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Changes in species richness and altitudinal distribution of vascular plants in Jotunheimen, Norway

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Ecology

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Photo: Visdalen with Kyrkjetjønne in the upper valley. The photo was taken on Spiterhøi.

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Preface

First of all, I want to thank my supervisor Kari Klanderud for the opportunity to resample the sites in Jotunheimen. I feel lucky to have been trusted with such an important task, and think my master's thesis could not have been more interesting. Because of personal issues I was not able to finish when planned, and at one time started to doubt if I would ever finish. However, thanks to Kari's continued support and patience I finally present this work. For this I am truly grateful.

I also want to thank my second supervisor John-Arvid Grytnes for being patient, and giving me the opportunity to finish my thesis. When I needed input on analysis and statistics he found time to help me in spite of busy days at work.

I want to thank fellow master student Jon Peder Lindemann for accompanying me on some of the mountains. I am also grateful for valuable information provided by Hanne Heiberg and Inger Hanssen-Bauer at The Norwegian Meteorological Institute and Wenche Aas at the Norwegian Institute for Air Research. Finally, thanks to Rigmor Solem, Pål Grev, Hans Nørstnes Graffer, Torkjel Solbakken and Rolv Rustem for providing information on reindeer and sheep in Jotunheimen.

Ås, 12 May 2019

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Erlend Tandberg Grindrud

Abstract

Species richness was sampled on 254 sites distributed along the altitudinal gradient of 23 mountains in Jotunheimen, Norway. The sampling was conducted during the summer of 2014, on sites that previously had been sampled in 1930-31 and 1998. The purpose of the study was to investigate possible changes in species richness and altitudinal distribution of vascular plants, and try to explain any observed change.

The results show that species richness in Jotunheimen increased between 1998 and 2014, and that the relative increase was highest at higher elevation sites. Species richness also increased more in eastern parts of Jotunheimen than in western parts, both in 1930/31-1998 and 1998-2014. Species richness on the most species-rich sites has declined in 1998-2014, and high-altitude species have possibly declined at lower elevations. The high-altitude species *Beckwithia glacialis*, *Ranunculus pygmeus, Poa flexuosa, Saxifraga Cernua* and *Erigeron uniflorus* experienced a reduced number of occurrences at lower elevations in 1930/31-1998, and has continued this tendency in 1998-2014. High-altitude species that did not decline at lower elevations in 1930/31-1998 (e.g. *Cardamine bellidifolia*, *Luzula confusa* and *Juncus biglumis*) have started to decline in 1998-2014. A process called thermophilization, which can be described as the decline of cold-adapted species and/or the increase of higher temperature-adapted species, was detected for both 1930/31-1998 and 1998-2014 in Jotunheimen. Plant communities have hence become “warmer”.

A strong warming tendency is observed after the 1998 sampling, and climate warming is the most likely driver of the observed changes in Jotunheimen. Nitrogen deposition and grazing pressure have been discussed, but further investigation is needed to determine their role. Hiking tourism, pseudoturnover and natural succession, are found to not explain the general changes observed in this study.

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Introduction

Life in alpine environments is harsh, with low temperatures, strong winds, lack of nutrients and prolonged snow cover during the year. In this environment facilitation is believed to be the dominant form of interaction among plants (Callaway et al., 2002). Abiotic stress is so limiting that amelioration of stress from neighbour plants, helps survival and reproduction. Under recent climate change however, abiotic stress is reduced as temperatures rise (Britton et al., 2009), and plant interactions in the alpine environment may switch from facilitation to competition (Callaway et al., 2002). Alpine plants can therefore be faced with another challenge: the competition from neighbour plants and new colonizers, which are climbing the mountains from lower elevations (Alexander et al., 2015; Steinbauer et al., 2018). In various studies, it has been suggested that competitive species might expand at the cost of less competitive alpine species (Alexander et al., 2015; Guisan et al., 1998; Klanderud & Birks, 2003; Steinbauer et al., 2018; Sætersdal & Birks, 1997; Vittoz et al., 2009), causing the latter to be pushed upward in elevation (Grabherr et al., 1994; Pauli et al., 2007; Speed et al., 2012; Walther et al., 2005). Other studies however suggest that environmental conditions vary so much on a micro scale, due to local microtopography, that most of the less competitive alpine plants are likely to find suitable habitat within a short distance (Scherrer & Koerner, 2010; Scherrer & Körner, 2011).

However, some observations indicate that alpine species might be experiencing retractions of their lower altitude range limits. For example, in Jotunheimen, Norway, Klanderud (2000) found that species frequent at high elevations (*Beckwithia glacialis*, *Ranunculus pygmaeus*, *Poa flexuosa*, *Trisetum spicatum* and *Cerastum alpinum* among others) had decreased in number of occurrences at lower altitudes between 1930-31 and 1998. In the Austrian Alps, Pauli et al. (2007) documented reduced cover of nival species, while many alpine and subnival species were increasing their ground cover. They concluded that alpine and subnival species are expanding their upper range edges, while nival species are experiencing a contraction of their lower range edges. In the Scottish highlands similar results were found, with a decline of species with a northern and alpine distribution (Britton et al., 2009). Possible range retractions of artic-alpine plants have also been reported from Montana, USA (Lesica & McCune, 2004). In spite of these findings, no broad-scale retraction of alpine plants' lower range limits has been documented.

Related to range retractions in the lower range-limits of alpine species, is thermophilization (Erschbamer et al., 2011; Gottfried et al., 2012). Thermophilization can be described as the decline of cold-adapted species and/or the increase of higher temperature-adapted species (species from lower elevation ranges), resulting in a relatively “warmer” plant community (Gottfried et al., 2012). Thermophilization has been detected by both Erschbamer et al. (2011) and Gottfried et al. (2012), the latter based on summit data from all mayor mountain systems in Europe, including Dovrefjell in Norway.

At the same time as thermophilization and possible decline of cold-adapted species have been observed, species richness has been found to increase on mountain summits around Europe (Grabherr et al., 1994; Jurasinski & Kreyling, 2007; Klanderud & Birks, 2003; Odland et al., 2010; Steinbauer et al., 2018; Wipf et al., 2013). The trend of increased species richness has also been observed to accelerate from 1,3 species to 3,7 species per decade in the Swiss Alps (Walther et al., 2005), and from 1,1 to 5,4 species per decade on a wide range of European summits (Steinbauer et al., 2018).

Between 1930-31 and 1998, Klanderud & Birks (2003) found an increase in species richness on 19 of 23 sampled mountains in Jotunheimen. Species richness in Jotunheimen also seemed to increase more at lower than higher elevations, and was more pronounced in the eastern mountains than in the western.

Although the vast majority of studies have found increased species richness on mountain sites, there are also examples of the opposite. Pauli et al. (2012) found that Mediterranean summits on average have experienced a significant decrease in species richness, possibly because of drought stress. On the Tibetan Plateau, Klein et al. (2004) found species losses in plots with high species richness, after a four year warming experiment. Klanderud (2000) between 1930-31 and 1998 also found reduced species richness on three of the westernmost mountains in Jotunheimen.

Most studies consider higher temperatures to be a main driver of the observed changes (Chen et al., 2011; Klanderud & Birks, 2003; Lenoir et al., 2008; Pauli et al., 2007; Pauli et al., 2012; Steinbauer et al., 2018). A growing number of studies however points at precipitation, or the interaction between precipitation and temperature, as a possible driver (Crimmins et al., 2011; Dolezal et al., 2016; Engler et al., 2011; Klanderud & Birks, 2003; Odland et al., 2010). Is has also been observed that herbivore grazing influences plant communities (Speed et al., 2012), and nitrogen deposition (Lenoir et al., 2008), migration lags in plants since the Little Ice Age (Dullinger et al., 2012b) and hiking disturbances (Haugum, 2016) are factors that should be considered when explaining possible changes in this study.

The work presented is a resampling of historical plant records from the Jotunheimen mountain massif in southern Norway. In 1930 and 1931, Jørgensen (1932) undertook a mapping of the altitudinal limits of vascular plants in Jotunheimen. Starting at approximately 1500 m a.s.l, he registered the occurrences of vascular plant species along the altitudinal gradient of 25 mountains. Almost 70 years later, in 1998, Klanderud (2000) did a resampling of the sites. Then, in 2014, I visited the sites a third time, resulting in this study.

What makes the monitoring of plants in mountain ecosystems important is the increasing anthropogenic influence in these environments (Chen et al., 2014; Pauchard et al., 2009; Steinbauer et al., 2018). Additionally, the Jotunheimen study can be considered valuable due to the mapping of plants along a large altitudinal gradient. The majority of similar studies tend to focus only on summits. In the Jotunheimen study area it is also possible to focus at lower range limits of alpine plants, and we can therefore detect trends that other studies might not detect. The study area is also situated across an oceanic gradient, where the western areas are wetter and experience milder winters than the eastern areas. It may therefore be possible to observe trends along a temperature and precipitation gradients within the study area.

The study wishes to answer the following questions: 1. Is species richness changing over time on the mountains in Jotunheimen? 2. How is species richness changing along the altitudinal and west-east gradients? 3. Are changes in species richness related to initial species richness on sites? 4. Are changes in species richness related to microclimate on sites? 5. Can thermophilization be detected in Jotunheimen over time? 6. If so, how is thermophilization occurring along the altitudinal and west-east gradients? 7. Between 1998 and 2014, how is the number of occurrences of species, grouped according to temperature requirements, changing along the altitudinal gradient?

If any significant changes can be observed in the study, possible drivers will be discussed.

Materials and methods

Geography, vegetation and topography

Jotunheimen forms part of the Caledonian mountain range, and all of Norway's 23 peaks above 2300 m a.s.l. are found in Jotunheimen. These mountains are the highest in Northern Europe. In Jotunheimen you can also find Norway's highest peak, Galdhøpiggen (2469 m a.s.l.), where the highest growing vascular plant in Scandinavia, *Beckwithia glacialis*, has an altitudinal limit at 2370 m a.s.l. (Jørgensen, 1932; Lid & Lid, 2005). In the eastern parts of Jotunheimenen, Norway's highest growing forest treeline is found at 1200 m a.s.l.

The bedrock is in some areas calcareous, giving home to chalk-demanding species such as *Dryas octopetala* and *Pulsatilla vernalis*. Many glaciers are covering high-altitude areas, the largest being Smørstabbrean in the west. While jagged peaks and steep topography dominate in the west, the terrain becomes gentler in eastern parts. Steep slopes and precipices however occur on almost all mountains.

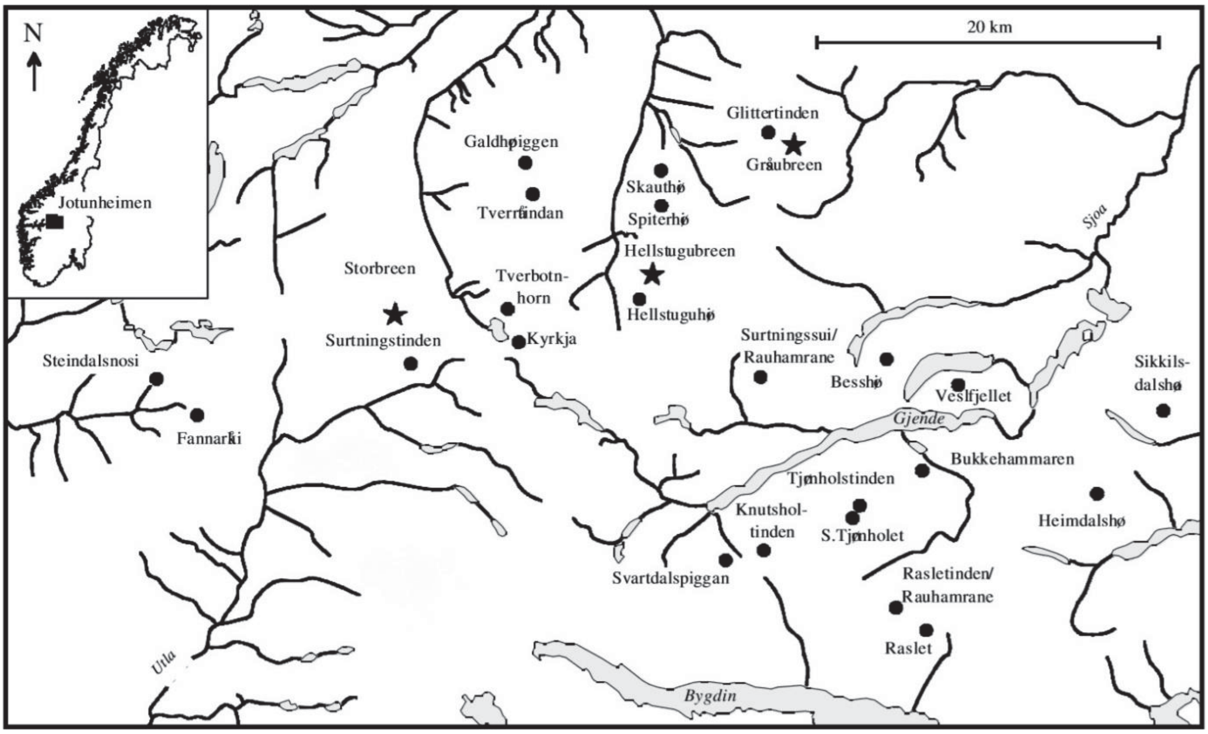


Figure 1. Map of the study area in Jotunheimen, showing the 23 sampled mountains and the glaciers Gråsubreen, Hellstugubreen and Storbreen. The map is modified from Klanderud (2000).

Temperature and precipitation

The western areas generally experience higher winter temperatures than eastern areas due to mild oceanic winds (Aune, 1993) (Table 1). The oceanic winds also create a precipitation gradient from west to east (Fig. 2). In the west, at the highest altitudes of Fannaråki, average annual precipitation is 2000-3000 mm, while annual precipitation around 1000-1500 mm is common around Heimdalshøa in the east (Fig. 2).

Table 1. Temperature values in the west (Fannaråki) and eastern Jotunheimen (represented by Vågåmo), from Aune (1993). Temperatures at Vågåmo have been modified to equal the height of Fannaråki meteorological station. Average lapse rates for January, July and the entire year (annual) have been calculated from Rolland (2003), and are respectively 0.46, 0.65 and 0.57 °C per 100 m. The table has been modified from Klanderud (2000).

		Mean temperatures in °C		
Station	M.a.s.l.	January	July	Annual
Fannaråken*	2062	-9.5	2.7	-4.4
Vågåmo**	371	(-17.5)	(2.9)	(-7.2)

*= from 1932-78, **=from 1949-1976

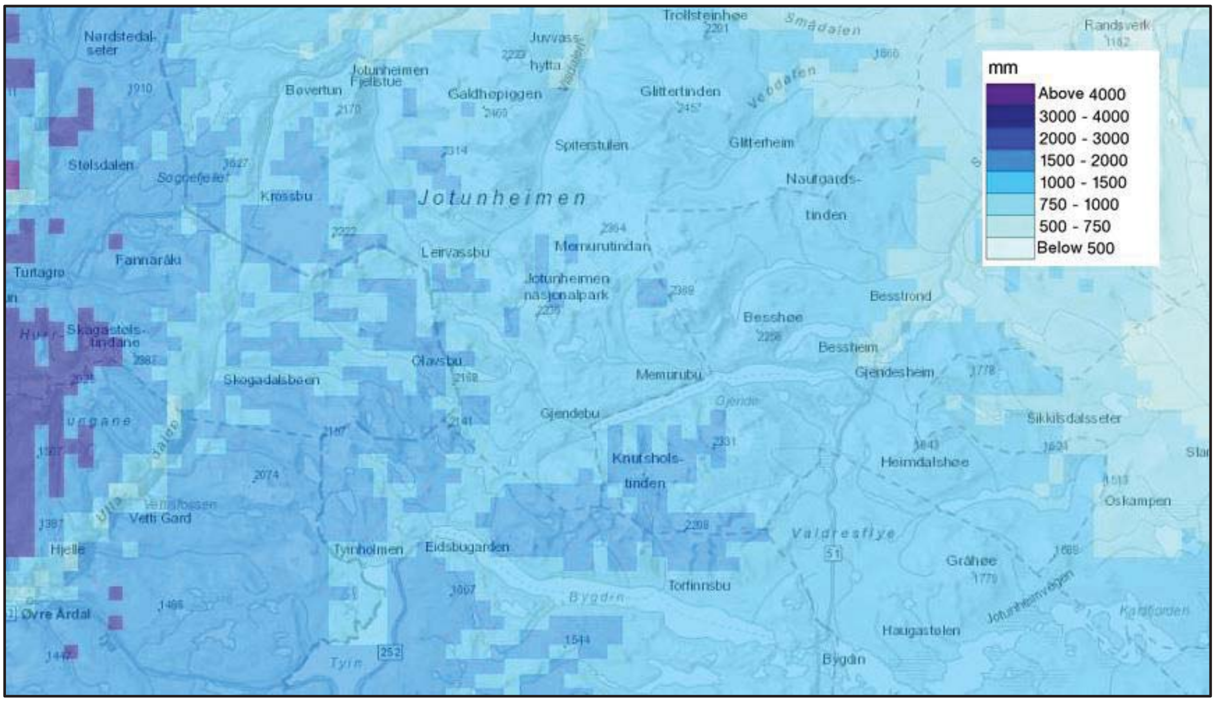


Figure 2. Average annual precipitation in Jotunheimen for normal period 1971-2000. The map was modified in Adobe Photoshop Creative Cloud (CC) 2015. Source: The Norwegian Water Resources and Energy Directorate et al. (n.d.).

Regional temperature values show that annual temperatures in Jotunheimen have mostly been above the 1961-1990 normal since 1990 (Fig. 3a). Summer- and autumn temperatures on the other hand, first show a consistent warming trend after 2000 (Fig. 3b-c). Spring temperatures, like annual temperatures, start to increase around 1990, and continue to increase after 2000 (Fig. 3d).

Both eastern and western Jotunheimen are experiencing a warming trend, although the annual warming trend seems to be stronger in the east (blue trendlines, Fig. 3a), and the summer warming trend is more accentuated in western Jotunheimen (red trendlines, Fig. 3b).

