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An autoecological study of *Cephalantera rubra* in Norway

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Title: An autoecological study of *Cephalanthera rubra* in Norway

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Abstract

Red helleborine (*Cephalanthera rubra*) is an endangered orchid in Norway. The Norwegian populations are part of the northernmost distribution of red helleborine and has been given a prioritized status in Norway, to ensure protection of the species. This status implies protection not only of the species, but also its ecological functional area. While the habitat of red helleborine is described in broad terms by many, a narrower description is needed. Seven known locations were investigated to more accurately describe habitat preferences of red helleborine in Norway, and investigate the main sources of variation in the lime-rich forests where red helleborine is found. Each location was mapped with the Norwegian EcoSyst implementation "Nature in Norway", and vascular plant species, mosses and lichens recorded in 54 one square metre plots several environmental variables. GNMDS and DCA ordination was used in parallel to identify important gradients in red helleborines habitat.

The results from this study were consistent with previous descriptions of red helleborines habitat but were unable to narrow down redd helleborines habitat preferences. No significant correlation was found between presence of red helleborine and the environmental variables recorded. Three main sources of variation in the sites were identified from the ordination: natural disturbance, calcium and tree-species composition. Further studies or experiments are recommended in order to more accurately understand distribution patterns of red helleborine in Norway.

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Abbrevations

The following table describes significant abbreviations used in the thesis, as well as where the abbreviation is first encountered.

Abbreviation	Description	Page
AF	Aspect favourability	11
BD	Bjørkedokk	5
BK	Bjørneknuen	5
BRB	Bare rock	11
BSB	Bare soil	11
C. rubra	*Cephalanthera rubra*	1
CA	Calcium content of the soil	12
CR	Presence/absence of *Cephalanthera rubra*	10
CS	Canopy opening in the south direction	11
CT	Tree canopy opening	10
DCA	Detrended correspondance analysis	17
ELN	Ellenberg indicator calue for nitrogen	13
HEP	Field layer cover	11
HF	Hamrefjell	6
HI	Heat index	11
GNDMS	Global non-metric multidimensional scaling	17
GRB	Ground layer cover	11
KA	Kirkeåsen	6
LEC	Local environmental complex variable	4
LIP	Litter cover	11
LOI	Loss on ignition	12
NiN	Nature in Norway	3
NKA	Lime richness	11
NUF	Drought risk	11
P	Phosphorus content of the soil	12
SD	Skjelldalen	6
SF	Solbergfjell	5
SHB	Shrub layer cover	11
SLO	Slope	11
SOI	Soil depth	11
SY	Synken	6
TRC	Vegetation layer cover	11

1 Introduction

1.1 Background

Cephalanthera rubra, the red helleborine, is one of the most striking visages in Norwegian flora with its unmistakable, beautiful pink flowers on a spindly dark green stem. If you happen to come across *C. rubra* in Norway, you have probably come looking for this ‘red maiden of the forest’, as it is called in Norwegian. *C. rubra* is listed as endangered on the Norwegian Red List for Species 2021 (Solstad et al., 2021), mainly because of its limited occurrence, fragmented distribution and limited genet count (plants of the same genetic makeup). *C. rubra* is found in most of Europe, from the Atlantic to the Caspian sea (Hultén, 1971; Hultén and Fries, 1986), and is listed with status of Least Concern in the European Red List for Vascular Plants (Bilz et al., 2011). The Norwegian *C. rubra* populations are on the northern margin of *C. rubras* distribution, with most Norwegian populations situated on the western side of the Oslo Fjord (Fægri and Danielsen, 1996; Hultén, 1971).

C. rubra is a member of the *Orchidaceae* family, one of the most diverse families of plants with over 28000 accepted species (Govaerts et al., 2022) that has fascinated many biologists over the years, perhaps most famously Darwin himself (1862). 35 species of the *Orchidaceae* family are found on the Norwegian mainland (Elven, 2021), and of these 12 are on the Norwegian Red List for Species 2021 (Artsdatabanken, 2021) including *C.rubra*. An action plan for the preservation of red helleborine was written in 2006 with the purpose of preservation of the localities where *C. rubra* is found in Norway (Direktoratet for naturforvaltning, 2006). This plan was the first of its kind for a plant species in Norway (Hoell, 2013).

In 2011 *C. rubra* was given status as a prioritized species in accordance with the Norwegian Nature Diversity Act §23 (Forskrift om rød skogfrue som prioritert art, 2011; Naturmangfoldloven, 2009). A species can be given the prioritized status by the government to assure that the species and its genetic diversity is preserved in its natural distribution (Naturmangfoldloven, 2009). This status implies that the ecological functional area of *C. rubra* is protected against all invasive measures except for those that are necessary to maintain the ecological functional area of the species (Forskrift om rød skogfrue som prioritert art, 2011). An ecological functional area is defined in the Nature Diversity Act as an area that fulfils an ecological function for a species, and has been defined by Framstad *et al.* (2018) as areas that are ecologically important for a species during any time of its life cycle, and includes the species' habitat. There is however no good description of *C. rubras* ecological functional area yet. Such a description would greatly assist in the preservation of the species in Norway and might contribute to locating undiscovered populations or make better prioritizations when it comes to protection efforts and resource management.

The action plan and prioritized species status dictates that known populations of *C. rubra* are to be closely monitored. The Norwegian Botanical Association has arranged for flora guardians to help with monitoring *C. rubra*. The flora guardians are volunteers organized through the Norwegian Botanical Association that monitor known populations of endangered plant species (Hoell, 2013). In 2013 there were 24 flora guardians assigned to *C. rubra* (Hoell, 2013). Six core locations where *C. rubra* is found are specially monitored on an individual level with population biological methods to identify important aspects of the population biology and life cycle of *C. rubra* in Norway (Bratli, 2016). These core localities in Drammen, Kragerø and Øvre Eiker cover the geographical variation of *C. rubra* on the western side of the Oslo Fjord.

1.2 The ecology of *C. rubra*

C. rubra is a rhizomatous species and has been known to enter a stage of dormancy for up to four years (Bratli, 2016; Reintal et al., 2010). This means that a single ramet (a single plant) might produce several shoots in the same year but also over the course of several years. Because genets are impossible to separate in the field the definition *individual* in this thesis refers to a single shoot of *C. rubra*. Like many other orchids, *C. rubra* is reliant on mycoheterotrophy for seed germination as orchid seeds are underdeveloped and most carry no endosperm and are thus dependent on nutrition from mycorrhizal fungi (Rasmussen, 1995; Smith and Read, 2008a; Yeung, 2017). Some species of orchid such as the achlorophyllous *Neottia nidus-avis* remain mycoheterotrophic for their entire life span, and some later turn autotrophic (Smith and Read, 2008b). Other species opt instead for a mixotrophic lifestyle and use both photosynthesis and mycoheterotrophy to obtain nutrition. Several *Cephalanthera* species, including *C. rubra*, have been proven to obtain nutrition from mycoheterotrophy at all life stages while also photosynthesizing (Gebauer and Meyer, 2003; Hemrová et al., 2019; Smith and Read, 2008b). This mixotrophic lifestyle explains how *C.*

rubra can remain dormant for several years without producing shoots to photosynthesize (Shefferson et al., 2018).

The habitat of *C. rubra* has been described in wide terms previously. *C. rubra* is generally accepted to be a calciphile plant (Delforge, 2006; Harrap and Harrap, 2010; Lid and Lid, 2005; Tutin et al., 1980), and is often mentioned to be found in sloping terrain (Blamey and Grey-Wilson, 2003; Jonsell, 2010). It is also generally agreed that *C. rubra* is found in forest (Harrap and Harrap, 2010; Sundberg, 2017; Tutin et al., 1980), but description of forest tree composition vary geographically between beech and oak trees in Britain and central Europe (Delforge, 2006; Harrap and Harrap, 2010) to pine forests in Scandinavia (Edqvist and Karlsson, 2007; Sundberg, 2017). It is also mentioned several places that *C. rubra* prefers shaded to half-shaded environments (Delforge, 2006; Harrap and Harrap, 2010; Mossberg and Stenberg, 2018). These descriptions are broad and include more suitable areas than where *C. rubra* is found currently in Norway. A narrower, more precise description of the species habitat is therefore needed to understand the species' needs and why it is restricted to the locations where it is currently found. Hemrová *et al*. (2019) investigated *C. rubras* habitat in the Czech Republic in 2019, and concluded that *C. rubras* distribution is also closely linked to orcanic matter content, potential direct solar radiation and an association index relating to three other orchid species. In the same study Hemrová *et al.* also performed a germination experiment which suggested that dispersion of *C. rubra* is also limited by availability of a fungal associate.

1.3 The Nature in Norway system

Structural variation in nature is often the result of a few underlying complex-gradients (Halvorsen, 2012; Halvorsen et al., 2020). A complex-gradient is defined as a gradient resulting from several variables that covary to some degree (Whittaker, 1956). The *Nature in Norway* (NiN) system for description of natural variation in Norway is centred around this principle, and is an implementation of the EcoSyst framework for systematization of natural diversity proposed by Halvorsen *et al.* (2020). NiN was first launched in 2009 and has since been updated (Halvorsen et al., 2016). Natural variation is in the NiN system defined as "variation in nature composition, structure and function" (Halvorsen et al., 2016) . The NiN system is a hierarchical type system that categorizes the natural variation based on the underlying causes of compositional variation for all levels of nature, from life medium to the landscape level. On the ecosystem level the NiN system integrates perspectives from both geological and biological diversity. NiN version 2.2 was used in this thesis and it contains 7 major-type groups, 92 major types and 741 minor types in nested hierarchical levels (Halvorsen et al., 2020). The NiN system also has an attribute system that contains descriptive variables that can be used to describe variation not captured by the type system.

The NiN system uses *local environmental complex variables* (LECs) to define major types and separate minor types from each other (Halvorsen et al., 2020). LECs are complex variables and gradients that are stable over centuries and typically vary on scales smaller than 1 km. The minor types in the NiN system are obtained by dividing major types into units of comparable amounts of variation on a species level. One of the overarching goals of the NiN system is that the results should be verifiable and reproducible, and the system is built up of strict rules and criteria to achieve this (Halvorsen et al., 2016). The NiN system is relevant for describing the habitat of *C. rubra* as well as the surrounding area.

C. rubra is found within the major type forest (T4), which is characterized by having trees as a structuring species group (Halvorsen et al., 2020). The forest minor types are separated by the LECs "lime-richness", "risk of drought" and "strength of spring-water influence" (Halvorsen et al., 2020). Lime-rich coniferous forest types are of special interest for preservation and conservation due to their rarity, species richness and diversity but remain poorly investigated in Norway and there is still much research to be done on species composition and variation (Bjørndalen and Brandrud, 1989; Brandrud and Bendiksen, 2018). A better understanding of ecological variation within these forest types will aid in the understanding of *C. rubras* autoecology.

1.4 Aims

The aim of this thesis is to increase knowledge about the autoecology of *Cephalanthera rubra* in Norway and provide a more precise description of the species' habitat and ecological functional area. Such a description could assist in not only in the preservation of the species' current habitat, but also help in identifying suitable habitats or discover new populations. The NiN system will be central in describing the natural variation around *C. rubra* and how *C. rubra* is distributed along important LECs. This thesis will provide knowledge not only about *C. rubra,* but could also potentially lead to information about how the species composition varies in the lime-rich forest where *C. rubra* is found.

2 Study area

2.1 Locations

The study areas consisted of several locations with populations of *C. rubra* in Norway known from herbarium specimens in Norwegian museum collections; the action plan for *C. rubra* (Direktoratet for naturforvaltning, 2006); surveillance and preservation work conducted by Bratli (2016); and communication with designated flora guardians. The locations are in the south-eastern part of Norway, up to 400 m above sea level and most of the locations lie west/north-west of the Oslo Fjord. One notable exception is the Skjelldalen location which is west of Aremark, further east than the other populations (Hanssen, 1996). From all the known locations a subset was chosen to cover both the geographical and ecological extent of the species, of which 7 were visited during the fieldwork season. Table 2.1 contains coordinates, information about altitude, bioclimatic zone and abbreviations used for plot IDs for all locations that were visited. Most locations were in the boreonemoral (BN) or southern boreal (SB) bioclimatic zone, and all locations were in the weak oceanic bioclimatic section (Bakkestuen et al., 2008).

Bjørkedokk (BD) lies in former Nedre Eiker municipality and has the largest population of *C. rubra* of the locations studied, with 239 recorded individuals between 2008 and 2021 (Bratli, 2021). The population lies predominantly in a south-eastern to south-western facing slope, with some subpopulations lying on the other, north-western facing side of the hill-ridge. A subpopulation is defined in this thesis as a grouping of *C. rubra* individuals with a maximum distance of 20 m between each individual shoot. The location is split by the road Nordlysveien, and only the northern, larger portion of the location was included in this study to not spend an exorbitant amount of time on one location only. The Bjørkedokk population is covered mostly by calcareous pine forest (Bratli, 2016).

Bjørneknuten (BK) lies in Kragerø municipality north-east of the Langtangtjenna lake. A total of 26 *C. rubra* individuals were reported between 2008 and 2021 (Bratli, 2021). The population is in a southwestern-facing slope in calcareous forest mostly dominated by oak with some other tree-species in between (Bratli, 2016).

Solbergfjell (SF) lies around two kilometres east of Bjørkedokk in Solbergfjellet nature reserve in Nedre Eiker, and 91 individuals were recorded between 2010 and 2021 (Bratli, 2021). The population is in a steep slope facing southeast, in a dry calcareous forest with a wetter strip dominated by grass running through the population down the hillside.

The Hamrefjell (HF) study location consists of several subpopulations of *C. rubra* in Øvre Eiker. They are all called “Hamrefjell” as a group and all are situated in calcareous pine forests in south facing hills. A total of 57 individuals have been recorded from 2008 until 2021 (Bratli, 2021, 2016). The subpopulation that was studied is on a south-southwestern facing slope of a mountain located on a geological nature reserve. The reserve is protected for geological reasons, for presence of contact-metamorphic rock and vesuvianite (Miljøverndepartementet, 1984).

Kirkeåsen (KA) is in a steep southwestern facing hill east of Heggen church in Modum municipality where *C. rubra* was discovered in 2011 by flora guardians Berit Spone and Svein Skretteberg. Around 20 individuals were found on visitation in 2011 (Eken, 2011). The population lies in calcareous forest influenced by calcareous rockslide deposits.

Skjelldalen (SD) outside Aremark municipality is the most isolated of the Norwegian populations found so far, and lies closer to the Dalsland population in Sweden (Sundberg, 2017) than it does any of the recently observed Norwegian populations. The two individual *C. rubra* plants found in this site are on lime-rich shell-sand banks in the middle of lime-poor forest. A small mire and swamp area to the north of the population is connected to a fen south of the population by a stream that runs along the shell bank.

Synken north (SY) is one of two sites with a single *C. rubra* near the artificial pond Synken in Bamble municipality, the other is on the south side of the pond. Both are in a small pine forest surrounded by an urban area. The northern individual, which lies on a small flat next to the trail, was chosen for study as *C. rubra* has been observed sporadically in both these sites but more often on the north side. The southern population is considered lost (Hanssen and Bratli, 2009).

Table 2.1. Overview of sites with abbreviations and number of plots per site. Altitude is rounded to the nearest 50 m for the middle of the location. Bioclimatic zones and sections are found in Bakkestuen *et al.* (2008). Bioclimatic zones are boreonemoral (BN) and southern boreal (SB).

Site	**Abbreviation**	**Bioclimatic zone**	**Latitude (°N)**	**Longitude (°E)**	**Altitude**
Bjørkedokk	BD	BN	59.764712	10.02317	200 m
Bjørneknuten	BK	BN	58.887747	9.409887	50 m
Hamrefjell	HF	SB	59.693093	9.907815	300 m
Kirkeåsen	KA	SB	59.940172	10.011384	300 m
Skjelldalen	SD	BN	59.306233	11.604144	150 m
Solbergfjell	SF	SB	59.771316	10.054992	350 m
Synken	SY	BN	59.027962	9.708213	100 m

3 Materials and methods

3.1 Study design

3.1.1 Mapping

The field work for this thesis was carried out between June and September in 2021.

The study areas were mapped with the NiN system version 2.2 in scale 1:5000 (Bryn and Ullerud, 2018) in QGIS (QGIS Development Team, 2022) before the selection of plot positions. The map included a buffer of 100 m along the ground around a minimum convex polygon that encompassed all individuals of *C. rubra* in the population. If only one or a few clustered individuals were known in the population the map was a circle with a radius of 100 m with the plant in the centre. The maps were drawn digitally in QGIS on a Getac field-tablet.

3.1.2 Plot selection and criteria

A stratified random sampling procedure was developed to capture the variation inside and close to *C. rubra*'s known habitat. A completely random sampling procedure was not chosen as it would capture variation that would obscure the finer scale gradients that can be used to narrow down the habitat description of *C. rubra* further than what has been done by others. For each mapping unit polygon containing at least one *C. rubra* individual, a plot was placed on one *C. rubra* plant (or where a shoot was known to have been recently) randomly selected in each subpopulation within the polygon. A subpopulation in this thesis is defined as a grouping of individuals no further apart than 20 m. For each plot containing *C. rubra* a random plot was placed within the same mapping unit polygon on the map. The random plots were placed by first using a random number generator to choose a coordinate within the polygon on the east–west axis to place a north–south axis by constricting the random number generator to coordinate values in the range of the western- and easternmost point in the polygon. A coordinate was then chosen on the created north–south axis by using a random number generator for values between the northern- and southernmost points on the axis that were inside the chosen polygon. If the amount of plots in a location was less than five, the selection of random plots continued until there was a minimum of five plots per location. The limit to amounts of plots per location was set to 30.

A plot was discarded if:

- The plot contained a permanent water table (such as a lake).
- The plot was in unsafe terrain or unapproachable.
- The plot was covered by more than 50% bedrock.
- The plot was on strongly altered or artificial substrate.

When approaching the coordinates in the field, the plot was placed where the GPS displayed the correct coordinates for three seconds. If a plot was discarded due to the discard-criteria, a new plot was chosen using the same procedure from the start.

3.1.3 Recording of vegetation

Each plot measured 1×1 m, and was further divided into 16 subplots each measuring 25×25 cm. All plots were measured by folding two carpenters' rulers 90°, attaching them together and rotating so that the plot faced directly north. Division of subplots was done visually to avoid damaging *C. rubra* with physical markers. The abundance of vascular plants, bryophytes and lichens was recorded for each plot and scored by a combination of frequency and cover (Table 3.1) both for species rooted inside and outside the plot. Specimen rooted on loose wood and rock were not recorded. Cover was recorded for each species by estimating how much of the plot was covered by the specimen when projecting vertically down onto the plot surface. If a specimen was significantly damaged from harvesting or grazing (or wilted later in the season), coverage was estimated conservatively. Coverage and frequency were transformed into an abundance score out of 10 by summing frequency and coverage scores from Table 3.1. If a plot had fewer than 10 species present, the size of the plot was doubled centred on the midpoint of the plot. Presence of new species in the extended plot was registered by giving them an abundance score of 1 and marking that they were found outside the original plot and how large the plot was when the species first occurred in the plot. This process was repeated until the expanded plot contained more than 10 species (after all species in the expanded plot was registered).

Table 3.1. Scoring table for frequency and coverage. Scores equal a frequency in the corresponding range, or coverage above the corresponding value.

Score	Frequency	Coverage
0	0	$0-\frac{1}{16}$
1	1	$\frac{1}{16}-\frac{1}{8}$
2	2	$\frac{1}{8}-\frac{1}{4}$
3	3–4	$\frac{1}{4}-\frac{1}{2}$
4	5–8	$\frac{1}{2}-1$
5	9–14	
6	15–16	

At some plots selected for presence of *C. rubra*, the plant was not present during analysis. This could be because an individual was either dormant or dead, but previously recorded at that position. In those plots the abundance score of *C. rubra* was set to 1 before statistical analysis was performed. A variable was also constructed for later analysis for each plot with presence or absence of *C. rubra* (CR).

Nomenclature followed the Norwegian Biodiversity Information Centre (Artsdatabanken, 2015). Some species were aggregated into genera as further identification was not possible. This includes *Cladonia* spp., *Cotoneaster* spp., *Hieracium* spp., *Rosa* spp., *Sphagnum* spp. and *Taraxacum* spp. *Betula pendula* and *Betula pubescens* as recorded in the variables nearby trees and shrubs were merged to form a *Betula* spp. in the analysis of environmental variables.

3.1.4 Environmental variables

Several variables were recorded in each plot to investigate *C. rubra*'s response to different environments and how it differed in the plots where *C. rubra* was not present.

Tree canopy opening (CT) was measured by using a densiometer, a reflective, gridded, convex metal instrument which is held level around 30 – 45 cm from the body at elbow height. The number of quarter-squares in the grid not covered by the tree canopy was counted, and the canopy opening given as the sum of all the open squares for all cardinal directions. (Lemmon, 1956). Canopy opening to the south (CS), which was obtained as a part of measuring the total forest canopy opening, was also used in statistical analysis to investigate if solar radiation from the southern direction impacted presence of *C. rubra*.

Vegetation layer cover was recorded in the tree (TRC), shrub (SHB), field (HEP) and bottom layer (GRB). Trees were defined as all woody plants above 2 m, and shrubs as all plant species between 0.5 and 2 m. Trees and shrubs taller than 0.5 m present within 5 m of the plot were recorded to be used for statistical analysis separately from the species abundance scores. Litter (LIP), bare soil (BSB) and rock coverage (ROB) was also recorded as percentage cover of the plot.

Soil depth (SOI) was measured by pushing a steel rod graduated at 5 cm intervals vertically into the substrate at eight points around the plot until it stopped. The average of all eight values was used in the statistical analysis. The main reason for using this technique is its simplicity and inexpensiveness. Soil samples were taken from all plots to be analysed later except for plot HF03 and HF04 which were 2 m apart in a geological nature reserve, therefore only one sample was taken in the midway between the HF03 and HF04 plots. Legal permissions for soil sample collecting were gathered prior to sampling.

Lime richness (NKA) and risk of drought (NUF) were derived from the NiN maps as factor variables of the LEC's in the "forest" major type. All plots were in the forest major type except for plots BD13 and BD14 which were in major type T35 (wasteland, extracted or deposited surficial deposit). For those two plots lime-richness could not be inferred directly from the mapping units and was estimated by the surrounding forest and risk of drought was estimated as high (4) as the plots were placed in an open, very dry sandy slope.

Slope (SLO) and dominant aspect were recorded with a clinometer. Slope and aspect were used to construct two synthetic variables to address the issues of circular data (where 0° and 360° are the same and 180° is opposite those) and favourability of some aspects of solar radiation and heat. The synthetic variables were heat index (HI)(Parker, 1991) and aspect favourability (AF)(Økland and Eilertsen, 1993) which was calculated with the underlying assumption that 202.5° (south-west) is the most favourable aspect at our latitude (Dargie, 1984). Formulas for both aspect favourability (3.1) and heat index (3.2) for the plots:

$$\boldsymbol{f_i = 175^g + a_i} \tag{3.1a}$$

$$\boldsymbol{f_i = |a_i - 225^g|} \tag{3.1b}$$

$$\boldsymbol{h_i = \cos(p_i - 225) \times \tan(s_i)} \tag{3.2}$$

Where a_i is the aspect directions in gradians in plot i; f_i is the aspect favourability; s_i is the slope; p_i is the aspect in degrees and h_i is the heat index. Formula 3.1a was used for plots with an aspect of less than 25^g, and 3.1b for plots with an aspect of above 25^g. The resulting aspect favourability is given on a scale from 0 (most favourable) to 200 (least favourable).

The tree and shrub species presence variables were joined into a single variable indicating presence or absence near the plot. Abbreviations for each species used in these variables are in Table 3.2. The purpose of the variables representing tree and shrub species near the plot was to see if the presence of *C. rubra* could be tied to a particular tree or shrub species. Only tree and shrub species present at multiple locations were investigated further in the statistical analyses.

3.1.5 Soil analyses

Chemical soil analyses were performed in the soil analysis lab at the Norwegian University of Life Sciences (NMBU) in January 2022. The soil was analysed for loss on ignition (LOI), pH, phosphorus (P), and calcium (CA) following “Metoder for Jordanalyser” by Krogstad (1992); “Jord200: Field and Laboratory methods” by Krogstad & Børresen (2015) and Norwegian Standard 4725 (Standard Norge, 1984). Soil samples collected from the topsoil from two corners where possible and deposited into paper boxes. Samples were stored in a commercial freezer at –5 °C until test preparation. The samples were then dried at 45 °C over a 72-hour period and then transported to the lab at NMBU, where they were sieved through a 2 mm mesh steel sieve. The sieve was cleaned with pressurised air between each sample. Subsamples were taken from the larger sample boxes for each test.

