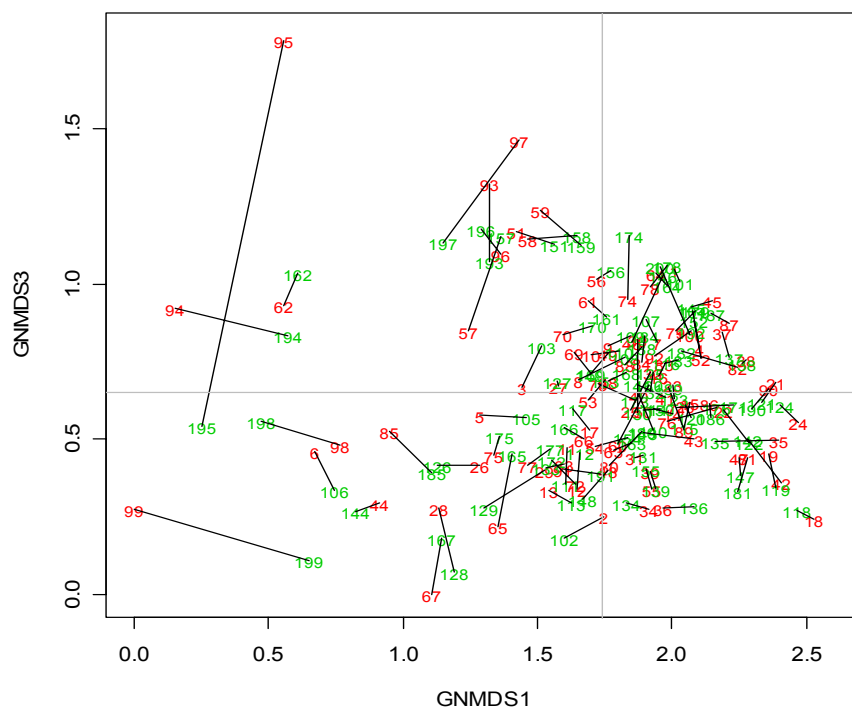
Figure 9b. Displacement along GNMDS 1 and 3 for each plot from the total dataset of 200 plots. Numbers connected represent the same plot in 1997 and 2005.
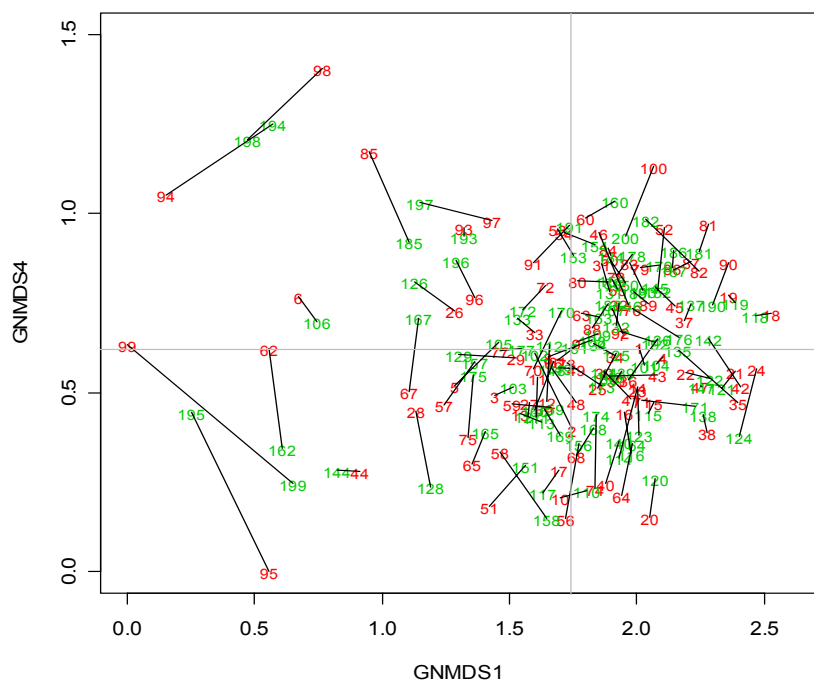
Figure 9c. Displacement along GNMDS 1 and 3 for each plot from the total dataset of 200 plots. Numbers connected represent the same plot in 1997 and 2005.
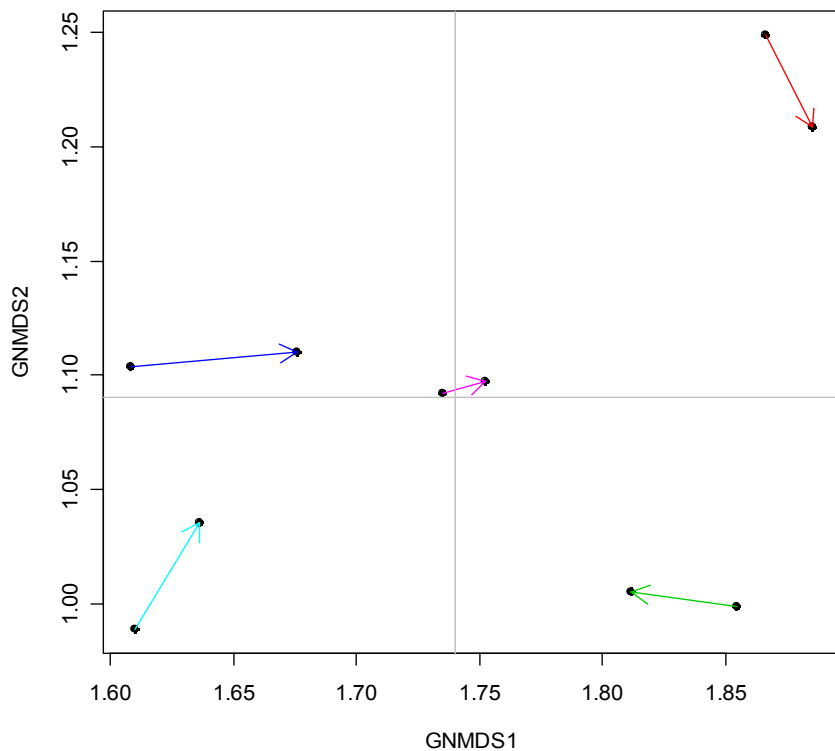
Figure 10a. Displacement along GNMDS 1 and 2 based on mean change in plot scores from 1997 to 2005 (scores drawn from the total dataset of 200 plots) for Total, Nat, MiSeC, MaSeC and CleC stands.
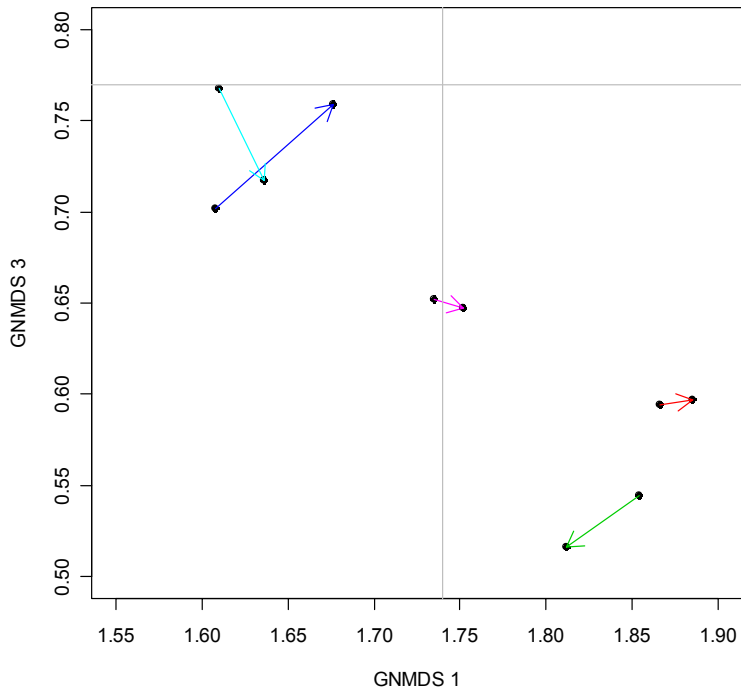
Figure 10b. Displacement along GNMDS 1 and 3 based on mean change in plot scores from 1997 to 2005 (scores drawn from the total dataset of 200 plots) for Total, Nat, MiSeC, MaSeC and CleC stands.
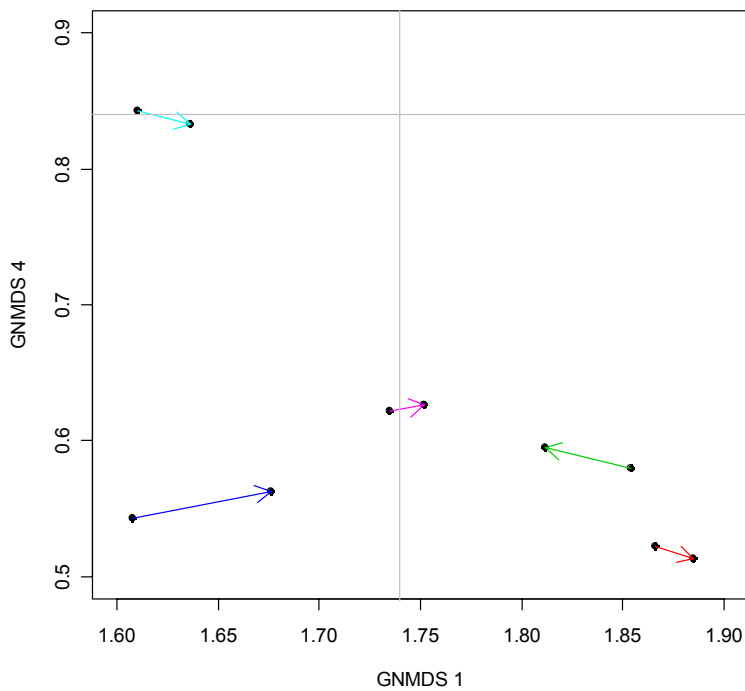
Figure 10c. Displacement along GNMDS 1 and 3 based on mean change in plot scores from 1997 to 2005 (scores drawn from the total dataset of 200 plots) for Total, Nat, MiSeC, MaSeC and CleC stands.

Further analyses of displacement along the first GNMDS-axis (representing a gradient in tree influence) separately for each stand, showed a significant relationship between change in plot score from 1997 to 2005 and plot score position along GNMDS 1 (100 plots in 1997) for the natural stand only (Fig. 11, Tab.14). All managed stands showed no significant relationship between GNMDS 1 representing 1997 and the change along the first GNMDS-axis.

Tree influence

There were significant changes in tree influence from 1997 to 2005 for all stands (Tab. 15). P-values were lower for the natural and the minor selectively cut stands ($0.01 < p < 0.05$) than the other two stands and total ($p < 0.0001$), and according to the split-plot GLM (Tab. 16) the change in tree influence was significant both on plot *and* stand level ($p < 0.0001$ and $p = 0.003$, respectively).
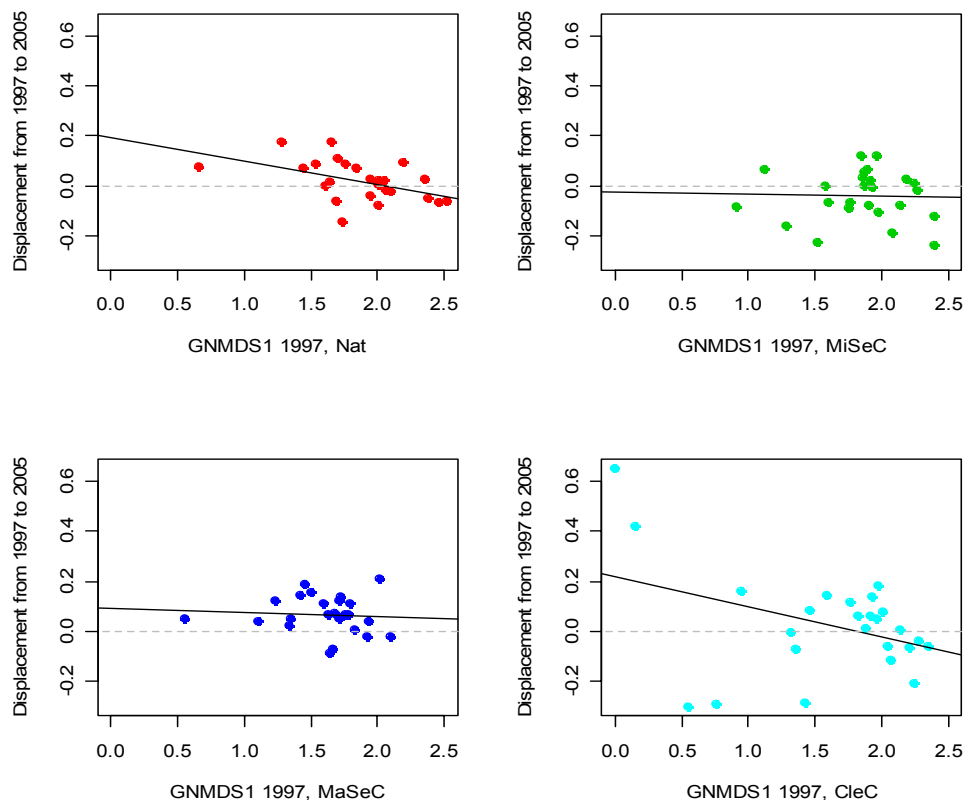
Figures 11a-d. Plot scores from GNMDS 1 in 1997 (extracted from the total 200 plots) plotted against *change* in plot scores from 1997 to 2005, separately for each stand (Nat (a), MiSeC (b), MaSeC (c) and CleC (d)). Lines based on linear models (Change in species composition 97 to 05 tested against GNMDS 1) for each stand. Punctuated line represents the nullhypothesis of no change.

Table 14. Linear models on plot scores from GNMDS1 in 1997 (drawn from the total 200 plots in the total dataset) against *change* in plot scores from 1997 to 2005 for each stand. Estimate: coefficients representing intercept and slope for each stand. t: *t*-statistic testing nullhypothesis of coefficients =0 with corresponding p-values. F: *F*-statistic testing nullhypothesis of no difference between sample means. df: degrees of freedom. Average change calculated within each stand from transformed and ranged plot scores.

Change in species composition 97 - 05 ~ GNMDS 1 1997

		t-statistic			F-statistic df = 24	
Stand		Estimate	t	P	F	Average change
Nat	Intercept	0.194	2.878	**0.009**		
	Slope	-0.094	-2.655	**0.014**	7.050	0.019
MiSeC	Intercept	-0.028	-0.266	0.793		
	Slope	-0.008	-0.141	0.889	0.020	-0.043
MaSeC	Intercept	0.093	1.196	0.244		
	Slope	-0.016	-0.333	0.742	0.111	0.067
CleC	Intercept	0.218	2.050	0.052		
	Slope	-0.120	-1.945	0.064	3.785	0.026

.

Table 15. Paired t-test on change in tree influence from 1997 to 2005 for each stand. Average TI and average change calculated on transformed and ranged TI-data. t: *t*-statistic testing nullhypothesis of the two means being equal, with corresponding p-values. p < 0.05

Change in TI 97 to 05 ~ TI1

	Average TI1	Average TI2	Average change	t-test t	p
Nat	0.346	0.365	0.019	-2.401	**0.024**
MiSeC	0.486	0.515	0.029	-2.285	**0.031**
MaSeC	0.517	0.546	0.029	-8.236	**<0.0001**
CleC	0.386	0.422	0.036	-5.669	**<0.0001**

Table16. Split-plot GLM (normal error and identity link) on tree influence index in 1997 (TI1) tested against tree influence index in 2005 (TI2) with stand as factor variable. SS: total variation on the scale in question. df: degrees of freedom distributed on the different scales and total. Coef: model coefficient. F: *F* statistic for test of the hypothesis that coef = 0 against the two-tailed alternative.

TI2~TI1

	Between stands SS=0.520 df=3			Plot within stand SS=7.345 df=96		
SS= 7.865 df= 99	Coef.	F	p	Coef.	F	p
Total	1.027	319.3	**0.003**	1.022	4230.4	**<0.0001**

The distributions of tree influence change (Figs 12a-d) differed considerably among the four stands. In the natural stand, change was small and mostly between −0.02 and +0.02, i.e. within the limits of measurement error. In the minor selectively cut stand, larger percentages of plots had positive and considerable (> 0.05) change. The major selectively cut stand, in which change was positive and ranging from 0.00 to 0.07, and the clear cut stand, with most values of change ranging from 0.02 to 0.06, showed a distinct pattern of increase in tree influence.
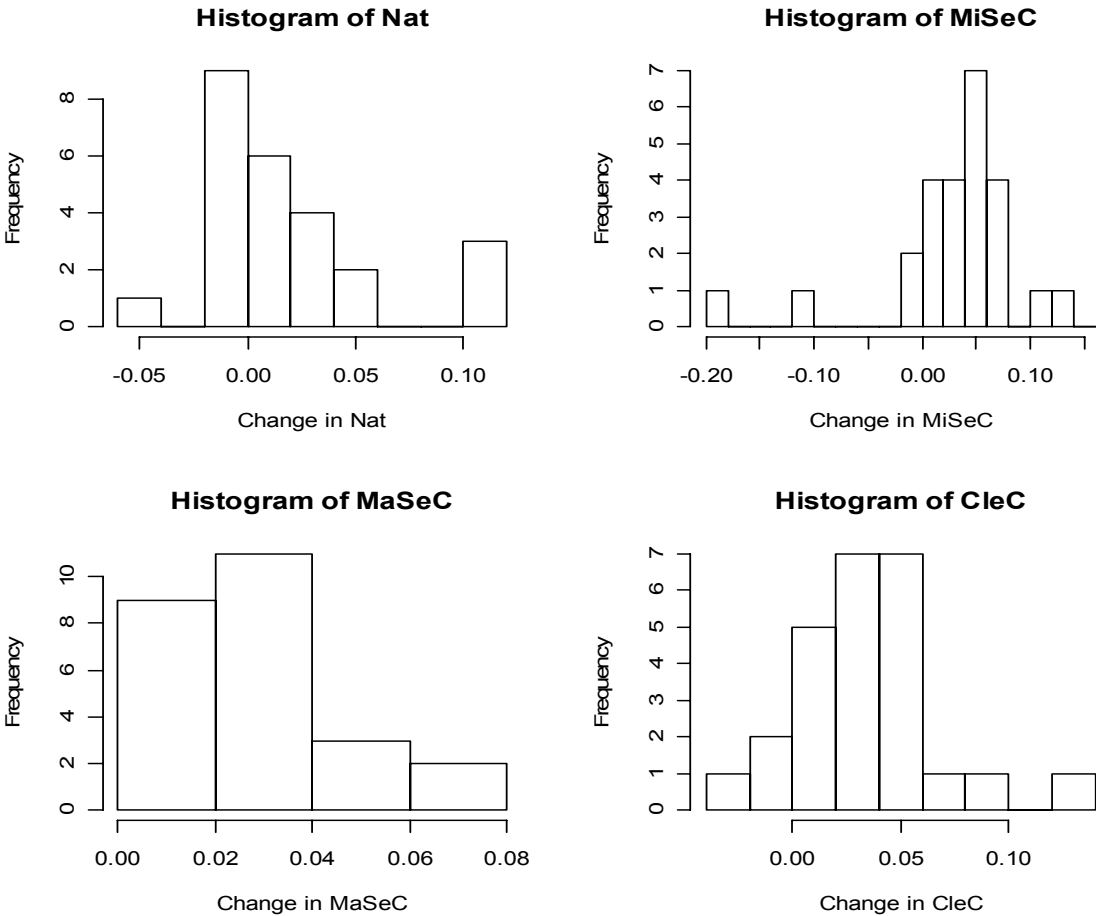
Figures 12a-d. Histograms of change in tree influence from 1997 to 2005 for each stand.

