Vegetation-environment analysis of the transition between avalanche meadows and semi-natural grasslands in Nærøyfjorden, Western Norway

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Abstract

Natural and anthropogenic disturbances have major effects on plant communities. While different disturbance regimes are often considered separately, this study emphasizes the combined effects of snow avalanches and traditional agricultural management. Meadows along Nærøyfjorden (Aurland municipality, Sogn og Fjordane) were investigated in order to identify the gradual variation from semi-natural grasslands to avalanche meadows, two nature types described in the classification system "Nature in Norway" (NiN). Vascular plants and mosses were registered in 82 plots of 2×2 meters, located within seven vertical transects in three main locations; Gudvangen, Bakka and Tufto. Additionally, 25 explanatory variables were registered in each plot. A multiple parallel ordination with DCA and GNMDS was used to identify the compositional turnover along main gradients and to see how the explanatory variables were related to the observed pattern.

Two distinct gradients were identified in the investigated meadows. The main gradient was related to regrowth, moving from open meadows to woodland. The second gradient was related to increasing disturbance by avalanches, associated with higher soil pH, larger patches of bare ground, steeper inclinations and southern aspect. Plots from transects at Tufto seemed to be more impacted by avalanches than transects at Bakka and Gudvangen, a pattern supported by historical information on avalanche activity and analyses of avalanche terrain based on inclination maps. The results from this study indicate that the strong forces from snow avalanches can alter the structure in woodlands, cause redistribution of nutrients and create new microhabitats with high species-richness. However, the overall species composition in the investigated meadows clearly points to a mixture of processes shaping the observed vegetational pattern. Species associated with semi-natural grasslands were highly abundant and reflected the land use with traditional management throughout centuries.

Regarding the NiN-system, a gradual transition between avalanche meadows (T16) and semi-natural grasslands (T32) was found. For future versions of NiN, it is suggested to implement avalanche impact (AI) as a subordinate local complex environmental gradient (LCE) in semi-natural grasslands. More research is needed to characterise the variation along the avalanche impact-gradient, and interdisciplinary cooperation between biologists and geologists are suggested.

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Contents

1 Introduction

Plant communities are dynamic systems structured and modified by a range of factors, comprising both natural and anthropogenic elements (Sousa, 1984; Kulakowski et al., 2010). Among numerous processes, disturbances serve as an important driving force in nature. Several definitions of disturbances have been proposed, most of them containing a main distinction between natural and anthropogenic disturbance processes (Battasti et al., 2016). Natural disturbances are traditionally described as uncommon, irregular events causing sudden, structural changes in natural communities (White, 1979), or events causing loss in biomass (Grime, 1979). More recent definitions are generally broader, including both regular and irregular events with a continuum of effects, ranging from negligible to extreme damage (Battisti et al., 2016). Examples of natural disturbances include fire, storms, drought and geohazards such as screes and avalanches (White, 1979; Sousa, 1984). From a human perspective, such processes are commonly seen as destructive hazards, while from an ecological point of view, natural disturbances might act as a key driver by creating new habitats and even increase biodiversity (Rixen & Brugger, 2004; Rixen et al., 2007).

One source of natural disturbance is snow avalanches, a common geohazard in mountain areas and hillsides with sufficient inclination (Luckman, 1977; McClung & Schaerer, 2006). Disturbance through snow avalanches can cause profound effects on landscapes and vegetation (Butler, 1979; Rixen et al., 2007). The vegetational impact from avalanches is unpredictable, as it largely depends on frequency, intensity and the character of the snow. A main distinction between wet and dry avalanches is common, based on the content of liquid water (Smith, 1973; McClung & Schaerer, 2006). The motion of wet avalanches is described as a dense mass flowing down a slope, usually with low velocity, while dry avalanches, often called powder-snow avalanches, usually have higher velocities and can be associated with powerful windblasts (Smith, 1973). Interactions between vegetation and avalanches are recognized, where forest serves as a protective cover against avalanches, while avalanches with sufficient energy can break trees, create open patches and increase vegetation complexity (Luckman, 1977; McClung & Schaerer, 2006; Rixen et al., 2007; Breien & Høydal, 2012). Additionally, avalanches can transport soil material and debris, creating microhabitats with altered soil chemistry in the deposition zone (Luckman, 1977; Freppaz et al., 2010). Most studies on this topic emphasize the interaction between avalanches and forest, while less research is done on the vegetational structure and species composition in open avalanche paths.

Anthropogenic disturbances include a wide range of regimes. Many of them are linked to land use and agriculture, which are considered among the most important factors affecting ecosystems (Helm et al., 2006; Kulakowski et al., 2010; Palm et al., 2014). Agriculture in Europe, including Norway, has gone through major changes during the last two centuries (Ihse, 1995; Emanuelsson, 2009; Hamre et al., 2010). In the 18^{th} century, the industrial revolution lead to technical innovations that changed farming techniques and made farming more efficient (Ihse, 1995; Emanuelsson, 2009). The result of this modernization was a reshaped landscape with more progressively and intensified use of areas, and fragmentation of semi-natural grasslands. After World War II, semi-natural grasslands have tended either to be transformed into intensively managed fields, or abandoned (Ihse, 1995; Johansson et al., 2008; Hamre et al., 2010). Semi-natural grasslands below the treeline typically go through a succession to shrubland and forest when grazing or hay-making are abandoned. Several areas in Norway are somewhere in this succession, but still containing the characteristic species composition of semi-natural grasslands. It has been shown that typical semi-natural grassland species can persist long after grazing and hay-making have come to an end (Hamre et al., 2010). This slow response to habitat loss and fragmentation is linked to species with long life-cycles, slow intrinsic dynamics and quite large populations (Helm et al., 2006).

Both avalanche-impacted meadows and semi-natural grasslands are described in “Nature in Norway” (further referred to as NiN), a system for classification and description of all Norwegian nature. The first version was published in 2009, named “Nature types in Norway” (Halvorsen et al*.*, 2009), while the second version was launched in 2015, renamed “Nature in Norway” (Halvorsen et al., 2016a). The ecological approach for NiN is grounded in the gradient-analytic perspective on natural variation, described by Whittaker (1967). Three main points from this theory are summarized by Halvorsen (2012): (1) external factors do not act on species one by one, but act in concert as complex gradients, (2) a few major complex-gradients normally account for most of the variation in species composition that can be explained by environmental factors, and (3) species occur within a restricted interval along each major complex-gradient.

The aim of NiN is to cover all natural variation at three scales, comprising landscapes, ecosystems and microhabitats (Halvorsen et al*.*, 2016b). The NiN-system is based on a hierarchical approach, where this variation is partitioned on three levels. The broadest level is major type groups, the intermediate level is major types, while the smallest level is basic types (Halvorsen et al., 2016b). At the ecosystem level, these types are differentiated by the use of local complex environmental gradients (further referred to as LCEs, translations of NiN-terms in Appendix 1) that explain much of the variation in species composition. The basic types are defined so that each of them contains roughly equal amount of species compositional variation along the major LCEs, while the major types are defined by differences in ecologically structuring processes and by possessing a unique group of important LCEs, not all shared with other major types. Variation along less important LCEs and other sources of variation (e.g., regional variation, condition and successional state, contents of species etc.) are incorporated in NiN by a set of standardised variables in a description system, which can be used to detail the characterisation (Halvorsen et al., 2016b).

NiN-definitions of avalanche meadows (T16) and semi-natural grasslands (T32)

In NiN, avalanche meadows (type code T16 – *Rasmarkeng og -hei*) and semi-natural grasslands (type code T32 – *Semi-naturlig eng*) are examples of major types at the ecosystem level. Avalanche meadows are characterised by snow avalanches during winter and spring, supplied with material released by weathering throughout the year (Halvorsen, 2016). This nature type is usually found on the upper part of talus slopes, where the finer material accumulates, and the soil is stable enough for vegetation to establish (Lundquist, 1968; Halvorsen & Sulebak, 2009). The sorting of talus slopes is a result of gravity and kinetic energy. Coarse and heavy material, such as boulders and blocks, will accumulate at the bottom of the slope, and finer fractions in the upper part (Luckman 1977; Halvorsen & Sulebak 2009). The structuring geological processes give talus slopes a very regular morphology, typically with an inclination of ca. 37°, decreasing downwards. Just like semi-natural grasslands, avalanche meadows are assumed to be species-rich (Halvorsen, 2016), but research on this nature type is scarce. Characterising LCEs are avalanche impact (AI – *rasutsatthet RU*) and lime richness (LR – *kalkinnhold KA*) (Halvorsen, 2016).

Semi-natural grasslands (T32) are defined by not containing any physical traces of ploughing or sowing, and none or only weak traces of artificial fertilisation (Halvorsen, 2016). The typical semi-natural grassland is open and sun-exposed due to lack of trees, even though the semi-natural grassland major type in NiN also comprises wooded pastures. Grazing and mowing contribute to an intermediate level of disturbance, which prevents further establishment of shrubs and trees (Halvorsen et al., 2016b). Semi-natural grasslands are often species-rich (Kull & Zobel, 1991; Norderhaug et al., 2000; Halvorsen, 2016). Several explanations for this have been proposed, including the "intermediate disturbance hypothesis" (Huston, 1979), and the fact that most species prefer open, sun-exposed growth conditions (Halvorsen, 2016). The LCEs characterising semi-natural grasslands are lime richness (LR – *kalkinnhold KA*), management intensity (MI – *hevdintensitet HI*) and risk of severe drought (SD – *uttørkingsfare UF*) (Halvorsen, 2016).

According to NiN, semi-natural grasslands and avalanche meadows share some common features. Both major types are open systems impacted by disturbances, and lime richness is an LCE in both major types. However, the disturbance processes differ. In NiN, avalanche impact is defined as a natural, regulating disturbance, while management intensity is a destabilizing disturbance conditioned on human activities (Halvorsen, 2016). Despite this difference, the species composition in avalanche meadows and semi-natural grasslands is often considered to be strongly overlapping (Halvorsen, 2016). Several theories on the origin of semi-natural grassland species have been suggested, among others that megaherbivore grazing played the major role, keeping meadows continuously open; and a more traditional explanation that the species have their origin in naturally open habitat, for instance including avalanche meadows and scree slopes, from which they later dispersed into agricultural habitats (Emanuelsson, 2009). Avalanche meadows are often herb- and grass-rich which makes them attractive for outfield grazers. Accordingly, a gradual variation in grazing pressure of avalanche meadows may be found. This complicates the differentiation into two distinct nature types and drawing a line between them can be challenging for landcover-mappers.

While semi-natural grasslands are well studied, our knowledge about avalanche meadows is scarce, especially in Scandinavia. Ytrehorn (1996) did an ecological vegetation analysis of avalanche-impacted meadows in Grasdalen (Stryn, Western Norway) where the floristic composition was investigated and related to avalanche frequency and other environmental variables. A few additional studies of avalanche-impacted vegetation in Scandinavia are carried out (Nordhagen, 1943; Lundquist, 1968; Toppe, 1982), but more research is required to understand interactions between avalanches and vegetation.

Aims

Natural and anthropogenic factors are often considered separately, as each of them have major effects on ecosystems (Kulakowski et al., 2010). However, less focus is put on the interacting effects, even though many areas are impacted by several disturbance regimes. The motivation for this master thesis was to investigate the vegetational and environmental pattern in meadows impacted by both agricultural management and avalanches, and to examine the border between semi-natural grasslands (T32) and avalanche meadows (T16) in NiN. The following research questions were used as the basis and motivation for this master thesis:

1) Which ecological gradients can be identified in the investigated meadows?

2) How do snow avalanches impact the vegetation, and are avalanche meadows associated with a unique plant species composition adapted to this impact?

3) Which are the primary habitats of semi-natural grassland species, and where did they exist before the introduction of agriculture?

4) Where should the limit between avalanche meadows (T16) and semi-natural grasslands (T32) in NiN be drawn?

2 Study area

2.1 Location

The study area was located along Nærøyfjorden (60^0 57' N 6^0 58' E), Aurland municipality, Sogn and Fjordane county. Nærøyfjorden is an arm in the inner, southern parts of Sognefjorden (Figure 2.1). The study area lies in the southern and middle boreal vegetation zone (Moen, 1999) with an annual precipitation of 688 mm, based on measurements in Aurland from 1946 to 1990 (Førland, 1993). The mean annual temperature is 4 – 6ºC, and length of the growing season is between 150 – 160 days, defined as number of days > 5ºC (Moen, 1999). Field sites were placed at three locations on the south-western part of the fjord, starting from Gudvangen in south and northwards to Bakka and Tufto (Figure 2.2).

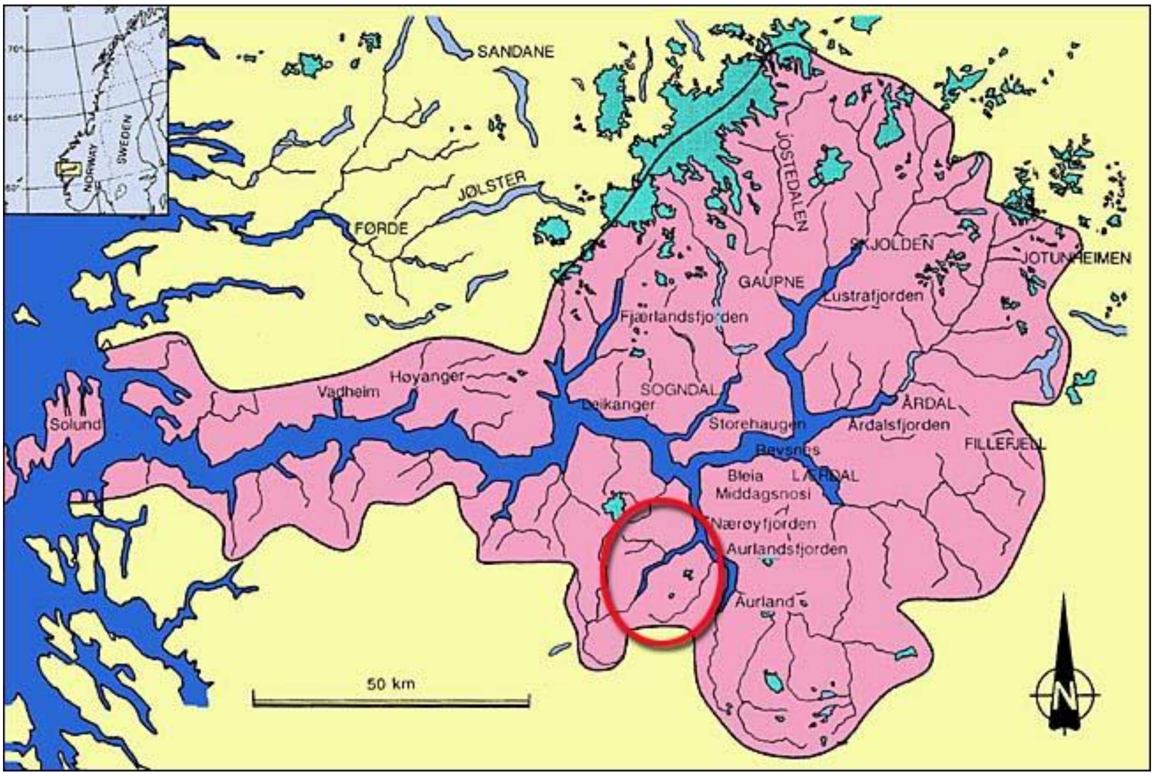

Figure 2.1. A map of Sognefjorden showing Nærøyfjorden in the red circle. Picture from www.aurlandsfjord.com (accessed 27/4-18).

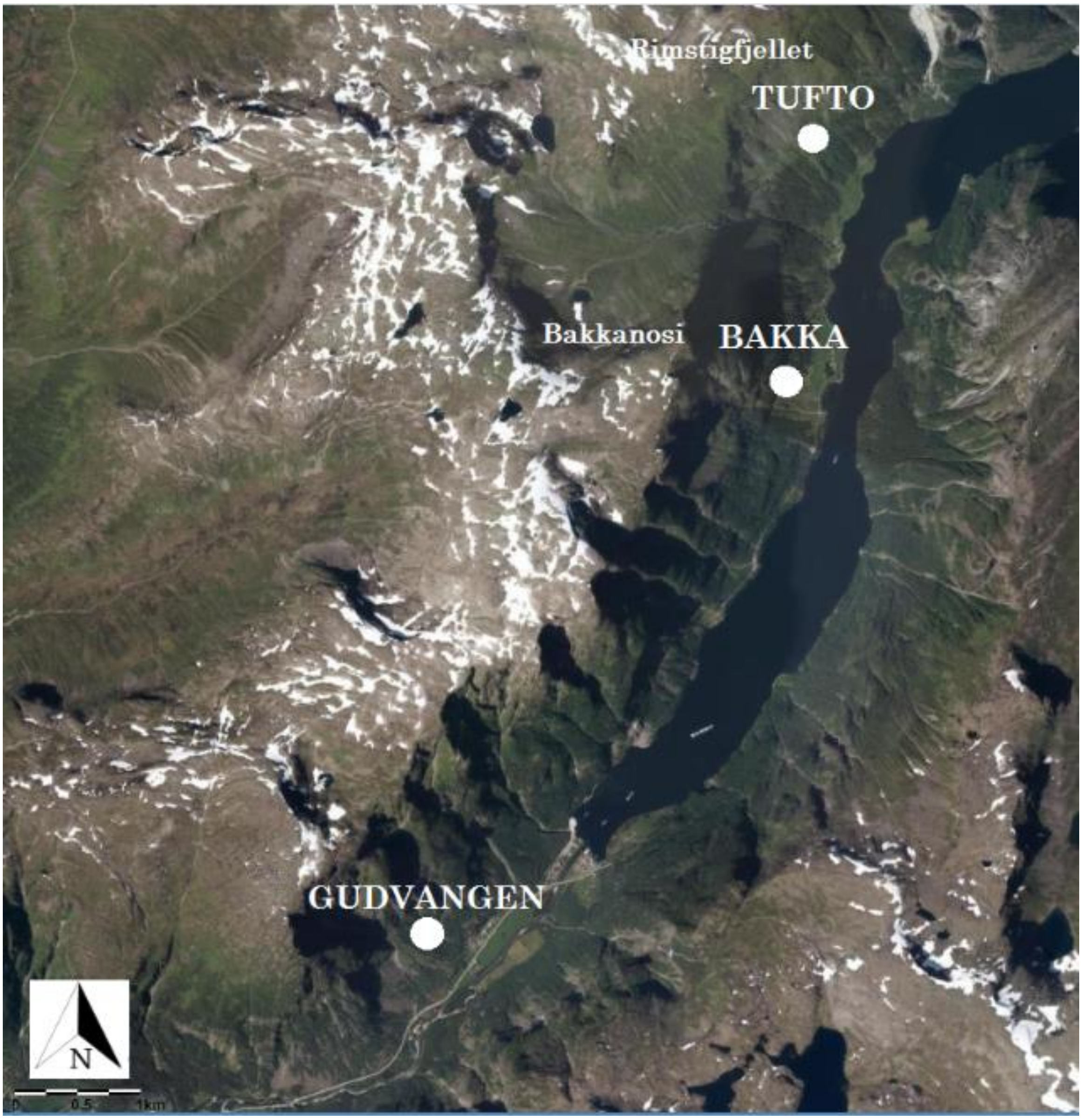

Figure 2.2. A map of the study area, showing the three main locations, starting from Gudvangen in south, and northwards to Bakka and Tufto. Orthophoto from www.norgeibilder.no (accessed 29/5-18).

2.2 Landforms, geohazards and geology

Together with Geirangerfjorden, Nærøyfjorden was pointed out as a World Heritage area by UNESCO in 2005, based on the characteristic fjord-landscape with geological values and a rich cultural heritage (UNESCO, 2018). Steep rock walls surround the narrow fjord, creating ideal conditions for natural hazards. Besides being a danger, rock falls, screes and snow avalanches have impacted the area by shaping landforms and disturbing the vegetation. Numerous talus slopes are found along Nærøyfjorden, and avalanches and screes have been common geohazards and major threats to the people along the fjord throughout history (Ohnstad, 2006). Annual snow avalanches between Gudvangen and Bakka have caused particularly large damages and problems for trafficability. In 2002, a tunnel of 1.8 km was finished and made the road stretch safer and more traversable during winter and spring. Several annual snow avalanches are described, among others "Tuftaskreda" northwards to the farm on Tufto (Ohnstad, 2006).

The bedrock along Nærøyfjorden is dominated by metamorphized Precambrian rock types such as gabbro, diorite, anorthosite and gneiss, settled on top of younger sheets of phyllite (Solli & Nordgulen, 2006). Dominated by feldspar minerals, quartz, and pyroxene, the bedrock types in the study site are generally hard and quite resistant to chemical weathering (Price & Walsh, 2012).

2.3 History and land use

The area along Nærøyfjorden is characterised by agricultural land where traditional management of mowing and grazing has been carried out throughout centuries. After the ravaging of the Black Death, most farms along Nærøyfjorden was repopulated around year 1550. The population increased rapidly during the 19th century, and the farms at Bakka and Tufto reached a maximum population around 1850. At this point, 70 persons lived at Bakka and 25 at Tufto, distributed on farmers, smallholders and their families (Ohnstad, 2006). Because of larger livestock and increased need for hay, the outfields served as an important resource and were utilized to great extent. In 1865, 62% of the hay at Bakka originated from outfields, while the corresponding numbers for Tufto and Gudvangen were 33% and 17%, respectively (Ohnstad, 2006). Mowing was carried out in quite inaccessible, steep terrain, even in patches above steep rock faces in Bakka and Gudvangen (Ohnstad, 2006). At some farms, pollarding was used to increase the winter fodder, even though it contributed to a minor part of the total amount of hay, and mountain summer farming was common until 1940. After World War II, smallholders left the farms and outfield recourses became less important (Ohnstad, 2006; S. Tufte, pers. comm., 2017). During field work in 2017, farms at Gudvangen, Bakka and Tufto were still in use with goat keeping, sheep and cattle, and grazing was observed both in infields and outfields at Bakka and Tufto.

3 Material and methods

3.1 Study design

Field work was carried out in July and August 2017.

3.1.1 Sampling design

The selection of sampling units was based on a three-step process, described in the following sections.

i) Selection of vertical transects

Seven vertical transects were subjectively placed in hillsides at three locations; Gudvangen, Bakka and Tufto. The aim was to cover variation in avalanche impact and grazing intensity along the meadows. All transects were placed on distinct talus slopes. Regarding the NiN-system, the transects were selected to primarily cover the gradual variation from avalanche meadows (T16) to semi-natural grasslands (T32), with adjacent forest occurring in some transects.

ii) Selection of transverse lines

Based on a set of criteria, transverse lines were placed across the vertical transects. The bottom line was placed 20 m above a defined starting point, while the top line was placed 20 m below the rock face or other inaccessible terrain. Additional lines were placed at regular altitudinal intervals. Starting from the middle of the vertical transect, 50 m were measured and marked to each side, resulting in transverse lines of 100 m. An illustration of the selection procedure is shown in Figure 3.1.

iii) Selection of plots

Quadrats (further referred to as plots) of 2×2 m were placed on the transverse lines, with a minimum distance of 8 m between the outer corners of the plots. For transverse lines with distinct topography, plots were placed on top points, bottom points and inflexion points facing south and north. If several candidates for a certain position were present, for instance two inflexion points facing north, a random choice was made between the candidates. For transverse lines with minor topography, four plot positions were generated at random. Plots with > 50% cover of bare rock were rejected. A special rule was applied to transversal lines crossing a forest. Starting at the forest edge, one plot was placed 5 m inside the forest, and another plot 5 m on the open meadow side. This rule was added to cover some of the variation found in the borders between meadows and forest. A total of 19 transverse lines and 82 plots were placed within the seven vertical transects. A summary is found in Table 3.1, and the 82 plots are shown on orthophotos in Figure 3.2. More detailed rules for the selection process are found in Appendix 2.

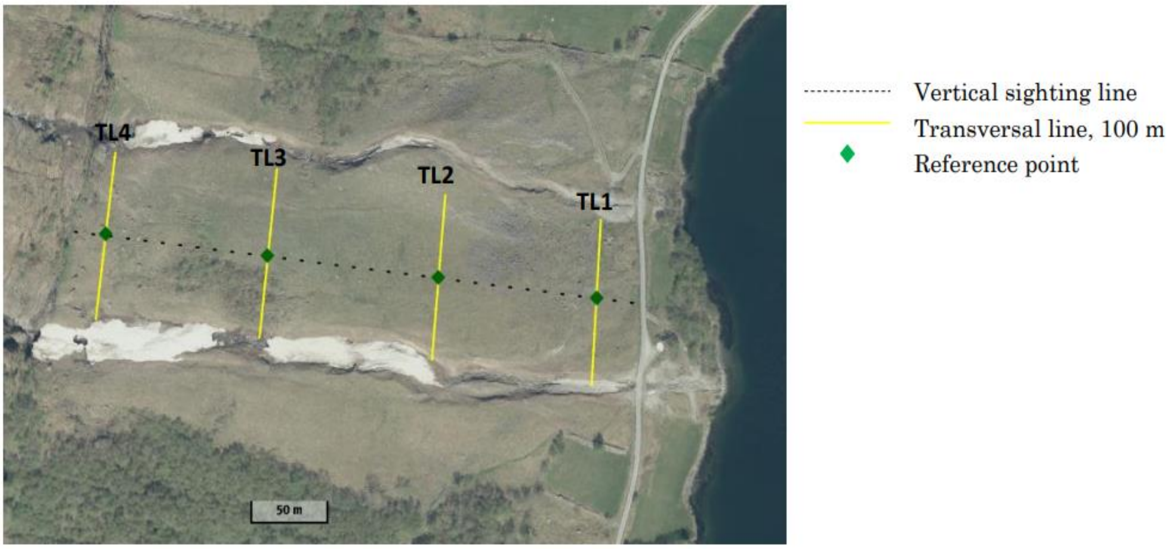

Figure 3.1. An example of a transect, represented by Transect 1 at Bakka. This transect contained four transverse lines, named TL1, TL2, TL3, TL4 in the figure. The bottom transverse line was placed 20 m above the road, while top transverse line was placed 20 m below the rock face "Seglet". The two remaining lines were placed at regular altitudinal intervals. Transverse lines spanned 100 m, 50 m to each side from the reference point.

Table 3.1. Overview of the transects and locations.

Transect number	Location	Number of transverse lines	Number of 2×2m plots	Altitudinal range (m.a.s.l.)
1	Bakka (Tåna)	4	18	31 – 184
2	Tufto (Ytre Bakkagrovi)	3	12	275 – 365
3	Bakka (Borgaviki)	2	8	40 – 170
4	Gudvangen (Langebakken)	2	8	181 – 230
5	Tufto (Flåtane)	2	8	40 – 361
6	Bakka (Seglet)	4	20	39 – 190
7	Tufto (Sauaskredgrovi)	2	8	320 – 401

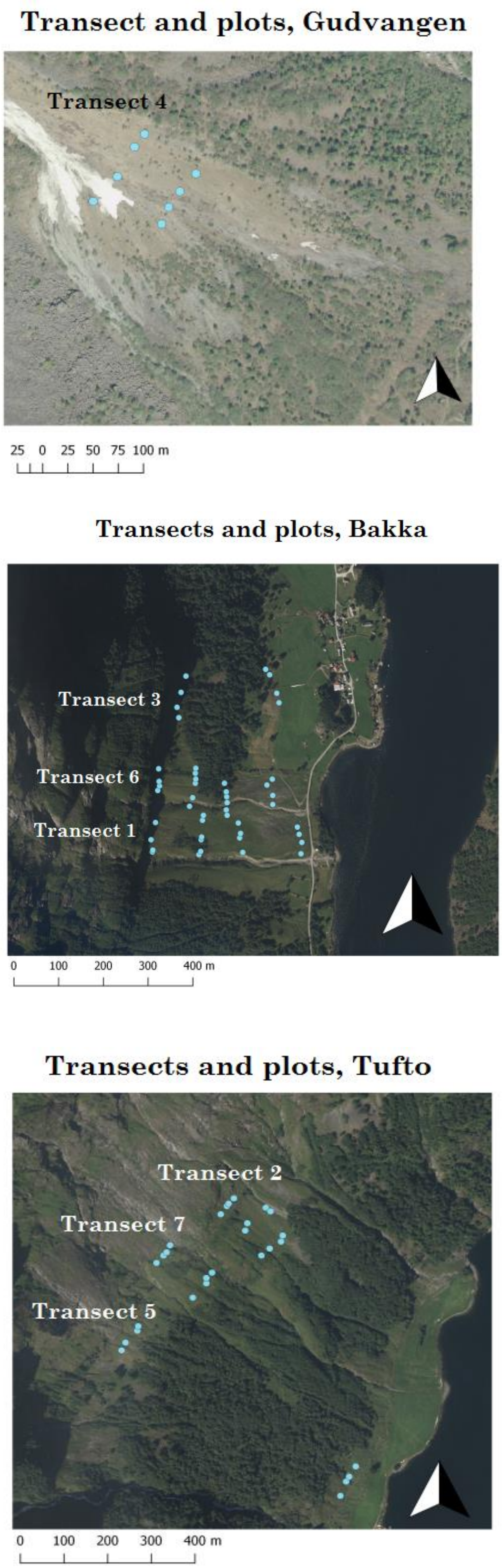

Figure 3.2. The 7 transects and 82 plots shown on orthophotos from Gudvangen, Bakka and Tufto. Figures made with QGIS version 2.18.14 (QGIS Development Team, 2018).

The numbering of plots was based on the location in vertical transects and transverse lines. For instance, in plot 231, the first number corresponds to vertical transect number 2, the second number corresponds to transverse line number 3, and the third number corresponds to the southern-most plot inside the transverse line (numbered from south to north across the transverse lines).

3.1.2 Recording of species data

The floristic composition was recorded in plots of 2×2 m. The plots were further divided into 16 subplots (50×50 cm), manually marked with sticks in every subplot corner (Figure 3.3). Subplot frequencies and percentage cover for all vascular plants and mosses were registered. The nomenclature of vascular plants follows Lid & Lid (2005), while the nomenclature of bryophytes follows the Plant List. Some genera were considered species pluralis (spp) because further identification was not possible.