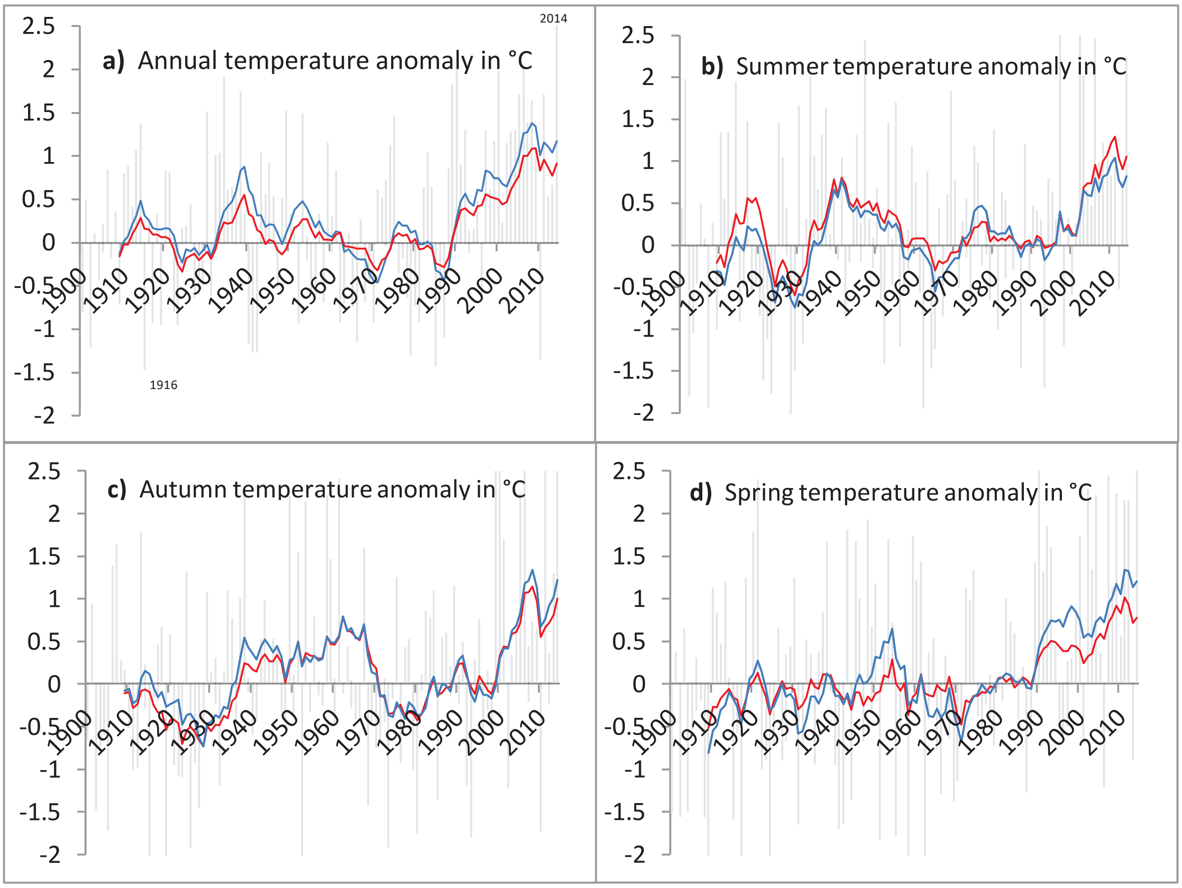


Figure 3. Regional temperature values between 1900 and 2014 with ten-year averaged trend-lines for **a)** annual temperature anomaly, **b)** summer temperature anomaly, **c)** autumn temperature anomaly and **d)** spring temperature anomaly in western (red line) and eastern (blue line) regions. The grey bars represent the annual values, and the values are shown relative to the 1961-1990 normal period. Data source: The Norwegian Meteorological Institute (n.d.).

Compared to the 1961-1990 normal period, in the eastern temperature region there has been an average temperature increase of 0.83°C between 1985 and 2014 (Hanssen-Bauer et al., 2015). In the western region the average temperature increase has been 0.63°C during the same time period.

Annual precipitation in the eastern areas has increased by 7 % when comparing the periods 1971-2000 and 1985-2014 (Fig. 4a), while it has increased by 1 % in the west (Hanssen-Bauer et al., 2015). The winter precipitation in the western region had an increase in the 1990-2005 period (Fig. 4b), but since around 2005 has been lower than in the previous years, although it has still kept above the 1961-90 average. In the east winter precipitation has remained above average, but relatively constant in recent years.

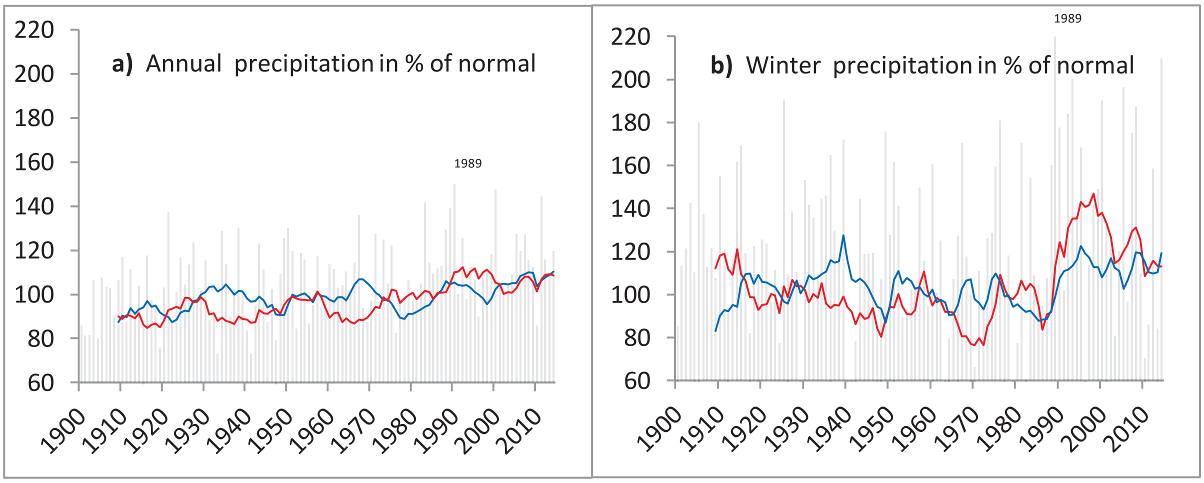


Figure 4. Regional precipitation values between 1900 and 2014 with ten-year averaged trend-lines for **a)** annual precipitation and **b)** winter precipitation in western (red line) and eastern (blue line) regions. The grey bars represent the annual values, and the values are shown relative to the 1961-1990 normal period. Data source: The Norwegian Meteorological Institute (n.d.)

In Jotunheimen, the growth or melting of glaciers can be an indicator of climate conditions since the 1998 sampling. In the western parts of the study area, Storbreen (Fig. 1) is retreating. Since monitoring of mass balance started at Storbreen in 1949, the four years with greatest mass balance losses have all occurred after year 2000 (Hanssen-Bauer et al., 2015; NVE, 2018a). The two other glaciers that are being monitored for mass balance in Jotunheimen, Gråsubreen and Hellstugubreen (Fig. 1) (NVE, 2018b), are also retreating, and have experienced increasing mass balance losses since the year 2000 (Kjøllmoen et al., 2010; NVE, 2018a).

Nitrogen (N) deposition

Interpolated data of N deposition from the Norwegian Institute for Air Research (Aas, 2017) indicate a small reduction of N deposition in eastern parts of Jotunheimen, while the values in western parts seem to remain constant. The values are approximate, but give an indication of trends, according to Aas (2017).

Table 2. Estimates of nitrogen (N) deposition in Jotunheimen. N deposition is estimated in mg N/m^2year.
* Estimates from 1983-1987 are not representative, due to methodological differences. Data are provided by Aas (2017).

Years	West	East
1978-1982	467	354
1983-1987*	NA	NA
1988-1992	438	300
1992-1996	448	301
1997-2001	410	253
2002-2006	469	280
2007-2011	426	259

Other anthropogenic impacts

In the Jotunheimen area west of Glittertinden (Fig. 1), there is a winter population of between 2200 and 2400 tame reindeer. These numbers have remained relatively stable since 1985 (Graffer, 2016). In the eastern areas of Jotunheimen there is a winter population of around 2300-2400 tame reindeer, a slight increase from 1998 when the herd counted around 2100 animals (Grev, 2017). In western Jotunheimen, west of Utla (Fig. 1) there is a population of 200-300 wild reindeer, descendants of tame reindeer released in the sixties (Snøtun, 2013; Solem, 2017). Between 1998 and 2013 this population has decreased and later increased to previous numbers (Snøtun, 2013). Wild reindeer in eastern Jotunheimen have not been observed since 1926 (Mølmen, 1975).

According to Landbrukskontoret for Sel og Vågå (2017) it is difficult to know the exact numbers of sheep within the study area. However, by looking at numbers from sheep production subsidies, it can be observed that numbers between 2000 and 2014 are stable in the western municipalities of the study area (Lom and Luster) (Lom Landbrukskontor, 2017). The numbers in Vågå municipality, containing most of the eastern mountains in this study, have in 2000-2014 increased from 10800 to 14100 (Landbrukskontoret for Sel og Vågå, 2017). It therefore seems likely that the number of sheep in eastern parts of Jotunheimen has increased since 1998.

Hiking tourism has probably increased in Jotunheimen since 1998. Paths frequently hiked by tourists are situated on Veslefjellet, Bukkhammaren, Surtningssui, Glittertinden, Galdhøpiggen, Kyrkja and Fannaråki. On some of the sampled sites tourists hike close to, or cross the sites. Most of the sampled sites are however situated in path-free areas.

Sampling

The sampling started 13 July 2014 at Sikkilsdalshøa in eastern Jotunheimen; two days earlier than Klanderud's 1998 sampling. It started earlier because the weather had been exceptionally warm, so conditions were considered equivalent or more advanced than in 1998. The sampling was finished the 16 August at Fannaråki in western Jotunheimen. The sampling was done as similar as possible to Jørgensen (1930-31) and Klanderud (1998), to assure that sampling differences played a minimal role. Except from Sikkilsdalshøa, where two extra days were spent to get familiar with sampling techniques and species identification, one day was spent on each mountain. Because western parts of Jotunheimen are richer in snow than eastern parts (Fig. 2), the sampling was initiated in the east, and then moved westwards.

To find the sites sampled by Klanderud and Jørgensen, descriptions from both were used to relocate the sites, although most weight was put on Klanderud (2000)'s more detailed descriptions. Klanderud had manually estimated the UTM-coordinates of the sites in 1998 by looking at maps (Klanderud, 2000), and while these coordinates often helped to find the proximity of the sites, they were in many cases imprecise. Site descriptions were therefore the most important source of information.

Site descriptions were on some sites improved, and altitudes were on many sites slightly corrected (mostly five or ten meters up or down) to facilitate future samplings. Measurements of site exposure were conducted with a 360 degrees compass. Subsequently all vascular plant species on the site were registered and simple abundance measurements were conducted (Appendix 1). To delimitate the sampling area on each site I always tried to keep within the area described by Klanderud (2000). However, because of time pressure, sampling delimited itself as it was necessary to continue to the next site, to be able to finish one mountain in one day.

When arriving at a site, a Garmin "GPSMAP 62 series" with TOPO maps was used to register the site's UTM coordinates. Observations of herbivore feces, signs of grazing on plants, animal tracks and herbivore presence on sites were also registered. This was however not done systematically on the first two mountains, Sikkilsdalshøa and Heimdalshøa. The amount of herbivore grazing was divided into two categories: signs of grazing on few (1 – 9) plants and signs of grazing on many plants (10 or more). At high-altitude sites with few specimens, but where a majority of the specimens had been browsed, sites were placed in the second category.

On some mountains new sites were established at high altitudes (Appendix 1). It is possible that these new sites were not sampled by Jørgensen (1932) or Klanderud (2000) because no plant species were found there in 1930-31 and 1998. A few new sites were also established at high altitudes where no species were found in 2014 (Appendix 1), for future research.

Specimens of most species were herborized during the field work, and the herborized material will be deposited in a herbarium. Specimens were often picked on the outskirts or between sites, to minimize impact on sites.

Recording problems

On some steep and rugged mountains, such as Knutsholstinden, Tverbotnhorn and Surtningstinden, considerable time was spent identifying the sites. Site identification was especially challenging in steep slopes between 1700-1900 m, where topography was irregular and personal security had to be considered. Klanderud also spent much time identifying the historic sites in 1998 (Klanderud, 2000).

In total 254 sites were resampled during the field work, while five sites were not found and are labelled “not found in 2014” in Appendix 1.

On some mountains the topography was so steep that future samplers should probably not work alone: these are Svartdalspiggan, Knutsholtinden, Tverbotnhorn and Surtningstiden. I was accompanied by fellow master-student Jon-Peder Lindemann on the steepest mountains.

Misidentifications and nomenclature of species

The two species *Luzula confusa* and *Luzula arcuata* are very similar species. In 1930/31 both species were recorded as *L. confusa* by Jørgensen (1932), while they in 1998 also were recorded together, but as *L. arcuata* (Klanderud, 2000). In 2014 the great majority of the *L. confusa* and *L. arcuata* specimens were identified as *L. confusa*. Therefore *Luzula arcuata* has been changed to *Luzula confusa*. Because the species have not been recorded as two species previously, they have been kept together in 2014.

The *Anthoxanthum* species in the dataset was by Jørgensen and Klanderud identified as *Anthoxanthum odoratum*. In the 2014 sampling this species was identified as *Anthoxanthum nipponicum.*

Agrostis mertensii was by Jørgensen wrongly identified as *Avenella flexuosa* (Klanderud, 2000), and there is therefore uncertainty about how many *A. mertensii* were found in 1930-1931. Klanderud (2000) deleted her own 27 findings of *A. mertensii* in 1998 due to Jørgensen (1932)'s sampling error. In the 2014 dataset *A. mertensii* is again included. This is because more weight is put on the comparison between 1998 and 2014 in this study. Also, the uncertainty around how many *A. mertensii* were found in 1930-1931 is assumed to have no influence on the general results of this study.

The nomenclature of species was adjusted according to Lid & Lid (2005).

Almost all species have been determined to species level. There are however a few exceptions (Appendix 2): *Alchemilla* species, except from *Alchemilla alpina,* and *Taraxacum* species are identified to genus. *Hieracium* species are identified to *Hieracium sect. hieracium* and *Hieracium sect. subalpina*.

Data analysis

The resampled data from the 23 mountains in Jotunheimen was plotted into Microsoft Excel 2010, and prepared for analysis in R (version 3.5.0.) Before starting any analysis, all sites were considered one by one, and six sampled sites that did not conform to descriptions from Jørgensen (1932) and Klanderud (2000), and showed unrealistic deviances in species composition between 1998 and 2014, were eliminated from the dataset (Appendix 1). One site which was most likely affected by landslide was also deleted. A total of 247 sites have therefore been analysed.

To analyse changes in species richness and possible thermophilization along a west-east gradient in Jotunheimen, UTM-coordinates of sites were used to spread the sites along the west-east axis.

To analyse whether species richness is changing according to the microclimate on sites, and to study possible thermophilization, the species were used as a temperature proxy. The species' Ellenberg Temperature (T.) indicator value was found for 79 species (Appendix 3), and the average Ellenberg T. value for the 247 sites, for each of the samplings, was calculated. Because the Ellenberg T. values could not be found for all species, Nordic

Indicator values (Helvik et al., n.d.) and indicator values from Gottfried et al. (2012) were also tried. Analyses were run with all three indicator values (Appendix 3), to see whether results were consistent. The Ellenberg T. values were finally found to be the most appropriate indicator values. This is discussed later.

As a second way to see if species richness is changing according to the microclimate on sites, a simple classification based on site exposure (Körner & Paulsen, 2004) (Appendix 1) was used. Sites exposed towards the northeast (1° to 90° degrees) were put in the “coldest” group and given a 0.25 score. Southeast sites (91° to 180°) were given a 0.75 score, southwest sites (181° to 270°) a 1.00 score, and northwest sites (271° to 360°) a 0.50 score. Sites on flat ground (for example summit sites) were given a 0.60 point score.

To group the species according to climate requirements a climate optimum value was calculated for each species (Appendix 5). To do this, the distribution of each species within bioclimatic vegetation zones in Norway was identified from Lid & Lid (2005). These vegetation zones are (1) nemoral zone, (2) boreonemoral zone, (3) southboreal zone, (4) middleboreal zone, (5) northboreal zone, (6) lowalpine zone, (7) middlealpine zone and (8) highalpine zone. Each zone was given a number in order to present each species' range numerically (Appendix 5). A species' range was the vegetation zones where a species could be found. The median of a species' range (Appendix 5) was determined to represent the species' optimum value, and optimum values were calculated.

When analysing changes in species richness between 1930/31 and 1998, and between 1998 and 2014, a one sample t-test was used. The sampling years 1930/31, 1998 and 2014 were the explanatory variables, and species richness the response variable. To examine how species richness changed between 1930/31, 1998 and 2014 along the altitudinal gradient, linear regression with F-tests was used. Altitude and the sampling years were the explanatory variables, and species richness the response variable.

The relative change in species richness along the altitudinal gradient was also analysed with linear regression. The altitude was the explanatory variable and relative change in species richness between 1998 and 2014 the response variable. The relative changes were analysed because a change in species richness at high altitudes can be small, but important taken the low number of existing species into account. Relative change in species richness can be defined as the ratio of change, and is dependent on the initial species richness on the sites.

For changes in species richness along the west-east gradient, the sampling years and west-east gradient were the explanatory variables and change in species richness the response variable. For change in species richness according to initial species richness, species richness in 1930/31 and 1998 was the explanatory variable and change in number of species in 1930/31-1998 and 1998-2014 the response variable.

For change in number of species according to Ellenberg T. indicator values, Ellenberg T. indicator values for 1930/31 and 1998 was the explanatory variable, and change in number of species in 1930/31-1998 and 1998-2014 the response variable. Here analyses were weighted, meaning that sites with many species were given more importance than sites with few species. This was done to remove statistical noise, as sites with few species can give more arbitrary values. The analyses were however also run without weight, and results were unchanging.