The intercept of the total changes in tree influence index were weakly significant, whereas the slope was insignificantly different from 0 (Tab. 17; Figs 13a-d). In the natural stand, the tree influence index increased strongly (> 0.2 units) for plots number 5, 6 and 10. According to the linear model, the plots made up two groups along the horizontal (TI1) axis, separating

plots with TI1 < 0.2 from plots with TI1 > 0.5 (Fig. 13a), however the slope was not significantly different from 0.

The minor selectively cut stand was the only stand in which the slope decreased (not significantly, though); meaning that plots with low TI in 1997 changed the most, while the plots having high values of TI in 1997 displayed smaller changes (Fig. 13b). MiSeC included the plots with the maximum *and* minimum change observed over all plots; plots number 38 and 27 had the strongest increase and decrease, respectively (Fig. 13c). Plot number 31 also had change in TI > 0.1; in both of plots number 31 and 27, TI had decreased due to death of one of the largest trees in the stand.

The only stand with a significant slope was the major selectively cut stand. Analysis showed a significant increasing trend with no negative values of change and no plots with change > 0.1 units.

In the clear cut stand, the trend was weakly (not significantly) increasing, however, the intercept was significant ($p = 0.028$). Plot number 77 increased > 0.1 units of change (Fig. 13d) due to the recent appearance of a tree (not present in 1997).

The average change in tree influence index increased along the gradient of forest management intensity; 0.019, 0.029, 0.029 and 0.036 for Nat, MiSeC, MaSeC and CleC, respectively (Tab. 17).

Strength of relationships between gradients in species composition (ordination axes) and environmental variables recorded at different times

Tree influence

GNMDS 1 was interpreted as a compositional gradient strongly related to tree influence (see results of split-plot GLM, Tab. 10a) for all combinations of years and tree influence indices. Between 92 and 95 % of the variation in GNMDS 1 scores was plot-level variation, of which c. 45% ($p < 0.0001$) was explained by tree influence. Only a small and insignificant fraction of stand-level variation was explained by tree influence.

τ-values between GNMDS 1 scores for different recording times (1997 and 2005) compared to the tree influence index (also recorded at two different times) showed that the species composition in 2005 was more strongly correlated with the tree influence index calculated for 1997 than with the tree influence index for 2005 ($\tau = 0.507$ vs. 0.492; Tab. 18). Furthermore, the tree influence index for 1997 was slightly more strongly correlated with the

species composition of 2005 than with the species composition of 1997 ($\tau = 0.507$ vs. 0.491); both trends indicating a possible delay in species response to environmental influence. The relationship between species composition and tree influence recorded the same year was about the same in 1997 and in 2005 ($\tau = 0.492$ vs. 0.491).
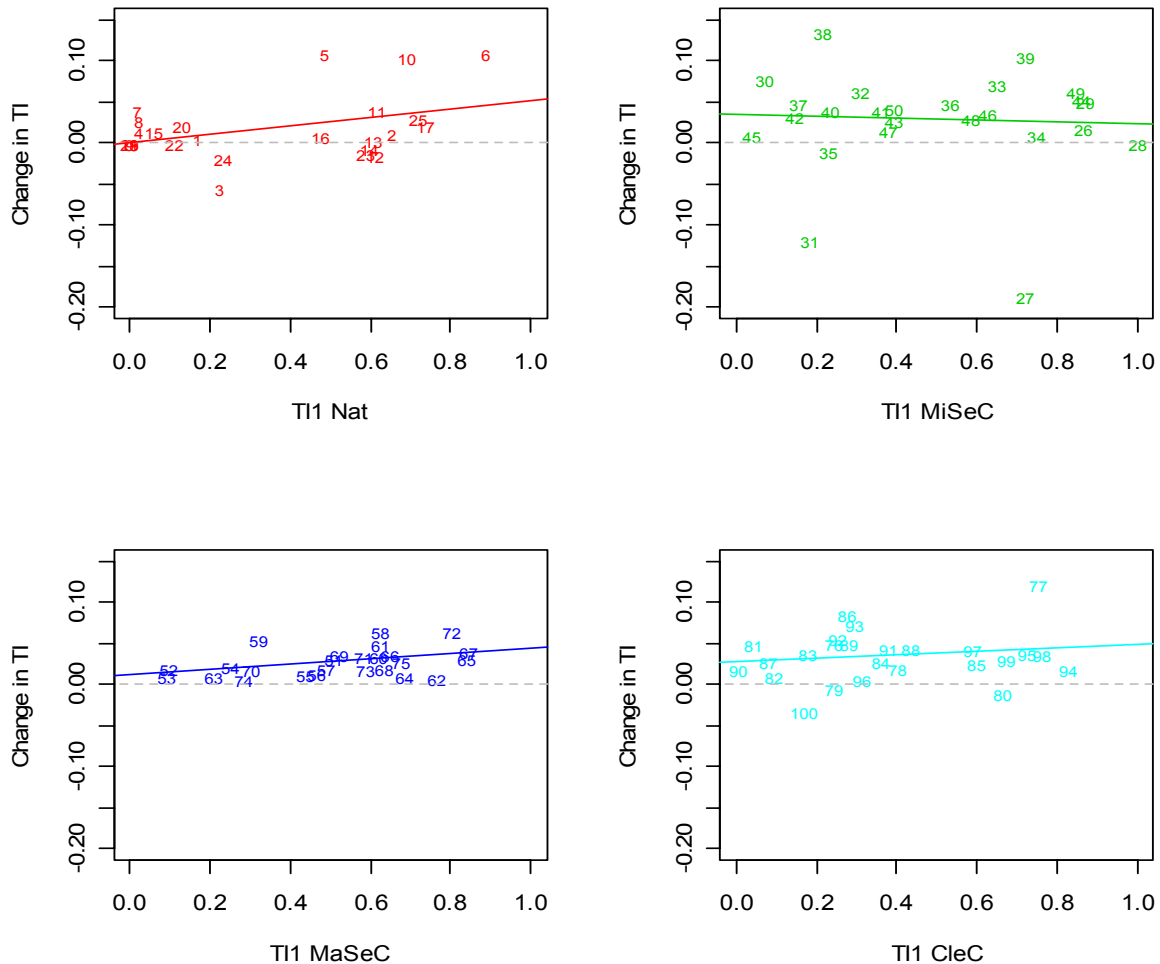
Figures 13a-d. Tree influence index 1997 (TI1) plotted against change in tree influence index from 1997 to 2005 separately for each stand (Nat, MiSeC, MaSeC and CleC). Lines based on linear models (Change in TI 97 to 05 ~ TI1) for each stand. Punctuated line represents nullhypothesis of no change.

All variables

Correlation coefficients (τ-values) between environmental variables (recorded in 1997) and plot ordination scores for species composition in 1997 and 2005, respectively, showed an overall tendency for correlations to be stronger with 2005 vegetation data than with data from 1997 (Tab. 19). In particular, this applied to GNMDS-axes 1 and 4. Exact binomial tests for

number of τ-values that had increased from 1997 to 2005 gave values < 10e-6 for each axis and for total.

Table 17. Linear models on tree influence index from 1997 (TI1) against *change* in tree influence index for each stand. Estimate: coefficients representing intercept and slope for each stand. t: *t*-statistic testing nullhypothesis of coefficients =0 with corresponding p-values. F: *F*-statistic testing nullhypothesis of no difference between sample means. df: degrees of freedom. Average change calculated within each stand from transformed and ranged TI-data.

		Change in TI 97 to 05 ~ TI1					
		t-statistic			F-statistic		
		Estimate	t	p	df	F	Change in TI
Nat	Intercept	0.001	0.112	0.912			
	Slope	0.051	2.038	0.053	24	4.153	0.019
MiSeC	Intercept	0.034	1.344	0.192			
	Slope	-0.011	-0.245	0.809	24	0.060	0.029
MaSeC	Intercept	0.012	1.400	0.175			
	Slope	0.033	2.189	**0.039**	24	4.790	0.029
CleC	Intercept	0.028	2.343	**0.028**			
	Slope	0.020	0.756	0.458	24	0.571	0.036

Table 18. Split-plot GLM (normal error and identity link) on tree influence index in 1997 (TI1) tested against species composition scores from both 1997 and 2005 (scores withdrawn from the total dataset of 200 plots) with stand as factor variable. SStot: total variation on the scale in question. df: degrees of freedom distributed on the different scales and total. FVE: fraction of variation explained on the scale in question. Coef: model coefficient. F: *F* statistic for test of the hypothesis that coef = 0 against the two-tailed alternative. τ: indicate correlation between TI and the given axis by Kendall's non-parametric test. p < 0.05

		Split-plot GLM										
		Between stands					Plot within stand					
		df=96					df=3					
TI1	SStot	FVE	SSexp/SSstand	Coef.	F	p	FVE	SSexp/SSplot	Coef.	F	p	τ
GNMDS1-97	21.658	0.073	0.081	0.510	0.175	0.716	0.927	0.444	1.139	75.845	**<0.0001**	0.492
GNMDS1-05	19.299	0.052	0.158	0.555	0.376	0.602	0.948	0.448	1.056	77.054	**<0.0001**	0.507
TI2												
GNMDS1-05	19.299	0.052	0.113	0.483	0.255	0.664	0.948	0.462	1.109	81.731	**<0.0001**	0.491

Table 19. Kendall's non-parametric test on environmental variables recorded in 1997 against plot scores from 1997 (100 plots) and 2005 (100 plots; both drawn from the total dataset of 200 plots) for each of the four GNMDS-axes. |τ| > 0.3

Explanatory variables	GNMDS1		GNMDS2		GNMDS3		GNMDS4	
	1997	2005	1997	2005	1997	2005	1997	2005
	τ	τ	τ	τ	τ	τ	τ	τ
Mois	0.244	-0.280	-0.100	-0.181	**0.377**	**0.354**	0.198	0.214
Litter	**-0.336**	**0.353**	-0.186	-0.104	-0.203	-0.203	-0.084	-0.077
BasalA	**-0.323**	**0.305**	-0.086	-0.036	0.215	0.224	0.095	0.138
Inclin	0.025	-0.029	0.220	0.186	-0.071	-0.075	-0.062	-0.140
Heatl	-0.182	0.182	0.128	0.156	-0.039	-0.015	0.038	0.020
SoilDMe	0.039	-0.034	-0.023	-0.020	0.099	0.133	-0.031	-0.046
RoughMe	0.120	-0.131	0.193	0.163	0.001	-0.013	-0.110	-0.151
InclMax	0.072	-0.112	**0.309**	0.211	0.084	0.025	-0.086	-0.153
GapAvg	**0.419**	**-0.431**	0.072	-0.028	0.054	0.070	-0.004	-0.019
LossOl	-0.117	0.127	-0.157	-0.157	-0.068	-0.022	-0.010	-0.011
pH	0.092	-0.138	-0.083	-0.102	0.246	0.267	0.131	0.120
Ca	-0.239	0.256	0.128	0.172	**-0.360**	**-0.409**	-0.075	-0.100
Mg	0.118	-0.115	0.177	0.166	-0.261	-0.280	-0.043	-0.093
TotN	0.192	-0.200	0.121	0.126	0.097	0.090	0.056	0.075
P.Al	0.004	0.036	-0.049	-0.007	-0.116	-0.109	0.283	**0.307**
Tl1	**-0.492**	**0.507**	-0.163	-0.091	-0.199	-0.183	-0.165	-0.173

51

DISCUSSION

Ecological interpretation of gradients in species composition

Reanalysis of the data provided by T. Økland et al. (2003) for south-facing stands in Oppkuven combined with my data collected in 2005 from the same 100 plots, confirmed the presence of four major coenoclines as interpreted by T. Økland et al. (2003) ($\tau > 0.75$ for all corresponding pairs of axes). A full ecological re-interpretation of the original compositional gradients will therefore not be given (see T. Økland et al. (2003) for details). However, the split-plot GLM analyses provide a new perspective on parts of the ecological interpretation, because the partitioning of variance adds important information on the spatial scale on which the variation in species composition on each axis takes place.

The first LNMDS-axis of T. Økland et al. (2003) was interpreted as related to tree influence and to some extent also soil moisture; running from dry sites below trees in dense forest to sites in gaps in more open forest with higher soil moisture. Practically all variation (93 %) along GNMDS 1 was due to variation between plots within stands and no environmental variable was found to be significantly ($p < 0.05$) related to the axis at stand scale. This absence of significant variation explained on stand scale and the high spread of plots within all stands along the axis confirm that the main coenocline indeed reflects fine-scaled variation on the forest floor.

The second LNMDS-axis of T. Økland et al. (2003) was interpreted as related to microtopography on a very fine scale; running from even forest-floor sites to uneven sites with small pockets (such as steep ledges, microsites adjacent to dead wood, underneath stones, peat, disturbed substrates etc.). Similar to the first axis, the major fraction of the variation along the second GNMDS-axis is expressed on plot scale (88 %), although a significant contribution of stand-scale variation in soil depth ($p = 0.036$) suggests that this axis also reflects stand-scale variation from vegetation typical of sites with a thin soil layer (minor selectively cut and clear cut) to sites with substantial soil depth (natural and major selectively cut).

A substantial amount of the variation (> 90 %) in species composition (plot positions) occurred on the plot-within-stand scale also for the third GNMDS-axis. The LNMDS counterpart was interpreted by T. Økland et al. (2003) as relating to soil moisture on a broader scale than the variation due to tree influence (GNMDS 1), running from dry to moist paludified sites. This might at a first glance seem contradictory; however there is room for variation on a broader scale than tree spacing (cf. GNMDS-axis 1 related to single-tree

influence) also *within* stands. Calcium and pH varied significantly within stands along this axis as well; nonetheless the opposite signs of their correlations with the coenocline indicate that the coenocline is not dependent on soil nutrient status. The split-plot analysis reveals a highly significant relationship between the axis and pH on stand scale (p = 0.001), which may be related to former forest management history. Soils of the natural and the minor selectively cut forest stands have lower pH than those of the major selectively cut and clear cut stands. Cutting of trees can cause immediate acidification (Nyquist 1997, Olsson and Staaf 1995), however, nutrient levels may return to pre-cutting levels or even higher within a five-year period after cutting (Palviainen et al. 2005). More relevant to interpretation of between-stand differences related to soil pH in this study is the natural acidification in response to forest ageing (C.O. Tamm & Hallbäcken 1988) brought about, among others, by immobilization of cations in the growing timber biomass (Johnson et al. 1991).

The fourth LNMDS-axis was interpreted by T. Økland et al. (2003) as separating the formerly clear-cut stand from the selectively cut and natural stands, related mainly to variation in the amount of phosphorus. T. Økland et al. (2003) considered this variation not to be brought about by former management history, though. According to split-plot analyses, both the amount of phosphorus and topographic variables contribute considerably to variation along GNMDS 4 on stand scale (28% of variation is explained at the stand scale), establishing GNMDS 4 as a coenocline from plots low in phosphorus and with large fine-scale topographic variation to *vice versa* (mostly strongly represented by plots from the clear-cut stand). This motivates for re-evaluation of the interpretation of LNMDS 4 as variation in phosphorus not related to former forest management (T. Økland et al. 2003). Finér et al. (2003) found that logging residues represent a significant proportion of the total nutrient pool originally bound in growing stands. In mature Norway spruce stands, logging residues account for as much as 90% of the total phosphorus of the standing tree biomass pools of nutrients (Kubin 1977). The absence of slash removal after clear-cutting in 1927 may have affected phosphorus availability to such an extent that it is still traceable today.

Use of small plots (fine-grained sampling; Wiens 1989) tends to emphasize variation within areas, whereas larger-sized grains tend to emphasize variation between areas (Mills and MacDonald 2004, 2005) because the ratio of among-plot variation to within-plot variation decreases with increasing grain size, hence the plots become overall more similar in environmental conditions (Palmer & Dixon 1990, Mills & MacDonald 2004). The use in this study of small sample plots placed within stands, in a system where most of the total variation occurs on plot scale, has two implications: (i) T. Økland et al. (2003) apparently succeeded in

selecting stands that were comparable in terms of environmental (topographic, edaphic and other) conditions; thus well suited for studying effects of former forest management; and (ii) fine-scaled variation within stands is of higher importance in the studied boreal forest ecosystem than variation between stands (e.g. due to former forestry). This is interesting considering that the stands were selected to be internally homogeneous, and nonetheless the majority of variation is explained within the stands.

Change in species composition reflected in species abundance

The natural stand

The displacement of species composition (as summarised by plot scores in the interpreted GNMDS ordination) from 1997 to 2005 for the natural stand is not significant ($p < 0.05$) along any of the four axes. Nevertheless, the *indication* of change in direction towards vegetation typical of a less rugged ground surface (lower inclination) and lower organic content in the soil (T. Økland 2003) is reflected in the significant decrease in abundance observed for *Maianthemum bifolium, Trientalis europaea* and *Dicranum fuscescens;* species mostly found on humus-rich, acidic soil (Smith 1978, Økland and Eilertsen 1993, Taylor et al. 2002, Lid and Lid 2005). The decrease for these species accords with the result of Nygaard and Ødegaard (1999) who investigated vegetation dynamics in an old-growth boreal forest over a sixty-year period (1931–1991). They found that only one out of forty species increased significantly in frequency while most species decreased significantly in abundance (e.g. *M. bifolium, T. europaea* and *D. fuscescens*) and ascribed the decline in species abundance to reduced light availability, mainly as a consequence of tree layer growth.

The significant increase of *Vaccinium myrtillus* could, as pointed out by Kubin (1983), Havas & Kubin (1983) and Nygaard and Ødegaard (1999) offer an explanation as to why a general decline in abundance is observed for several species. Increased dominance of *V. myrtillus* may influence other species directly through shading, increased amounts of litter or indirectly via nutrient cycling (Nygaard and Ødegaard 1999). Furthermore, with increasing production and accumulation of material resistant to decomposition (van Breemen 1995), the environment may change in a direction favouring *V. myrtillus* relative to other species (Nygaard and Ødegaard 1999). It is also worth mentioning that in a disturbance experiment, Rydgren et al. (1998) found neither *Maianthemum bifolium, Trientalis europaea* nor *Dicranum fuscescens* to be present in the propagule bank of the boreal forest floor three years after disturbance, and that they decreased significantly from the initial vegetation plots compared to three years after disturbance.

The decrease in abundance for *Pohlia nutans* in the natural stand may be linked to the absence of major disturbances in the eight-year period (as reflected also by the change towards vegetation typical of less rugged terrain), since this pioneer species typically occurs in disturbed sites (Mäkipää & Heikkinen 2003). *P. nutans* is a monoicous species with abundant spore production (Jonsson 1993), well suited for colonising recently disturbed sites (During 1979, 1992) such as denuded or burnt soil, consequently to decrease rapidly after disturbance (Jonsson 1993, Rydgren et al. 1998).