LOI was used as a proxy variable for organic material in the soil. Crucibles were weighed individually before and after adding between 3–5 g of soil from each sample and weighing again, with an accuracy of 0.001 g. The samples were then dried again overnight at 105 °C to ensure no moisture was left and weighed to determine dry matter content. The crucibles were put in a calcinating oven at 550 °C for at least 3 hours before cooling in the oven overnight and weighed again the following morning. The LOI value was the percentage difference in weight between the incinerated sample and the dried sample, subtracting the crucible weight.

10 ml of soil was extracted for the pH analysis and then submerged in 25 ml deionized water inside a plastic tube. The samples were shaken thoroughly by hand to mix them and then left in room temperature overnight and shaken again the next day. Once the sediment had settled, pH was measured using a Meterlab PHM 210 pH-meter. The pH-meter was calibrated using a pH 4 and a pH 7 solution and recalibrated every 25 samples.

Phosphorus and calcium in the samples was measured using the ammonium-lactate (AL) method. 2 g of soil was submerged in 40 ml AL-solution in 100 ml glass bottles, then shaken on a machine for 1.5 hours. Blue ribbon filters were prepared by washing in a 10 times diluted AL solution. After shaking was performed, the samples were filtered through the washed blue ribbon filters into 50 ml bottles and sent for analysis after the Norwegian Standard for water samples (Standard Norge, 1984). Calcium (CA) and phosphate (P) values were expressed as a percentage of LOI by multiplying the values with 100 and then dividing on LOI in order to better reflect exchangeable cation availability, as recommended by Økland (1988).

Ellenberg indicator values for nitrogen (ELN) were used in place of nitrogen soil tests for logistical reasons in the soil lab. The replacement was used as a suboptimal approximation to nitrogen content in the soil. Ellenberg indicator values are estimates of species optima on a 1-9 scale, where 1 is the least content of nitrogen in the soil and 9 is the most. The Ellenberg score per plot were weighted according to abundance. Values were found in Ellenberg (2001). The Ellenberg values are only indicators of soil properties and have been criticised for their inherent bias (Wamelink et al., 2002; Zelený and Schaffers, 2012), and significant results from the use of Ellenberg indicator values should therefore be evaluated carefully.

3.2 Data

3.2.1 Data manipulation

The plot-species data was transformed into a species abundance matrix with the cast function from the reshape package (Wickham, 2007) in R.

All continuous environmental variables were subjected to a zero-skewness standardization (Økland et al., 2001). Zero-skewness was obtained using the “goal seek” function in Excel by changing the c-value in the following formulas until the skewness of the resulting variables was less than 10^{-5}:

$$\boldsymbol{y_{kj}} = \mathbf{ln}(\boldsymbol{c_k} + \boldsymbol{x_{kj}}) \tag{3.3}$$

$$\boldsymbol{y_{kj}} = \mathbf{ln}(\boldsymbol{c_k} + \mathbf{ln}(\boldsymbol{c_k} + \boldsymbol{x_{kj}})) \tag{3.4}$$

$$\boldsymbol{y_{kj}} = \boldsymbol{e}^{\boldsymbol{c_k x_{kj}}} \tag{3.5}$$

$$\boldsymbol{y_{kj}} = \boldsymbol{e}^{\boldsymbol{c_k}(\boldsymbol{e}^{\boldsymbol{c_k x_{kj}}})} \tag{3.6}$$

where x_{kj} is the original variable k in plot j and y is the replacement value for that variable resulting in zero skewness. Formula 3.3 was used for right skewed variables and Formula 3.4 was applied to right-skewed variables if Formula 3.3 failed to standardize to zero skewness. Formulae 3.5 and 3.6 were used similarly for left-skewed variables. All categorical variables and values that were not able to be transformed to zero skewness were made into binary variables.

After the zero-skewness procedure was performed the variables were rescaled to between 0 and 1 by the following formula:

$$\boldsymbol{y_{scaled}} = \frac{\boldsymbol{y - y_{min}}}{\boldsymbol{y_{max} - y_{min}}} \tag{3.7}$$

The shrub and bottom layer cover as well as soil and rock cover were transformed into binary variables. For the NiN LEC’s lime richness and risk of drought, threshold values were set at 4 for lime richness and 3 for risk of drought. Values equal to or higher than the threshold value were transformed to 1, values below the threshold value were transformed to 0.

Table 3.2. Summary statistics for the 27 variables used in the analyses, range and mean for the untransformed variables, as well as transformation type and c-value used in transformations. Abbreviations used for further statistical analyses are in column 2. Recorded variables for each plot are in appendix 2.

Variable	**Abbreviation**	**Comment**	**Untransformed**		**Transformation**	
			Range	**Mean**	**Type**	**C-value**
Presence of C. rubra	CR	*Presence (1) or absence (0) of Cephalanthera rubra in the plot*	0–1	0.5	Binary	-
Canopy opening south	CS	*Measure of solar radiation entering the plot measured on the densiometer, for the south direction*	0–25	6.04	ln(c+x)	1.5590
Canopy opening total	CT	*Sum of densiometer open squares from all cardinal directions (maximum 384)*	0–217	38.5	ln(c+x)	5.1079
Tree layer	TRC	*Percentage vegetation cover of in the tree layer*	0–100	66.2	e^cx	2.2053
Shrub layer	SHB	*Percentage vegetation cover in the shrub layer*	0–70	12.4	Binary	-
Field layer	HEP	*Percentage vegetation cover in the field layer (below 0.5 m)*	0–80	27.0	ln(c+x)	0.090583
Bottom layer	GRB	*Percentage vegetation bottom layer cover*	0–85	10.9	Binary	-
Litter	LIP	*Percentage cover of litter*	0–90	45.2	e^c(e^cx)	0.29793
Bare soil	BSB	*Percentage bare soil cover*	0–60	9.54	Binary	-
Bare rock	ROB	*Percentage bare rock cover*	0–50	8.15	Binary	-
Soil depth	SOI	*Average soil depth in cm*	1.25–61.125	16.7	ln(c+ln(c+x))	3.0399
NiN Lime richness	NKA	*Based on the mapping units for the LCE lime richness in NiN for scale 1:5000*	2–4	3.5	Binary	-
NiN Drought risk	NUF	*Based on the mapping units for the LCE drought risk in NiN for scale 1:5000*	2–4	2.6	Binary	-
Slope	Slope	*Slope measured with a clinometer in degrees*	0–55	22.3	e^c(e^cx)	247.14
Aspect favourability	AF	*Aspect favourability measured on a scale from 0 – 200, 0 being most favourable (formulae 3.1a & 3.1b)*	2.78 - 186	51.6	ln(c+x)	20.363

Table 3.2. cont.

Heat Index	HI	*Heat index (formula 3.2)*	–0.315 – +0.839	0.240	ln(c+ln(c+x))	2.0154
Betula **spp.**	BES	*Presence or absence of* Betula *species taller than 0.5 m within 5 m of the plot*	0 – 1	0.41	Binary	-
J. communis	JUC	*Presence or absence of* Juniperus communi*s taller than 0.5m within 5 m of the plot*	0 – 1	0.57	Binary	-
P. abies	PIA	*Presence or absence of* Picea abies *taller than 0.5 m within 5 m of the plot*	0 – 1	0.87	Binary	-
P. sylvestris	PIS	*Presence or absence of* Pinus sylvestri*s taller than 0.5 m within 5 m of the plot*	0 – 1	0.74	Binary	-
P. tremula	POT	*Presence or absence of* Popula tremula *taller than 0.5 m within 5 m of the plot*	0 – 1	0.28	Binary	-
Q. robur	QUR	*Presence or absence of* Quercus robur *taller than 0.5 m within 5 m of the plot*	0 – 1	0.13	Binary	-
S. aucuparia	SOA	*Presence or absence of* Sorbus aucuparia *taller than 0.5 m within 5 m of the plot*	0 – 1	0.61	Binary	-
Loss on ignition	LOI	*Loss on ignition measured in percent*	5.54%–83.73%	24.1%	ln(c+ln(c+x))	0.55547
pH	PH	*Soil pH*	3.89–7.59	6.08	e^c(e^cx)	0.041718
Phosphorus	P	*Soil phosphorus (mg/kg)*	1.30–260	21.9	ln(c+ln(c+x))	-2.3786
Calcium	CA	*Soil calcium (g/kg)*	0.46–300	29.10	ln(c+ln(c+x))	-0.99514

3.2.2 Statistical analyses

All statistical analyses was done using the R package, version 4.1.2 (R core team, 2021) in R studio (RStudio Team, 2021). The vegan package (Oksanen et al., 2020) was used for all multivariate analysis.

Correlation between the environmental values was calculated using Kendall's rank correlation coefficient (Kendall, 1938) for pairs of continuous variables; the Mann-Whitney U-test (Mann and Whitney, 1947) was used for pairs of continuous and binary variables; and a χ^2-test (Pearson, 1900) was used for pairs of binary variables.

Ordination was performed on species-abundance data using the abundance score derived from both coverage and frequencies. Both global non-metric multidimensional scaling (GNMDS) (Kruskal, 1964) and detrended correspondance analysis (DCA) (Hill and Gauch, 1980) was used in parallel to help identify major ecological structure in the data (van Son and Halvorsen, 2014). The DCA was performed with the decorana function from the vegan package (Oksanen et al., 2020) with default values on the species-abundance matrix. The GNMDS was performed with three dimensions. The three-dimensional solution was chosen because comparing the DCA and GNMDS yielded significantly correlating results up to the third dimension of the GNMDS when comparing the axes. A stepacross algorithm with a threshold value of 0.8 was used to calculate distance between plots with little to no joint occurences (Williamson, 1978) as this has been shown to improve ordination results when the dataset has a high beta diversity (De'ath, 1999). The number of starting configurations was set to 1000, maximum iterations to 2000 and convergence limit to 1×10^{-7}. Scaling was done automatically to SD-units for the DCA through the decorana function. The GNMDS was scaled to half-units of dissimilarity using the postMDS function from the vegan package (Oksanen et al., 2020).

Comparison of the results from the GNMDS and DCA was performed using Kendall's rank correlation coefficient. The GNMDS and DCA produced pairwise correlating axes, and (see chapter 4 Results) only the GNMDS result was analysed further. The DCA was also tested with the environmental variables and yielded similar results. Correlation between the DCA ordination and environmental variables can be seen in appendix 3.

Correlation between the transformed environmental variables and the GNMDS-axes was tested using a Mann-Whitney U test (Mann and Whitney, 1947) for the binary variables and Kendall correlation test (Kendall, 1938) for the continuous variables.

Plots for ordination results were made with the ggplot2 package (Wickham, 2016). Isoline diagrams for the environmental variables were made using the ordisurf function from the vegan package (Oksanen et al., 2020) and ggplot2. Biplots with environmental variable were produced with the envfit function from the vegan package which allowed for extraction of vectors corresponding to environmental variable scores which could be plotted onto the ordination results.

4 Results

A total of 94 species were recorded in 54 plots. *C. rubra* was the second most recorded species and was observed in 27 plots. The most common recorded species was *Hieracium* spp. which was observed in 36 plots, and it was also most common species found together with *C. rubra* in 19 of the 27 *C. rubra* plots. *Epipactis atrorubens* was the second most common species observed together with *C. rubra*, in 14 of the *C. rubra* plots. *E. atrorubens* was observed in 18 plots in total. A complete species inventory with frequency and coverage scores is shown in appendices 4 and 5.

4.1 Map characteristics and location descriptions

A table with mapping unit descriptions is shown in appendix 1. After mapping and plot placement 22 plots were placed at Bjørkedokk; six plots were placed at Hamrefjell and Solbergfjell and five plots were placed at the remaining locations.

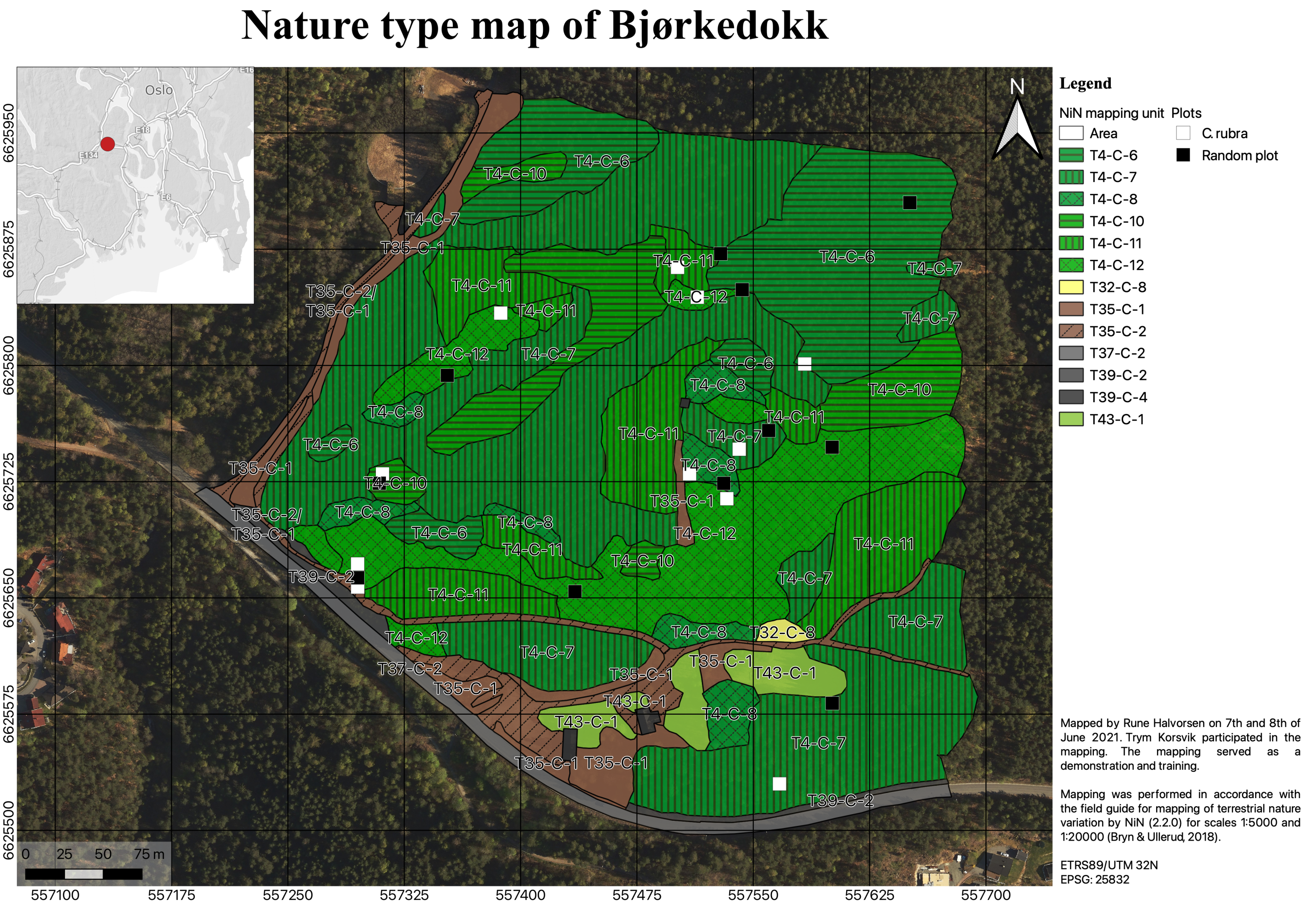
The most common nature type measured by area mapped was moderately lime-rich submesic to subxeric forest (T4-C-07) which made up 23.4% of the total area, followed by intermediately lime-rich submesic to subxeric (T4-C-06) which made up 12.1% of the total area mapped (Table 4.1). *C. rubra* was found in 8 mapping units, 7 of which were in the forest major type. The individuals in the “wasteland, extracted or deposited surficial deposit” major type were close to a forest subpopulation in Bjørkedokk (Figure 4.1). The 8 mapping units in which *C. rubra* was found make up 69.5% of the total area mapped. 18 of 27 *C. rubra* plots were in the highest level of lime-richness, T4-C-08, -12 or -16. These three lime-rich minor types make up a total of 15.24% of the total area mapped. *C. rubra* was not observed in the most lime-poor mapping units. The forest around all populations was mostly coniferous, but Kirkeåsen and Bjørneknuten had larger deciduous parts.

Most of the localities showed signs disturbance of either natural or anthropogenic origin. Most of the natural disturbance is the result of slope and/or loose substrate. In Solbergfjell the steep slope causes loose substrate to slide down the hill, which also happens in Kirkeåsen where rocks are dominant on the forest floor where *C. rubra* is found. Bjørkedokk is also affected by natural disturbance as it is in a slope, but an old ski-jump hill is found in the middle of the population and indicates historic anthropogenic disturbance. The *C. rubra* in

Synken is 3 m from a hiking path, and an old forestry access road runs through Skjelldalen where the *C. rubra* individuals are found. Field layer cover was low in most locations except for some grass-covered parts in Skjelldalen and Solbergfjell, and some parts of Bjørkedokk with colonies of *Pteridium aquilinum.* Coniferous forest was by far the most common forest type around *C. rubra*, except for in Bjørneknuten where *Quercus robur* was the most common tree species found near *C. rubra*.

Table 4.1. Land-cover statistics for all locations. Mapping unit descriptions are found in appendix 1. Statistics for mapping units where *C. rubra* was either known or present in are in bold.

Mapping unit	**Area mapped**		**Mapping unit**	**Area mapped**	
	m^2	**Per cent**		**m^2**	**Per cent**
T1-C-03	681	0.20%	T4-C-14	3694	1.07%
T1-C-04	206	0.06%	T4-C-15	2596	0.75%
T1-C-08	1450	0.42%	**T4-C-16**	**6473**	**1.87%**
T2-C-1	398	0.11%	T16-C-5	312	0.09%
T2-C-4	308	0.09%	T32-C-08	395	0.11%
T4-C-01	641	0.19%	T35-C-1	10328	2.98%
T4-C-02	4838	1.40%	**T35-C-2**	**7530**	**2.17%**
T4-C-03	10189	2.94%	T37-C-2	4637	1.34%
T4-C-04	1995	0.58%	T39-C-2	1783	0.51%
T4-C-05	7450	2.15%	T39-C-4	981	0.28%
T4-C-06	**41966**	**12.10%**	T40-C-1	744	0.21%
T4-C-07	**81148**	**23.40%**	T43-C-1	3312	0.96%
T4-C-08	**15695**	**4.53%**	V1-C-1	5613	1.62%
T4-C-09	16513	4.76%	V1-C-2	822	0.24%
T4-C-10	**28058**	**8.09%**	V1-C-6	1999	0.58%
T4-C-11	**29726**	**8.57%**	V2-C-1	1087	0.31%
T4-C-12	**30644**	**8.84%**	V2-C-2	1382	0.40%
T4-C-13	15737	4.54%	Water	5387	1.55%
Total	346716	100.00%			



Mapped by Rune Halvorsen on 7th and 8th of June 2021. Trym Korsvik participated in the mapping. The mapping served as a demonstration and training.

Mapping was performed in accordance with the field guide for mapping of terrestrial nature variation by NiN (2.2.0) for scales 1:5000 and 1:20000 (Bryn & Ullerud, 2018).

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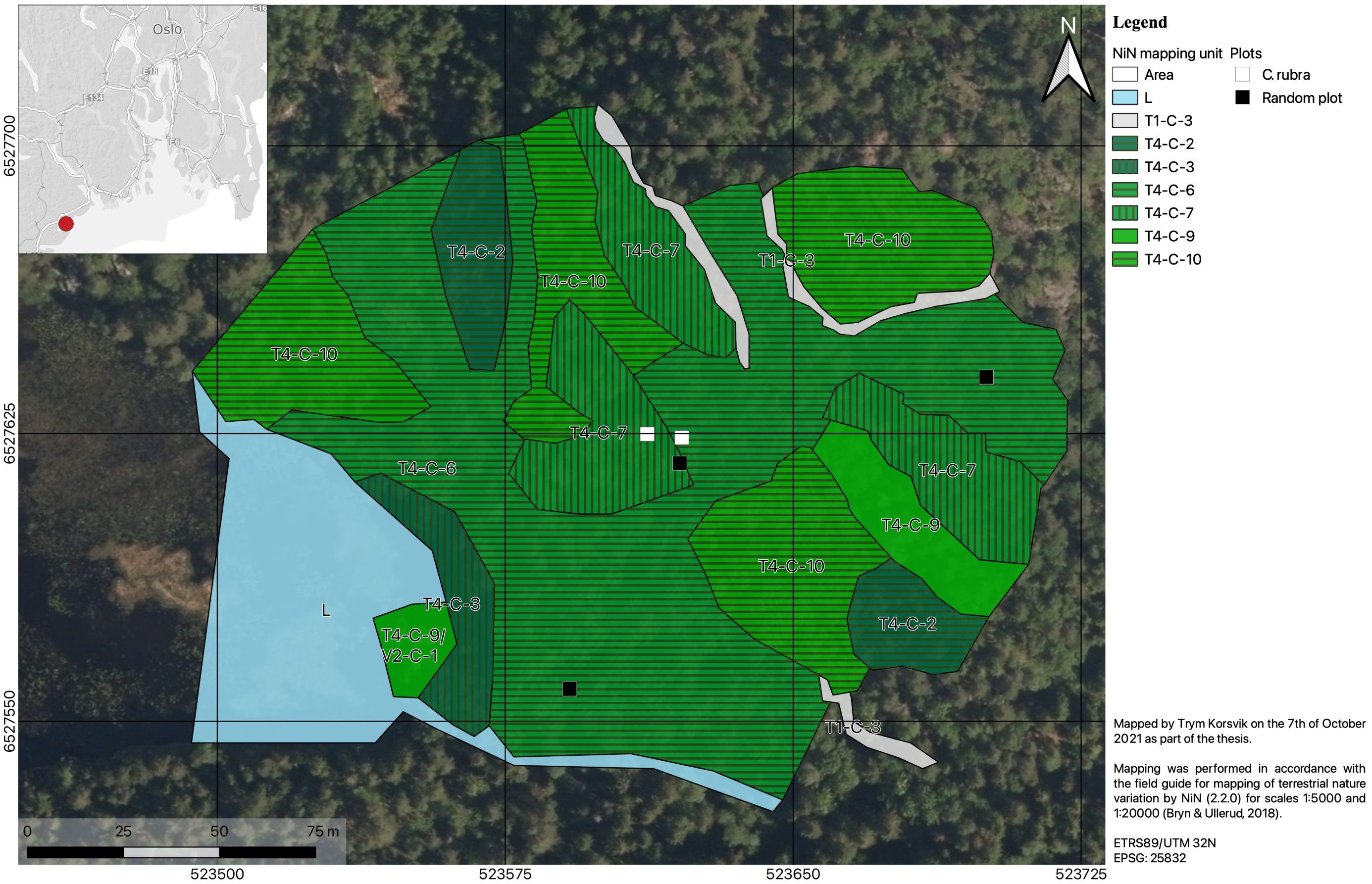
Figure 4.1. Land-cover map of Bjørkedokk, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows nature type polygons as well as positions of plots for the vegetational analysis over aerial photos from 2017 (COWI AS, 2019)

Bjørkedokk

Bjørkedokk was the largest population which was examined and mapped in size, number of different species recorded (61) and number of *C. rubra* individuals. The most frequently recorded species in the plots other than *C. rubra* were *Avenella flexuosa, Calamagrostis arundinacea*, *Epipactis atrorubens*, *Hieracium sp., Hylocomium splendens, Picea abies, Sorbus aucuparia* and *Viola riviniana*. The most common minor type was moderately lime-rich submesic to subxeric forest (T4-C-3). An overview of the different minor types encountered as well as cover statistics are shown in Table 4.2.