Figure 3.3. A picture of plot No. 421. Each plot was 2×2 m manually marked with sticks at every 50th cm.

3.1.3 Explanatory variables

25 variables were recorded in all plots. The variables were recorded in a standardised way, for which a detailed description is included in Appendix 3. Adjusted values for aspect were calculated to a 0 – 180^0 scale, built on the view that 202,5^0 (south-west) is the most

favourable aspect and 2,5^0 (north) the least favourable, as described by Dargie (1984). Three of the variables, SD (risk of severe drought), LR (lime-richness) and MI (management intensity) were based on subjectively considerations of basic steps along the LCEs from the NiN-system.

Soil samples were collected from five positions in each plot (Figure 3.4), before the five sub-samples were mixed in a paper box. In positions with too shallow soil, soil was collected from area as close to the positions as possible. Soil depth was measured at eight positions in each plot (Figure 3.4), from which an average value was calculated afterwards. Soil samples were stored at room temperature and air-dried from the day of sampling until analyses in October.

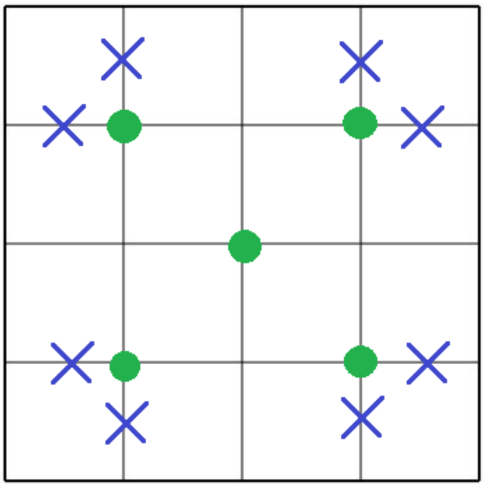

Figure 3.4. Soil samples were collected from five positions in all 82 plot, illustrated with green circles, while soil depth was measured in eight positions, illustrated with blue crosses.

Chemical soil analyses

Chemical soil analyses were conducted at the Norwegian University of Life Sciences in October 2017, where pH, loss on ignition, total nitrogen and total phosphorous were analyzed for all samples. Prior to the chemical analyses, all samples were prepared by sieving dry soil through a steel sieve with a 2 mm mesh width. A small amount of sieved soil was set aside for the nitrogen and phosphorous analyses and further crushed to finer material with a mortar. The sieve and mortar were thoroughly cleaned after each operation.

For pH-measurements, 10 mL of soil was mixed with 25 mL of deionized water, shaken by hand and left overnight. The mixture was stirred once more the following day. After sedimentation, pH-values were measured using an Orion SA 720 pH-meter. The pH-meter was calibrated with two buffer solutions (pH = 4 and pH = 7) before start and recalibrated for every 10^{th} sample.

Loss on ignition (LOI) was used as a proxy for the content of organic matter. To make sure that the results were based on the amount of dry matter, a soil dry matter analysis was conducted prior to the LOI-analysis. A tablespoon of soil was weighed into a previously weighed crucible put in a drying cabinet overnight at 105°C. After cooling down and weighing, the crucibles were put in a muffle furnace oven for 3 hours at 550°C (+/- 25°C). The crucibles were weighed after ignition. Loss on ignition was given as a percentage of the dry matter (formulas in Appendix 4).

Analysis of total nitrogen (N) followed the Dumas method (Bremner & Mulvaney, 1982), where nitrogen compounds (NO_x) are reduced to N_2, and thus undergo a phase transition from solid to gas. To carry out the analysis, 0.20 g of finely crushed soil from each sample was heated to 1050°C on Leco TruSpec CHN (carbon-hydrogen-nitrogen). The concentration of N_2 was measured by thermal conductivity on the same instrument. Values for total N were reported as percentages of dry weight. For analysis of total phosphorous (P), samples of approximately 0.25 g soil were decomposed with 10% v/V (volume percent) ultrapure HNO3 on Ultraclave for 1,5 h at 260°C and a pressure of 50 bar. After decomposition, the samples were thinned with 50 mL of deionized water and analysed on Perkin Elmer Dual View ICP-OES. Values for total phosphorous were given as g/kg, but values for total nitrogen and total phosphorous were recalculated and expressed as percentage of loss on ignition.

3.2 Data

3.2.1 Data manipulation

Continuous explanatory variables were subjected to a zero-skewness standardization (Økland et al., 2001). Variables with zero skewness were obtained by manual iteration, changing the constant *c* of the following formulas until the standardised skewness of the standardised variables was $<10^{-5}$.

$$y = \ln(c+x) \text{ for right-skewed frequency distributions} \quad (3.1)$$

$$y = e^{cx} \text{ for left-skewed frequency distributions} \quad (3.2)$$

$$y = \ln(c+\ln(c+x)) \text{ for highly right-skewed frequency distributions} \quad (3.3)$$

$$y = e^{c(e^{cx})} \text{ for highly left-skewed frequency distributions} \quad (3.4)$$

Formula 3.1 and 3.2 were tested first. If standardised skewness was not obtained by these, formula 3.3 and 3.4 were tested. Some of the variables could not be standardised by either of the formulas. If possible, these variables were converted to presence-absence data and treated as binary variables in the analyses. After all *c*-values were found, the transformed variables were ranged from 0 to 1 by using the formula $y_{scaled} = (y-y_{min}/(y_{max}-y_{min}))$. An overview of the explanatory variables with associated characteristics and transformations are shown in Table 3.2.

Table 3.2. Summary statistics for all 25 explanatory variables used in the analyses, including untransformed range, mean for the frequency distributions and transformation type and corresponding *c*-value for the transformed variables. More detailed descriptions in Appendix 3, including the standardised recording procedure. Values for all explanatory variables, both untransformed and transformed, in each plot are found in Appendix 5 and 6, respectively.

Variabel	Abbreviation	Comment	Untransformed		Transformation	
			Range	Mean	Type	*c*-value
Aspect	*Aspect*	*Aspect favourability on a 0 – 180 ^{0} scale*	29.5 – 42.5	80.0	ln(c+ln(c+x))	101.29
Altitude	*Altitude*	*Meters above sea level*	31 – 401	184.6	ln(c+x)	187.7
Animal droppings	*Droppings*	*Presence (1) or absence (0) of animal droppings*	0 – 1	0.3	Binary	–
Bare ground	*BareGround*	*Percentage cover of bare ground*	0 – 19	2.8	ln(c+x)	0.19391
Bottom layer	*BotLayer*	*Percentage cover of mosses*	1 – 70	23.1	ln(c+x)	22.439
Convexity (horizontal)	*ConvH*	*Horizontal plot convexity. Scale from -2 to +2, where +2 is strongly convex*	-2 – +1.5	0.1	e^cx	0.23333
Convexity (vertical)	*ConvV*	*Vertical plot convexity. Scale from -2 to +2, where +2 is strongly convex.*	-1.5 – +1	0	e^cx	0.31062
Dead wood	*DeadWood*	*Presence (1) or absence (0) of dead wood*	0 – 1	0.2	Binary	–
Field layer	*FieldLayer*	*Percentage cover of the field layer*	30 – 100	73	e^cx	0.010972
Grain size	*GrainSize*	*Grain size classes from Wentworth's scale: 1 = 4-64, 2 = 64-256, 3 > 256.*	1 – 3	2.3	e^cx	1.2502
Lime richness	*LR*	*Based on basic steps c (1), d (2), e (3) and f (4) for the LCE "LR" in NiN*	1 – 4	1.9	ln(c+ln(c+x))	0.658
Litter	*Litter*	*Presence (1) or absence (0) of litter*	0 – 1	0.1	Binary	–
Loss on ignition	*LOI*	*Loss on ignition, % of soil organic matter*	5.0 – 43.0	13.1	ln(c+ln(c+x))	0.4037
Management intensity	*MI*	*Based on basic steps b(1), c(2), d(3) and e(4) for the LCE "MI" in NiN*	1 – 4	2.2	ln(c+x)	1.6464
Mineral/rock	*Mineral*	*Fraction of supplied, loose rocks*	0 – 1	0.1	ln(c+x)	0.007585
pH	*pH*	*Soil pH measured in water*	4.3 – 6.3	5.3	e^cx	0.03055
Position	*Position*	*Positioning of plots*	1 – 4	2.2	ln(c+ln(c+x))	2.188
Risk of severe drought	*SD*	*Based on basic steps b(0) and c(1). for the LCE "SD" in NiN*	0 – 1	0.2	Binary	–
Rock cover	*Rock*	*Percentage cover of rocks in the plot*	0 – 60	11.7	ln(c+x)	1.6374
Shrub cover	*Shrub*	*Presence (1) or absence (0) of shrubs*	0 – 1	0.0	Binary	–
Slope inclination	*Slope*	*Inclination inside plots, average from 4 measurements*	16.0 – 40.8	30.8	e^c(e^cx)	0.030058
Soil depth	*SoilDepth*	*Average soil depth in cm*	0.9 – 29.0	7.3	ln(c+x)	0.9143
Total N	*TotN*	*Total nitrogen, % of organic matter*	2.8 – 4.1	3.5	e^cx	0.81229
Total P	*TotP*	*Total phosphorous, % of organic matter*	4.4 – 40.2	17.9	ln(c+x)	24.544
Tree	*Tree*	*Presence (1) or absence (0) of trees*	0 – 1	0.1	Binary	–

3.2.2 Statistical analyses

For all statistical analyses, the statistical software package R Version 3.4.2 (R Core Team, 2018) was used. The built-in vegan-package version 2.4-6 (Oksanen et al., 2018) was used for all multivariate analyses.

Pairwise-correlations between all continuous explanatory variables were calculated using Kendall's rank correlation coefficient τ. A Wilcoxon test was used for obtaining p-values for pairs of continuous variables and factor variables, while a χ^2 test was applied to pairs of factor variables.

Species-abundance data with original subplot frequencies (0 – 16) was used for the statistical analyses. The use of raw data or weighted abundances can impact the ordination results (Økland, 1990; van Son & Halvorsen, 2014). In this analysis, both percentage coverages and subplot frequencies (0 – 16) of species were registered in field. Registered percentage coverages could potentially have been converted to abundance/dominance (AD) data and subjected to ordination. However, more uncertainties related to subjectivity are associated with AD-data (Økland, 1990; Podani, 2006; van Son & Halvorsen, 2014), and a species-abundance matrix with subplot-frequencies was therefore used in this analysis.

Ordination methods were applied to the species-abundance matrix in order to identify vegetational structure and estimate compositional turnover along the main gradients. A multiple parallel ordination (MPO) was performed as suggested by van Son & Halvorsen (2014), including detrended correspondence analysis (DCA) (Hill & Gauch, 1980) and global-non-metric multidimensional scaling (GNMDS) (Kruskal, 1964). Kendall's rank correlation coefficient τ was used to compare axes from DCA and GNMDS ordination.

DCA was run with standard options for Decorana-function (Hill, 1979), including four rescaling cycles and 26 segments in each cycle. A two-dimensional GNMDS solution was obtained, where Bray Curtis-dissimilarities were compared to the distance matrix. For unreliable distances, new Geodesic distances were calculated with stepacross with threshold value ε = 0.8 (Williamson, 1978). Number of starting configurations was 100, maximum iterations was 2000 and convergence limit was set to $1x10^{-7}$. DCA axes were scaled in S.D. units, while gradient lengths for GNMDS axes were scaled in half change units.

Beside the original dataset, two additional subsets were made to test how plots from spring-water influenced depressions and woodland impacted the structure of the ordinations. Thus, GNMDS and DCA ordinations were performed on the following three datasets:

a) Full dataset: all 82 plots included.
b) Subset 1 (sub1): 80 plots. Two weak outlier-plots from spring-water influenced depressions excluded (plots 144 and 724).
c) Subset 2 (sub2): 74 plots. Plots from spring-water influenced depressions and woodland excluded (plots 144, 724, 132, 133, 625, 626, 634 and 635).

For ecological interpretation, biplots were made with plot positions from GNMDS and vectors for explanatory variables. Kendall's correlations between explanatory variables and ordination axes were calculated for all continuous variables, while p-values from Wilcoxon test were reported for the relationships between binary variables and the axes. Additionally, isoline representations were made as a graphical visualization of the most important variables.

3.3 Historical information and interviews

Historical aerial photographs were used to detect changes in vegetation cover and land use in the field area. Orthophotos from 1971 were compared to recent orthophotos from 2013 and 2014, private photos and field observations. Additionally, interviews with land owners and locals at Bakka and Tufto were carried out to obtain more historical information from the area.

3.4 Assessment of avalanche terrain

Inclination maps from The Norwegian Water Resources and Energy Directorate (NVE, 2018) were used to detect typical avalanche terrain and estimate the risk of snow avalanches in the study site, supplemented with historical information on avalanche activity. Based on definitions from McClung & Schaerer (2006), the starting zone is the location where unstable snow start to move, either from a crown (slab avalanches) or from a point (loose snow avalanches). The avalanche path is defined as a fixed locality within an area where the avalanche moves. Slope inclination is the primary terrain requirement for a starting zone (Schaerer, 1972; McClung & Schaerer, 2006) and therefore serves as the basis for this snow avalanche evaluation. In the inclination map, terrain steeper than 27 ° is divided into the following inclination classes: 27 – 30°, 30 – 35°, 35 – 40°, 40 – 45°, 45 – 50°, 50 – 90°. An inclination between 30 and 45° is considered the most ideal for starting zones (Schaerer, 1972; McClung & Schaerer, 2006; Sulebak, 2007). An overview of geological terms related to snow avalanches is included in Appendix 7.

4 Results

4.1 Transect characteristics

The complete list of registered species with subplot-frequencies is found in Appendix 8.

Gudvangen

One transect (No. 4) was placed in Gudvangen, located on a distinct talus slope. Plots from Transect 4 were dominated by *Hieracium umbellata, Pilosella lactucella and Pilosella officinarum*. Other abundant species included *Anthoxanthum odoratum, Avenella flexuosa*, *Campanula rotundifolia* and *Pimpinella saxifraga*. Some unique species to this transect were found, including *Convallaria majalis, Solidago virgaurea* and *Viscaria vulgaris*. Trees and shrubs were scattered around in this transect. No recent grazing or animal droppings were observed, in contrast to transects at Bakka and Tufto.

Bakka

Three transects (No. 1, 3 and 6) were located at Bakka, all sharing a quite similar character. The most abundant species were *Agrostis capillaris, Anthoxanthum odoratum, Poa pratensis, Achillea millefolium, Cerastium fontanum, Rumex acetosa, Trifolium pretense, Trifolium repens, Ranunculus acris, Ranunculus repens* and *Rhytidiadelphus squarrosus*. A few plots were located in woodland (plot 132, 133, 625, 626, 634 and 635), and included e.g. *Alnus incana, Equisetum sylvaticum, Galeopsis sp., Impatiens noli-tangere, Rubus idaeus* and *Lophocolea sp*. Vegetation was generally denser and taller in the upper transverse lines. Typical species found in these parts included *Arrhenatherum elatius* (Transect 3*), Filipendula ulmaria, Urtica dioica* and *Verbascum nigrum*.

Tufto

Three transects (No. 2, 5 and 7) were located at Tufto. One transverse line was located near the farm, with plots containing some species unique to the dataset, including *Elytrigia repens* and *Holcus lanatus*. The remaining transverse lines were placed in higher parts of the hillsides, and common species included *Achillea millefolium, Clinopodium vulgare, Euphrasia stricta, Galium boreale, Hypericum macalatum, Knautia arvensis, Origanum vulgare, Pimpinella saxifraga, Plantago lanceolata, Plagiomnium undulatum, Rhytidiadelphus squarrosus* and *Thuidium sp*. The transects at Tufto were surrounded by forest, mainly dominated by *Alnus incana*. Numerous trees were tilted downwards and bent to the ground, shown in Figure 4.1. Scattered trees of *Ulmus glabra* and *Corylus avellana* were observed near the transects.

Figure 4.1. A picture from the area below Transect 7 at Tufto, showing Alder-trees bent to the ground by avalanches.

Figure 4.2. Picture from May 2017, showing the vegetational impact of a severe snow avalanche that passed Tufto in March 2017.

Transects at Tufto showed the highest average number of species per plot, with all three transects containing an average of 40 species or more. The mean species-richness per plot for all transects is shown in Figure 4.3.

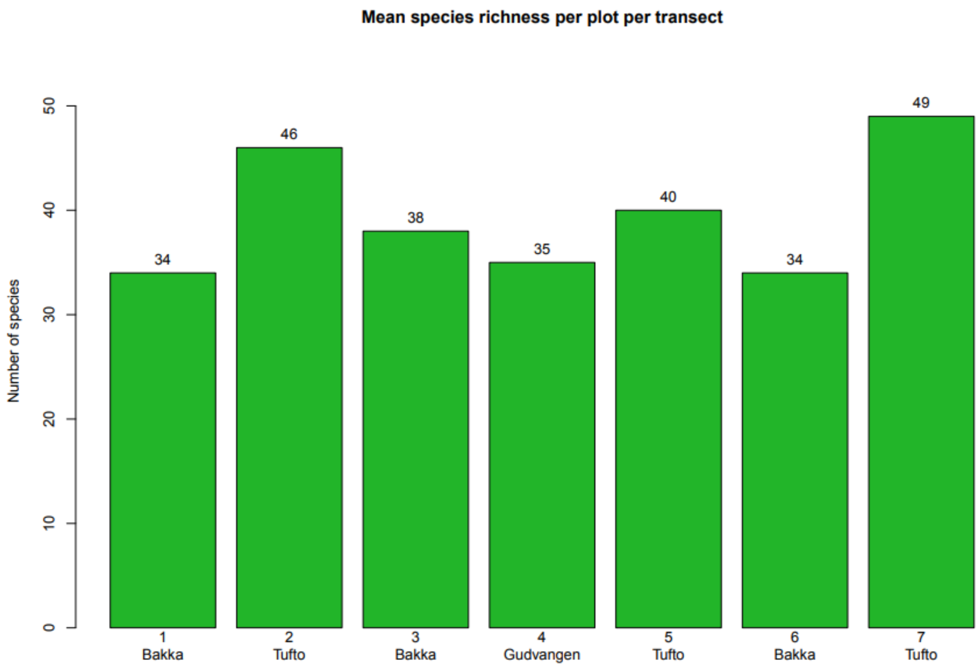

Figure 4.3. Average number of species (vascular plants and mosses) per plot, calculated for each transect. The calculated averages are rounded to integers.

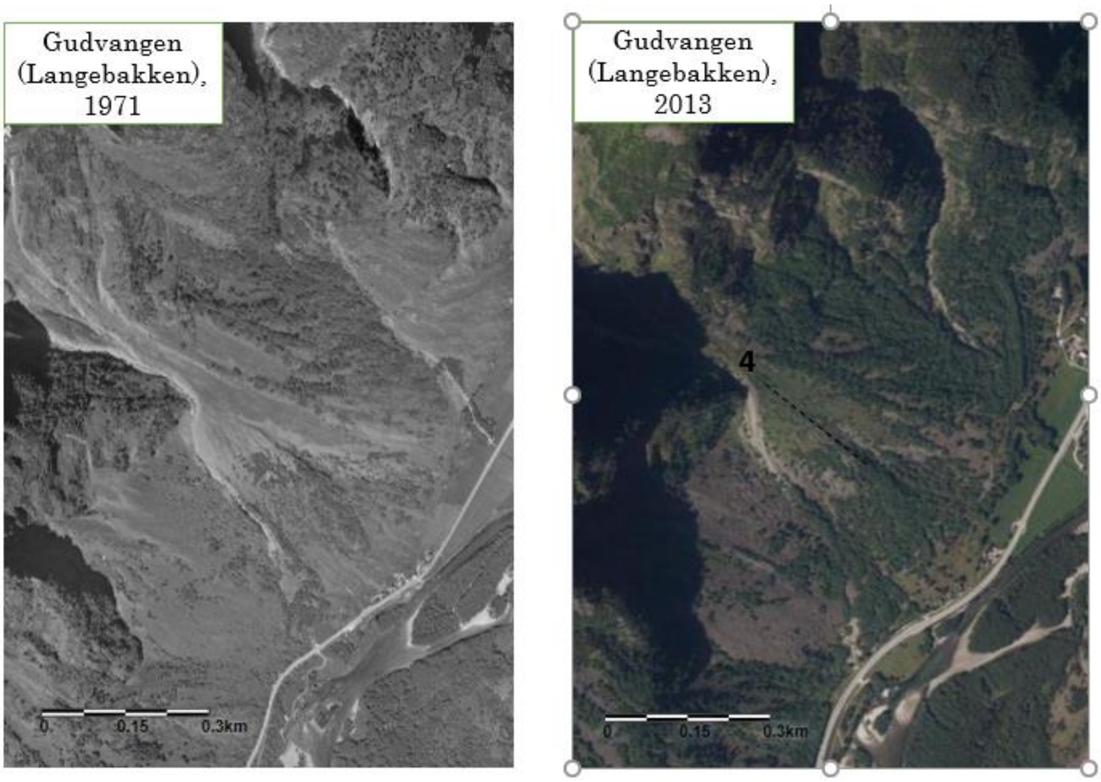

Figure 4.4. Orthophotos from 1971 and 2013, covering Transect 4 in Gudvangen (marked with dotted lines on 2013-photo). Photos from www.norgeibilder.no (accessed 30/5-18).

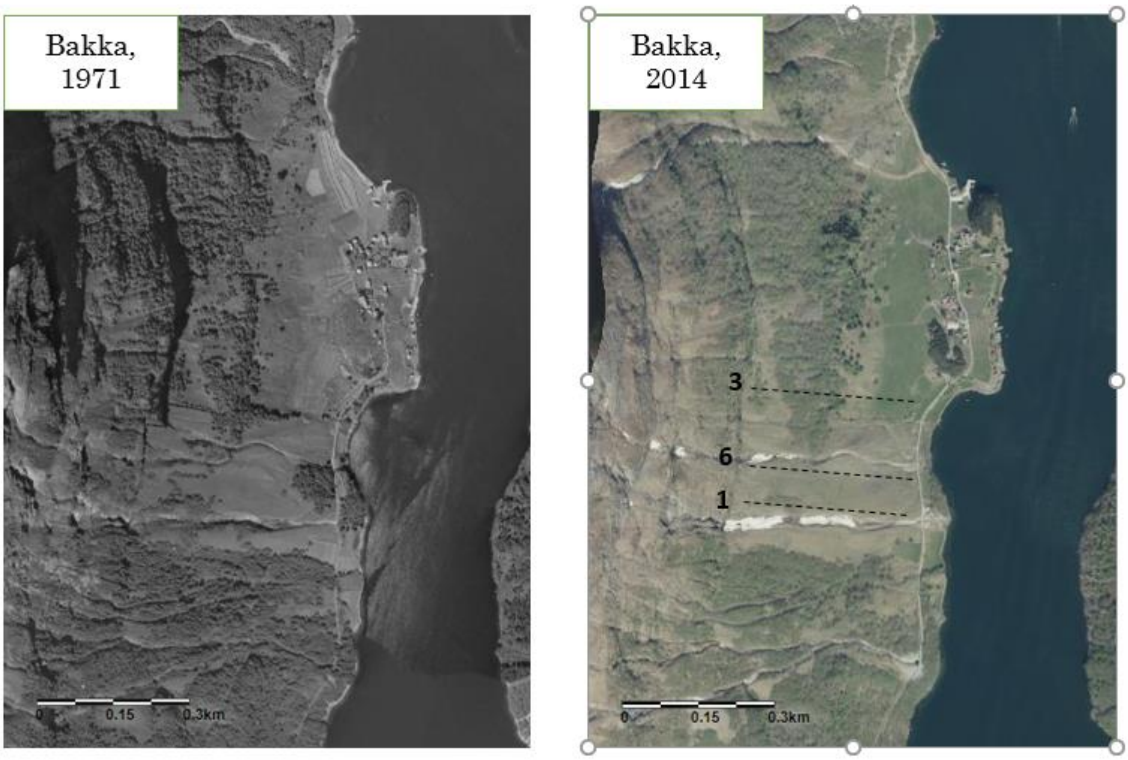

Figure 4.5. Orthophotos from 1971 and 2014, covering Transect 1, 3 and 6 at Bakka (transects marked with dotted lines on 2014-photo). Photos from www.norgeibilder.no (accessed 30/5-18).

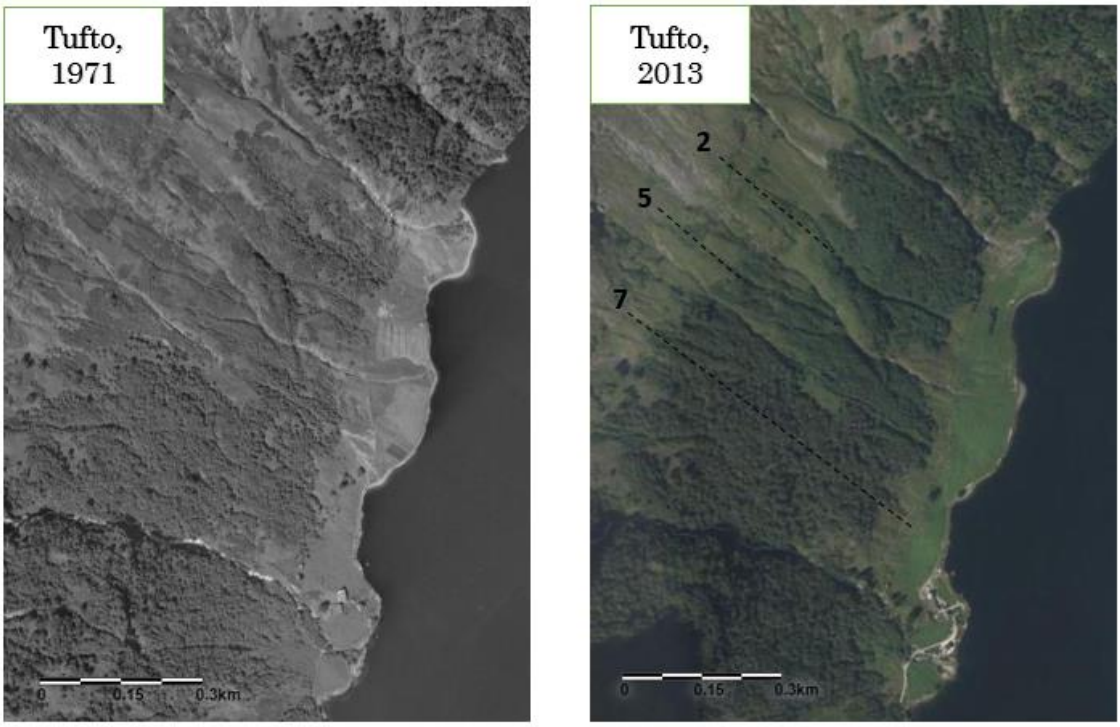

Figure 4.6. Orthophotos from 1971 and 2013, covering Transect 2, 5 and 7 at Bakka (transects marked with dotted lines on 2013-photo). Photos from www.norgeibilder.no (accessed 30/5-18).

Figure 4.4, 4.5 and 4.6 show orthophotos from 1971, 2013 and 2014, covering the transect areas in Gudvangen, Bakka and Tufto. The photographs show that tree cover has generally increased, especially in Gudvangen and around Transect 3 at Bakka. Still, some patches of woodland have decreased or disappeared, for instance lower parts of Transect 6 at Bakka. The photograph from Tufto 2014 shows dense woodland below transect 2, but most parts of this woodland were disrupted by an avalanche in 2017.

4.3 Explanatory variables

Summary statistics

Starting from Gudvangen in south, the vertical transects were located within approximately 7 km north along Nærøyfjorden. All 82 plots were located in sloping terrain, with a mean incline inside the plots ranging from 16 to 41°. Aspect of the slopes varied from north-east to south (52 – 165°), and pH values ranged from 4.3 to 6.3. An overview of the characteristics for the explanatory variables are shown in Table 3.2, and values for each plot are found in Appendix 5 (untransformed) and Appendix 6 (transformed).

Table 4.1. Kendall's τ correlation coefficients for pairs of continuous explanatory variables shown in lower triangle, with corresponding p-values shown in upper triangle. $P < 0.05$ in bold.