The minor selectively cut stand

In the former minor selectively cut stand a significant increase in TI from 1997 to 2005 is accompanied by a significant displacement along GNMDS-axis 1 in direction of vegetation typical of more closed forest, and a significant decrease in species abundance for several hepatic species, i.e. *Barbilophozia floerkei*, *B. lycopodioides*, *Calypogeia integristipula*, *Cephalozia lunulifolia* and the *Lophozia ventricosa* group. Bryophytes, and hepatics in particular, prefer mesic-moist habitats (R.Økland and Eilertsen 1993) which are inevitably linked to the impact of tree canopies (Sirén 1955, R.Økland and Eilertsen 1993, Rydgren 1993, T. Økland 1996) in two ways: i) by the strong gradient in throughfall precipitation from low close to tree stems due to canopy interception to larger in canopy gaps (cf. Stålfelt 1937, R. Økland et al. 1999), and ii) by the large amounts of litter with low moisture-retaining capacity close to tree stems (cf. Malmström 1937, Stålfelt 1937, T. Økland 1996). A decrease of *Barbilophozia floerkei* and *B. lycopodioides* with time has been reported both in old-growth forest (Nygaard and Ødegaard 1999, Framstad 2005) and in managed forest where the decline is partly attributed to the absence of a diaspore bank in disturbed patches (Jonsson 1993). The increase in abundance of a large feathermoss (e.g. *Pleurozium schreberi*) may also have affected the survival and colonisation of these smaller bryophytes negatively (R. Økland 2000, T. Økland et al. 2004ab).

The decrease of *Lophozia ventricosa* agg. accords with the results of for instance Vellak and Paal (1999). In addition to favouring moist sites, this taxon prefers decaying wood (Damsholt 2002). Formerly managed forest will naturally contain less dead wood and stumps than more mature forest, and even though my recordings of abundance are restricted to presence on soil, lack of dead-wood as a source for dispersion may contribute to a decline in *L. ventricosa* agg. Both Lesica et al. (1991) and Söderström (1988a) mention high sensitivity of liverworts to microclimate and substrate as a potentially important cause of decline in managed stands (Muhle and LeBlanc 1975). These results conform to mine, suggesting that

presence of dead wood in different stages of decay is important for maintenance, particularly of hepatic and saproxylic species assemblages in managed stands (Gustafsson and Hallingbäck 1988, Berg et al. 1994, Crites and Dale 1997). Nevertheless, the significant *increase* of *Lophozia ventricosa* agg. in the former *major* selectively cut stand emphasizes the stochastic nature of changes in abundance merely from one point in time to another.

The significant increase in abundance for *Plagiothecium laetum* can be ascribed to its ability to persist throughout disturbance events (Jonsson 1993, Rydgren et al. 1998) and for its propagules to survive in the litter layer (Rydgren and Hestmark 1997). The probability of burial increases from gaps between trees to underneath trees, where the litter-load is considerably higher (R.Økland and Eilertsen 1993); consequently few species can establish and survive on the loose, thick and generally dry humus close to trees, except for some bryophytes, such as *P. laetum* (T. Økland 1996).

The major selectively cut stand

As in the other stands, the former major selectively cut stand shows a significant increase in forest density (as shown by the tree inluence index). This increase is particularly strong in sites where tree influence was already quite high in 1997, and accords with the increase in abundance for *Chiloscyphus profondus,* a highly shade- and litter-tolerant species (R. Økland and Eilertsen 1993).

At the same time, species composition in the former major selectively cut stand is significantly displaced from vegetation typical of dry sites below trees towards that typical of moist openings between trees (GNMDS 1 and 3). This displacement is reflected in the increase in abundance for *Lophozia ventricosa* agg., *Polytrichum formosum* and *Barbilophozia floerkei,* all of which are species typical of a humid microenvironment (Frisvoll and Prestø 1997, Damsholt 2002).

The clear cut stand

No significant displacement of vegetation related to any of the four GNMDS-axes is observed for this stand. However, there is a slight overall change in direction of vegetation typical of more open sites with high fine-scale topographic variability as well as a significant increase in tree influence index.

The species increasing in abundance (*Dryopteris expansa* agg. and *Plagiothecium laetum*) in the clear cut stand are both frequent in the soil propagule bank (Rydgren and Hestmark 1997). *D. expansa* agg. represent a long-lived soil propagule bank favoured by a

rugged micro-environment for germination and development (Schupp 1995), whereas *P. laetum* is highly abundant in the propagule bank due to its large production of gemmae (Rydgren and Hestmark 1997).

It should be mentioned that the p-values for the tests of species abundance change showing significance are quite low ($0.02 < p < 0.05$) for all species in this stand and the number of species significantly changing was also low compared to the other stands. Several plots in this stand display a low number of species and a high turnover, reflected in large displacements along the first GNMDS-axis (> 0.3 HC units), which adds uncertainty to plot positions in the ordination. Low occurrences within each plot thus may explain why the p-values in this stand observed in tests of change in abundance for several species are relatively low.

Changes related to former forest management

Species abundance

My results do not conform with the general decline in abundance of vascular plant species observed in several monitoring areas in SE Norway by T. Økland et al. 2004ab attributed to soil acidification over the last century (Steinnes et al. 1993, Stuanes and Abrahamsen 1994, R. Økland et al. 2001). Furthermore, my results do not show indications of a distinct trend of change in abundance for neither mosses nor hepatics. To the contrary, my results indicate that seemingly unpredictable, small, localised shifts in abundance occur in the investigated boreal forest floor (R. Økland 1990ab, R. Økland 2000a) as part of an internal fine-scaled dynamics. Previous natural history as well as stochastic events (such as grazing, mammal trampling etc.) add unpredictability to interpretation of long-term trends. Especially when change is based on recordings from one point in time to another, great caution should be taken when interpreting change in abundance because of random year-to-year fluctuations (R. Økland and Eilertsen 1996, Nygaard and Ødegaard 1999, Bergstedt and Milberg 2001, Framstad 2005).

Changes in species abundance attributed to the increase in tree influence index, may not be directly relevant. Even though the average tree influence index has increased in all stands, it may not be a suitable measure for *general* increase in tree density, demonstrated by the fact that the plots already covered by trees often increase the most in TI, while for plots in gaps (low value of the tree influence index) the TI index has not changed much. It can therefore be questioned whether development into a locally denser forest has affected the current species in this study.

The observed patterns of change vary substantially among stands, seemingly without a consistent direction or in ways that are clearly relatable to former forest management. Like T. Økland et al. (2003), I find few significant differences in species abundance that can be ascribed to previous logging history and no clear patterns related to selective vs. clear cut stands, as seen in for instance Hannerz and Hånell (1997). Reasons for the apparent lack of species abundance response to former management may, for instance, be the relatively humid climatic conditions in Oppkuven, in which ecosystems are more tolerant to moderate disturbances such as logging, than ecosystems of a more xeric character (Haussler et al. 2002). Also, timber harvesting at Oppkuven was more likely done without the use of heavy machinery, slash was not removed, and the area that was clear cut was not very large and surrounded by patches of mature forest. All of these factors may have contributed to the apparently low to moderate disturbance impact on the vegetation.

Species composition

A few large tree-falls in the period 1997–2005 have not counteracted the general trend, visible in all stands, for the forest to have grown denser. This overall increase in forest density is not directly reflected in observed vegetation changes along the first GNMDS-axis (related to tree influence) for most of the stands, though. In the major selectively cut stand, species composition seemingly changes in the opposite direction (towards vegetation typical of more open forest), even though the tree influence index increases and plot positions are highly significantly related to GNMDS 1. Hence, factors other than the tree influence index may be responsible for this pronounced displacement of vegetation. Also the average TI for each stand in both 1997 and 2005 is lowest in the natural and the clear cut stands and highest in the selectively cut stands. However, the positions of the centroids (representing the average species composition for each stand) along the first GNMDS-axis does not comply with the expected order of stands according to average TI values. According to the linear models on change in tree influence, plots with high tree influence in 1997 experienced the strongest increase in tree influence in general, whereas plots situated between trees and/or in more open sites have not changed as much regarding tree influence index. Thus, it seems that the ordination axis related to tree influence reflects the individual plots' position relative to nearby trees, rather than overall stand density of trees, as mentioned earlier. This is also reflected in the split-plot analysis, as the main portion of the variation (93 %) along the first GNMDS-axis is explained on plot level and very little (7 %) on stand level.

Changes in species composition related to climate change?

The change in direction of a species composition typical of moist and open forest while at the same time the forest has become more closed, suggest occurrence of processes influencing vegetation more strongly other than those reflected by the measured environmental variables. This applies significantly to the major selectively cut stand as well as indicative for the natural and clear cut stands. I hypothesise the consistent change in climate over most of SE Norway over the last decades, with increasing temperatures as well as increasing precipitation as the reason for this "discrepancy". Precipitation (relative to the annual average from 1960 to 1990) in the years prior to the first recording (1997) compared to the years prior to the latest recording (2005), display substantially higher relative amounts of precipitation in the period before 2005, than 1997 (Norwegian Meteorological Institute 2007). Throughfall precipitation is the most important source of moisture for bryophytes (Tamm 1953, Weibull 2000). Thus, the general increase in soil moisture and the consequent improvement of growth conditions may have compensated for the closure of the canopy, allowing vegetation typical of more moist gaps between trees to survive in the denser forest or even encroach towards tree stems as indicated in this study. However, the change in species composition in accordance with predictions given a wetter climate are moderate and not reflected in significant changes of single species' abundances, though, as seen in other long-term studies (a general increase in abundance for mosses; e.g. Framstad et al. 2003, 2005, Bakkestuen et al. in press).

Convergent species compositional change across stands?

Although no general pattern of species abundance change across stands with different logging histories is found that can be related to logging *per se*, a weak but general trend in vegetation shift is observed in Oppkuven 1997–2005; a change in direction of a common focal point in the ordination space defined by the two first GNMDS-axes. In fact, the former managed stands all converge towards the reference stand (Nat), indicating a tendency for species composition in the investigated forests to have become slightly more similar during the eight-year period between analyses. This observation accords with the change after disturbance towards higher similarity observed by Rydgren et al. (2004) and the hypothesis of Brumelis and Carleton (1989) that nutrient-poor post-logged sites experiencing low levels of mechanical disruption will approach pre-logged species composition and structural conditions over time. In fact, no major disturbances have taken place in the studied forests in Oppkuven during the study period.

The converging trend is also partly reflected in some of the species significantly changing in *total* abundance; late-successional species like *Vaccinium myrtillus, Linnaea borealis* and *Pleurozium schreberi* increase while early/intermediate successional species like *Maianthemum bifolium, Pohlia nutans* and *Cladonia coniocraea* (Brumelis and Carleton 1989) are declining. Thus, forest-floor successions after disturbance, driven by tree-stand regeneration, still go on decades (or near a century) after disturbance (Meier et al. 1995, Kneeshaw and Burton 1997, R. Økland 2000b).

Time-lagged response of species composition to environmental change
The species composition in 2005 correlates slightly better with the tree influence index recorded in 1997 than the tree influence index in 2005. Similarly, the species composition in 2005 correlates somewhat better with the recordings of environmental variables in 1997 than does the species composition recorded in 1997. However, the overall differences in τ-values between ordination axes for plots recorded at the two points in time and the environmental variables are small and probably not significant, so they should be interpreted only as indicative.

Nevertheless, the indication of a slight delay in response of vegetation to environmental change accords with the delayed (7–11 years) response of vegetation to reduction of tree influence, demonstrated by Bergstedt and Milberg (2001) and Nilson and Lundquist (2001). Plant communities on grasslands have also been found to respond slowly to environmental change (Hanski and Ovaskainen 2002, Hanski 2005). Helm et al. (2006) discovered current species richness not to be significantly related to environmental variables recorded at the same time; however with a delayed significant effect on species richness of up to 70 years.

While ectohydric bryophytes may respond almost instantaneously to changes in moisture conditions (Busby et al. 1978, Skre et al. 1983, R. Økland 1997, R. Økland & Eilertsen 1996), time-lags are expected when vascular plants with long-lived ramets respond to its surroundings. Most likely, delay in the response is longer in the situation explored in the present study, in which changes mostly occur by *gradual* increase in tree influence, than in cases of more abrupt environmental change.

Conclusion
Both the tree layer and the understorey vegetation of the boreal forest are in constant change. In this study I demonstrate a slight convergence of the species composition of formerly

logged stands towards the composition of the reference area (unlogged forest), although much of the change in single-species abundances is erratic and seemingly not related to environmental change. Logging that occurred more than 60 years ago does not seem to directly influence today's species abundances or species composition, although indirect effects via tree-layer properties seem to occur. This accords with previous conclusions made by T. Økland et al. (2003) based upon a chronosequence of the same stands in Oppkuven. My results also accord with an effect of climate on vegetation that prevails over species compositional dynamics in response to a closing canopy. Further insights into the complex dynamics of the studied post-logging boreal forests calls for continuation of long-term studies in permanent plots.

References

Andersson LI, Hytteborn H (1991) Bryophytes and decaying wood - a comparison between managed and natural forest. Holarct. Ecol. 14:121-130

Anonymous (2001) Parliamentary Report. Stortingsmelding 42 (2000-01). Biologisk mangfold. Sektoransvar og samordning. Miljøverndepartementet, Oslo

Anonymous (2003) Microsoft Office Excel 2003. Microsoft Corporation 1985-2003

Atlegrim O, Sjöberg K (1996) Effects of clear-cutting and single-tree selection harvests on herbivorous insect larvae feeding on bilberry Vaccinium myrtillus in uneven-aged boreal Picea abies forest. For. Ecol. Mgmt 87:139-148

Aune B (1993) Temperaturnormaler, normalperiode 1961-1990. Norske meteorol. Inst. Rapp. Klima 1993:1-63

Bakker JP, Olff H, Willems JH, Zobel M (1996) Why do we need permanent plots in the study of long-term vegetation dynamics? J. Veg. Sci. 7:147-156

Bakkestuen V, Stabbetorp OE, Eilertsen O (1999a) Terrestrisk naturovervåking. Vegetasjonsøkologiske undersøkelser av boreal bjørkeskog i Åmotsdalen, Sør-Trøndelag. Norsk Inst. Naturforsk. Oppdragsmeld. 610:1-43

Bakkestuen V, Stabbetorp OE, Eilertsen O (1999b) Terrestrisk naturovervåking. Vegetasjonsøkologiske undersøkelser av boreal bjørkeskog i Møsvatn-Austfjell, Telemark. Norsk Inst. Naturforsk. Oppdragsmeld. 611:1-44

Bakkestuen V, Stabbetorp OE, Eilertsen O, Often A, Brattbakk I (2000) Terrestrisk naturovervåking. Vegetasjonsøkologiske undersøkelser av boreal bjørkeskog i Øvre Dividal og Gutulia nasjonalparker - reanalyser 1998. Norsk Inst. Naturforsk. Oppdragsmeld. 612:1-55

Bakkestuen V, Stabbetorp OE, Erikstad L, Wilmann B, Brattbakk I, Sørlie R (2002) Terrestrisk naturovervåking. Vegetasjonsøkologiske undersøkelser av boreal bjørkeskog i Lund og Åmotsdalen - reanalyser 2001. Norsk Inst. Naturforsk. Oppdragsmeld. 758:1-42

Bakkestuen V, Stabbetorp OE, Framstad E (2001) Terrestrisk naturovervåking. Vegetasjonsøkologiske undersøkelser av boreal bjørkeskog i Børgefjell nasjonalpark - reanalyser 2000. Norsk Inst. Naturforsk. Oppdragsmeld. 700:1-41

Framstad, E., Bakkestuen, V., Bruteig, IE., Kålås, JA., Nygård, T. and Økland, RH (2003) Natur i endring. Terrestrisk naturovervåking 1990–2002. NINA Temahefte 24

Berg, Å, Ehnström B, Gustafsson L, Hallingbäck T, Jonsell M, Weslien J (1994) Threatened plant, animal, and fungus species in Swedish forests: distribution and habitat associations. Conserv. Biol. 8:718-731

Bergstedt J, Milberg P (2001) The impact of logging intensity on field-layer vegetation in Swedish boreal forests. For. Ecol. Mgmt 154:105-115

Bjor K (1965) Temperaturgradients betydning for vannhusholdningen på skogmark. Meddr norske SkogforsVesen 20:275-306

Brumelis G, Carleton TJ (1989) The vegetation of postlogged black spruce lowlands in central Canada. II. Understorey plant cover. J. Appl. Ecol. 26:321-339

Busby JR, Whitfield DWA (1978) Water potenial, water content, and net assimilation of some boreal forest mosses. Can. J. Bot. 56:1551-1558

Crites S, Dale RTM (1998) Diversity and abundance of bryophytes, lichens, and fungi in relation to woody substrate and successional stage in aspen mixedwood boreal forests. Can. J. Bot. 76:641-651

Damsholt K (2002) Illustrated flora of nordic liverworts and hornworts. Nord. Bryol. Soc., Lund

During HJ (1992) Ecological classifications of bryophytes and lichens. In: Bates JW, Farmer AM (eds) Bryophytes and lichens in a changing environment Clarendon Press, Oxford [1-31]

During HJ (1979) Life strategies of bryophytes. Lindbergia 5:2-18

Ehnström B (2001) Leaving dead wood for insects in boreal forests. Suggestions for the future. Scand. J. For. Res. Suppl. S3:91-98

Esseen P-A, Ehnström B, Ericson L, Sjöberg K (1997) Boreal forests. Ecol. Bull. 46:16-47

Faith DP, Minchin PR, Belbin L (1987) Compositional dissimilarity as a robust measure of ecological distance. Vegetatio 69:57-68

Finér L, Mannerkoski H, Piirainen S, Starr M (2003) Carbon and nitrogen pools in an old-growth, Norway spruce mixed forest in eastern Finland and changes associated with clear-cutting. For. Ecol. Mgment. 174:51-63

Fitje A, Strand L (1973) Tremålingslære, ed. 2. Universitetsforlaget, Oslo

Førland E (1993) Nedbørhyppighet i 1:7 mill. Nasjonalatlas for Norge, kartblad 3.1.3. Statens kartverk, Hønefoss

Foster BL, Tilman D (2000) Dynamic and static views of succession: testing the descriptive power of the chronosequence approach. Pl. Ecol. 146:1-10

Framstad E, Bakkestuen V, Bruteig IE, Kålås JA, Nygård T and Økland RH (2003) Natur i endring. Terrestrisk naturovervåking 1990–2002. NINA Temahefte 24.