Table 4.2. Land-cover statistics for Bjørkedokk and list over which mapping unit *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	**Area**		***C. rubra* presence**
	m^2	**Per cent**	
T4-C-06	22854	13.56%	Yes
T4-C-07	61117	36.25%	Yes
T4-C-08	5573	3.31%	Yes
T4-C-10	12009	7.12%	Yes
T4-C-11	19836	11.77%	Yes
T4-C-12	22107	13.11%	Yes
T32-C-08	395	0.23%	No
T35-C-1	8462	5.02%	No
T35-C-2	6093	3.61%	Yes
T37-C-2	4637	2.75%	No
T39-C-2	1783	1.06%	No
T39-C-4	408	0.24%	No
T43-C-1	3312	1.96%	No
Total	168587	100.00%	



Nature type map of Bjørneknuten

Mapped by Trym Korsvik on the 7th of October 2021 as part of the thesis.

Mapping was performed in accordance with the field guide for mapping of terrestrial nature variation by NiN (2.2.0) for scales 1:5000 and 1:20000 (Bryn & Ullerud, 2018).

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Figure 4.2. Land-cover map of Bjørneknuten, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2015 (Omløpsfoto, 2016). L indicates limnic systems (fresh water).

Bjørneknuten

Bjørneknuten had only a single subpopulation spanning two different minor types, resulting in a total of five plots. *Vaccinium myrtillus* was found in all plots, and *Convallaria majalis* was found in four of the five plots. A total of 26 different species were recorded in Bjørneknuten. Close to 40% of the land cover was intermediately lime-rich submesic to subxeric forest (T4-C-06). An overview of the different minor types encountered as well as cover statistics are shown in Table 4.3.

Table 4.3. Land-cover statistics for Bjørneknuten and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	**Area**		***C. rubra* presence**
	m^2	**Per cent**	
Water (L)	3723	12.36%	No
T1-C-03	681	2.26%	No
T4-C-02	1598	5.31%	No
T4-C-03	873	2.90%	No
T4-C-06	11709	38.88%	Yes
T4-C-07	3619	12.02%	Yes
T4-C-09	1181	3.92%	No
T4-C-10	6582	21.85%	No
V2-C1	149	0.50%	No
Total	30117	100.00%	

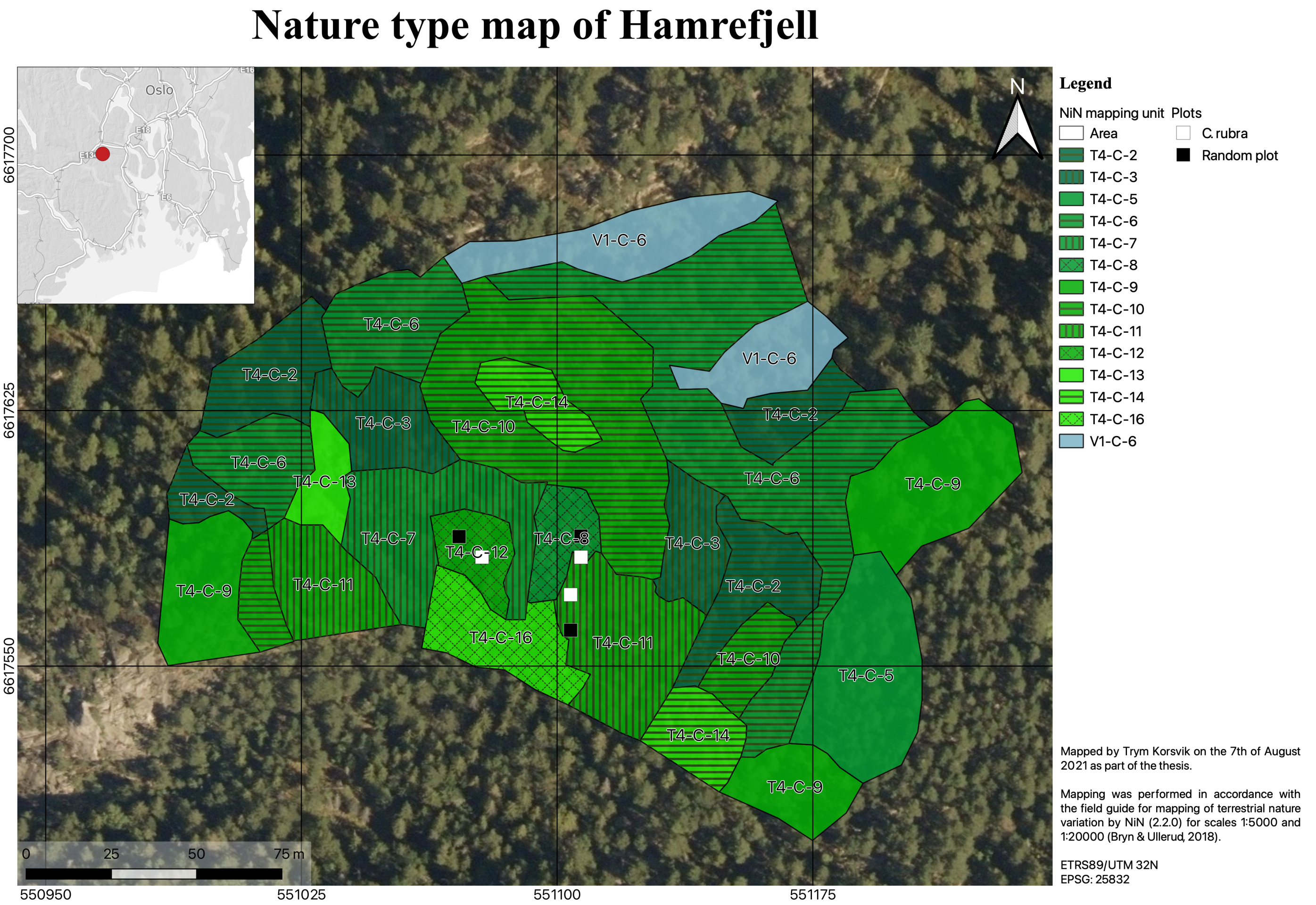


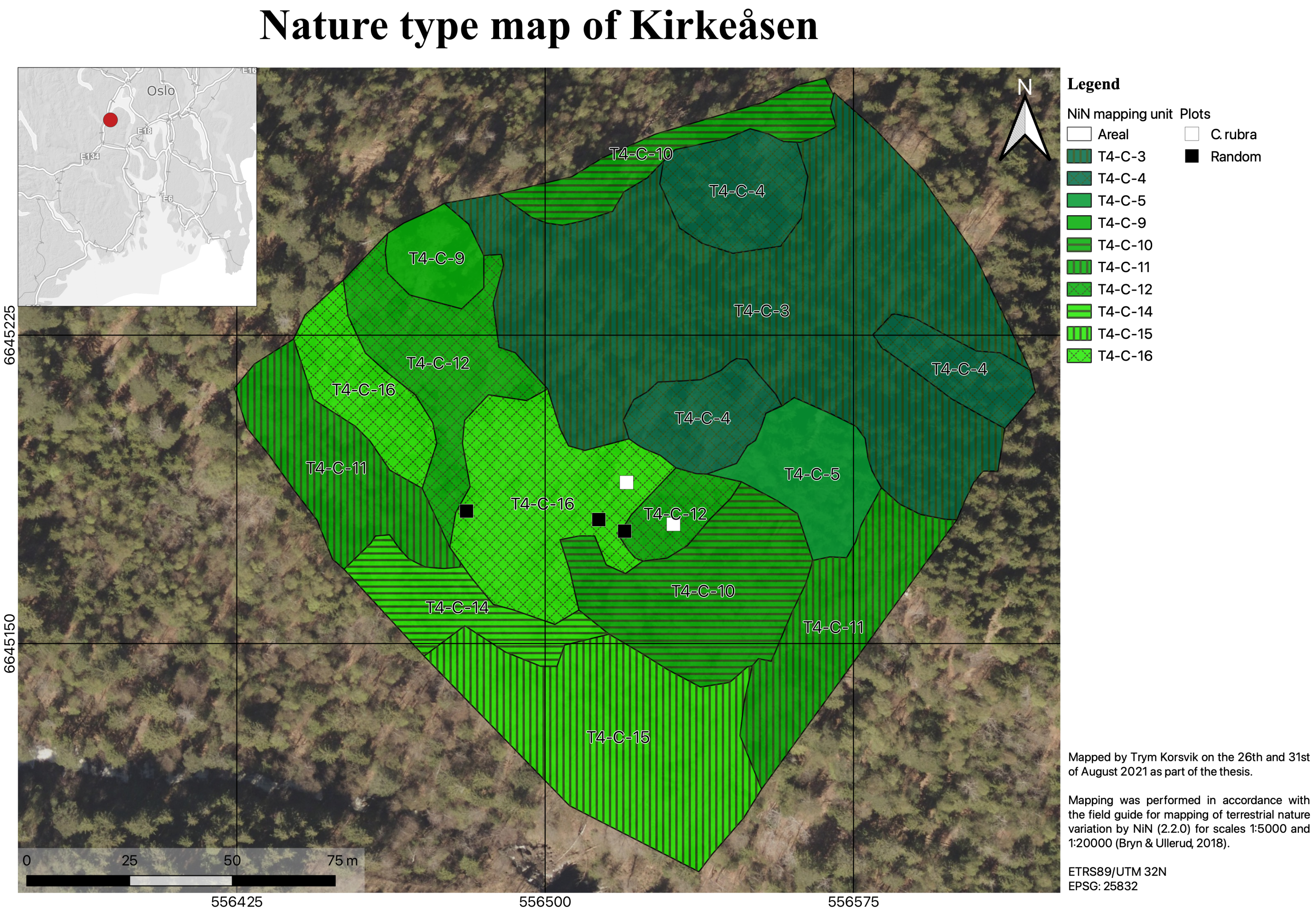
Figure 4.3. Land-cover map of Hamrefjell, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2016 (Omløpsfoto, 2017) Mapping was cut short southwest of the population due to dangerously steep terrain.

Hamrefjell

The Hamrefjell population was found in the most lime-rich minor types mapped in the location (see Figure 4.3). A total of six plots were placed in Hamrefjell. The species *Avenella flexuosa, Carex digitata, Convallaria majalis, Melampyrum pratense* and *Viola riviniana* were the most common species in the plots of the 31 different species that were recorded in Hamrefjell. An overview of the different minor types encountered as well as area statistics are shown in Table 4.4.

Table 4.4. Land-cover statistics for Hamrefjell and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	Area		*C. rubra* presence
	m^2	Per cent	
T4-C-02	2675	9.72%	No
T4-C-03	1455	5.29%	No
T4-C-05	1713	6.22%	No
T4-C-06	6200	22.53%	No
T4-C-07	909	3.30%	No
T4-C-08	486	1.77%	Yes
T4-C-09	3222	11.71%	No
T4-C-10	4096	14.89%	No
T4-C-11	1812	6.59%	Yes
T4-C-12	479	1.74%	Yes
T4-C-13	420	1.53%	No
T4-C-14	1103	4.01%	No
T4-C-16	948	3.45%	No
V1-C-6	1999	7.26%	No
Total	275167	100.00%	



Mapped by Trym Korsvik on the 26th and 31st of August 2021 as part of the thesis.

Mapping was performed in accordance with the field guide for mapping of terrestrial nature variation by NiN (2.2.0) for scales 1:5000 and 1:20000 (Bryn & Ullerud, 2018).

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Figure 4.4. Land-cover map of Kirkeåsen, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2017 (Geovekst, 2018).

Kirkeåsen

Kirkeåsen had the least diverse species inventory (21 species in total) of the sites in this study. *Betula pubescens*, *Calamagrostis arundinacea* and *Hieracium sp.* were found in all five plots. An overview of the different minor types encountered as well as area statistics are shown in Table 4.5.

Table 4.5. Land-cover statistics for Kirkeåsen and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	Area		*C. rubra* presence
	m^2	Per cent	
T4-C-03	6319	28.58%	No
T4-C-04	1995	9.02%	No
T4-C-05	843	3.81%	No
T4-C-09	441	1.99%	No
T4-C-10	2432	11.00%	No
T4-C-11	2545	11.51%	No
T4-C-12	1641	7.42%	Yes
T4-C-14	788	3.56%	No
T4-C-15	2596	11.74%	No
T4-C-16	2514	11.37%	Yes
Total	22112	100.00%	

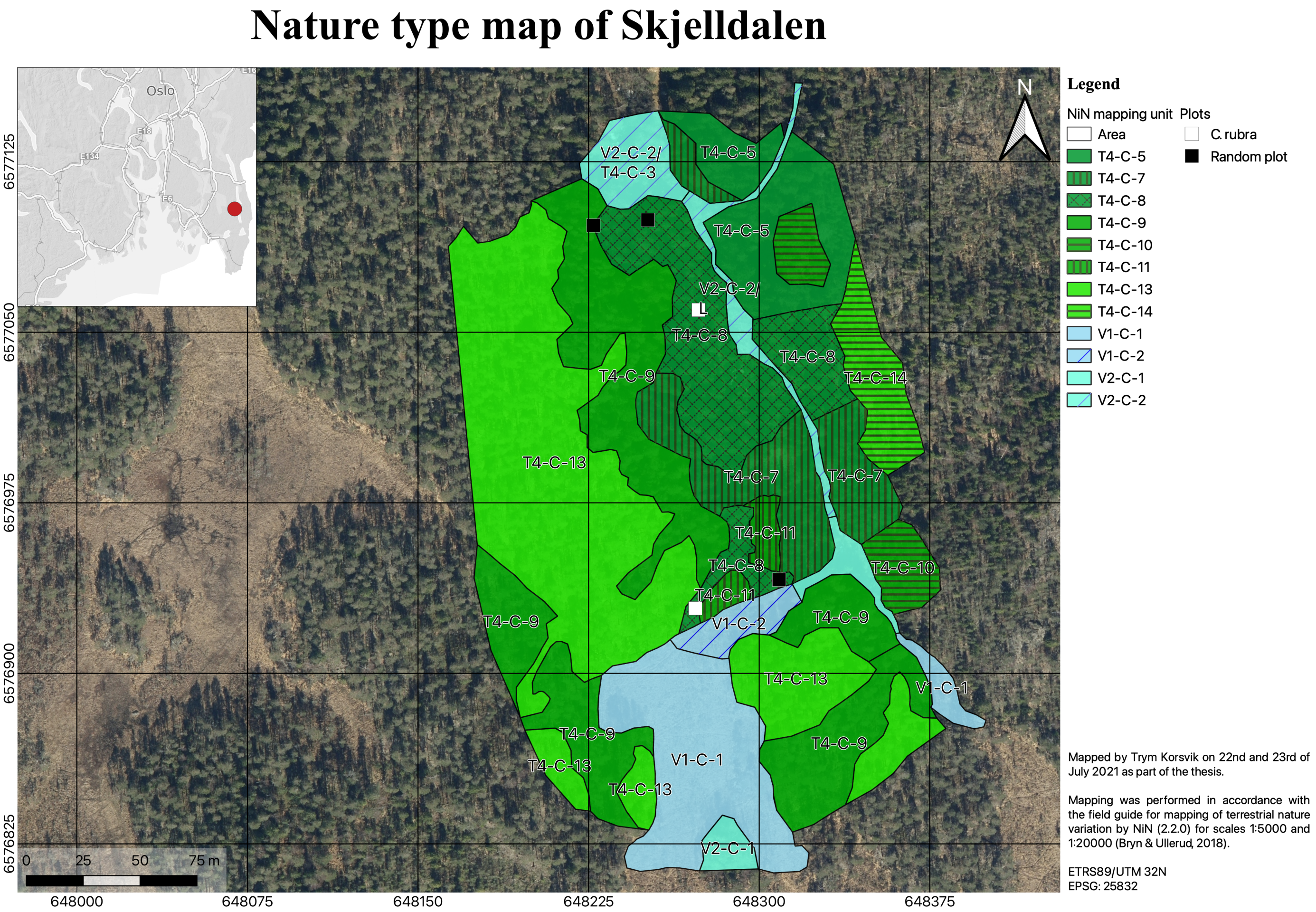


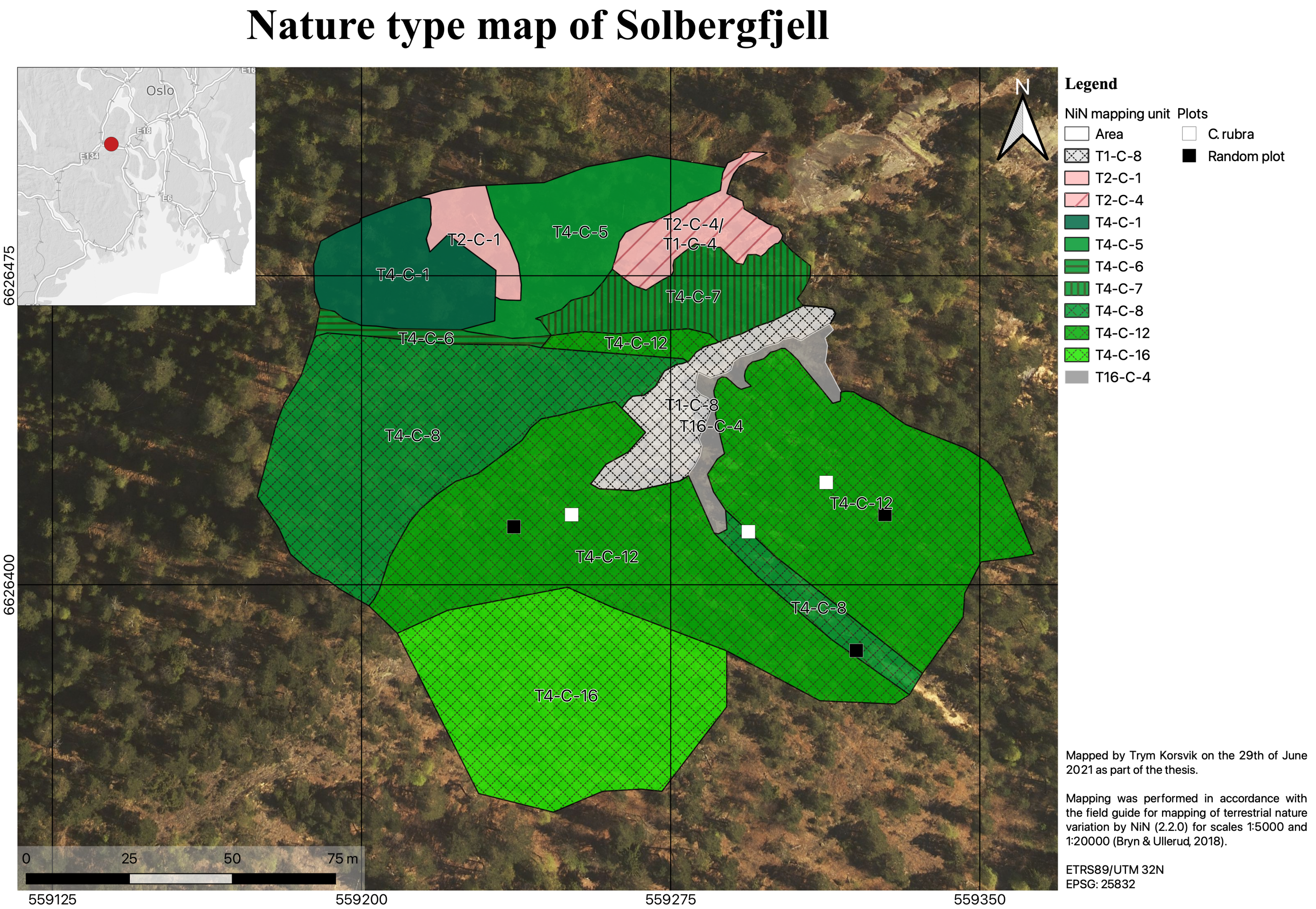
Figure 4.5. Land-cover map of Skjelldalen, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2019 (Geovekst, 2020). The wetland polygons east and northeast of the population were mosaics that also contained fresh water (L) and moderately lime-rich submesic forest (T4-C-3)

Skjelldalen

A total of 40 different species were recorded in the Skjelldalen plots. The most common species were *Dicranum polysetum, Fragaria vesca, Hylocomium splendens* and *Vaccinium vitis-idaea*, all of which were found in four of five plots. An overview of the different minor types encountered as well as area statistics are shown in Table 4.6.

Table 4.6. Land-cover statistics for Kirkeåsen and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	Area		*C. rubra* presence
	m^2	Per cent	
Water	181	0.35%	No
T4-C-03	656	1.25%	No
T4-C-05	3753	7.14%	No
T4-C-07	4435	8.44%	No
T4-C-08	3709	7.06%	Yes
T4-C-09	11669	22.21%	No
T4-C-10	1585	3.02%	No
T4-C-11	676	1.29%	No
T4-C-13	15317	29.15%	No
T4-C-14	1803	3.43%	No
V1-C-1	5613	10.68%	No
V1-C-2	822	1.56%	No
V2-C-1	938	1.79%	No
V2-C-2	1382	2.63%	No
Total	52539	100.00%	



Mapped by Trym Korsvik on the 29th of June 2021 as part of the thesis.

Mapping was performed in accordance with the field guide for mapping of terrestrial nature variation by NiN (2.2.0) for scales 1:5000 and 1:20000 (Bryn & Ullerud, 2018).

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Figure 4.6. Land-cover map of Solbergfjell, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2017 (Geovekst, 2019)

Solbergfjell

A total of 28 different species were recorded in Solbergfjell. *Carex digitata* and *Convallaria majalis* were found in all six plots. *Geranium sanguineum* and *Rubus saxatilis* was found in five of six plots. An overview of the different minor types encountered as well as area statistics are shown in Table 4.7.

Table 4.7. Land-cover statistics for Solbergfjell and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	Area		*C. rubra* presence
	m^2	Per cent	
T1-C-08	711	4.19%	No
T1-C-04	206	1.21%	No
T16-C-5	312	1.84%	No
T2-C-1	398	2.35%	No
T2-C-4	308	1.82%	No
T4-C-01	641	3.78%	No
T4-C-05	1142	6.73%	No
T4-C-06	274	1.61%	No
T4-C-07	903	5.33%	No
T4-C-08	2636	15.55%	Yes
T4-C-12	6417	37.84%	Yes
T4-C-16	3011	17.76%	No
Total	16958	100.00%	

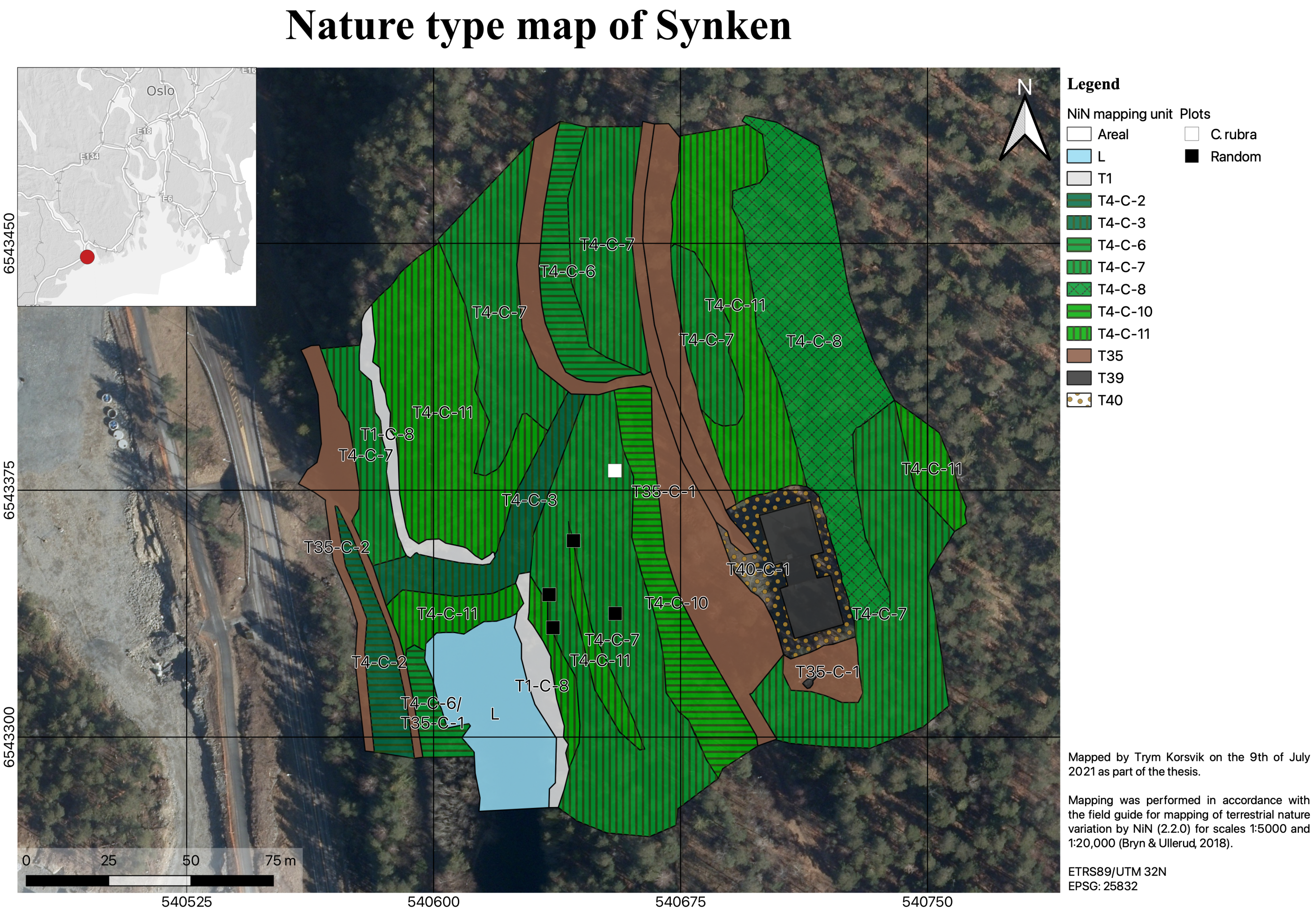

Figure 4.7. Land-cover map of Synken, mapped using the NiN system for scale 1:5000 (Bryn & Ullerud, 2018). The map shows minor type mapping unit polygons as well as positions of plots for the vegetational analysis over aerial photos from 2020 (Geovekst, 2021). The artificial pond Synken can be seen in the southwestern mapped area (L).