	Aspect	Slope	ConvH	ConvV	Rock	Bare Ground	Mineral	Grain Size	Field Layer	Bot Layer	Soil Depth	Altitude	pH	LOI	TotN	TotP	LR	MI	Position
Aspect		**0.0105**	0.3430	0.2550	0.2782	**0.0013**	0.0825	0.5823	0.3121	**0.0037**	0.0758	**0.0006**	**0.0058**	0.3823	0.3693	0.4658	**0.0011**	0.9649	**0.0284**
Slope	**0.1951**		**0.0106**	0.0866	**0.0036**	**<0.0001**	0.1746	**0.0004**	0.0657	**0.0070**	**0.0001**	**<0.0001**	**0.0002**	0.1220	0.1694	0.9012	**<0.0001**	**0.0020**	0.5716
ConvH	0.0807	**0.2168**		**0.0001**	0.7795	**0.0497**	0.5294	0.3978	0.5037	0.1669	0.3895	0.3958	0.7399	0.4793	0.8579	0.5096	0.3615	0.8032	0.6416
ConvV	0.0994	0.1491	**0.3763**		0.7948	0.9574	0.1430	0.3022	0.8538	0.2373	0.5056	0.1230	0.3876	0.0966	0.9925	0.0875	0.3924	0.3458	0.4359
Rock	-0.0939	**-0.2243**	0.0241	0.0229		0.6173	**0.0001**	0.8888	**<0.0001**	0.6788	**<0.0001**	**0.0233**	0.8315	0.5419	0.0556	0.2302	**0.0196**	0.1293	0.1585
BareGround	**0.2618**	**0.3644**	**0.1783**	0.0050	0.0412		**0.0016**	**<0.0001**	0.3241	**0.0072**	0.0568	**<0.0001**	**<0.0001**	0.5337	0.7541	0.0697	**<0.0001**	**0.0002**	**0.0081**
Mineral	0.1376	0.1072	0.0555	0.1324	**0.3088**	**0.2671**		**<0.0001**	**0.0200**	**0.0062**	0.0511	**0.0018**	**0.0008**	**0.0018**	**0.0040**	**0.0098**	0.0629	**0.0001**	0.1028
GrainSize	-0.0482	**-0.3121**	-0.0826	-0.1033	-0.0124	**-0.4014**	**-0.4683**		0.6373	**0.0368**	0.8443	**<0.0001**	**<0.0001**	**0.0395**	**0.0144**	0.8512	0.0022	**<0.0001**	**0.0232**
FieldLayer	0.0776	0.1407	-0.0571	0.0161	**-0.4996**	-0.0807	-0.1848	0.0414		0.1735	**0.0006**	0.1770	0.6855	0.4535	0.0907	0.9043	**0.0105**	0.2727	0.5405
BotLayer	**-0.2241**	**-0.2072**	-0.1186	-0.1039	-0.0323	-0.2210	**-0.2187**	**0.1844**	-0.1052		**0.0114**	**0.0055**	0.0604	0.4224	0.8568	0.7697	**0.0090**	0.1125	0.5047
SoilDepth	0.1353	**0.2948**	0.0729	0.0578	**-0.3678**	0.1547	-0.1539	0.0171	**0.2624**	**-0.1944**		0.1013	0.9712	0.0865	**0.0004**	0.4635	**0.0286**	0.3155	0.0560
Altitude	**0.2665**	**0.5453**	0.0734	0.1367	**-0.1781**	**0.5130**	**0.2507**	**-0.5011**	0.1052	**-0.2172**	0.1267		**<0.0001**	**0.0179**	0.7209	0.9201	**<0.0001**	**<0.0001**	**0.0022**
pH	**0.2102**	**0.2879**	0.0281	0.0751	-0.0164	**0.3644**	**0.2636**	**-0.4352**	0.0309	-0.1442	0.0027	**0.4930**		**0.0084**	0.2848	0.9840	**<0.0001**	**0.0007**	**<0.0001**
LOI	-0.0663	-0.1170	0.0597	-0.1438	-0.0468	-0.0504	**-0.2452**	**0.1789**	0.0570	0.0613	-0.1295	**-0.1825**	**-0.1992**		0.5374	**<0.0001**	0.9932	**0.0008**	0.2104
TotN	0.0681	0.1039	-0.0151	0.0008	-0.1468	-0.0253	**-0.2260**	**0.2126**	0.1286	-0.0138	**0.2677**	-0.0275	-0.0808	-0.0464		0.0982	0.4142	0.1006	0.0821
TotP	-0.0553	-0.0094	-0.0556	0.1478	0.0920	-0.1467	**0.2030**	-0.0163	-0.0091	-0.0224	0.0554	-0.0077	0.0015	**-0.6441**	0.1244		0.0641	0.1106	0.2358
LR	**0.2824**	**0.5136**	0.0879	0.0845	**-0.2041**	**0.5137**	0.1667	**-0.3045**	**0.2219**	**-0.2277**	**0.1885**	**0.5976**	**0.4641**	-0.0007	0.0700	-0.1587		**0.0173**	**0.0335**
MI	-0.0038	**-0.2660**	-0.0239	-0.0929	-0.1322	**-0.3382**	**-0.3398**	**0.4583**	0.0949	0.1379	0.0862	**-0.3905**	**-0.2926**	**0.2880**	0.1403	0.1557	**-0.2036**		**0.0389**
Position	**0.1858**	0.0478	-0.0439	-0.0754	0.1208	**0.2396**	0.1432	**-0.2206**	-0.0520	-0.0570	-0.1612	**0.2634**	**0.3529**	-0.1053	-0.1461	-0.0996	**0.2039**	**-0.1975**	

Table 4.2. Reported test statistics (w) and p-values from Wilcoxon signed-rank test for pairs of factor variables and continuous variables.

	Shrub		**Tree**		**Litter**		**DeadWood**		**Droppings**		**SD**	
	w	p	w	p	w	p	w	p	w	p	w	p
Aspect	112.5	0.8919	379.5	0.4535	662.5	**0.0002**	536	0.2691	497.5	0.0898	429.5	0.5705
AspectOpt	124.5	0.8919	277.5	0.4535	118.5	**0.0002**	361	0.2691	822.5	0.0898	522.5	0.5705
Slope	111.5	0.8724	248	0.2352	285	0.1530	392	0.4770	875	**0.0247**	560	0.3033
ConvH	138	0.6095	351	0.7224	297	0.1684	475.5	0.7142	564.5	0.2791	468.5	0.9252
ConvV	129	0.7714	344	0.7936	391.5	0.9936	523.5	0.2660	655.5	0.9607	454.5	0.7609
Rock	145	0.5200	369	0.5522	399.5	0.9078	375.5	0.3565	512.5	0.1233	423	0.5169
BareGround	105.5	0.7509	290	0.5622	351	0.5854	369.5	0.3056	748.5	0.3437	576	0.2075
Mineral	85.5	0.4157	306	0.7407	466	0.3008	413.5	0.6570	700	0.6751	259	**0.0068**
GrainSize	154.5	0.3406	434	0.0905	541.5	**0.0261**	513.5	0.3735	541	0.1777	507.5	0.6780
FieldLayer	111.5	0.8724	323	0.9408	434	0.5582	474.5	0.7459	741.5	0.3962	370	0.1932
BotLayer	176	0.1586	294	0.6135	270	0.1020	466.5	0.8239	698	0.6943	535	0.4703
SoilDepth	93.5	0.5450	254.5	0.2755	489.5	0.1801	405	0.5850	866.5	**0.0311**	636.5	**0.0486**
Altitude	112.5	0.8917	300.5	0.6827	330.5	0.4172	431	0.8288	901	**0.0117**	409	0.4115
pH	203	**0.0380**	402	0.2787	270.5	0.1039	489.5	0.6071	803	0.1358	449	0.7939
LOI	42	0.0605	307.5	0.7610	354	0.6243	410.5	0.6340	367	**0.0022**	565	0.2754
TotN	128	0.8241	261	0.3203	471	0.2764	583	0.0889	712	0.5899	569	0.2543
TotP	195	0.0605	346	0.8009	462	0.3340	521	0.3607	875	**0.0248**	337	0.0879
LR	103.5	0.7028	403.5	0.2390	410.5	0.7774	458.5	0.8978	836.5	**0.0497**	452.5	0.7627
MI	103	0.6845	459	**0.0344**	548	**0.0191**	570	0.0920	410.5	**0.0043**	509.5	0.6555
Position	135.5	0.6704	414.5	0.1854	438	0.5043	449.5	0.9947	586	0.4218	513.5	0.634

Table 4.3. Reported test-statistic (the χ^2 with 1 degree of freedom) from χ^2-test between pairs of factor variables (lower triangle) with corresponding p-values in upper triangle.

	Shrub	**Tree**	**Litter**	**DeadWood**	**Droppings**	**SD**
Shrub	-	**0.0276**	1.0000	0.0990	0.6857	1.0000
Tree	4.8534	-	0.1802	**0.0449**	0.1269	0.9726
Litter	<0.0001	1.7956	-	0.1193	0.2885	0.7448
DeadWood	2.7216	4.0212	2.4271	-	0.1749	1.0000
Droppings	0.1638	2.3306	1.1264	1.8400	-	0.4054
SD	<0.0001	0.0012	0.1060	<0.0001	0.6923	-

Table 4.1 shows Kendall's τ values with corresponding p-values for all continuous explanatory variables. Some groupings of strongly correlated variables were found. BareGround, Slope, Altitude, pH, LR and Mineral appeared as the most distinct group, all variables positively correlated with each other. MI, Droppings and LOI made up another small assemblage of positively correlated variables. pH, BareGround, Altitude and LR

showed strong, negative correlations with MI and GrainSize ($\tau < -0.25$ for all correlation pairs). The Wilcoxon-test (Table 4.2) showed that Droppings were related to several variables, including Slope, LR, pH, Altitude, TotP and MI, while the χ^2 - test (Table 4.3) showed that there were significant relations between Tree, Shrub and DeadWood.

4.4 Ordinations

Compositional turnover along DCA axes showed that axes of higher order were longer than subsequent axes in all datasets, with one exception ($DCA3^{sub1}$ = 2.4852 S.D. > $DCA2^{sub1}$ = 2.1938 S.D.) (Table 4.4). In GNMDS ordination, first axes were longer than second axes in all three datasets (Table 4.5).

Table 4.4. Gradient lengths and characteristics for DCA axes, estimated in S.D.-units.

	DCA axis 1		**DCA axis 2**		**DCA axis 3**		**DCA axis 4**	
	Eigenvalue	**S.D. units**	**Eigenvalue**	**S.D. units**	**Eigenvalue**	**S.D. units**	**Eigenvalue**	**S.D. units**
Full dataset	0.3610	3.3328	0.2364	2.7982	0.2591	2.3192	0.0991	1.9357
Subset 1	0.3635	3.4684	0.2701	2.1938	0.1676	2.4852	0.1022	1.9838
Subset 2	0.2917	2.6261	0.2582	2.4657	0.1372	2.3270	0.0943	1.9142

Table 4.5. Gradient lengths for GNMDS axes, estimated in half-change units.

	GNMDS axis 1			**GNMDS axis 2**		
Dataset	**Full dataset**	**Subset 1**	**Subset 2**	**Full dataset**	**Subset 1**	**Subset 2**
H.C. units	2.3670	2.4153	1.8718	1.9345	1.3708	1.6665

With a highly significant τ-value (> 0.8), first axes of DCA and GNMDS were strongly correlated and confirmed each other in ordination of the full dataset (Table 4.6). Second axes showed a weaker correlation (τ = -0.36), while DCA2 was stronger correlated to GNMDS1 (τ = -0.60). In ordination of Subset 1, both first and second axes of DCA and GNMDS were strongly correlated and confirmed each other (Table 4.6). DCA ordination of Subset 2 rotated the dimensional space, leading to a reversed pattern where DCA axis 1 was strongly correlated to GNMDS axis 2, and DCA axis 2 correlated with GNMDS axis 1. DCA ordinations showed a distinct tongue-effect for all three datasets, with plots spread out along second axes. Because of this distortion, GNMDS was given more weight in this study, and further analyses and discussion are mainly based on GNMDS ordination. DCA ordinations diagrams for Subset 1 and Subset 2 are found in Appendix 9, where correlations between explanatory variables and DCA-axes are included as well.

Table 4.6. Kendall's correlation coefficients with corresponding p-values between DCA and GNMDS axes for all three datasets. p-values <0.05 in bold.

	Full dataset				Subset 1				Subset 2			
	DCA1		DCA2		DCA1		DCA2		DCA1		DCA2	
	τ	p	τ	p	τ	p	τ	p	τ	p	τ	p
GNMDS1	**0.8314**	**<0.0001**	**-0.6001**	**<0.0001**	**0.8595**	**<0.0001**	-0.0430	0.5721	0.0722	0.3628	**0.7275**	**<0.0001**
GNMDS2	0.0864	0.2504	**-0.3574**	**<0.0001**	0.1867	0.0142	**0.5968**	**<0.0001**	**0.8030**	**<0.0001**	0.0152	0.8483

Pairwise correlations of corresponding GNMDS axes across datasets were significant in all cases (Table 4.7). GNMDS1 vs. $GNMDS1^{sub1}$ and GNMDS2 vs. $GNMDS2^{sub1}$ were perfectly correlated ($\tau > 0.9$), while second axes in subset 1 and subset 2 showed a slightly weaker correlation ($\tau < 0.6$).

Table 4.7. Kendall's rank correlation coefficients and corresponding p-values for GNMDS axes across the datasets. "sub1" and "sub2"-annotations correspond to Subset 1 and Subset 2.

Axes	τ	p
$GNMDS1^{full}$ - $GNMDS1^{sub1}$	0.9658	**p < 0.0001**
$GNMDS2^{full}$ - $GNMDS2^{sub1}$	0.9278	**p < 0.0001**
$GNMDS1^{sub1}$ - $GNMDS1^{sub2}$	0.6690	**p < 0.0001**
$GNMDS2^{sub1}$ - $GNMDS2^{sub2}$	0.5972	**p < 0.0001**
$GNMDS1^{full}$ - $GNMDS1^{sub2}$	0.6971	**p < 0.0001**
$GNMDS2^{full}$ - $GNMDS2^{sub2}$	0.6357	**p < 0.0001**

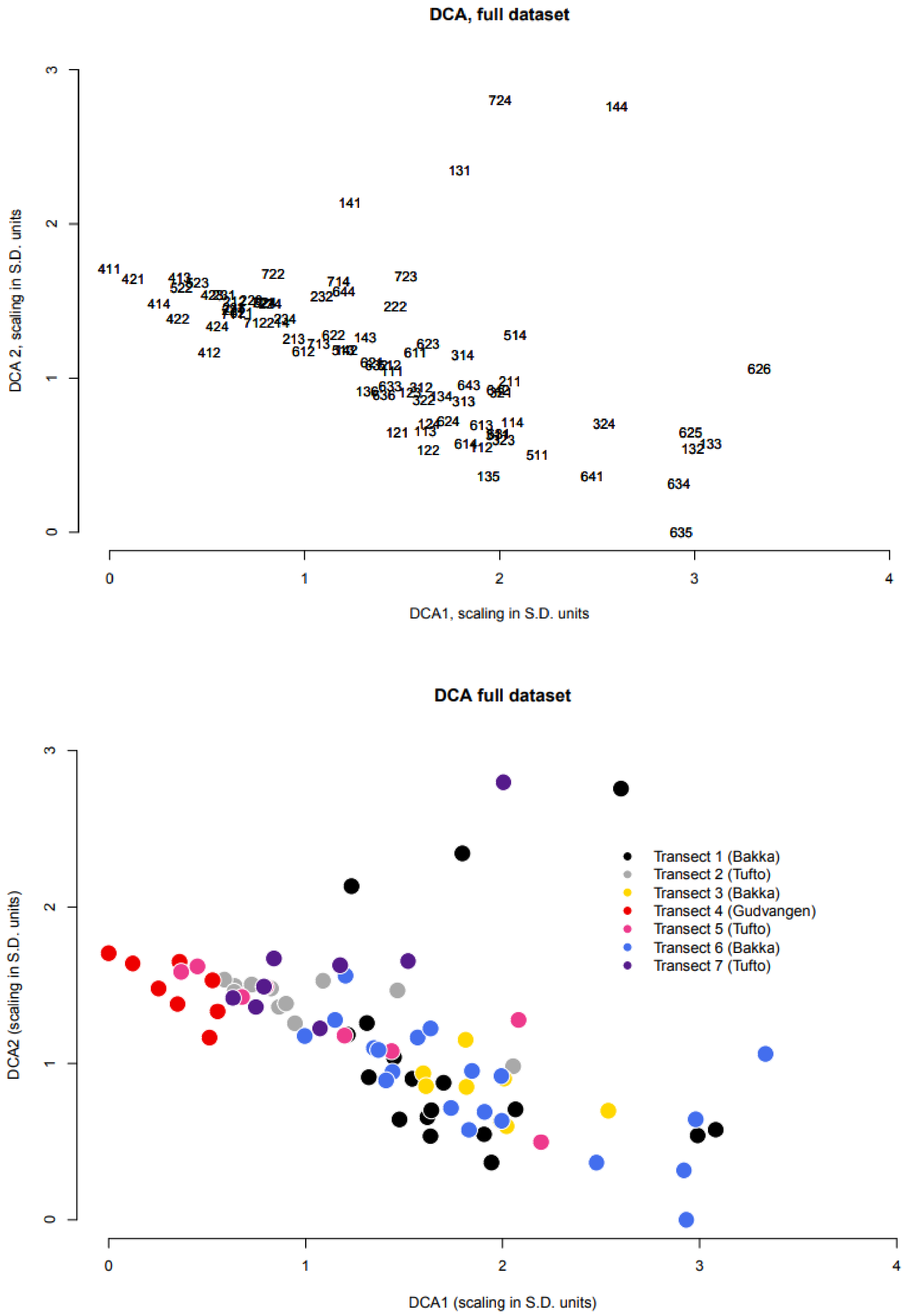

Figure 4.7. DCA ordination of full dataset. Plot positions represented as plot numbers (upper) and coloured dots (lower), each colour corresponding to a certain transect as shown in legend.

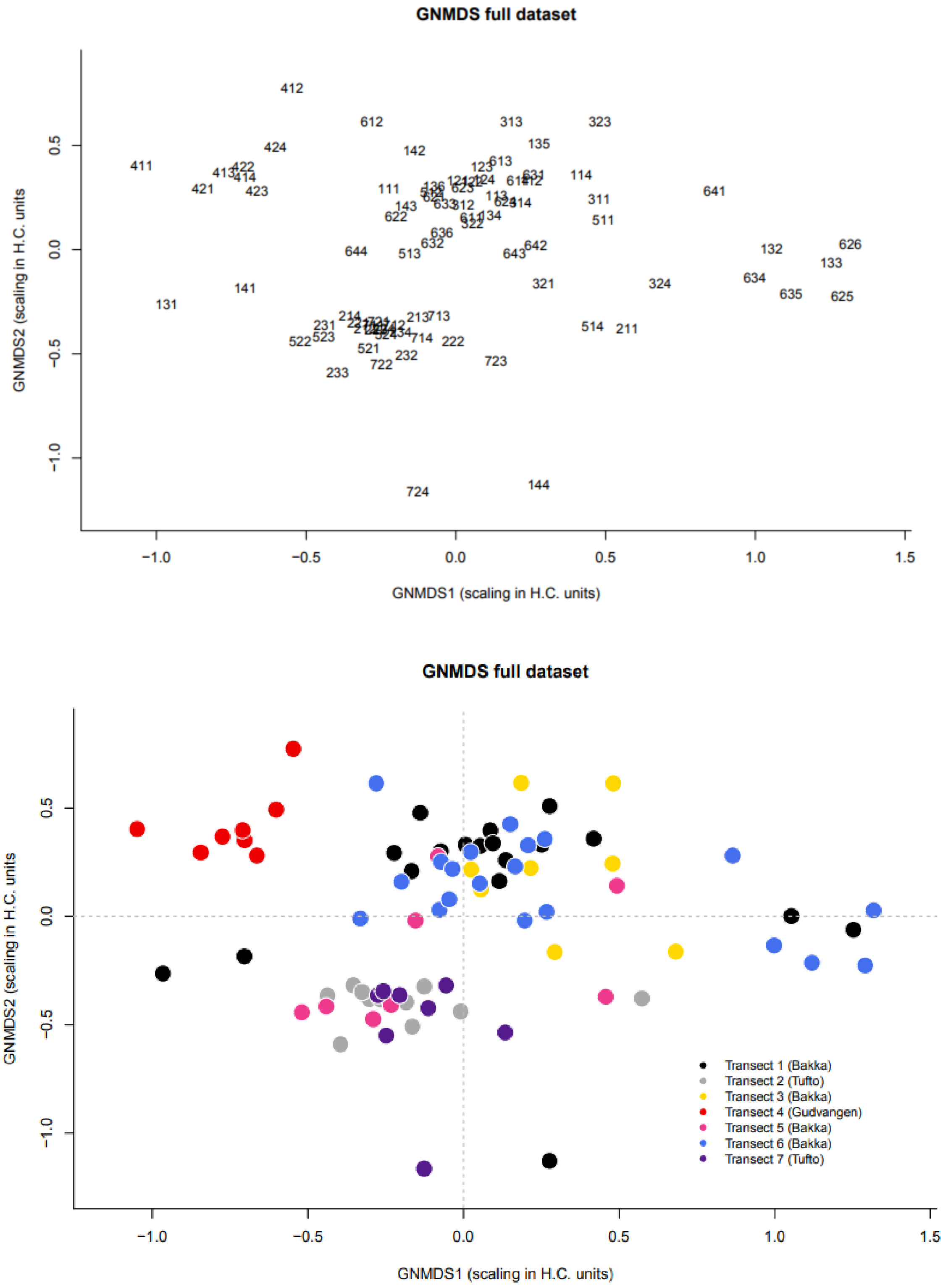

Figure 4.8. GNMDS ordination of full dataset. Plot positions represented as plot numbers (upper) and coloured dots (lower). Each colour corresponds to one transect, as shown in legend.

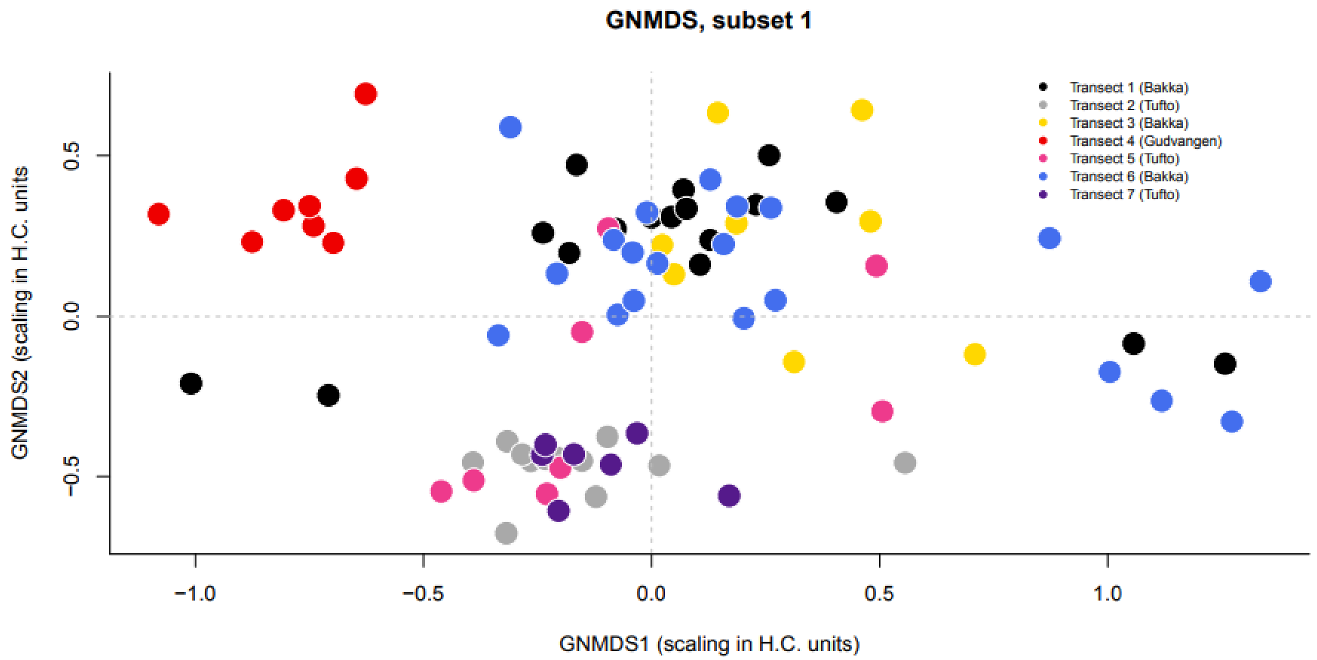

Figure 4.9. GNMDS ordination diagram for Subset 1. Plot positions represented as coloured dots, with each colour corresponding to one transect, as shown in legend.

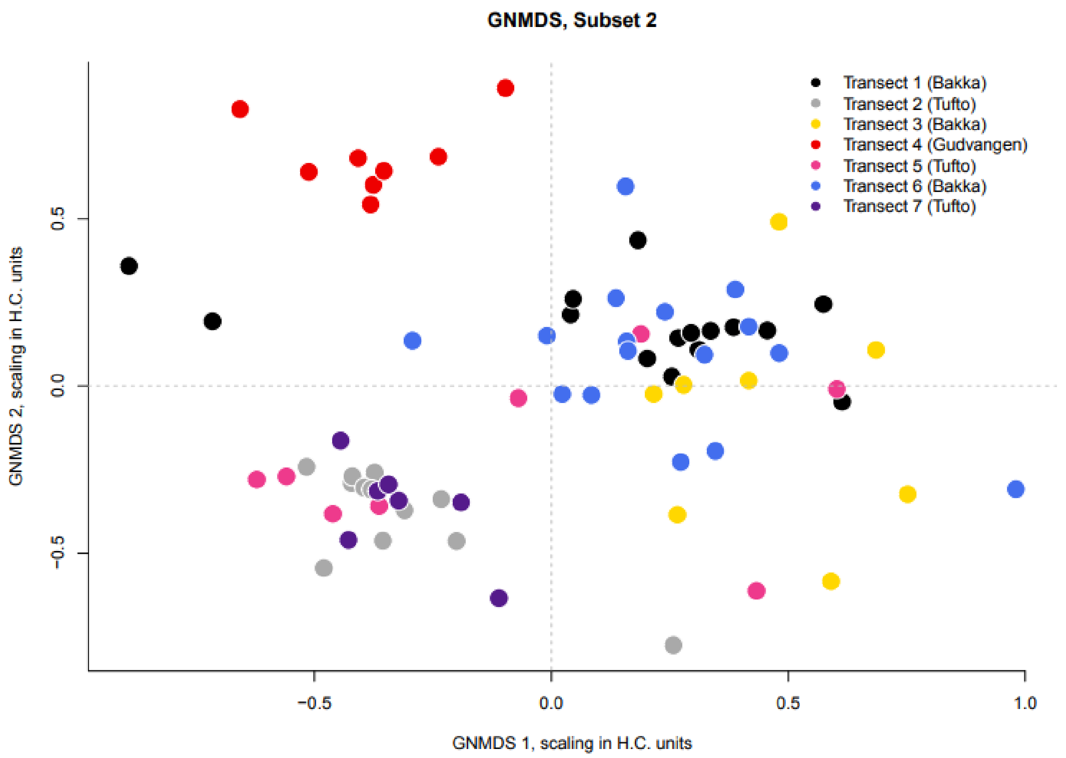

Figure 4.10. GNMDS ordination of Subset 2, where plots from spring-water influenced depressions and forest were removed. Plot positions represented as coloured dots, each colour corresponding to a certain transect, as shown in legend.

Some common structuring patterns were found in all ordinations. Plots from Transect 4 clustered together at high axis scores in GNMDS1 and GNMDS2, distinctly separated from the rest of the plots (Figure 4.8, 4.9 and 4.10). An assemblage of plots from forest were found at high scores on GNMDS axis 1. Another characteristic structure was the grouping of plots from Tufto (transects 2, 5 and 7) in the lower left part of the ordination diagrams, at low axis scores for GNMDS1 and GNMDS2. Two plots (144 and 724) were located in spring-water influenced depressions and appeared as weak outliers in ordination of the full dataset. While ordination of Subset 1 altered the structure in DCA, the plot positions remained more or less unchanged in GNMDS. Ordination of Subset 2 caused the plots to spread more out, but the main structure and plot positions along the axes were maintained in this ordination as well.

4.5 Correlations patterns

Some correlation patterns between the ordination axes and the explanatory variables were identified. Regarding the full dataset, GNMDS1 was positively correlated with GrainSize, LOI, MI and TotN, while it was negatively correlated with Slope, LR, Altitude, BareGround, Mineral, Position and ConvV (Table 4.7). Several variables showed strong negative correlations with GNMDS2, including pH, Slope, BareGround, Altitude, LR and Aspect. These correlation patterns also appeared in ordinations of Subset 1 and 2, where the same group of variables were negatively correlated to $GNMDS2^{sub1}$ and $GNMDS2^{sub2}$. Among the factor variables, Tree and Shrub were related to GNMDS1 and $GNMDS^{sub1}$ (Table 4.8). A biplot with plot positions from GNMDS ordination and vectors with maximum increase for the explanatory variables are shown in Figure 4.11. Only variables with significant correlations to the GNMDS-axes were included. Graphical visualizations of the most important variables are shown in Figure 4.12 – 4.16 with isolines (trend lines) for Altitude, pH, BareGround, LR and Slope plotted on GNMDS ordination of the full dataset.

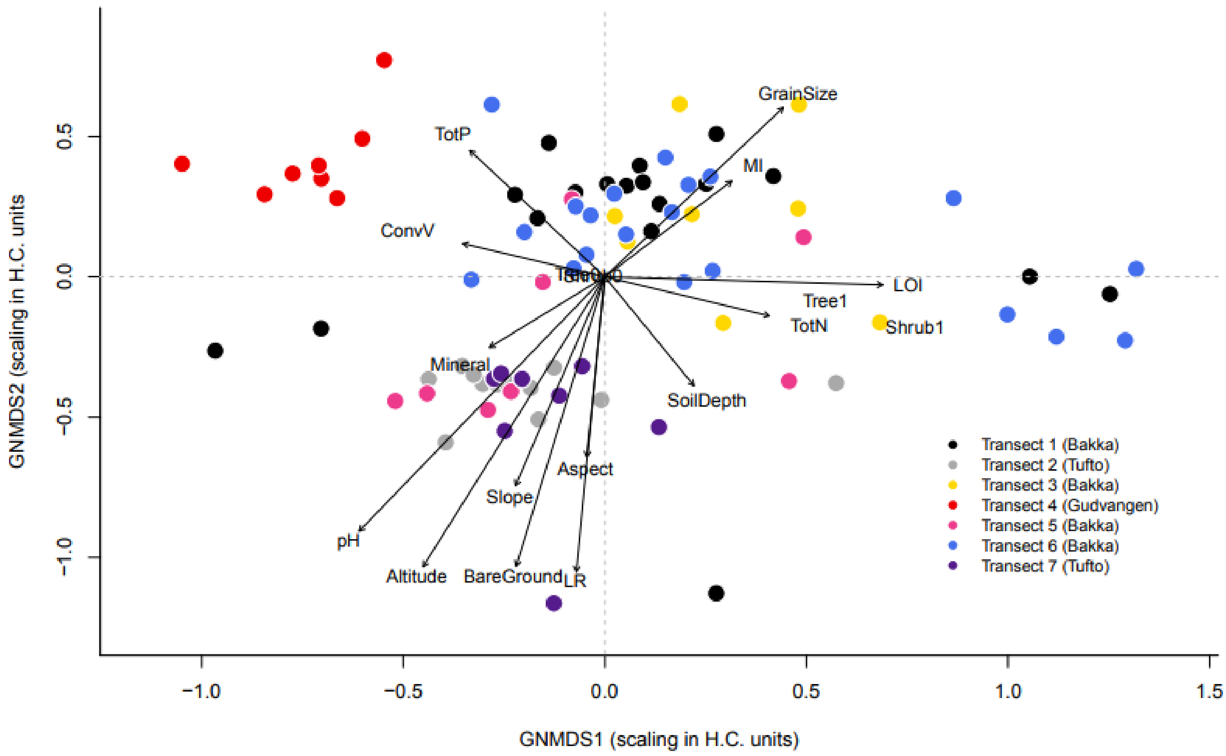

Figure 4.11. Biplot made with envfit-function in R, with vectors of maximum increase for continuous variables and optimum points for factor variables, fitted to plot positions from GNMDS ordination. Only a selection of significant variables is shown in the plot.