Framstad E (2005) Natur i endring. Terrestrisk naturovervåking i 2005: Markvegetasjon, epifytter, smågnagere og fugl. Norsk Inst. Naturforsk. Oppdragsmeld. 150[16-23]

Frisvoll AA, Elvebakk A, Flatberg KI, Økland RH (1995) Sjekkliste over norske mosar. Vitskapleg og norsk namneverk. Norsk Inst. Naturforsk. Temahefte 4:1-104

Frisvoll AA, Prestø T (1997) Spruce forest bryophytes in central Norway and their relationships to environmental factors including modern forestry. Ecography 20:3-18

Gjerde I, Baumann C (2002) Miljøregistreringer i skog - biologisk mangfold. Hovedrapport. Skogforsk, Ås

Gustafsson L, Hallingbäck T (1988) Bryophyte flora and vegetation of managed and virgin coniferous forests in south-west Sweden. Biol. Conserv. 4:283-300

Hannerz M, Hånell B (1997) Effects on the flora in Norway spruce forests following clearcutting and shelterwood cutting. For. Ecol. Mgmt 90:29-49

Hanski I (2005) Landscape fragmentation, biodiversity loss and the societal response . EMBO reports 6:388-392

Hanski I, Ovaskainen O (2002) Extinction debt at extinction threshold. Conserv. biol. 16:666-673

Haussler S, Bedford L, Leduc A, Bergeron Y, Kranabetter JM (2002) Silvicultural disturbance severity and plant communities of the southern Canadian boreal forest. Silva fenn. 36:307-327

Havas P, Kubin E (1983) Structure, growth and organic matter content in the vegetation cover of an old spruce forest in Northern Finland. Annls bot. fenn. 20:115-149

Heikkinen RK (1991) Multivariate analysis of esker vegetation in southern Häme, S Finland. Annls bot. fenn. 28:201-224

Helm A, Hanski I, Pärtel M (2006) Slow response of plant species richness to habitat loss and fragmentation. Ecol. Letters 9:72-77

Hill MO (1979) DECORANA - A FORTRAN program for detrended correspondence analysis and reciprocal averaging. Cornell University, Ithaca, New York, USA

Hill MO, Gauch HGJ (1980) Detrended correspondence analysis: an improved ordination technique. Vegetatio 42:47-58

Hurlbert SH (1984) Pseudoreplication and the design of ecological field experiments. Ecol. Monogr. 54:187-211

Johnson DW, Cresser MS, Nilsson SI, Turner J, Ulrich B, Binkley D, Cole DW (1991) Soil changes in forest ecosystems: evidence for and probable causes. Proc. r. Soc. Edinburgh sect. B biol. Sci. 97B:81-116

Jonsell M, Weslien J, & Ehnström B (1998) Substrate requirements of red-listed saproxylic invertebrates in Sweden. Biodiv. Conserv. 7:749-764

Jonsson BG (1993) The bryophyte diaspore bank and its role after small-scale disturbance in a boreal forest. J. Veg. Sci. 4:819-826

Kendall MG (1938) A new measure of rank correlation. Biometrika 30:81-93

Kneeshaw DD, Burton PJ (1997) Canopy and age structures of some old sub-boreal Picea stands in British Columbia. J. Veg. Sci. 8:615-626

Krog H, Østhagen H, Tønsberg T (1994) Lavflora. Norske busk- og bladlav. Ny revidert utgave ved Hildur Krog og Tor Tønsberg, ed. 2. Universitetsforlaget, Oslo, Norway

Kruskal JB (1964a) Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika 29:1-27

Kruskal JB (1964b) Nonmetric multidimensional scaling: a numerical method. Psychometrika 29:115-129

Kubin E (1977) The effect of clear cutting upon the nutrient status of a spruce forest in northern Finland (64° 28' N). Acta for. fenn. 155:5-38

Kubin E (1983) Nutrients in the soil, ground vegetation and tree layer in an old spruce forest in Northern Finland. Annls bot. fenn. 20:361-390

Kuuluvainen T (2000a) Natural variability of forests as a reference for restoring and managing biological diversity in boreal Fennoscandia. Silva fenn. 36:97-125

Kuuluvainen T (2002b) Disturbance dynamics in boreal forests: defining the ecological basis of restoration and management of biodiversity. Silva fenn. 36:5-11

Kålås JA, Viken Å, Bakken Ted (2006) Norsk Rødliste - Norwegian Red List. Artdatabanken, Norway

Larsen BT (1978) Krokskogen lava area. Norg. geol. Unders. 337:143-162

Larsson S, Danell K (2001) Science and the management of boreal forest diversity. Scand. J. For. Res. Suppl. 3:5-9

Legendre P (1993) Spatial autocorrelation: trouble or new paradigm? Ecology 74:1659-1673

Legendre P, Legendre L (1998) Numerical ecology, ed. 2. Elsevier, Amsterdam

Lemmon PE (1956) A spherical densiometer for estimating forest overstory density. For. Sci. 2:314-320

Lesica P, McCune B, Cooper SV, Hong WS (1991) Differences in lichen and bryophyte communities between old-growth and managed second-growth forests in the Swan Valley, Montana. Can. J. Bot. 69:1745-1755

Lid J, Lid DT (2005) Norsk flora. 7 utgåve ved R. Elven. Det Norske Samlaget, Oslo, Norway.

Likens GE, Bormann FH, Pierce RS, Reiners WA (1978) Recovery of a deforested ecosystem. Science 199:492-496

Linder P, Östlund L (1992) Förändringar i norra Sveriges skogar 1870-1991. Svensk bot. Tidskr. 86:199-215

Mäkipää R, Heikkinen J (2003) Large-scale change in abundance of terrocolous bryophytes and macrolichens in Finland. J. Veg. Sci. 14:497-598
Malmström C (1937) Tönnerssjöhedens försökspark i Halland. Ett bidrag till kännedomen om sydvästra Sveriges skogar, ljunghedar och torvmarker. Meddn St. SkogsförsAnst. 30:323-528

Mardia KV, Kent JT, Bibby JM (1979) Multivariate analysis. Academic Press

Meier AJ, Bratton SP, Duffy DC (1995) Possible ecological mechanism for loss of vernal-herb diversity in logged eastern deciduous forests. Ecol. Appl. 5:935-946

Mills SE, Macdonald SE (2004) Predictors of moss and liverwort species diversity of microsites in conifer-dominated boreal forest. J. Veg. Sci. 15:189-198

Mills SE Macdonald E (2005) Factors influencing bryophyte assemblage at different scales in the western Canadian boreal forest. Bryologist 108:86-100

Moen A (1998) Nasjonalatlas for Norge: Vegetasjon. Statens Kartverk, Hønefoss

Muhle H, LeBlanc F (1975) Bryophyte and lichen succession on decaying logs. I. Analysis along an evaporational gradient in eastern Canada. J. Hattori bot. Lab. 39:1-33

Nellemann C, Thomsen MG (1994) Terrain ruggedness and caribou forage availability during snowmelt on the arctic coastal plain, Alaska. Arctic 47:361-367

Nilson K, Lundqvist L (2001) Effect of stand structure and density on development of natural regeneration in two Picea abies stands in Sweden. Scand, J. For. Res. 16:253-259

Nilsson SG, Hedin J, Niklasson M (2001) Biodiversity and its assessment in boreal and nemoral forests . Scand. J. For. Res. Suppl. 3:10-26

Norwegian Meteorological Institute (2007) [Online] URL: http://www.eklima.no

Nygaard PH, Ødegaard T (1999) Sixty years of vegetation dynamics in a south boreal coniferous forest in southern Norway. J. Veg. Sci. 10:5-16

Nykvist N (1997) Changes in species occurrence and phytomass after clearfelling, prescribed burning and slash removal in two Swedish spruce forests. Stud. for. suec. 201:1-33

Nykvist N, Skyllberg U (1989) The spatial variation of pH in the mor layer of some coniferous forest stands in northern Sweden. Scand. J. For. Res. 4:3-11

Ohlson M, Tryterud E (1999) Long-term spruce forest continuity - a challenge for a sustainable Scandinavian forestry. For. Ecol. Mgmt 124:27-34

Økland RH (1996) Are ordination and constrained ordination alternative or complementary strategies in general ecological studies? J. Veg. Sci. 7:289-292

Økland RH (1995) Changes in the occurrence and abundance of plant species in a Norwegian boreal coniferous forest, 1988-1993. Nord. J. Bot. 15:415-438

Økland RH (1997) Reanalyse av permanente prøveflater i barskog i overvåkingsområdet Solhomfjell 1995. Bot. Hage Mus. Univ. Oslo Rapp. 2:1-35

Økland RH (2000a) Population biology of the clonal moss *Hylocomium splendens* in Norwegian boreal spruce forests. 5. Consequences of the vertical position of individual shoot segments. OIKOS. 88: 449-469

Økland RH (2000b) Understorey vegetation development in North Finnish feathermoss-spruce forests after disturbance: re-analysis of Sirén´s data. J. Veg. Sci. 11:533-546

Økland RH (1990a) Vegetation ecology: theory, methods and applications with reference to Fennoscandia. Sommerfeltia Suppl. 1:1-233

Økland RH (1990b) A phytoecological study of the mire Northern Kisselbergmosen, SE Norway. II. Identification of gradients by detrended (canonical) correspondence analysis. Nord. J. Bot. 10:79-108

Økland RH, Eilertsen O (1996) Dynamics of understory vegetation in an old-growth boreal coniferous forest, 1988-1993. J. Veg. Sci. 7:747-762

Økland RH, Eilertsen O (1993) Vegetation-environment relationships of boreal coniferous forests in the Solhomfjell area, Gjerstad, S Norway. Sommerfeltia 16:1-254

Økland RH, Økland T, Rydgren K (2001) Vegetation-environment relationships of boreal spruce swamp forests in Østmarka Nature Reserve, SE Norway. Sommerfeltia 29:1-190

Økland RH, Rydgren K, Økland T (1999) Single-tree influence on understorey vegetation in a Norwegian boreal spruce forest. Oikos 87:488-498

Økland T (1988) An ecological approach to the investigation of a beech forest in Vestfold, SE Norway. Nord. J. Bot. 8:375-407

Økland T (1996) Vegetation-environment relationships of boreal spruce forest in ten monitoring reference areas in Norway. Sommerfeltia 22:1-349

Økland T, Bakkestuen V, Økland RH, Eilertsen O (2004a) Changes in forest understory vegetation in Norway related to long-term soil acidification and climatic change. J. Veg. Sci. 15:437-448

Økland T, Økland RH, Bratli H, Eilertsen O (2004b) Nasjonalt nettverk av flater for intensivovervåking i skog: Endringer i planteartsmangfold i granskog i perioden 1988-2002. Norsk Inst. Jord- Skogkartlegging Rapp. 2004:1-55

Økland T, Rydgren K, Økland RH, Storaunet KO, Rolstad J (2003) Variation in environmental conditions, understorey species richness, abundance and composition among natural and managed Picea abies forest stands. For. Ecol. Mgmt 177:17-37

Olsson BA, Staaf H (1995) Influence of harvesting intensity of logging residues on ground vegetation in coniferous forests. J. appl. Ecol. 32:640-654

Östlund L (1993) Exploitation and structural changes in the north Swedish boreal forest 1800-1992. Dissertation. Swedish University of Agricultural Sciences, Department of Forest Vegetation Ecology, Umeå, Sweden
Östlund L, Zackrisson O, Axelsson AL (1997) The history and transformation of a Scandinavian boreal forest landscape since the 19th century. Can. J. For. Res. 27:1198-1206

Palmer MW (1988) Fractal geometry: a tool for describing spatial patterns of plant communities. Vegetatio 75:91-102

Palmer MW, Dixon PM (1990) Small-scale environmental heterogeneity and the analysis of species distributions along gradients. J. Veg. Sci. 1:57-65

Palviainen M, Finér L, Mannerkoski H, Piirainen S, Starr M (2005) Responses of ground vegetation species to clear-cutting in a boreal forest: aboveground biomass and nutrient contents during the first 7 years. Ecol. Res. 20:652-660

Parker KC (1988) Environmental relationships and vegetation associates of columnar cacti in the northern Sonoran Desert. Vegetatio 78:125-140

Pearson K (1901) On lines and planes of closest fit to systems of points in space. Phil. Mag. 6. Ser. 2:559-572

Peres-Neto PR, Jackson DA (2001) How well do multivariate data sets match? The advantages of a Procrustean superimposition approach over the Mantel test. Oecologia 129:169-178

Piirainen S, Finér L, Mannerkoski H, Starr M (2004) Effects of forest clear-cutting on the sulphur, phosphorus and base cations fluxes through podzolic soil horizons. Biogeochemistry 69:405-424

Pitkänen S (1997) Correlation between stand structure and ground vegetation: an analytical approach. Pl. Ecol. 131:109-126

Ponge J-F, Ferdy J-B (1997) Growth of Fagus sylvatica saplings in an old-growth forest as affected by soil and light conditions. J. Veg. Sci. 8:789-796

R Development Core Team (2005) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria

Rossi RE, Mulla DJ, Journel AG, Franz EH (1992) Geostatistical tools for modeling and interpreting ecological spatial dependence. Ecol. Monogr. 62:277-314

Rydgren K (1993) Herb-rich spruce forests in W Nordland, N Norway: an ecological and methodological study. Nord. J. Bot. 13:667-690

Rydgren K, Hestmark G (1997) The soil propagule bank in a boreal old-growth spruce forest: changes with depth and relationship to aboveground vegetation. Can. J. Bot. 75:121-128

Rydgren K, Hestmark G, Økland RH (1998) Revegetation following experimental disturbance in a boreal old-growth Picea abies forest. J. Veg. Sci. 9:763-776

Rydgren K, Økland RH, Hestmark G (2004) Disturbance severity and community resilience in a boreal forest. Ecology 85:1906-1915

Rydgren K, Økland T, Økland RH, Storaunet KO (1999) Hogstpåvirkning på biologisk mangfold og undervegetasjonens sammensetning i granskog. Norsk Inst. Jord-Skogkartlegging Rapp. 1999:1-35

Schupp EW (1995) Seed-seedling conflicts, habitat choice, and patterns of plant recruitment. Am. J. Bot. 82:399-409

Siitonen J (2001) Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecol. Bull. 49:11-41

Sirén G (1955) The development of spruce forest on raw humus sites in northern Finland and its ecology. Acta for. fenn. 62:1-408

Skre O, Oechel WC, Miller PM (1983) Moss leaf water content and solar radiation at the moss surface in a mature black spruce forest in central Alaska. Can. J. For. Res. 13:860-868

Skyllberg U (1991) Seasonal variation of pHH2O and pHCaCl2 in centimeter-layers of mor humus in a Picea abies (L.) Karst. stand. Scand. J. For. Res. 6:3-18

Smith AJE (1978) The moss flora of Britain and Ireland. Cambridge University Press, Cambridge

Söderström L (1981) Distribution of bryophytes in spruce forests on hill slopes in central Sweden. Wahlenbergia 7:141-153

Söderström L (1988a) The occurrence of epixylic bryophyte and lichen species in an old natural and managed forest stand in northeast Sweden. Biol. Conserv. 45:169-178

Söderström, L. (1988b) Sequence of bryophytes and lichens in relation to substrate variables of decaying coniferous wood in Northern Sweden. Nord. J. Bot. 8:89-97

Stålfelt MG (1937) Die bedeutung der Vegetation im Wasserhaushalt des Bodens. Svenska Skogsvårdsfören. Tidskr. 35:161-195

Steinnes E, Flaten TP, Varskog P, Låg J, Bølviken B (1993) Acidification status of Norwegian forest soils as evident from large scale studies of humus samples. Scand. J. For. Res. 8:291-304

Storaunet KO, Groven R, Rolstad E, Rolstad J (2006) Urskog på Oppkuven. Snø og ski 2, 28-30

Storaunet KO, Rolstad J, Gjerde I, Gundersen VS (2005) Historical logging, productivity, and structural characteristics of boreal coniferous forests in Norway. Silva fenn. 39:429-442

Stuanes AO, Abrahamsen G (1994) Long-term experiments with acid rain in Norwegian forest ecosystems: soil chemistry. Ecol. Stud. 104:37-100

Tamm CO (1953) Growth, yield and nutrition in carpets of a forest moss (Hylocomium splendens). Meddn St. SkogsforskInst. 43:1-140

Tamm CO, Hallbäcken L (1988) Changes in soil acidity in two forest areas with different acid deposition: 1920s to 1980s. Ambio 17:56-61

Taylor K, Havill DC, Pearson J, Woodall J (2002) Biological flora of the British Isles. Trientalis europaea L. J. Ecol. 90:404-418

ter Braak CJF (1994) Canonical community ordination. Part I: Basic theory and linear methods. Écoscience 1:127-140

ter Braak CJF, Prentice IC (1988) A theory of gradient analysis. Adv. ecol. Res. 18:271-317

van Breemen N (1995) How Sphagnum bogs down other plants. Trends Ecol. Evol. 10:270-275

Vellak K, Paal J (1999) Diversity of bryophyte vegetation in some forest types in Estonia: a comparison of old unmanaged and managed forests. Biodiv. Cons. 8:1595-1620

Weibull H (2000) Bryophytes on boulders: diversity, habitat preferences and conservation aspects. Dissertation. Swedish University of Agricultural Sciences, Department of Conservation Biology, Uppsala, Sweden

Wiens JA (1989) Spatial scaling in ecology. Funct. Ecol. 3:385-397

Appendix 1a-d. Subplot frequency (0-16) for all plots in all the stands from 1997. Species are listed in the first column, and plots (n = 25) in subsequent columns.

Appendix 1a. The natural stand.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Betula pubescens	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0
Picea abies	1	0	1	2	0	0	5	0	0	9	0	1	4	0	2	0	0	0	0	0	0	0	0	1	0
Sorbus aucuparia	10	4	1	0	3	3	7	1	2	3	2	6	10	3	1	2	4	0	0	1	0	0	4	5	11
Vaccinium myrtillus	15	16	16	16	16	1	16	16	16	15	16	10	12	16	12	16	16	16	16	16	16	16	16	16	16
Vaccinium vitis-idaea	5	0	5	14	0	0	0	14	0	10	1	0	0	3	0	0	2	0	3	3	7	8	0	0	1
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0
Dryopteris expansa agg.	0	0	1	4	0	0	2	0	5	0	0	0	3	0	0	1	1	0	0	0	1	0	0	2	5
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maianthemum bifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	4	0	0	1	1	13	10
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	10	1	0	2	1	0	2	0	11	0	0	0	0	0	0	0	0	2	0	0	11	0	13	10	7
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	16	16	0	16	5	0	16	2	16	11	10	16	13	16	1	16	7	15	16	9	16	11	16	16	14
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	3	0	0	4	0	0	5	2	0	0	0	2	0	0	1	0	0	1	8	0	0	0	0	0	0
Brachythecium starkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	8	2	15	10	8	12	8	11	13	15	11	9	16	3	13	13	14	0	0	4	5	5	1	0	6
Dicranum majus	9	0	0	1	0	0	0	0	1	0	0	0	6	0	5	0	1	4	0	15	7	16	0	16	12
Dicranum montanum	0	0	0	0	0	2	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	1
Dicranum scoparium	11	0	5	14	4	0	16	11	13	9	16	13	13	16	16	16	15	16	16	14	16	16	7	15	11
Hylocomiastrum umbratum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15	0	4	4	1	12	0
Hylocomium splendens	7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	11	3	0	0	8	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium laetum	14	0	8	16	11	13	15	15	14	5	5	4	7	4	6	3	1	0	6	1	4	14	0	1	8
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	1	0	0	5	0	0	1	0	0	0	1	0	0	7	11	1	0	16	16	0	16	16	0	15	0
Pohlia nutans	4	0	0	1	0	0	2	1	0	0	2	2	0	1	0	1	0	1	0	11	0	0	2	0	3
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Polytrichum formosum	16	2	4	12	4	1	16	6	10	11	0	1	0	16	8	16	10	0	7	12	16	10	14	14	14
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1a cont.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	3	0	8	9	3	1	1	6	6	11	1	0	9	1	2	1	1	0	0	0	2	1	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Barbilophozia attenuata	1	0	2	8	1	0	9	5	6	1	5	0	2	0	8	5	1	0	0	2	4	4	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	3	0	0	0	1	0	0	0	0	0	0	4	2	0	4	5	0	15	4	0	5	0
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	4	0	3	15	0	0	11	2	3	0	0	3	2	11	15	15	1	16	16	8	16	16	4	16	5
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	0	0	0	7	1	0	3	0	3	0	0	0	0	1	2	1	0	0	0	2	0	2	0	0	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	2	0	0	8	1	0	2	0	5	3	3	0	0	1	1	5	0	0	0	1	0	2	0	0	0
Cephaloziella cf. divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
Chiloscyphus profundus	12	0	2	1	0	2	10	3	4	0	8	1	2	0	2	0	0	0	0	0	0	3	0	0	1
Diplophyllum taxifolium	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	6	0	3	5	0	0	8	5	1	4	2	0	1	0	3	5	2	0	0	2	1	4	0	0	0
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	1	0	0	0	0	0	6	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	0	6	1
Ptilidium pulcherrimum	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	3	0	0	1	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Cladonia chlorophaea agg.	2	0	2	6	0	0	0	6	1	3	1	0	3	0	14	2	1	3	5	1	5	0	0	0	0
Cladonia coniocraea	2	0	5	3	1	0	0	3	2	4	2	0	6	2	7	0	0	0	0	0	0	0	0	0	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	1	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0

Appendix 1b. The minor selectively cut stand.