Synken

Carex digitata was found in all five plots in Synken. 33 other species were recorded. *Elymus caninus* and *Fragaria vesca* were also frequently recorded, in four of five plots. *C. rubra* was not present at the time of mapping (an exact position was shown by flora guardian Bjørn Erik Halvorsen). An overview of the different minor types encountered as well as area statistics are shown in Table 4.8.

Table 4.8. Land-cover statistics for Solbergfjell and list over which mapping units *C. rubra* was found in. Mapping unit descriptions are found in appendix 1.

Mapping unit	Area		*C. rubra* presence
	m^2	Per cent	
Water	1483	5.13%	No
T1-C-08	739	2.56%	No
T4-C-02	565	1.96%	No
T4-C-03	885	3.06%	No
T4-C-06	930	3.22%	No
T4-C-07	10164	35.19%	Yes
T4-C-08	3289	11.39%	No
T4-C-10	1354	4.69%	No
T4-C-11	4856	16.81%	No
T35-C-1	1866	6.46%	No
T35-C-2	1437	4.97%	No
T39-C-4	573	1.99%	No
T40-C-1	744	2.57%	No
Total	28885	100.00%	

4.2 Correlation between environmental variables

A summary of the explanatory variables is shown in Table 3.2. *C. rubra* was either found, or known to have been present recently, in 27 of the 54 plots. Results from correlation tests for all transformed explanatory variables is found in Tables 4.9 to 4.11.

Several pairs of highly correlated ($p<0.001$) variables were found in the dataset: Canopy opening south and canopy opening total; litter cover and field layer cover; calcium and pH; slope and heat index; soil depth and presence of bare rock; and aspect favourability and presence of bare rock. Other significantly correlated ($p<0.05$) are printed in bold in Tables 4.9 to 4.11. The negative correlation between the canopy opening variables and the tree layer cover (Table 4.9) stems from the recording of the canopy variables. For the canopy variables, a higher value corresponds to a higher number of open squares and more solar radiation entering the plot while a higher tree layer cover value corresponds to less solar radiation and a denser canopy. Presence of some tree- and shrub-species was correlated with either each other or environmental variables. *Betula* spp., *Pinus sylvestris* and *Sorbus aucuparia* formed one such group of correlated species. *Quercus robur* was highly correlated with lime-richness, risk of drought, canopy opening and slope.

No correlations were found between the presence or absence of *C.rubra* and the other environmental variables found in the plots. The variable with the lowest p-value for correlation was tree-layer cover, which had a p-value of 0.125.

Table 4.9. Kendall rank correlation coefficient from pairs of continuous environmental variables in the lower triangle with corresponding p-values in the upper triangle. P-values below 0.05 and corresponding correlation coefficients are in bold.

	CS	**CT**	**TRC**	**HEP**	**LIP**	**SOI**	**PH**	**LOI**	**CA**	**P**	**AF**	**HI**	**SLO**	**ELN**
CS		**<0.0001**	**0.0011**	0.7799	0.1954	0.9581	0.9045	0.1225	0.9164	**0.0245**	0.7522	0.3149	0.2992	0.5585
CT	**0.7056**		**<0.0001**	0.7350	**0.0320**	0.7537	0.8112	**0.0471**	0.8695	**0.0487**	0.5694	0.5959	0.6131	0.6486
TRC	**-0.3307**	**-0.4235**		0.8360	0.3672	0.4647	0.0826	0.8610	0.0986	0.3651	0.5723	0.2008	0.9816	0.7261
HEP	0.0279	0.0332	0.0213		**<0.0001**	0.9700	0.6039	0.0907	0.7014	0.4658	0.7977	0.2624	0.5791	0.8040
LIP	-0.1275	**-0.2073**	0.0916	**-0.4203**		0.4488	0.2804	0.5339	0.1611	0.9582	0.3437	0.7022	0.8085	0.1224
SOI	0.0051	0.0298	0.0730	0.0037	0.0734		0.2500	**0.0063**	0.2380	0.1353	**0.0084**	**0.0073**	0.0542	0.1910
PH	-0.0115	-0.0226	0.1724	-0.0508	0.1042	0.1090		0.0975	**<0.0001**	0.0560	0.8165	0.4200	0.0910	0.7312
LOI	-0.1483	**-0.1873**	0.0174	-0.1653	0.0599	**-0.2586**	-0.1560		0.0664	0.7202	0.8988	0.7652	0.4461	0.3702
CA	-0.0101	-0.0155	0.1637	-0.0375	0.1350	0.1116	**0.7899**	-0.1725		0.3395	0.9344	0.7996	0.1081	0.4030
P	**-0.2160**	**-0.1859**	0.0898	0.0712	-0.0051	-0.1413	-0.1799	0.0337	-0.0898		0.6056	0.1561	0.0668	**0.0190**
AF	-0.0309	-0.0547	0.0570	-0.0255	0.0929	**0.2541**	0.0223	-0.0122	0.0079	-0.0494		**0.0028**	0.4771	0.7305
HI	0.0968	0.0502	-0.1272	-0.1099	-0.0370	**-0.2546**	0.0762	-0.0282	0.0239	-0.1338	**-0.2870**		**<0.0001**	0.1963
SLO	0.1043	0.0499	-0.0024	-0.0567	-0.0244	-0.1906	0.1665	-0.0749	0.1580	-0.1803	0.0713	**0.5005**		**0.0372**
ELN	-0.0565	-0.0432	-0.0349	-0.0244	0.1495	0.1243	-0.0325	0.0846	-0.0790	**-0.2214**	0.0331	-0.1225	**-0.2059**	

Table 4.10. χ^2 test results for pairs of binary variables with 1 degree of freedom in the lower triangle and corresponding p-values in the upper triangle. P-values below 0.05 and corresponding correlation coefficients are in bold. Values affiliated with *C. rubra* are marked in pink.

	SHB	**GRB**	**BSB**	**ROB**	**NKA**	**NUF**	**CR**	**PIA**	**BES**	**PIS**	**SOA**	**QUR**	**JUC**	**POT**
SHB		0.7806	0.2624	0.4238	1.0000	1.0000	1.0000	**0.0330**	0.5777	0.3563	0.4103	1.0000	1.0000	0.1199
GRB	0.1879		**0.0320**	**0.0165**	1.0000	0.7801	0.3938	0.4348	0.7676	1.0000	0.4253	0.6752	0.2689	**0.0305**
BSB	1.4732	**5.0983**		0.1704	0.1579	**0.0290**	0.6232	0.6862	0.4138	1.0000	0.1609	0.4343	0.2879	0.0725
ROB	0.7793	**6.2345**	2.6192		0.3968	0.1859	0.1769	0.6972	0.5897	0.5447	0.7726	0.2479	0.7776	0.3878
NKA	0.0226	0.0650	2.5538	1.1154		0.5812	0.5612	0.6867	0.7826	0.3563	0.5822	**0.0060**	1.0000	0.5167
NUF	0.0000	0.3000	**6.0331**	2.6703	0.7308		0.5862	0.3958	0.7726	0.1169	0.2819	**0.0100**	0.2664	1.0000
CR	0.0000	1.2000	0.6703	2.6703	0.7308	0.6667		1.0000	0.3878	0.7541	1.0000	1.0000	1.0000	0.5442
PIA	5.5293	0.8207	0.3806	0.2606	0.2076	1.4772	0.1641		0.6922	0.3688	0.4278	0.2194	0.4258	0.6432
BES	0.3417	0.1879	1.0161	0.6086	0.1846	0.3068	1.2273	0.4933		**0.0095**	1.0000	0.6677	0.1794	1.0000
PIS	**1.1593**	0.0193	0.0899	0.6125	1.5684	3.4714	0.3857	1.2005	**7.3724**		**0.0295**	0.3518	0.0725	0.7411
SOA	0.7810	0.8766	2.3225	0.2466	0.6591	1.9481	0.0779	1.1276	0.0638	**5.1295**		0.4103	0.3998	0.3383
QUR	0.0149	0.5252	1.0163	1.7460	**9.0042**	**8.0426**	0.1641	1.7366	0.4933	1.2005	1.1276		0.4373	1.0000
JUC	0.0430	1.5147	1.6849	0.2601	0.0028	1.8934	0.0757	0.6964	2.1692	3.6375	1.2049	0.6964		1.0000
POT	3.1909	**5.0262**	3.4663	1.1686	0.6609	0.0923	0.8308	0.7298	0.0047	0.3798	1.3055	0.0025	0.0571	

Table 4.11. Mann Whitney U test statistic and corresponding P-values for pairs of continuous and factor variables. P-values below 0.05 and corresponding test statistics are in bold. Values affiliated with the *C. rubra* presence variable are marked in pink.

	SHB		**GRB**		**BSB**		**ROB**		**NKA**		**NUF**		**CR**	
	U	***p***	**U**	***p***	**U**	***p***	**U**	***p***	**U**	***p***	**U**	***p***	**U**	***p***
CS	322.00	0.6020	282.50	0.1799	259.00	0.0724	**243.00**	**0.0366**	304.00	0.6115	299.50	0.2643	301.50	0.2793
CT	335.50	0.7780	346.50	0.8209	300.00	0.2799	286.00	0.1791	349.00	0.7718	372.00	0.9036	375.00	0.8626
TRC	**485.00**	**0.0189**	342.00	0.7603	277.50	0.1354	**229.00**	**0.0195**	335.00	0.9710	323.00	0.4772	275.50	0.1250
HEP	422.50	0.2171	**499.50**	**0.0154**	272.00	0.1162	258.00	0.0660	371.00	0.4903	320.50	0.4509	341.00	0.6904
LIP	457.50	0.0642	285.50	0.1975	279.00	0.1483	**229.00**	**0.0197**	294.00	0.4896	300.50	0.2716	298.50	0.2568
SOI	431.50	0.1639	442.00	0.1559	303.00	0.3038	**118.00**	**<0.0001**	381.00	0.3842	349.50	0.8018	334.50	0.6097
PH	**464.00**	**0.0495**	383.50	0.6888	335.00	0.6379	310.00	0.3537	432.00	0.0727	389.00	0.6779	430.00	0.2607
LOI	430.50	0.1694	381.00	0.7212	300.00	0.2804	370.00	0.9240	393.00	0.2768	389.50	0.6716	350.00	0.8086
CA	462.50	0.0526	395.50	0.5423	312.00	0.3840	302.00	0.2864	422.00	0.1067	373.00	0.8899	391.50	0.6466
P	462.50	0.0526	419.00	0.3085	295.00	0.2429	291.00	0.2088	371.00	0.4910	339.50	0.6716	368.50	0.9517
AF	413.50	0.2824	371.50	0.8481	252.00	0.0554	**145.00**	**0.0002**	338.00	0.9277	329.00	0.5446	290.00	0.2003
HI	458.00	0.0631	424.50	0.2652	354.00	0.8891	459.00	0.1013	406.00	0.1858	456.00	0.1153	444.50	0.1690
SLO	432.50	0.1584	320.00	0.4910	332.00	0.6009	365.00	0.9931	379.00	0.4029	410.50	0.4308	385.00	0.7289
ELN	376.00	0.6789	372.00	0.8413	299.00	0.2727	261.00	0.0756	343.00	0.8561	354.00	0.8626	324.50	0.4943

Table 4.11. cont.

	PIA		**BES**		**PIS**		**SOA**		**QUR**		**JUC**		**POT**	
	W	***p***	**W**	***p***	**W**	***p***	**W**	***p***	**W**	***p***	**W**	***p***	**W**	***p***
CS	**79.00**	**0.0280**	309.00	0.4541	**176.50**	**0.0416**	248.50	0.0828	**53.50**	**0.0044**	371.00	0.8062	262.50	0.5687
CT	95.00	0.0755	325.00	0.6408	210.50	0.1731	300.00	0.4142	**64.00**	**0.0100**	401.00	0.4410	277.00	0.7720
TRC	141.00	0.5500	324.00	0.6279	292.00	0.8188	362.00	0.7890	190.50	0.5110	313.00	0.4504	225.00	0.1953
HEP	116.00	0.2140	358.50	0.9158	235.50	0.3833	354.00	0.9009	209.00	0.2570	447.00	0.1144	286.00	0.9077
LIP	98.00	0.0884	272.50	0.1642	222.00	0.2553	318.50	0.6253	100.00	0.0992	281.00	0.1887	223.00	0.1825
SOI	121.00	0.2680	256.50	0.0944	251.50	0.5804	362.00	0.7900	89.50	0.0550	384.00	0.6363	241.50	0.3293
PH	119.00	0.2464	379.00	0.6408	282.50	0.9685	371.00	0.6702	103.00	0.1161	421.00	0.2624	351.00	0.2625
LOI	107.50	0.1456	320.50	0.5852	278.50	0.9843	352.00	0.9293	183.00	0.6429	411.00	0.3443	344.50	0.3198
CA	102.00	0.1103	348.50	0.9579	275.50	0.9371	349.50	0.9646	122.50	0.2850	452.00	0.0962	320.00	0.6019
P	100.00	0.0993	353.00	0.9930	237.50	0.4070	343.00	0.9575	223.00	0.1352	413.00	0.3267	300.50	0.8848
AF	100.00	0.0988	**225.50**	**0.0265**	219.50	0.2358	278.50	0.2299	101.50	0.1074	316.00	0.4834	242.00	0.3340
HI	132.00	0.4098	420.50	0.2312	238.50	0.4182	392.50	0.4193	148.50	0.6897	411.00	0.3443	389.50	0.0623
SLO	101.00	0.1026	290.50	0.2824	226.00	0.2887	319.00	0.6311	**86.50**	**0.0459**	397.00	0.4798	350.50	0.2665
ELN	92.00	0.0636	335.00	0.7714	249.00	0.5471	348.50	0.9788	110.00	0.1642	362.00	0.9302	268.00	0.6428

4.3 Ordinations, correlations and plots

Axes of a higher order were of greater length than axes of lower order in the DCA analysis (Table 4.12). In the GNMDS analysis the first axis was longest, followed by the third and then second axis (Table 4.13). For the remainder of the thesis the axis of ordinations will be referred to as the ordination type followed by axis order (e.g., first axis of DCA is DCA1).

Table 4.12. DCA eigenvalues and gradient lengths measured in S.D.-units for axes 1–4.

	DCA1	**DCA2**	**DCA3**	**DCA4**
Eigenvalues	0.4891	0.4132	0.3249	0.3059
S.D.Units	4.1936	3.4173	3.3233	2.6869

Table 4.13. GNMDS gradient lengths measured in half-change units for axes 1–3.

	GNMDS1	**GNMDS2**	**GNMDS3**
Axis length	2.4669	2.1780	2.2213

A strong correlation was found between GNMDS1 and DCA2 ($\tau = 0.6115$); GNMDS2 and both DCA1 ($\tau = -0.7428$) and DCA3 ($\tau = -0.2061$); and GNMDS3 with DCA4 ($\tau = -0.5597$) (Table 4.14).

Table 4.14. Kendall correlation coefficient between ordination methods and corresponding p-values. P-values below 0.05 and corresponding coefficients are marked in bold.

	DCA1		**DCA2**		**DCA3**		**DCA4**	
	τ	**p**	**τ**	**p**	**τ**	**p**	**τ**	**p**
GNMDS1	–0.1083	0.2475	**0.6115**	**<0.0001**	–0.0692	0.4602	0.4878	–0.0650
GNMDS2	**–0.7428**	**<0.0001**	–0.1600	0.0876	**–0.2061**	**0.0278**	–0.1069	0.2537
GNMDS3	0.1433	0.1262	0.1195	0.2021	–0.0860	0.3588	**–0.5597**	**<0.0001**

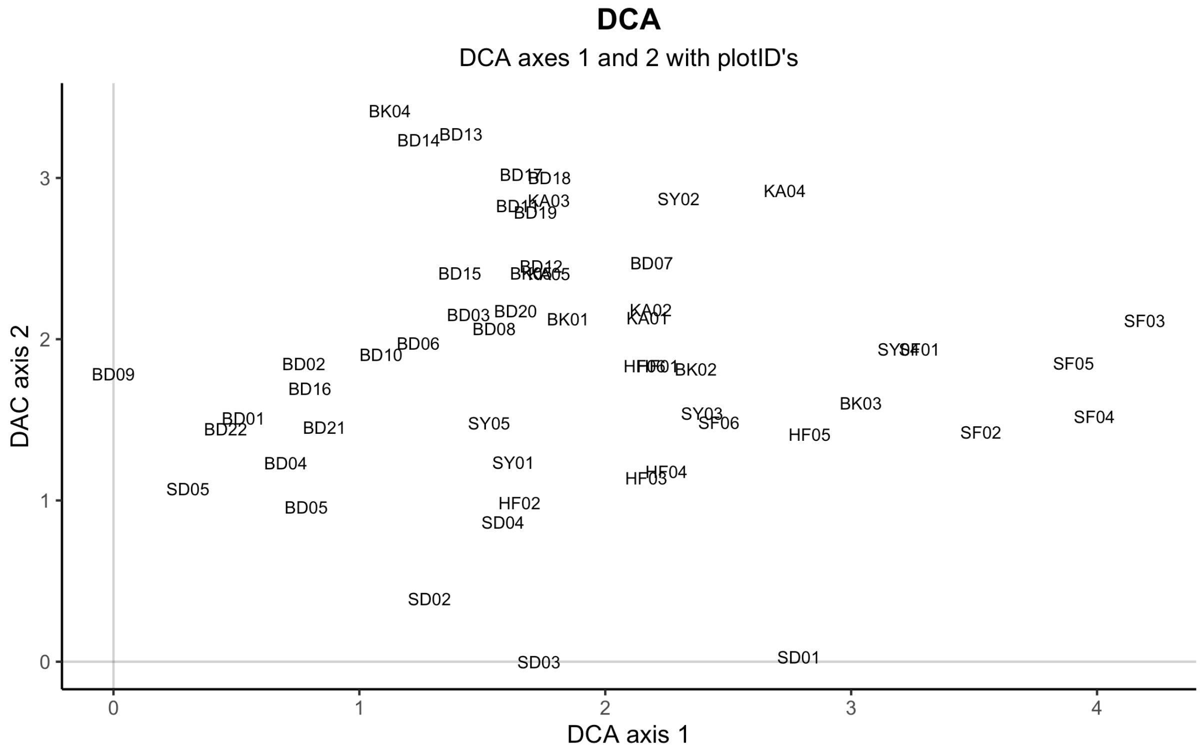

Figure 4.8. DCA ordination axes 1 and 2 with plot scores represented by labels with plot ID. Plot IDs are given as abbreviation for location and then plot number.

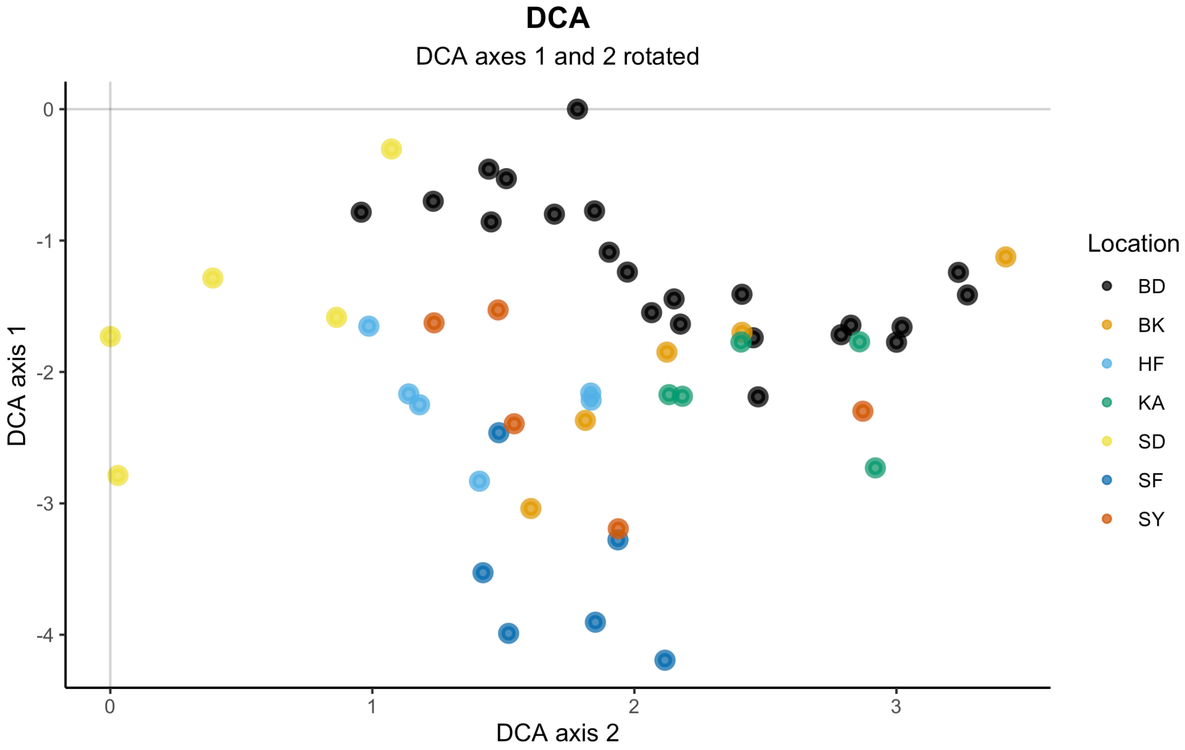

Figure 4.9. The DCA axes 1 and 2 rotated in relation to Figure 4.8 with plot scores represented as coloured points. Colour indicates location, as shown in the legend.