In the exposure analysis, the exposure score of sites was the explanatory variable and change in number of species between 1998 – 2014 and 1930/31 – 1998 the response variables.

To analyse whether thermophilization is occurring, a one sample t-test was used; the explanatory variable being the years and the response variable the Ellenberg T. indicator values on sites. To analyse thermophilization along the altitudinal gradient, altitude and years were the explanatory variables and Ellenberg T. indicator values the response variable. To analyse thermophilization along the west-east gradient, UTM-coordinates and years were the explanatory variables and Ellenberg T. indicator values the response variable.

To see if any of the species in Jotunheimen showed significant changes in number of occurrences between 1998 and 2014, a randomization test with 999 permutations was run on the species (Appendix 3).

To compare groups with different climate optimum, along the altitudinal gradient, the species were divided in groups according to their optimum value (Appendix 5). The number of occurrences of each species was organized in altitudinal bands of 100 m. No statistical analysis has been conducted on the groups, but results are presented and discussed.

Results

Change in species richness between 1930, 1998 and 2014.

Species richness has increased on the sampled mountains in Jotunheimen between 1998 and 2014 (T-test, $T = 3.88$, $p < 0.001$), as it did between 1930-31 and 1998 ($T = 9.49$, $p < 0.001$).

Between 1930/31 and 1998, regression analysis shows a significant relationship between change in species richness and altitude (F-test, $F = 32.24$, $R^2 = 0.113$, $p < 0.001$), the increase in species richness being higher at lower altitudes. Between 1998 and 2014 there is no relationship between absolute change in species richness and altitude.

For the relative changes between 1998 and 2014, there is a highly significant relationship ($F = 22.34$, $R^2 = 0.080$, $p < 0.001$) between change in species richness and altitude, and at higher altitudes the relative increase is larger than at lower altitudes (Fig. 5b).

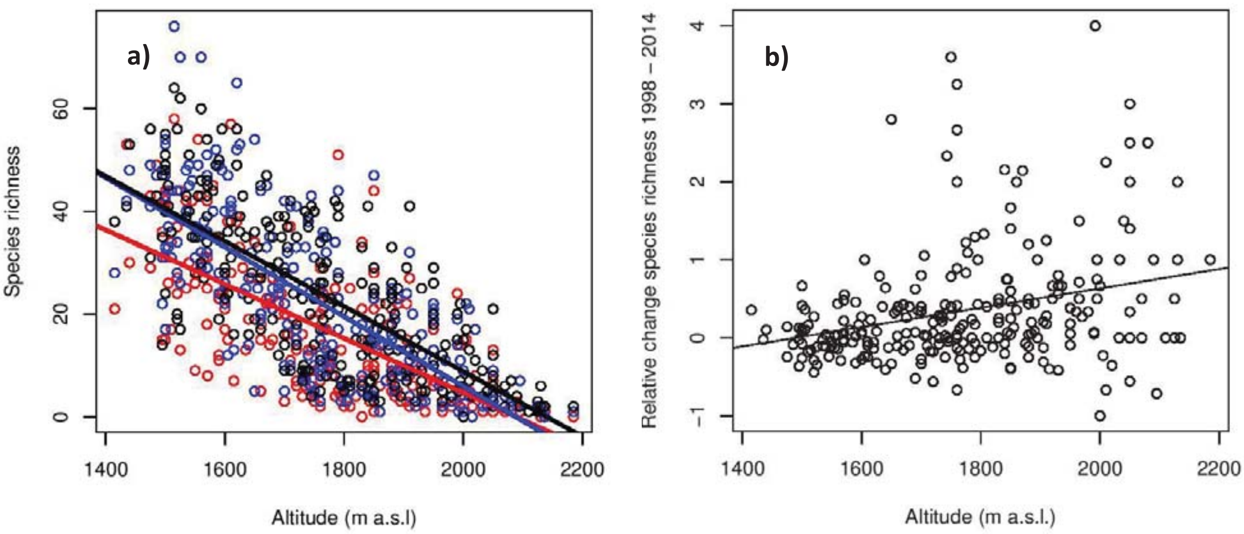


Figure 5. a) Species richness at different altitudes in Jotunheimen. Red line and circles represent the 1930/31 sampling, blue represents 1998 and black represents 2014. **b)** The relative change in species richness along the altitudinal gradient from 1998 to 2014.

Change in species richness along the west-east gradient

Between 1930/31 and 1998 there was a significant relationship between change in species richness and the west-east gradient ($F = 9.49$, $R^2 = 0.033$, $p = 0.002$). Species richness increased more in eastern parts of Jotunheimen than in western parts. Between 1998 and 2014 there is a continuation of this trend ($F = 8.7$, $R^2 = 0.030$, $p = 0.003$), with further increase of species richness in eastern Jotunheimen (Fig. 6).

In 1930/31 species richness was higher in western parts of Jotunheimen than in eastern parts ($F = 10.03$, $R^2 = 0.035$, $p = 0.002$) (Fig. 6). Between 1930/31 and 2014 this has changed, and in 2014 there is no relationship between species richness and the west-east gradient ($F = 0.05$, $R^2 = - 0.004$, $p = 0.832$).

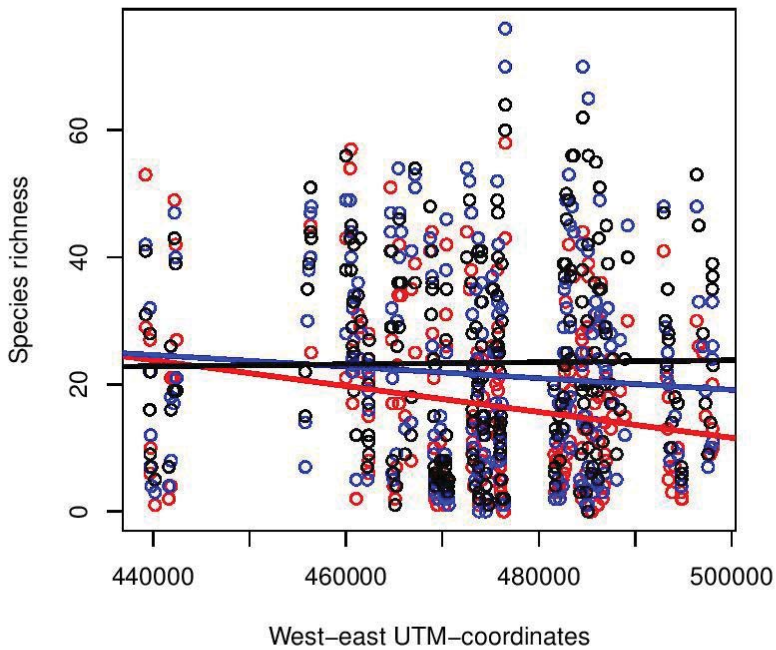


Figure 6. Species richness along the west-east gradient in 1930/31 (red circles and trendline), 1998 (blue) and 2014 (black).

Change in number of species according to initial species richness

Between 1930-31 and 1998 no significant relationship (F = 2.11, R^2 = 0.005, p = 0.147) between initial species richness and change in number of species can be observed (Fig. 7a). Species richness increased along the entire species richness gradient, although some of the most species-rich sites experienced species reduction (Fig. 7a).

Between 1998 and 2014, there was a significant relationship (F = 22.36, R^2 = 0.080, p < 0.001) between initial species richness and change in number of species (Fig. 7b). Species richness increased on species poor sites, but decreased towards sites with higher species richness, which have experienced species losses.

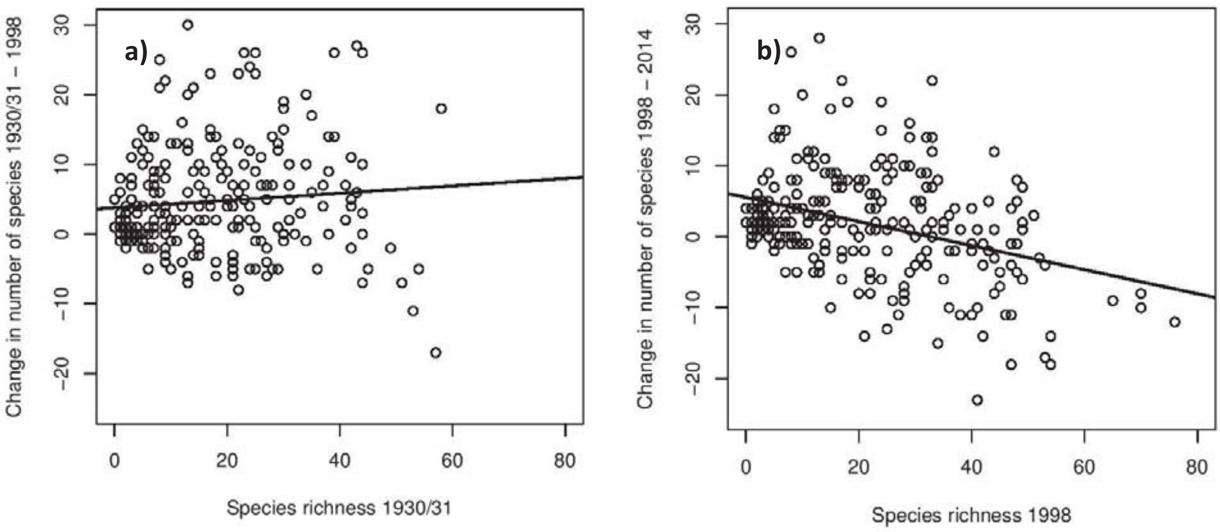


Figure 7. Change in number of species from **(a)** 1930-31 to 1998 and from **(b)** 1998 to 2014, according to initial species richness.

Change in number of species according to temperature indicator values

There is a significant relationship between the Ellenberg Temperature (T) indicator values and change in number of species, both for 1930/31 – 1998 (F = 11.08, Mean Sq = 3344.9, p = 0.001) (Fig. 8a) and for 1998 – 2014 (F = 17.78, Mean Sq = 5520.3, p < 0.001) (Fig. 8b). However, the trendlines are pointing in opposite directions. In 1930/31 – 1998 (Fig. 8a) sites with higher Ellenberg T. values experienced a higher increase in number of species than sites with lower Ellenberg T. values. Between 1998 and 2014 (Fig. 8b) sites with higher Ellenberg T. values experienced a lower increase in number of species (or species stagnation), compared to sites with lower Ellenberg T. values.

Analyses performed with Nordic Indicator values and indicator values from Gottfried et al. (2012), find the same significant relationships.

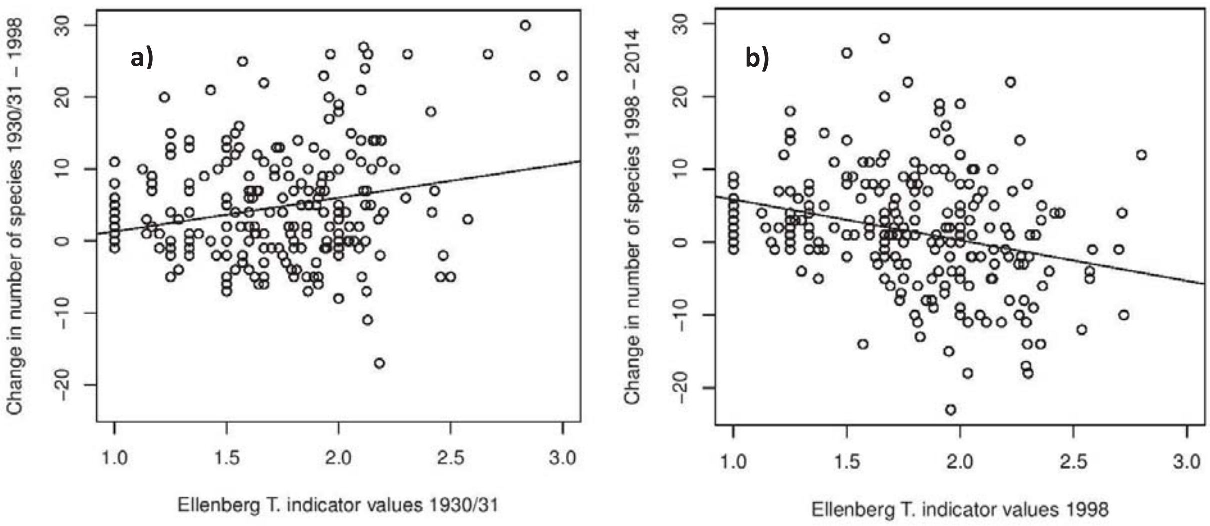


Figure 8. Change in number of species from **(a)** 1930/31 to 1998, according to Ellenberg T. indicator values for 1930/31**,** and for **(b)** 1998 - 2014 according to Ellenberg T. indicator values for 1998.

No relationship between site exposure and change in species richness could be observed between 1998 and 2014 (F = 0.57, Mean Sq = 33.828, p = 0.451). Between 1930/31 and 1998 there was a tendency (F = 3.67, Mean Sq = 217.182, p = 0.057), showing higher species increase on sites with high exposure (the "warmer" sites).

Thermophilization

Between 1998 and 2014 there is significant thermophilization within the study area (T-test, T = 5.87, p < 0.001). There is also thermophilization between 1930/31 and 1998 (T = 3.95, p < 0.001).

There seems to be a trend between altitude and thermophilization from 1930/31 to 1998 (Fig. 9a), indicating higher thermophilization at lower altitudes, but this apparent trend is not significant (F = 1.82, R^2 = 0.003, p = 0.179). Nor is there any relationship between thermophilization and altitude between 1998 and 2014 (F = 0.02, R^2 = - 0.004, p = 0.895).

Neither from 1930/31 to 1998 nor from 1998 to 2014 is there any relationship between the west-east gradient and thermophilization (1930/31 – 1998, F = 0.79, R^2 = - 0.001, p = 0.375) (1998 – 2014, F = 0.47, R^2 = - 0.002, p = 0.493) (Fig. 9b).

Between 1930/31 and 1998 Nordic Indicator values and indicator values from Gottfried et al. (2012) show significantly greater thermophilization in western parts of Jotunheimen (Nordic, F = 4.37, R^2 = 0.014, p = 0.038) (Gottfried, F = 5.30, R^2 = 0.017, p = 0.022). Between 1998 and 2014 indicator values from Gottfried et al. (2012) show greater thermophilization towards the east (F = 5.57, R^2 = 0.018, p = 0.019), and towards higher altitudes (F = 4.78, R^2 = 0.015, p = 0.030).

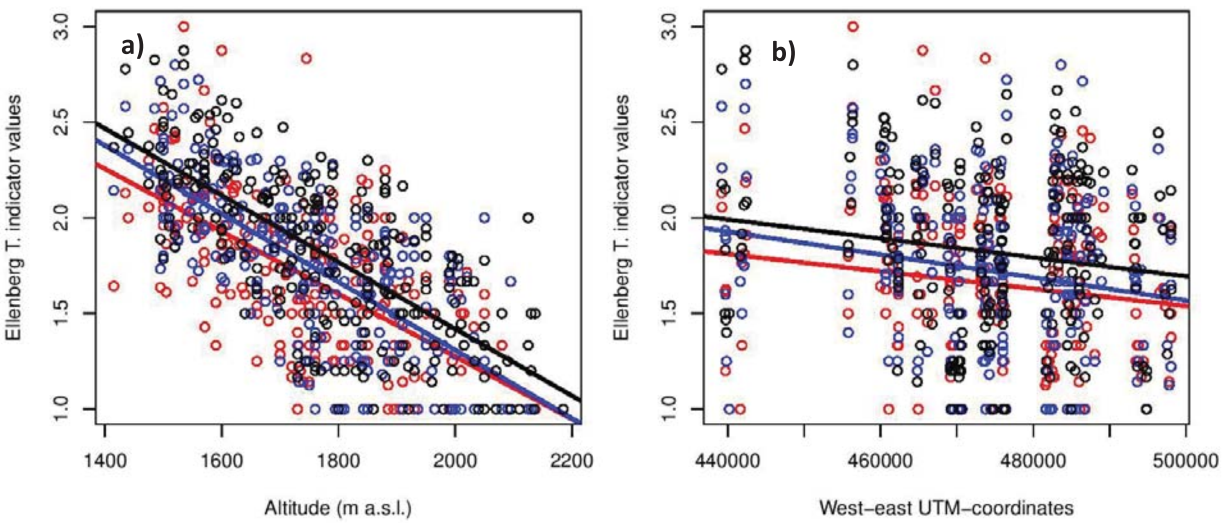


Figure 9. Thermophilization along an **(a)** altitudinal gradient and **(b)** west-east gradient, between 1930/31 (red circles and trendline), 1998 (blue) and 2014 (black).

Changes in species groups with different climate optimum, along the altitudinal gradient

In the following analysis, changes when the number of occurrences is below 20 (in one or two plots) (Table 3) are ignored, as low numbers are easily influenced by arbitrary changes.

The only group showing reduction in the total number of occurrences between 1998 and 2014, is the Southboreal, Southboreal-Middleboreal group (SBor, SBor-MBor) (Table 3), containing species that prefer relatively high temperatures. The significant decrease in *Trientalis europea* (Randomizations, p = 0.029) (Appendix 3) can explain some of the observed reduction. The other groups are all increasing their total number of occurrences, and generally also seem to increase more at higher than lower altitudes, in terms of percent (relative) increase (Table 3). In terms of number of occurrences the groups Middleboreal, Middleboreal-Northboreal (MBor, Mbor-NBor) and Northboreal, Northboreal-Lowalpine (NBor, NBor-LAlp) also seem to increase considerably at lower altitudes.

The only group at lower altitudes which shows a substantial reduction in number of occurrences between 1998 and 2014 is the Middlealpine, Middlealpine-Highalpine (MAlp, MAlp-HAlp) group, containing cold-adapted, high-altitude species. The observed decrease is greatest in the 1500-1599 m altitude band, but reduction in number of occurrences is also observed in the 1600 – 1699 m and 1400 – 1499 m bands.

Table 3. Number of occurrences of climate optimum groups, in 1998 and 2014, divided into 100 m altitudinal bands. Percent change between 1998 and 2014 is not shown when number of occurrences is below 20. Abbreviations: BNem = Boreonemoral, SBor = Southboreal, MBor = Middleboreal, NBor = Northboreal, LAlp = Lowalpine, MAlp = Middlealpine, HAlp = Highalpine.