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	0	0	0	8	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Sorbus aucuparia	3	14	3	4	2	2	1	7	9	5	4	2	2	7	2	1	5	6	7	0	4	7	4	9	1
Vaccinium myrtillus	6	13	3	16	16	13	13	16	16	16	12	16	16	16	13	16	16	12	6	16	16	16	16	16	16
Vaccinium vitis-idaea	0	0	0	0	2	4	0	0	7	11	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	0	3	1	0	1	4	4	0	2	0	1	5	0	0	0	0	1	6	1	6	5	1	0	0	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	9	0	0	0
Lycopodium annotinum	0	0	0	2	0	0	0	0	6	0	0	0	0	0	0	7	2	0	0	0	0	0	0	0	0
Maianthemum bifolium	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	6	1	0	0	0	1	7	0	1
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	0	6	3	0	9	7	11	3	0	2
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	10	13	0	12	8	9	12	15	16	16	16	16	16	16	16	16	0	16	3	16	16	16	16	14	16
Luzula pilosa	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	0	0	0	0	0	0	1	1	0	2	0	9	0	0	0	1	4	1	0	5	2	0	0	0	0
Brachythecium starkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	10	2	9	6	16	2	3	2	0	0	8	4	0	6	6	1	0	0	5	0	4	0	4	7	0
Dicranum majus	0	7	0	10	0	11	0	4	6	5	3	7	16	16	0	8	9	10	0	1	2	16	9	4	2
Dicranum montanum	4	0	1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium	10	8	16	8	16	11	16	10	16	16	16	3	11	11	8	13	16	13	3	1	5	10	8	9	3
Hylocomiastrum umbratum	0	0	0	0	0	0	0	0	0	1	0	8	0	0	0	0	12	2	0	2	0	0	0	0	0
Hylocomium splendens	0	0	0	0	0	2	0	0	0	13	0	0	10	0	8	0	0	4	0	0	5	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium laetum	8	5	2	11	16	14	15	10	3	0	1	13	0	6	2	4	0	0	1	1	5	0	2	9	5
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	0	0	4	9	6	0	1	12	16	7	14	7	5	6	10	2	0	0	0	16	0	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	16	0	0	0	13
Polytrichum formosum	0	9	0	0	14	0	16	0	0	10	0	16	16	3	16	16	10	9	0	10	4	8	3	10	0
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Tetraphis pellucida	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	16	12	0	0	12	16
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	0	0	1	0	6	2	0	0	0	3	3	4	0	1	0	0	0	0	0	0	1	0	0	2	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	1	0	0	0	6	0	4	0	0	10	0	10	3	0	1	1	0	0	0	0	1	0	0	4	0
Barbilophozia hatcheri	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	2	0	0	0	4	9	13	0	6	16	7	15	3	12	1	4	16	10	1	3	5	9	0	7	3
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	0	0	0	0	3	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	1	6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	0
Cephaloziella cf. divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	4	3	2	4	14	6	9	3	0	0	1	4	0	1	0	2	0	0	0	0	5	0	1	3	0
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	1	0	3	6	8	1	1	0	0	2	4	2	2	0	0	0	0	0	0	0	0	0	0	1	0
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	0	0	1	6	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	2
Ptilidium pulcherrimum	6	0	2	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cladonia coniocraea	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1c. The major selectively cut stand.

	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Picea abies	13	9	3	1	2	0	0	1	1	0	1	0	0	5	0	0	0	0	0	5	1	0	1	8	0
Sorbus aucuparia	14	8	1	0	3	6	1	0	1	2	1	2	1	2	6	4	4	0	2	7	0	3	4	6	6
Vaccinium myrtillus	7	16	13	16	16	7	9	11	10	8	11	1	15	16	9	15	12	16	13	12	16	10	16	14	10
Vaccinium vitis-idaea	0	0	0	3	1	0	0	0	0	0	0	0	5	6	0	0	0	0	2	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	4	14	5	1	2	1	0	6	2	4	2	6	2	0	7	8	1	0	8	1	0	2	0	5	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	0	11	0	0	5	13	0	0	3	0	2	1	9	0	0	0	0	0	1	2	0	1	0	1	0
Maianthemum bifolium	1	0	1	0	4	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	3	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	2	1	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Calamagrostis purpurea	0	9	5	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	4	2	5	0	12	12	0	3	1	14	14	0	8	8	2	12	1	15	8	10	12	15	16	15	5
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	0	2	5	7	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Brachythecium starkei	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	9	8	4	6	1	2	10	3	1	0	2	5	11	4	9	10	0	5	14	0	8	3	5	12	4
Dicranum majus	0	6	0	0	0	3	6	16	1	0	2	0	5	2	0	0	0	3	3	0	10	0	5	0	0
Dicranum montanum	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
Dicranum scoparium	9	16	13	16	16	9	7	2	9	16	5	1	10	7	16	14	3	5	13	11	15	15	7	13	12
Hylocomiastrum umbratum	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0
Plagiothecium laetum	4	10	13	12	6	3	7	6	2	9	1	6	12	1	0	6	0	3	10	6	2	4	9	2	1
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	16	6	1	8	1	0	0	0	1	1	0	10	0	0	3	0	0	0	8	1	5	0	0	
Pohlia nutans	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum formosum	9	0	4	0	0	16	8	16	11	3	10	0	1	15	1	4	0	16	9	12	14	0	14	13	5
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1c cont.

	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	8	4	0	1	0	3	2	1	0	0	0	3	0	0	0	0	0	0	8	0	1	0	0	1	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	13	3	0	0	0	5	0	0	0	0	8	0	0	13	0	0	0	0	0	8	0	0	0	11	0
Sphagnum quinquefarium	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	0	7	0	4	0	1	0	0	0	1	0	1	2	2	1	6	0	0	10	0	1	0	0	3	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	0	2	0	0	5	2	0	0	1	0	0	0	0	2	0	0	0	0	1	2	0	0	0	10	0
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	0	12	4	6	9	0	0	0	3	15	1	0	6	3	1	3	0	0	1	0	15	3	0	0	0
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Calypogeia azurea	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	2	1	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	5	0	0	0	0	2	0
Calypogeia muelleriana	7	9	0	0	0	2	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	6	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	6	4	0	0	0	0	0	0	4	0	1	0	0	3	0	0	0	0	0	3	0	0	0	7	0
Cephalozia leucantha	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	3	2	0	0	0	4	4	4	1	0	0	3	2	0	0	1	0	0	5	0	0	0	0	3	0
Cephaloziella cf. divaricata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	2	5	6	7	3	0	4	5	2	3	6	0	6	0	1	2	1	0	2	1	5	5	8	0	2
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	2	5	0	0	0	1	1	1	4	1	2	0	1	1	1	0	0	0	0	0	2	0	0	2	0
Plagiochila asplenioides	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium pulcherrimum	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	0	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	1	0
Cladonia coniocraea	0	2	2	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	1	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1d. The clear cut stand.

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	1	0	2	4	4	2	0	2	1	0	5	1	1	2	2	1	0	0	0	1	0	0	0	0	1
Sorbus aucuparia	2	2	4	4	8	2	11	11	3	0	1	1	8	14	1	1	3	0	1	0	2	0	0	2	0
Vaccinium myrtillus	16	14	16	15	15	16	16	15	9	6	16	16	16	16	16	14	16	0	0	0	7	0	3	0	15
Vaccinium vitis-idaea	2	0	0	8	12	11	0	0	0	0	13	0	0	0	8	1	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	4	2	12	4	2	5	12	8	4	1	4	7	6	5	1	0	3	4	0	0	10	1	0	0	1
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	8
Linnaea borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Maianthemum bifolium	0	0	0	0	2	0	6	1	6	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	14	13	9	13	9	8	5	0	5	13	2	9	14	0	0	0	0	0	0	0	0	0	14
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	15	9	16	16	16	16	16	16	16	0	16	16	16	16	15	8	16	0	0	0	5	1	0	0	16
Luzula pilosa	0	0	3	0	0	1	4	1	0	0	0	0	1	2	4	0	1	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	1	0	4	3	0	4	11	7	0	0	1	15	4	10	12	0	0	0	0	0	0	0	0	0	4
Brachythecium starkei	5	0	0	0	0	1	6	6	0	0	7	0	0	0	0	1	2	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	5	6	5	7	14	3	0	8	1	1	3	1	2	2	1	0	1	1	1	2	1	0	0	0	0
Dicranum majus	0	1	0	6	2	0	0	0	0	0	0	0	0	2	0	3	7	0	0	0	0	0	0	0	0
Dicranum montanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium	14	12	9	15	15	16	4	15	16	7	15	16	14	16	16	10	8	7	2	0	3	7	6	0	6
Hylocomiastrum umbratum	0	0	4	4	1	6	2	4	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hylocomium splendens	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Plagiothecium laetum	12	8	9	7	15	2	0	10	6	11	4	13	8	2	0	11	5	8	1	1	7	6	4	1	2
Plagiothecium undulatum	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	10	0	0	2	3	16	0	13	2	0	2	12	1	1	10	2	0	0	0	0	0	0	0	0	0
Pohlia nutans	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Polytrichum formosum	5	0	13	6	3	0	11	10	9	1	6	16	14	9	9	3	11	8	0	3	14	10	0	0	0
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	0	3	3	1	0	0	0	1	0	0	0	0	1	0	0	0	0	4	1	0	0	0	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	2	0	12	15	0	1	3	8	10	0	0	7	2	0	0	0	12	1	0	1	4	6	0	0	16
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	4	0	0	8	0	0	0	1	0	0	2	5	0	0	0	0	0	1	0	0	0	0	0	0	4
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	13	1	6	6	0	15	9	5	11	0	16	16	6	9	16	3	15	5	0	0	1	4	1	0	2
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	2	0	3	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	7	0	1	0	0	0	0	0
Cephaloziella cf. divaricata	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	2	0	11	7	9	4	0	9	7	0	4	13	5	0	13	0	4	3	2	0	5	3	1	0	9
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Lophozia obtusa	0	0	1	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	4	0	3	3	0	0	0	2	0	0	3	11	3	0	5	0	0	0	0	0	0	4	0	0	1
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	0	0	1	0	6	0	0	0	0	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium pulcherrimum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	2	0	0	0	1	1	0	1	0	0	6	0	0	0	8	0	0	0	0	0	0	0	0	0	0
Cladonia coniocraea	0	1	0	0	0	0	0	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2a-d. Subplot frequency (0-16) for all plots in all the stands from 2005. Species are listed in the first column, and plots (n = 25) in subsequent columns.

Appendix 2a. The natural stand.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	7	3	1	0	0
Picea abies	2	0	1	3	1	0	1	0	0	10	0	0	3	0	4	0	0	0	0	0	1	0	0	0	0
Sorbus aucuparia	6	3	0	0	4	6	2	1	3	2	11	6	8	1	1	4	4	0	0	1	1	0	3	1	7
Vaccinium myrtillus	16	16	16	16	16	4	15	16	16	16	16	15	14	16	16	16	16	16	16	16	16	16	16	16	16
Vaccinium vitis-idaea	6	2	1	16	0	0	0	10	0	10	0	0	0	1	0	0	0	2	0	2	0	5	0	0	1
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0
Dryopteris expansa agg.	0	0	0	0	0	0	0	0	5	0	0	0	3	0	0	1	1	0	0	0	0	0	0	0	6
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Maianthemum bifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	5	2
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	3	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	6	0	0	4	0	0	4	0	9	1	0	0	0	0	0	0	0	0	0	0	6	0	3	3	3
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	16	13	0	10	14	0	16	7	15	12	11	16	15	9	6	16	0	16	16	8	16	9	16	13	16
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	11	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	3	0	0	2	0	0	6	8	0	0	0	0	0	0	0	0	0	8	11	0	0	0	0	0	0
Brachythecium starkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	5	0	13	5	10	11	4	15	12	12	6	10	16	3	12	12	8	0	0	2	0	0	1	0	2
Dicranum majus	6	0	0	0	0	0	1	0	2	0	9	4	0	12	0	7	3	0	0	13	6	11	0	15	12
Dicranum montanum	0	0	0	0	1	13	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium	8	0	7	6	5	0	13	16	14	12	13	13	15	16	15	10	15	16	16	15	15	14	10	9	11
Hylocomiastrum umbratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	1	0
Hylocomium splendens	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	6	0	11	8	0	8	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium laetum	10	5	10	15	16	11	14	13	14	4	4	11	4	3	5	1	0	0	2	2	2	9	0	3	5
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	4	0	0	5	0	0	0	0	2	0	0	0	1	4	10	0	0	16	16	4	11	15	1	14	3
Pohlia nutans	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Polytrichum formosum	15	0	9	15	4	0	16	9	13	11	0	1	1	15	7	16	11	0	2	9	15	6	16	10	15
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	4	0	8	2	2	2	1	7	3	10	1	0	8	0	1	2	0	0	0	2	0	2	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	6	0	1	8	0	0	5	2	4	5	0	0	0	0	5	10	2	0	0	4	2	4	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	2	0	0	0	3	0	0	0	0	0	0	2	5	0	4	5	0	2	7	0	9	0
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	4	0	4	13	0	0	7	2	6	0	0	4	2	4	14	13	2	16	16	8	16	15	4	13	7
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	0	0	0	4	1	0	0	0	3	1	0	0	0	1	1	0	0	0	0	2	0	3	0	0	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	3	0	0	5	1	0	10	0	6	5	1	0	0	1	3	4	0	0	0	1	0	1	0	0	0
Cephaloziella cf. divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0
Chiloscyphus profundus	6	0	2	2	3	4	11	15	14	0	2	4	1	0	0	2	2	0	0	0	0	0	0	0	5
Diplophyllum taxifolium	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	4	0	3	3	1	0	1	11	7	9	0	0	1	0	1	6	4	0	0	2	1	2	0	5	1
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	2	0	0	0	0	0	6	2	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	2
Ptilidium pulcherrimum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	3	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cladonia chlorophaea agg.	3	0	6	5	0	0	2	8	0	2	0	1	1	0	12	1	0	3	3	3	0	0	0	0	0
Cladonia coniocraea	4	0	1	3	0	0	2	6	1	0	0	0	1	0	6	0	0	0	0	1	0	0	0	0	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	2	0	0	6	2	0	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0
Sorbus aucuparia	4	12	8	10	0	3	2	5	14	3	2	0	2	8	4	3	7	11	12	0	4	7	7	5	4
Vaccinium myrtillus	5	15	9	16	16	16	15	16	16	16	16	16	16	16	13	16	16	14	5	16	16	16	16	16	14
Vaccinium vitis-idaea	0	0	0	4	9	3	0	0	8	11	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	0	10	0	0	1	7	2	0	1	0	6	3	0	0	0	0	1	4	2	6	7	1	0	0	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	0	0	0	0	6	0	0	0	0	0	10	0	0	0	3	0	0	0	0	0	0	0	10	0	0
Lycopodium annotinum	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	7	7	0	0	1	0	0	0	0	0
Maianthemum bifolium	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	7	0	0	0	3	4	0	3
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	0	0	0	0	0	0	0	0	1	5	1	0	0	0	9	2	0	9	13	14	0	0	8
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	9	11	0	4	11	7	12	14	15	16	16	16	16	14	16	16	16	16	3	16	16	16	16	10	16
Luzula pilosa	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	0	0	0	0	0	0	0	0	0	1	0	10	0	0	0	1	14	2	0	1	2	0	0	0	0
Brachythecium starkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	9	5	16	13	11	7	5	4	0	1	5	1	0	3	5	4	0	5	9	0	2	0	12	10	0
Dicranum majus	0	8	0	1	0	2	0	3	5	7	5	7	15	13	0	10	10	6	0	1	0	16	1	4	2
Dicranum montanum	5	0	8	3	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium	5	6	12	5	15	14	15	9	13	16	15	11	10	13	14	8	14	13	1	1	1	3	16	13	2
Hylocomiastrum umbratum	0	0	0	0	0	0	0	0	0	2	0	11	0	0	0	0	3	0	0	9	0	0	0	0	0
Hylocomium splendens	0	0	0	0	0	2	0	0	0	9	2	2	11	0	13	0	0	2	0	0	5	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium laetum	11	4	1	11	14	16	15	14	6	9	0	13	2	6	7	10	0	3	2	4	4	0	8	9	1
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	0	0	8	13	13	0	0	10	15	8	13	9	13	8	10	3	0	1	0	16	1	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	14	0	0	0	13
Polytrichum formosum	0	9	0	0	9	0	16	0	1	7	0	16	16	1	16	16	9	10	0	8	16	4	0	11	1
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2b cont.

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Tetraphis pellucida	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	16	14	4	0	11	16
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	0	0	0	0	2	3	0	0	0	8	0	8	0	0	0	0	0	0	0	0	1	0	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	0	2	0	3	0	0	2	0	6	2	1	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	0	0	0	0	3	13	10	0	6	15	9	14	7	10	0	3	14	6	0	0	0	2	0	6	3
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cephaloziella cf. divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	7	4	0	3	2	7	9	4	0	1	4	7	0	0	5	7	0	0	2	0	4	0	0	3	1
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	0	0	0	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1
Ptilidium pulcherrimum	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia coniocraea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2c. The major selectively cut stand.