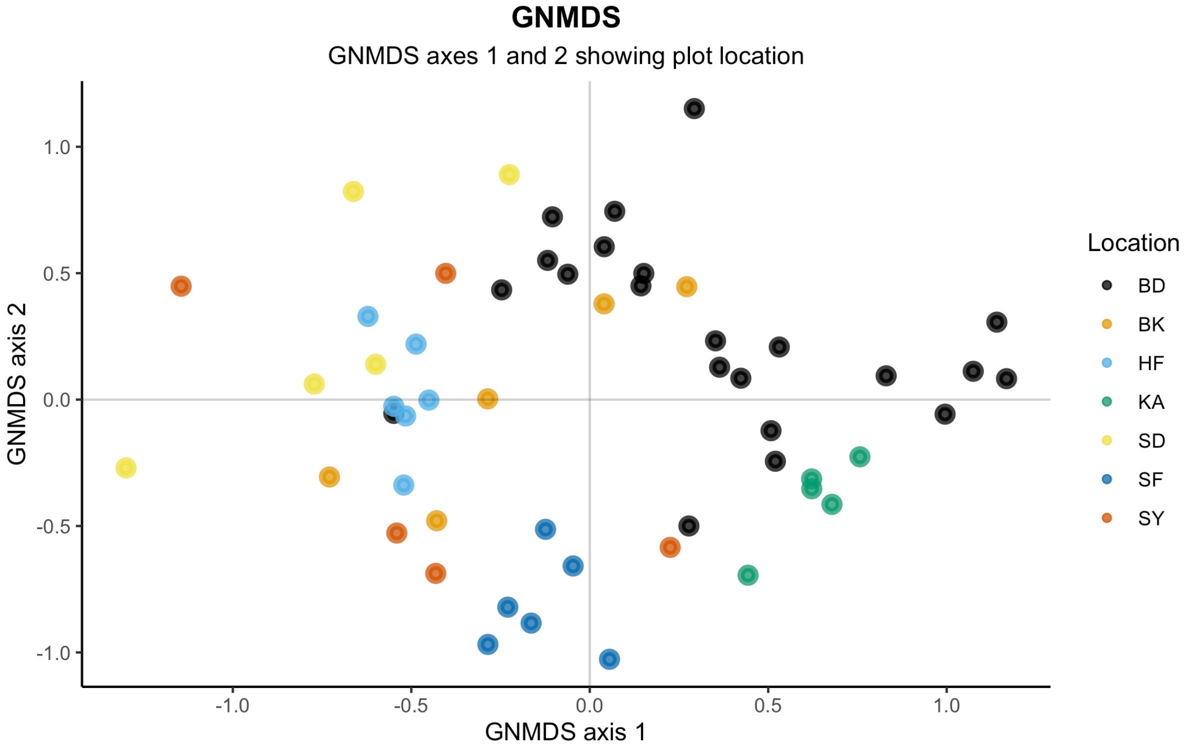

Figure 4.10. GNMDS ordination axes 1 and 2 with plot scores represented as coloured points. Colour represents location, as shown in the legend.

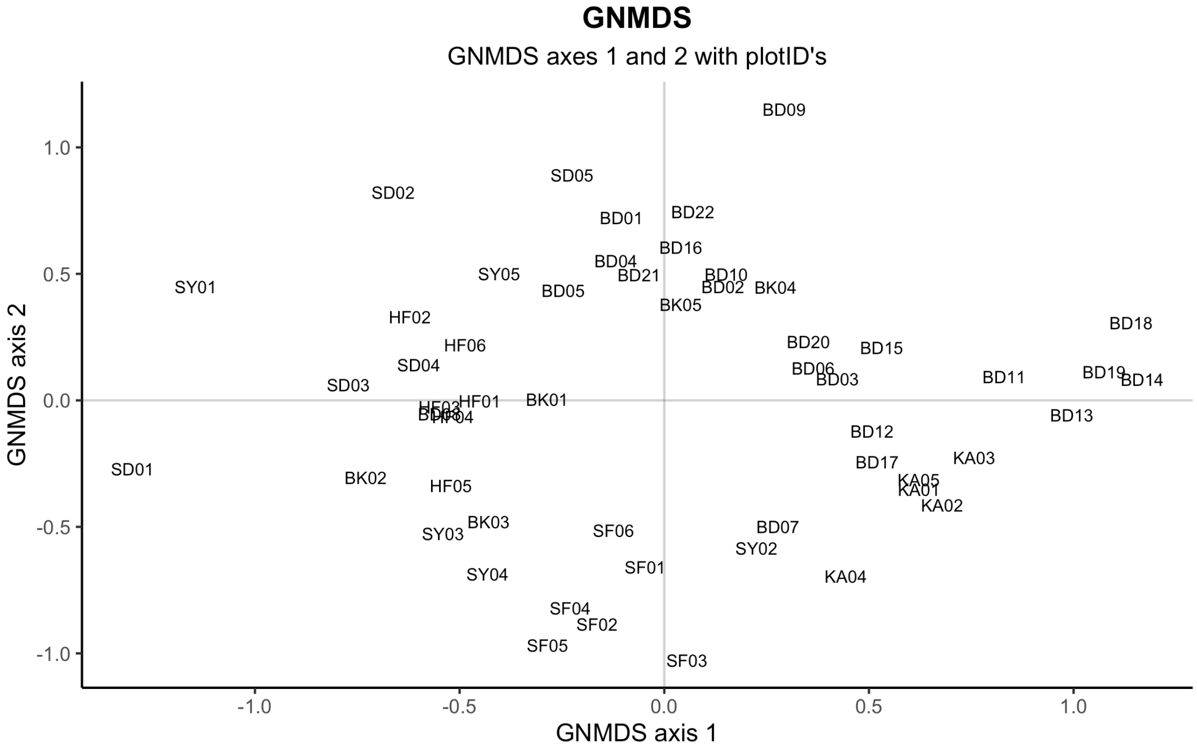

Figure 4.11. GNMDS ordination axes 1 and 2 with plot scores represented by labels with plot ID. Plot IDs are given as abbreviation for location and then plot number.

The Bjørkedokk plots spans almost half of GNMDS1 and most of GNMDS2 (Figure 4.10). On GNMDS1 both Kirkeåsen, Bjørneknuten and Solbergfjell are all partially or fully within the same area as Bjørkedokk. Hamrefjell, Skjelldalen and Synken span most of the variation that is left on the negative side of GNMDS1. Skjelldalen and Bjørkedokk span the same variation along GNMDS2. Solbergfjell is grouped tightly on the end of the negative side of GNMDS2, with Kirkeåsen also closely following. Synken and Bjørneknuten are scattered along the second axis.

The pattern is similar in DCA1 and DCA2 (Figure 4.9). The main difference is that the Synken and Bjørneknuten plots are shifted further towards the positive side in DCA2 in Figure 4.9. This shift is seen particularly in plot BK04 which moves from being the most positive plot on the DCA2 axis to a more central position in the corresponding GNMDS1 axis (Figures 4.8 and 4.11). The Kirkeåsen plots also shift further toward 0 in DCA1 (towards positive on GNMDS2 in Figure 4.11) compared to the GNMDS ordination. Except for this the ordinations are visually similar.

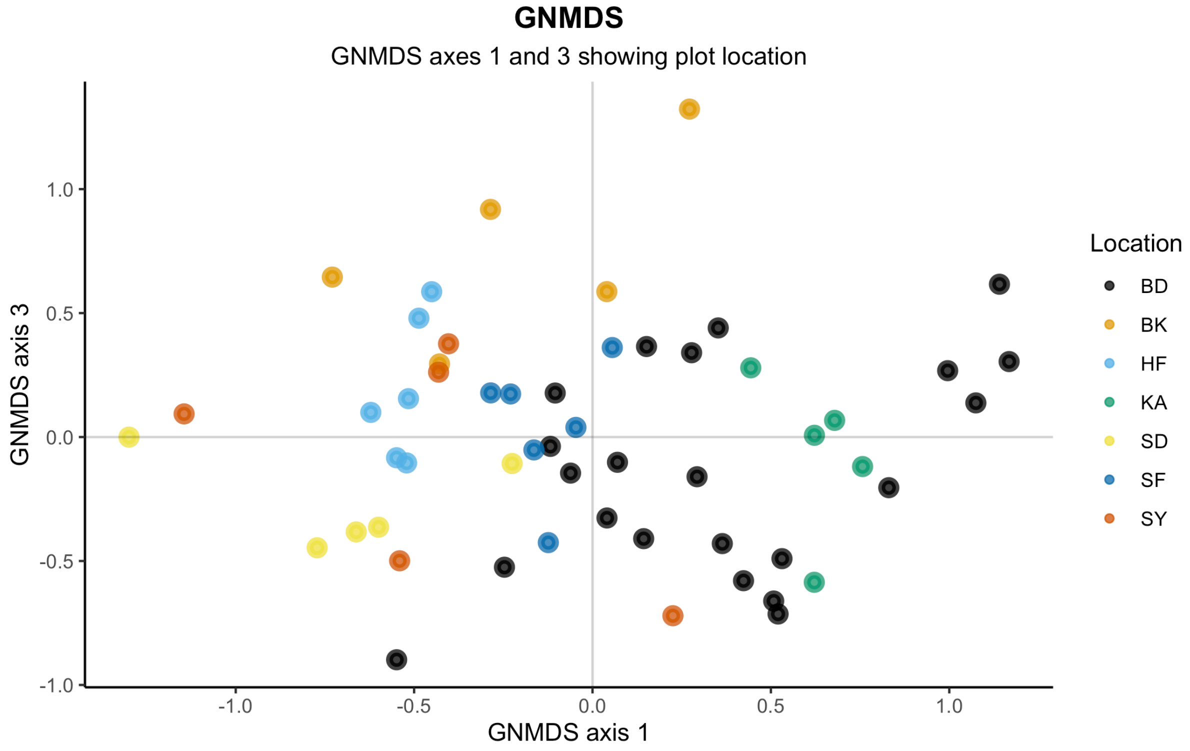

Figure 4.12. GNMDS ordination axes 1 and 3 with plot scores represented as points. Colour indicates plot location

.

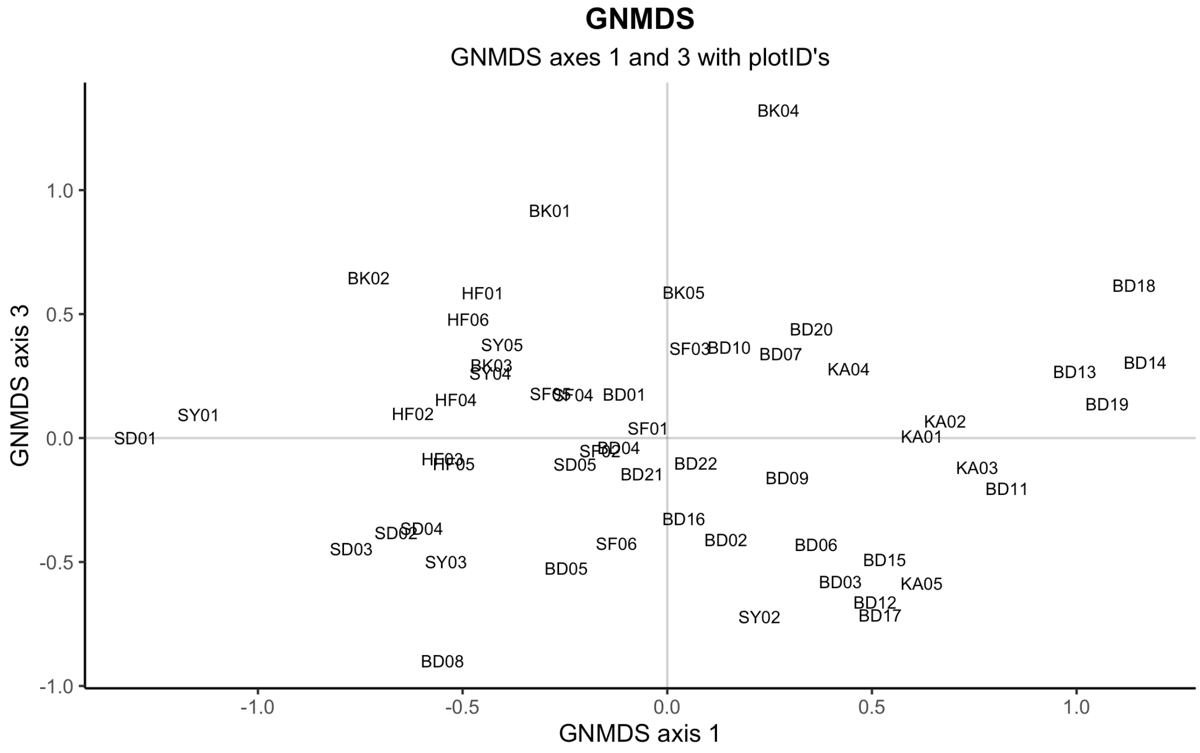

Figure 4.13. GNMDS ordination axes 1 and 3 with plot scores represented by labels with plot ID. Plot IDs are given as abbreviation for location and then plot number

Bjørneknuten is solitary on the positive side of GNMDS3 (Figure 4.12). The other locations seem to be bundled together, with Bjørkedokk covering the part of the axis that Bjørneknuten does not cover.

C. rubra was found evenly across the entire ordination, as shown in Figure 4.14. *C. rubra* is a bit more spread on the first axis than the randomly placed plots on GNMDS1. There is also a slight tendency toward presence in the lower right part of the GNMDS ordination in figure 4.14.

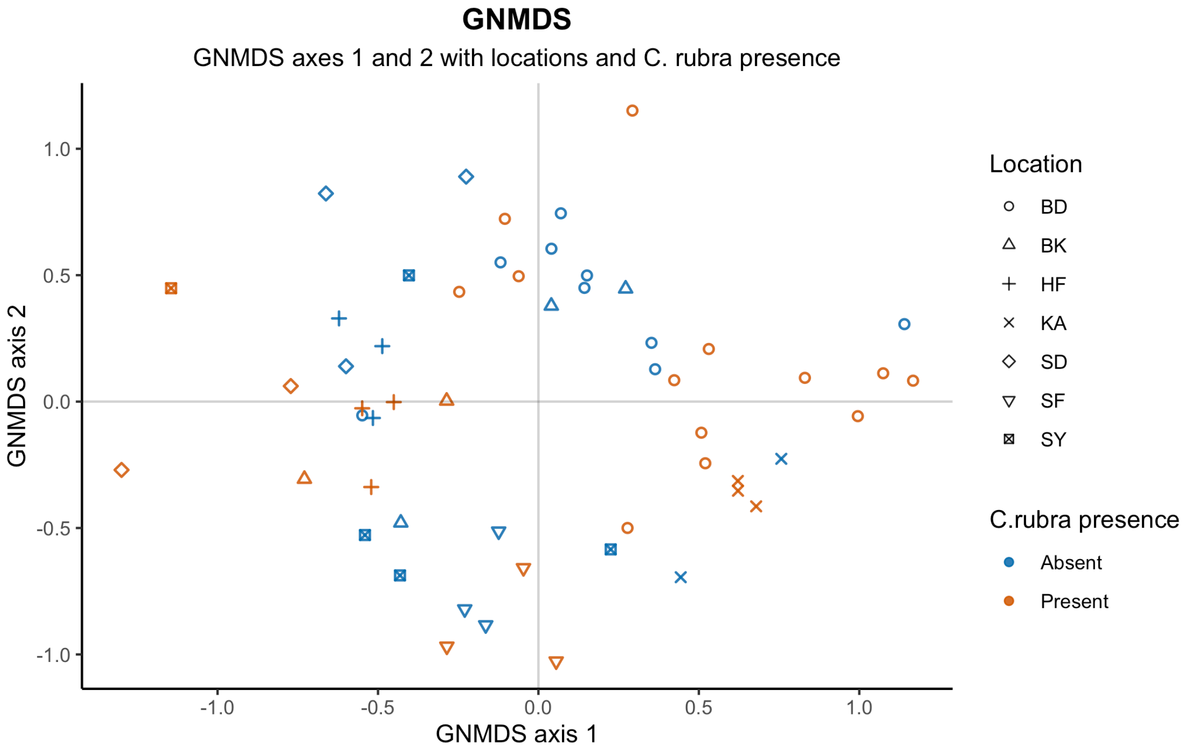

Figure 4.14. GNMDS ordination axes 1 and 2 with plot scores represented as points. Shape represents location and colour indicates presence or absence of *C. rubra*.

4.4 Correlations between ordinations and environmental variables

GNMDS1 was significantly correlated (p-values < 0.05) with field layer cover (HEP); bottom layer cover (GRB); presence of *Sorbus aucuparia* (SOA); risk of drought (NUF); bare soil (BSB); phosphorus (P); litter cover (LIP); heat index (HI) and slope. GNMDS2 was highly correlated with bottom layer cover (GRB); calcium (CA); presence of *Picea abies* (PIA); bare soil (BSB); slope (SLO) and pH (PH). GNMDS3 was highly correlated with presence of *Quercus robur* (QUR); presence of *Picea abies* (PIA); phosphorus (P); soil depth (SOI) and loss on ignition (LOI). None of the GNMDS axes were correlated with presence of *C. rubra*. A full overview of axes correlation with environmental variables is shown in Tables 4.15 and 4.16

Table 4.15. Correlation coefficients and corresponding p-values from Kendall correlation tests between GNMDS axes and continuous environmental variables. Significant results (p-values < 0.05) are in bold.

	GNMDS axis 1		**GNMDS axis 2**		**GNMDS axis 3**	
	τ	**p**	**τ**	**p**	**τ**	**p**
CS	-0.0223	0.8163	-0.0367	0.7023	-0.1560	0.1038
CT	-0.0591	0.5307	-0.0787	0.4032	-0.1097	0.2443
TRC	0.0648	0.5128	-0.0949	0.3376	0.0844	0.3940
HEP	**-0.4854**	**<0.0001**	0.0293	0.7636	-0.0044	0.9640
LIP	**0.2190**	**0.0227**	0.0807	0.4013	-0.0692	0.4719
SOI	-0.0473	0.6169	0.1375	0.1454	**-0.2066**	**0.0287**
PH	0.1122	0.2325	**-0.2062**	**0.0282**	-0.1754	0.0621
LOI	0.1484	0.1137	0.0168	0.8579	**0.1960**	**0.0367**
CA	0.0420	0.6544	**-0.2548**	**0.0066**	-0.1624	0.0834
P	**-0.2338**	**0.0127**	-0.0714	0.4466	**0.2114**	**0.0242**
AF	-0.0143	0.8810	0.0529	0.5798	0.0629	0.5103
HI	**0.1961**	**0.0373**	-0.0119	0.8990	-0.0471	0.6170
SLO	**0.1970**	**0.0448**	**-0.2163**	**0.0276**	-0.0281	0.7744
ELN	0.1394	0.1394	0.1394	0.1394	0.0225	0.8112

Table 4.16. Test statistics and corresponding p-values from Mann–Whitney tests between GNMDS axes and binary environmental variables. Significant results (p-values < 0.05) are in bold.

	GNMDS axis 1		**GNMDS axis 2**		**GNMDS axis 3**	
	U	**p**	**U**	**p**	**U**	**p**
SHB	337	0.8002	336	0.7868	377	0.6688
GRB	**570**	**0.0002**	**88**	**<0.0001**	380	0.7364
BSB	**202**	**0.0049**	**492**	**0.0244**	348	0.8097
ROB	262	0.0788	432	0.2448	295	0.2378
NKA	317	0.7878	373	0.4722	418	0.1244
NUF	**188**	**0.0019**	355	0.8773	329	0.5478
CR	299	0.2632	434	0.2347	390	0.6679
PIA	163	0.9799	**76**	**0.0210**	**256**	**0.0167**
BES	409	0.3228	421	0.2300	341	0.8546
PIS	220	0.2433	238	0.4170	257	0.6605
SOA	**169**	**0.0013**	307	0.4922	452	0.0621
QUR	235	0.0709	129	0.3754	**30**	**0.0001**
JUC	470	0.0475	372	0.7947	380	0.6899
POT	208	0.1053	339	0.3783	195	0.0605

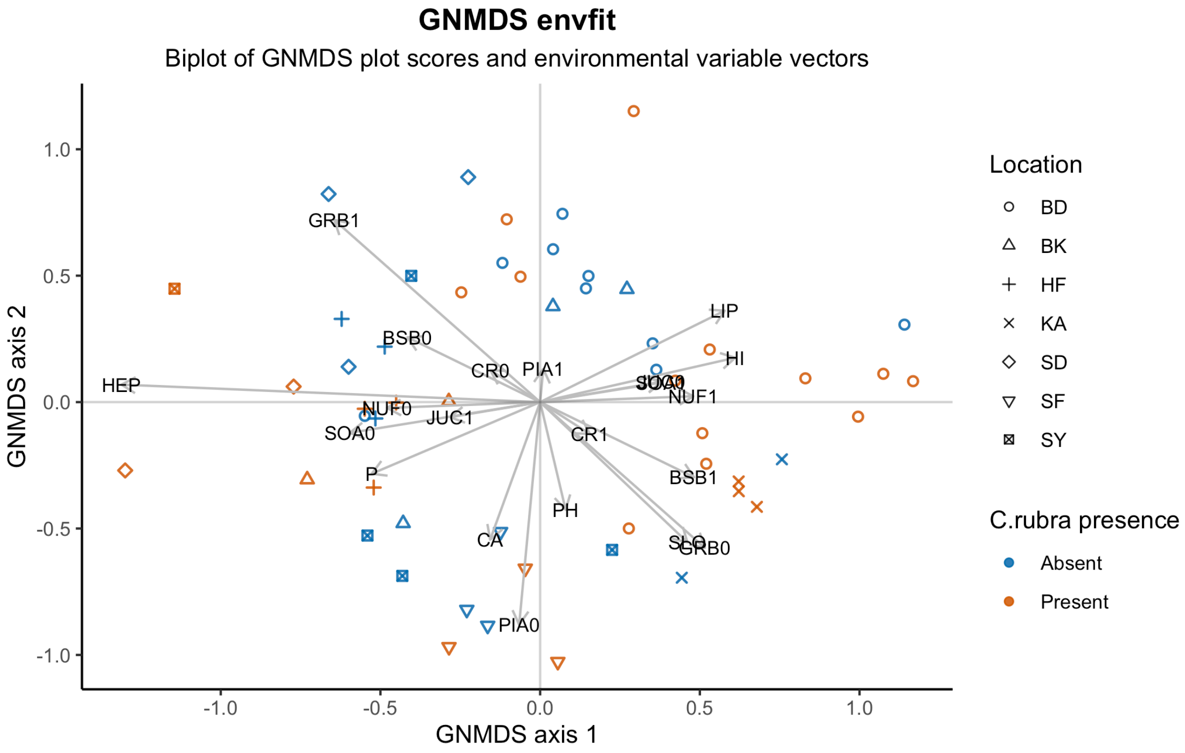

Figure 4.15. Biplot with GMDS axis 1 and 2. Points represent plot scores with shapes as location and colour indicating presence or absence of *C. rubra*. The arrows represent direction of influence of the environmental variables significantly correlating with the ordination axes and presence/absence of *C. rubra* for illustration purposes even though it did not have significant correlation with any single axis. A binary variable with a 0 indicates absence and 1 indicates presence.

Figure 4.15 shows the directionality of the variation in environmental variables highly correlated with either GNMDS1 or GNMDS. The Figure shows a clear correlation with increase in vegetation cover towards the negative side of GNMDS1, with the vegetation layer and bottom layer cover both pointing in the negative direction, on the positive side of GNMDS1 heat index, litter, slope and bare soil are important. On the same figure calcium, slope, and absence of *Picea abies* or bottom layer cover are the most prominent variables correlated with GNMDS2 on the negative side, and presence of bottom layer cover featuring in the opposite direction.

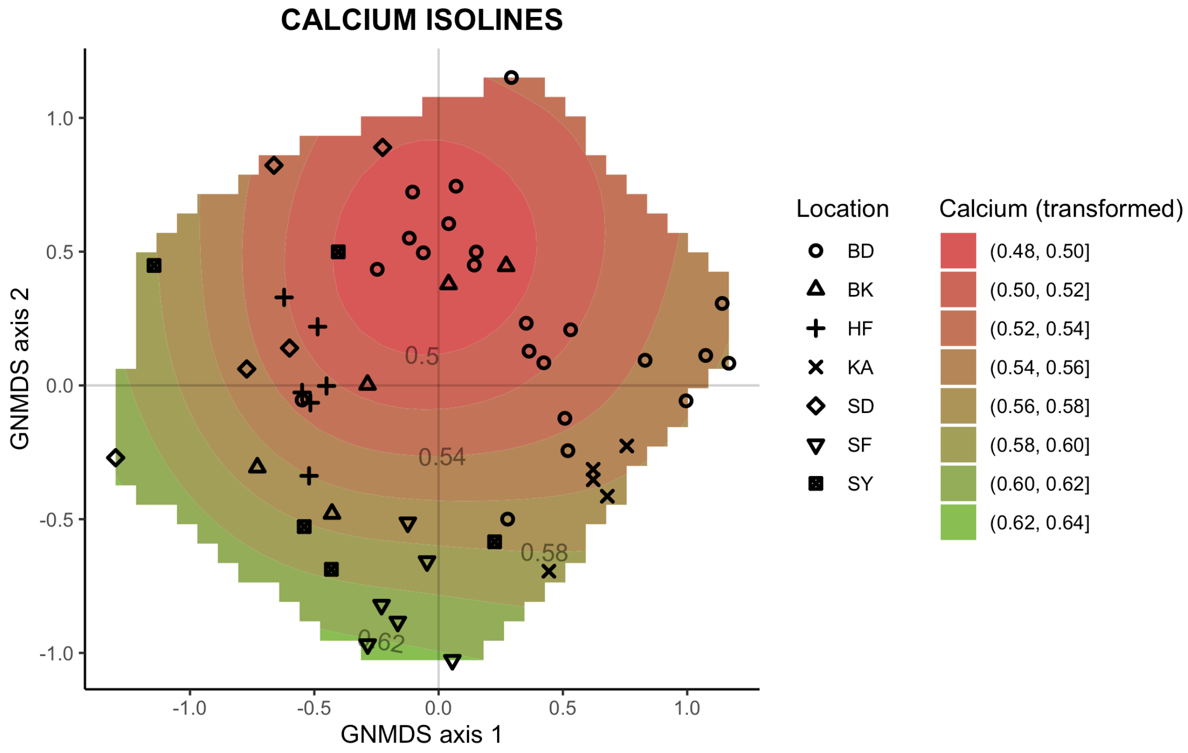

Figure 4.16. Isoline diagram representing the variation in soil calcium content on the GNMDS ordination. Plot scores are points with shapes representing location. Transformed variables were used because of outlier values in the Solbergfjell population.