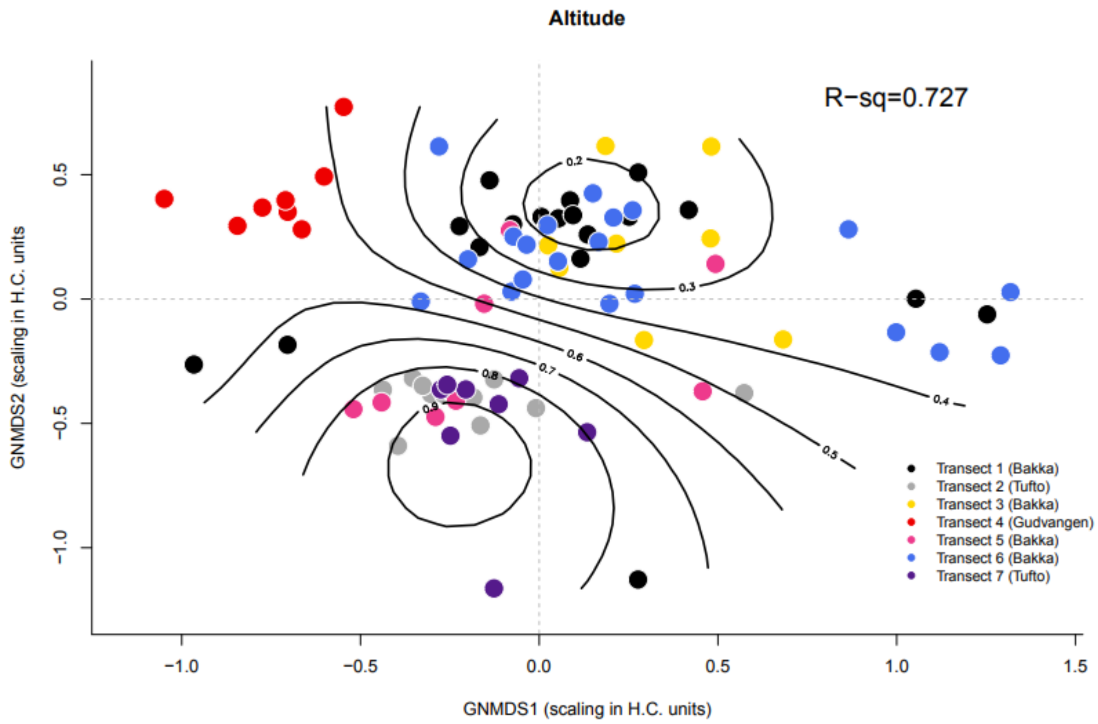

Figure 4.12. Isoline representations for Altitude. High values along the isolines indicate high altitude, increasing towards low axis-scores at GNMDS2.

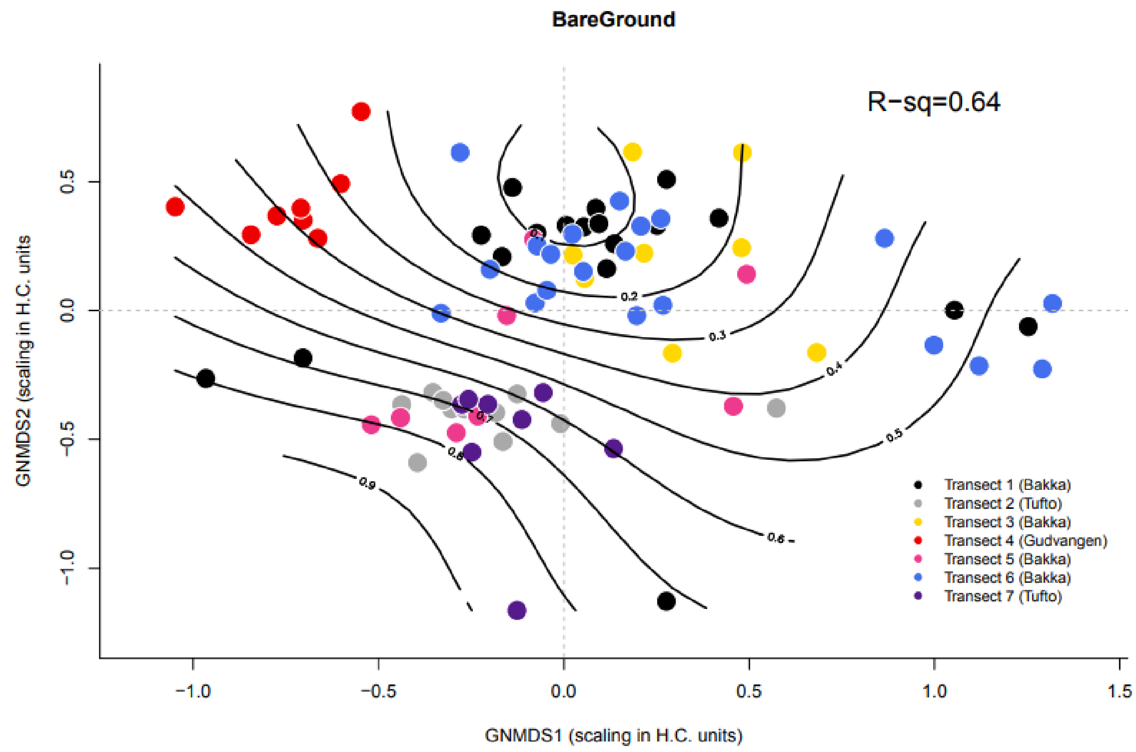

Figure 4.13. Isoline representation for the BareGround-variable. High values along the isolines indicate more bare ground in the plots, increasing towards low axis-scores at GNMDS1 and GNMDS2.

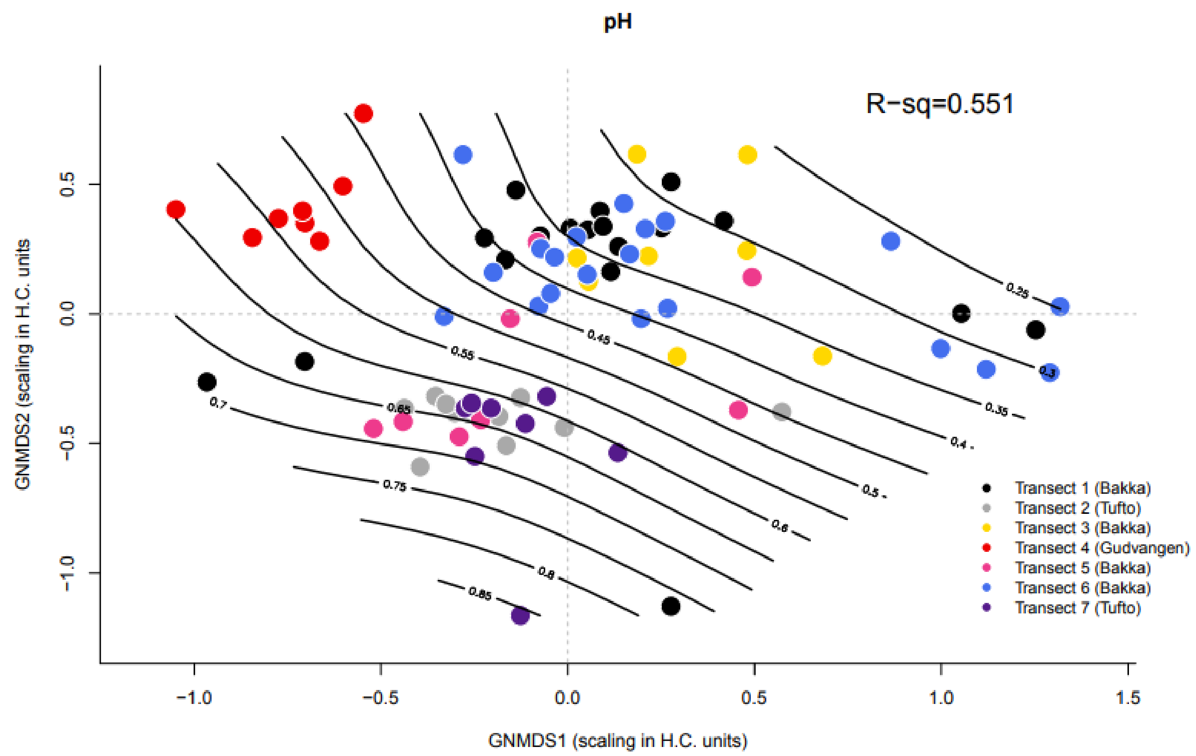

Figure 4.14. Isoline representation for the BareGround-variable. High values along the isolines indicate more bare ground in the plots, increasing towards low axis-scores at GNMDS2.

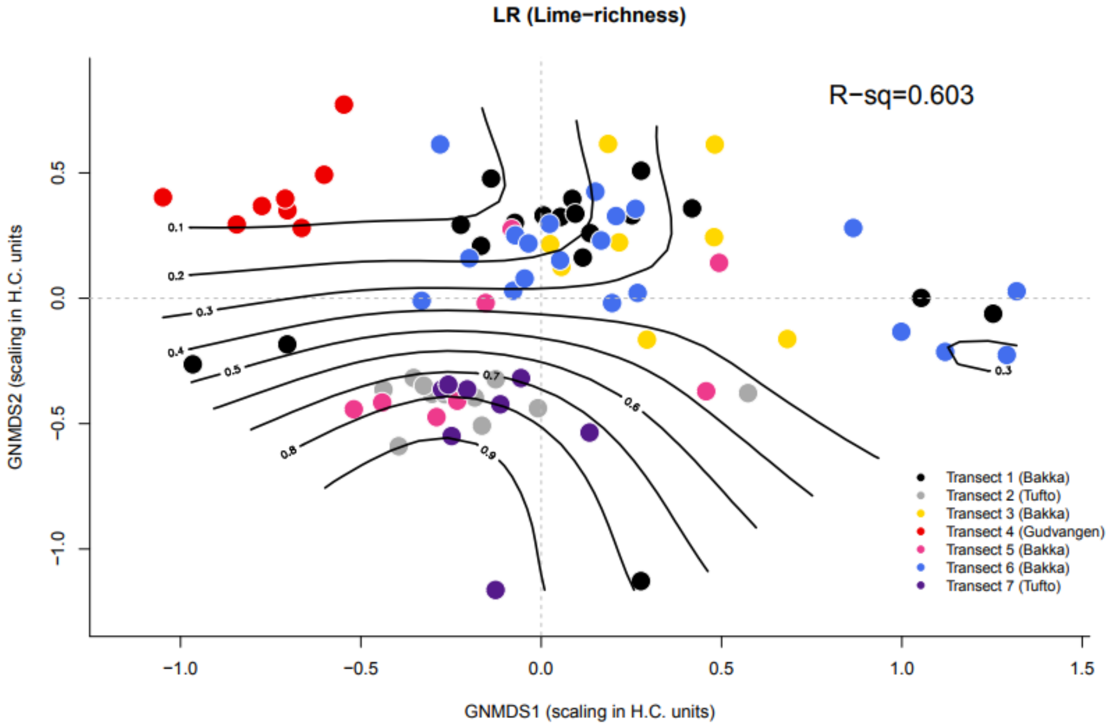

Figure 4.15. Isoline representation for lime richness (LR). High values along the isolines indicate higher values of LR in the plots, increasing towards low axis-scores at GNMDS2.

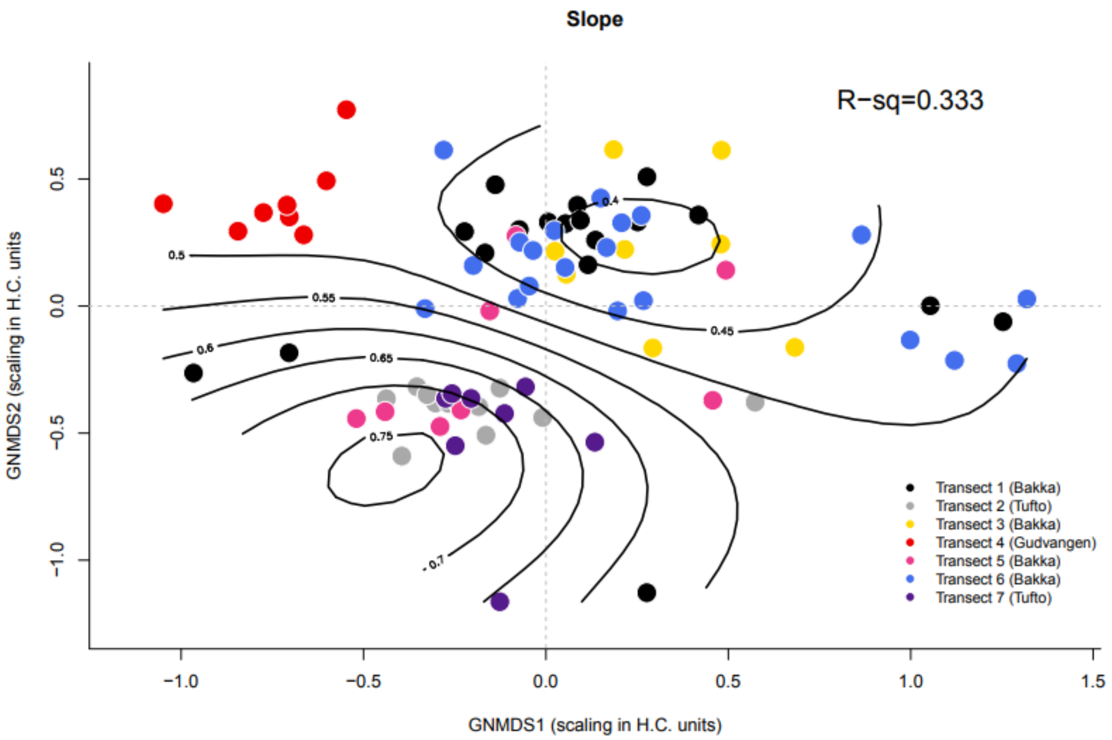

Figure 4.16. Isoline representation for the BareGround-variable. High values along the isolines indicate more bare ground in the plots, increasing towards low axis-scores at GNMDS1 and GNMDS2.

Table 4.7. Correlation coefficients between GNMDS-axes and continous explanatory variables for all three datasets. p-values <0.05 in bold.

	GNMDS1		GNMDS2		GNMDS1 sub1		GNMDS2 sub1		GNMDS1 sub2		GNMDS2 sub2	
	τ	p	τ	p	τ	p	τ	p	τ	p	τ	p
Aspect	-0.1094	0.1491	**-0.3046**	**<0.0001**	-0.0952	0.2153	**-0.3225**	**<0.0001**	**-0.1783**	**0.0256**	**-0.3454**	**<0.0001**
Slope	**-0.1651**	**0.0290**	**-0.3540**	**<0.0001**	**-0.1512**	**0.0484**	**-0.3796**	**<0.0001**	**-0.2947**	**0.0002**	**-0.2344**	**0.0033**
ConvH	-0.1389	0.0997	-0.0047	0.9547	-0.1360	0.1133	-0.0710	0.4088	-0.1760	0.0488	0.0055	0.9509
ConvV	**-0.2385**	**0.0058**	-0.0098	0.9098	**-0.2376**	**0.0070**	-0.0888	0.3130	**-0.2649**	**0.0039**	0.0249	0.7861
Rock	-0.0151	0.8441	0.1043	0.1737	-0.0243	0.7548	0.1238	0.1108	0.0034	0.9664	**0.1936**	**0.0168**
BareGround	**-0.2273**	**0.0049**	**-0.5293**	**<0.0001**	**-0.2190**	**0.0077**	**-0.5562**	**<0.0001**	**-0.5130**	**<0.0001**	**-0.3286**	**0.0001**
Mineral	**-0.1960**	**0.0126**	-0.0651	0.4071	**-0.2083**	**0.0090**	-0.0575	0.4705	**-0.2514**	**0.0025**	0.0501	0.5465
GrainSize	**0.3346**	**0.0001**	**0.2808**	**0.0012**	**0.3275**	**0.0002**	**0.2908**	**0.0004**	**0.4542**	**<0.0001**	0.0990	0.2788
FieldLayer	0.1390	0.0676	-0.1262	0.0970	0.1521	0.0677	-0.1278	0.0971	0.1072	0.1815	**-0.2887**	**0.0003**
BotLayer	-0.0426	0.5771	**0.2198**	**0.0040**	-0.0728	0.3469	**0.2172**	**0.0050**	0.0260	0.7470	**0.2816**	**0.0005**
SoilDepth	0.0910	0.2279	**-0.1842**	**0.0147**	0.1091	0.1540	**-0.1784**	**0.0197**	-0.0160	0.8410	**-0.1752**	**0.0279**
Altitude	**-0.2965**	**0.0001**	**-0.4900**	**<0.0001**	**-0.2815**	**0.0003**	**-0.5175**	**<0.0001**	**-0.4811**	**<0.0001**	**-0.3716**	**<0.0001**
pH	**-0.3749**	**<0.0001**	**-0.3670**	**<0.0001**	**-0.3775**	**<0.0001**	**-0.3463**	**<0.0001**	**-0.4627**	**<0.0001**	**-0.2522**	**0.0016**
LOI	**0.2681**	**0.0004**	-0.0283	0.7066	**0.2656**	**0.0005**	-0.0218	0.7744	**0.2233**	**0.0049**	**-0.1885**	**0.0175**
TotN	**0.2135**	**0.0045**	-0.0702	0.3508	**0.2317**	**0.0024**	-0.0703	0.3564	**0.1640**	**0.0387**	**-0.1729**	**0.0293**
TotP	-0.1273	0.0903	**0.1948**	**0.0096**	-0.1380	0.0701	**0.1994**	**0.0089**	-0.0241	0.7616	**0.2966**	**0.0002**
LR	-0.1155	0.1781	**-0.5971**	**<0.0001**	-0.1189	0.1738	**-0.5557**	**<0.0001**	-0.2996	**0.0010**	**-0.5293**	**<0.0001**
MI	**0.3059**	**0.0003**	0.1674	0.0502	**0.3197**	**0.0002**	0.1867	0.0310	**0.4304**	**<0.0001**	-0.0727	0.4197
Position	-0.2552	0.0024	**-0.2340**	**0.0053**	**-0.2635**	**0.0020**	**-0.0271**	**0.0271**	-0.2369	0.0074	**-0.2008**	**0.0231**

Table 4.8. Relationships between GNMDS-axes and factor variables for all three datasets, showing Wilcoxon test-statistic (w) and corresponding p-values. p <0.05 in bold.

	GNMDS1		GNMDS2		GNMDS1 sub1		GNMDS2 sub1		GNMDS1 sub2		GNMDS2 sub2	
	w	p	w	p	w	p	w	p	w	p	w	p
Shrub	221	**0.0118**	81	0.3608	215	**0.0122**	70	0.2545	116	0.1471	2.0	**0.0205**
Tree	489	**0.0176**	278	0.4583	480	**0.0148**	242	0.2410	102	0.3700	132	0.8577
Litter	253	0.0623	443	0.4793	244	0.0593	407	0.7060	166	**0.0372**	417	**0.0403**
DeadWood	545	0.2229	406	0.5939	535	0.1967	373	0.4187	286	0.9210	282	0.8686
Droppings	712	0.5899	777	0.2228	687	0.6013	748	0.2380	731	0.0609	559	0.8825
SD	531	0.5018	555	0.3333	518	0.4822	521	0.4588	507	0.2326	384	0.6242

4.6 Inclination maps

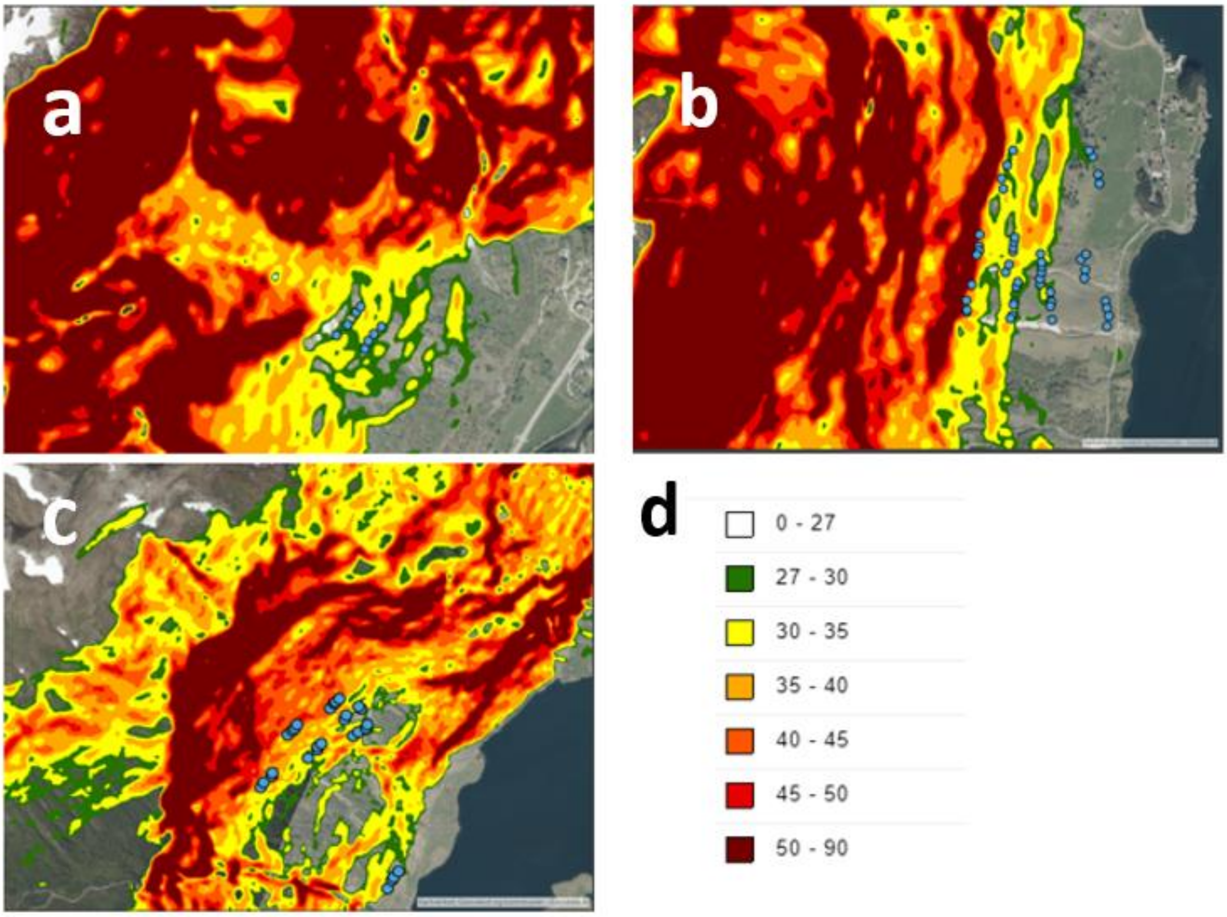

Figure 4.17. Inclination maps from NVE (https://temakart.nve.no/link/?link=bratthet, accessed 2/3-18) showing slope inclinations and plot positions in a) Gudvangen b) Bakka and c) Tufto. Colours on map corresponds to inclination-classes (measured in degrees) shown in d). Blue dots represent plot positions for all 82 plots.

Figure 4.17 shows inclination maps for the three transect-locations (Gudvangen, Bakka and Tufto). All plots were situated in sloping terrain. Plots in Gudvangen (Figure 4.17 a) were located below a channel with inclination ranging from 30 to 45^0, while plots at Bakka (Figure 4.17 b) were located in more gentle slopes, with the lowest plots situated in terrain with inclination $< 27^0$. Steeper terrain ($> 45^0$) dominated the area right above Bakka. At Tufto (Figure 4.17 c), most plots were located in terrain with a mean inclination between 30 and 40^0, while the inclinations above Tufto varied from 30^0 to $> 50^0$.

5 Discussion

5.1 Interpretation of ordinations

5.1.1 Evaluation of ordination methods

Overall, the similar structure and significant correlations between corresponding DCA and GNMDS axes indicate that both methods capture the same underlying structure. An exception is the second axes in ordination of the full dataset, which shows a slightly weaker correlation ($\tau = -0.36$). Some structural differences were observed between DCA ordinations of the three different datasets, indicating that DCA was more affected by outlier-plots than GNMDS.

Because of the distinct tongue-distortion in all DCA ordinations, I used GNMDS as the basis for interpretation and discussion. The tongue-distortion in DCA (Minchin, 1987), seen as a flattening plot-pattern along second axis, is a direct result of the detrending procedure, in which the mean plot scores of segments along the first axis are set equal to the general mean score along the second axis (Økland, 1990). More variation along the second axis close to one end of axis 1 is often a real structure of the data. Because of the detrending procedure, the DCA axis is distorted and does not provide a correct representation of how the sites on the tongue are related to other sites (Økland, 1990; van Son & Halvorsen, 2014).

5.1.2 Identification of gradients and ecological interpretation

Based on similar patterns and strong correlations found in all ordinations, two distinct gradients are identified. This pattern clearly points to an underlying structure in the dataset, strongly associated with some of the recorded explanatory variables.

1) Main gradient: from open meadows to woodland

The main coenocline, represented by GNMDS1 in the ordination of the full dataset, expresses the variation from plots in open meadows towards woodland. Moving from low to high scores along GNMDS1, this gradient is related to increasing organic matter (LOI), more trees and shrubs. Total nitrogen (TotN) is also positively correlated with GNMDS1, increasing towards woodland plots. In a study of active and inactive avalanche tracks in Switzerland, Rixen et al. (2007) found that species associated with high nitrogen values were found in the least disturbed areas, and that a decrease in disturbance led to dominance of more competitive species. This seems to coincide with the observed pattern in Nærøyfjorden, where plots located in woodland were considered less impacted by avalanches based on inclination maps and historical information on avalanche activity, and also contained higher values for total nitrogen compared to plots located in open meadows. *Filipendula ulmaria* and *Urtica dioica* are examples of nitrophilous species found in these plots, while some typical forest species found in the plots include *Alnus incana, Impatiens noli-tangere, Oxalis acetosella, Rubus idaeus, Barbilophozia spp.* and *Pleurozium schreberi.*

The main gradient along GNMDS1 is maintained in ordination of Subset 2, in which plots from woodland were removed. This can be explained by some plots situated at woodland edges, containing some of the same species as the woodland plots and structured by the same explanatory variables (LOI, Tree, Shrub and TotN). However, quite few species from these plots are considered as typical forest species, and the woodland is apparently a meadow in a late regrowth-successional stage. *Achillea millefolium, Agrostis capillaris, Anthoxanthum odoratum, Campanula rotundifolia, Festuca ovina* and *Pimpinella saxifraga* are species associated with regrowth (Bratli & Halvorsen, 2014), with high abundancies. This implies that the variation captured by the main gradient is not necessarily related to the variation from open meadows to woodland, but rather related to regrowth succession and therefore applies to open meadows as well.

Second gradient: disturbance gradient

The second gradient is related to variation in nutrients, aspect, altitude, slope, grain size and management intensity. Management intensity (MI) is positively correlated with GNMDS1 and GNMDS2. Plots from low altitudes at Bakka were positioned at high scores of the second axis (upper, right part in Figure 4.8), and the observed increase in MI along this axis indicates that lowland areas have been more intensively used for agricultural purposes than areas at higher altitudes, since these plots are located closer to the farm and infields. GrainSize is also increasing along GNMDS 2. This is simply explained by sorting of deposit material because of gravity, with coarse deposit material (rocks and blocks) found in plots located at the lowest altitudes at Bakka, while more fine-grained deposits are found in plots located at higher altitudes at Tufto.

pH, Aspect, BareGround, Slope, Mineral and Altitude increase towards low scores along GNMDS1 and GNMDS2, where plots from Tufto were positioned. This shows that plots from Tufto were generally located in richer and steeper terrain at higher altitudes, and in more favourable aspect. I interpret this pattern as a disturbance gradient and assume that the mentioned variables can be part of a complex gradient related to avalanche impact. Snow avalanches are agents for transport and deposition of debris that can influence the soil characteristics (Smith, 1973; Bell et al., 1990; Freppaz et al., 2010). The distinct increase in pH towards plots at Tufto is probably a result of erosion and weathering of the bedrock, causing nutrients to be released and altered soil chemistry in the deposition zone. Several calciole plant species are found in this area, e.g. *Clinopodium vulgare, Galium boreale, Galium verum* and *Origanum vulgare* (Lid & Lid, 2005). High values for BareGround and Mineral in plots at Tufto can also be related to avalanche impact, as strong erosive forces from avalanches can create patches of bare ground, while high values of Mineral are linked to transport and deposition of debris material (Freppaz et al., 2010). Some species associated with bare ground are also found, e.g. *Linaria vulgaris, Sedum acre, Viola tricolor* and *Pogonatum urnigerum*. According to the negative correlation between Aspect and GNMDS2, the most favourable aspects were found at Tufto, with slopes facing south and south-east. Aspect is important for avalanche activity because solar radiation affects the stability and properties of the snow (McClung & Schaerer, 2006). Intense solar radiation can weaken the snow layers, and south-facing slopes are therefore highly exposed to snow avalanches in the spring (McClung & Schaerer, 2006).