	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Betula pubescens	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Picea abies	3	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Sorbus aucuparia	9	5	1	0	3	2	2	0	2	1	1	1	2	1	4	6	2	1	5	6	0	5	2	3	3
Vaccinium myrtillus	11	15	13	16	16	7	5	12	12	7	13	2	16	16	12	15	14	16	15	10	16	11	16	11	8
Vaccinium vitis-idaea	0	0	0	8	3	0	0	0	0	1	0	0	11	10	0	0	0	0	2	0	0	0	0	2	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	5	12	6	1	3	1	0	8	2	7	1	4	9	0	4	12	2	0	9	1	0	2	0	3	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linnaea borealis	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	0	11	7	2	5	5	0	0	3	4	3	2	4	4	0	0	3	6	0	0	1	0	3	0	1
Maianthemum bifolium	1	0	1	0	3	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	5	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Calamagrostis purpurea	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	5	4	6	0	13	14	0	2	3	14	15	0	7	14	3	8	2	16	9	15	15	12	16	16	6
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	0	0	4	4	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Brachythecium starkei	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	5	7	6	6	3	1	1	0	5	0	1	3	14	2	14	10	0	0	11	0	3	11	4	4	10
Dicranum majus	0	3	0	0	0	3	2	16	3	1	3	0	1	2	0	0	0	5	7	0	10	0	4	0	0
Dicranum montanum	0	1	0	0	0	0	0	0	0	0	0	6	0	0	0	0	4	0	0	0	0	0	0	0	0
Dicranum scoparium	12	16	13	16	16	10	15	5	11	16	9	3	16	6	16	16	3	4	13	15	16	13	13	5	15
Hylocomiastrum umbratum	0	0	0	7	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	1	0	0	0	0	0	0	1	0	0	7	0	5	0	0	0	0	0	0	0	0
Plagiothecium laetum	6	5	13	13	7	3	3	2	5	6	5	3	11	2	3	3	2	4	5	8	0	11	5	5	5
Plagiothecium undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	15	7	3	6	3	0	0	0	2	3	0	14	0	0	2	0	0	1	0	13	3	10	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum formosum	12	9	7	0	0	16	11	16	15	6	11	0	2	10	5	6	0	16	10	16	16	0	14	16	5
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2c cont.

	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	6	1	0	2	0	2	1	2	0	2	0	4	0	0	0	1	0	0	5	0	0	0	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	11	2	0	0	0	4	0	0	0	0	5	0	0	15	0	0	0	0	0	10	0	0	0	12	0
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	0	11	0	6	0	1	0	0	0	4	1	0	1	2	0	1	0	0	3	0	13	1	0	8	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	0	7	1	0	6	3	0	0	5	0	0	0	0	1	0	0	0	0	4	1	0	0	0	10	0
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	0	10	5	7	10	0	0	1	3	15	2	0	7	1	1	2	0	0	1	0	16	2	0	0	1
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Calypogeia azurea	5	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Calypogeia integristipula	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Calypogeia muelleriana	5	4	0	0	0	3	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	5	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	4	0	0	0	2	0
Cephalozia leucantha	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	3	0	0	0	0	3	3	4	7	0	1	3	2	0	0	3	0	0	6	0	0	0	0	1	0
Cephaloziella cf. divaricata	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	0	7	7	8	8	2	7	3	7	6	7	0	5	0	3	2	2	1	2	8	5	6	10	0	3
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	2	7	1	2	0	4	5	2	8	1	3	1	3	3	0	0	0	0	0	0	1	0	0	4	0
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptilidium pulcherrimum	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	0	2	2	4	0	0	0	0	1	0	0	1	0	1	0	0	0	0	3	0	0	0	0	0	0
Cladonia coniocraea	0	0	0	0	0	1	2	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	1	0
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2d. The clear cut stand.

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0
Picea abies	1	0	0	0	1	0	0	2	1	0	0	0	0	0	0	1	0	0	2	0	0	1	0	1	1
Sorbus aucuparia	0	2	3	1	8	3	5	10	7	10	0	2	2	6	2	0	2	0	2	4	4	3	2	6	0
Vaccinium myrtillus	16	14	16	16	16	16	16	15	8	8	15	15	16	16	16	11	16	4	1	0	5	0	2	6	13
Vaccinium vitis-idaea	4	0	0	7	12	8	0	0	0	0	8	0	0	0	11	0	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornus suecica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa agg.	8	3	13	3	3	5	15	8	5	1	2	10	5	7	0	0	4	2	0	2	10	2	0	0	2
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Linnaea borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium annotinum	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maianthemum bifolium	0	0	0	0	2	1	11	0	7	0	1	0	0	1	1	5	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thelypteris phegopteris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	10	7	6	10	6	7	13	0	7	12	2	5	7	2	0	0	0	0	0	0	0	0	10
Calamagrostis purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex brunnescens	0	0	1	0	0	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia flexuosa	16	7	16	16	16	16	16	16	16	0	16	16	16	16	16	9	14	0	0	0	0	2	0	0	16
Luzula pilosa	0	0	6	0	0	1	1	0	0	0	0	1	1	2	4	0	0	0	0	0	0	0	0	0	0
Molinia cerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium reflexum	6	1	7	4	0	3	13	8	0	0	2	6	6	14	8	0	0	0	0	0	0	0	0	0	4
Brachythecium starkei	1	0	0	0	0	0	4	4	0	0	8	0	0	0	0	1	3	0	0	0	0	0	0	0	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranella heteromalla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum fuscescens	3	10	2	2	5	1	0	7	1	1	2	0	1	0	0	0	0	1	1	4	1	0	0	1	0
Dicranum majus	2	3	0	1	1	0	0	0	2	0	1	0	0	3	0	3	8	0	0	0	0	0	0	0	0
Dicranum montanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium	14	15	6	6	14	16	9	15	15	10	16	13	16	15	16	15	10	11	2	0	7	6	2	0	3
Hylocomiastrum umbratum	0	0	6	1	2	6	3	7	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Hylocomium splendens	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopterygium elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium denticulatum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiothecium laetum	5	8	9	6	12	1	6	6	8	14	14	11	12	9	1	15	2	12	6	4	6	6	5	1	7
Plagiothecium undulatum	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	15	0	0	2	8	15	1	11	0	0	5	9	0	2	15	4	1	0	0	0	0	1	0	0	0
Pohlia nutans	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Polytrichum formosum	10	0	11	8	4	0	11	12	13	2	5	16	15	12	11	4	14	8	0	0	12	6	0	0	9
Polytrichum juniperinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium heterostichum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Rhodobrym roseum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus loreus	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Rhytidiadelphus subpinnatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraphis pellucida	0	2	3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	8	0	1	0	0	0	0	0
Tetraploidon mnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum girgensohnii	0	0	13	16	0	0	5	8	10	0	2	8	2	1	1	0	14	0	0	0	4	5	0	0	16
Sphagnum quinquefarium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum russowii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anastrophyllum minutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia attenuata	1	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	5	0	0	6	0	0	0	0	1	0	3	4	2	0	0	0	0	0	0	0	0	0	0	0	1
Barbilophozia hatcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia lycopodioides	15	3	7	11	4	6	8	8	10	0	16	16	7	12	15	4	15	2	0	0	1	2	0	0	5
Bazzania tricrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blepharostoma trichophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia azurea	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia integristipula	0	0	2	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia muelleriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calypogeia neesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia bicuspidata	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0
Cephalozia leucantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalozia lunulifolia	0	0	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	9	0	0	0	1	0	0	3
Cephaloziella cf. divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus profundus	0	2	5	6	11	0	4	4	8	1	1	9	7	4	4	2	9	8	5	0	12	4	2	0	6
Diplophyllum taxifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidozia reptans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia excisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia obtusa	0	0	1	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia sudetica	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophozia ventricosa agg.	1	1	3	2	2	0	0	5	0	0	3	10	2	2	2	0	0	0	0	0	0	0	0	0	2
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium ciliare	0	1	0	1	0	3	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilidium pulcherrimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapania scandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tritomaria quinquedentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetraria islandica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea agg.	2	1	0	0	1	0	0	1	0	0	3	0	0	0	6	0	0	0	0	0	0	0	0	0	0
Cladonia coniocraea	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Cladonia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia deformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia furcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia squamosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia sulphurina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3. Untransformed environmental variables for 100 plots recorded in 1997 (except TI2: recorded in 2005).

Plot	Mois	Litter	BasalA	Inclin	HeatI	SoilDMe	RoughMe	InclMax
1	73.0	0.3	15	22	0.19	48.5	6	60
2	63.9	388.5	16	16	0.22	35.5	4	52
3	70.2	80.8	15	48	0.87	31	3.5	80
4	73.3	29.8	13	13	0.17	25	13	100
5	58.2	503.6	12	21	0.33	33.5	9.5	100
6	66.7	924.3	17	34	0.57	23.5	1	58
7	71.4	0.0	12	26	0.11	33	4.5	60
8	71.0	0.0	21	10	0.12	37.5	10.5	74
9	74.2	0.0	23	40	0.13	41	7	100
10	72.9	59.1	24	30	0.33	44	6	100
11	73.0	148.5	20	6	0.05	39	4	96
12	66.8	206.9	19	6	0.06	55	4	28
13	74.8	92.8	20	33	0.51	25	8	94
14	71.8	26.2	11	39	0.46	38.5	6.5	90
15	73.6	0.0	11	18	0.25	28	8	100
16	62.1	8.8	11	31	-0.45	17	5	90
17	68.0	417.5	8	15	0.16	23	4	38
18	74.3	0.0	11	24	-0.10	39.5	4	60
19	74.4	0.0	12	27	0.04	39	2	60
20	69.3	30.6	10	15	0.23	20.5	4	70
21	59.4	0.0	12	28	-0.14	40	7.5	62
22	70.1	102.2	10	37	-0.52	41	7	94
23	75.8	907.4	9	7	0.05	46	5.5	24
24	76.4	169.2	12	22	-0.22	43.5	2	38
25	71.8	522.4	11	11	0.11	30	5.5	52
26	59.3	737.4	20	32	0.34	24	5.5	54
27	62.1	231.8	16	32	0.32	27.5	11	80
28	49.2	262.4	20	24	0.23	19.5	6	70
29	55.6	748.7	18	32	0.30	23.5	3.5	65
30	72.8	39.4	17	23	0.20	19.5	10.5	86
31	70.8	24.1	24	20	0.20	11	9	94
32	61.0	191.7	22	31	0.28	14	6.5	88
33	62.0	1234.2	17	29	0.36	24.5	5	43
34	54.9	1072.5	17	24	0.36	23	4.5	60
35	64.7	106.8	18	16	0.13	22.5	4	62
36	70.8	86.2	21	10	0.13	11.5	4	80
37	74.1	85.1	18	16	0.22	16	6.5	100
38	73.8	0.0	19	30	0.38	25	4.5	90
39	69.1	421.0	15	26	0.40	13.5	4.5	100
40	69.3	118.4	15	30	-0.04	7	9	78
41	74.3	207.1	18	18	0.26	38	5	30
42	70.4	0.0	15	20	0.03	44	5	40
43	59.6	335.0	17	14	0.14	41.5	5	24
44	63.9	936.0	17	4	0.04	31	5.5	28
45	80.7	22.3	21	8	0.02	18.5	4.5	18
46	78.3	57.6	17	18	0.22	44	5	60
47	69.6	62.1	15	14	0.12	33	4.5	42
48	60.8	837.9	16	5	0.03	52	4.5	46

Appendix 3. cont.

Plot	Mois	Litter	BasalA	Inclin	HeatI	SoilDMe	RoughMe	InclMax
49	62.9	524.6	18	16	0.11	27	11.5	98
50	76.0	122.4	20	20	0.27	25	4.5	60
51	79.2	366.9	20	32	0.55	26	8	100
52	71.5	0.0	19	22	0.35	50	6.5	70
53	64.1	112.8	24	20	0.32	22	5	54
54	68.6	11.2	22	20	0.30	53	4	40
55	69.6	29.3	26	24	0.37	41	4	30
56	71.2	198.8	23	20	0.32	10	5	80
57	70.2	78.4	31	32	0.51	55.5	4	40
58	64.2	145.1	31	20	0.32	51	4	72
59	75.8	19.5	33	18	0.19	27	3	56
60	70.8	656.5	29	18	0.29	49	5.5	65
61	79.5	776.6	27	18	0.15	45	5	50
62	66.9	178.3	34	20	0.26	50.5	4.5	50
63	67.0	87.8	28	21	0.26	30	14	80
64	78.9	408.3	28	10	0.04	32.5	6	80
65	63.2	943.2	32	11	0.15	2	5	32
66	66.6	389.8	22	20	-0.08	40	8.5	64
67	69.7	256.2	26	11	0.15	27.5	5	36
68	65.3	533.8	24	20	-0.32	20.5	1.5	40
69	69.3	945.0	25	12	0.19	40	18.5	100
70	78.8	16.7	29	20	0.32	38	5.5	50
71	67.8	280.7	31	9	0.11	26	3.5	30
72	65.2	832.0	28	10	0.15	25	7.5	30
73	68.5	108.7	22	6	0.09	33.5	4	60
74	75.1	3.2	27	12	0.04	28	4	34
75	48.4	694.4	24	9	0.14	18.5	3	24
76	72.6	352.8	15	28	0.07	16.5	8.5	100
77	71.1	591.8	22	8	0.11	24.5	2	34
78	80.8	203.9	26	5	0.04	31.5	5	80
79	78.2	67.0	18	6	0.08	32.5	2	30
80	68.1	294.0	9	10	0.08	27	2.5	34
81	75.0	12.2	17	20	0.17	15.5	7	90
82	78.5	87.9	27	14	0.19	24.5	5	34
83	77.2	107.0	25	15	0.20	28.5	6	60
84	75.7	265.9	21	20	0.32	30.5	3	46
85	70.4	1034.0	18	26	0.38	25	3	60
86	77.7	270.1	17	10	0.15	26	2	36
87	75.2	77.5	20	6	0.09	18	2	28
88	79.6	758.9	18	24	0.37	22	4.5	50
89	73.9	292.0	21	14	0.20	25	5.5	50
90	74.1	0.0	13	14	0.21	24	6	44
91	72.3	155.8	16	16	0.12	24	4	50
92	81.3	316.7	29	11	0.15	27	2	46
93	69.5	13.9	26	8	0.11	16.5	3	60
94	73.8	184.7	40	12	0.19	41.5	2	26
95	65.0	495.7	34	4	0.06	27.5	1.5	30
96	74.8	18.2	31	10	0.10	26	2	24
97	76.2	407.4	36	4	0.03	23.5	1	70
98	70.9	472.6	30	6	0.09	15.5	1.5	30
99	59.3	650.4	27	20	0.25	5.5	0.5	40
100	78.6	12.1	25	7	0.07	31	1	44

Appendix 3. cont.

Plot	GapAvg	LossOl	pH	Ca	Mg	TotN	P-Al	Tl1	Tl2
1	15.1	95.9	3.8	2382	353.5	1.72	139.7	0.136	0.155
2	2.6	95.2	3.7	2842	339.5	2.09	145.0	0.582	0.601
3	2.6	95.9	3.9	1822	266.1	2.08	116.8	0.184	0.150
4	4.4	93.9	4.1	1071	179.9	2.28	77.7	0.016	0.031
5	0.3	95.2	3.7	2505	255.3	1.90	95.6	0.418	0.535
6	0.0	94.8	3.8	2621	260.2	1.91	102.3	0.823	0.907
7	21.1	94.3	3.9	1845	380.1	2.22	107.1	0.013	0.052
8	17.9	92.8	3.9	3131	284.1	2.16	119.6	0.017	0.045
9	1.3	95.3	3.7	1907	327.7	1.91	94.4	0.000	0.000
10	5.7	84.4	3.8	2170	310.9	1.92	98.3	0.618	0.718
11	1.0	95.4	3.8	2668	374.4	1.97	109.0	0.545	0.594
12	6.0	95.6	3.8	2092	302.5	1.97	121.3	0.541	0.540
13	7.5	95.1	3.7	3456	376.9	1.88	82.0	0.536	0.551
14	6.2	95.4	3.9	2437	336.2	2.14	115.3	0.525	0.532
15	16.6	95.2	3.8	2442	315.2	2.08	116.6	0.049	0.067
16	4.7	95.3	3.8	1701	312.4	1.97	107.0	0.412	0.437
17	0.8	95	3.6	1726	313.3	1.97	93.7	0.666	0.686
18	26.3	96.2	4	2333	409.2	2.25	132.0	0.000	0.000
19	26.8	96.5	3.8	2264	452.0	1.99	96.4	0.000	0.000
20	2.6	83.5	4.6	2592	518.0	2.31	76.6	0.106	0.136
21	36.9	67.8	4	2303	426.5	2.23	90.0	0.000	0.000
22	0.8	94.1	3.6	2449	392.5	1.98	112.6	0.090	0.100
23	8.3	97.1	3.9	1125	236.5	1.67	87.5	0.518	0.519
24	8.8	95.8	3.8	2196	431.2	1.89	131.5	0.194	0.194
25	0.5	96.3	3.8	1819	280.1	2.12	92.4	0.647	0.677
26	0.0	94.3	3.8	2826	255.1	2.04	119.8	0.800	0.801
27	0.0	94.7	3.9	2391	265.6	1.94	99.3	0.652	0.484
28	0.0	95.1	3.7	1989	178.9	2.01	125.1	0.948	0.909
29	0.0	94.6	3.8	1902	205.5	1.97	115.2	0.806	0.837
30	5.5	93.8	3.7	1857	287.6	2.06	137.5	0.059	0.135
31	1.8	93.2	3.7	2430	367.6	2.17	122.3	0.151	0.060
32	0.0	80.8	3.8	2267	341.3	2.60	133.7	0.258	0.333
33	0.8	94.9	3.7	2365	254.8	1.93	113.8	0.578	0.652
34	1.6	92.9	3.7	2610	207.9	2.00	116.3	0.678	0.686
35	4.2	61	3.8	1764	312.7	2.39	145.9	0.188	0.195
36	12.7	92.7	3.8	1561	306.7	2.00	99.2	0.464	0.525
37	2.3	88.5	3.9	645	216.9	2.41	105.1	0.126	0.181
38	3.9	92.6	4	1065	229.6	2.33	101.5	0.177	0.314
39	0.0	93.6	3.8	2291	216.8	2.09	111.1	0.648	0.748
40	1.6	87.6	4	2333	284.3	2.01	121.0	0.195	0.248
41	1.0	95.8	3.7	2025	301.8	2.07	142.0	0.305	0.360
42	1.3	95.7	3.8	1606	275.5	1.85	124.3	0.120	0.162
43	1.0	93.6	3.7	2013	284.3	1.94	125.0	0.333	0.379
44	1.3	96.2	3.8	2416	232.4	1.84	107.1	0.797	0.831
45	2.1	94	4.1	599	143.5	2.65	96.8	0.029	0.042
46	16.4	95.5	3.9	1167	271.0	1.90	106.8	0.558	0.602
47	2.6	94.9	3.9	2019	320.1	1.84	114.9	0.324	0.357
48	0.0	96.1	3.6	2039	268.0	2.09	165.5	0.514	0.556

Appendix 3. cont.