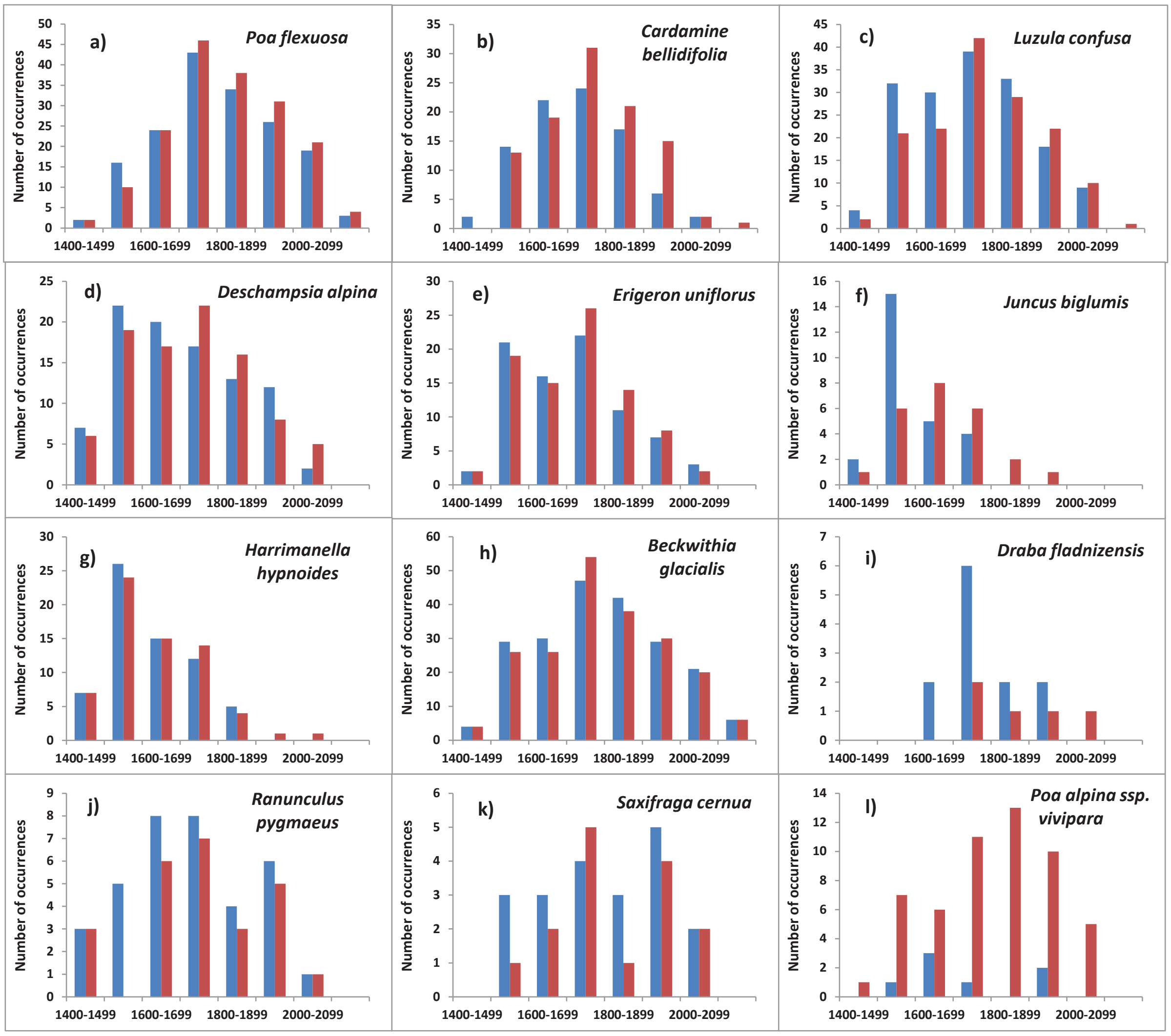
		Number of occurrences and percent change (%) in groups											
Altitude (m a.s.l.)	Year	BNem, BNem-SBor	%	SBor, SBor-MBor	%	MBor, MBor-NBor	%	NBor, NBor-LAlp	%	LAlp, LAlp-Malp	%	MAlp, MAlp-HAlp	%
1400-1499	1998	0		10		46		70		173		37	
	2014	3		10		48	4.3	71	1.4	175	1.2	32	-13.5
1500-1599	1998	1		51		222		330		809		196	
	2014	2		47	-7.8	260	17.1	351	6.4	795	-1.7	160	-18.4
1600-1699	1998	0		22		106		200		552		186	
	2014	1		9		109	2.8	217	8.5	585	6.0	167	-10.2
1700-1799	1998	0		2		82		185		588		233	
	2014	2		3		91	11.0	224	21.1	642	9.2	275	18.0
1800-1899	1998	0		0		21		60		288		167	
	2014	0		1		29	38.1	96	60.0	361	25.3	183	9.6
1900-1999	1998	0		0		6		33		170		118	
	2014	0		0		6		48	45.5	206	21.2	143	21.2
2000-2099	1998	0		0		2		10		59		60	
	2014	0		0		0		12		74	25.4	74	23.3
2100-2199	1998	0		0		0		0		1		9	
	2014	0		0		0		0		7		12	
Total	1998	1		85		485		888		2640		1006	
	2014	8		70	-17.6	543	12.0	1019	14.8	2845	7.8	1046	4.0

Species changes in the "MAlp, MAlp-HAlp" group, between 1998 and 2014

In the Middlealpine, Middlealpine-Highalpine (MAlp, MAlp-HAlp) group, which contains most of the highest-growing alpine plants in Jotunheimen, the only species experiencing a significant change in number of occurrences is *Poa alpina ssp. vivipara* (Randomizations, p = 0.001), which is increasing (Fig. 10l). None of the species in the group are experiencing significant reductions in number of occurrences (Appendix 3).

Seven of the species in the MAlp, MAlp-HAlp group seem to follow a tendency of reduction in number of occurrences at lower altitudes and increase at higher altitudes (Fig. 10a-g). These are abundant high-altitude species such as *Poa flexuosa* (Fig. 10a), *Cardamine bellidifolia* (Fig. 10b)*, Luzula confusa* (Fig. 10c), *Deschampsia alpina* (Fig. 10d), *Erigeron uniflorus* (Fig. 10e), *Harrinmanella hypnoides* (Fig. 10g), and not so abundant *Juncus biglumis*

(Fig. 10f). The high-altitude species *Beckwithia glacialis* (Fig. 10h) seems to experience a small reduction in number of occurrences at lower elevations, but stagnates at higher altitudes. Three species, *Draba fladnizensis* (Fig. 10i), *Ranunculus pygmaeus* (Fig. 10j) and *Saxifraga cernua* (Fig. 10k), seem to experience a tendency of reduced number of occurrences along most of the altitudinal gradient. The species *Poa alpina ssp. vivipara* (Fig. 10l) shows an increase in number of occurrences along the entire altitudinal gradient. The last four species, *Saxifraga rivularis* (Fig. 10m), *Saxifraga tenuis* (Fig. 10n), *Draba nivalis* (Fig. 10o) and *Ranunculus acris ssp. pumilus* (Fig. 10p) do not fit into any of the above patterns.



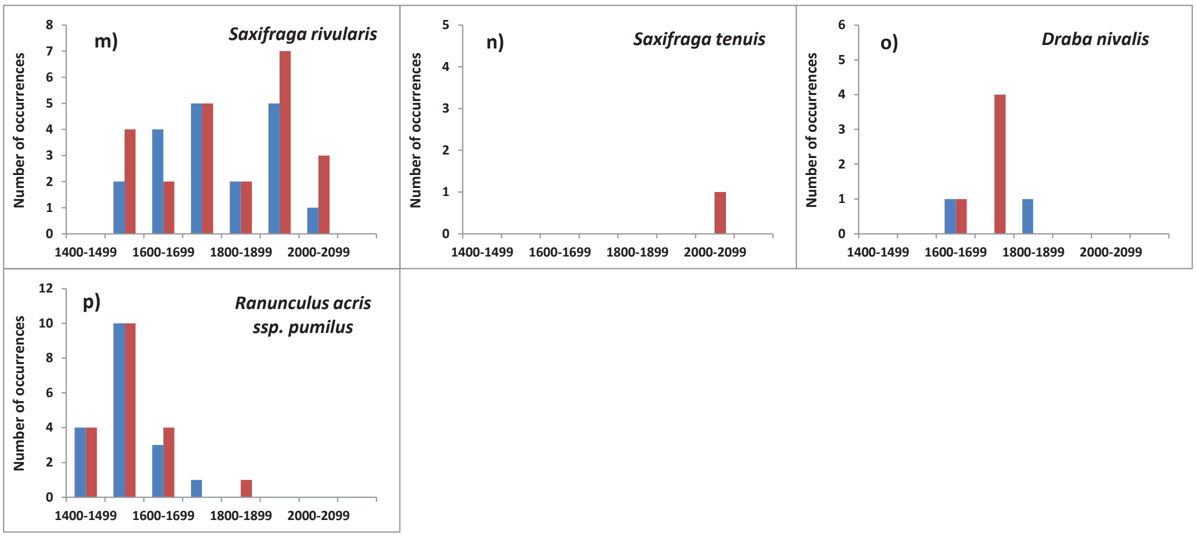


Figure 10. Number of occurrences (Y-axis) of the species in the MAlp, MAlp-HAlp group, at different altitudinal bands of 1400-1499 m, 1500-1599 m, 1600-1699 m etcetera. Blue bars represent 1998, red bars 2014.

New altitudinal limits, altitudinal shifts and change in Poaceae family

In the 2014 sampling, a total of 57 species exceeded their recorded altitudinal limits in Norway (Appendix 2), when comparing with previous records (Lid & Lid, 2005). This is 37.3 % of the total number of species recorded in 2014. One of the species exceeding its recorded altitudinal limit was birch, *Betula pubescens* (Fig. 11), which was registered at 1740 m a.s.l. at Sikkilsdalshøa, 160 altitudinal meters higher than previous records (Appendix 2).

A total of 140 species were registered in Jotunheimen in 2014. In the 1998 and 1930/31 samplings, 138 and 125 species were registered, respectively (Appendix 2). A total of 127 species were registered both in 1998 and 2014. Between 1998 and 2014 these species on average experienced an upward shift of 33.2 altitudinal meters, the equivalent of 20.7 meters per decade.

Species of the Poaceae family (29 species registered) have expanded in Jotunheimen between 1998 and 2014. The total number of occurrences increased from 833 to 1119 (Appendix 2), which is a 34.3 % increase. Eleven of the species showed significant increase in number of occurrences (Appendix 3). None decreased significantly.

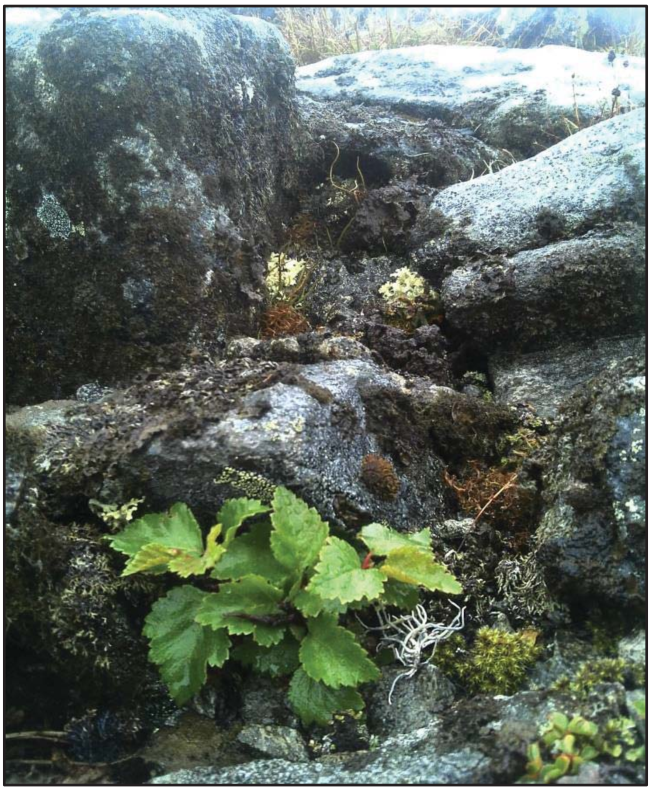


Figure 11. Specimen of *Betula pubescens* found on 1750 m a.s.l., Sikkilsdalshøa, 170 altitudinal meters higher than previous records in Norway (Lid & Lid, 2005). UTM-coordinates: west 0497710, north 6819223. This specimen was not found on any of the sites, and is not the same as the specimen found at 1740 m a.s.l. on Sikkildalshøa (see results above).

Signs of grazing

A total of 30 sites demonstrated signs of grazing on plants. Of the 30 sites, eight sites had signs of grazing on many plants (10 or more plants) while 22 sites had signs of grazing on a few plants (1-9 plants). Three sites on the high altitudes of Rauhamrane/Surtningssui had signs of extreme grazing, and nearly all specimens of *Beckwithia glacialis* and *Poa flexuosa* had been browsed (Fig. 13). Signs of heavy grazing on *Beckwithia glacialis* were also detected at high-altitude sites at Besshøi.

On 28 sites animal feces were registered. On three sites tracks with hoof prints from reindeer were registered. On two sites grazing sheep were also observed.

Signs of grazing and signs of herbivore presence were mainly observed in the east (Fig. 11), but also on the mountains Galdhøpiggen, Tverråtindan, Skauthøi and Spiterhøi, which are situated around Visdalen. In the western parts of Jotunheimen and around western Gjende (Fig. 1), signs of grazing and herbivore presence were fewer.

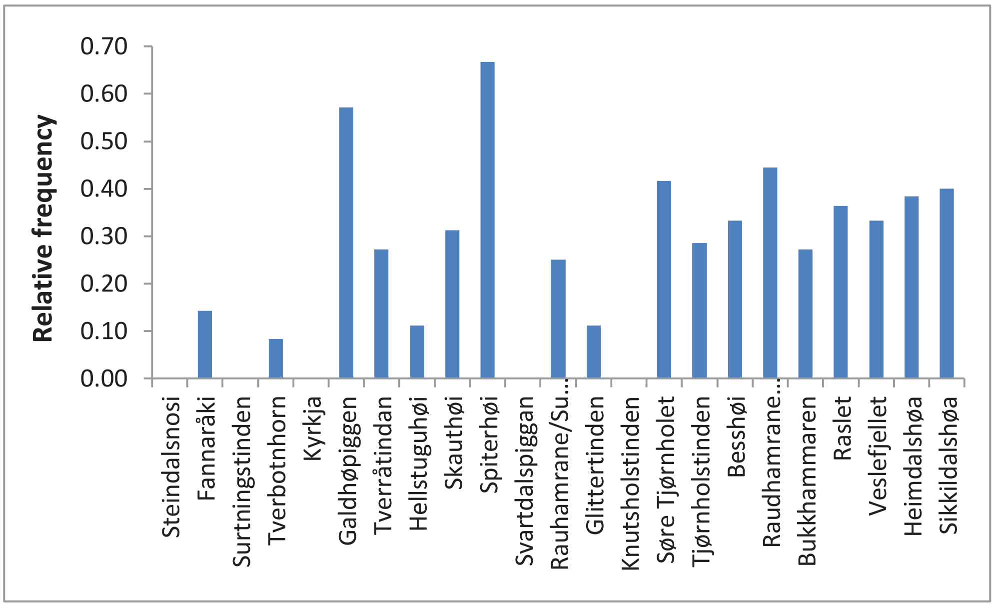


Figure 12. Signs of grazing and herbivore presence on the surveyed mountains, arranged from west to east.

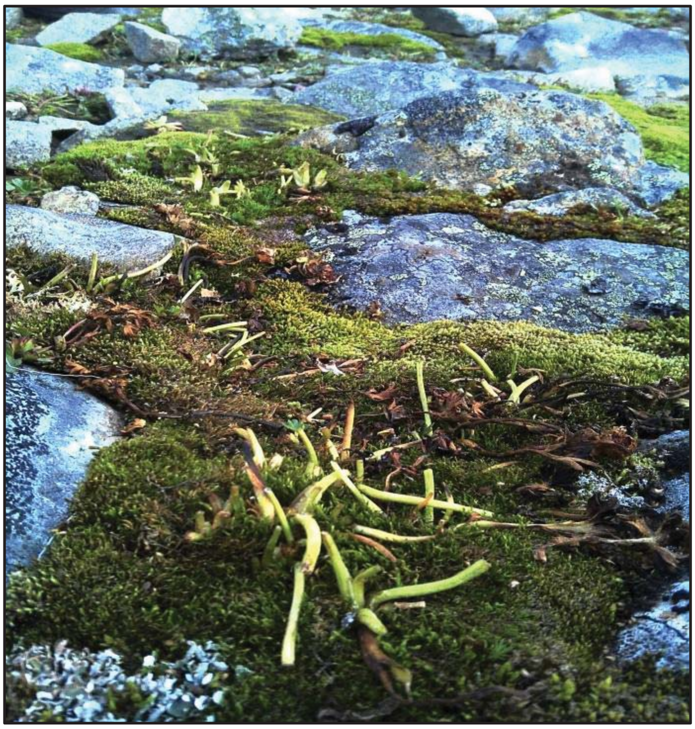


Figure 13. Signs of grazing on specimens of *Beckwithia glacialis* at Surtingssui, site number 20, 2070 m a.s.l.

Discussion

Change in species richness, new altitudinal limits and upward shifts

As expected, species richness in Jotunheimen has increased between 1998 and 2014. The increase of species richness is in line with other European studies (Grabherr et al., 1994; Jurasinski & Kreyling, 2007; Odland et al., 2010; Steinbauer et al., 2018; Wipf et al., 2013), and is a continuation of the trend observed in Jotunheimen between 1930-31 and 1998 (Klanderud & Birks, 2003).