Other possible gradients

In addition to the two distinct gradients, some weaker patterns and gradients were identified. Total phosphorous (TotP) was positively correlated with GNMDS2 and negatively correlated with GNMDS1, increasing towards plots from Transect 4 in Gudvangen (Figure 4.8). The generally accepted view is that low levels of phosphorous are associated with high species richness in grasslands (Janssens et al., 1998; Austrheim et al., 1999). This corresponds to the observed pattern in Nærøyfjorden, where plots from Gudvangen with high P-levels were considerably less species-rich than plots from Tufto (Figure 4.3). Akhzari & Pessarakli (2016) argue that levels of phosphorous may flux with slope aspect and grazing, a pattern recognized by Gong et al. (2007) as well. In these studies, higher values of available phosphorous were found in exclosure sites facing north compared to grazed sites located at southern aspects, which is consistent with the observed pattern in Nærøyfjorden. Transect 4 in Gudvangen was the only transect

where management (including grazing) was abandoned, with most plots facing north-east and east. However, soil samples from Nærøyfjorden were analysed for total phosphorous, which might differ from available phosphorous.

Even though several variables were significantly correlated with the ordination axes, some of them showed quite low τ-values (<0.3). Among the 25 recorded variables, some did not seem to explain much of the observed variation, for instance Litter and Rock. There is also a chance that some important explanatory variables are lacking in this analysis, potentially explaining a lot of the underlying structure, for instance soil carbon, distance to farm or length of snow cover. Additionally, some of the variation can be a result of randomness.

5.2 Assessment of avalanche terrain

How is the identified disturbance gradient related to the avalanche assessment and historical information on snow avalanches? According to the inclination maps from NVE (2018) (Figure 4.17), all transects contained terrain with sufficient inclination for starting zones for snow avalanches. However, the areas above the transects are of greatest interest because the impact from avalanches will be stronger for avalanches with long vertical falls and more energy (Schaerer, 1972; McClung & Schaerer, 2006). The most ideal conditions for starting zones are found above the transects at Tufto, below Rimstigfjellet and Breiskredosi (from 900 to 1200 m.a.s.l., see Figure 2.2), with an average inclination between 30 and 40°. Avalanches starting from this area can probably follow several paths, with a high possibility of passing transects 2, 5 and 7 at Tufto. Frequent avalanche activity in this area is confirmed by Ohnstad (2006) and land owners. A severe avalanche passed Tufto in March 2017 (O. Stalheim, pers. comm., 2017), three months before field work was conducted. This avalanche caused large damage by breaking and bending trees, and also disrupted the vegetation cover (Figure 4.1 and 4.2). High avalanche activity at Tufto is therefore consistent with the suggested disturbance gradient.

With an average inclination > 50°, the areas above the transects at Bakka are considered too steep for large snowpack to accumulate. Hence, the risk of large avalanches is probably smaller compared to transects at Tufto. Still, there are avalanches sprinkling over the steep rock face above the transects. In 2002, a dry snow avalanche passed the hillsides south of the farm at Bakka, starting from the mountain Bakkanosi (Ohnstad, 2006, see Figure 2.2). Despite a small amount of snow, the long vertical fall and associated windblast caused severe damage and breakage of tree stems. The aerial photograph from 1971 (Figure 4.5) shows a tree-covered area at the bottom of Transect 6, while no traces of these trees were observed during field work in 2017. This observation clearly indicates that single avalanche events can have huge impact on vegetation, and that avalanche intensity can be more important than the frequency, a theory supported by other studies as well (Smith, 1973; Malanson & Butler, 1984). However, my consideration is that avalanche impact is generally less important in the meadows at Bakka compared to Tufto, and that management intensity has more influence on the vegetation at Bakka.

A channel with appropriate inclination for starting zones (35 – 40º) is located right above Transect 4 in Gudvangen. The adjacent areas are dominated by coarse scree, indicating strong influence by geohazards in the transect area. Schaerer (1972) describes gullies and channels as characteristic avalanche terrain, usually with no well-defined starting zone. Channels and gullies are associated with frequent and small avalanches, most often wet snow avalanches with low velocity following the terrain contours (Schaerer, 1972). However, little historical information on avalanches was obtained from this area. According to the observed terrain characteristics, repeated avalanche activity is expected to impact the vegetation to some extent. The orthophoto from 2013 shows more woodland compared to 1971 (Figure 4.4), indicating that the area is in a regrowth-succession.

Even though terrain characteristics and inclination are important factors for avalanche terrain, estimation of avalanche risk is a complex subject depending on a range of conditions (Schaerer, 1972). This includes climatic factors, e.g. temperature, snow fall and exposure to sun and wind, in addition to vegetation cover and terrain ruggedness (Schaerer, 1972; Smith, 1973; McClung & Schaerer, 2006). More detailed data on avalanche activity in Nærøyfjorden would have improved this study. If information on avalanche frequency and intensity was available, the analysis could have been designed to cover variation in species composition along the different zonations of the avalanche tracks, for instance from the most disturbed, erosional zone to undisturbed areas at the forest-edges, as described by Brücker (1981) and Erschbamer (1989).

5.3 The impact of avalanches on vegetation

5.3.1 High diversity in avalanche paths

In this study, the most avalanche-impacted area (Tufto) showed the highest number of species per plot. This observation is consistent with other studies of avalanche-impacted vegetation. A wide range of ecological niches are found in avalanche paths, indicating that intermediate or high levels of disturbance by avalanches contribute to habitat heterogeneity and increased species richness (Fox, 1981; Erschbamer, 1989; Rixen & Brugger, 2004; Rixen et al., 2007; Fischer et al., 2012). This increase can be a result of fragmented vegetation, in which open habitats are created in otherwise closed forest, causing open space and more favourable light conditions (Fischer et al., 2012). Rixen et al. (2007) found that the number of species was higher in active and inactive avalanche tracks compared to the adjacent undisturbed forest, while Fischer et. al. (2012) suggest that avalanches enhance the diversity by initiating a range of different successional pathways. Additionally, avalanches can influence soil conditions by erosion and debris deposits, and thus create new microhabitats with more available nutrients (Smith, 1973; Freppaz et al., 2010).

Kulakowski et al. (2010) emphasize a three-way interaction between land use, climate change and natural disturbances. Abandonment of agricultural land is a global trend (Emanuelsson, 2009), causing conversion from semi-natural meadows and pastures into forest (Johansson et al., 2008; Hamre et al., 2010). Increased temperatures cause tree- and forest lines to move upwards, a trend observed both in Scandinavia (Aas, 1969; Kullman & Öberg, 2009) and on a global scale (Harsch et al., 2009). Increased tree cover is known to suppress avalanche activity (Breien & Høydal, 2012). Even though the historical aerial photographs from Nærøyfjorden (Figure 4.4, 4.5 and 4.6) show that woodland cover has generally increased, a decrease is also observed in some areas. These observations indicate that avalanches can be strong enough to cause disruptive changes in woodlands and create open paths, and thus contribute to enhanced diversity.

5.3.2 Stress or disturbance?

Accumulation of snow from frequent or large avalanches can lead to long-lasting snow cover and short growing seasons (Malanson & Butler, 1984). Thus, the topography in avalanche paths is crucial, as terrain depressions can accumulate more snow and hold the longest snow cover. Malanson & Butler (1984) argue that snow burial by avalanches is the more important factor, and that magnitude and frequency of avalanche events do not directly control the vegetational patterns in avalanche paths. It has therefore been suggested that the effect from avalanches varies between stress and disturbance, depending on the intensity (Malanson & Butler, 1984; Erschbamer, 1989). According to the definitions of stress and disturbance by Grime (1979), several environmental events can stress some species and disturb others. Species composition in avalanche paths with long-lasting snow cover can possibly be associated with species composition in snowbeds (Erschbamer, 1989; Ytrehorn, 1996). Following Grime's triangle of plant strategies (Grime, 1979), stress-tolerators will be favoured in such areas. Few species found in the meadows along Nærøyfjorden were associated with snowbeds. Even though it might contribute to small-scale variations, I consider reduced growth season due to long-lasting snow cover as a minor factor in Nærøyfjorden. The investigated meadows were located at low altitudes (41 – 401 m.a.s.l.), and avalanche meadows with snowbed character are more likely to be found at higher altitudes.

5.4 Comparison with other studies of avalanche-impacted meadows

It is not easy to conclude whether the observed species composition of avalanche-impacted meadows along Nærøyfjorden is typical for avalanche meadows or not. Most studies on avalanche-impacted vegetation are carried out in North-America (Smith, 1973; Malanson & Butler, 1984) and in the European Alps (Erschbamer, 1989; Rixen & Brugger, 2004; Rixen et al., 2007). The most recent and relevant study from Norway is done by Ytrehorn (1996) who studied avalanche terrain in Grasdalen (Stryn, Sogn og Fjordane). A similarity between the studies from Grasdalen and Nærøyfjorden is the importance of organic matter, related to the main ordination gradients in both studies. Except for this, little resemblance was found in the observed vegetation patterns in Grasdalen and Nærøyfjorden, probably because the meadows in Grasdalen were located at higher altitudes (613 – 929 m.a.s.l.). Ytrehorn found that the species composition was more similar to snowbeds than semi-natural grasslands, with high occurrence of e.g. *Salix herbacea*, *Cerastium cerastoides, Cryptogramma crispa, Omalotheca supina* and *Sibbaldia procumbens*. Ytrehorn (1996) concluded that avalanche frequency and length of snow cover were important variables, and his findings thus support the theory of avalanches acting as stress on plants (Malanson & Butler, 1984; Erschbamer, 1989).

Nordhagen (1943) made a detailed description of plant communities based on observations from Sikilsdalen, central Norway. Among numerous plant communities, three avalanche-associated communities were distinguished based on the following bedrock features; 1) extremely lime-poor and hard bedrocks, e.g. gneiss, 2) nutrient-rich, lime-poor or slightly lime-rich bedrocks, e.g. amphibolite, gabbro and phyllites, and 3) lime-rich bedrocks, dolomite and mica. According to this description, meadows along Nærøyfjorden belong to the second category, with bedrock dominated by amphibolite and gabbro and an average pH-value of 5.3. Nordhagen describes this intermediate-rich, avalanche community as "an interesting vegetation and flora which is hard to classify because of the combination of species from lowland, subalpine and alpine regions". Several abundant species from meadows in Nærøyfjorden are listed as characterising species in the avalanche-associated community described by Nordhagen, including *Anthoxanthum odoratum, Campanula rotundifolia, Convallaria majalis, Fragaria vesca, Geranium sylvaticum, Origanum vulgare, Rumex acetosella, Poa nemoralis, Ranunculus acris, Silene dioica, Solidago virgaurea, Valeriana sambucifolia, Verbascum nigrum* and *Veronica fruticans*.

Where do the semi-natural species come from?

Overall, the species composition from the open meadows along Nærøyfjorden reflects the land use in the study area, where grazing and mowing have influenced the meadows throughout centuries. The landscape we see today contains elements from different periods (Ihse, 1995), and it has been argued that land use history as far back as 200 years is important for predicting species composition and species richness in semi-natural grasslands (Austrheim & Olsson, 1999, Johansson et al., 2008). Even though species associated with several habitats occurred, the investigated meadows were generally dominated by species associated with typical semi-natural grasslands, e.g. *Agrostis capillaris*, *Achillea millefolium*, *Alchemilla*-species, *Lotus corniculatus*, *Plantago lanceolata, Ranunculus acris, Trifolium pratense, Trifolium repens, Knautia arvensis* and *Parnassia palustris*. Agriculture has influenced the European fauna and flora for at least five thousand years (Emanuelsson, 2009), but what is the origin of semi-natural species, and what characterised the European landscapes before agriculture was introduced? Questions related to "the open land problem" have been discussed for a long time, yet without any simple answer (Emanuelsson, 2009). Apparently, avalanches have impacted the vegetation along Nærøyfjorden longer than traditional agricultural management. The appearance of several typical semi-natural species in avalanche terrain therefore supports a theory of semi-natural species originating from naturally open systems, for instance avalanche paths and scree slopes. This is also the most traditional explanation (Emanuelsson, 2009). Erschbamer (1989) reported that avalanches may transport seeds or other propagules from higher altitudes, and that plants from alpine areas can establish at lower elevations if they get sufficient space. Thus, disturbance from grazing and mowing may have contributed to keep avalanche paths open, maintain favourable growing conditions for small alpine species and reduce competition from denser and taller vegetation (Rixen et al., 2007). Except for *Veronica fruticans*, few alpine species were found in Nærøyfjorden, but this might be a difference between avalanche meadows located at high and low altitudes.

5.5 Implications for NiN

Based on the observed vegetational pattern in Nærøyfjorden, it is challenging to draw a line between avalanche meadows (T16) and semi-natural grasslands (T32), especially in the most avalanche-impacted areas at Tufto where both avalanches and management impact the vegetation to great extent. There is no basic type in NiN comprising a combination of the LCEs avalanche impact (AI) and management intensity (MI). Management intensity is included as a subordinate LCE in T16 (including basic step a – distinctly impacted by grazing), while avalanche impact is not implemented T32 (Halvorsen, 2016). The criteria for creating a major type in NiN is that the type can be identified by a unique combination of LCEs, specific differentiating LCEs and a distinct species composition with a minimum of one ecological distance unit (EDU) from other major types (Halvorsen et al., 2016b). Future versions of NiN should recognize the gradual variation from semi-natural grasslands to avalanche meadows by implementing avalanche impact as a subordinate LCE in T32 and keep management intensity as a subordinate LCE in T16, as the border between the two major types should be drawn somewhere in the midway of a typical semi-natural grassland and a typical avalanche meadow. The challenge is to identify the shift between avalanche impact and management intensity as dominating processes, and to find out where the distinction between T16 and T32 should be placed along the species compositional gradient. While the variation in species composition along management intensity (MI) is fully elaborated with generalized species lists (Halvorsen et al., 2016a), increased understanding of avalanche impact (AI) is required to partition the variation in species composition along this LCE.

5.6 Future studies

More research is needed to examine whether the variation in species composition in avalanche meadows is sufficient to constitute basic types in NiN, and to gain understanding of how the meadows differ from semi-natural grasslands. Studies should be conducted in areas with various management intensity and avalanche impact. Detailed information on avalanche activity is crucial, including data on frequency, intensity and length of snow cover. Snow avalanches generate low-frequency infrasonic waves that can be used to monitor avalanche activity (Naugolnykh & Bedard, 2002; Ulivieri et al., 2011). During the last two decades, infrasound detection of avalanches has been developed and highly improved (Ulivieri et al., 2011). “Infrasound detection of avalanches”, abbreviated IDA, is implemented in Norway by The Norwegian Public Roads Administration. So far, the system is installed in Grasdalen (Stryn), Indreeidsdalen (Norddal) and Kattjordeidet (Tromsø) (Humstad et al., 2016; Lunde et al., 2017). Hence, it would be beneficial to study avalanche-impacted vegetation in areas where such information on avalanche activity is available. This invites to interdisciplinary cooperation between biologists and geologists, with long-term studies in areas with varying avalanche frequencies and intensities.

Malanson & Butler (1984) suggest that magnitude and frequency of avalanche events do not directly control the vegetational patterns in avalanche paths, and that the observed patterns rather are a result of avalanche-related stress, a view which is supported by other studies as well (Erschbamer, 1989; Ytrehorn, 1996). Thus, the importance of reduced growth season due to snow cover should be further investigated. Erschbamer (1989) argues that the impact from avalanches on vegetation strongly depends on local topography and geomorphology, and that it is difficult to transfer results of one region to another. This study emphasizes the distinction from semi-natural grasslands. However, avalanche meadows in mountain regions probably share character with mountain heaths (T3 in NiN). Analyses of avalanche meadows should therefore be conducted both in mountain areas and subalpine areas in order to observe different types of avalanche meadows and how they differ from adjacent vegetation.

6 Conclusions

Two distinct gradients were identified in the investigated meadows in Nærøyfjorden. The main gradient was related to regrowth succession, moving from open meadows to woodland, while the second gradient was related to disturbance by snow avalanches, with increased pH, larger patches of bare ground, steeper inclination and southern aspect. Additionally, some weaker patterns were identified, including a gradient related to phosphorous.

The study indicates that strong erosive forces associated with snow avalanches can cause abrupt changes in forest and woodland structure by creating open paths. Additionally, avalanches can transport and deposit debris material, and thus change the soil chemistry and create microhabitats with favourable conditions and increased species-richness. However, the observed species composition in this study clearly reflects the land use with traditional management throughout centuries.

Based on the observed species composition in the investigated meadows, this study supports the traditional view that semi-natural grasslands species have their origin in other naturally open systems, e.g. avalanche meadows and scree slopes.

A gradual transition between avalanche meadows and semi-natural grasslands was recognized, supporting the general assumption that it is challenging to draw a line between the two major types from NiN. For future versions of NiN, this study suggests implementing avalanche impact (AI) as a subordinate local complex environmental gradient (LCE) in semi-natural grasslands. More research is needed to characterise the variation along the avalanche impact-gradient, and detailed information on avalanche activity is crucial to obtain trustworthy assessments. This could be facilitated by interdisciplinary cooperation between biologists and geologists.

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Appendices

Appendix 1.

Translations of NiN-terms used in this master thesis. For further details, see Halvorsen (2012) and Halvorsen et al. (2016).

Norwegian terms	English translations
T4 – Skogsmark	T4 – Forest
T 16 – Rasmarkeng- og hei	T 16 – Avalanche meadow
T 32 – Semi-naturlig eng	T32 – Semi-natural grasslands
Tresatt areal	Woodland
Rasutsatthet (RU)	Avalanche impact (AI)
Uttørkingsfare (UF)	Risk of severe drought (SD)
Kalkinnhold (KA)	Lime richness (LR)
Hovudtypegruppe	Major type group
Hovudtype	Major type
Grunntype	Basic type
Landskapstype	Landscape type
Natursystem	Ecosystem level
Livsmedium	Microhabitat
LKM – lokal kompleks miljøvariabel	LCE – local complex environmental variable
Økologisk avstandsenhet (ØAE)	Ecological distance unit (EDU)
Basistrinn	Basic step

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Appendix 2. Rules for selection of transects, transverse lines and plots.

Vertical transects:

- All transects was placed on talus slopes. Regarding the NiN-system, the transects were placed to cover the gradual variation from T16 to T32, and also include some areas with woodland.

Transverse lines:

- Bottom line was located 20 meters above a defined starting point (e.g. the road, or above inaccessible terrain), while the top line was placed 20 meters below a rock face or other inaccessible terrain.
- Each transverse line spanned 100 meters, 50 meters to each side from the reference point (= the middle of vertical transect).
- Maximum 2 transverse lines in a row located in woodland
- If the whole transect was placed in woodland: 2 plots, one located at -25 and one at +25, measured from the reference point in the middle of the transect.

Plots:

- Absolute rule: ≥ 8 meters between the outer corners of the plots.
- If woodland occurred inside the transverse line, a special rule was applied. Starting at the woodland edge, one plot was placed 5 meters inside the forest, and another plot 5 meter on the open meadow side.
- For transverse lines in open meadows: plot positions were based on topography. All top points, bottom points and inflexion points to the north and to the south were identified.
- Priority of candidates: 1) Top points 2) bottom points 3) Inflexion points. If there were several candidates for a certain position (e.g. three top points), and only one candidate for another position (e.g. one bottom point), the position with only one candidate was prioritized.

- If the inflexion points were positioned closer than 8 meters, the depression between them was considered too small, and inflexion points were left out.

- For transverse lines with minor topography, four random plot positions numbers were generated (4 plots).

- Plots placed in the following major types were rejected: T1 (bare rock), T4 (forest that was not located at talus slopes) T13 (scree slope) T17 (active scree slope).

Appendix 3. Details on the standardised recording of explanatory variables.

Variabel	**Abbreviation**	**Description**
Aspect	Aspect	Aspect were measured from the middle of a plot, facing towards the dominant aspect. A Silva express 360 ^{0} C compass was used, and the values were recalculated to 0-180 ^{0} afterwards (further description in Methods chapter 2.2.3)
Altitude	Altitude	Altitude was measured for each transversal line in meters above sea level. A Garmin eTrex 30x was used.
Animal droppings	Droppings	Frequency of animal droppings in 64 small plots (each of the 16 subplots divided into four). Because of transformation problems due to high number of zeroe-values, it was treated as presence/absence of droppings in the entire plot.
Bare ground	BareGround	Percentage cover of bare ground in each plot.
Bottom layer	BotLayer	Percentage cover of mosses (bryophytes).
Convexity (horizontal)	ConvH	To cover microtopography in the plot, a convexity scale from -2 → +2 was used. -2 corresponds to strongly concave topography, while +2 corresponds to strongly convex topography. Applied for the horizontal direction (transverse in the plot)
Convexity (vertical)	ConvV	The same scale as Convexity (horizontal) (from -2 → +2), applied for the vertical direction of the plot.
Grain size	GrainSize	Dominant grain size of the supplied rocks based on Wentworth's scale. Classes: Boulder > 256 mm, cobble 64-256 mm, pebble 4-64 mm, gravel 2-4 mm, very coarse sand 1-2 mm, coarse sand 0.5-1mm, medium sand 0.25-0.5 mm, fine sand 0.125-0.25 mm, very fine sand 0.062-0.125mm, silt 0.004-0.062 mm, clay <0.004. Three classes were found in this study, converted to a 1-3 scale; 4-64 mm (1), 64-256 mm (2) and >256 mm (3).
Lime richness	LR	Based on basic steps in the LCE LR (*KA*) in NiN. Four steps were registered; c, d, e, f, corresponding to steps 1 – 4 in the analyses. Uncertainty: subjective decisions.
Litter	Litter	Presence/absence of litter (*strømateriale*) in the plots.
Loss on ignition	LOI	Loss on ignition was analysed from the soil samples and used as a proxy for organic matter. Detailed description in Materials and methods, chapter 2.2.4.
Management intensity	MI	Based on basic steps from the LCE "MI" in NiN. Four steps were registered; b, c, d, e, corresponding to step 1 – 4 in the analyses. Uncertainty: subjective decisions.
Mineral	Mineral	Frequency of supplied mineral material (rocks) in 64 minor plots (each subplot divided into four). Only loose material was registered e.g. loose rocks, pebbles and gravel.
pH	pH	Soil pH measured in water. Detailed description in Methods, chapter 2.2.4.
Position	Position	Topographical positioning of the plots. Plots from forest and random generated positions were given the value 1, plots on turning points

		=2, plots on top points = 3 and plots positioned on bottom points = 4.
Rock cover	Rock	Percentage cover of rocks in the plot, including both stable rocks and loose rocks.
Risk of severe drought (SD)	SD	Based on basic steps from the LCE "SD" in NiN. Two levels were registered, b and c.
Slope incline	Slope	A Silva Expeditions S 360 compass with a clinometer was used to estimate the inclination in the plots. Four measurements were taken along the diagonal of the plots, from which an average value was calculated.
Soil depth	SoilDepth	Soil depth was measured with a shear vane (*jordbor*) from eight positions in each plot, from which an average value was calculated afterwards. Description in Methods (3.1.3).
Shrub cover	Shrub	Percentage cover of shrubs. Converted to presence/absence data because of high frequencies of zeroes.
Total nitrogen	TotN	Total nitrogen analysed from the soil samples, detailed description in Methods 2.2.4.
Total phosphorous	TotP	Total phosphorous analysed from the soil samples, detailed description in Methods 2.2.4.
Field layer	FieldLayer	Percentage cover of vascular plants in the plot.
Tree	Tree	Percentage cover of trees in the plots, based on the tree canopy. Converted to presence/absence data because of high frequencies of zeroes.
DeadWood	DeadWood	Presence/absence of dead wood (trees) in the plots, e.g. broken tree stems.

Appendix 4.

Formulas used for calculations for chemical soil analyses.

1) % dry matter = $\frac{(w3-w1)x100}{w2}$

2) % loss on igniton = $\frac{(w3-w4)x100}{(w3-w1)}$

where w1 =weight of crucible, w2= weight of soil sample before drying, w3= weight of crucible with sample after drying, w4= weight of crucible and sample after combustion.

Calculations of total nitrogen and phosphorous:

1) Total nitrogen: ((% total N / % LOI) *100)

2) Total phosphorous: ((g/kg total P / % LOI) *100)

Appendix 5. Untransformed values for explanatory variables in all plots.

Plot	Location	UTM E	UTM N	Aspect	Slope	ConvH	ConvV	Rock	Bare Ground	Mineral	GrainSize	Tree	Shrub	FieldLayer	BotLayer
111	Bakka	384378	6754938	122	24.00	0	0	35	1	0.21875	3	0	0	65	28
112	Bakka	384380	6754963	114	28.00	0.5	0	18	0	0.00000	3	0	0	65	15
113	Bakka	384374	6754981	110	26.00	0.5	0	34	0	0.00000	3	0	0	44	45
114	Bakka	384370	6754997	92	16.00	-0.5	-0.5	4	0	0.00000	3	0	0	82	37
121	Bakka	384248	6754941	102	23.00	1	0.5	20	0	0.17188	3	0	0	68	55
122	Bakka	384241	6754973	64	27.25	0	0	12	0	0.00000	3	0	0	62	40
123	Bakka	384243	6754983	98	25.50	0.5	0	3	0	0.06250	3	0	0	73	20
124	Bakka	384238	6755006	78	28.75	-0.5	0	31	0	0.00000	3	0	0	63	30
131	Bakka	384150	6754936	78	33.50	0.5	0	4	5	0.00000	2	0	0	78	1
132	Bakka	384154	6754943	101	33.00	0	0	7	2	0.21875	2	1	1	77	13
133	Bakka	384155	6754969	78	27.00	0	0	19	2	0.03125	3	0	0	48	23
134	Bakka	384156	6754975	96	35.50	0	0	0	1	0.00000	3	0	0	78	25
135	Bakka	384158	6755012	102	34.75	0.5	0	7	1	0.17188	3	0	0	71	20
136	Bakka	384160	6755023	112	33.50	1	0.5	8	1	0.03125	3	0	0	60	20
141	Bakka	384046	6754942	127	34.00	0.5	0.5	19	6	0.15625	2	0	0	70	48
142	Bakka	384047	6754946	124	38.50	1	0.5	1	0	0.17188	3	0	0	80	8
143	Bakka	384043	6754969	98	31.00	-0.5	0	2	0	0.01563	2	0	0	68	30
144	Bakka	384053	6755007	102	30.00	-1.5	-0.5	8	3	0.09375	2	0	0	82	40
211	Tufto	384165	6756954	118	35.25	0	0	2	6	0.03125	2	1	1	48	8
212	Tufto	384184	6756971	158	32.00	1.5	0	6	8	0.03125	2	0	0	72	12
213	Tufto	384210	6756988	132	32.35	0	0	5	5	0.81818	1	0	0	90	5
214	Tufto	384214	6757003	142	35.75	0.5	1	40	3	1.00000	2	0	0	57	2
221	Tufto	384128	6757015	136	34.75	1	0	0	4	0.00000	3	0	0	90	19
222	Tufto	384133	6757033	122	32.25	-2	0	16	4	0.15625	2	0	0	75	10
223	Tufto	384175	6757071	108	36.50	0	0	2	2	0.06250	1	0	0	77	32
224	Tufto	384186	6757062	135	37.50	0.5	0.5	12	2	0.07813	2	0	0	68	20
231	Tufto	384072	6757055	120	40.25	0.5	0	5	8	0.07813	1	0	0	82	21
232	Tufto	384086	6757075	140	36.50	0	0	1	2	0.00000	3	0	0	95	12
233	Tufto	384090	6757081	130	25.75	-1	0	26	19	0.62500	1	0	0	52	3
234	Tufto	384102	6757094	118	40.75	0	0	5	4	0.06250	1	0	0	86	12
311	Bakka	384329	6755272	84	24.50	0	0	0	1	0.00000	3	0	0	100	60
312	Bakka	384324	6755293	73	35.00	0	0	0	0	0.00000	3	0	0	100	70
313	Bakka	384308	6755334	78	33.00	0	0	0	0	0.00000	3	0	0	100	20
314	Bakka	384299	6755346	74	28.75	0	0	0	0	0.00000	3	0	0	80	21
321	Bakka	384105	6755239	85	27.00	1	0	6	2	0.17188	2	0	0	90	8
322	Bakka	384101	6755262	85	26.50	-1	-1	25	1	0.18750	3	0	0	65	45
323	Bakka	384110	6755295	109	31.50	0	0	2	0	0.04688	2	0	0	90	15
324	Bakka	384121	6755331	90	26.25	0	0	6	0	0.10938	2	0	1	97	18
411	Gudvangen	381645	6750436	108	24.50	0	0	21	5	0.23438	2	0	0	41	33
412	Gudvangen	381652	6750453	68	29.25	-0.5	0	23	2	0.25000	2	0	0	42	35
413	Gudvangen	381663	6750469	90	28.25	0	0	5	2	0.83333	1	0	0	67	33
414	Gudvangen	381679	6750487	52	28.50	0	0	5	1	0.03125	2	0	0	60	32
421	Gudvangen	381577	6750459	94	31.00	0	0	3	1	0.20313	1	1	0	82	30
422	Gudvangen	381601	6750484	60	31.00	0	0	4	0	0.04688	1	1	0	76	34
423	Gudvangen	381618	6750514	78	31.50	0	0	15	1	0.10938	2	0	0	58	40
424	Gudvangen	381628	6750527	62	32.50	0.5	0.5	16	0	0.06250	1	0	0	53	33
511	Tufto	384346	6756366	80	29.25	0	-1.5	8	2	0.00000	3	0	0	72	35
512	Tufto	384359	6756401	116	27.50	0	0	2	0	0.00000	3	0	0	67	35
513	Tufto	384366	6756413	138	19.00	0	0	8	0	0.00000	3	0	0	61	40
514	Tufto	384381	6756438	130	23.75	-1	-0.5	6	2	0.00000	3	0	0	78	8
521	Tufto	383845	6756722	114	35.50	0	0.5	3	4	0.18750	2	0	0	82	19
522	Tufto	383854	6756741	144	38.00	1	0	10	14	0.34375	1	0	0	68	9
523	Tufto	383881	6756770	154	37.75	0.5	0.5	3	16	0.15625	2	0	0	67	12
524	Tufto	383883	6756781	116	37.50	0	0	2	3	0.00000	3	0	0	85	23
611	Bakka	384315	6755047	83	24.50	-0.5	0	48	0	0.17188	2	0	0	50	20
612	Bakka	384315	6755067	79	24.00	0	0	27	0	0.07813	3	0	0	30	30
613	Bakka	384302	6755090	61	26.50	0	0	20	0	0.07813	2	0	0	65	15
614	Bakka	384314	6755103	79	16.00	0.5	-0.5	50	0	0.00000	3	0	0	50	20
621	Bakka	384213	6755023	94	25.50	0	0.5	8	1	0.03125	3	0	0	85	10
622	Bakka	384211	6755035	89	23.50	0.5	1	20	2	0.06250	3	0	0	70	18
623	Bakka	384213	6755051	112	25.50	0	0.5	25	0	0.28125	2	0	0	80	2
624	Bakka	384212	6755064	78	25.00	0	0.5	12	0	0.00000	3	0	0	90	15
625	Bakka	384211	6755075	78	34.00	0.5	-0.5	60	5	0.06250	2	1	0	52	15
626	Bakka	384207	6755094	92	30.00	0.5	0.5	45	5	0.12500	2	1	0	72	40

Appendix 5, cont.