Plot	GapAvg	LossOI	pH	Ca	Mg	TotN	P-Al	Tl1	Tl2
49	1.8	96.4	3.8	2474	264.7	1.85	107.9	0.780	0.825
50	9.4	95.4	4	1241	222.9	1.95	104.8	0.336	0.393
51	0.3	94.9	4.1	1214	210.0	2.16	80.1	0.443	0.490
52	3.1	75.9	4.2	1093	228.9	2.66	114.6	0.077	0.104
53	8.6	84	3.9	1637	352.9	2.48	153.6	0.073	0.089
54	3.6	90.2	3.9	2888	292.3	2.43	164.1	0.207	0.243
55	0.0	93.6	3.7	2377	284.3	2.18	118.6	0.375	0.403
56	1.0	94	3.9	1320	201.6	2.06	97.9	0.401	0.431
57	0.0	91	3.8	1812	295.1	2.08	97.8	0.425	0.461
58	0.3	95.7	3.9	2136	280.6	2.02	122.3	0.554	0.625
59	3.6	93.3	4.2	546	113.7	2.41	68.6	0.269	0.338
60	1.6	94.8	3.9	2177	283.2	2.11	111.8	0.549	0.591
61	3.6	95.3	3.8	738	202.7	1.97	88.1	0.553	0.609
62	0.0	95.8	3.8	1312	196.6	1.93	96.0	0.698	0.702
63	1.8	93.4	3.7	2167	327.8	1.96	123.1	0.170	0.195
64	2.1	94.3	4.1	561	101.7	2.27	79.5	0.615	0.630
65	1.8	95.5	3.8	1964	250.6	1.92	122.5	0.773	0.790
66	0.3	92.2	4	2565	346.6	1.92	108.5	0.579	0.622
67	1.6	95.8	4	2048	249.8	2.00	112.7	0.781	0.806
68	2.9	95.1	3.7	1972	297.7	1.87	120.9	0.563	0.591
69	0.3	93.2	3.9	2473	275.1	2.14	117.0	0.456	0.506
70	1.6	93.9	4	1112	221.3	2.00	108.6	0.255	0.289
71	1.6	81	3.7	1423	283.5	2.17	122.2	0.513	0.557
72	1.6	92.6	3.9	2052	299.2	1.84	126.3	0.736	0.788
73	0.5	95.1	3.7	1690	255.5	1.84	91.5	0.519	0.549
74	4.2	78.7	3.9	1655	196.1	1.74	99.1	0.236	0.259
75	0.0	95.4	3.8	2143	261.1	1.79	93.3	0.607	0.640
76	2.9	91.5	3.9	1542	285.5	2.12	189.1	0.202	0.264
77	0.0	94.9	4	3273	242.0	1.91	165.4	0.685	0.795
78	4.2	95	3.9	1639	211.0	1.88	126.3	0.346	0.383
79	11.7	94.5	4	284	120.6	2.03	87.8	0.204	0.216
80	0.8	96.3	3.8	2206	368.4	1.70	134.0	0.591	0.589
81	13.8	94.5	3.8	1754	312.4	1.93	196.8	0.033	0.081
82	1.3	94.9	3.9	1761	280.4	2.07	164.4	0.076	0.093
83	2.6	94.7	3.9	1134	191.2	2.28	117.2	0.146	0.195
84	0.3	94.5	4	1268	223.7	2.07	121.7	0.307	0.353
85	0.0	94.3	3.9	2954	283.5	1.97	140.0	0.529	0.566
86	0.0	95.5	4.1	422	142.5	1.81	106.8	0.230	0.326
87	15.3	93.3	3.9	1104	222.7	2.26	125.4	0.064	0.098
88	0.0	94.8	4	1262	176.9	2.31	131.9	0.373	0.432
89	0.0	94.8	4	1391	174.3	1.89	147.7	0.234	0.299
90	33.3	91	3.9	1398	283.1	2.22	178.0	0.004	0.021
91	0.3	93.1	4	4305	405.9	2.12	265.3	0.322	0.383
92	0.0	95	4	994	197.0	2.03	154.7	0.210	0.279
93	0.0	94.9	4	2015	230.5	2.13	143.3	0.246	0.331
94	0.0	94.8	3.8	2023	233.3	1.93	163.5	0.764	0.770
95	0.0	90.5	3.9	2834	247.0	1.94	154.7	0.654	0.692
96	0.0	96	3.7	1555	220.2	1.91	180.2	0.265	0.289
97	0.0	96.6	3.9	1556	233.9	1.70	166.7	0.520	0.571
98	0.0	95.8	3.9	2510	238.4	2.00	188.9	0.693	0.724
99	0.0	93.3	3.9	3222	307.3	2.05	115.8	0.601	0.636
100	9.9	94.7	3.9	959	179.6	2.12	136.2	0.138	0.122

Appendix 4. Ranged and zero-skewness transformed environmental variables for 100 plots recorded in 1997 (except TI2: recorded in 2005).

Ranged and zero-skewness transformed data

Plot	Mois	Litter	BasalA	Inclin	Heatl	SoilDMe	RoughMe	InclMax
1	0.589	0.002	0.303	0.551	0.468	0.890	0.556	0.605
2	0.290	0.682	0.340	0.403	0.491	0.672	0.420	0.510
3	0.484	0.314	0.303	1.000	1.000	0.591	0.379	0.817
4	0.602	0.157	0.224	0.318	0.459	0.480	0.853	1.000
5	0.159	0.751	0.182	0.528	0.575	0.636	0.728	1.000
6	0.368	0.918	0.377	0.787	0.760	0.451	0.088	0.582
7	0.528	0.000	0.182	0.637	0.411	0.627	0.458	0.605
8	0.513	0.000	0.512	0.225	0.420	0.707	0.767	0.757
9	0.638	0.000	0.574	0.885	0.423	0.766	0.612	1.000
10	0.583	0.257	0.604	0.715	0.573	0.817	0.556	1.000
11	0.590	0.443	0.479	0.081	0.372	0.732	0.420	0.965
12	0.373	0.521	0.446	0.081	0.378	0.992	0.420	0.172
13	0.665	0.341	0.479	0.770	0.708	0.480	0.662	0.948
14	0.542	0.142	0.139	0.869	0.668	0.724	0.585	0.912
15	0.612	0.000	0.139	0.455	0.512	0.536	0.662	1.000
16	0.244	0.056	0.139	0.734	0.041	0.323	0.493	0.912
17	0.410	0.701	0.000	0.375	0.445	0.442	0.420	0.323
18	0.642	0.000	0.139	0.595	0.265	0.741	0.420	0.605
19	0.646	0.000	0.182	0.657	0.365	0.732	0.227	0.605
20	0.450	0.160	0.095	0.375	0.497	0.393	0.420	0.716
21	0.184	0.000	0.182	0.677	0.238	0.749	0.638	0.628
22	0.481	0.361	0.095	0.837	0.000	0.766	0.612	0.948
23	0.711	0.913	0.048	0.120	0.368	0.849	0.526	0.106
24	0.737	0.473	0.182	0.551	0.185	0.808	0.227	0.323
25	0.542	0.761	0.139	0.257	0.412	0.573	0.526	0.510
26	0.182	0.855	0.479	0.752	0.583	0.461	0.526	0.534
27	0.245	0.549	0.340	0.752	0.562	0.527	0.786	0.817
28	0.011	0.580	0.479	0.595	0.497	0.373	0.556	0.716
29	0.109	0.860	0.412	0.752	0.552	0.451	0.379	0.662
30	0.583	0.194	0.377	0.573	0.475	0.373	0.767	0.875
31	0.505	0.133	0.604	0.504	0.479	0.199	0.707	0.948
32	0.219	0.503	0.543	0.734	0.533	0.262	0.585	0.894
33	0.241	1.000	0.377	0.696	0.593	0.471	0.493	0.393
34	0.097	0.960	0.377	0.595	0.595	0.442	0.458	0.605
35	0.311	0.370	0.412	0.403	0.430	0.432	0.420	0.628
36	0.503	0.327	0.512	0.225	0.428	0.210	0.420	0.817
37	0.633	0.324	0.412	0.403	0.491	0.303	0.585	1.000
38	0.623	0.000	0.446	0.715	0.608	0.480	0.458	0.912
39	0.447	0.703	0.303	0.637	0.625	0.252	0.458	1.000
40	0.451	0.392	0.303	0.715	0.309	0.113	0.707	0.798
41	0.643	0.521	0.412	0.455	0.521	0.715	0.493	0.203
42	0.490	0.000	0.303	0.504	0.354	0.817	0.493	0.351
43	0.187	0.643	0.377	0.347	0.434	0.775	0.493	0.106
44	0.291	0.922	0.377	0.000	0.364	0.591	0.526	0.172
45	0.961	0.125	0.512	0.156	0.349	0.354	0.458	0.000
46	0.834	0.253	0.377	0.455	0.492	0.817	0.493	0.605
47	0.460	0.266	0.303	0.347	0.417	0.627	0.458	0.379
48	0.214	0.891	0.340	0.042	0.357	0.946	0.458	0.433

Appendix 4. cont.

Plot	Mois	Litter	BasalA	Inclin	HeatI	SoilDMe	RoughMe	InclMax
49	0.264	0.762	0.412	0.403	0.410	0.518	0.803	0.983
50	0.720	0.400	0.479	0.504	0.529	0.480	0.458	0.605
51	0.879	0.666	0.479	0.752	0.739	0.499	0.662	1.000
52	0.531	0.000	0.446	0.551	0.587	0.914	0.585	0.716
53	0.296	0.382	0.604	0.504	0.568	0.423	0.493	0.534
54	0.429	0.069	0.543	0.504	0.550	0.961	0.420	0.351
55	0.463	0.155	0.661	0.595	0.599	0.766	0.420	0.203
56	0.518	0.511	0.574	0.504	0.562	0.178	0.493	0.817
57	0.482	0.308	0.794	0.752	0.708	1.000	0.420	0.351
58	0.298	0.437	0.794	0.504	0.562	0.930	0.420	0.737
59	0.710	0.111	0.843	0.455	0.469	0.518	0.333	0.558
60	0.503	0.823	0.743	0.455	0.540	0.898	0.526	0.662
61	0.894	0.870	0.689	0.455	0.442	0.833	0.493	0.484
62	0.376	0.485	0.867	0.504	0.523	0.922	0.458	0.484
63	0.378	0.330	0.716	0.528	0.521	0.573	0.883	0.817
64	0.863	0.695	0.716	0.225	0.361	0.618	0.556	0.817
65	0.271	0.924	0.819	0.257	0.440	0.000	0.493	0.234
66	0.365	0.682	0.543	0.504	0.284	0.749	0.685	0.650
67	0.466	0.574	0.661	0.257	0.440	0.527	0.493	0.294
68	0.327	0.767	0.604	0.504	0.121	0.393	0.163	0.351
69	0.452	0.925	0.633	0.288	0.470	0.749	1.000	1.000
70	0.855	0.098	0.743	0.504	0.568	0.715	0.526	0.484
71	0.404	0.597	0.794	0.191	0.411	0.499	0.379	0.203
72	0.326	0.889	0.716	0.225	0.441	0.480	0.638	0.203
73	0.425	0.374	0.543	0.081	0.398	0.636	0.420	0.605
74	0.677	0.021	0.689	0.288	0.367	0.536	0.420	0.265
75	0.000	0.839	0.604	0.191	0.433	0.354	0.333	0.106
76	0.572	0.656	0.303	0.677	0.382	0.313	0.685	1.000
77	0.514	0.795	0.543	0.156	0.411	0.471	0.227	0.265
78	0.971	0.518	0.661	0.042	0.364	0.600	0.493	0.817
79	0.826	0.279	0.412	0.081	0.392	0.618	0.227	0.203
80	0.413	0.609	0.048	0.225	0.390	0.518	0.283	0.265
81	0.673	0.075	0.377	0.504	0.455	0.293	0.612	0.912
82	0.844	0.330	0.689	0.347	0.470	0.471	0.493	0.265
83	0.774	0.371	0.633	0.375	0.480	0.546	0.556	0.605
84	0.704	0.583	0.512	0.504	0.566	0.582	0.333	0.433
85	0.490	0.950	0.412	0.637	0.612	0.480	0.333	0.605
86	0.800	0.587	0.377	0.225	0.438	0.499	0.227	0.294
87	0.682	0.306	0.479	0.081	0.400	0.344	0.227	0.172
88	0.902	0.863	0.412	0.595	0.599	0.423	0.458	0.484
89	0.625	0.607	0.512	0.347	0.475	0.480	0.526	0.484
90	0.635	0.000	0.224	0.347	0.482	0.461	0.556	0.406
91	0.562	0.454	0.340	0.403	0.417	0.461	0.420	0.484
92	1.000	0.628	0.743	0.257	0.440	0.518	0.227	0.433
93	0.459	0.083	0.661	0.156	0.411	0.313	0.333	0.605
94	0.622	0.494	1.000	0.288	0.469	0.775	0.227	0.139
95	0.319	0.747	0.867	0.000	0.378	0.527	0.163	0.203
96	0.664	0.105	0.794	0.225	0.403	0.499	0.227	0.106
97	0.729	0.694	0.913	0.000	0.359	0.451	0.088	0.716
98	0.509	0.734	0.768	0.081	0.401	0.293	0.163	0.203
99	0.182	0.821	0.689	0.504	0.511	0.079	0.000	0.351
100	0.849	0.074	0.633	0.120	0.382	0.591	0.088	0.406

Appendix 4. cont

Plot	GapAvg	LossOl	pH	Ca	Mg	TotN	P-Al	TI1	TI2
1	0.838	0.638	0.358	0.546	0.678	0.105	0.618	0.167	0.174
2	0.526	0.491	0.204	0.658	0.647	0.593	0.642	0.653	0.665
3	0.526	0.638	0.483	0.406	0.475	0.578	0.493	0.223	0.168
4	0.619	0.302	0.677	0.212	0.244	0.754	0.143	0.020	0.035
5	0.181	0.491	0.204	0.576	0.447	0.384	0.336	0.484	0.594
6	0.000	0.423	0.358	0.604	0.460	0.394	0.392	0.887	0.998
7	0.898	0.351	0.483	0.411	0.735	0.704	0.428	0.016	0.059
8	0.869	0.200	0.483	0.727	0.519	0.652	0.510	0.021	0.050
9	0.410	0.510	0.204	0.427	0.620	0.395	0.326	0.000	0.000
10	0.664	0.009	0.358	0.493	0.582	0.407	0.360	0.690	0.793
11	0.374	0.529	0.358	0.616	0.723	0.468	0.442	0.616	0.658
12	0.672	0.570	0.358	0.474	0.562	0.463	0.521	0.612	0.599
13	0.713	0.473	0.204	0.804	0.728	0.359	0.198	0.607	0.612
14	0.680	0.529	0.483	0.559	0.640	0.637	0.484	0.596	0.590
15	0.856	0.491	0.358	0.560	0.592	0.582	0.492	0.061	0.075
16	0.629	0.510	0.358	0.375	0.585	0.470	0.427	0.478	0.485
17	0.329	0.456	0.000	0.381	0.588	0.465	0.319	0.736	0.758
18	0.938	0.714	0.587	0.534	0.795	0.728	0.580	0.000	0.000
19	0.942	0.799	0.358	0.516	0.879	0.489	0.343	0.000	0.000
20	0.526	0.006	1.000	0.597	1.000	0.778	0.128	0.130	0.153
21	1.000	0.000	0.587	0.526	0.829	0.713	0.284	0.000	0.000
22	0.329	0.325	0.000	0.562	0.761	0.474	0.466	0.112	0.112
23	0.731	1.000	0.483	0.226	0.399	0.000	0.259	0.588	0.576
24	0.742	0.615	0.358	0.500	0.838	0.369	0.577	0.234	0.217
25	0.270	0.741	0.358	0.405	0.509	0.619	0.307	0.718	0.749
26	0.000	0.351	0.358	0.654	0.447	0.539	0.512	0.865	0.883
27	0.000	0.407	0.483	0.548	0.473	0.435	0.368	0.723	0.538
28	0.000	0.473	0.204	0.448	0.241	0.509	0.542	1.000	1.000
29	0.000	0.392	0.358	0.426	0.316	0.463	0.483	0.871	0.923
30	0.656	0.291	0.204	0.414	0.527	0.560	0.607	0.073	0.151
31	0.465	0.232	0.204	0.557	0.708	0.663	0.526	0.184	0.067
32	0.000	0.002	0.358	0.517	0.651	0.965	0.588	0.308	0.371
33	0.329	0.439	0.204	0.541	0.446	0.418	0.474	0.649	0.721
34	0.440	0.208	0.204	0.602	0.323	0.503	0.490	0.748	0.759
35	0.608	0.000	0.358	0.391	0.586	0.837	0.646	0.228	0.218
36	0.808	0.193	0.358	0.339	0.572	0.496	0.367	0.532	0.582
37	0.508	0.040	0.483	0.098	0.347	0.846	0.413	0.154	0.203
38	0.597	0.186	0.587	0.210	0.381	0.794	0.386	0.215	0.350
39	0.000	0.270	0.358	0.523	0.347	0.596	0.456	0.719	0.826
40	0.440	0.029	0.587	0.534	0.519	0.510	0.519	0.235	0.277
41	0.374	0.615	0.204	0.457	0.561	0.570	0.628	0.360	0.401
42	0.410	0.592	0.358	0.350	0.498	0.315	0.538	0.148	0.182
43	0.374	0.270	0.204	0.454	0.519	0.437	0.542	0.392	0.422
44	0.410	0.714	0.358	0.554	0.389	0.301	0.428	0.862	0.916
45	0.488	0.313	0.677	0.086	0.135	0.993	0.347	0.036	0.047
46	0.853	0.549	0.483	0.237	0.487	0.376	0.426	0.629	0.666
47	0.526	0.439	0.483	0.455	0.603	0.307	0.481	0.382	0.398
48	0.000	0.688	0.000	0.460	0.479	0.594	0.726	0.585	0.617

.

Appendix 4. cont.