In 1930/31- 1998 species richness increased more at lower than higher elevations. This is in line with findings of higher increase in species richness at lower rather than higher mountain summits in the Austrian Alps (Grabherr et al., 1994), and a similar tendency on Filefjell, Norway (Odland et al., 2010). In Jotunheimen, between 1998 and 2014, small or no relative increase in species richness was observed at the lower altitudes, and a higher relative increase was observed at the higher altitudes. It is difficult to find studies that can confirm this trend. The high relative increase at higher altitudes is, however, supported by reports of accelerated increase in species richness on summits in the Swiss Alps (Walther et al., 2005) and on many European summits (Steinbauer et al., 2018).

In 1998 a total of 40 species exceeded their recorded altitudinal limits (Klanderud, 2000), which was a 24,6 % of the total number of species (Klanderud & Birks, 2003). In 2014, 57 species and 37,3% of the total number of species, exceeded their recorded altitudinal limits (Lid & Lid, 2005). When a large proportion of the species are found at unrecorded altitudes, it might indicate that little work has been done to register the species' altitudinal limits. The increase from 24,6 % to 37,3 % might however imply that species are migrating upwards at a faster rate than before. The average upward shift rate of species in Jotunheimen, has between 1930/31-1998 and 1998-2014 also increased from 12 m per decade (Klanderud & Birks, 2003) to 20,3 m per decade. The 20,3 m per decade rate is in line with upward shifts reported by Lenoir et al. (2008) (29 m per decade) and Parolo & Rossi (2008) (24 m per decade).

Change in species richness along the west-east gradient

In 1930/31 - 1998 the species richness increase was most pronounced in eastern Jotunheimen and less pronounced in the west (Klanderud, 2000). Between 1998 and 2014 this trend continues, and species richness increases more in eastern Jotunheimen than in western parts. Klanderud & Birks (2003) suggested that increased snowfall in western Jotunheimen, in combination with steep topography causing erosion events, could be causing low species increase in the west. The advance of Storbreen in western Jotunheimen (from 1988 to 1995) and the simultaneous retreat of Gråsubreen in the east were considered indicators of a winter precipitation gradient within the study area, possibly impacting vegetation along a west-east axis (Klanderud, 2000). After the 1998 sampling however, both Storbreen in the west and Gråsubreen in the east have experienced large mass balance losses (Hanssen-Bauer et al., 2015; Kjøllmoen et al., 2010; NVE, 2018a). Winter precipitation in western Jotunheimen has also decreased since 1998. The trend of stagnation in species richness in westernmost Jotunheimen has however continued. It therefore seems unlikely that the historic increase in winter precipitation in western Jotunheimen, can explain the west-east gradient in increase of species richness.

In Jotunheimen reindeer and sheep are found in both west and east. Heavy grazing by herbivores has been found to reduce species richness in nutrient-poor ecosystems (Proulx & Mazumder, 1998). Moderate to low grazing has been found to reduce species richness in snowbeds and heaths with low productivity in Scandinavian mountains , but might increase species richness in productive habitats (Austrheim & Eriksson, 2001). Assuming that most sites in Jotunheimen (high altitudes and nutrient poor) are low productive, increased grazing pressure in western parts could explain why species richness stagnates. However, there are no indications of heavier grazing pressure in western Jotunheimen. Since 1998, the number of reindeer and sheep has probably remained the same in western Jotunheimen (Graffer, 2016; Lom Landbrukskontor, 2017) and increased in eastern parts of Jotunheimen (Grev, 2017; Landbrukskontoret for Sel og Vågå, 2017). During the 2014 field work, signs of grazing and signs of herbivore presence were also more frequent in eastern areas.

The probable increase in grazing pressure in eastern Jotunheimen should in theory decrease species richness in the east. The increased species richness in eastern Jotunheimen however signals that grazing might not be an important driver of the observed changes.

Increase in species richness has been found to be closely linked to climate warming on European summits (Steinbauer et al., 2018). Because there is a west-east gradient in increase of species richness in Jotunheimen, a stronger warming trend could be expected in the east. However, the temperature increase has been consistent in both western and eastern Jotunheimen in 1998-2014, with only slight differences that can probably not explain the west-east gradient in increase of species richness.

Changes in species groups with different climate optimum, along the altitudinal gradient

The possible decline at lower elevations of species in the Middlealpine, Middlealpine-Highalpine group (MAlp, MAlp-HAlp), is in line with predictions that these species are vulnerable to competition from lower-altitude species shifting upwards when temperature rises (Alexander et al., 2015; Klanderud & Birks, 2003; Steinbauer et al., 2018; Sætersdal & Birks, 1997; Vittoz et al., 2009). It is also a continuation of the tendency observed by Klanderud (2000) in 1998, when several high-altitude species were declining at lower altitudes. Many of the same species have continued to decline in 1998-2014, as for example *Beckwithia glacialis, Ranunculus pygmeus, Poa flexuosa*, *Saxifraga cernua, Erigeron uniflorus*, and *Cerastium alpinum*. Some high-altitude species which did not decline at lower elevations in 1930/31-1998 now seem to decline. These are *Cardamine bellidifolia*, *Luzula confusa*, *Deschampsia alpina*, *Harrinmanella hypnoides*, *Juncus biglumis* and *Draba fladnizensis*.

Guisan et al. (1998) suggested that the alpine sedge *Carex curvula ssp. curvula* (not present in Jotunheimen) is limited by the competition for light by more competitive taller plants. Competitive exclusion of alpine and low-growing species by shading has also been reported by Vittoz et al. (2009). Several of the high-altitude species that in 1998-2014 are declining at lower elevations in Jotunheimen, are indeed small-stature plants that could be vulnerable to light competition, such as *Cardamine bellidifolia, Ranunculus pygmeus, Saxifraga cernua, Harrimanella hypnoides, Juncus biglumis* and *Draba fladnizensis.* The concurrent increase in number of occurrences of species from lower elevations (MBor, Mbor-NBor and NBor, NBor-LAlp groups) indicates that light competition, or competition for other resources, might have occurred.

Although many species in the MAlp, MAlp-HAlp group seem to decline at lower altitudes, none show a significant overall decline. Significant declines in number of occurrences of high-altitude species were neither recorded by Pauli et al. (2007) in the Austrian Alps, nor by Klanderud & Birks (2003) in 1998.

The Southboreal, Southboreal-Middleboreal group (SBor, SBor-MBor), consisting of species associated with a milder climate, also seems to decline. This group has a low total number of occurrences, and has like the MAlp, MAlp-HAlp group not been tested statistically. Therefore, too much weight should perhaps not be put on these results. However, species have in several studies been found to shift both upwards and downwards in elevation (Chen et al., 2009; Crimmins et al., 2011; Lenoir et al., 2008). Mechanisms that could make species shift downwards are for example changes in snow cover duration or drought (Lenoir et al., 2010). Warmer temperatures can cause early snow melt and increase risk of frost damage on plants (Lenoir et al., 2010).

Change in number of species according to initial species richness

Between 1998 and 2014 the sites with highest initial species richness experience species loss, while initially species poor sites experience increase in species richness. It is not surprising that species richness increases on the initially species poor sites, because these sites are generally found at high altitudes, where increase in species richness has already been observed in many studies (Grabherr et al., 1994; Jurasinski & Kreyling, 2007; Odland et al., 2010; Pauli et al., 2012; Steinbauer et al., 2018; Wipf et al., 2013). On species rich sites, which are generally found at lower altitudes, species richness has also been found to increase (Britton et al., 2009; Klanderud & Birks, 2003). A species decline has however been observed at the Tibetan Plateau, where experimental warming by open top champers caused species loss in plots with initially high species richness (Klein et al., 2004).

Between 1930/31 and 1998, species richness increases both on species-rich and species-poor sites, but five of the six most species-rich sites experienced species losses. This indicates that the first signs of what later occurred in 1998-2014 can possibly already be observed in 1930/31-1998.

Heavy herbivore grazing may have caused species loss (Proulx & Mazumder, 1998) on species-rich sites in 1998-2014. Very few signs of heavy grazing were however registered at the most species-rich sites. Reindeer herders and sheep owners have neither observed any change in grazing patterns since 1998 (Graffer, 2016; Grev, 2017; Landbrukskontoret for Sel og Vågå, 2017; Solbakken, 2017). However, the grass *Nardus stricta*, which can be a dominant species where grazing pressure is high (Bele & Norderhaug, 2008), increased from 0 to 14 sites in 1998- 2014 (Appendix 2), and has become dominant on several low-elevation sites (Appendix 1). Many other grass species also increased between 1998 and 2014 (Appendices 2 and 3), among them *Festuca ovina* which like *Nardus stricta* has been found to benefit from high grazing pressure (Eskelinen & Oksanen, 2006). However, increased temperature has also been observed to increase abundance and cover of grasses (Elmendorf et al., 2012; Walker et al., 2006).

Studies have found that addition of nitrogen in grassland ecosystems has caused the dominance of nitrogen-demanding grass-species and declines in other species (Silvertown, 1980; Silvertown et al., 2006; Vitousek et al., 1997). In Jotunheimen grass species might have become dominant on species-rich sites, causing competitive exclusion of neighbour species. Nitrogen (N) deposition rates found to cause biodiversity losses in British habitats vary between 500 to 4000 mg N/m^{2}year, according to Maskell et al. (2010). This is larger than the amounts deposited in Jotunheimen (253-469 mg N/m^{2}year). The N deposition in Jotunheimen has neither changed substantially between the two decades prior to 1998 and the years prior to 2014. If N deposition was an important driver of the species loss species rich sites, a similar species loss could have been expected in both samplings. This has not occurred. However, N deposition has been shown to have a negative cumulative effect on species richness in heathlands and grasslands (De Schrijver et al., 2011).

On the other hand, N deposition on nutrient-poor sites in Jotunheimen might have contributed to the increase in species richness at species poor sites (higher altitudes sites). However, a higher increase in species richness would have been expected in western parts of Jotunheimen, because N deposition rates are higher in the west. Nevertheless, species richness increases more in the east.

An alternative explanation for the species increase at higher altitudes is climate warming. Jotunheimen has since 1998 experienced a warming tendency, which might have facilitated species' upward migration into habitats that until recently were too harsh to colonize. Climate warming is by most authors considered the main driver of recent increase in species richness on European summits (Grabherr et al., 1994; Odland et al., 2010; Pauli et al., 2012; Steinbauer et al., 2018; Walther et al., 2005; Wipf et al., 2013). The increase of species richness on European summits has also been observed to be positively correlated with climate warming (Steinbauer et al., 2018).

An alternative hypothesis for the species loss on the most species-rich sites in 1998-2014, is that climate warming is causing the species loss. This could occur through competive exclusion of high-altitude species, which has been discussed earlier. Slow growing and shade intolerant alpine species (Sætersdal & Birks, 1997) might be facing new competition for light and nutrients from new colonizers or already existing neighbours (Alexander et al., 2015).

The 1998-2014 stagnation in species richness at lower altitudes in Jotunheimen can most likely be discussed in the same manner.

Change in number of species according to temperature indicator values

The change in species richness in Jotunheimen, both in 1930/31-1998 and 1998-2014, is related to microclimate on sites. In 1930/31-1998 sites with warmer microclimate experience a higher increase in species richness, and sites with colder microclimate experience a lower increase. In 1998-2014 the relationship has been reversed.

I had suspected that the sites with the warmest microclimate would experience species decline in 1998-2014, because high-altitude species on the warmest sites would be exposed to competition from lower-altitude species. However, no clear trend of reduced species richness on sites with warmer microclimate was observed.

Exposure is a proxy for temperature. However, because parameters such as altitude and slope inclination of sites are not included in the proxy, the exposure is probably an imprecise way of measuring temperature on sites, which might explain why the exposure results do not concur with the results from the Ellenberg T. indicator values. The tendency of higher species richness on warmer sites between 1930-31 and 1998 is however in line with results from the Ellenberg T. indicator values analyses.

Thermophilization

Thermophilization is occurring both in 1930/31-1998 and 1998-2014, in line with the findings of Erschbamer et al. (2011) and Gottfried et al. (2012). Plant communities are hence becoming "warmer".

Thermophilization is occurring along the entire altitudinal gradient, both in 1930/31-1998 and 1998-2014. The stagnation in species richness on lower altitudes in 1998-2014 and the concurrent thermophilization suggest that warmer temperature-adapted species have become more common, while cold-adapted species have declined. However, no statistical tests have been conducted.

Thermophilization is also occurring along the entire west-east gradient in Jotunheimen, both in 1930/31-1998 and 1998-2014, according to the Ellenberg T. values.

However, both Nordic Indicator Values and Gottfried et al. (2012) values in 1930/31-1998 find higher thermophilization in western parts of Jotunheimen. In 1930/31-1998, it is therefore uncertain whether there has been a west-east gradient in thermophilization or not. Thermophilization has in any case occurred in the west, while species richness on the westernmost mountains seems to stagnate. This suggests that warmer temperature-adapted species have become more common, while cold-adapted species have declined.

One of the disadvantages with the Gottfried et al. (2012) indicator values is the lack of an indicator value for the species *Poa flexuosa,* a frequent high-altitude species in Jotunheimen. If *Poa flexuosa* is given the value 1 (the same value as *Poa flexuosa* is given by the other indicator values) and included in the analysis with the Gottfried values, the west-east thermophilization gradient detected by the Gottfried et al. (2012) values in 1930/31-1998, becomes insignificant. A downside with Nordic Indicator values is that many species are given the value 1. This means that almost all alpine species are given the same value, no matter whether they grow on the treeline or on the highest summits. The Ellenberg T. indicator values mostly give alpine species values from 1 to 3, and therefore offer more chances to detect changes within the alpine plant communities. However, many species lack an Ellenberg T. indicator value, so all indicator values have downsides. Nevertheless, the Ellenberg T. indicator values were considered the best alternative.

Possible drivers for the observed changes

Climate change

In Jotunheimen the regional values show that spring, summer and autumn temperature have increased since 1998, which makes it likely that less precipitation is falling as snow in spring and autumn, and that snowmelt is increasing (Räisänen, 2008). Since 1998 winter precipitation has also decreased in western Jotunheimen and remained stable in eastern Jotunheimen. The glaciers in Jotunheimen are losing mass balance (Hanssen-Bauer et al., 2015; Kjøllmoen et al., 2010; NVE, 2018a), and although there is no direct link between melting glaciers and snow cover, “the same climatic phenomena” causing melting glaciers “will also influence snowmelt” (Klanderud, 2000) and snow cover on the ground.

Higher temperatures and possibly fewer days with snow cover have most likely prolonged the growth season in Jotunheimen since 1998. Based on satellite data and

phenology data from birch, Karlsen et al. (2009) found that the Jotunheimen area has extended its growth season by between 1 and 3 weeks in the 1982 – 2016 period.
A prolonged growth season has been demonstrated to influence plant communities in alpine and tundra ecosystems (Galen & Stanton, 1995; Henry & Molau, 1997).

Before the 1998 sampling there had been no temperature increase in summer or autumn in Jotunheimen. Much of the warming has therefore occurred after 1998, and has taken place both in the west and east. There are many signs of the recent warming. During the field work, numerous diminishing permanent snow fields were observed. The recent melting was evident because rocks revealed by the melting snow and ice, had not yet been colonized by lichens (Fig. 14). On several occasions site descriptions from Klanderud (2000) did not fit because permanent snow fields included in the site descriptions had disappeared.

Figure 14. The photo was taken on Galdhøpiggen, August 2. The grey areas around the snow fields have recently been deglaciated, and are barren and free from lichens. The black areas are black because of lichen growth.

Grazing

The sheep in Jotunheimen seldom browse above 1500 m (Landbrukskontoret for Sel og Vågå, 2017; Solbakken, 2017) where most sites are situated. During the summer of 2014, sheep were once observed to browse above 1500 m (personal observation). Sheep grazing in the study area may therefore not be relevant to the general changes observed in this study.

The reindeer mostly browse between 1000 and 1500 m a.s.l. in Jotunheimen, according to Grev (2017). However, during warm days of the field work, at Søre Tjørnholet, hundreds of reindeer were observed on snow fields above 1900 m a.s.l. Smaller herds were also observed on Sikkildalshøa, Raslet and Rasletinden.

Reindeer on Hardangervidda have been found to show specific preference for fresh *Salix herbacea* leaves in the month of June (Gaare & Skogland, 1971). Increased grazing on *S. herbacea* should decrease, not increase the number of occurrences of this species. Yet *S. herbacea* increases significantly in Jotunheimen in 1998-2014 (Appendix 3). In July *Avenella flexuosa* was found to be one of the most important grazing plants for reindeer on Hardangervidda, along with *Solidago virgaurea* and *Hieracium alpina* (Gaare & Skogland, 1971). However, in Jotunheimen, *Avenella flexuosa*, *Solidago virgaurea* and *Hieracium sect. subalpina* have all increased their total number of occurrences between 1998 and 2014 (Appendix 2). There are therefore no indications of intensified grazing on preferred plants. Although severe grazing damage on *Beckwithia glacialis* specimens at high altitudes was observed during the field work, no decline in *B. galcialis* at high altitudes has been observed.

In spite of observations of substantial grazing damage on some high elevation sites, there were generally few signs of grazing on the majority of the sites in Jotunheimen.

Natural succession

According to Matthews (1992) mid-alpine areas above 1500 m a.s.l, around Storbreen in Jotunheimen, deglaciated for more than 220 years, experience a simple succession pattern: first-pioneer species are typically *Poa alpina*, *Cerastium alpinum* and *Cerastium cerastoides*, while typical late successional typical species are *Salix herbaceae* and *Bistorta vivipara*. Late successional species such as *Salix glauca*, *Salix lanata*, *Betula nana*, *Phyllodoce caerula* and *Empetrium nigrum* do not normally appear at such altitudes, due to the severe environmental conditions (Matthews, 1992). If the recent changes in Jotunheimen were caused by natural succession, it would therefore be difficult to explain the findings of *Betula pubescens* specimens above 1700 m a.s.l. (Glittertind and Sikkilsdalshøa), or findings of specimens of late successional species such as *Empetrum nigrum* (1965 m a.s.l.), *Salix glauca* (1950 m a.s.l.) and *Salix lanata* (1905 m a.s.l.) breaking previous altitudinal records.

According to the findings by Matthews (1992), the upward expansion of such species should be attributed to other factors than natural succession.