Plot	Location	UTM E	UTM N	Aspect	Slope	ConvH	ConvV	Rock	Bare Ground	Mineral	GrainSize	Tree	Shrub	FieldLayer	BotLayer
631	Bakka	384129	6755043	90	30.00	0	-0.5	9	1	0.04688	3	0	0	85	5
632	Bakka	384136	6755062	102	32.75	0	0	3	1	0.01563	2	0	0	95	20
633	Bakka	384142	6755094	100	35.50	0	0.5	20	0	0.01563	3	0	0	70	9
634	Bakka	384143	6755103	98	34.50	0	0	3	1	0.04688	3	1	0	77	34
635	Bakka	384142	6755116	110	29.00	-0.5	-0.5	1	0	0.00000	3	1	0	86	34
636	Bakka	384143	6755127	111	22.50	-0.5	0	0	0	0.00000	3	0	0	87	43
641	Bakka	384058	6755078	165	29.00	0	-0.5	15	4	0.04688	3	0	0	70	15
642	Bakka	384062	6755088	110	34.50	0	0	10	0	0.14063	3	0	0	83	8
643	Bakka	384061	6755098	118	33.25	0	0	1	0	0.25000	1	0	0	96	1
644	Bakka	384060	6755126	140	37.75	0	0	15	3	0.14063	2	0	0	73	25
711	Tufto	384008	6756851	82	36.00	0	0	5	2	0.00000	3	0	0	88	30
712	Tufto	384039	6756886	94	34.00	0.5	0	2	3	0.03125	1	0	0	85	22
713	Tufto	384039	6756899	128	30.00	0	0.5	0	2	0.00000	3	0	0	94	23
714	Tufto	384052	6756912	71	33.50	0.5	0.5	5	13	0.06250	2	0	0	68	15
721	Tufto	383925	6756936	90	37.25	1	0	3	6	0.01563	1	0	0	68	34
722	Tufto	383941	6756954	96	40.50	0.5	0	9	13	0.39063	1	0	0	71	8
723	Tufto	383948	6756962	110	39.50	0	1	4	2	0.03125	1	1	0	84	14
724	Tufto	383956	6756979	102	37.00	-1	-1.5	15	19	0.53125	2	0	0	52	5

Plot	DeadWood	Litter	Droppings	SoilDepth	Position	LR	MI	SD	Altitude	Species	pH	LOI	TotN (raw)	TotN	TotP (raw)	TotP
111	0	0	0.12500	3.25	Top	d	d	b	31	39	5.22	10.34	0.30	2.90	2.0	19.34
112	0	0	0.03125	5.63	IP north	d	d	b	31	24	4.48	29.06	0.98	3.39	1.8	6.19
113	0	0	0.09375	2.00	IP south	d	d	b	31	20	4.64	34.91	1.23	3.51	2.2	6.30
114	0	0	0.09375	2.38	Bottom	d	d	b	31	24	4.97	25.81	0.93	3.60	2.4	9.30
121	0	0	0.06250	1.25	Top	d	d	c	82	20	5.03	20.63	0.70	3.39	2.7	13.09
122	0	0	0.01563	1.50	Random	d	d	b	82	22	4.81	18.47	0.66	3.56	2.9	15.70
123	0	0	0.01563	6.25	Random	d	d	b	82	23	5.01	15.91	0.59	3.74	3.0	18.86
124	0	0	0.00000	4.00	Random	d	d	b	82	22	4.75	14.20	0.55	3.84	2.8	19.72
131	1	1	0.00000	10.63	Forest edge	e	c	b	133	53	5.72	14.20	0.45	3.18	1.9	13.38
132	1	0	0.00000	29.00	Forest	e	c	b	133	36	4.43	18.29	0.66	3.58	1.4	7.65
133	1	0	0.00000	4.00	Forest	e	c	b	133	28	4.30	43.00	1.20	2.78	1.9	4.42
134	0	0	0.00000	13.30	Forest edge	e	d	b	133	34	4.96	11.75	0.47	3.96	2.9	24.68
135	0	0	0.01563	7.50	Random	e	d	b	133	16	4.9	12.22	0.44	3.60	2.3	18.82
136	0	0	0.03125	8.13	Random	d	d	b	133	21	4.83	12.09	0.44	3.65	2.4	19.85
141	0	0	0.00000	4.63	IP north	e	c	c	184	64	5.27	5.53	0.16	2.88	1.3	23.51
142	0	0	0.00000	7.50	Top	e	c	c	184	36	5.35	7.59	0.28	3.74	2.0	26.35
143	0	0	0.00000	7.63	Random	e	c	b	184	35	5.25	9.39	0.31	3.28	1.8	19.17
144	0	0	0.00000	3.38	Bottom	f	b	b	184	87	5.81	16.87	0.55	3.26	2.8	16.60
211	0	0	0.00000	7.50	Random	e	c	b	275	31	4.49	23.07	0.85	3.68	1.6	6.94
212	0	0	0.00000	7.50	Top	e	c	b	275	45	5.33	14.03	0.48	3.45	1.6	11.40
213	0	0	0.01563	3.63	Bottom	e	c	b	275	34	5.33	20.36	0.68	3.35	1.8	8.84
214	0	0	0.01563	1.00	IP south	f	c	b	275	48	5.81	14.81	0.49	3.28	1.9	12.83
221	0	0	0.01563	8.13	Top	f	c	b	320	45	5.46	13.51	0.45	3.37	1.7	12.58
222	1	0	0.00000	7.38	Bottom	f	c	b	320	58	5.85	9.88	0.32	3.26	1.4	14.17
223	0	1	0.00000	6.75	IP north	f	c	b	320	52	5.50	8.03	0.27	3.30	1.5	18.68
224	0	0	0.00000	12.40	IP south	f	c	b	320	45	5.60	7.06	0.25	3.61	1.5	21.25
231	0	0	0.00000	8.38	Top	f	c	b	365	48	5.76	11.54	0.40	3.46	1.5	13.00
232	0	0	0.00000	6.63	IP south	f	c	b	365	47	5.67	13.61	0.49	3.62	1.6	11.76
233	0	0	0.23438	2.13	Bottom	f	c	c	365	52	5.51	11.32	0.41	3.63	1.2	10.60
234	0	0	0.06250	6.63	IP north	f	c	b	365	46	5.71	16.73	0.54	3.22	1.7	10.16
311	0	0	0.00000	14.80	Random	e	e	b	40	24	4.96	10.70	0.42	3.88	2.1	19.63
312	0	0	0.00000	10.10	Random	e	e	b	40	31	4.97	11.96	0.46	3.87	1.9	15.89

Appendix 5, cont.

Plot	DeadWood	Litter	Droppings	SoilDepth	Position	LR	MI	SD	Altitude	Species	pH	LOI	TotN (raw)	TotN	TotP (raw)	TotP
313	0	1	0.00000	11.30	Random	e	e	b	40	35	4.77	15.19	0.55	3.60	1.8	11.85
314	0	0	0.00000	9.50	Random	e	e	b	40	34	5.01	11.34	0.39	3.48	1.7	14.99
321	0	0	0.00000	6.88	Top	f	d	c	170	51	5.58	15.36	0.47	3.05	2.2	14.32
322	0	0	0.00000	0.88	Random	f	d	c	170	41	5.26	16.02	0.55	3.43	2.7	16.85
323	0	0	0.00000	5.25	Random	e	d	c	170	37	5.44	13.93	0.48	3.47	2.1	15.08
324	1	0	0.00000	3.13	Bottom	e	d	c	170	48	5.10	13.25	0.43	3.22	2.0	15.09
411	0	0	0.00000	3.63	IP south	d	c	b	181	36	5.44	5.60	0.19	3.39	1.8	32.14
412	0	0	0.00000	2.13	IP north	d	b	b	181	33	5.32	6.59	0.21	3.25	1.6	24.28
413	0	0	0.00000	8.50	Top	d	b	b	181	37	5.33	8.13	0.24	2.96	1.7	20.91
414	0	1	0.00000	3.50	Random	d	b	b	181	32	5.59	12.14	0.37	3.05	1.8	14.83
421	0	0	0.00000	4.25	IP south	d	b	c	230	39	5.47	5.86	0.18	3.04	1.7	29.01
422	1	1	0.00000	3.38	Bottom	d	b	b	230	29	5.47	7.58	0.23	3.05	1.8	23.75
423	0	1	0.00000	3.00	Top	d	b	c	230	42	5.38	10.78	0.35	3.28	1.9	17.63
424	1	1	0.00000	4.25	IP north	d	c	b	230	35	5.48	9.76	0.29	2.95	2.0	20.49
511	1	0	0.01563	10.10	IP north	d	c	b	40	33	4.45	27.97	0.84	3.01	1.5	5.36
512	0	0	0.00000	14.30	Top	d	e	b	40	26	5.03	18.26	0.69	3.78	1.6	8.76
513	0	0	0.01563	3.13	IP south	d	e	b	40	40	5.38	12.19	0.43	3.51	1.4	11.48
514	0	0	0.03125	13.50	Bottom	d	e	b	40	42	6.02	11.69	0.44	3.74	1.6	13.69
521	1	0	0.00000	4.88	Top	f	c	b	361	46	6.00	13.33	0.42	3.12	1.4	10.50
522	0	0	0.00000	12.25	IP north	f	c	b	361	44	5.67	5.13	0.19	3.75	1.4	27.29
523	0	0	0.00000	6.50	IP south	f	b	b	361	41	5.85	6.47	0.23	3.54	1.4	21.64
524	0	0	0.00000	13.90	Bottom	f	b	b	361	46	5.76	11.04	0.42	3.80	1.6	14.49
611	0	0	0.00000	2.63	Random	d	c	b	39	42	5.56	7.27	0.26	3.54	1.9	26.13
612	0	0	0.00000	1.50	IP south	d	c	b	39	22	4.97	10.91	0.37	3.40	2.5	22.91
613	0	0	0.04688	3.25	IP north	d	c	b	39	26	4.93	12.09	0.46	3.79	2.8	23.16
614	0	0	0.00000	2.88	Bottom	d	c	b	39	23	5.21	10.46	0.39	3.74	2.0	19.12
621	0	0	0.01563	6.88	Random	e	c	b	95	30	4.89	9.62	0.35	3.67	2.5	25.99
622	0	0	0.00000	6.63	Top	d	c	b	95	39	4.89	9.82	0.34	3.46	2.6	26.48
623	0	0	0.01563	7.38	Random	d	c	b	95	35	5.03	8.65	0.30	3.41	2.7	31.21
624	0	0	0.00000	5.75	Forest	d	c	c	95	27	4.88	11.46	0.42	3.66	2.7	23.56
625	1	1	0.00000	3.13	Forest	d	b	b	95	28	4.89	31.39	1.14	3.64	2.3	7.33
626	0	1	0.00000	4.63	Forest	e	b	b	95	35	5.76	13.45	0.51	3.80	2.4	17.84
631	0	0	0.00000	4.50	IP north	d	c	b	142	35	4.79	9.49	0.30	3.11	2.1	22.13
632	0	0	0.04688	12.00	Top	d	c	b	142	35	4.98	10.56	0.41	3.86	2.7	25.57
633	0	0	0.00000	11.90	Forest edge	d	c	b	142	28	4.92	8.84	0.32	3.62	2.5	28.28
634	1	0	0.00000	22.00	Forest	d	c	b	142	35	4.64	9.76	0.37	3.81	2.4	24.59
635	0	0	0.00000	7.75	Forest	d	d	b	142	29	4.79	10.08	0.37	3.68	2.1	20.83
636	0	0	0.00000	5.50	Forest edge	d	d	b	142	34	4.95	12.53	0.47	3.76	2.4	19.15
641	1	0	0.00000	15.50	Random	e	c	c	190	35	5.12	6.22	0.24	3.93	2.1	33.76
642	0	0	0.00000	3.25	Top	e	b	c	190	42	5.44	8.56	0.30	3.51	2.1	24.53
643	0	0	0.00000	7.75	Random	e	b	c	190	44	5.28	9.14	0.34	3.68	2.6	28.45
644	1	0	0.00000	4.13	IP south	f	b	b	190	58	5.59	5.22	0.21	4.04	2.1	40.23
711	0	1	0.00000	6.00	IP south	f	c	b	320	43	5.53	12.7	0.52	4.07	1.9	14.96
712	0	0	0.00000	7.38	Top	f	c	b	320	38	5.42	14.75	0.54	3.69	1.4	9.49
713	0	0	0.00000	7.25	Bottom	f	c	b	320	39	5.2	16.12	0.59	3.66	1.5	9.31
714	0	0	0.00000	16.90	IP north	f	c	b	320	61	5.29	5.00	0.19	3.77	1.2	24.00
721	0	1	0.06250	3.00	Top	f	c	b	401	50	5.67	12.25	0.44	3.63	1.7	13.88
722	0	0	0.00000	12.10	IP north	f	c	b	401	55	5.93	11.79	0.43	3.67	1.6	13.57
723	0	0	0.00000	25.00	IP south	f	c	b	401	52	5.85	11.71	0.44	3.77	1.7	14.52
724	0	0	0.00000	10.30	Bottom	g	c	b	401	52	6.33	7.87	0.28	3.60	1.6	20.33

Appendix 6. Transformed values for the 19 continuous variables for all 82 plots.

Plot	Aspect	Slope	ConvH	ConvV	Rock	BareGround	Mineral	GrainSize	FieldLayer	BotLayer	SoilDepth	Altitude	pH	LOI	TotN	TotP	LR	MI	Position
111	0.6890	0.2412	0.4709	0.5056	0.8566	0.3956	0.6946	1.0000	0.4052	0.5585	0.2992	0.0000	0.4455	0.4111	0.0535	0.5163	0.0000	0.7428	0.4335
112	0.6238	0.3869	0.6271	0.5056	0.6847	0.0000	0.0000	1.0000	0.4052	0.3413	0.4596	0.0000	0.0862	0.8591	0.3442	0.0739	0.0000	0.7428	0.7514
113	0.5901	0.3118	0.6271	0.5056	0.8490	0.0000	0.0000	1.0000	0.1437	0.7702	0.1724	0.0000	0.1632	0.9267	0.4361	0.0783	0.0000	0.7428	0.7514
114	0.4293	0.0000	0.3318	0.3103	0.3408	0.0000	0.0000	1.0000	0.6657	0.6782	0.2154	0.0000	0.3232	0.8138	0.5071	0.1935	0.0000	0.7428	1.0000
121	0.5206	0.2076	0.8027	0.7336	0.7115	0.0000	0.6471	1.0000	0.4477	0.8710	0.0666	0.2117	0.3525	0.7243	0.3482	0.3253	0.0000	0.7428	0.4335
122	0.1414	0.3582	0.4709	0.5056	0.5842	0.0000	0.0000	1.0000	0.3640	0.7141	0.1055	0.2117	0.2454	0.6782	0.4741	0.4087	0.0000	0.7428	0.0000
123	0.4847	0.2937	0.6271	0.5056	0.2869	0.0000	0.4548	1.0000	0.5217	0.4327	0.4921	0.2117	0.3427	0.6136	0.6329	0.5025	0.0000	0.7428	0.0000
124	0.2918	0.4164	0.3318	0.5056	0.8248	0.0000	0.0000	1.0000	0.3776	0.5869	0.3581	0.2117	0.2164	0.5626	0.7414	0.5269	0.0000	0.7428	0.0000
131	0.2918	0.6206	0.6271	0.5056	0.3408	0.7155	0.0000	0.2227	0.5999	0.0000	0.6615	0.3866	0.6930	0.5626	0.2093	0.3349	0.5358	0.4230	0.0000
132	0.5117	0.5976	0.4709	0.5056	0.4584	0.5280	0.6946	0.2227	0.5840	0.3013	1.0000	0.3866	0.0622	0.6740	0.4954	0.1316	0.5358	0.4230	0.0000
133	0.2918	0.3487	0.4709	0.5056	0.6984	0.5280	0.3340	1.0000	0.1890	0.4824	0.3581	0.3866	0.0000	1.0000	0.0000	0.0000	0.5358	0.4230	0.0000
134	0.4664	0.7164	0.4709	0.5056	0.0000	0.3956	0.0000	1.0000	0.5999	0.5138	0.7356	0.3866	0.3183	0.4739	0.8723	0.6590	0.5358	0.7428	0.0000
135	0.5206	0.6797	0.6271	0.5056	0.4584	0.3956	0.6471	1.0000	0.4916	0.4327	0.5492	0.3866	0.2891	0.4927	0.5142	0.5015	0.5358	0.7428	0.0000
136	0.6070	0.6206	0.8027	0.7336	0.4886	0.3956	0.3340	1.0000	0.3373	0.4327	0.5749	0.3866	0.2551	0.4876	0.5575	0.5307	0.0000	0.7428	0.0000
141	0.7284	0.6439	0.6271	0.7336	0.6984	0.7539	0.6285	0.2227	0.4768	0.8019	0.4009	0.5356	0.4701	0.0633	0.0481	0.6290	0.5358	0.4230	0.7514
142	0.7049	0.8724	0.8027	0.7336	0.1314	0.0000	0.6471	1.0000	0.6325	0.1904	0.5492	0.5356	0.5095	0.2483	0.6340	0.7004	0.5358	0.4230	0.4335
143	0.4847	0.5092	0.3318	0.5056	0.2200	0.0000	0.2288	0.2227	0.4477	0.5869	0.5547	0.5356	0.4603	0.3620	0.2728	0.5114	0.5358	0.4230	0.0000
144	0.5206	0.4671	0.0980	0.3103	0.4886	0.6097	0.5302	0.2227	0.6657	0.7141	0.3101	0.5356	0.7379	0.6393	0.2566	0.4361	1.0000	0.0000	1.0000
211	0.6567	0.7041	0.4709	0.5056	0.2200	0.7539	0.3340	0.2227	0.1890	0.1904	0.5492	0.7568	0.0910	0.7696	0.5791	0.1035	0.5358	0.4230	0.0000
212	0.9533	0.5527	1.0000	0.5056	0.4244	0.8148	0.3340	0.2227	0.5066	0.2804	0.5492	0.7568	0.4996	0.5571	0.3914	0.2684	0.5358	0.4230	0.4335
213	0.7669	0.5682	0.4709	0.5056	0.3858	0.7155	0.9593	0.0000	0.8062	0.1148	0.3303	0.7568	0.4996	0.7189	0.3198	0.1765	0.5358	0.4230	1.0000
214	0.8412	0.7288	0.6271	1.0000	0.8919	0.6097	1.0000	0.2227	0.2984	0.0304	0.0230	0.7568	0.7379	0.5817	0.2739	0.3167	0.8166	0.4230	0.7514
221	0.7971	0.6797	0.8027	0.5056	0.0000	0.6690	0.0000	1.0000	0.8062	0.4153	0.5749	0.8505	0.5638	0.5398	0.3300	0.3085	0.8166	0.4230	0.4335
222	0.6890	0.5638	0.0000	0.5056	0.6551	0.6690	0.6285	0.2227	0.5525	0.2368	0.5441	0.8505	0.7579	0.3881	0.2576	0.3605	0.8166	0.4230	1.0000
223	0.5730	0.7667	0.4709	0.5056	0.2200	0.5280	0.4548	0.0000	0.5840	0.6141	0.5160	0.8505	0.5836	0.2792	0.2856	0.4974	0.8166	0.4230	0.7514
224	0.7896	0.8187	0.6271	0.7336	0.5842	0.5280	0.4960	0.2227	0.4477	0.4327	0.7123	0.8505	0.6332	0.2078	0.5199	0.5691	0.8166	0.4230	0.7514
231	0.6729	0.9708	0.6271	0.5056	0.3858	0.8148	0.4960	0.0000	0.6657	0.4496	0.5846	0.9363	0.7129	0.4652	0.3968	0.3224	0.8166	0.4230	0.4335
232	0.8267	0.7667	0.4709	0.5056	0.1314	0.5280	0.0000	1.0000	0.9004	0.2804	0.5104	0.9363	0.6680	0.5432	0.5250	0.2806	0.8166	0.4230	0.7514
233	0.7517	0.3027	0.2081	0.5056	0.7789	1.0000	0.9048	0.0000	0.2363	0.0597	0.1879	0.9363	0.5886	0.4558	0.5398	0.2404	0.8166	0.4230	1.0000
234	0.6567	1.0000	0.4709	0.5056	0.3858	0.6690	0.4548	0.0000	0.7344	0.2804	0.5104	0.9363	0.6880	0.6357	0.2310	0.2247	0.8166	0.4230	0.4335
311	0.3522	0.2584	0.4709	0.5056	0.0000	0.3956	0.0000	1.0000	1.0000	0.9166	0.7712	0.0407	0.3183	0.4281	0.7814	0.5243	0.5358	1.0000	0.0000
312	0.2397	0.6919	0.4709	0.5056	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000	0.6449	0.0407	0.3232	0.4824	0.7696	0.4144	0.5358	1.0000	0.0000
313	0.2918	0.5976	0.4709	0.5056	0.0000	0.0000	0.0000	1.0000	1.0000	0.4327	0.6817	0.0407	0.2260	0.5931	0.5090	0.2838	0.5358	1.0000	0.0000
314	0.2503	0.4164	0.4709	0.5056	0.0000	0.0000	0.0000	1.0000	0.6325	0.4496	0.6250	0.0407	0.3427	0.4567	0.4139	0.3866	0.5358	1.0000	0.0000
321	0.3620	0.3487	0.8027	0.5056	0.4244	0.5280	0.6471	0.2227	0.8062	0.1904	0.5220	0.4969	0.6233	0.5980	0.1341	0.3654	0.8166	0.7428	0.4335
322	0.3620	0.3301	0.2081	0.1431	0.7688	0.3956	0.6642	1.0000	0.4052	0.7702	0.0000	0.4969	0.4652	0.6167	0.3723	0.4438	0.8166	0.7428	0.0000
323	0.5816	0.5308	0.4709	0.5056	0.2200	0.0000	0.4032	0.2227	0.8062	0.3413	0.4386	0.4969	0.5539	0.5539	0.4047	0.3893	0.5358	0.7428	0.0000
324	0.4103	0.3209	0.4709	0.5056	0.4244	0.0000	0.5595	0.2227	0.9396	0.3975	0.2888	0.4969	0.3867	0.5308	0.2342	0.3899	0.5358	0.7428	1.0000
411	0.5730	0.2584	0.4709	0.5056	0.7239	0.7155	0.7082	0.2227	0.1110	0.6274	0.3303	0.5274	0.5539	0.0711	0.3470	0.8343	0.0000	0.4230	0.7514
412	0.1858	0.4365	0.3318	0.5056	0.7473	0.5280	0.7210	0.2227	0.1218	0.6532	0.1879	0.5274	0.4947	0.1682	0.2514	0.6488	0.0000	0.0000	0.7514
413	0.4103	0.3967	0.4709	0.5056	0.3858	0.5280	0.9630	0.0000	0.4333	0.6274	0.5891	0.5274	0.4996	0.2859	0.0869	0.5599	0.0000	0.0000	0.4335
414	0.0000	0.4065	0.4709	0.5056	0.3858	0.3956	0.3340	0.2227	0.3373	0.6141	0.3199	0.5274	0.6283	0.4895	0.1350	0.3814	0.0000	0.0000	0.0000
421	0.4480	0.5092	0.4709	0.5056	0.2869	0.3956	0.6799	0.0000	0.6657	0.5869	0.3757	0.6535	0.5688	0.0987	0.1296	0.7637	0.0000	0.0000	0.7514
422	0.0956	0.5092	0.4709	0.5056	0.3408	0.0000	0.4032	0.0000	0.5681	0.6404	0.3101	0.6535	0.5688	0.2476	0.1334	0.6352	0.0000	0.0000	1.0000
423	0.2918	0.5308	0.4709	0.5056	0.6390	0.3956	0.5595	0.2227	0.3112	0.7141	0.2772	0.6535	0.5243	0.4318	0.2713	0.4667	0.0000	0.0000	0.4335
424	0.1187	0.5749	0.6271	0.7336	0.6551	0.0000	0.4548	0.0000	0.2484	0.6274	0.3757	0.6535	0.5737	0.3819	0.0812	0.5485	0.0000	0.4230	0.7514
511	0.3122	0.4365	0.4709	0.0000	0.4886	0.5280	0.0000	1.0000	0.5066	0.6532	0.6449	0.0407	0.0718	0.8447	0.1101	0.0399	0.0000	0.4230	0.7514
512	0.6403	0.3677	0.4709	0.5056	0.2200	0.0000	0.0000	1.0000	0.4333	0.6532	0.7597	0.0407	0.3525	0.6733	0.6760	0.1736	0.0000	1.0000	0.4335
513	0.8119	0.0834	0.4709	0.5056	0.4886	0.0000	0.0000	1.0000	0.3506	0.7141	0.2888	0.0407	0.5243	0.4915	0.4345	0.2712	0.0000	1.0000	0.7514
514	0.7517	0.2327	0.2081	0.3103	0.4244	0.5280	0.0000	1.0000	0.5999	0.1904	0.7405	0.0407	0.8432	0.4714	0.6356	0.3449	0.0000	1.0000	1.0000
521	0.6238	0.7164	0.4709	0.7336	0.2869	0.6690	0.6642	0.2227	0.6657	0.4153	0.4166	0.9289	0.8332	0.5335	0.1746	0.2369	0.8166	0.4230	0.4335
522	0.8557	0.8453	0.8027	0.5056	0.5405	0.9343	0.7845	0.0000	0.4477	0.2140	0.7083	0.9289	0.6680	0.0164	0.6474	0.7231	0.8166	0.4230	0.7514
523	0.9260	0.8320	0.6271	0.7336	0.2869	0.9630	0.6285	0.2227	0.4333	0.2804	0.5042	0.9289	0.7579	0.1576	0.4605	0.5797	0.8166	0.0000	0.7514
524	0.6403	0.8187	0.4709	0.5056	0.2200	0.6097	0.0000	1.0000	0.7169	0.4824	0.7502	0.9308	0.7129	0.4435	0.6986	0.3709	0.8166	0.0000	1.0000
611	0.3423	0.2584	0.3318	0.5056	0.9403	0.0000	0.6471	0.2227	0.2124	0.4327	0.2419	0.0363	0.6134	0.2243	0.4637	0.6951	0.0000	0.4230	0.0000
612	0.3020	0.2412	0.4709	0.5056	0.7887	0.0000	0.4960	1.0000	0.0000	0.5869	0.1055	0.0363	0.3232	0.4377	0.3545	0.6136	0.0000	0.4230	0.7514
613	0.1072	0.3301	0.4709	0.5056	0.7115	0.0000	0.4960	0.2227	0.4052	0.3413	0.2992	0.0363	0.3037	0.4876	0.6827	0.6200	0.0000	0.4230	0.7514
614	0.3020	0.0000	0.6271	0.3103	0.9512	0.0000	0.0000	1.0000	0.2124	0.4327	0.2662	0.0363	0.4406	0.4168	0.6327	0.5100	0.0000	0.4230	1.0000
621	0.4480	0.2937	0.4709	0.7336	0.4886	0.3956	0.3340	1.0000	0.7169	0.2368	0.5220	0.2592	0.2843	0.3745	0.5737	0.6915	0.5358	0.4230	0.0000
622	0.4008	0.2243	0.6271	1.0000	0.7115	0.5280	0.4548	1.0000	0.4768	0.3975	0.5104	0.2592	0.2843	0.3850	0.3998	0.7035	0.0000	0.4230	0.4335
623	0.6070	0.2937	0.4709	0.7336	0.7688	0.0000	0.7444	0.2227	0.6325	0.0304	0.5441	0.2592	0.3525	0.3191	0.3636	0.8138	0.0000	0.4230	0.0000
624	0.2918	0.2759	0.4709	0.7336	0.5842	0.0000	0.0000	1.0000	0.8062	0.3413	0.4663	0.2592	0.2794	0.4618	0.5646	0.6303	0.0000	0.4230	0.0000
625	0.2918	0.6439	0.6271	0.3103	1.0000	0.7155	0.4548	0.2227	0.2363	0.3413	0.2888	0.2592	0.2843	0.8879	0.5495	0.1189	0.0000	0.0000	0.0000
626	0.4293	0.4671	0.6271	0.7336	0.9231	0.7155	0.5852	0.2227	0.5066	0.7141	0.4009	0.2592	0.7129	0.5377	0.6983	0.4732	0.5358	0.0000	0.0000
631	0.4103	0.4671	0.4709	0.3103	0.5158	0.3956	0.4032	1.0000	0.7169	0.1148	0.3925	0.4145	0.2357	0.3675	0.1660	0.5928	0.0000	0.4230	0.7514
632	0.5206	0.5862	0.4709	0.5056	0.2869	0.3956	0.2288	0.2227	0.9004	0.4327	0.7015	0.4145	0.3281	0.4216	0.7526	0.6812	0.0000	0.4230	0.4335
633	0.5028	0.7164	0.4709	0.7336	0.7115	0.0000	0.2288	1.0000	0.4768	0.2140	0.6987	0.4145	0.2989	0.3306	0.5270	0.7466	0.0000	0.4230	0.0000
634	0.4847	0.6677	0.4709	0.5056	0.2869	0.3956	0.4032	1.0000	0.5840	0.6404	0.9053	0.4145	0.1632	0.3819	0.7097	0.6567	0.0000	0.4230	0.0000
635	0.5901	0.4264	0.3318	0.3103	0.1314	0.0000	0.0000	1.0000	0.7344	0.6404	0.5596	0.4145	0.2357	0.3982	0.5837	0.5578	0.0000	0.7428	0.0000
636	0.5986	0.1912	0.3318	0.5056	0.0000	0.0000	0.0000	1.0000	0.7520	0.7483	0.4528	0.4145	0.3135	0.5046	0.6595	0.5110	0.0000	0.7428	0.0000
641	1.0000	0.4264	0.4709	0.3103	0.6390	0.6690	0.4032	1.0000	0.4768	0.3413	0.7867	0.5518	0.3965	0.1344	0.8328	0.8693	0.5358	0.4230	0.0000
642	0.5901	0.6677	0.4709	0.5056	0.5405	0.0000	0.6080	1.0000	0.6826	0.1904	0.2992	0.5518	0.5539	0.3135	0.4391	0.6552	0.5358	0.0000	0.4335
643	0.6567	0.6090	0.4709	0.5056	0.1314	0.0000	0.7210	0.0000	0.9199	0.0000	0.5596	0.5518	0.4750	0.3480	0.5819	0.7505	0.5358	0.0000	0.0000
644	0.8267	0.8320	0.4709	0.5056	0.6390	0.6097	0.6080	0.2227	0.5217	0.5138	0.3674	0.5518	0.6283	0.0273	0.9622	1.0000	0.8166	0.0000	0.7514
711	0.3323	0.7414	0.4709	0.5056	0.3858	0.5280	0.0000	1.0000	0.7699	0.5869	0.4794	0.8505	0.5985	0.5109	1.0000	0.3857	0.8166	0.4230	0.7514
712	0.4480	0.6439	0.6271	0.5056	0.2200	0.6097	0.3340	0.0000	0.7169	0.4662	0.5441	0.8505	0.5440	0.5799	0.5925	0.2005	0.8166	0.4230	0.4335
713	0.7362	0.4671	0.4709	0.7336	0.0000	0.5280	0.0000	1.0000	0.8812	0.4824	0.5385	0.8505	0.4357	0.6194	0.5650	0.1937	0.8166	0.4230	1.0000
714	0.2184	0.6206	0.6271	0.7336	0.3858	0.9184	0.4548	0.2227	0.4477	0.3413	0.8158	0.8505	0.4799	0.0000	0.6683	0.6417	0.8166	0.4230	0.7514
721	0.4103	0.8055	0.8027	0.5056	0.2869	0.7539	0.2288	0.0000	0.4477	0.6404	0.2772	1.0000	0.6680	0.4938	0.5384	0.3511	0.8166	0.4230	0.4335
722	0.4664	0.9854	0.6271	0.5056	0.5158	0.9184	0.8101	0.0000	0.4916	0.1904	0.7042	1.0000	0.7980	0.4755	0.5724	0.3412	0.8166	0.4230	0.7514
723	0.5901	0.9280	0.4709	1.0000	0.3408	0.5280	0.3340	0.0000	0.6997	0.3216	0.9490	1.0000	0.7579	0.4722	0.6666	0.3716	0.8166	0.4230	0.7514
724	0.5206	0.7925	0.2081	0.0000	0.6390	1.0000	0.8720	0.2227	0.2363	0.1148	0.6513	1.0000	1.0000	0.2682	0.5096	0.5440	1.0000	0.4230	1.0000

Appendix 7. Avalanche terminology and geological terms used throughout this thesis.