Plot	GapAvg	LossOl	pH	Ca	Mg	TotN	P-Al	TI1	TI2
49	0.465	0.769	0.358	0.568	0.471	0.310	0.434	0.846	0.909
50	0.752	0.529	0.587	0.256	0.363	0.443	0.411	0.394	0.437
51	0.181	0.439	0.677	0.249	0.328	0.657	0.174	0.510	0.544
52	0.558	0.000	0.756	0.217	0.379	1.000	0.479	0.095	0.116
53	0.737	0.007	0.483	0.358	0.677	0.891	0.679	0.090	0.100
54	0.585	0.076	0.483	0.669	0.538	0.860	0.721	0.249	0.271
55	0.000	0.270	0.204	0.544	0.519	0.673	0.504	0.437	0.449
56	0.374	0.313	0.483	0.277	0.306	0.567	0.356	0.466	0.479
57	0.000	0.102	0.358	0.403	0.545	0.580	0.355	0.491	0.512
58	0.181	0.592	0.483	0.485	0.510	0.518	0.526	0.625	0.692
59	0.585	0.241	0.756	0.071	0.040	0.849	0.000	0.321	0.377
60	0.440	0.423	0.483	0.495	0.517	0.611	0.461	0.620	0.655
61	0.585	0.510	0.358	0.123	0.308	0.470	0.265	0.625	0.674
62	0.000	0.615	0.358	0.274	0.291	0.421	0.340	0.767	0.776
63	0.465	0.250	0.204	0.492	0.621	0.455	0.531	0.207	0.218
64	0.488	0.351	0.677	0.075	0.000	0.747	0.167	0.687	0.698
65	0.465	0.549	0.358	0.441	0.436	0.403	0.527	0.839	0.872
66	0.181	0.160	0.587	0.591	0.663	0.407	0.438	0.651	0.688
67	0.440	0.615	0.587	0.463	0.434	0.505	0.467	0.847	0.888
68	0.543	0.473	0.204	0.444	0.551	0.345	0.518	0.634	0.655
69	0.181	0.232	0.483	0.568	0.497	0.634	0.494	0.524	0.561
70	0.440	0.302	0.587	0.222	0.359	0.503	0.439	0.304	0.322
71	0.440	0.002	0.204	0.303	0.517	0.668	0.526	0.583	0.618
72	0.440	0.186	0.483	0.463	0.555	0.295	0.549	0.804	0.869
73	0.270	0.473	0.204	0.372	0.448	0.301	0.299	0.590	0.609
74	0.608	0.001	0.483	0.363	0.290	0.143	0.366	0.283	0.289
75	0.000	0.529	0.358	0.486	0.462	0.229	0.316	0.679	0.709
76	0.543	0.123	0.483	0.334	0.522	0.621	0.807	0.243	0.295
77	0.000	0.439	0.587	0.761	0.413	0.392	0.726	0.755	0.877
78	0.608	0.456	0.483	0.359	0.331	0.362	0.549	0.405	0.426
79	0.792	0.378	0.587	0.000	0.063	0.534	0.262	0.246	0.241
80	0.329	0.741	0.358	0.502	0.710	0.072	0.589	0.663	0.652
81	0.822	0.378	0.358	0.388	0.586	0.415	0.831	0.042	0.091
82	0.410	0.439	0.483	0.390	0.510	0.568	0.722	0.094	0.105
83	0.526	0.407	0.483	0.228	0.276	0.755	0.496	0.178	0.218
84	0.181	0.378	0.587	0.263	0.366	0.577	0.523	0.363	0.393
85	0.000	0.351	0.483	0.685	0.517	0.470	0.619	0.599	0.627
86	0.000	0.549	0.677	0.038	0.132	0.259	0.426	0.276	0.363
87	0.841	0.241	0.483	0.220	0.363	0.740	0.544	0.080	0.110
88	0.000	0.423	0.587	0.261	0.235	0.777	0.579	0.435	0.480
89	0.000	0.423	0.587	0.295	0.228	0.367	0.654	0.281	0.333
90	0.981	0.102	0.483	0.297	0.516	0.707	0.771	0.006	0.024
91	0.181	0.224	0.587	1.000	0.788	0.617	1.000	0.380	0.426
92	0.000	0.456	0.587	0.191	0.292	0.534	0.684	0.253	0.311
93	0.000	0.439	0.587	0.454	0.383	0.628	0.635	0.295	0.369
94	0.000	0.423	0.358	0.456	0.391	0.420	0.719	0.831	0.850
95	0.000	0.085	0.483	0.656	0.426	0.438	0.684	0.725	0.765
96	0.000	0.662	0.204	0.337	0.356	0.390	0.779	0.316	0.322
97	0.000	0.829	0.483	0.338	0.393	0.061	0.731	0.590	0.633
98	0.000	0.615	0.483	0.577	0.404	0.505	0.807	0.763	0.800
99	0.000	0.241	0.483	0.749	0.574	0.550	0.486	0.673	0.704
100	0.762	0.407	0.483	0.182	0.243	0.623	0.601	0.168	0.137

Appendix 5. GNMDS plot scores for the total 200 plots. Plot numbers 1-100 represent plots analysed in 1997 and plot numbers 101-200 represent the respective plots analysed in 2005.

Plot	GNMDS1	GNMDS2	GNMDS3	GNMDS4	Plot	GNMDS1	GNMDS2	GNMDS3	GNMDS4
1	2.008468	1.140579	1.046843	0.62608	101	2.027908	1.124646	1.008923	0.575859
2	1.744005	0.505172	0.25157	0.398416	102	1.598288	0.559163	0.181354	0.610371
3	1.443959	1.659386	0.668209	0.490995	103	1.515094	1.577262	0.799339	0.516775
4	2.102726	1.505903	0.793271	0.601059	104	2.07646	1.48085	0.916095	0.579484
5	1.282831	1.180738	0.579403	0.519244	105	1.455173	1.114153	0.569745	0.640712
6	0.668463	1.73373	0.459552	0.767092	106	0.743415	1.629681	0.334135	0.697555
7	1.946947	1.337569	0.811258	0.665518	107	1.903191	1.255735	0.886199	0.736395
8	1.653315	1.681902	0.690957	0.600744	108	1.824785	1.683337	0.76381	0.646378
9	1.760919	1.308411	0.80127	0.639195	109	1.844559	1.305779	0.833967	0.663696
10	1.699278	1.434455	0.772599	0.206105	110	1.805307	1.443531	0.783921	0.225286
11	1.610167	1.397395	0.472437	0.541154	111	1.605885	0.996289	0.355631	0.430182
12	1.644101	1.006096	0.338866	0.476723	112	1.658253	1.10948	0.457707	0.63482
13	1.541219	1.460274	0.336331	0.440739	113	1.62673	1.272723	0.295707	0.419002
14	2.004989	1.066308	0.583784	0.516665	114	1.927189	1.038064	0.599277	0.318303
15	2.064914	1.788481	0.61966	0.473184	115	2.045108	1.614412	0.538651	0.441382
16	1.9486	1.268836	0.701755	0.44616	116	1.975527	1.199343	0.747402	0.329219
17	1.690902	1.215208	0.529866	0.283298	117	1.628829	1.232144	0.597009	0.21799
18	2.527216	1.126995	0.240583	0.720594	118	2.462775	1.150235	0.269496	0.715213
19	2.361554	1.193875	0.451416	0.772639	119	2.388117	1.134181	0.34321	0.752445
20	2.050535	1.152518	0.610201	0.151299	120	2.071326	1.268291	0.568291	0.259639
21	2.387405	1.24074	0.684913	0.558144	121	2.335505	1.032847	0.61882	0.512014
22	2.192847	1.379483	0.592575	0.556088	122	2.285044	1.362896	0.490404	0.539695
23	2.002732	0.61693	0.673987	0.508366	123	2.007225	0.702772	0.631819	0.379213
24	2.469631	0.935746	0.555508	0.565551	124	2.399537	0.999833	0.609076	0.376071
25	1.846125	0.883711	0.59394	0.513896	125	1.916531	0.927726	0.716945	0.611144
26	1.286561	1.291958	0.417618	0.729307	126	1.124837	1.245428	0.414916	0.80797
27	1.580329	0.847532	0.671583	0.473409	127	1.575159	0.896746	0.687108	0.433781
28	1.130248	1.633741	0.278005	0.449687	128	1.191344	1.377903	0.073317	0.23725
29	1.526825	0.987457	0.400747	0.594949	129	1.297721	1.238181	0.277661	0.606209
30	1.871504	1.57131	0.819933	0.56007	130	1.870068	1.454317	0.585721	0.543297
31	1.861587	1.337326	0.440781	0.860477	131	1.892132	1.394285	0.449819	0.781783
32	1.927779	1.254579	0.716872	0.747368	132	1.917638	1.239748	0.653819	0.686455
33	1.601372	0.916185	0.419611	0.666948	133	1.531452	0.981943	0.40854	0.708215
34	1.912123	0.921828	0.272966	0.603431	134	1.831493	0.906391	0.296268	0.637427
35	2.398679	1.178784	0.498097	0.473208	135	2.16019	1.226394	0.494875	0.621065
36	1.964525	1.169299	0.277389	0.536638	136	2.08056	1.070198	0.282882	0.649937
37	2.186597	1.141129	0.843837	0.701313	137	2.213306	1.156747	0.763266	0.749169
38	2.275492	0.87106	0.755076	0.387619	138	2.25739	0.864812	0.744315	0.436572
39	1.919356	1.034813	0.394981	0.534622	139	1.939026	1.021539	0.338842	0.559877
40	1.876813	0.874609	0.642592	0.246031	140	1.931743	1.055296	0.529826	0.364778
41	1.97791	0.941402	0.63301	0.480676	141	1.870145	0.965857	0.67723	0.557953
42	2.404318	1.079474	0.359992	0.514468	142	2.278907	0.918838	0.500476	0.652178
43	2.08203	0.841699	0.501164	0.548629	143	1.894344	0.930763	0.520242	0.544944
44	0.909363	0.833758	0.293299	0.279501	144	0.824594	1.066625	0.264836	0.284636
45	2.147897	0.546652	0.947714	0.742587	145	2.068716	0.493226	0.924585	0.79517
46	1.85091	0.675959	0.814735	0.94756	146	1.968034	0.547238	1.026259	0.746481
47	2.249281	0.828715	0.439142	0.518738	147	2.255066	0.559089	0.38262	0.516644
48	1.759655	0.752998	0.401732	0.470484	148	1.666233	1.092415	0.305302	0.565147
49	1.764037	1.03217	0.777846	0.567709	149	1.693923	1.086097	0.705937	0.569323
50	1.892505	0.401891	0.593708	0.872965	150	1.956733	0.332648	0.596862	0.806751

Appendix 5. cont.

Plot	GNMDS1	GNMDS2	GNMDS3	GNMDS4	Plot	GNMDS1	GNMDS2	GNMDS3	GNMDS4
51	1.419273	1.283897	1.168190	0.181492	151	1.56081	1.167785	1.130380	0.297409
52	2.105732	1.693213	0.761329	0.959513	152	2.083871	1.489201	0.879984	0.785204
53	1.686927	1.349078	0.626719	0.957950	153	1.752611	1.319862	0.693220	0.883035
54	1.712021	1.576635	0.478155	0.946497	154	1.832926	1.632041	0.506160	0.915102
55	1.922349	1.127289	0.339831	0.788698	155	1.901309	1.154849	0.402835	0.814416
56	1.720367	0.885511	1.013513	0.146611	156	1.771825	0.952963	1.041709	0.358706
57	1.241856	1.305519	0.847738	0.466706	157	1.364238	1.355210	1.152959	0.587489
58	1.460444	0.916527	1.145698	0.332828	158	1.64533	0.883481	1.155001	0.147835
59	1.5101	1.063019	1.239525	0.467709	159	1.663673	1.291661	1.122863	0.457506
60	1.800825	1.115846	0.486633	0.986918	160	1.913164	1.217163	0.673844	1.033808
61	1.686312	0.714373	0.944574	0.590665	161	1.757461	0.907679	0.892794	0.628508
62	0.556621	1.536272	0.930192	0.623064	162	0.606523	1.520347	1.036473	0.344024
63	1.78021	1.431111	0.465209	0.722084	163	1.848736	1.469978	0.488818	0.711081
64	1.941368	0.892259	1.034805	0.211709	164	1.979197	0.763301	0.996325	0.355848
65	1.353441	1.318776	0.216571	0.300942	165	1.403404	1.302104	0.454617	0.389567
66	1.670008	1.210994	0.502916	0.586897	166	1.597971	1.221150	0.536290	0.451997
67	1.10468	0.562623	0.000000	0.501541	167	1.141149	0.571513	0.183577	0.709117
68	1.759499	0.783600	0.687919	0.321782	168	1.827388	0.659148	0.714429	0.399845
69	1.633524	1.473643	0.781816	0.454189	169	1.69928	1.292787	0.713057	0.380877
70	1.594934	0.799473	0.838058	0.567314	170	1.704191	0.864616	0.865255	0.727691
71	2.017103	1.177552	0.603977	0.477617	171	2.228388	1.138784	0.609920	0.460420
72	1.639973	0.995565	0.355307	0.800226	172	1.54947	1.209621	0.434115	0.729816
73	1.724017	0.961909	0.677678	0.583886	173	1.862702	1.010192	0.625105	0.518620
74	1.833615	1.160399	0.949802	0.233874	174	1.840718	0.886969	1.156145	0.439086
75	1.335777	0.960641	0.446983	0.375550	175	1.360203	1.246218	0.508329	0.548029
76	1.983588	1.259135	0.556175	0.733523	176	2.166486	1.171433	0.604041	0.652642
77	1.464609	1.134298	0.415075	0.617115	177	1.547157	1.287402	0.470429	0.622963
78	1.921082	1.016062	0.991715	0.825487	178	1.982925	0.958232	1.058830	0.888006
79	2.011574	1.108236	0.848736	0.849600	179	2.087647	0.952401	0.912608	0.854915
80	1.769111	1.251443	0.416607	0.812938	180	1.887404	1.177118	0.527173	0.809223
81	2.280627	1.126780	0.441856	0.969912	181	2.243663	0.965038	0.329885	0.892294
82	2.246644	0.604949	0.732047	0.840696	182	2.035330	0.828778	0.784861	0.984153
83	1.972540	1.129170	0.742448	0.864648	183	2.023668	1.091474	0.755784	0.784466
84	1.886427	0.953376	0.750084	0.904052	184	1.899779	0.912844	0.833923	0.883027
85	0.946322	1.261100	0.526965	1.172991	185	1.106547	1.128875	0.393188	0.919009
86	2.137919	1.290520	0.613883	0.849822	186	2.142129	1.251527	0.571524	0.896617
87	2.212098	1.170648	0.875104	0.867463	187	2.144493	1.115188	0.905988	0.841975
88	1.824982	1.050281	0.738335	0.682358	188	1.886228	1.102749	0.794914	0.747036
89	2.044314	0.881329	0.530921	0.749740	189	1.986295	1.016409	0.668441	0.781567
90	2.357882	1.191860	0.663698	0.861945	190	2.295423	1.116087	0.596643	0.745571
91	1.594161	0.981423	0.405290	0.864148	191	1.735841	1.139015	0.388199	0.968608
92	1.936517	0.838331	0.770120	0.670143	192	2.073466	0.850863	0.851229	0.639311
93	1.323533	1.468999	1.321467	0.961131	193	1.320031	1.543723	1.072202	0.938840
94	0.153419	0.757456	0.920595	1.051514	194	0.571845	1.101024	0.834018	1.249125
95	0.557541	0.770575	1.786128	0.000000	195	0.253307	1.102395	0.543143	0.444136
96	1.361033	0.844501	1.094259	0.764791	196	1.291675	0.981175	1.176627	0.868962
97	1.433022	1.108242	1.463780	0.982480	197	1.146217	0.940042	1.132300	1.030616
98	0.767190	0.972734	0.482918	1.404262	198	0.473622	0.885320	0.557471	1.205646
99	0.000000	0.000000	0.276094	0.634618	199	0.649008	0.498139	0.107363	0.245640
100	2.067466	0.550763	0.839273	1.131926	200	1.953877	0.766150	1.054722	0.935612

Appendix 6. Vector lengths of displacement along GNMDS-axes 1 and 2, 1 and 3, 1 and 4, and total 4-dimensional displacement.

Plot	1 and 2	1 and 3	1 and 4	4-dimensional	Plot	1 and 2	1 and 3	1 and 4	4-dimensional
1	0.025	0.043	0.054	0.068	51	0.155	0.151	0.186	0.198
2	0.109	0.100	0.224	0.248	52	0.036	0.122	0.176	0.214
3	0.185	0.217	0.174	0.228	53	0.128	0.100	0.106	0.163
4	0.093	0.130	0.049	0.155	54	0.171	0.174	0.174	0.177
5	0.084	0.084	0.147	0.148	55	0.106	0.123	0.109	0.126
6	0.401	0.125	0.070	0.426	56	0.104	0.032	0.213	0.238
7	0.206	0.114	0.111	0.230	57	0.083	0.315	0.144	0.339
8	0.175	0.075	0.050	0.195	58	0.075	0.028	0.187	0.200
9	0.064	0.070	0.067	0.076	59	0.069	0.133	0.065	0.136
10	0.065	0.029	0.033	0.069	60	0.118	0.188	0.051	0.226
11	0.214	0.128	0.123	0.268	61	0.094	0.106	0.100	0.114
12	0.086	0.119	0.158	0.216	62	0.095	0.127	0.288	0.313
13	0.083	0.081	0.074	0.095	63	0.168	0.163	0.162	0.170
14	0.049	0.016	0.198	0.205	64	0.263	0.072	0.157	0.302
15	0.340	0.243	0.231	0.351	65	0.117	0.238	0.089	0.280
16	0.065	0.055	0.121	0.141	66	0.018	0.035	0.135	0.140
17	0.096	0.097	0.096	0.134	67	0.082	0.201	0.223	0.289
18	0.243	0.240	0.239	0.245	68	0.153	0.119	0.140	0.173
19	0.031	0.111	0.033	0.114	69	0.019	0.071	0.076	0.102
20	0.024	0.046	0.110	0.119	70	0.189	0.061	0.170	0.249
21	0.111	0.126	0.117	0.137	71	0.204	0.126	0.127	0.205
22	0.208	0.214	0.188	0.232	72	0.248	0.116	0.110	0.269
23	0.096	0.090	0.151	0.166	73	0.174	0.128	0.134	0.193
24	0.270	0.054	0.190	0.334	74	0.352	0.227	0.225	0.457
25	0.088	0.142	0.120	0.180	75	0.094	0.089	0.184	0.206
26	0.183	0.142	0.162	0.199	76	0.205	0.053	0.084	0.226
27	0.072	0.067	0.077	0.084	77	0.133	0.133	0.121	0.144
28	0.035	0.206	0.213	0.297	78	0.085	0.085	0.081	0.125
29	0.132	0.174	0.123	0.181	79	0.188	0.196	0.185	0.198
30	0.275	0.280	0.154	0.362	80	0.151	0.158	0.112	0.187
31	0.206	0.072	0.106	0.221	81	0.052	0.123	0.092	0.146
32	0.079	0.093	0.092	0.118	82	0.134	0.065	0.148	0.204
33	0.053	0.051	0.065	0.068	83	0.073	0.073	0.108	0.109
34	0.038	0.043	0.050	0.056	84	0.142	0.108	0.071	0.166
35	0.192	0.066	0.162	0.243	85	0.127	0.173	0.276	0.314
36	0.215	0.211	0.240	0.243	86	0.232	0.100	0.102	0.241
37	0.147	0.160	0.147	0.174	87	0.274	0.032	0.026	0.276
38	0.287	0.027	0.055	0.291	88	0.203	0.191	0.194	0.220
39	0.174	0.100	0.086	0.185	89	0.085	0.151	0.070	0.165
40	0.173	0.136	0.141	0.239	90	0.140	0.136	0.166	0.194
41	0.166	0.058	0.086	0.188	91	0.308	0.212	0.236	0.326
42	0.064	0.149	0.147	0.207	92	0.043	0.082	0.034	0.097
43	0.208	0.161	0.160	0.209	93	0.039	0.249	0.023	0.253
44	0.087	0.073	0.068	0.092	94	0.081	0.106	0.207	0.230
45	0.147	0.062	0.078	0.158	95	0.098	1.245	0.449	1.324
46	0.212	0.255	0.246	0.361	96	0.138	0.160	0.172	0.191
47	0.075	0.057	0.004	0.094	97	0.541	0.534	0.421	0.637
48	0.450	0.319	0.319	0.470	98	0.153	0.102	0.210	0.262
49	0.332	0.296	0.287	0.340	99	0.306	0.339	0.487	0.523
50	0.818	0.649	0.652	0.821	100	0.244	0.244	0.227	0.380