In Scandinavia, The Little Ice Age maxima has been dated to 1750 (Nesje & Dahl, 2003). The species in Jotunheimen therefore probably have had more than 200 years to recolonize areas lost during the Little Ice Age. If the recent increase in species richness at higher altitudes is caused by natural succession, it therefore seems unlikely that species have not colonized earlier.

Pseudoturnover

Species have most likely been overlooked during the fieldwork, especially on the most species-rich sites. Large species numbers combined with time pressure make it difficult not to overlook any species. This problem has however also been observed by Klanderud (personal communication) and Jørgensen (1932). It can be argued that the possible decline of high-altitude species ("MAlp, MAlp-HAlp" group) at lower elevations, is caused by such sampling errors. Several of the species in the "MAlp, MAlp-HAlp" group are small stature, and are easier overlooked than taller lower-altitude species. However, if a systematic overlooking of small stature high-altitude species was a pattern during the 2014 field work, it could be expected that other small stature species were also overlooked. However, *Epilobium anagallidifolium*, *Euphrasia wettsteinii, Gentiana nivalis*, *Omalotheca supina* and *Saxifraga stellaris* are examples of small stature species that in 1998-2014 have increased in number of occurrences at lower elevations in Jotunheimen.

Finding the correct sites was in some cases difficult. A few of the sites sampled in 1998 might in 2014 have been changed for similar sites nearby. This should however be of small importance to the general results. Klanderud (2000) states that: "as the historic and recent records are always compared within altitudinal bands rather than site-by-site, small sampling inaccuracies should be averaged out". Some sites, such as summits, where species richness has increased between 1998 and 2014, are however difficult to confuse with other sites, so there can be small doubt about the changes observed here.

Many of the species that are found at higher altitudes than previously recorded, such as *Betula pubescens*, *Salix glauca*, *Salix lanata* and *Empetrium nigrum*, are easy to detect, and should have been recorded if they were present in 1998.

Tourism

Tourism has probably increased within the study area since 1998. Most visited is Veslefjellet, where thousands of hikers pass each year on their way from Besseggen (Klanderud, 2000). Hikers can act as seed dispersal vectors (Mount & Pickering, 2009), but can also kill plants by repetitive trampling (Cole, 2004; Monz et al., 2010). Hiking disturbance might also create micro-sites apt for seed germination and can therefore have a positive effect on species richness (Klanderud, 2000). At the Veslefjellet summit, species richness increased from 6 to 20 species between 1998 and 2014 (Appendix 1), and disturbances from hiking might have had a positive effect on species richness. On other summit sites visited by hikers, such as Bukkhammaren and Sikkildalshøa, species richness has also increased from 1998 to 2014 (Appendix 1). However, species richness has also increased on summits where fewer people hike, such as Raslet, Svartdalspiggan and Spiterhøi and Hellstuguhøi among others. There is therefore no clear difference between summit sites frequently crossed by hikers and those that are not.

In Jotunheimen most tourists keep to the footpaths. During the 2014 field work, only a few hikers were observed outside marked paths. The majority of sites sampled in Jotunheimen are situated dozens or hundreds of meters away from the paths hikers usually frequent. Of the 254 sampled sites, only 18 are situated where hikers frequently cross. These are Veslefjellet (sites 2,6), Surtningssui (sites 14-17), Kyrkja (site 13), Bukkhammaren (sites 8,14), Sikkilsdalshøa (sites 5,6,9,10) and Glittertinden (sites 2,3,5,7,8) (Klanderud, 2000) (Appendix 1). It therefore seems unlikely that hiking disturbances can explain the general results of this study. However, hiking disturbances might have had effects on specific sites. To make further assessments more investigation is needed.

Conclusions

Major changes have occurred in Jotunheimen from 1998 to 2014. Species richness has increased at higher elevations, while species richness at lower elevations has stagnated. Cold-adapted species have possibly declined at lower elevations, while higher temperature-adapted species at lower elevations seem to increase in number of occurrences. The most likely driver of these changes is climate warming, and a strong warming tendency is observed in Jotunheimen between 1998 and 2014. More investigation is however needed to determine the impacts of large herbivore grazing and nitrogen deposition. It is unlikely that natural succession since the last Ice Age, pseudoturnover or tourism can explain the general results of this study.

Walther et al. (2005) states that "future studies should focus on the lower margins of alpine species' distribution", where a retreat in species' ranges can first be detected. Because high-altitude species are possibly declining at lower elevations in Jotunheimen, it is important that monitoring on the lower elevations continues. High-altitude species are still frequent in the lower altitude bands, but with unknown amounts of accumulated extinction debt (Dullinger et al., 2012a) and predicted climate warming, it is important to monitor for future changes. High-altitude species might still find suitable microhabitats on the colder north faces of the mountains in Jotunheimen (Scherrer & Koerner, 2010; Scherrer & Körner, 2011), which are scarcely represented in this study. Either way, monitoring of the lower range limits of high-altitude species should be intensified, so that changes do not occur unnoticed.

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Appendix 1

Site descriptions and species list

Appendix 1 is a continuation of site descriptions and species lists from Klanderud (2000) and Jørgensen (1932). UTM-coordinates (Coordinates system WGS84, zone 32 V, standard) from all sites have been included in the appendix. New sites established in 2014, which were excluded from analysis, have been included and labelled "new site". Species abbreviations are explained in Appendix 2.

The species are as in 1998 (Klanderud, 2000) given a number on each site, indicating their abundance. **1 = one specimen. 5 = two to several specimens. 10 = dominant/found everywhere or nearly everywhere.**

Sikkilsdalshøa, 1778 m
13.07-15.07 2014

1. UTM: 0496358 – 6819153. 1440 m. The only course of a brook/soak found which runs in a southwest direction (250° SW). 11° slope.
2. UTM: 0496586 – 6819417. 1505 m. Course of a brook, moist soaks. 280° W, 10° slope.
3. UTM: 0497012 – 6919524. 1600 m. In the steeper part of the slope (20°) towards the top-ridge. Moist patch of vegetation in between numerous small stones. 285° W.
4. UTM: 0497279 – 6819470. 1660 m. Same west facing slope (21°). Moist moss covered patch on the stony ground. Small brook surfaces among the stones.
7. UTM: 0497545 – 6819772. 1730 m. The first top plateau, even, dry plain with stones and mosses. 250° NW.
9. UTM: 0497782 – 6819171. 1750 m. In the northwest slope up towards the summit. Even, dry plain with small stones and mosses. Marked path crosses through the site.
10. UTM: 0498052 – 6818818. 1778 m. Summit. Stony and dry. Rocky outcrops give shelter. Marked path frequently used.
8. UTM: 0498012 – 6818638. 1740 m. Down from the summit. Stony uneven slope (32°) facing 220° SSW. 20 m east of the path, patches of vegetation on the dry ground.
6. UTM: 0497985 – 6818607. 1720 m. Same slope, 28°. Close to a one meter high cairn of stones. Path crosses through the site. Stony and dry.
5. UTM: 0497996 – 6818521. 1690 m. Same stony slope. Grassy and moist. 5 m east of the path.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
M a.s.l.	**1440**	**1505**	**1600**	**1660**	**1690**	**1720**	**1730**	**1737**	**1750**	**1778**
Beck gla	5		5	10		1	5	1	5	5
Luz con						1	10	5	1	1
Poa fle		5			1		1			5
Sal her	10	5	10	10	5	5	5	5	5	
Sil aca	1	5	10	1	1	10		10	10	5
Eri uni	1	1	5		1	5		1	1	1
Cer alp		5	5		5	1	10	5	1	10
Car bel			5	5		5	5	1		1
Sib pro	10	5	10	5	1	5				
Tri spi		1	1		1	5		5	1	1
Fes viv			1	5	1	5	10	5		5
Rho ros	5	5	5		1	5		5		1
Sax opp								5		5

Ant alp	5	1	5		5	1		5	5	5
Bis viv	10	5	5	5	5	10		5		
Sax cer						5				
Des alp	5	5								
Car big	10	10	5		1					
Cer cer	1	10								
Har hyp	5	1	5	1						
Min bif	1					1			5	
Sax ces								5		5
Fes ovi			1		1	5	5	5		
Pot cra	5	1	5	1	1	10		10		5
Emp nig	5	1		1	1			1		
Tarax	5	5			1	1		5		
Sau alp	10	5	5		5	1		5		5
Oxy dig	5	5		1	5	5		1		
Luz spi		1	5	5	1	5	1	5	1	1
Hie sub	5		5		1	1		5		
Ant nip	10	10			1	5				1
Agr mer		1	5			1		1		
Eup wet					5	5		5		
Oma sup			5			5		5		
Sax ste		5								
Tha alp	5	5			5					
Sol vir	5		1		1	1		1		
Ver alp	5	5				1				
Jun tri	5	1	10			5		5		
Ped lap	5	1								
Ped oed	5	5			1			5		
Phle alp		1								
Alch alp	1									
Poa alp	5	1				5		5	5	
Poa viv						5				
Bar alp	5	1				1				
Cam rot	5		5		5			5		
Car lac	5	5				1				
Car rup					1			5		1
Car vag	5	1			1					
Dra niv										1
Eri ang	5									
Gen niv						5				
Hup sel	5								1	
Phy cae	5		5	1				1		
Jun big				1	5					
Poa gla			1	5				1		5
Leo aut		5								
Pul ver			1		5					
Loi pro	1									
Luz mul	5	5								

Ran acr	1	5								
Ran pyg	1			5					5	
Sal gla	5	1			5			5		
Sal lan	5	1			1					
Sal lap	5	1								
Sal phy	1									
Sal ret					1			1		
Vac myr	5									
Vac vit	1									
Alc spp.	5									
Ant dio					1					
Bet nan	5	1								
Bet pub	5				1			1		
Dra fla										1
Epi ana		5								
Jun com					5					
Vis alp	5	1	1	1	5	1		5		5
Pin vul	1									
Poa pra		1								
Rum acsa		5								
Vac uli	1				1					
Ang arc	1									
Arc uva					5					
Lyc ann	1									
Equ arv		5								

Heimdalshøa, 1843 m

16.07

1. UTM: 0492938 - 6813614. 1495 m. Even, moist slopes towards the west.
2. UTM: 0493128 - 6813624. 1560 m. Same slope. Green spot surrounded by boulder field. Wet soak towards west.
3. UTM: 0493267 - 6813623. 1600 m. Moist boulder field along a wet soak/small brook. 22° slope, 270° west.
4. UTM: 0493361 - 6813662. 1635 m. Moist, even plain facing west.
5. UTM: 0493449 - 6813842. 1660 m. Moist 12° slopes with small stones, pointing towards west.
6. UTM: 0493445 - 6813795. 1660 m. Course of a brook towards west.
9. UTM: 0493613 - 6813219. 1732 m. Top plateau. Even stony plain with mosses in between.
7. UTM: 0493802 - 6813658. 1700 m. Straight north of a small lake. Even, dry plain with soft moss cover.
8. UTM: 0494122 - 6813692. 1720 m. Moist soak with bryophytes, slope 16°. Surrounded by boulder field, 300° NW.
10. UTM: 0494414 - 6813845. 1760 m. Moist soak in a steep (16°) stony slope. Small brook runs through site, 330° NW.
11. Not found in 1998.
12. Not found in 1998.
15. UTM: 0494784 - 6813410. 1843 m. The top plateau. Flat, even and stony. Dry.
14. UTM: 0494870 - 6813922. 1810 m. Downhill, straight north from the top point. 10° stony slope.
13. UTM: 0494783 - 6813963. 1800 m. Downhill, same aspect and slope as 14. Stony.

Site	1	2	3	4	5	6	7	8	9	10	13	14	15
M a.s.l.	**1495**	**1560**	**1600**	**1635**	**1660**	**1660**	**1700**	**1720**	**1732**	**1760**	**1800**	**1810**	**1843**
Beck gla		5	1	5	5	5	5	1	5	5	5	5	5
Luz con		5	5	1	1		10	5	10	1	5	5	5
Poa fle	5	1	5	5	5	5	5		5	1	5	5	5
Sal her	5	5	5	10	5	5	10	10	10	5		5	5
Sil aca	5	10	5	10	5	5			5				1
Eri uni	5				5	5							
Cer alp	1			5	5	5		5	5	5			
Car bel		5	5	5	1	5	5	5	5	5	5	5	5
Sib pro	10	5	5	10	1	5							
Tri spi	5			5	1	5							
Fes viv		5	1	10	5	10	5	10	5	5		5	1
Rho ros	1	1		1	5	5		5					
Ant alp	5	10	5	5	5	5				5			
Bis viv	10	5	1	5	1	5		5					
Sax cer										5			
Des alp	5			5	5	5	5	5		5	1		
Car big	10	5	1	5	5	5	5						
Cer cer	5									5			
Har hyp	1		5	1			5						
Min bif	5	5			5	5				1			
Sax ces								1		5			
Fes ovi				1			1						
Pot cra	1				5	5							
Emp nig	5	5		1	1	1							
Tarax	5			5	1	1							
Sau alp	5	5		5	5	5			5				
Oxy dig	5			5		1				1			
Luz spi	1	5	1	5	5	5	5	5	1				
Hie sub	1	5	5	5		1							
Ant nip	5	5	10	1									
Agr mer		5	5	1	1	5							
Eup wet		1		5									
Oma sup		5	5	1									
Tha alp	1			5									
Sol vir		5	1	5									
Ver alp	5	1	5	5									
Jun tri	1	10	5	5	1	1	5						
Ped oed				5									
Phle alp	1												
Alch alp	5												
Poa alp	5		1			5		5					
Poa viv								5					
Bar alp	5												
Cam rot	5												
Car lac	5												

Car vag	1	5								
Phy cae	1		1	5	1					
Jun big								5		5
Poa gla		1						1		
Leo aut	1									
Loi pro				1	1		1			
Luz mul	5									
Ran acr	10					1				
Poa arc								5		
Ran pyg	5				1	1				5
Sal gla								1		
Sal lap		1								
Sax riv								5		5
Vac vit	5	5	5							
Alc spp.	5									
Bet nan	1									
Bet pub		5								
Eri sch	5									
Jun com	1									
Vis alp		5		1						
Pyr min	1									
Rum acsa	1									
Tri eur	5									
Vac uli	1									
Sed vil							1			

Veslefjellet, 1743 m

17.07

I started from Gjendesheim and walked towards Memurubu, the opposite way of Klanderud (1998).

1. UTM: 0489202 – 6819520. 1540 m. Mountain outcrops and sheltered corners on the way up from Gjendesheim. Dry, rich ground in between large stones and rocks. 220° S.
2. UTM: 0488917 – 6819544. 1605 m. Flat, stony plain in the rugged part of the eastern slope. Mountains outcrops. 2 m south of the path.
4. UTM: 0488438 – 6819311. 1640 m. In the eastern slope. Ledges facing southwest. Dry. Green ledges, mountain outcrops and boulder field of small stones.
5. UTM: 0488057 – 6819327. 1700 m. In the eastern slope on the way up to the summit. Green patches of vegetation surrounded by small and medium large stones. Dry.
6. UTM: 0486846 – 6819116. 1743 m. The top plateau, flat, even and stony. Path straight across. Many people pass.
3. UTM: 0485535 – 6818869. 1590 m. The western slope of Veslefjellet. Green ledges and mountain outcrops in the upper part of Besseggen. Dry. 190° S.

Site	**1**	**2**	**3**	**4**	**5**	**6**
M a.s.l.	**1540**	**1605**	**1590**	**1640**	**1700**	**1743**
Beck gla	1	5		5	5	5
Luz con		5		10	10	5
Poa fle		5		5	5	5
Sal her	5	5		5	5	5

Sil aca	5	5			5	5
Cer alp	5					5
Car bel	5	5	1	5		
Sib pro		1				
Tri spi		5		1		5
Fes viv	5		5	1	5	5
Rho ros	5		5			
Ant alp	5	5	5			5
Bis viv	5					
Sax cer						5
Des alp				1		
Car big	5	1				
Har hyp		5		5		
Min bif	5	1				
Fes ovi	5	5	5	5		5
Pot cra	5					
Emp nig	10	5	10	5		1
Tarax	5					5
Sau alp	5		5			
Oxy dig	5			5		1
Luz spi	5	5	5	5		5
Hie sub	5	1	5			1
Ant nip	5					
Agr mer	5	1				
Eup wet	5					
Oma sup	5	5		1	5	
Sax ste		1				
Sol vir	1	1	5			
Jun tri	5	5				
Ped oed	5					
Alch alp	5		5	5		
Cam rot	5		5			1
Ave fle	5	1				
Car vag	5					
Diph alp	5					
Dra niv						5
Hup sel		5	1		5	
Phy cae	5	1		5	5	
Poa gla	5					1
Pul ver	5					
Sal gla	5					
Vac myr	5					
Vac vit	5		5			1
Ant dio	1					
Jun com	5		5			
Sax cot			5			
Vac uli	5		5			
Ara pet			5			

Arc uva 1

Besshøi, 2258 m

19.07

1. UTM: 0484559 – 6819465. 1525 m. Started from Gjendesheim. Walked the path over Veslefjellet and left the path from Bandet at 1500 m, and followed the altitude to the third ravine (course of a brook). Rich and steep slope. 170° S.
2. UTM: 0484506 – 6819548. 1610 m. Follow the eastern ridge of the brook. Extreme steep climbing across a rocky area (1530-1580) and up to a gentler plateau along the brook, facing south. Stony. Moist patches close to the brook.
3. UTM: 0484477 – 6819632. 1655 m. Followed the ridge upwards. Green spot in the boulder field 10 m east-northeast of the brook. 190° S.
4. Deleted because of landslide on site, 2014.
5. Deleted due to uncertain site, in 2014.
6. UTM: 0484363 – 6819799. 1775 m. Followed a grassy, stony slope upwards. Cliffs in the boulder field. Dry, but some moisture coming down the cliffs.
8. UTM: 0484268 – 6819877. 1850 m. Same direction upwards to a small plateau in the huge boulder field. Gravel. 180° S.
10. Snow covered in 1998.
11. Not found in 1998.
12. UTM: 0483924 – 6820059. 2070 m. New site. Gentler slope. Dry, facing SE.
13. UTM: 0483567 – 6820302. 2185 m. New site. Similar slope as on site 12, but 180° S and moist.
14. UTM: 0483389 – 6820520. 2258 m. New site. Summit area, stony.
9. UTM: 0484902 – 6821055. 1860 m. On the way down. Followed the marked path from the summit. Slope facing north-east. Neither moist nor dry. Close to a field of snow.
7. UTM: 0485124 – 6821069. 1795 m. Along the path downhill. Dry patch. 100° E.