Avalanche: Mass movement of snow caused by deformation of the snowpack and gravity. The terms avalanche and snow avalanche are used synonymously in this thesis.
Avalanche area: a location with one or more avalanche paths.
Avalanche path: a fixed locality within an avalanche area which avalanches move.
Starting zone: a location where the unstable snow failed and began to move.
Avalanche track: the slope below the starting zone that connects the starting zone with the runout zone. Two main categories of avalanche tracks are recognized: open slopes and channels.
Runout zone/depozition zone: the area where debris is deposited. Debris usually comes to rest when the slope angle equals the static-friction angle.
Channel: includes gullies and other depressions, a main types of avalanche tracks.

Reference:

McClung, D., & Schaerer, P. A. (2006). *The avalanche handbook.* 3rd ed. Seattle, WA: Mountaineers Books.

Appendix 8. Species lists showing subplot-frequencies for all species in all 82 plots.

	111	112	113	114	121	122	123	124	131	132	133	134	135	136	141	142	143	144	211	212	213	214	221
Achillea millefolium	10	0	0	16	8	6	9	0	2	0	0	3	0	8	2	3	14	2	0	13	16	16	16
Agrostis capillaris	16	16	16	16	16	16	5	15	15	14	3	16	16	14	16	4	15	6	16	16	11	15	16
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla alpina	0	0	0	0	0	0	0	0	3	0	0	0	0	0	6	0	0	2	0	1	0	1	5
Alchemilla filicaulis	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Alchemilla glabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Alchemilla murbeckiana	0	0	0	0	0	0	0	0	6	0	0	6	2	0	0	0	4	0	0	0	0	0	0
Alchemilla subcrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla wichurae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Alnus incana	0	0	0	0	0	0	0	0	1	16	3	0	0	0	7	0	0	0	15	0	0	0	0
Alopecurus pratensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Angelica sylvestris	0	0	0	0	0	0	0	0	1	0	0	4	0	0	2	3	11	6	0	0	0	0	0
Antennaria dioica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthoxanthum odoratum	12	16	16	1	16	16	16	13	6	0	2	16	16	7	16	13	16	6	10	16	16	10	16
Anthriscus sylvestris	1	0	0	0	0	0	0	0	0	0	0	3	1	5	0	3	10	0	0	0	2	2	0
Arabidopsis thaliana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artemisia vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Athyrium filix-femina	0	1	0	0	0	0	0	0	0	7	0	0	0	0	4	1	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	6	0	0	0	0	1	1
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
Bistorta vivipara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16	0	0	0	0	0
Calamagrostis phragmitoides	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Calluna vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Campanula rotundifolia	16	4	15	0	13	12	2	13	3	0	0	14	5	8	14	9	12	2	2	3	2	1	13
Cardamine pratensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Carex brunnescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Carex capillaris	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex flava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
Carex leporina	0	0	2	0	0	0	4	4	6	3	0	5	0	4	2	0	0	5	2	0	0	1	0
Carex nigra	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	16	0	0	0	0	0
Carex pallescens	0	0	0	0	0	0	0	0	6	0	0	0	0	0	15	0	1	16	0	0	0	1	0
Carex pilulifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Carex spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carum carvi	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerastium fontanum	9	0	0	11	0	0	1	0	3	0	0	0	0	0	4	0	0	4	3	4	0	1	1
Chrysosplenium alternifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Circaea alpina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium heterophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0	10	0	0	0	0	0
Cirsium palustre	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	9	0	0	0	0	0
Cirsium vulgare	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinopodium vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptogramma crispa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cystopteris fragilis	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Dactylis glomerata	1	0	5	4	2	2	0	4	0	8	0	4	2	0	9	1	4	2	1	7	11	0	9
Deschampsia cespitosa	0	4	12	12	0	3	4	0	7	16	3	7	15	0	4	11	5	2	6	0	0	0	0
Dianthus deltoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Dryopteris expansa	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris filix-mas	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Elymus caninus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elytrigia repens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium collinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Epilobium montanum	0	0	0	0	0	0	0	0	0	7	2	2	0	0	0	0	1	0	0	0	0	0	0
Equisetum arvense	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equisetum pratense	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	7	10
Equisetum sylvaticum	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0

	212	213	214	221	222	223	224	231	232	233	234	311	312	313	314	321	322	323	324	411	412	413	414
Achillea millefolium	13	16	16	16	6	16	16	16	14	13	15	0	5	3	9	5	2	0	0	13	7	13	12
Agrostis capillaris	16	11	15	16	13	14	16	15	16	15	13	16	16	2	9	16	13	3	13	12	12	14	16
Ajuga pyramidalis	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla alpina	1	0	1	5	0	12	3	9	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
Alchemilla filicaulis	0	0	2	0	5	4	0	0	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla glabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0
Alchemilla murbeckiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Alchemilla subcrenata	0	0	0	0	0	0	0	0	0	0	0	16	16	5	0	0	3	0	0	0	0	0	0
Alchemilla wichurae	0	0	0	0	5	0	0	0	9	9	0	0	0	0	0	3	0	0	0	0	0	0	0
Alnus incana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Alopecurus pratensis	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0
Angelica sylvestris	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2	0	0	0	0	0	9	2
Antennaria dioica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthoxanthum odoratum	16	16	10	16	15	14	6	16	16	4	10	15	16	14	15	11	11	0	1	2	14	11	7
Anthriscus sylvestris	0	2	2	0	2	1	4	0	0	1	2	11	12	0	0	16	3	2	1	0	0	0	0
Arabidopsis thaliana	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	9	16	16	0	0	0	0
Artemisia vulgaris	0	0	1	0	4	0	0	0	0	0	0	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	3	5	0	3	0	13	0	0	0	0
Avenella flexuosa	0	0	1	1	0	0	0	14	0	0	0	2	13	16	5	0	3	1	0	16	0	16	16
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
Bistorta vivipara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Calamagrostis phragmitoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calluna vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	3	2	1	13	12	12	12	13	7	5	9	0	16	10	9	1	10	5	1	12	13	16	15
Cardamine pratensis	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
Carex capillaris	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex flava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carex leporina	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0
Carex nigra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex pallescens	0	0	1	0	0	0	5	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Carex pilulifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex spicata	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0
Carum carvi	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerastium fontanum	4	0	1	1	2	9	3	0	0	0	0	8	5	0	0	0	0	1	0	0	0	0	0
Chrysosplenium alternifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Circaea alpina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium heterophyllum	0	0	0	0	10	0	0	0	11	0	0	0	0	0	16	3	0	0	0	0	0	0	0
Cirsium palustre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinopodium vulgare	0	0	0	0	3	3	1	2	4	1	8	0	0	0	0	5	0	0	0	0	0	0	0
Convallaria majalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cryptogramma crispa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Cystopteris fragilis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0
Dactylis glomerata	7	11	0	9	11	8	3	11	14	12	15	8	15	1	7	16	7	16	15	0	0	1	0
Deschampsia cespitosa	0	0	0	0	0	1	0	0	0	0	0	6	0	11	6	0	8	3	15	0	16	0	0
Dianthus deltoides	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris filix-mas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	0	0	0	0
Elymus caninus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Elytrigia repens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium collinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium montanum	0	0	0	0	8	0	0	0	0	0	0	0	0	3	0	1	0	1	3	0	0	0	0
Equisetum arvense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Equisetum pratense	0	0	7	10	0	0	0	0	0	0	0	0	0	0	5	14	0	1	16	0	0	0	0
Equisetum sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 8, cont.

	421	422	423	424	511	512	513	514	521	522	523	524	611	612	613	614	621	622	623	624	625	626	631
Achillea millefolium	16	16	9	10	0	15	16	3	14	16	16	16	3	0	3	8	6	4	7	5	0	0	1
Agrostis capillaris	16	16	13	16	16	16	16	16	16	16	15	16	14	15	16	15	16	16	16	16	0	0	16
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla alpina	8	1	0	0	0	0	0	0	0	4	2	0	0	0	0	0	2	4	1	0	0	0	0
Alchemilla filicaulis	0	0	0	0	0	0	5	15	0	0	0	10	0	0	0	0	0	0	0	0	0	0	1
Alchemilla glabra	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla murbeckiana	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	5	6	0	0	0	0
Alchemilla subcrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla wichurae	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0
Alnus incana	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0
Alopecurus pratensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Angelica sylvestris	0	1	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Antennaria dioica	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthoxanthum odoratum	7	7	12	15	7	16	16	0	4	13	16	15	10	11	16	16	16	16	16	16	1	0	16
Anthriscus sylvestris	0	0	0	2	0	0	7	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	1
Arabidopsis thaliana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artemisia vulgaris	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	5
Avenella flexuosa	16	16	16	16	0	10	0	0	1	0	3	0	0	12	0	0	1	2	3	0	0	0	0
Betula pubescens	2	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bistorta vivipara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0
Calamagrostis phragmitoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Calluna vulgaris	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	14	16	16	16	2	7	16	2	11	11	12	14	13	13	12	1	15	16	12	5	0	0	9
Cardamine pratensis	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
Carex capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex flava	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex leporina	0	0	0	0	2	11	0	0	0	0	0	0	0	0	0	0	3	4	8	2	0	0	7
Carex nigra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex pallescens	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Carex pilulifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carum carvi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerastium fontanum	0	0	0	0	0	0	0	14	0	5	4	1	0	0	5	0	0	3	2	0	0	0	0
Chrysosplenium alternifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0
Circaea alpina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Cirsium heterophyllum	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium palustre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinopodium vulgare	0	0	0	0	0	0	0	0	2	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptogramma crispa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cystopteris fragilis	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0
Dactylis glomerata	0	0	3	1	2	9	8	14	0	0	1	11	3	0	0	2	1	1	6	2	2	0	3
Deschampsia cespitosa	0	0	0	0	16	1	0	2	0	0	0	0	5	0	9	0	0	0	4	9	9	12	4
Dianthus deltoides	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris filix-mas	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Elymus caninus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elytrigia repens	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium collinum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium montanum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	3	0
Equisetum arvense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equisetum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Equisetum sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0

Appendix 8, cont.

	632	633	634	635	636	641	642	643	644	711	712	713	714	721	722	723	724
Achillea millefolium	10	6	0	0	16	0	0	2	2	16	16	13	15	11	15	0	0
Agrostis capillaris	15	16	3	2	16	8	16	16	14	16	16	16	16	16	16	15	13
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla alpina	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0
Alchemilla filicaulis	10	0	0	0	7	0	0	0	0	2	0	0	0	0	10	5	0
Alchemilla glabra	0	0	0	0	0	0	4	8	2	0	0	0	4	0	0	0	10
Alchemilla murbeckiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla subcrenata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alchemilla wichurae	1	3	0	0	0	1	0	0	1	0	0	0	2	0	7	6	0
Alnus incana	0	0	16	16	3	0	0	0	3	0	0	0	1	1	0	0	0
Alopecurus pratensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Angelica sylvestris	0	0	0	0	5	3	5	4	2	0	0	0	2	0	0	0	0
Antennaria dioica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthoxanthum odoratum	16	16	4	0	16	3	16	12	16	16	16	14	16	14	11	9	0
Anthriscus sylvestris	8	0	0	12	3	13	16	16	6	0	0	0	0	12	0	5	0
Arabidopsis thaliana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artemisia vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Athyrium filix-femina	0	3	2	0	0	3	5	0	1	0	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bistorta vivipara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliergonella cuspidata	0	0	3	0	0	0	2	4	0	0	0	0	0	0	0	0	0
Calamagrostis phragmitoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calluna vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	16	14	0	0	15	0	4	10	14	3	5	5	14	15	8	5	0
Cardamine pratensis	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
Carex capillaris	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0
Carex flava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Carex leporina	4	2	0	0	1	0	2	0	5	0	0	0	0	0	0	0	0
Carex nigra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex pallescens	0	0	0	0	0	0	0	2	1	0	0	0	2	2	6	0	0
Carex pilulifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carum carvi	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0
Cerastium fontanum	0	0	0	0	0	1	0	0	0	2	0	0	1	2	0	0	0
Chrysosplenium alternifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Circaea alpina	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium heterophyllum	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	12	14
Cirsium palustre	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinopodium vulgare	0	0	0	0	0	0	0	0	0	3	0	9	0	11	5	4	0
Convallaria majalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptogramma crispa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cystopteris fragilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dactylis glomerata	0	3	12	13	4	10	16	16	6	7	16	13	9	15	10	16	4
Deschampsia cespitosa	11	13	16	16	4	15	3	12	8	0	0	4	13	0	1	8	1
Dianthus deltoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris expansa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryopteris filix-mas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elymus caninus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Elytrigia repens	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium collinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epilobium montanum	0	0	15	10	0	4	2	1	1	0	0	0	0	0	0	0	0
Equisetum arvense	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Equisetum pratense	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Equisetum sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 8, cont.

	111	112	113	114	121	122	123	124	131	132	133	134	135	136	141	142	143	144	211	212	213	214	221
Euphrasia stricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	15	0	0	15
Eurhynchium striatum	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
Festuca ovina	2	0	0	0	3	0	0	0	3	0	0	0	0	0	15	0	0	0	0	8	0	0	10
Festuca rubra	16	16	16	16	16	16	16	15	14	0	0	16	15	16	4	13	15	16	0	1	15	7	0
Filipendula ulmaria	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	2	16	0	2	0	0	0
Fragaria vesca	0	1	6	0	0	0	0	0	5	0	0	0	0	4	16	11	10	2	0	15	1	14	15
Galium boreale	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	3	0	16	0	16	16
Galeopsis sp.	7	0	0	0	0	0	0	0	0	15	15	2	0	0	0	0	0	2	15	0	0	0	0
Galium uliginosum	1	0	0	0	2	1	0	0	8	0	0	4	0	0	5	4	11	6	0	0	0	8	0
Galium verum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	11	9	16
Geranium robertianum	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	0	0	0	0	5
Geum rivale	3	0	0	0	0	0	0	0	16	0	0	4	0	0	0	0	0	16	0	0	0	2	0
Geum urbanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	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
Heracleum sphondylium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Hieracium lactucella	1	0	0	0	0	0	0	0	3	0	0	0	0	0	15	9	0	0	0	0	0	0	0
Hieracium pilosella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	4
Hieracium sect. Foliosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Hieracium sect. Vulgata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium umbellatum	0	0	0	0	0	0	0	0	3	0	0	0	0	0	9	4	4	0	0	0	0	0	0
Holcus lanatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypericum macalatum	0	0	0	0	0	0	0	1	10	0	0	2	0	0	9	0	0	3	16	7	16	8	14
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impatiens noli-tangere	0	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0	0	1	0	0	0	0	0
Juncus articulatus	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Juncus filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Knautia arvensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	1	10	16	13	13
Lapsana communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Lathyrus pratensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Leontodon autumnalis	11	0	0	1	0	0	0	0	15	0	0	0	0	1	16	0	0	10	0	0	0	0	0
Linaria vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	8	10
Lotus corniculatus	1	0	0	0	0	0	0	0	4	0	0	0	0	0	5	0	0	2	0	8	1	0	2
Luzula campestris	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	7	14	0	0	0	0	0	1
Luzula multiflora	0	1	0	0	0	0	1	2	0	0	0	0	0	0	16	3	0	2	0	3	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia caerulea	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	15	2	0	0	0	0
Myosotis arvensis	10	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1	0	0	0	1	0	1	5
Omalotheca sylvaticum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oreopteris limbosperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Origanum vulgare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	8	0	0	0	2	0	6	14
Oxalis acetosella	4	16	9	15	10	9	5	8	0	16	16	13	7	0	0	4	11	0	1	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Phegopteris connectilis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phleum pratense	1	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0	0
Pimpinella saxifraga	13	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	16	16	16	16
Pinguicula vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	8	7	10
Plantago major	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa nemoralis	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa pratensis	12	16	8	16	14	16	14	13	3	0	0	15	14	14	0	2	0	0	4	2	0	3	1
Poa trivialis	0	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Potentilla argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	1	4	0	0	0	0	0	0	14	0	0	6	1	5	16	12	16	15	0	0	0	0	0
Prunella vulgaris	3	0	0	0	0	0	0	0	9	0	0	0	0	0	14	0	0	14	0	12	4	0	3
Ranunculus acris	12	4	0	0	0	14	14	5	11	0	0	12	6	11	10	3	16	1	0	7	5	10	7

Appendix 8, cont.

	222	223	224	231	232	233	234	311	312	313	314	321	322	323	324	411	412	413	414	421	422	423	424
Euphrasia stricta	7	13	15	15	10	8	12	0	0	0	0	0	0	0	0	1	0	1	3	0	0	0	0
Eurhynchium striatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Festuca ovina	0	2	0	2	0	2	0	0	0	0	0	0	2	0	0	10	0	0	0	0	0	1	0
Festuca rubra	9	8	3	2	11	7	16	16	16	1	16	16	15	16	2	6	0	15	16	14	15	14	6
Filipendula ulmaria	11	1	0	1	0	0	0	0	0	5	1	13	9	1	13	0	0	0	0	0	0	0	0
Fragaria vesca	8	10	16	16	3	7	14	0	0	0	0	2	13	0	7	0	0	0	11	1	0	14	0
Galium boreale	9	16	15	15	16	10	15	0	0	2	0	10	2	2	0	10	2	14	4	15	16	10	1
Galeopsis sp.	9	0	0	0	16	1	6	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Galium uliginosum	12	2	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0
Galium verum	4	10	7	12	10	12	14	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Geranium robertianum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sylvaticum	2	13	8	3	14	1	15	15	2	15	16	4	13	0	7	0	0	8	0	15	5	9	4
Geum rivale	7	0	0	0	0	1	3	0	0	0	0	11	0	2	15	0	0	0	0	0	0	0	0
Geum urbanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Heracleum sphondylium	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium lactucella	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	0	0	3	13
Hieracium pilosella	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0	9	5	3	9	16	0	0	0
Hieracium sect. Foliosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	21	3
Hieracium sect. Sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hieracium sect. Vulgata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	15	16	10	15	7	0	16
Hieracium umbellatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	15	16	16	16	9	16	16
Holcus lanatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypericum macalatum	11	16	14	12	15	6	16	0	0	0	0	1	0	0	0	0	0	0	0	3	1	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impatiens noli-tangere	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus articulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Knautia arvensis	7	16	15	15	12	9	16	0	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lathyrus pratensis	3	2	0	0	0	11	4	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Leontodon autumnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	15	3	0	0	12	0
Linaria vulgaris	0	6	3	12	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	4	0	1	1	0	0	0	0	0	0	0	0	0	0	7	5	5	0	8	4	0	0
Luzula campestris	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	3	0	8	0	0	0	0	0
Luzula multiflora	0	1	0	2	0	0	0	0	3	0	0	0	0	0	0	0	1	0	7	12	2	5	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia caerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	7	0	2	2	8	0
Myosotis arvensis	1	1	2	9	2	1	4	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
Omalotheca sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oreopteris limbosperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Origanum vulgare	0	12	12	12	7	9	12	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0
Oxalis acetosella	0	0	0	0	0	0	0	10	1	16	15	16	5	2	10	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phegopteris connectilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phleum pratense	3	0	0	0	0	1	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Pimpinella saxifraga	9	15	16	16	15	11	16	0	0	0	0	0	0	0	0	16	7	16	16	16	16	16	16
Pinguicula vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	6	15	15	15	9	12	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago major	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa nemoralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa pratensis	0	0	7	0	2	0	0	10	16	1	12	3	3	16	11	0	12	0	0	0	0	0	0
Poa trivialis	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla argentea	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	0	0	0	9	0	0	0	0	14	5	4	0	0	0	0	0	0	1	0	0	0	0
Prunella vulgaris	7	12	13	8	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	12	8	7	3	2	2	5	16	16	12	9	16	8	4	2	9	5	15	8	9	4	11	16

Appendix 8, cont.

	511	512	513	514	521	522	523	524	611	612	613	614	621	622	623	624	625	626	631	632	633	634	635
Euphrasia stricta	0	0	0	0	12	16	16	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eurhynchium striatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Festuca ovina	0	0	2	0	0	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Festuca rubra	15	16	16	16	3	0	0	0	16	14	15	15	16	16	16	16	0	0	9	16	16	4	2
Filipendula ulmaria	0	0	0	16	0	0	0	3	0	0	0	0	0	0	3	0	0	9	0	0	0	0	0
Fragaria vesca	1	10	14	0	13	13	9	13	11	14	6	0	2	15	5	2	0	5	0	7	14	0	0
Galium boreale	1	0	9	6	9	15	16	16	2	0	0	0	0	0	0	0	0	0	0	6	0	0	0
Galeopsis sp.	8	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	2
Galium uliginosum	0	0	9	3	0	0	0	0	10	0	0	5	10	3	7	1	0	0	0	0	3	1	0
Galium verum	0	1	14	1	14	6	13	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium robertianum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9	9	0	0	0	0	0
Geranium sylvaticum	0	0	3	0	0	0	0	6	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Geum rivale	0	0	0	2	1	0	0	8	1	0	0	0	0	0	2	0	2	14	3	0	0	0	0
Geum urbanum	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	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	6	0	0	0	0
Heracleum sphondylium	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium lactucella	0	0	1	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0
Hieracium pilosella	0	0	0	0	5	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Foliosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Vulgata	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium umbellatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
Holcus lanatus	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypericum macalatum	0	0	2	0	14	0	6	16	1	0	0	0	0	2	2	0	0	0	3	0	0	0	1
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Impatiens noli-tangere	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	1
Juncus articulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Knautia arvensis	0	0	0	0	14	14	15	15	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Lathyrus pratensis	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leontodon autumnalis	0	0	0	0	0	0	0	0	13	15	0	0	0	0	12	0	0	0	2	2	0	0	0
Linaria vulgaris	0	0	0	0	5	12	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula campestris	0	0	4	0	0	6	1	0	0	0	2	0	3	1	0	0	0	0	0	0	4	0	0
Luzula multiflora	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	0	7	2	0
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
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molinia caerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myosotis arvensis	0	0	0	0	10	0	2	0	3	1	0	0	0	1	1	0	0	0	0	0	0	0	0
Omalotheca sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oreopteris limbosperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Origanum vulgare	0	0	0	0	8	13	7	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis acetosella	16	4	0	7	0	0	0	0	13	1	15	15	0	0	9	14	16	14	16	4	4	16	16
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phegopteris connectilis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0	0
Phleum pratense	0	3	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0
Pimpinella saxifraga	0	0	5	0	15	15	16	16	3	0	0	0	2	12	0	0	0	0	0	9	0	0	0
Pinguicula vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata	0	0	3	2	11	14	15	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago major	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa nemoralis	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	13	0	0	0	9	0
Poa pratensis	11	16	5	6	0	0	0	4	2	0	11	6	15	8	13	7	0	0	16	15	9	0	0
Poa trivialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0
Potentilla argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	10	9	1	0	4	0	0	0	0	3	0	15	12	13	4	0	0	1	10	8	0	0
Prunella vulgaris	0	0	0	0	0	2	14	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	4	1	8	15	12	13	6	4	10	1	4	10	1	10	1	8	9	4	0	10	11	12	0

Appendix 8, cont.

	636	641	642	643	644	711	712	713	714	721	722	723	724
Euphrasia stricta	0	0	0	0	0	15	13	5	4	13	4	0	2
Eurhynchium striatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Festuca ovina	0	0	0	0	3	3	1	0	3	0	0	0	0
Festuca rubra	16	3	16	15	10	16	7	13	0	14	9	10	13
Filipendula ulmaria	0	6	12	6	0	0	0	0	0	0	4	15	12
Fragaria vesca	8	2	7	14	13	13	16	3	1	15	13	11	0
Galium boreale	8	0	2	10	0	16	15	8	8	16	12	12	6
Galeopsis sp.	0	0	0	0	0	1	1	7	3	0	0	3	0
Galium uliginosum	12	0	2	1	8	2	2	2	11	4	2	8	7
Galium verum	0	0	0	0	0	15	9	5	0	13	12	0	0
Geranium robertianum	0	7	0	0	1	0	0	0	0	0	0	0	0
Geranium sylvaticum	0	4	4	0	2	2	1	0	4	5	16	13	5
Geum rivale	0	0	2	5	0	0	1	0	2	2	11	12	6
Geum urbanum	0	0	0	0	0	0	0	0	0	0	1	0	0
Gymnocarpium dryopteris	0	0	0	0	0	0	0	0	0	0	0	0	0
Heracleum sphondylium	0	0	6	13	1	0	0	0	0	0	2	0	0
Hieracium lactucella	0	0	0	0	0	0	0	0	7	0	0	0	0
Hieracium pilosella	0	0	0	0	0	9	0	0	2	0	2	0	0
Hieracium sect. Foliosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium sect. Vulgata	0	0	0	0	0	0	0	0	4	2	3	1	0
Hieracium umbellatum	0	0	1	0	11	0	0	0	1	1	0	0	0
Holcus lanatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypericum macalatum	2	0	0	0	10	11	16	16	16	16	15	13	4
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Impatiens noli-tangere	0	0	0	0	0	0	0	0	0	0	0	1	0
Juncus articulatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
Knautia arvensis	10	0	0	0	0	16	16	16	11	16	13	2	0
Lapsana communis	0	0	0	0	4	0	0	0	0	0	0	0	0
Lathyrus pratensis	0	0	0	0	0	0	0	0	0	11	11	11	5
Leontodon autumnalis	0	0	0	0	16	0	0	0	0	0	0	0	1
Linaria vulgaris	0	0	0	0	0	9	0	10	0	1	9	6	0
Lotus corniculatus	0	0	0	0	1	1	0	0	4	0	0	0	7
Luzula campestris	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula multiflora	0	0	0	0	9	0	0	0	5	0	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	9	5	2	1
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	2
Molinia caerulea	0	0	1	0	0	0	0	0	3	0	0	1	15
Myosotis arvensis	0	0	2	0	5	0	0	0	0	1	0	8	0
Omalotheca sylvaticum	0	0	0	0	0	0	0	0	10	2	3	0	0
Oreopteris limbosperma	0	0	0	0	0	0	0	0	0	0	0	0	0
Origanum vulgare	0	3	0	6	14	7	9	2	4	12	16	5	0
Oxalis acetosella	12	9	0	6	7	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	9
Phegopteris connectilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Phleum pratense	7	0	0	3	0	6	0	0	0	0	0	0	1
Pimpinella saxifraga	0	1	0	2	13	16	16	13	10	16	12	0	0
Pinguicula vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	8
Plantago lanceolata	0	0	0	0	0	16	16	14	14	14	12	1	0
Plantago major	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa nemoralis	0	0	0	0	4	0	0	0	0	0	0	0	0
Poa pratensis	16	1	14	15	0	0	0	8	0	0	1	1	0
Poa trivialis	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla argentea	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	2	0	6	0	4	0	0	0	15	12	8	5	13
Prunella vulgaris	0	0	0	0	6	10	0	5	16	2	11	5	9
Ranunculus acris	8	5	3	13	11	0	0	7	14	4	0	4	8

Appendix 8, cont.