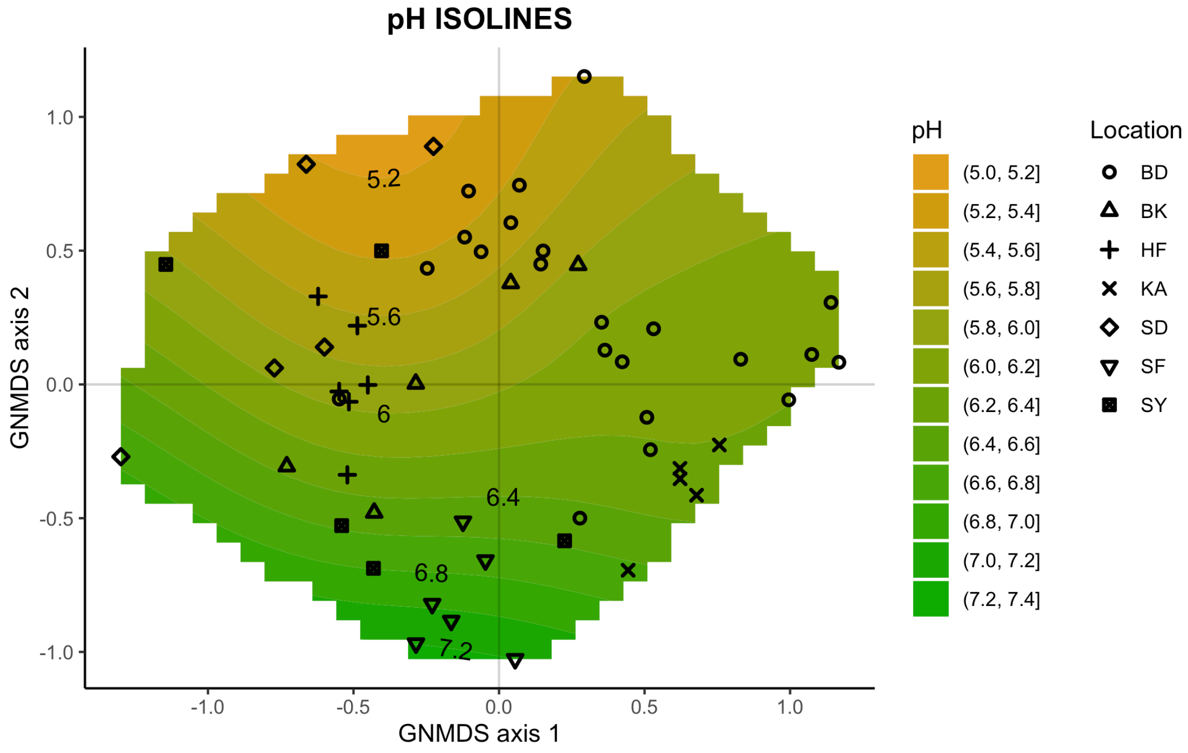

Figure 4.17. Isoline diagram representing the variation in pH on the GNMDS ordination. Plot scores are points with shapes representing location.

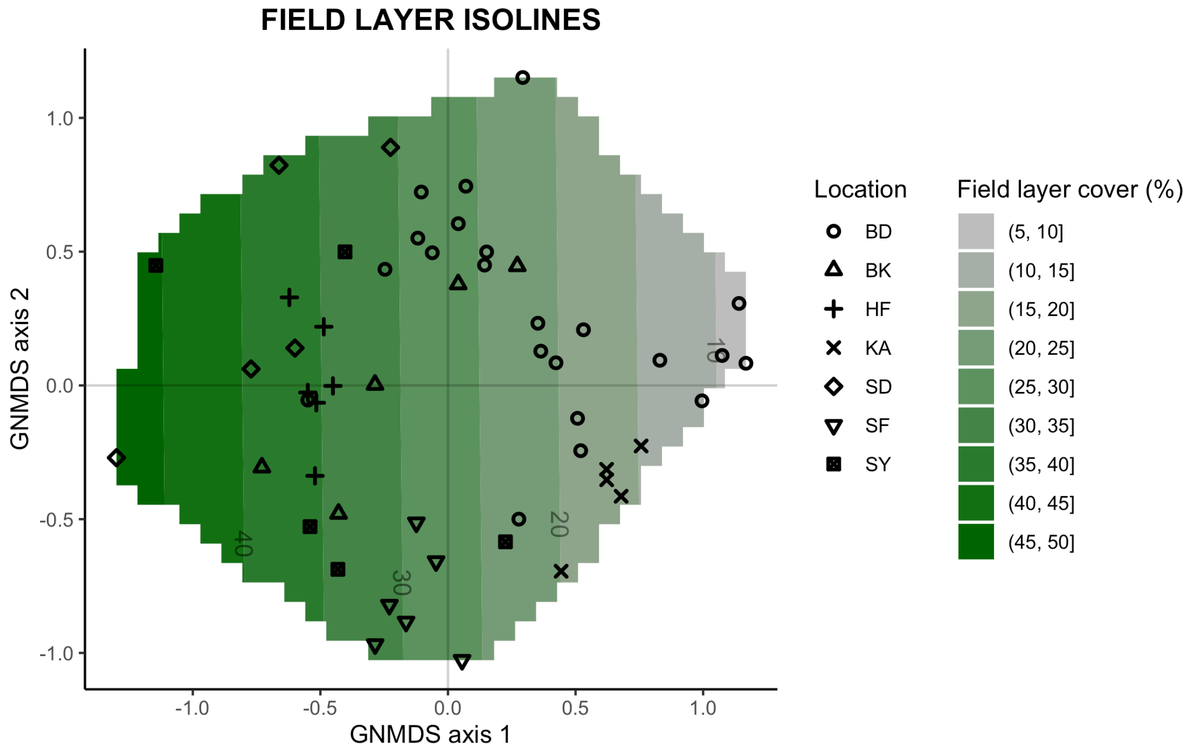

Figure 4.18. Isoline diagram representing the variation in field layer cover on the GNMDS ordination. Plot scores are points with shapes representing location.

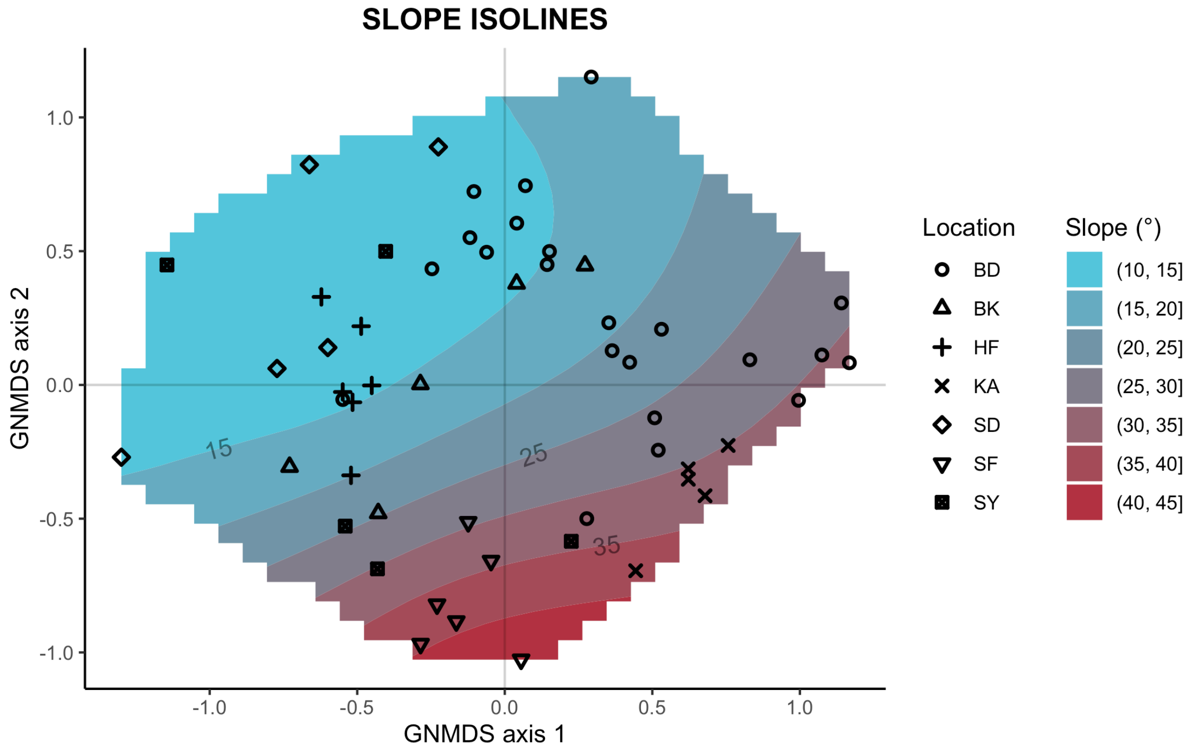

Figure 4.19. Isoline diagram representing the variation in slope on the GNMDS ordination. Plot scores are points with shapes representing location.

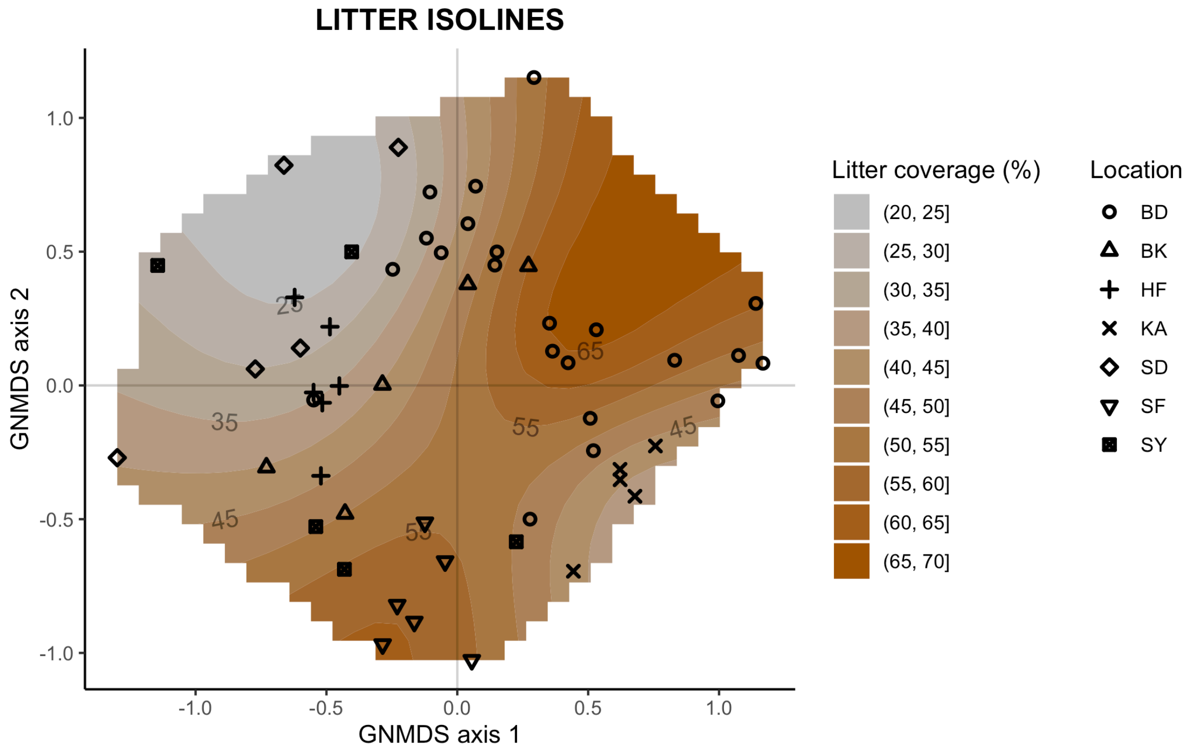

Figure 4.20. Isoline diagram representing the variation in litter coverage on the GNMDS ordination. Plot scores are points with shapes representing location.

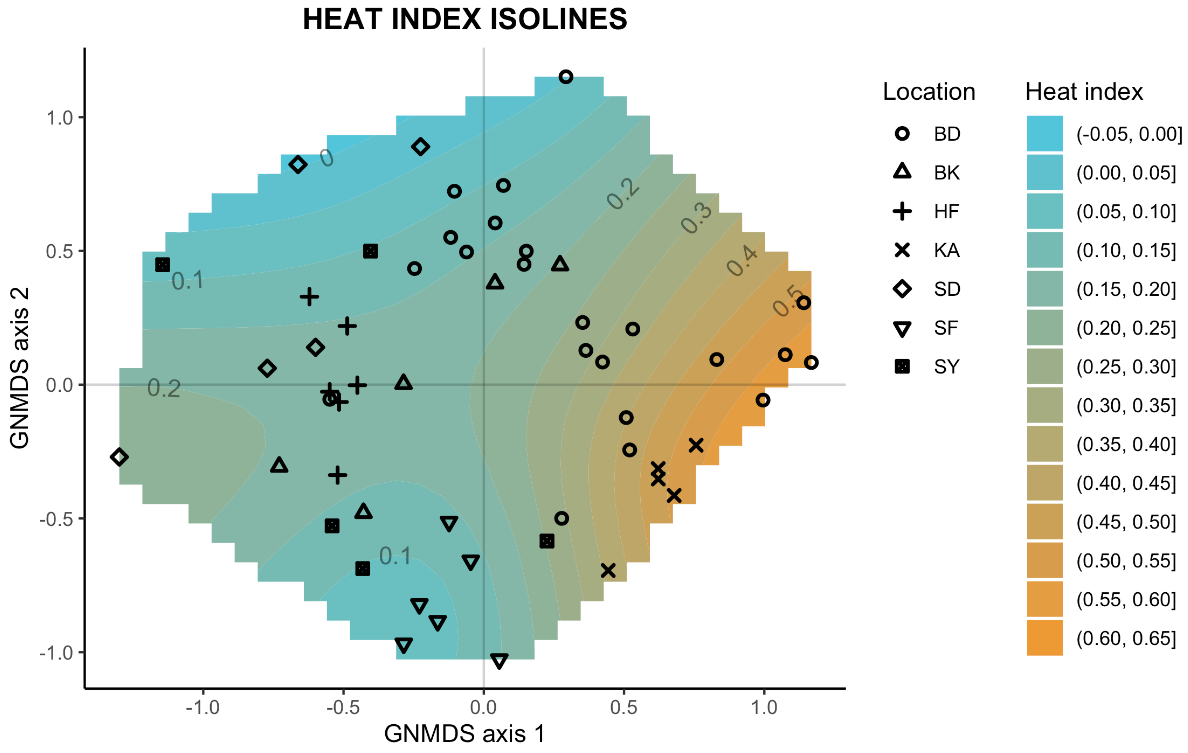

Figure 4.21. Isoline diagram representing the variation in pheat index on the GNMDS ordination. Plot scores are points with shapes representing location.

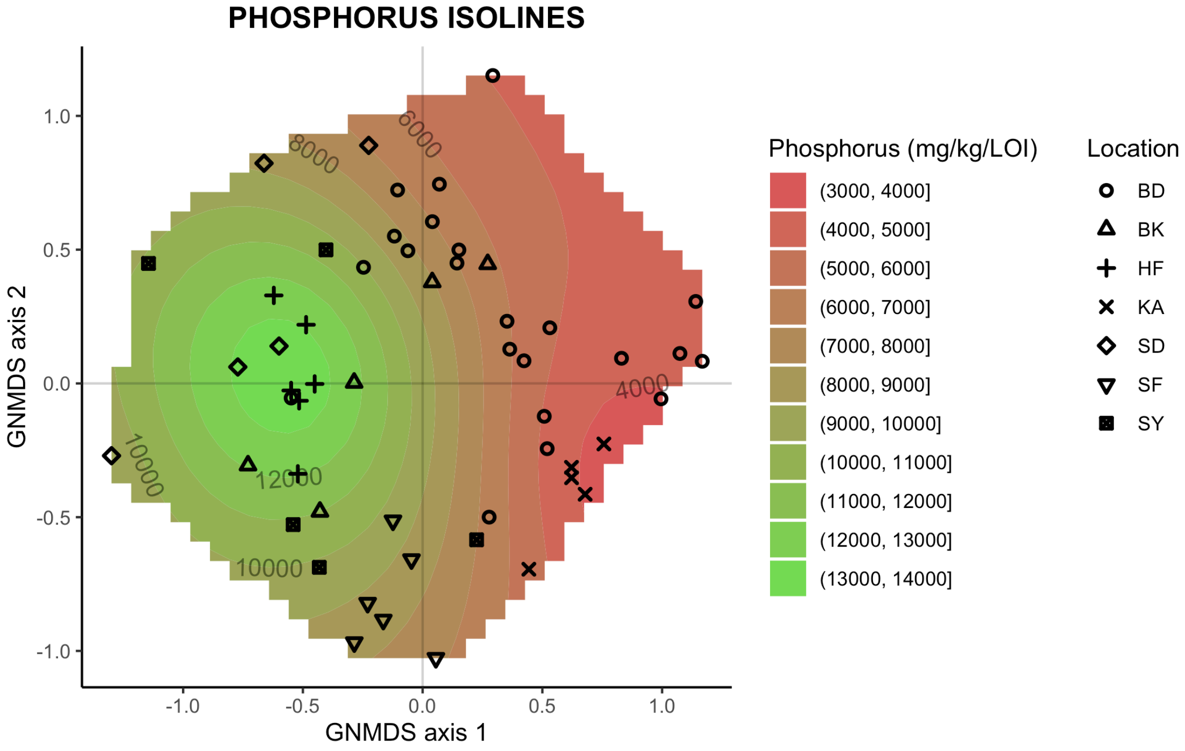

Figure 4.22. Isoline diagram representing the variation in phosphorus soil content values on the GNMDS ordination. Plot scores are points with shapes representing location.

The calcium gradient on GNMDS2 can also be seen in figure 4.16, where the most calcium-rich plots are located on the lower side of the plot and is similar with the pH-variation in the ordination (Figure 4.17). Vegetation layer cover varies mostly with GNMDS 1 (Figure 4.18). Slope is steeper towards the lower right of the ordination (Figure 4.19). Litter varies bimodally (Figure 4.20), as does heat index values (Figure 4.21).

5 Discussion

The aim of this thesis was to describe the habitat preferences of *C. rubra* in Norway more precisely, expanding upon the previous more general descriptions of habitat preferences of *C. rubra*. A secondary goal was to find sources of variation and species composition in the lime-rich forest type where *C. rubra* is found. The results support previous findings of *C. rubras* habitat preferences and identify some important factors of variation in the area around where *C. rubra* is found, but fail to identify new information about habitat preferences of *C. rubra* in Norway.

5.1 Summary and interpretation of the results

C. rubra was found mostly in the most lime-rich forest mapping units, even though these lime-rich mapping units were not the most common mapping units. All except for four plots were placed in slopes, and the average inclination was 22.3°. The recorded canopy opening and tree layer cover variables indicate a general shaded environment where *C. rubra* was found, as all plots had either partial or total cover in the tree canopy and the tree layer cover was generally high while canopy opening was moderate. The forest type was mostly coniferous in all locations, with a notable exception is Bjørneknuten, where European oak (*Quercus robur*) was the dominant forest type near all the plots. These results support the generally accepted descriptions of *C. rubras* habitat, which describe the habitat as lime-rich, sloped, shaded and (in Scandinavia) coniferous forest (Delforge, 2006; Hanssen, 1996; Hanssen and Bratli, 2009; Lid and Lid, 2005; Tutin et al., 1980). In contrast to the findings of Hemrová (2019) the results do not identify organic soil content (here measured in LOI) or solar radiation as significantly correlated to presence of *C. rubra* within the study locations. It is however important to note that Hemrová *et al.* investigated a larger area than what was done in this study. This means that organic soil content and solar radiation could be relevant for presence of *C. rubra* when comparing to dissimilar types of nature, but not within the calcareous forest investigated in this thesis.

Apart from the general description, a narrower definition of *C. rubras* preferred habitat or ecological functional area is hard to describe from the results. Presence of *C. rubra* was not significantly correlated with any of the environmental variables, which suggests the presence or absence of *C. rubra* within the general habitat is not linked to any single environmental variable recorded in the study. No clear pattern of habitat preference for *C. rubra* is present in the ordinations either. The plots containing *C. rubra* were not clumped in any corner of the ordination, but the plots with *C. rubra* have a wider range along GNMDS1 in Figure 4.14 than the randomly placed plots, which indicates more dissimilarity in species composition in plots with *C. rubra*. Plots with *C. rubra* appear to be more frequent in the lower right area of the ordination diagram, but with no clear correlation it remains unclear if this is the result of a random distribution or not. Falsely identifying a a specific habitat for *C. rubra* could potentially lead to misguided protection efforts, or in worst case failure to protect the habitat necessary for the preservation of *C. rubra* in Norway and it is therefore advised to utilize the precautionary principle (Lemons et al., 1997). This study therefore failed to identify the most important factors for narrowly describing the habitat of *C. rubra*.

While no conclusive results can be inferred about the habitat preferences of *C. rubra,* information about the habitat and underlying sources of variation can be inferred from the ordination results. The first axis of the GNMDS ordination (Figure 4.15) is negatively correlated with field and bottom layer cover and positively correlated slope, bare soil, risk of drought and litter. This combination of correlated variables suggests that GNMDS1 is a disturbance gradient. Erosion due to slope steepness can be a source of natural disturbance, and erosion has been shown to increase with slope steepness (Fox and Bryan, 2000). This would explain why both bottom layer and field layer cover decrease towards the negative side of GNMDS1. The second axis of the GNMDS appears to be caused by a calcium and incline gradient. Calcium, absence of Norwegian spruce (*Picea abies*), pH and slope vary opposite the bottom layer gradient on GNMDS2. The environmental variables with the strongest correlation with the third axis of the GNMDS were the tree-species *Picea abies* and *Quercus robur*. With the Bjørneknuten plots, which were in the oak (*Quercus robur*) woods, highly skewed to one side of the third axis it can be hypothesized that this axis is a tree-composition gradient. It can thus be suggested that the main sources of variation in *C. rubras* habitat are grade of disturbance, calcium content and forest composition.

It is interesting to note that all habitats had shown signs of some disturbance either recently or in the past that has probably led to bare soil. This is important because orchid seeds are dependent on making almost direct contact with a mycorrhizal partner in order to germinate (Smith and Read, 2008a), which is presumably more probable to happen in sites where the ground is bare or only covered by a thin layer of vegetation.

5.2 Future research

With global climate change already making impacts across the world (IPCC, 2022), an argument should be made as to why spending valuable resources on a margin distribution of a species that is not threatened internationally is important. Populations at the edge of a species' range are likely to genetically differ from the populations in the core range of the species distribution, and preserving these edge populations will therefore leave the species better suited to adapt to global climate change (Hunter and Hutchinson, 1994; Morente-López et al., 2021). Continued research on *C. rubra* would also lead to increased knowledge of the rare lime-rich forest types where it is found and help protecting not only *C. rubra* but also other at-risk rare species in the same habitat (Bjørndalen and Brandrud, 1989). There is also an argument to be made for preserving *C. rubra* for its general appeal as a beautiful orchid, as "charismatic" species can be utilized for spreading awareness of biodiversity and also around the protected species concept from the Nature Diversity Act (Hoell, 2013; Naturmangfoldloven, 2009). More research is needed in order to understand what the habitat preferences of *C. rubra* is and define the ecological functional area of *C. rubra*.