Site	**1**	**2**	**3**	**6**	**7**	**8**	**9**	**12**	**13**	**14**
M a.s.l.	**1525**	**1610**	**1655**	**1775**	**1795**	**1850**	**1860**	**2070**	**2185**	**2258**
Beck gla	5	5	5	5	5	5	5	5	1	
Luz con	5	1			5					
Poa fle	1		1	5	5		5			
Sal her	5	5	5	5	5					
Sil aca	5	5	5							
Eri uni			5	5						
Cer alp	5		5							
Car bel	5	1								
Sib pro	5	5								
Tri spi	5	5	5	5						
Fes viv	5		10	5			1			
Rho ros	5	5	5							
Sax opp	5		10	5		1				
Ant alp	1	5	5		5					
Bis viv	5	5	5	5						
Des alp	5	5								
Har hyp	5	5	5	5	1	5				
Sax ces			5							
Fes ovi	5	5								
Pot cra	5	1	5							
Emp nig	10	5	5	5	5					
Tarax	5	5								
Sau alp	5		5							

Oxy dig	5	5		5	
Luz spi	1	5	5		1
Hie sub	5	5			
Ant nip	5	5	5		
Agr mer	5	5		5	
Eup wet	5				
Oma sup	5	5		5	5
Sax ste	5	5			
Sol vir	5	5		5	
Ver alp	5				
Jun tri	5	5	5	5	
Ped oed	5				
Alch alp	5	5			
Poa alp	5	5		5	
Poa viv	1				
Bar alp	5	5	5		
Cam rot	5	5	5		
Ave fle	5				
Car lac		5			
Dra niv			5		
Gen niv			5		
Hup sel		5	1	5	10
Phy cae	1	5			
Jun big	5				
Poa gla	1		5		
Leo aut				5	
Pul ver	1		1		
Loi pro	5				
Luz mul	5				
Sal gla	5		1	5	
Sal lan	5	1	5		
Sal lap	5	1			
Sal phy	1		1		
Sal ret	5				
Vac myr	5	5			
Vac vit	1		1	1	
Ca atra	5	5			
Ver fru			5		
Arc alp			5		
Bet nan	1				
Bet pub	5				
Ger syl	5				
Jun com					
Vis alp	5	5			
Pin vul	5				
Pyr min		5			
Sax cot	5				
Sax niv	1				
Tof pus	5				
Vac uli	5				

Bukkhammaren, 1910 m.

20.07

1. UTM: 0485906 – 6813566. 1500 m. Green, moist 22° slope, 100° E. Long belt of permanent snow situated above.
2. UTM: 0485790 – 6813889. 1510 m. Green, swampy plateau, 11° slope, 60° NE.
3. Deleted due to uncertain site, in 1998.
4. UTM: 0485137 – 6814456. 1620 m. Passed between the two Bukkhammartjørni and went for the greenest spots in the ascent to Bukkehammaren. Hillside with both dry and moist spots, rocks and stones, 190° S, straight above the smallest of the lakes.
5. Not found in 1998.
6. UTM: 0485106 – 6814572. 1710 m. Rock crevice running from just above 4 and upwards. Wet.
7. UTM: 0485009 – 6814702. 1760 m. Up above the crevice in 6, more open terrain. Green plain between bare rocks and stones, 230° S.
8. UTM: 0484932 – 6814807. 1810 m. Dry plain along the path towards the summit.
9. Not found in 1998.
10. UTM: 0484919 – 6814952. 1840 m. First top-point on the ridge. Uneven terrain with large blocks and rocks.
11. UTM: 0484681 – 6815066. 1855 m. Next top-point, same terrain as 10. Dry.
12. UTM: 0484531 – 6815065. 1860 m. Ledges and crevices close to large-stoned boulder field up towards the last top-point.
13. UTM: 0484483 – 6815087. 1880 m. Ledge in the steep mountain side. Surrounded by bare rocks, in the same boulder field as 12. Dry. 200° S.
14. UTM: 0484455 – 6815142. 1910 m. Top plateau in an uneven terrain. Dry between stones and gravel.

Site	**1**	**2**	**4**	**6**	**7**	**8**	**10**	**11**	**12**	**13**	**14**
M a.s.l.	**1500**	**1510**	**1620**	**1710**	**1760**	**1810**	**1840**	**1855**	**1860**	**1880**	**1910**
Beck gla		5		5	1	5	5	5	5		10
Luz con	5	5		1		5	5	5			5
Poa fle				5	5	5	5	5	5		5
Sal her	5	10	5	5	5	10	10	10		10	5
Sil aca	5	5	5	5	5	10	5	5	10	5	
Eri uni	5	1	5	5	5				5	5	
Cer alp	5	5	5	5	5	5		5	5	1	
Car bel						5	5	5	5		1
Sib pro	5	5	5			5					
Tri spi	5	5	5		5	5	5		1	5	
Fes viv	10	5	5	5	5	5	5	5	5	5	5
Rho ros	5	5	5	5	5			1	10	5	
Sax opp			5	5							
Ant alp	5	5	1	1	5	5		5	5	5	5
Bis viv	5	5	5	5	5					5	
Sax cer		5		5							
Des alp	5	5	5								
Car big	5	5	5							5	
Cer cer		5	5								
Har hyp	5	5									
Min bif			5								
Sax ces				5							
Fes ovi	5		1	1	5	5	1	5	1	5	1
Pot cra	5	5	1	5	5					5	
Emp nig	5	5	5			5					
Tarax	5	5	5	1	1						

Sau alp	5	5	5	5	5	5	5	5	5	5	
Oxy dig		5	5	5					1	5	
Luz spi	5	5	5	5	5	5	5	5	5	5	5
Hie sub	5	5	5	5	5	5	1	5		5	
Ant nip	5		5		1					5	
Agr mer	5			1							
Eup wet	5		5	5	5				5	5	
Oma sup			5		5					5	
Sax ste		5	1								
Tha alp	5	5	5	5	5				5	5	
Sol vir			5	5	5		1			5	
Ver alp	5	1	5	1						5	
Jun tri	5	1	5	5	1			1			
Ped oed	5		5	1	5						
Phle alp	5	5	5								
Poa alp	5		5		1						
Poa viv						1					
Bar alp	5		5	5							
Cam rot	5		5	1	5				5	5	
Ave fle	5		5	1						5	
Car lac	5	5									
Car rup						5					
Car vag	5				5					1	
Dra niv				1							
Eri ang	5										
Gen niv	5										
Oma nor			5								
Hup sel	5										
Phy cae	5		1	1							
Jun big	1		5								
Poa gla				5				5	1	1	
Leo aut	5										
Pul ver	5		5	5		5				5	
Ran acr			5							5	
Sal gla	5		5	5	1	1		1			
Sal lan	5		1								
Sal lap	5	1									
Sal ret			5								
Sax riv		5									
Vac vit	5		1								
Ca atra	5		5	5						5	
Ver fru				5					1	5	
Alc spp.			5	5	1					5	
Arc alp	5										
Ast alp			5								
Dra fla				1							
Eri sch		5									
Ger syl			5								

Jun com	5		5							1		
Kob myo				5								
Vis alp			1		5					1		
Poa pra	5	5										
Pyr min	5											
Rum acsa	5		5									
Sal myrs			1									
Sax niv				5								
Vac uli	5											
Sed vil		5										
Epi lac			5									
Arc uva			5									
Equ arv	5	5										
Bot bor	5											

Søre Tjørnholet, 2145 m

22.07

1. UTM: 0483115 – 6810021. 1500 m. Straight west of Tjernhulsbekken. Steep green slope with bare rocks and stones, 140° SE.
2. UTM: 0482874 – 6810023. 1560 m. Up and westwards in the same slope passing a small height. Bare rocks and stones, 140° SE.
3. UTM: 0482846 – 6810136. 1590 m. Same slope straight above a small plain. Grass between stones and bare rocks, trickling water, 150° SE.
4. UTM: 0482773 – 6810188. 1625 m. Up and northwest. 22° slope along a stream running 230° southwest. 180° S.
5. UTM: 0482649 – 6810257. 1675 m. Green ledges in the steep rock face. Large stones, bare rocks, moist.
6. UTM: 0482566 – 6810268. 1700 m. Northwest up from 5, green ledge between bare rock and stone, 160° S.
7. UTM: 0482617 – 6810375. 1730 m. Small height with a cairn of stones before the next ascent. Bare rocks, large stones, bryophytes on the ground.
8. UTM: 0482357 – 6810484. 1760 m. In the direction straight towards the summit. Gentle, stony 10° slopes, 220° SW. Stream nearby.
9. UTM: 0482073 – 6810597. 1820 m. Same plain and aspect as 8. Between bare rocks and stones. Moss cover, 15° slope, 160° S.

10\. UTM: 0481926 – 6810706. 1850 m. Before the pass before the summit. Gentle slope with gravel and stones, 160° S.

12\. UTM: 0481715 – 6810800. 1910 m. Even, stony plateau on the dry ridge. Look straight down on a small glacier to the west.

11\. UTM: 0481606 – 6810707. 1885 m. Downhill. Steep, grassy slope with gravel in the middle of the boulder field.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
M a.s.l.	**1500**	**1560**	**1590**	**1625**	**1675**	**1700**	**1730**	**1760**	**1820**	**1850**	**1885**	**1910**
Beck gla				5			5	5		5	5	5
Luz con				5			5	10	5	5	5	5
Poa fle							5	1	5	5	5	5
Sal her	5	10	5	5	5	10	5	10	10	10	5	10
Sil aca		5	5	5	5	1	5	5	5	5	10	5
Eri uni		5			5	5	1		5		5	
Cer alp					5	5	5	5			5	5

Car bel							5	5				5
Sib pro	1	5	5	1	5	5				5	5	
Tri spi					5		1	1	5	5	5	5
Fes viv	1		5	5		5	5	5	10	5	5	10
Rho ros	5	5	5	5	10	5					1	
Ant alp		5	5	5	5	5	5	5	5		10	
Bis viv	5	5	5	5	5	5			5		5	
Sax cer												
Des alp	5		5	5	5	1						
Car big	5	5	5	5	5	5	5	5	5	5	5	5
Cer cer						5						
Har hyp		1				1						
Min bif			5		5		5					
Fes ovi	1	1		5			5		5			
Pot cra	1	5		5	5	5					5	
Emp nig	5	10	5	5		5	5					
Tarax	1	5	5	1	5	5					5	
Sau alp	5	5	5	5	5	5		5	5		5	
Oxy dig		1	1		5	5						
Luz spi	1	5	5	5	5	1	5	5	5	5	5	5
Hie sub	5	5	5	5	5	5	5	1				
Ant nip	5	5	5	5	5	5	5					
Agr mer	5	5		5	5	1						
Eup wet	5	5	5	5	5	5						
Oma sup	5	5	1	5	5	5				5		
Sax ste		5	5		5							
Tha alp			5	5	5	5			1			
Sol vir	5	5										
Ver alp	5	5	5		5	5						
Jun tri	5	5	5	5	5		5	5				
Ped lap												
Ped oed	1		5		5	1						
Phle alp	5		5		5	5						
Poa alp		1	5			5						
Poa viv											5	
Bar alp	5	5	5	5	5	5						
Cam rot	1	5		5			5	5	1			
Ave fle	5	5	5	1								
Car lac						5						
Car rup							5				5	5
Car vag	5	5	5	5								
Diph alp		5	5									
Eri ang				5								
Gen niv	1		5	1	5	5						
Hie hie												
Oma nor	5	1	5		5	5						
Hup sel	1					5						
Phy cae	5	1	5	5		5						

Jun big			5									
Leo aut	1		5									
Pul ver		1		1								
Loi pro				1								
Luz mul	1		5									
Ran acr	5		5									
Sal gla	5	1		1								
Sal lan					1							
Sal lap	1	1										
Sal phy	1											
Vac myr	10	5	5	5								
Vac vit	5	5		5			5	5				
Nar str	5		10									
Car sax			5	10								
Vahl atr			5			5						
Alc spp.	5		5		5	5						
Ant dio	1	5	5									
Dra fla										5		1
Epi ana	5		5		5	5						
Eri sch												
Ger syl	5		5									
Jun com	5	5	5	5	1							
Vis alp		1										
Pyr min		5	5									
Rum acsa	5	5	5		5							
Sax niv					5							
Tri eur	5											
Vac uli	5	5	5	5								
Ath dis			5			5						
Cha ang	1	5										
Car arc							5					
Gym dry		5										

Raslet, 1854 m

23.07

1. UTM: 0487695 – 6807332. 1500 m. Even, stony land, sloping 16° in 80° NE direction. View straight down at the two northernmost “Fisketjerni”.
2. UTM: 0487469 – 6807162. 1525 m. Kept the elevation towards Rasletjern, to the top of the only small hill observed in the area. Dry.
3. UTM: 0487457 – 6807147. 1520 m. In the south-exposed slope of 2. Dry in spite of stream 30 m. to the south.
4. UTM: 0487167 – 6806658. 1570 m. South westwards through a boulder field until the 1560 elevation is reached. 22° dry slope down towards Rasletjern, 160° SE.
5. Not found in 1998.
6. UTM: 0486999 – 6806335. 1570 m. In the steepest part of the southeast-wall, 140° SE. Stones and gravel in a 21° slope, a small boulder field within the site, with the northern end of Rasletjern in a straight line below.
7. UTM: 0486963 – 6806330. 1600 m. Continue straight up from 6 in the same exposition. Ledges and crevices, gentle water flows from snowmelt.
8. Not found in 1998.

9. Not found in 1998.
10. UTM: 0486843 – 6806293. 1675 m. To the southwest across a field of permanent snow in the southeast wall of Raslet. Green ledges in a grey rock face, 140° S. Incredible view!
11. Not found in 1998.
13. UTM: 0485974 – 6805487. 1740 m. Transversed the last part of the southeast wall across another large field of permanent snow, to reach the south slope of the peak. Large stones and gravel.
15. UTM: 0486122 – 6805912. 1850 m. Top point. Boulder field in an even terrain.
14. UTM: 0486623 – 6806595. 1760 m. Downhill and northeast from the top. Sandy ground with gravel and stones, 360° N.
12. UTM: 0486767 – 6806724. 1730 m. Continue downwards in the northeast direction. Ridge with bryophytes, stones and gravel, 18° slope to the northeast. Moist.

Site	**1**	**2**	**3**	**4**	**6**	**7**	**10**	**12**	**13**	**14**	**15**
M a.s.l.	**1500**	**1525**	**1520**	**1570**	**1570**	**1600**	**1675**	**1730**	**1740**	**1760**	**1850**
Beck gla	5	5	5		1		5	5	5	5	5
Luz con	5	5	5	1	1	5	5	10	5	5	5
Poa fle		5	5			5	1	5	5	5	5
Sal her	5	5	5	10	5	5	5	5	10	10	
Sil aca	5	5	5	5				5	5	5	
Eri uni				5			1				
Cer alp				5	5	5	1				
Car bel	5				5	1		1		5	
Sib pro	5		5	5	5	5	5				
Tri spi	5	1	5	5		5	5			1	
Fes viv			1	5	5	5			1	1	
Rho ros				5	5	5	5				
Ant alp				5	5		5				
Bis viv	5			5	5	5					
Sax cer							10				
Des alp				5	5			5		5	
Car big	5		5	5	5				5		5
Cer cer							5				
Har hyp	5		5	5							
Min bif						5	5				
Sax ces							1				
Fes ovi		5	5	1	5	5					
Pot cra				5	1						
Emp nig	5	5	5	5		1					
Tarax				5	5	5	5				
Sau alp				5	5	1					
Oxy dig					5		5				
Luz spi	5	5	5	5	5	5	1		5		1
Hie sub	5	5	5	5	5	5					
Ant nip	10	1	5	5	5	5	5				
Agr mer	5			5		5					
Eup wet				5							
Oma sup	5		5	5	5		5				
Sax ste						5	5				
Sol vir						5					

Ver alp				5			5			
Jun tri	10	10	10	5	1	5	1		5	
Ped lap					1					
Ped oed				5	1					
Phle alp				1			5			
Poa alp							10			
Poa viv			5			5	5			
Bar alp				5	1					
Cam rot		5		5	5					
Ave fle	5			5	5	1				
Car lac					5	5	5			1
Diph alp				1						
Hie hie					5					
Oma nor					5		5			
Hup sel				5						5
Phy cae				5	5					
Pul ver		1	5							
Luz mul				5	1					
Ran acr					5					
Ran pyg							5			
Sal gla					1					
Sal lan					1					
Vac myr					5					
Vac vit	5	5	5	5						
Vahl atr	5			1	5	5				
Arc alp	5									
Epi ana					5		5			
Jun com	1				1					
Vis alp	5				5	5				
Pyr min					5					
Rum acsa	5				5	5				
Sil dio					5					
Vac uli		5		1	5					
Sed vil		5								
Cha ang					5					

Raudhamrane og Rasletinden, 2105 m

25.07

1. UTM: 0486443 – 6809154. 1495 m. Grassy 22° slope surrounded by bare rocks, trickling water in the northern border. 120° E.
2. UTM: 0486308 – 6809015. 1540 m. Rock face south of a stream, small ledges with gravel, stones and mosses. Mostly moist, 100° E.
3. UTM: 0486229 – 6809015. 1570 m. Straight up and east from 2. Stony, dry snow-bed, 120° E.
4. Not found in 1998.
5. UTM: 0486211 – 6808924. 1590 m. Continued southwards from 3 following the same elevation, then uphill from a depression in the terrain. Dry little ridge, 60° NE.
6. Not found in 1998.