	111	112	113	114	121	122	123	124	131	132	133	134	135	136	141	142	143	144	211	212	213	214	221
Ranunculus auricomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ranuculus repens	15	2	3	16	16	5	0	5	3	6	3	1	0	0	0	0	0	12	0	4	4	9	0
Rhinanthus minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	0	1	1
Rhodiola rosea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Rubus idaeus	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	16	0	0	5	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	12	16	13	15	15	15	14	13	3	6	0	15	0	16	1	5	9	8	16	12	16	15	16
Rumex acetosella	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Sagina procrumbens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Saxifraga aizoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
Schedonorus pratensis	1	0	0	0	0	1	1	1	0	0	0	4	0	0	0	0	0	3	0	4	7	8	2
Selaginella selaginoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silene dioica	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0
Silene vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
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
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stachys sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria graminea	6	0	0	0	14	7	7	8	0	0	0	16	15	7	5	1	1	1	4	11	12	9	12
Stellaria media	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria nemorum	0	0	1	5	0	0	0	0	0	13	16	1	15	0	0	0	0	0	5	0	0	0	0
Succisa pratensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	0	1	0	0	0	0	0
Taraxacum spp.	7	0	0	2	0	0	0	0	1	0	0	0	0	0	3	0	0	7	0	0	0	0	0
Trientalis europaea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium pratense	4	0	0	0	2	0	1	0	6	0	0	1	0	4	16	2	11	3	0	16	15	12	14
Trifolium repens	4	0	5	3	0	1	11	0	6	0	0	2	0	3	1	0	0	0	0	11	15	10	16
Tussilago farfara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	15	0	0	0	0	0
Ulmus glabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Urtica dioica	2	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	0
Valeriana sambucifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	2	0	0	0	0
Veronica chamaedrys	0	2	8	12	15	6	0	2	0	0	0	9	0	15	0	6	4	0	1	12	16	14	15
Veronica fruticans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verbascum nigrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica officinalis	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	3	5
Vicia cracca	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8	10
Vicia sepium	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Vicia sylvatica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	14	0	0	0	0	0
Viola canina	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	15	7	5	11
Viola palustris	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Viola tricolor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viscaria vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 8, cont.

	222	223	224	231	232	233	234	311	312	313	314	321	322	323	324	411	412	413	414	421	422	423	424
Ranunculus auricomus	10	0	0	0	0	0	0	0	0	0	0	1	0	5	3	1	0	1	0	5	0	5	1
Ranuculus repens	4	0	0	0	0	0	0	0	0	0	0	16	3	9	15	0	16	1	0	0	16	11	16
Rhinanthus minor	2	2	2	8	6	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rhodiola rosea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rubus idaeus	0	1	0	0	6	0	6	0	0	1	0	0	0	0	2	0	0	0	3	0	0	4	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	12	15	16	14	16	19	16	0	16	14	14	16	12	3	15	0	0	0	0	0	1	0	0
Rumex acetosella	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagina procrumbens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saxifraga aizoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schedonorus pratensis	4	6	5	5	7	6	7	1	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0
Selaginella selaginoides	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silene dioica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silene vulgaris	9	2	0	2	1	9	0	0	0	0	0	0	0	0	0	4	0	0	8	0	0	5	3
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	0	3	0	0	0
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	0	1	0	1	0
Stachys sylvatica	7	0	0	0	0	0	0	0	0	0	0	3	0	8	0	0	0	0	0	0	0	0	0
Stellaria graminea	10	15	9	10	3	11	7	0	11	5	5	13	10	15	3	0	0	1	2	1	0	4	0
Stellaria media	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria nemorum	0	0	0	0	0	0	0	0	0	0	0	14	0	1	16	0	0	0	0	0	0	0	0
Succisa pratensis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum spp.	0	0	0	0	0	0	0	8	7	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	12	4	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium pratense	9	15	15	16	16	3	7	0	1	0	0	3	4	0	0	0	0	0	0	0	0	4	0
Trifolium repens	11	15	4	2	13	16	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tussilago farfara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmus glabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urtica dioica	11	0	0	0	0	0	0	0	0	0	0	3	5	6	0	0	0	0	0	0	0	0	0
Valeriana sambucifolia	11	0	0	0	2	0	3	0	1	16	16	14	0	5	16	0	0	0	0	0	2	0	0
Veronica chamaedrys	8	16	10	11	6	10	15	0	0	7	16	8	2	13	8	0	0	0	0	0	0	0	0
Veronica fruticans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Verbascum nigrum	4	0	0	2	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Veronica officinalis	0	0	0	4	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia cracca	0	4	0	5	2	3	0	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sepium	0	0	1	1	0	0	0	0	5	0	0	3	0	7	0	0	0	0	0	0	0	0	0
Vicia sylvatica	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola canina	1	16	15	5	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Viola palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola tricolor	2	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viscaria vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

Appendix 8, cont.

	511	512	513	514	521	522	523	524	611	612	613	614	621	622	623	624	625	626	631	632	633	634	635
Ranunculus auricomus	0	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1
Ranuculus repens	0	0	0	11	0	0	0	0	7	0	14	13	4	1	13	14	0	16	16	0	6	0	10
Rhinanthus minor	0	0	0	0	7	5	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodiola rosea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rubus idaeus	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa	16	26	12	15	16	14	18	16	7	3	0	15	15	13	12	13	0	3	16	14	12	1	3
Rumex acetosella	0	10	0	0	0	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagina procrumbens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saxifraga aizoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schedonorus pratensis	0	0	0	13	8	0	0	3	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Selaginella selaginoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silene dioica	1	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
Silene vulgaris	0	0	0	0	12	10	10	0	0	0	0	0	0	1	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
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Stachys sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria graminea	0	0	9	6	15	8	9	16	6	10	4	3	13	9	3	9	0	0	10	13	14	0	0
Stellaria media	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria nemorum	15	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	16	16	7	0	2	16	16
Succisa pratensis	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum spp.	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium pratense	0	7	0	0	13	4	16	15	5	0	0	0	0	0	0	0	0	0	0	16	1	0	0
Trifolium repens	0	0	0	2	14	16	0	5	1	0	0	0	1	1	1	4	0	0	0	9	0	0	0
Tussilago farfara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmus glabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urtica dioica	0	0	0	1	0	0	0	0	0	0	0	6	0	0	1	0	0	2	0	0	0	0	4
Valeriana sambucifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	13	0	0	4	0	0
Veronica chamaedrys	0	7	15	5	13	4	4	11	0	0	4	2	13	0	0	0	0	0	0	8	13	0	1
Veronica fruticans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verbascum nigrum	0	0	0	0	3	9	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica officinalis	0	0	0	0	0	8	3	1	0	4	1	0	1	0	1	1	0	0	1	0	0	0	0
Vicia cracca	0	0	0	0	0	6	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sepium	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola canina	2	0	0	0	12	10	15	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Viola tricolor	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viscaria vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 8, cont.

	636	641	642	643	644	711	712	713	714	721	722	723	724
Ranunculus auricomus	0	0	0	0	0	0	0	3	0	0	0	0	2
Ranuculus repens	7	0	12	10	0	0	0	0	7	0	0	0	0
Rhinanthus minor	0	0	0	0	0	2	3	4	2	3	4	0	3
Rhodiola rosea	0	0	0	0	1	0	0	0	0	0	0	0	0
Rubus idaeus	0	0	0	0	0	0	0	6	0	1	0	1	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	5	1	0	0
Rumex acetosa	16	2	14	15	6	18	16	16	15	16	15	5	9
Rumex acetosella	0	0	0	0	0	2	0	0	0	0	0	0	0
Sagina procrumbens	0	0	0	0	1	0	0	0	0	0	0	0	0
Saxifraga aizoides	0	0	0	0	0	0	0	0	0	0	0	0	5
Schedonorus pratensis	0	0	2	0	0	2	4	6	4	4	5	12	2
Selaginella selaginoides	0	0	0	0	0	0	0	0	0	0	0	0	0
Silene dioica	0	2	4	1	0	0	0	0	0	0	0	0	0
Silene vulgaris	0	0	0	0	4	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbus aucuparia	0	0	0	0	1	0	0	0	0	0	0	0	0
Stachys sylvatica	0	5	0	0	0	0	0	0	0	0	0	6	0
Stellaria graminea	13	1	16	16	10	16	11	13	4	15	16	8	0
Stellaria media	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria nemorum	0	16	13	13	0	0	0	0	0	0	0	0	0
Succisa pratensis	0	0	0	0	0	0	0	0	0	0	0	0	1
Taraxacum spp.	0	0	0	0	16	0	0	0	0	0	0	0	0
Trientalis europaea	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium pratense	0	0	0	6	13	15	15	2	16	10	8	0	6
Trifolium repens	0	0	0	0	3	16	6	0	13	0	10	0	0
Tussilago farfara	0	0	0	0	0	0	0	0	0	0	2	0	13
Ulmus glabra	0	0	0	0	0	0	0	0	0	0	0	0	0
Urtica dioica	0	3	0	1	0	0	0	0	0	0	0	0	0
Valeriana sambucifolia	0	0	0	3	0	0	0	0	0	1	0	13	7
Veronica chamaedrys	16	0	1	1	1	16	16	16	4	13	11	9	0
Veronica fruticans	0	0	0	0	0	0	0	0	0	0	0	0	0
Verbascum nigrum	0	0	0	2	0	0	3	4	4	1	5	5	0
Veronica officinalis	0	0	0	0	2	2	4	0	0	1	3	0	0
Vicia cracca	0	0	0	0	0	0	0	0	2	0	0	0	7
Vicia sepium	0	4	10	2	0	0	0	0	0	0	0	0	5
Vicia sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	3
Viola canina	0	0	0	0	0	12	13	12	0	13	12	8	0
Viola palustris	1	0	0	0	0	0	0	0	0	0	0	0	0
Viola tricolor	0	0	0	0	0	0	1	0	0	0	3	0	0
Viscaria vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 8, cont.

	111	112	113	114	121	122	123	124	131	132	133	134	135	136	141	142	143	144	211	212	213	214	221
Atrichum undulatum	0	0	0	16	1	0	8	0	6	7	4	0	0	0	16	0	0	14	1	0	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium sp.	0	2	0	13	0	0	2	1	0	8	15	0	0	0	3	0	0	6	0	5	0	0	2
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16	0	0	0	0	0
Campylium stellatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Chiloscyphus polyanthos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
Cirriphyllum piliferum	0	0	0	0	0	0	0	3	0	13	14	0	0	0	3	0	0	4	15	0	14	5	4
Climacium dendroides	1	0	0	0	0	0	0	0	2	0	0	0	0	1	3	0	0	1	0	0	0	0	0
Conocephalum conicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Cratoneuron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0
Dicranum sp.	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0
Fissidens sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Hylocomium splendens	6	16	16	7	16	15	8	3	0	3	5	1	0	1	12	16	10	8	1	4	0	1	14
Hypnum sp.	0	0	0	0	0	0	0	0	0	5	8	0	0	0	13	0	0	1	3	0	0	0	0
Isothecium alopecuroides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophocolea bidentata	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0
Lophocolea heterophylla	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium sp.	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Moerckia blyttii	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mylia sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Nardia scalaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Pellia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	4	0	0	0	0	0
Philonotis sp.	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Plagiochila porelloides	0	0	0	0	0	0	0	0	0	1	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
Plagiomnium sp.	0	0	0	0	0	0	0	0	0	10	5	2	0	0	3	0	2	15	12	11	11	6	6
Plagiomnium undulatum	0	13	0	0	0	8	0	4	0	0	7	5	0	0	1	0	0	3	0	0	0	0	0
Pleurozium schreberi	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Pogonatum urnigerum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
Pohlia wahlenbergii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Polytrichum sp.	0	2	0	0	0	0	0	0	0	2	0	0	0	0	8	0	2	0	0	0	1	0	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0
Racomitrium canescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0
Racomitrium lanuginosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Rhytidium rugosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus squarrosus	16	16	16	16	16	16	16	15	2	16	14	16	16	16	16	16	16	6	14	16	16	11	16
Rhytidiadelphus triquetrus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sanionia uncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Thuidium sp.	1	11	15	1	0	8	3	2	0	6	14	4	0	0	16	5	4	12	12	15	12	0	13

Appendix 8, cont.

	222	223	224	231	232	233	234	311	312	313	314	321	322	323	324	411	412	413	414	421	422	423	424
Atrichum undulatum	5	0	0	0	2	0	0	5	13	0	13	0	0	2	3	3	0	0	0	0	0	0	0
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	5	1	0	0	0	8	1
Barbilophozia floerkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium sp.	12	4	3	14	5	5	0	1	0	0	0	2	1	0	12	0	0	0	0	0	0	0	0
Bryum sp.	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	4	7	15	4	11	0	16	11
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	10	0	0	0	0	0	0	0	0
Campylium stellatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus polyanthos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirriphyllum piliferum	6	12	15	0	0	0	10	0	0	0	0	4	1	0	16	0	0	0	0	0	0	8	0
Climacium dendroides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	4	0	4	2	0	0
Conocephalum conicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cratoneuron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum sp.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	11	13	1	4	5	0	6	6
Fissidens sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	4	14	8	16	0	0	2	12	16	15	14	1	13	4	14	0	0	0	0	3	0	5	15
Hypnum sp.	1	0	4	0	0	0	1	0	1	0	4	0	0	0	1	4	2	0	0	0	0	5	2
Isothecium alopecuroides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophocolea bidentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Lophocolea heterophylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moerckia blyttii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mylia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nardia scalaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pellia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philonotis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiochila porelloides	0	0	0	0	0	0	0	0	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	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiomnium sp.	14	14	16	1	16	4	14	10	0	3	1	12	1	0	18	0	0	0	3	0	1	0	11
Plagiomnium undulatum	0	0	0	0	11	0	6	13	6	5	0	1	1	3	10	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	12	16	16	14	16	16
Pogonatum urnigerum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	5	0	0	1	0	0	3
Pohlia wahlenbergii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	2	0	0	0	0	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	3	0	3	2	1	0	3	3
Racomitrium canescens	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	15	7	0	4	0	0	1	1
Racomitrium lanuginosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Rhytidium rugosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	2	0	0	0
Rhytidiadelphus squarrosus	12	16	16	13	10	7	15	16	16	16	10	15	15	14	15	16	16	16	16	16	16	16	16
Rhytidiadelphus triquetrus	0	3	1	0	0	0	8	0	0	0	0	0	4	1	2	2	1	0	1	0	1	2	0
Sanionia uncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	5
Sphagnum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thuidium sp.	13	14	12	0	16	2	9	14	13	3	7	2	1	4	14	0	0	0	0	0	0	1	0

Appendix 8, cont.

	511	512	513	514	521	522	523	524	611	612	613	614	621	622	623	624	625	626	631	632	633	634	635
Atrichum undulatum	2	2	4	10	0	0	4	0	0	1	14	0	1	1	3	2	0	4	4	3	0	3	1
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Brachythecium sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	12	0	1	0	11	16
Bryum sp.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliergonella cuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0	0	0	3	0
Campylium stellatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus polyanthos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirriphyllum piliferum	5	0	1	3	14	11	12	0	0	0	0	0	0	0	0	0	12	7	0	1	0	15	13
Climacium dendroides	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0
Conocephalum conicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cratoneuron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum sp.	7	0	5	0	0	0	0	0	0	5	0	1	0	0	0	0	2	0	0	0	0	0	0
Fissidens sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	12	16	16	0	3	8	9	11	13	15	16	15	5	7	8	2	1	6	1	0	2	8	1
Hypnum sp.	3	0	7	0	0	0	0	1	0	0	0	0	0	0	1	0	11	0	1	0	0	1	0
Isothecium alopecuroides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lophocolea bidentata	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	4	0	0	0	3	6
Lophocolea heterophylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moerckia blyttii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mylia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nardia scalaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pellia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Philonotis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiochila porelloides	0	0	0	0	0	0	0	0	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
Plagiomnium sp.	10	0	13	14	16	3	0	14	2	0	0	0	1	0	0	3	24	10	3	8	0	22	15
Plagiomnium undulatum	8	2	0	0	4	0	0	0	8	0	0	10	0	0	0	4	3	11	0	7	0	15	14
Pleurozium schreberi	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0
Pogonatum urnigerum	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pohlia wahlenbergii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum sp.	6	0	3	0	0	0	0	0	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0
Ptilium crista-castrensis	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Racomitrium canescens	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium lanuginosum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Rhytidium rugosum	0	0	0	0	0	10	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidiadelphus squarrosus	16	16	16	4	16	8	15	16	8	10	16	10	16	16	16	15	8	9	16	16	16	16	14
Rhytidiadelphus triquetrus	0	0	0	0	6	0	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Sanionia uncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Sphagnum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thuidium sp.	13	1	3	5	14	4	13	16	8	1	7	8	2	5	4	6	12	6	1	4	0	16	16

Appendix 8, cont.

	636	641	642	643	644	711	712	713	714	721	722	723	724
Atrichum undulatum	0	2	0	0	11	0	0	0	14	0	0	2	8
Barbilophozia barbata	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbilophozia floerkei	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachythecium sp.	3	1	1	1	0	0	0	16	5	0	0	7	0
Bryum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliergonella cuspidata	0	0	2	4	0	0	0	0	0	0	0	0	0
Campylium stellatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloscyphus polyanthos	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirriphyllum piliferum	2	0	3	0	5	0	3	9	10	7	10	14	6
Climacium dendroides	0	0	3	0	0	0	0	0	0	0	0	0	9
Conocephalum conicum	0	0	0	0	0	0	0	0	0	0	0	0	7
Cratoneuron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum sp.	0	0	0	0	0	0	0	0	1	0	0	0	0
Fissidens sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	8	5	2	9	7	9	1	0	0	0	0	0
Hypnum sp.	0	2	0	0	5	1	0	0	0	0	0	0	0
Isothecium alopecuroides	0	0	0	0	0	0	0	0	0	0	0	0	0
Lophocolea bidentata	0	0	0	0	0	0	0	0	13	0	0	0	0
Lophocolea heterophylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Moerckia blyttii	0	0	0	0	0	0	0	0	0	0	0	0	0
Mylia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Nardia scalaris	0	0	0	0	0	0	0	0	0	0	0	0	0
Pellia sp.	0	0	0	0	0	0	0	0	0	0	0	0	11
Philonotis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiochila porelloides	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
Plagiomnium sp.	1	0	6	3	1	16	16	15	15	16	13	15	9
Plagiomnium undulatum	1	0	0	0	0	0	0	0	4	0	0	0	0
Pleurozium schreberi	0	0	0	0	0	4	0	0	8	15	4	3	0
Pogonatum urnigerum	0	0	0	0	10	0	0	0	4	0	0	0	0
Pohlia wahlenbergii	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilium crista-castrensis	0	0	0	0	1	0	0	0	0	0	0	0	0
Racomitrium canescens	0	0	0	0	0	0	0	0	0	0	0	0	0
Racomitrium lanuginosum	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizomnium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhytidium rugosum	0	0	0	0	0	0	0	0	0	0	0	2	0
Rhytidiadelphus squarrosus	16	14	16	9	16	16	16	16	16	16	10	16	3
Rhytidiadelphus triquetrus	0	1	1	0	3	0	0	0	0	0	0	1	1
Sanionia uncinata	0	0	0	1	0	0	0	0	1	0	0	0	2
Sphagnum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Thuidium sp.	1	12	11	3	7	12	15	12	14	16	14	15	2

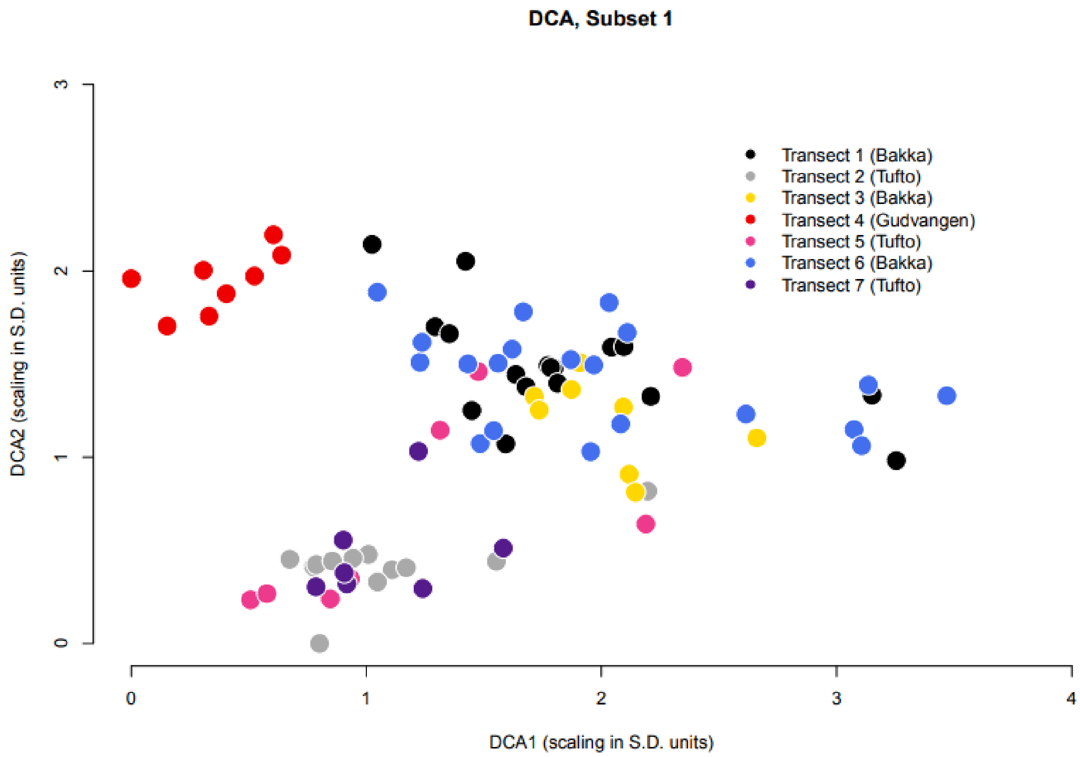
Appendix 9. Figures and tables from DCA ordinations.

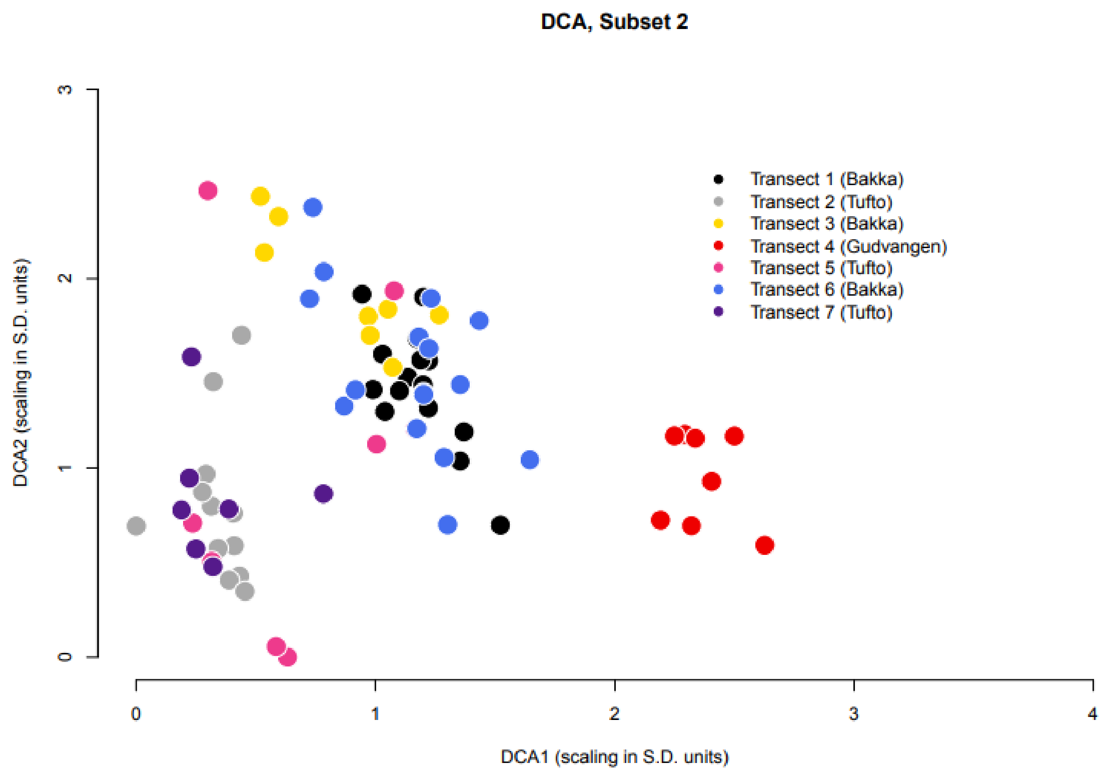
a) Kendall's τ correlation coefficients between DCA-axes and continuous explanatory variables for all three datasets. p-values <0.05 in bold.

	DCA1		DCA2		DCA1 sub1		DCA2 sub1		DCA1 sub2		DCA2 sub2	
	τ	p	τ	p	τ	p	τ	p	τ	p	τ	p
Aspect	0.1210	0.1107	**-0.1806**	**0.0173**	0.1220	0.1122	**0.3710**	**<0.0001**	**0.3565**	**<0.0001**	**0.2066**	**0.0097**
Slope	**-0.1584**	**0.0362**	**0.2874**	**0.0001**	**-0.1823**	**0.0173**	**-0.2574**	**<0.0001**	**-0.2582**	**0.0012**	**-0.2940**	**0.0002**
ConvH	-0.1625	0.0541	0.0564	0.5040	-0.1392	0.1052	-0.0435	0.4088	-0.0376	0.6739	**-0.2420**	**0.0097**
ConvV	**-0.2801**	**0.0012**	**0.1952**	**0.0241**	**-0.2516**	**0.0043**	-0.0083	0.3130	0.0208	0.8211	**-0.2826**	**0.0021**
Rock	0.0458	0.5499	-0.0403	0.5991	0.0320	0.6802	0.2066	0.1108	**0.2095**	**0.0097**	0.0231	0.7753
BareGround	**-0.1980**	**0.0144**	**0.4280**	**<0.0001**	**-0.2626**	**0.0014**	**-0.3612**	**<0.0001**	**-0.3385**	**<0.0001**	**-0.4286**	**<0.0001**
Mineral	**-0.1609**	**0.0496**	**-0.2362**	**0.0026**	**-0.1942**	**0.0149**	0.0178	0.4705	0.0564	0.4972	**-0.1946**	**0.0192**
GrainSize	**0.3126**	**0.0003**	**-0.4534**	**<0.0001**	**0.3682**	**<0.0001**	**0.1153**	**0.0004**	0.1046	0.2526	**0.3417**	**0.0002**
FieldLayer	0.0963	0.2053	-0.0372	0.6248	0.1060	0.1687	-0.2232	0.0971	**-0.2617**	**0.0011**	0.1027	0.2005
BotLayer	-0.0659	0.3884	-0.0868	0.2563	-0.0560	0.4690	**0.2082**	**0.0050**	**0.2409**	**0.0028**	-0.0162	0.8407
SoilDepth	0.0850	0.2603	0.0650	0.3891	0.0792	0.3008	**-0.1434**	**0.0197**	**-0.1826**	**0.0219**	-0.0056	0.9442
Altitude	**-0.3397**	**<0.0001**	**0.4621**	**<0.0001**	**-0.3790**	**<0.0001**	**-0.3783**	**<0.0001**	**-0.3656**	**<0.0001**	**-0.4332**	**<0.0001**
pH	**-0.3434**	**<0.0001**	**0.5710**	**<0.0001**	**-0.4137**	**<0.0001**	**-0.2509**	**<0.0001**	**-0.2976**	**0.0002**	**-0.3772**	**<0.0001**
LOI	**0.2482**	**0.0010**	**-0.2681**	**0.0004**	**0.2631**	**0.0006**	-0.1523	0.7744	**-0.2093**	**0.0084**	**0.1715**	**0.0307**
TotN	0.1472	0.0502	-0.1376	0.0672	**0.1835**	**0.0160**	-0.1658	0.3564	**-0.1892**	**0.0171**	0.0678	0.3931
TotP	-0.0973	0.1959	0.0828	0.2708	-0.1051	0.1678	**0.2835**	**0.0089**	**0.3573**	<0.0001	-0.0063	0.9368
LR	-0.1287	0.1335	**0.3765**	**<0.0001**	**-0.1899**	**0.0299**	**-0.5487**	**<0.0001**	**-0.5786**	**<0.0001**	**-0.2813**	**0.0020**
MI	**0.2886**	**0.0007**	**-0.3571**	**<0.0001**	**0.3473**	**<0.0001**	**-0.0475**	**0.0310**	-0.0755	0.4021	**0.3720**	**<0.0001**
Position	**-0.2559**	**0.0023**	**0.3530**	**<0.0001**	**-0.3029**	**0.0004**	**-0.1587**	**0.0271**	**-0.1991**	**0.0243**	**-0.2326**	**0.0085**

b) Wilcoxon test between the six factor variables and DCA-axes for all three datasets.

	DCA1		DCA2		DCA1 sub1		DCA2 sub1		DCA1 sub2		DCA2 sub2	
	w	p	w	p	w	p	w	p	w	p	w	p
Shrub	219	**0.0135**	52	0.1031	85	0.4474	513	0.5225	121	0.7012	90	0.6610
Tree	472	**0.0339**	252	0.2596	329	0.5160	339	0.4180	210	0.3517	265	0.9931
Litter	283	0.1454	506	0.1177	259	0.0936	496	0.1051	387	0.1200	207	0.1598
DeadWood	609	**0.0422**	341	0.1743	577	0.0659	492	0.4652	325	0.5967	342	0.4177
Droppings	694	0.7259	474	0.0522	714	0.4159	593	0.6316	503	0.4179	662	0.2899
SD	546	0.3917	397	0.3333	534	0.3653	513	0.5225	456	0.6252	572	**0.0365**





c) Ordination diagrams for DCA ordination of Subset 1 and Subset 2