An important driver of occurrence of *C. rubra* that was not investigated in this study is the mycorrhizal relationship of *C. rubra* and fungal associates in Norway. Prior studies have noted the importance of finding the correct fungal associate for orchid seed germination both for the genus but also *C. rubra* in particular (Hemrová et al., 2019; McCormick and Jacquemyn, 2014; Smith and Read, 2008a). It has been widely accepted that *C. rubra* is associated with a fungal partner throughout its life cycle, and lack of such a partner could also limit *C. rubras* available habitat (Bell et al., 2020; Bidartondo et al., 2004; McCormick and Jacquemyn, 2014). Research into which mycorrhizal fungi are involved with *C. rubra* in Norway and how these fungi are distributed could therefore be important for describing *C. rubras* habitat and distribution range, and also help improve research on the field of fungi-orchid relationships.

Some edge populations of *C. rubra* have been either discovered or revitalized after major disturbance episodes. This happened in Hampshire in 1986 after the felling of some yew trees (Harrap and Harrap, 2010) and recently in Modum near Kirkeåsen where *C. rubra* was discovered east of the Kirkeåsen locality after a forest area was clear-felled (Berit & Svein Skretteberg, personal communication, 2021). The most vital *C. rubra* individual of the entire Hamrefjell location (including the subpopulations not studied in this thesis) lies in a previously clear-felled flat, and this subpopulation seems to be growing in recent years (Bratli, 2021, 2016). Future research could therefore also look into this relationship with disturbance and investigate if partial thinning of felling of nearby suitable forest can lead to colonization of *C. rubra.*

6 Conclusion

The threatened orchid *Cephalanthera rubra* remains an elusive maiden of the forest, as this study failed to narrow down the specific habitat preferences of *C. rubra,* due to lack of correlation between *C. rubra* and environmental variables and ordination axes. The previous more general descriptions of *C. rubras* habitat were strengthened, as almost all *C. rubra* individuals studied in this thesis were all recorded in lime-rich forest, mostly in slopes and half-shaded to shaded woods.

Based on the ordination axes and variation of environmental variables along these axes ordination main sources of variation were found within the lime-rich forest types where *C. rubra* is found: level of disturbance, calcium content and tree species composition.

More research is needed to identify what *C. rubras* habitat preferences are. Investigating what fungal partners *C. rubra* depend on both for germination and in later life stages as well as what relationship, if any, *C. rubra* has to disturbance and colonization are recommended as topics for future research.

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Appendix 1 NiN mapping units encountered

Table A1. Mapping units encountered during the mapping phase of the field work, with lime-richness (KA) and drought risk (UF) for the forest types

Code	Name	KA	UF
L	Limnic system		
T1-C-03	Lime-poor moderately desiccation-prone rock wall		
T1-C-04	Lime-poor strongly desiccation-prone rock wall		
T1-C-08	Weakly intermediately lime-rich strongly desiccation-prone rock wall		
T2-C-1	Lime-poor open subxeric shallow-soil ground		
T2-C-4	Intermediately lime-rich open xeric shallow-soil ground		
T4-C-01	Lime-poor submesic forest	1	1
T4-C-02	Intermediately lime-rich submesic forest	2	1
T4-C-03	Moderately lime-rich submesic forest	3	1
T4-C-04	Strongly lime-rich submesic forest	4	1
T4-C-05	Lime-poor submesic to subxeric forest	1	2
T4-C-06	Intermediately lime-rich submesic to subxeric forest	2	2
T4-C-07	Moderately lime-rich submesic to subxeric forest	3	2
T4-C-08	Strongly lime-rich submesic to subxeric forest	4	2
T4-C-09	Lime-poor subxeric forest	1	3
T4-C-10	Intermediately lime-rich subxeric forest	2	3
T4-C-11	Moderately lime-rich subxeric forest	3	3
T4-C-12	Strongly lime-rich subxeric forest	4	3
T4-C-13	Lime-poor xeric forest	1	4
T4-C-14	Intermediately lime-rich xeric forest	2	4
T4-C-15	Moderately lime-rich xeric forest	3	4
T4-C-16	Strongly lime-rich xeric forest	4	4

Table A1. cont.

Code	Name	KA	UF
T16-C-5	Intermediately lime-rich tall-herb talus slope		
T32-C-08	Moderately lime-rich high-intensity managed semi-natural grassland		
T35-C-1	Wasteland and artificial soil deposit		
T35-C-2	Gravel pits and artificial gravel deposit		
T37-C-2	Inorganic strongly modified or synthetic, new soft artificial substrate		
T39-C-2	Stone deposit in consolidation phase		
T39-C-4	Quarry, road cut and other artificial hard substrate in consolidation phase		
T40-C-1	Strongly modified land with semi-natural grassland character		
T43-C-1	Landscaped grassland (parks, lawns etc.)		
V1-C-1	Strongly lime-poor fen expanse carpet		
V1-C-2	Strongly lime-poor fen expanse lower lawn		
V1-C-6	Moderately lime poor fen expanse carpet		
V2-C-1	Lime-poor mire forest lawn		
V2-C-2	Lime-poor mire forest hummock		

Appendix 2 Environmental variables used in statistical analysis

Table A2.1. Untransformed environmental variables used in the statistical analysis. Abbreviations and transformations are found in Table 3.2

Plot ID	CS	CT	TRC	SHB	HEP	GRB	BSB	ROB	LIP	SOI	NKA	NUF
BD01	1	24	90	0	15	27	15	0	50	61.125	4	3
BD02	8	48	20	0	18	7.5	5	0	35	46.25	4	3
BD03	32	87	0	0	10	0	15	10	65	20.5	3	3
BD04	7	12	100	35	10	40	0	0	50	29.375	3	3
BD05	5	21	90	0	30	45	0	0	25	33.125	2	2
BD06	11	21	90	0	20	0	0	10	65	21.875	2	2
BD07	0	6	70	5	15	0	30	0	55	27.5	4	2
BD08	0	4	100	10	50	15	0	0	35	29.375	4	2
BD09	6	36	0	0	10	15	0	0	75	54.375	2	3
BD10	0	6	90	0	70	5	0	0	25	2.5	2	3
BD11	0	2	70	0	5	0	15	5	75	4.375	4	2
BD12	63	131	10	70	10	0	15	5	70	7.5	4	2
BD13	13	89	20	0	5	0	55	30	10	16.875	3	4
BD14	0	5	70	5	0	0	0	50	50	4.375	3	4
BD15	0	0	100	10	30	0	0	0	70	25.625	4	2
BD16	2	17	70	0	20	30	0	0	50	15.625	4	2
BD17	87	217	0	50	10	0	30	5	55	10.625	4	3
BD18	14	18	100	65	5	0	5	15	75	3.125	4	3
BD19	2	2	100	10	5	0	40	5	50	7.5	4	3
BD20	2	9	100	5	10	0	0	0	90	18.125	4	3
BD21	12	32	0	10	10	30	0	0	60	10	4	3
BD22	9	40	80	0	50	40	0	0	10	16.25	4	3
BK01	4	22	0	0	30	5	5	20	40	4.375	2	2
BK02	5	21	30	0	15	0	0	35	50	1.875	3	2
BK03	0	4	100	0	50	0	0	15	35	1.25	3	2
BK04	2	3	100	60	15	5	10	0	70	23.75	2	2
BK05	15	35	100	15	35	0	0	5	50	8.125	2	2

Table A2.1. cont.

Plot ID	CS	CT	TRC	SHB	HEP	GRB	BSB	ROB	LIP	SOI	NKA	NUF
HF01	16	55	0	0	20	5	10	15	50	6.25	4	3
HF02	31	127	0	0	10	5	20	10	55	6.25	4	3
HF03	19	38	30	50	70	30	0	0	0	9.375	4	2
HF04	12	38	25	0	30	0	10	0	60	13.125	4	2
HF05	12	46	30	25	50	0	0	25	20	5	3	3
HF06	4	35	50	40	50	20	0	20	20	1.25	3	3
KA01	14	58	100	0	5	0	60	30	25	5.625	4	4
KA02	7	34	70	0	5	0	10	40	45	2.5	4	3
KA03	0	8	90	0	15	0	40	10	40	8.75	4	4
KA04	10	31	60	0	40	0	40	20	10	5.625	4	4
KA05	18	39	40	0	40	0	30	40	30	6.875	4	3
SD01	12	50	80	0	50	5	0	0	45	31.25	4	2
SD02	48	151	40	10	80	15	0	0	5	15.625	4	2
SD03	22	50	50	0	15	85	0	0	0	59.375	4	2
SD04	0	0	100	0	20	70	0	0	10	9.375	4	2
SD05	19	26	100	0	30	70	0	0	0	13.125	4	2
SF01	23	103	90	0	30	0	10	5	55	17.5	4	3
SF02	19	69	100	0	20	0	5	0	75	21.25	4	3
SF03	8	78	100	0	70	0	0	0	30	17.5	4	2
SF04	7	11	100	0	40	0	0	0	60	29.375	4	2
SF05	5	24	100	30	20	0	0	0	80	30.625	4	3
SF06	1	3	100	50	15	5	10	5	65	31.25	4	3
SY01	4	12	70	60	50	5	0	0	55	14.375	3	2
SY02	18	36	100	50	20	0	0	0	80	4.375	3	2
SY03	0	11	100	5	10	0	20	0	65	10.625	3	2
SY04	4	23	100	0	40	0	10	0	50	17.5	3	2
SY05	1	11	50	0	60	10	0	10	20	5	3	2

Table A2.1. cont.

Plot ID	CR	PH	LOI	CA	P	AF	HI	PIA	BES
BD01	1	5.92	15.96	1064.9	3508	77.2	0.248	1	0
BD02	0	5.82	15.76	761.4	3300	19.4	0.286	1	0
BD03	1	6.88	12.15	5924.2	2798	86.1	0.358	1	0
BD04	0	5.28	18.46	400.9	2384	75.0	0.150	1	0
BD05	1	5.54	14.71	952.0	6800	#N/A	#N/A	1	0
BD06	0	5.77	17.97	1001.8	4564	8.3	0.450	1	1
BD07	1	5.99	21.43	1400.0	4667	119.4	-0.234	1	1
BD08	0	5.8	9.70	1340.8	22690	25.0	0.125	1	1
BD09	1	5.8	27.32	878.6	3588	141.7	-0.069	1	0
BD10	0	5.51	34.72	374.4	5473	75.0	0.257	1	0
BD11	1	7.42	20.00	8000.0	3700	25.0	0.257	1	0
BD12	1	5.94	19.14	1776.4	3239	25.0	0.330	1	0
BD13	1	6.29	10.07	1589.6	1987	36.1	0.569	1	0
BD14	1	4.98	83.73	549.4	9793	30.6	0.575	1	0
BD15	1	6.92	23.34	3599.0	7284	25.0	0.268	1	0
BD16	0	6.12	20.05	2194.9	5986	25.0	0.062	1	0
BD17	1	5.91	21.50	1581.4	2884	13.9	0.382	1	0
BD18	0	6.39	33.42	1915.1	3591	13.9	0.690	1	1
BD19	1	6.32	34.15	1873.9	3221	19.4	0.698	1	0
BD20	0	5.92	17.79	1686.5	5059	186.1	-0.144	1	0
BD21	1	5.47	20.16	942.4	4762	75.0	0.257	1	0
BD22	0	5.76	16.05	997.1	5359	19.4	0.135	1	0
BK01	1	5.12	22.96	566.1	21773	2.8	0.243	0	0
BK02	1	5.37	48.86	614.0	18419	41.7	0.170	1	1
BK03	0	5.31	24.75	889.0	19396	13.9	0.358	1	0
BK04	0	5.19	6.78	885.6	20664	58.3	0.315	1	1
BK05	0	5.28	71.84	64.0	4454	41.7	0.170	1	0

Table A2.1. cont.

Plot ID	CR	PH	LOI	CA	P	AF	HI	PIA	BES
HF01	1	5.39	10.19	962.1	7265	8.3	0.259	1	1
HF02	0	4.6	61.88	452.5	42014	69.4	0.023	1	1
HF03	1	5.99	11.16	1343.8	8958	63.9	0.219	1	1
HF04	0	5.99	11.16	1343.8	8958	8.3	0.352	1	1
HF05	1	6.33	5.54	1984.6	12629	2.8	0.423	1	1
HF06	0	4.78	28.99	1104.0	17940	25.0	0.330	1	1
KA01	1	6.11	19.03	1156.3	3259	19.4	0.698	0	1
KA02	1	6.04	20.44	1272.1	4893	36.1	0.826	1	1
KA03	0	6.23	22.50	1511.1	3111	36.1	0.209	1	1
KA04	0	6.26	19.39	1753.4	3301	25.0	0.839	0	1
KA05	1	6.06	19.58	1123.8	3269	8.3	0.811	1	1
SD01	1	7.44	17.93	18957.6	2899	19.4	0.267	1	1
SD02	0	4.33	14.44	207.8	900	69.4	0.041	1	1
SD03	1	7.01	26.59	41366.2	9025	#N/A	#N/A	1	0
SD04	0	7.41	15.10	86098.4	22518	113.9	-0.209	1	0
SD05	0	3.89	82.50	77.6	12121	141.7	-0.315	1	1
SF01	1	7.29	16.19	92656.2	5806	80.6	-0.087	1	0
SF02	0	7.53	13.89	100800.0	5040	63.9	0.122	1	0
SF03	1	7.42	7.90	265745.5	16451	58.3	0.217	0	0
SF04	0	7.31	10.28	136161.3	13616	80.6	-0.104	0	0
SF05	1	7.55	11.43	105000.0	8750	80.6	-0.124	1	0
SF06	0	7.59	16.64	54686.7	7211	80.6	-0.073	1	0
SY01	1	6.19	58.38	1404.6	3768	91.7	0.088	1	0
SY02	0	6.5	15.95	5517.3	4389	58.3	0.094	1	1
SY03	0	6.16	19.75	2228.0	4760	#N/A	#N/A	1	1
SY04	0	6.81	26.37	12135.8	2655	58.3	0.181	0	0
SY05	0	6	34.95	1373.3	3147	#N/A	#N/A	0	0

Table A2.1. cont.

Plot ID	PIS	SOA	QUR	JUC	POT	SLO	ELN
BD01	1	0	0	1	0	20	3.40
BD02	1	1	0	1	0	16	3.00
BD03	1	0	0	1	0	32	3.63
BD04	1	1	0	1	0	12	3.92
BD05	1	1	0	0	0	0	3.70
BD06	1	1	0	1	0	25	3.42
BD07	1	1	0	0	1	20	4.38
BD08	0	1	0	0	0	10	4.67
BD09	1	1	0	0	0	15	4.50
BD10	1	1	0	1	0	20	3.33
BD11	1	1	0	0	1	20	4.10
BD12	1	1	0	1	1	25	3.64
BD13	1	1	0	1	1	30	3.92
BD14	1	1	0	1	1	30	4.11
BD15	0	1	0	0	0	15	4.00
BD16	1	1	0	0	0	5	4.00
BD17	1	1	0	1	0	25	4.00
BD18	1	1	0	0	1	35	4.18
BD19	1	1	0	0	1	35	4.00
BD20	1	0	0	0	0	10	3.30
BD21	1	1	0	1	0	20	3.00
BD22	1	1	0	1	0	10	3.22
BK01	0	0	1	0	0	15	3.58
BK02	0	0	1	0	0	10	4.09
BK03	0	0	1	1	0	20	3.82
BK04	1	1	1	0	0	20	4.10
BK05	1	0	1	0	1	10	3.50

Table A2.1. cont.

Plot ID	PIS	SOA	QUR	JUC	POT	SLO	ELN
HF01	1	0	0	1	0	15	3.08
HF02	1	1	0	1	0	15	3.27
HF03	0	0	0	1	1	15	3.59
HF04	0	0	0	1	1	20	3.43
HF05	1	1	0	1	0	25	3.73
HF06	1	0	0	1	1	25	3.21
KA01	0	0	0	0	0	35	3.58
KA02	0	1	0	0	0	40	4.00
KA03	1	1	0	0	0	20	3.44
KA04	0	1	0	0	1	40	4.09
KA05	0	1	0	0	0	40	3.67
SD01	1	0	0	1	0	15	3.19
SD02	0	0	0	1	0	25	2.93
SD03	0	0	0	1	0	0	3.75
SD04	1	0	0	0	0	20	4.11
SD05	0	0	0	0	0	20	2.92
SF01	1	1	0	1	1	45	3.64
SF02	1	1	0	1	1	35	4.00
SF03	1	0	0	1	0	40	3.10
SF04	1	0	0	1	0	50	3.09
SF05	1	0	0	1	0	55	2.67
SF06	1	0	0	1	0	40	3.67
SY01	1	1	1	1	1	10	4.00
SY02	1	1	0	1	0	20	4.00
SY03	1	1	0	0	0	0	4.90
SY04	1	1	0	0	0	35	4.36
SY05	1	1	1	1	0	0	4.00

Table A2.2. Transformed environmental variables used in the statistical analysis. Abbreviations and transformations are found in Table 3.2

Plot ID	CS	CT	TRC	SHB	HEP	GRB	BSB	ROB	LIP
BD01	0.12268	0.46131	0.77758	0	0.42737	1	1	0	0.51090
BD02	0.44891	0.62071	0.06867	0	0.47878	1	1	0	0.34691
BD03	0.75979	0.76667	0.00000	0	0.32544	0	1	1	0.68505
BD04	0.42156	0.32042	1.00000	1	0.32544	1	0	0	0.51090
BD05	0.35568	0.43247	0.77758	0	0.63938	1	0	0	0.24289
BD06	0.51648	0.43247	0.77758	0	0.50998	0	0	1	0.68505
BD07	0.00000	0.20594	0.45609	1	0.42737	0	1	0	0.56779
BD08	0.00000	0.15331	1.00000	1	0.82028	1	0	0	0.34691
BD09	0.39080	0.55281	0.00000	0	0.32544	1	0	0	0.80718
BD10	0.00000	0.20594	0.77758	0	0.94789	1	0	0	0.24289
BD11	0.00000	0.08759	0.45609	0	0.19230	0	1	1	0.80718
BD12	0.92175	0.87018	0.03056	1	0.32544	0	1	1	0.74549
BD13	0.55306	0.77237	0.06867	0	0.19230	0	1	1	0.09433
BD14	0.00000	0.18093	0.45609	1	0.00000	0	0	1	0.51090
BD15	0.00000	0.00000	1.00000	1	0.63938	0	0	0	0.74549
BD16	0.20434	0.38839	0.45609	0	0.50998	1	0	0	0.51090
BD17	1.00000	1.00000	0.00000	1	0.32544	0	1	1	0.56779
BD18	0.56951	0.40012	1.00000	1	0.19230	0	1	1	0.80718
BD19	0.20434	0.08759	1.00000	1	0.19230	0	1	1	0.51090
BD20	0.20434	0.26931	1.00000	1	0.32544	0	0	0	1.00000
BD21	0.53545	0.52567	0.00000	1	0.32544	1	0	0	0.62583
BD22	0.47354	0.57743	0.59918	0	0.82028	1	0	0	0.09433
BK01	0.31473	0.44244	0.00000	0	0.63938	1	1	1	0.40049
BK02	0.35568	0.43247	0.11618	0	0.42737	0	0	1	0.51090
BK03	0.00000	0.15331	1.00000	0	0.82028	0	0	1	0.34691
BK04	0.20434	0.12248	1.00000	1	0.42737	1	1	0	0.74549
BK05	0.58493	0.54628	1.00000	1	0.69208	0	0	1	0.51090

Table A2.2. cont.

Plot ID	CS	CT	TRC	SHB	HEP	GRB	BSB	ROB	LIP
HF01	0.59944	0.65353	0.00000	0	0.50998	1	1	1	0.51090
HF02	0.75230	0.86228	0.00000	0	0.32544	1	1	1	0.56779
HF03	0.63849	0.56540	0.11618	1	0.94789	1	0	0	0.00000
HF04	0.53545	0.56540	0.09111	0	0.63938	0	1	0	0.62583
HF05	0.53545	0.61053	0.11618	1	0.82028	0	0	1	0.19240
HF06	0.31473	0.54628	0.24925	1	0.82028	1	0	1	0.19240
KA01	0.56951	0.66644	1.00000	0	0.19230	0	1	1	0.24289
KA02	0.42156	0.53959	0.45609	0	0.19230	0	1	1	0.45515
KA03	0.00000	0.24982	0.77758	0	0.42737	0	1	1	0.40049
KA04	0.49594	0.51843	0.34131	0	0.73911	0	1	1	0.09433
KA05	0.62615	0.57148	0.17541	0	0.73911	0	1	1	0.29439
SD01	0.53545	0.63051	0.59918	0	0.82028	1	0	0	0.45515
SD02	0.85630	0.90653	0.17541	1	1.00000	1	0	0	0.04671
SD03	0.67221	0.63051	0.34131	0	0.73911	1	0	1	0.09433
SD04	0.00000	0.00000	0.17541	0	0.73911	1	0	1	0.29439
SD05	0.63849	0.47892	0.59918	0	0.82028	1	0	0	0.45515
SF01	0.68250	0.80913	0.17541	0	1.00000	0	1	0	0.04671
SF02	0.63849	0.70903	0.24925	0	0.42737	0	1	0	0.00000
SF03	0.44891	0.73942	1.00000	0	0.50998	0	0	0	0.09433
SF04	0.42156	0.30446	1.00000	0	0.63938	0	0	0	0.00000
SF05	0.35568	0.46131	0.77758	1	0.63938	0	0	1	0.56779
SF06	0.12268	0.12248	1.00000	1	0.50998	1	1	0	0.80718
SY01	0.31473	0.32042	1.00000	1	0.94789	1	0	0	0.29439
SY02	0.62615	0.55281	1.00000	1	0.50998	0	0	0	0.87014
SY03	0.00000	0.30446	1.00000	1	0.32544	0	1	0	0.68505
SY04	0.31473	0.45204	1.00000	0	0.73911	0	1	0	0.51090
SY05	0.12268	0.30446	0.24925	0	0.88872	1	0	1	0.19240

Table A2.2. cont.

Plot ID	SOI	NKA	NUF	CR	PH	LOI	CA	P	AF
BD01	1.00000	1	1	1	0.53792	0.47424	0.49466	0.42910	0.67647
BD02	0.92079	1	1	0	0.51028	0.46931	0.44999	0.41207	0.28938
BD03	0.68167	0	1	1	0.80949	0.36633	0.68972	0.36527	0.71410
BD04	0.78851	0	1	0	0.36313	0.52884	0.35656	0.31854	0.66652
BD05	0.82386	0	0	1	0.43355	0.44253	0.48002	0.60233	0.00000
BD06	0.70103	0	0	0	0.49651	0.51885	0.48672	0.50024	0.14809
BD07	0.76901	1	0	1	0.55733	0.58313	0.52926	0.50612	0.83168
BD08	0.78851	1	0	0	0.50477	0.27085	0.52390	0.87624	0.34578
BD09	0.96698	0	1	1	0.50477	0.66759	0.46937	0.43530	0.89536
BD10	0.11743	0	1	0	0.42538	0.74657	0.34590	0.54754	0.66652
BD11	0.24383	1	0	1	0.96738	0.55826	0.71931	0.44377	0.34578
BD12	0.38693	1	0	1	0.54346	0.54222	0.55816	0.40692	0.34578
BD13	0.62361	0	1	1	0.64123	0.28710	0.54481	0.26363	0.44036
BD14	0.24383	0	1	1	0.28287	1.00000	0.40387	0.69031	0.39565
BD15	0.74809	1	0	1	0.82106	0.61339	0.63798	0.61928	0.34578
BD16	0.60067	1	0	0	0.59355	0.55911	0.58295	0.57039	0.34578
BD17	0.48672	1	1	1	0.53515	0.58432	0.54419	0.37398	0.22449
BD18	0.16466	1	1	0	0.66944	0.73430	0.56706	0.43554	0.22449
BD19	0.38693	1	1	1	0.64968	0.74131	0.56450	0.40530	0.28938
BD20	0.64493	1	1	0	0.53792	0.51513	0.55195	0.52727	1.00000
BD21	0.46907	1	1	1	0.41451	0.56118	0.47869	0.51141	0.66652
BD22	0.61236	1	1	0	0.49376	0.47622	0.48610	0.54217	0.28938
BK01	0.24383	0	0	1	0.32020	0.60769	0.40822	0.86759	0.05520
BK02	0.06327	0	0	1	0.38741	0.85172	0.41989	0.83207	0.48086
BK03	0.00000	0	0	0	0.37121	0.63379	0.47094	0.84313	0.22449
BK04	0.72551	0	0	0	0.33894	0.10442	0.47043	0.85658	0.58360
BK05	0.40948	0	0	0	0.36313	0.95999	0.00000	0.49379	0.48086

Table A2.2. cont.

Plot ID	SOI	NKA	NUF	CR	PH	LOI	CA	P	AF
HF01	0.33666	1	1	1	0.39282	0.29224	0.48141	0.61863	0.14809
HF02	0.33666	1	1	0	0.18272	0.91935	0.37507	1.00000	0.64061
HF03	0.45040	1	0	1	0.55733	0.33110	0.52417	0.66926	0.61305
HF04	0.54888	1	0	0	0.55733	0.33110	0.52417	0.66926	0.14809
HF05	0.27762	0	1	1	0.65250	0.00000	0.57125	0.74891	0.05520
HF06	0.00000	0	1	0	0.22995	0.68754	0.49931	0.82640	0.34578
KA01	0.30842	1	1	1	0.59076	0.54004	0.50524	0.40858	0.28938
KA02	0.11743	1	1	1	0.57124	0.56611	0.51733	0.51854	0.44036
KA03	0.43058	1	1	0	0.62436	0.60048	0.53865	0.39556	0.44036
KA04	0.30842	1	1	0	0.63279	0.54699	0.55661	0.41216	0.34578
KA05	0.36274	1	1	1	0.57681	0.55048	0.50159	0.40949	0.14809
SD01	0.80674	1	0	1	0.97330	0.51818	0.79848	0.37553	0.28938
SD02	0.60067	1	0	0	0.11256	0.43538	0.24720	0.00000	0.64061
SD03	0.30842	1	0	1	0.63279	0.54699	0.55661	0.41216	0.00000
SD04	0.36274	1	0	0	0.57681	0.55048	0.50159	0.40949	0.81418
SD05	0.80674	1	0	0	0.97330	0.51818	0.79848	0.37553	0.89536
SF01	0.60067	1	1	1	0.11256	0.43538	0.24720	0.00000	0.69097
SF02	0.99183	1	1	0	0.84716	0.65847	0.86369	0.67104	0.61305
SF03	0.45040	1	0	1	0.96442	0.45279	0.92031	0.87465	0.58360
SF04	0.54888	1	0	0	0.00000	0.99620	0.04633	0.73959	0.69097
SF05	0.63446	1	1	1	0.92902	0.47959	0.92576	0.56267	0.69097
SF06	0.69239	1	1	0	1.00000	0.42006	0.93197	0.52626	0.69097
SY01	0.63446	1	0	1	0.96738	0.17851	1.00000	0.80762	0.73606
SY02	0.24383	0	0	0	0.70062	0.47391	0.68254	0.48986	0.58360
SY03	0.48672	0	0	0	0.60474	0.55366	0.58468	0.51132	0.00000
SY04	0.63446	0	0	0	0.78930	0.65559	0.75856	0.35012	0.58360
SY05	0.27762	0	0	0	0.56011	0.74872	0.52688	0.39881	0.00000

Table A2.2. cont.

Plot ID	HI	PIA	BES	PIS	SOA	QUR	JUC	POT	SLO	ELN
BD01	0.57512	1	0	1	0	0	1	0	0.46520	0.64864
BD02	0.60628	1	0	1	1	0	1	0	0.37501	0.40838
BD03	0.66495	1	0	1	0	0	1	0	0.72788	0.64864
BD04	0.49016	1	0	1	1	0	1	0	0.28344	0.40838
BD05	0.34907	1	0	1	1	0	0	0	0.00000	0.38791
BD06	0.73577	1	1	1	1	0	1	0	0.57606	0.78333
BD07	0.09808	1	1	1	1	0	0	1	0.46520	0.68984
BD08	0.46707	1	1	0	1	0	0	0	0.23712	0.63226
BD09	0.27902	1	0	1	1	0	0	0	0.35225	0.91029
BD10	0.58279	1	0	1	1	0	1	0	0.46520	0.89056
BD11	0.58279	1	0	1	1	0	0	1	0.46520	0.79851
BD12	0.64212	1	0	1	1	0	1	1	0.57606	0.26689
BD13	0.82168	1	0	1	1	0	1	1	0.68489	0.66882
BD14	0.82630	1	0	1	1	0	1	1	0.68489	0.43831
BD15	0.59163	1	0	0	1	0	0	0	0.35225	0.53630
BD16	0.40883	1	0	1	1	0	0	0	0.11974	0.57533
BD17	0.68344	1	0	1	1	0	1	0	0.57606	0.44959
BD18	0.90437	1	1	1	1	0	0	1	0.79179	0.48356
BD19	0.90964	1	0	1	1	0	0	1	0.79179	0.49115
BD20	0.19921	1	0	1	0	0	0	0	0.23712	0.70433
BD21	0.58279	1	0	1	1	0	1	0	0.46520	0.52465
BD22	0.47648	1	0	1	1	0	1	0	0.23712	0.43831
BK01	0.57058	0	0	0	0	1	0	0	0.35225	0.32701
BK02	0.50795	1	1	0	0	1	0	0	0.23712	0.47448
BK03	0.66498	1	0	0	0	1	1	0	0.46520	0.27885
BK04	0.63041	1	1	1	1	1	0	0	0.46520	0.32701
BK05	0.50795	1	0	1	0	1	0	1	0.23712	0.62186

Table A2.2. cont.

Plot ID	HI	PIA	BES	PIS	SOA	QUR	JUC	POT	SLO	ELN
HF01	0.58401	1	1	1	0	0	1	0	0.35225	0.77008
HF02	0.37192	1	1	1	1	0	1	0	0.35225	0.52465
HF03	0.55071	1	1	0	0	0	1	1	0.35225	0.34907
HF04	0.65954	1	1	0	0	0	1	1	0.46520	0.40838
HF05	0.71475	1	1	1	1	0	1	0	0.57606	0.41865
HF06	0.64212	1	1	1	0	0	1	1	0.57606	0.36171
KA01	0.90964	0	1	0	0	0	0	0	0.79179	0.44959
KA02	0.99211	1	1	0	1	0	0	0	0.89680	0.16837
KA03	0.54149	1	1	1	1	0	0	0	0.46520	0.53306
KA04	1.00000	0	1	0	1	0	0	1	0.89680	0.62654
KA05	0.98224	1	1	0	1	0	0	0	0.89680	0.57533
SD01	0.59078	1	1	1	0	0	1	0	0.35225	0.79218
SD02	0.38860	1	1	0	0	0	1	0	0.57606	0.57533
SD03	1.00000	1	0	0	0	0	1	0	0.89680	0.00000
SD04	0.98224	1	0	1	0	0	0	0	0.89680	0.19846
SD05	0.59078	1	1	0	0	0	0	0	0.35225	0.49115
SF01	0.38860	1	0	1	1	0	1	1	0.57606	0.57533
SF02	0.34907	1	0	1	1	0	1	1	0.00000	0.24702
SF03	0.12724	0	0	1	0	0	1	0	0.46520	0.32701
SF04	0.00000	0	0	1	0	0	1	0	0.46520	0.52465
SF05	0.26049	1	0	1	0	0	1	0	1.00000	0.23118
SF06	0.46426	1	0	1	0	0	1	0	0.79179	0.26146
SY01	0.54873	1	0	1	1	1	1	1	0.89680	0.04530
SY02	0.43911	1	1	1	1	0	1	0	0.46520	0.51206
SY03	0.34907	1	1	1	1	0	0	0	0.00000	0.62186
SY04	0.51755	0	0	1	1	0	0	0	0.79179	0.63226
SY05	0.34907	0	0	1	1	1	1	0	0.00000	1.00000

Appendix 3 Correlation between environmental variables and DCA

Table A3.1. Correlation coefficients and corresponding p-values from Kendall correlation tests between DCA axes and continuous environmental variables.

	DCA axis 1		**DCA axis 2**		**DCA axis 3**		**DCA axis 5**	
	τ	**p**	**τ**	**p**	**τ**	**p**	**τ**	**p**
CS	0.0596	0.5338	-0.1085	0.2577	-0.0668	0.4857	0.0596	0.5338
CT	0.0801	0.3948	-0.1083	0.2504	-0.0815	0.3866	0.0801	0.3948
TRC	0.0889	0.3692	0.1100	0.2665	0.0331	0.7377	0.0889	0.3692
HEP	0.0953	0.3284	-0.3519	0.0003	-0.0557	0.5678	0.0953	0.3284
LIP	-0.1124	0.2424	0.2522	0.0087	-0.1066	0.2674	-0.1124	0.2424
SOI	-0.2475	0.0088	-0.1403	0.1373	-0.0190	0.8402	-0.2475	0.0088
PH	0.1656	0.0782	0.0435	0.6436	0.0154	0.8696	0.1656	0.0782
LOI	0.0308	0.7427	0.1148	0.2211	-0.0532	0.5707	0.0308	0.7427
CA	0.2156	0.0216	0.0420	0.6544	0.0336	0.7202	0.2156	0.0216
P	0.1386	0.1396	-0.0882	0.3471	0.0966	0.3032	0.1386	0.1396
AF	-0.0672	0.4819	-0.0286	0.7647	-0.0300	0.7533	-0.0672	0.4819
HI	-0.0457	0.6275	0.1581	0.0931	0.0035	0.9702	-0.0457	0.6275
SLO	0.1777	0.0702	0.1955	0.0464	0.0592	0.5462	0.1777	0.0702
ELN	-0.1492	0.1135	0.1324	0.1605	-0.0972	0.3029	-0.1492	0.1135

Table A3.2. Correlation coefficients and corresponding p-values from Mann–Whitney tests between DCA axes and binary environmental variables.

	DCA axis 1		**DCA axis 2**		**DCA axis 3**		**DCA axis 5**	
	U	**p**	**U**	**p**	**U**	**p**	**U**	**p**
SHB	355	0.9652	267	0.1378	390	0.5124	355	0.9652
GRB	579	0.0001	609	<0.0001	449	0.1241	579	0.0001
BSB	270	0.1110	184	0.0016	354	0.8905	270	0.1110
ROB	295	0.2378	220	0.0121	379	0.8034	295	0.2378
NKA	283	0.3782	378	0.4185	300	0.5655	283	0.3782
NUF	397	0.5827	277	0.1331	436	0.2213	397	0.5827
CR	332	0.5827	307	0.3269	332	0.5827	332	0.5827
PIA	260	0.0120	192	0.4951	192	0.4951	260	0.0120
BES	259	0.1038	343	0.8821	317	0.5467	259	0.1038
PIS	320	0.4400	242	0.4636	367	0.0879	320	0.4400
SOA	458	0.0483	202	0.0098	330	0.7784	458	0.0483
QUR	158	0.8799	155	0.8206	230	0.0947	158	0.8799
JUC	321	0.5435	499	0.0121	443	0.1333	321	0.5435
POT	225	0.1980	186	0.0397	240	0.3189	225	0.1980

Appendix 4 Plot species frequency scores

Table A4. Species frequency scores.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Acer platanoides	0	0	0	0	0	0	0	4	0	0	1	1	0	0	0	0	1	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alnus incana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Anemone nemorosa	0	0	0	1	0	1	4	0	1	0	1	0	0	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
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Avenella flexuosa	5	3	1	5	0	1	0	0	0	6	0	0	0	0	0	4	0	0
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Betula pubescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachypodium pinnatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	4	0	2	4	5	1	0	3	3	0	0	1	0	0	0	1	1	0
Campanula rotundifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carex digitata	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	1	0	1	0	0	0	0	0	3	0	0	1	3	1	2	0	1	0
Cladonia spp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	1
Corylus avellana	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Deschampsia cespitosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Dicranum majus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table A4. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Dicranum polysetum	2	3	0	3	0	1	0	0	3	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
Epipactis atrorubens	0	0	1	0	1	1	0	0	2	0	1	1	1	0	4	1	1	0
Fragaria vesca	0	0	1	2	0	0	0	0	0	0	0	3	0	0	0	1	1	0
Frangula alnus	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0
Fraxinus excelsior	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Galium album	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	0	0	1	1	1	1	6	0	0	0	0	0	0	2	0	0	0
Hieracium spp.	1	5	5	1	4	1	1	1	0	2	3	2	1	0	5	6	2	3
Hylocomiadelphus triquetrus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0
Hylocomium splendens	0	1	0	5	6	1	1	1	4	2	0	0	0	0	0	6	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hypochaeris maculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	2	0
Lathyrus linifolius	0	0	0	1	4	1	1	0	0	0	1	0	0	0	0	0	0	0
Lonicera xylosteum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lotus corniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melica nutans	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Mnium hornum	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
Mycelis muralis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0

Table A4. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Oxalis acetosella	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	1	0	1	0	0	0	0	0	1	0	0	1	1	1	1	0	1
Pinus sylvestris	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	1
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	5	5	0	2	2	1	1	2	0	0	0	0	0	0	0	0	0	0
Pohlia nutans	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0
Polygonatum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	0	0	0	0	0	0	3	1	0	0	1	0	1	0	0	0	0	1
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	4	3	0	0	2	0	0	0	0	0	4	0	0	4	0	5	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Rubus idaeus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	1
Rubus saxatilis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Salix caprea	0	0	0	0	0	0	0	0	0	0	1	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
Sorbus aucuparia	0	0	0	0	0	0	3	3	0	1	1	0	1	1	0	3	0	0
Succisa pratensis	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	0	4	0	0	0	1	1	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Thuidium tamariscinum	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	1	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	4	0	0	0	0	0	0	0	0	0
Vaccinium myrtillus	5	1	0	5	0	1	1	0	0	4	0	0	0	0	4	0	0	0
Vaccinium vitis-idaea	0	3	0	0	0	0	0	0	0	2	1	0	0	0	0	1	0	0
Veronica chamaedrys	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	0	0	0	0	0	0	0	1
Vicia cracca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sepium	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Viola riviniana	0	0	1	1	4	2	0	3	0	0	1	1	0	0	1	1	0	0

Table A4. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Acer platanoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	1	0	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
Anemone nemorosa	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avenella flexuosa	0	2	6	6	0	0	1	2	6	5	4	6	5	0	6	0	0	0
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula	0	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	1	1	0	0	0	0	0	1	1	1
Brachypodium pinnatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Campanula rotundifolia	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Carex digitata	0	0	0	0	2	4	5	0	0	4	2	3	5	0	2	0	1	0
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	2	0	2	0	1	1	0	0	0	0	0	2	0	2	0	1	1	0
Cladonia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	0	1	0	0	1	1	6	0	1	2	0	5	5	3	2	1	1	1
Corylus avellana	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia cespitosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum majus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Dicranum polysetum	0	0	2	4	0	0	0	0	0	0	2	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
Epipactis atrorubens	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Fragaria vesca	0	0	0	0	0	0	0	0	0	0	2	5	6	5	0	0	0	0
Frangula alnus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium album	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	1	0	0	0	1	4	0	0	0	0	5	5	4	0	1	0	0
Hieracium spp.	1	1	4	6	0	0	0	0	1	0	0	3	1	2	0	1	1	1
Hylocomiadelphus triquetrus	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	0	5	4	0	0	0	0	0	0	0	6	1	0	0	0	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Hypochaeris maculata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis	1	0	0	0	0	0	0	0	0	0	0	5	0	4	4	0	0	0
Lathyrus linifolius	0	1	2	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1
Lonicera xylosteum	0	0	0	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula pilosa	0	0	0	0	1	2	1	0	0	1	0	2	0	0	2	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	1	5	4	5	4	2	0	0	0
Melica nutans	0	0	0	0	1	3	4	0	0	0	3	6	5	6	0	0	0	0
Mnium hornum	0	0	0	0	0	0	0	3	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
Mycelis muralis	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Oxalis acetosella	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Pinus sylvestris	1	1	0	1	0	0	0	0	1	2	0	0	0	0	4	0	0	4
Plagiochila asplenioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	3	1	0	0	0	0	0	2	3	4	0	0	3	0	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonatum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	3
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	1	0	0	0	0	0	0	0	0	0	4	2	0	0	1	0	0
Pyrola minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	1	0	1	0	2	0	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	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	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	1	2	0
Salix caprea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	1	0	0	3	2	1	0	0
Sorbus aucuparia	1	1	3	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1
Succisa pratensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum spp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	0	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
Vaccinium myrtillus	0	4	0	3	5	2	1	3	4	0	0	0	4	0	5	0	0	0
Vaccinium vitis-idaea	0	0	3	0	1	1	0	0	5	0	5	0	4	0	5	0	0	0
Veronica chamaedrys	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Veronica officinalis	0	0	0	0	4	0	1	1	0	4	0	1	0	0	0	0	0	0
Vicia cracca	0	0	0	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	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola riviniana	1	0	0	0	0	3	1	2	0	2	1	5	6	5	3	0	0	0

Table A4. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Acer platanoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Agrostis capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	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
Anemone nemorosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antennaria dioica	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	4
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	0	0	6
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Betula pendula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pubescens	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Brachypodium pinnatum	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	1	1	0	6	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Carex digitata	0	0	4	0	5	6	0	4	1	2	6	3	3	3	1	1	4	1
Carex panicea	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	0	1	2	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0
Cladonia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	5	0	1	0	0	0	0	5	5	5	5	4	4	0	4	0	6	1
Corylus avellana	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia cespitosa	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum majus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Dicranum polysetum	0	0	2	2	2	0	6	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	5	4	3	3
Epipactis atrorubens	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Fragaria vesca	0	0	2	2	4	3	0	0	2	0	0	0	0	4	0	3	1	4
Frangula alnus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Galium album	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	4	1	3	4	3	0	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	0	2	0	6	6	0	3	1	0	4	0	6	0	0	2	1	0
Hieracium spp.	1	1	0	2	5	3	0	3	1	0	0	1	3	0	0	0	0	0
Hylocomiadelphus triquetrus	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Hylocomium splendens	0	0	0	3	6	6	6	0	0	0	0	0	3	0	0	0	0	4
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypochaeris maculata	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
Juniperus communis	0	0	0	2	0	0	0	4	0	0	0	5	1	0	0	0	0	0
Lathyrus linifolius	1	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0
Lonicera xylosteum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Luzula pilosa	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Melica nutans	0	0	0	0	3	0	0	0	0	0	0	0	0	2	0	2	1	0
Mnium hornum	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	6	6	5	0	0	0	0	0	0
Mycelis muralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Oxalis acetosella	0	0	0	0	0	6	0	0	0	0	0	0	0	6	0	0	0	0
Parnassia palustris	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	1	0	0	0	3	1	0	0	0	0	0	0	0	0	1	0	0
Pinus sylvestris	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0
Plagiochila asplenioides	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurozium schreberi	0	0	0	4	0	4	4	0	0	0	0	0	0	0	0	0	0	2
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Polygonatum odoratum	0	0	4	0	0	0	0	0	4	0	1	1	4	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	1	4	1	4	0	0	0	0	0	0	0	0	2	0	0	0	0
Pteridium aquilinum	0	5	0	0	1	0	1	0	0	0	0	0	4	0	5	0	0	0
Ptilium crista-castrensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	1	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pyrola minor	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ranunculus acris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	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	0	0	0	0	0	0	0	0	0	0	0
Rubus saxatilis	1	1	0	3	0	0	0	5	5	1	1	0	1	4	0	1	0	0
Salix caprea	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sorbus aucuparia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Succisa pratensis	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table A4. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	0	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
Vaccinium myrtillus	0	0	2	0	0	0	6	0	0	0	0	0	0	0	0	0	1	0
Vaccinium vitis-idaea	0	0	3	1	0	1	4	0	0	0	0	0	0	3	0	0	0	1
Veronica chamaedrys	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica officinalis	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Vicia cracca	0	0	4	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	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola riviniana	0	0	0	0	2	4	0	0	1	0	0	0	0	0	0	4	1	0

Appendix 5 Plot species cover score

Table A5. Species cover scores

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Acer platanoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	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
Anemone nemorosa	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula	0	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	0
Brachypodium pinnatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex digitata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia spp.	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	1	0	0	0	0	0	0	0	0	0	0	0
Corylus avellana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia cespitosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum majus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table A5. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Dicranum polysetum	0	0	0	0	0	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
Epipactis atrorubens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragaria vesca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frangula alnus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium album	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Hieracium spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0
Hylocomiadelphus triquetrus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hylocomium splendens	0	0	0	3	4	0	0	0	1	0	0	0	0	0	0	2	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypochaeris maculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lathyrus linifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lonicera xylosteum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium hornum	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
Mycelis muralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Oxalis acetosella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	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
Pleurozium schreberi	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonatum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	1	1	0	0	2	0	0	0	0	0	4	0	0	2	0	4	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	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	0	0	0	0	0	0	0	0	0	0	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salix caprea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Succisa pratensis	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	0	0	0	0	0	0	0	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD01	BD02	BD03	BD04	BD05	BD06	BD07	BD08	BD09	BD10	BD11	BD12	BD13	BD14	BD15	BD16	BD17	BD18
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tussilago farfara	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vaccinium myrtillus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vaccinium vitis-idaea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica chamaedrys	3	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	0	0	0	0	0	0	0	0
Vicia cracca	0	0	0	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	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola riviniana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Acer platanoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	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
Anemone nemorosa	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula	0	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	0
Brachypodium pinnatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex digitata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia spp.	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	3	0	0	0	0	1	0	1	0	0	0	0
Corylus avellana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia cespitosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum majus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Dicranum polysetum	0	0	0	1	0	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
Epipactis atrorubens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragaria vesca	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Frangula alnus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium album	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium spp.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomiadelphus triquetrus	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Hypochaeris maculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	0	0	0
Lathyrus linifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lonicera xylosteum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
Mnium hornum	0	0	0	0	0	0	0	1	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
Mycelis muralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Oxalis acetosella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	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
Pleurozium schreberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonatum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	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	0	0	0	0	0	0	0	0	0	0	0
Rubus saxatilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Salix caprea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Succisa pratensis	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	0	0	0	0	0	0	0	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	BD19	BD20	BD21	BD22	BK01	BK02	BK03	BK04	BK05	HF01	HF02	HF03	HF04	HF05	HF06	KA01	KA02	KA03
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	0	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
Vaccinium myrtillus	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Vaccinium vitis-idaea	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
Veronica chamaedrys	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	0	0	0	0	0	0	0	0
Vicia cracca	0	0	0	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	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola riviniana	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table A5. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Acer platanoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actaea spicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga pyramidalis	0	0	0	0	0	0	0	0	0	0	0	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
Anemone nemorosa	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arabis hirsuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asplenium trichomanes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avenella flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4
Berberis vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula	0	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	0
Brachypodium pinnatum	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calamagrostis arundinacea	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex digitata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalanthera rubra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convallaria majalis	3	0	0	0	0	0	0	1	2	0	2	0	0	0	0	0	2	0
Corylus avellana	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cotoneaster scandinavicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daphne mezereum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deschampsia cespitosa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum majus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Dicranum polysetum	0	0	0	0	0	0	4	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
Epipactis atrorubens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragaria vesca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frangula alnus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Galium album	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galium boreale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium sanguineum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Geranium sylvaticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatica nobilis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomiadelphus triquetrus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomium splendens	0	0	0	0	4	3	1	0	0	0	0	0	0	0	0	0	0	0
Hypericum perforatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypochaeris maculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Lathyrus linifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lonicera xylosteum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopodium clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melampyrum pratense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melica nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mnium hornum	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	4	1	1	0	0	0	0	0	0
Mycelis muralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Oxalis acetosella	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0
Parnassia palustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea abies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinus sylvestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plagiochila asplenioides	0	0	0	0	3	0	0	0	0	0	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	0	0	0
Pohlia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonatum odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum commune	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Populus tremula	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	3	0	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0
Ptilium crista-castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola chlorantha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrola minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus acris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhodobryum roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa spp.	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	0	0	0	0	0	0	0	0	0	0	0
Rubus saxatilis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Salix caprea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solidago virgaurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbus aucuparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Succisa pratensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxus baccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5. cont.

	KA04	KA05	SD01	SD02	SD03	SD04	SD05	SF01	SF02	SF03	SF04	SF05	SF06	SY01	SY02	SY03	SY04	SY05
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	0	0	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
Vaccinium myrtillus	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Vaccinium vitis-idaea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica chamaedrys	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	0	0	0	0	0	0	0	0
Vicia cracca	0	0	0	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	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola mirabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola riviniana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0