7. Not found in 1998.
8. UTM: 0486080 – 6808795. 1650 m. Continue southwest up to a flat ground with bare rocks, stones and mosses.
9. UTM: 0485793 – 6808808. 1750 m. At the southern foot of "1787", north of the small lake and before the ascent towards "2010". Gently, dry ground with stones and a green patch, 200° S.
10. UTM: 0485574 – 6808455. 1805 m. In the ascent to "2010". Small, stony and rocky spot with mosses. 20° NE.
10a. UTM: 0485485 – 6808269. 1830 m. Dry stony plain.
11. UTM: 0485103 – 6807302. 2000 m. At the 2000 m altitude close to the height "2010". Boulder field.
12. Not found in 1998.
13. UTM: 0484217 – 6806668. 2050 m. New site. Dry little plain in middle of boulder field. South-exposed. An elk is observed on a permanent snow field close to site.
14. UTM: 0483946 – 6806837. 2105 m. New site. Top plateau of Rasletind. Crevices in the rocks.

Site	**1**	**2**	**3**	**5**	**8**	**9**	**10**	**10a**	**11**	**13**	**14**
M a.s.l.	**1495**	**1540**	**1570**	**1590**	**1650**	**1750**	**1805**	**1830**	**2000**	**2050**	**2105**
Beck gla		5		5	5	5	10	5	-	5	
Luz con		5		5	5	1	5	5			
Poa fle				5	5		5	5			
Sal her	10	5	10	5	10	10	5	10			
Sil aca		5	5	5	5	5		5			
Eri uni		5	5			5					
Cer alp			5	5	5						
Car bel				5	5	5	1				
Sib pro	5	5		5	5						
Tri spi			5	5	5						
Fes viv				5	5	5				1	
Rho ros		5	5	5		5					
Sax opp		-									
Ant alp		5	5	5	5	5					
Bis viv	5	5	5	5		5					
Des alp	5	5									
Car big	5	5		5							
Cer cer	5										
Har hyp	1	5	5	5							
Min bif		5	5								
Sax ces											
Fes ovi		5	5	5		1					
Pot cra		5	5	5		1					
Emp nig	5	5	5	5							
Tarax	1	5	5								
Sau alp		5	5	5		5					
Oxy dig		5			5						
Luz spi		5	5	5	5	5					
Hie sub	5	5	5	5		5					
Ant nip	10	5	10			5					
Agr mer		5	5	5	1			1			
Eup wet			5			5					
Oma sup	10		5		5						
Sax ste	5	5									

Tha alp		5	5	5			
Sol vir	5						
Ver alp	5	5	5				
Jun tri	5	5	5	5	1	5	
Ped oed		5	5				
Phle alp	5	5					
Alch alp	5						
Poa alp		5	5		5		
Poa viv		5		1	1		
Bar alp			5				
Cam rot			5	5		5	
Ave fle	5		5				
Car lac	5	5			5		1
Car rup				5			
Car vag	5	5	5				
Diph alp	5						
Dry oct			10				
Eri ang	5	5					
Gen niv		1					
Oma nor	5						
Hup sel	5	1	5	5			1
Phy cae	5	5	10	1			
Jun big		5					
Poa gla				5		5	
Leo aut	1	5					
Pul ver			5	1		5	
Loi pro	1	1					
Luz mul			5	5			
Sal ret			5				
Sax riv		1					
Vac myr	5	1	5				
Vac vit			5	5		5	
Ca atra		5	5				
Nar str	10	5					
Vahl atr	10	5					
Ant dio			5				
Ast alp		5					
Epi ana	1	5					
Eri sch	5						
Jun com						1	
Pyr min			5				
Rum acsa	5						
Sax niv		5					
Vac uli	5	1	5	5		1	
Sel sel		5	5				
Arc uva				1			
Ath dis		1					
Car arc						5	

Tjørnholstinden, 2330 m

26.07

1. UTM: 0483615 – 6810367. 1520 m. About 3 km on the path from Svarthammarbui, crossing uphill a little to the northwest, in the direction of Tjørnholsbekken. 22° slopes with grasses and dwarf-shrubs. Medium large stones scattered. 180° S.
2. UTM: 0483448 – 6910509. 1595 m. Further up and slightly to the northwest. Stony and grassy downhill towards Tjørnholsbekken. View straight down to the Tjørnholsbekken outlet, 180° S from site.
3. UTM: 0483248 – 6810697. 1670 m. Straight up and a little westwards from 2. Course of a brook, 190°S.
4. UTM: 0483276 – 6810941. 1705 m. Continue uphill in the more gentle terrain. Moist plain with mosses and sedges, dryer at the borders.
5. UTM: 0483278 – 6811001. 1715 m. 10 m up northwest, in the direction towards a green spot above. Stony 12° slopes flushed with melt-water from snow further up. One brook on each side of site, 170°S.
6. UTM: 0483212 – 6811145. 1760 m. Straight up from 5. Snow-bed just beyond field of permanent snow.
7. Not found in 1998.
8. UTM: 0482931 – 6811373. 1850 m. Green spot in the southwest slope. Stones and gravel.
9. UTM: 0482764 – 6811425. 1880 m. Moist, stony slope in the ascent towards the ridge which has a huge field of permanent snow in the eastern side (visible on the map).
10. UTM: 0482600 – 6811615. 1950 m. Green, dry spot with gravel and stones in a surrounding steep boulder field with large stones, 190° S.
11. UTM: 0482462 – 6811783. 2010 m. Further up and northwest in the same steep boulder field. Stones and gravel, 210° S.
12. UTM: 0482175 – 6811996. 2050 m. The entire flat ridge towards Tjørnholstinden.
13. UTM: 0481690 – 6812150. 2080 m. Between huge stones in the beginning of the last ascent towards the peak. Southwest exposed.
14. UTM: 0481717 – 6812179. 2090 m. Same as 13 but further up. Dry.
15. UTM: 0481651 – 6812238. 2130 m. Further up towards the summit. Steep, dry boulder field with large blocks. South exposed.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
M a.s.l.	**1520**	**1595**	**1670**	**1705**	**1715**	**1760**	**1850**	**1880**	**1950**	**2010**	**2050**	**2080**	**2090**	**2130**
Beck gla			1	5	5	1	5	1	5	5	5	10	10	10
Luz con				5	5			5	5	5	1		1	
Poa fle			1	1	1	5	5	5	5	5	5	10	10	5
Sal her		5	5	5	10	5	10	5	10	10	5	10	5	5
Sil aca	5	5	5	5	5	5	5	5	10	1				**5**
Eri uni		5	5			5	1		5					
Cer alp		5	5						5		5			
Car bel			1		5			1						1
Sib pro		5	5	5		5	5	5	5	5		5		
Tri spi			5				5	5	5	5	5	5		
Fes viv		5		5	5	5	5	10	5	10	5	1		
Rho ros	5	5	5	5		5	5	5	5					
Sax opp		5						5						
Ant alp	5	5	5	5	5	10	5		5	5				5
Bis viv	5	5	5	5	5	5	5	5	5					
Sax cer														
Des alp		5	1	5	5	5	5	5		5	5			
Car big	5	5	5	5	5	5	5	5						
Cer cer			5											
Har hyp		5			5									
Min bif		5			5		5	5	5					

Fes ovi	5	1	5	1								
Pot cra	5	5	5			1						
Emp nig	5	10	1	5	5							
Tarax	5	5	5	5		5	5	5				
Sau alp	5	5	5	5	5	5	5	5	5			
Oxy dig	5	5	5	1		5		5				
Luz spi	5	5	5	5	5	5	5	5	5	1		5
Hie sub	5	5		5	5	5				1		
Ant nip	5	5	5	5		5	1					
Agr mer	5	5	5	5	1	1	5					
Eup wet	5	5	5			5						
Oma sup		5	5	5		5	5			5		
Sax ste		5	5	5	5		1	5				
Tha alp	5	5	5	5		5		5				
Sol vir		5										
Ver alp	1	5	1	1		5	5					
Jun tri	5	5	5	5		1						
Ped oed	5	5	5			5		5				
Phle alp	5											
Poa alp	5	5	5			5	1					
Poa viv							5					
Bar alp	5	5				5						
Cam rot	5	5	5	5		5			1			
Ave fle	5	5										
Car lac		1	5	5	1		5					
Car rup									5			
Car vag	5	5	5	5								
Diph alp				5								
Eri ang				5	5							
Eri vag				5								
Gen niv	5	5		1								
Oma nor	1	5										
Hup sel		5	1	5	5							
Phy cae	5	5										
Jun big				5								
Leo aut	5	5	1									
Pul ver	5					5						
Loi pro	5											
Luz mul	5	5			5							
Ran acr	5	5										
Poa arc								5				
Sal gla	5	5										
Sal lan	5	5										
Sal lap	5											
Sal phy	1											
Sal ret	5											
Sax riv		1										
Vac myr	5	5										

Vac vit	5			5	
Ca atra	5	5			
Nar str	10				
Vahl atr		10	5	5	1
Alc spp.	5	5			
Ant dio	5				
Ast alp	5				
Bet nan	5				
Car cap	5				
Epi ana	1	5			
Ger syl	1				
Jun com	5	5			
Pyr min		5			
Rum acsa	1				
Vac uli	5	5			
Sel sel	5				
Arc uva	1				
Coe vir	1				

Rauhamrane/Surtningssui, 2368 m

28.07

1. UTM: 0476521 – 6819139. 1515 m. Left the path in Memurudalen when the terrain flattened out. Crossed the valley slope towards the south slope of Rauhamrane. Rugged, rich slope with medium large stones and several small brooks. 210° S.
2. UTM: 0476507 – 6819200. 1560 m. Higher up in the same slope.
3. UTM: 0475687 – 6819614. 1620 m. Followed the elevation westwards. Along a brook. Cliffs and large stones. 240° SW.
4. UTM: 0475755 – 6819685. 1670 m. Small hill (rock) just northwest of 3. A stream just beneath ending in Memurudalen. Dry.
5. UTM: 0475806 – 6819722. 1700 m. Just above 4. Rich ledge before a rock wall. A brook east of site, running to Memurudalen. 210° S.
7. UTM: 0475773 – 6819864. 1750 m. Followed the stream further up to plateau. Fields of permanent snow that are melting away. Stony slope, neither moist nor dry. 200° S.
9. UTM: 0476151 – 6819729. 1770 m. Mountain outcrop in the boulder field. Ledges and clefts in the rock wall facing south. Stones and gravel. 200° S.
10. UTM: 0476153 – 6819773. 1790 m. Just above 9. Same aspect.
11. UTM: 0475991 – 6820441. 1830 m. Even top plateau by the Rauhamrane. Bare rocks and small stones.
6. UTM: 0475505 – 6821646. 1720 m. Followed the path from Memurubu to Surtningssui. Moist snow-bed with mosses and small stones, crossed by the path. 240° SW.
8. UTM: 0475647 – 6821714. 1760 m. Followed the path uphill. Boulder field and rocks by the ascent of Surtningssui. 280° W.
12. Not found in 1998.
13. UTM: 0475935 – 6821813. 1890 m. Course of a brook along the path. Small green plateau surrounded by the boulder field. 290° W.
14. UTM: 0476004 – 6821809. 1930 m. Along the path at the steepest part of the climb to Surtingssui. Moist snow-bed facing southwest.
15. UTM: 0476019 – 6821840. 1950 m. Along the path. Green patch of vegetation on gravel ground. Steep slopes.
16. UTM: 0476031 – 6821869. 1970 m. Along the path. Rocky outcrop with ledges and crevices. Gravel on the ground beneath.

17. UTM: 0476061 – 6821877. 1990 m. A rich belt along the path (continues up to 2010), loose gravel. Rich patches occur outside the path as well.
18. UTM: 0476118 – 6821935. 2040 m. Above the steepest climb. Even ascent. Green patch 20 m. north from large stones. Extensive browsing damages.
19. UTM: 0476157 – 6821939. 2050 m. Small green patches along the path. Extensive browsing damages.
20. UTM: 0476216 – 6821982. 2070 m. South facing snow-bed along the path. Almost all vascular plants have been heavily browsed.
21. UTM: 0476407 – 6822107. 2130 m. Last observed specimens of *B. glacialis* and *Saxifraga oppositifolia*.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
M a.s.l.	1515	1560	1620	1670	1700	1720	1750	1760	1770	1790	1830	1890	1930	1950	1970	1990	2040	2050	2070	2130
Beck gla		5	5	1	10	5		5	5	5	5	5	5	5	5	5	5	10	5	1
Luz con			5		5	5		5	5	5	5	5	5	5	5	5	5			
Poa fle				5		5			5	5	5	5	5	5	5	5	5	5	5	
Sal her	5	5	5		5	10	5	10	5	5	5	10	5	5	5	5				
Sil aca	5	5	5	5	10		10	5	5	5	5						5			
Eri uni	5	1	1	5	5		5	5	5	5						1				
Cer alp	5	5		5			5		5	5					5	5				
Car bel			1		5	5		5			5	5	5							
Sib pro		5	5		5		5	5	5	5				1	1					
Tri spi			1	1	1		10	5	5	5		5	5	5	5	5				
Fes viv		5	5	5	5	5	5	5	5	5	5	10	5	10	5	5	5			
Rho ros	5	5	5	1			1	5	5	5		5				5				
Sax opp		5	5	5			5	5	5	5		5			5	5				1
Ant alp	5	1	5	5	5	5	5	5	5	5	5	5			5	5				
Bis viv	5	5	5	5	5		5	5	5	5										
Des alp		1	5					5				5								
Car big	5		5	5						5	5									
Cer cer																				
Har hyp			5		5	5	5	5		5										
Min bif	5						5	5	5	5										
Sax ces							5								5	5				
Fes ovi	5	5	1	5																
Pot cra	5	5	5	5			5	5		5										
Emp nig	1	5	5	5	5		1		1	5										
Tarax	5	5	5		5		5	5	5	5										
Sau alp	5	5	5	5	5		5	5		5		5								
Oxy dig	5	1	5	1	1			5	5	5			5			1				
Luz spi	5	1	5	5	5	5	5	5	5	5	5	5			5					
Hie sub	5	5		5	5		1	5												
Ant nip	5	5	5	5	5			5												
Agr mer	5	5			5	5		5		5										
Eup wet	5	5		5	5			5		5										
Oma sup		5	5		5	5	5	5	5		5			5						
Sax ste		1	5			5								5						
Tha alp	5	5	5	5			5			5										
Sol vir	5	5						5												
Ver alp	1	1	5		5		5	5												
Jun tri	5	10	5	5	5		5	1	5	5										

Ped oed		5	5	5	5					5						
Phle alp	5															
Alch alp	5															
Ara alp									5							
Poa alp	5		5				5	5	5	5			1			
Poa viv									5	1						
Bar alp	5	5	5													
Cam rot	10	5		5			1	1		5						
Ave fle	5	5			1											
Car lac			5						5	5						
Car rup				5			5									5
Car vag	5	5	5	5												
Diph alp										5						
Dra niv							1									
Dry oct				10												
Gen niv	5	5	5				5	5		5						
Hie hie	1															
Oma nor	5	5														
Hup sel			5	5		5	5	5	1							
Phy cae	5	5	5	5		5	5			1	1				1	
Jun big			5													
Poa gla	1		1	5			1			5					5	5
Leo aut	5	1														
Pul ver	5	1		5	5		5									
Loi pro			1	5												
Luz mul	5	5														
Ran acr	1	5														
Sal gla	5	5	5				1		5					1		
Sal lan	5	5					1									
Sal phy	5		1													
Sal ret			5	5			1									
Vac myr	5	5														
Vac vit		5		5												
Ca atra	1		5	5	5		5	5	5	5						
Ver fru	5															
Nar str	10	10														
Alc spp.	5	5														
Ant dio	5	5		5												
Arc alp				5												
Car cap				5												
Ger syl	5	10														
Jun com	5	5	1	5					1							
Kob myo				5												
Vis alp							5									
Pin vul	5	5	5	1												
Pyr min	5	5														
Rum acsa	5	5														
Sal myrs			5													

Sax cot		5								
Sax niv									1	1
Sil dio	5	5								
Tof pus			5	5			1			
Tri eur		5								
Vac uli	5	5	5	5						
Sel sel	5	5		5						1
Epi lac	5	1								
Ang arc	5									
Arc uva				5						
Ath dis	1									
Bot lun	5						5			
Cir het	5									
Par pal	5	1		5						
Pol lon	1									

Svartdalspiggan, 2137 m

30.07

1. UTM: 0473172 – 6811367. 1495 m. Near the foot of a steep rock face, 65° NE. Green ledge or ridge in a small boulder field.
2. UTM: 0473108 – 6811293. 1550 m. Moist ledge in the rock, 90° E.
3. UTM: 0473116 – 6811127. 1615 m. On the plateau, snow-bed in the cleft. Moist soak, 40° NE.
4. UTM: 0473149 – 6811012. 1640 m. Snow bed close to a small path (not very much used) and little cairn of stones marking the way to the summit. Large stones, mosses and bare soil, 40° NE.
5. UTM: 0473131 – 6810735. 1710 m. Most plain close to the same path as in 4. Bare rocks, stones and trickling water, 320° NW.
7. UTM: 0473248 – 6810477. 1785 m. Wet plain with ledges, large stones mosses and lichens. Both the path and a stream cross the site. 320° NW.
8. UTM: 0473422 – 6810465. 1840 m. Ridges with mosses in a boulder field, just above a stream, 320°NW.
10. Not found in 1998.
17. UTM: 0473799 – 6809879. 2137 m. The top. Rocky and uneven with blocks and crevices.
16. UTM: 0473773 – 6809853. 2125 m. Downhill, in a rock crevice towards the south.
15. Not found in 1998.
14. UTM: 0473736 – 6809736. 2050 m. Downhill. Ledge in the rock face. Stones and gravel.
13. UTM: 0473744 – 6809639. 2010 m. Downhill. Crevice in the rock. Moist, 260° SW.
12. Not found in 1998.
11. UTM: 0473700 – 6809522. 1950 m. Moist ledge in the western rock face. Gravel, bare rocks and trickling water, 270° V.
9. UTM: 0473622 – 6809468 – 1880 m. Moist slope in the rock face with trickling water. 250° W. Steep terrain, so do not walk directly towards site 6, but around.
6. UTM: 0473477 – 6809457. 1765 m. Steep, moist slope with gravel and bare rocks in the west-facing mountain slope.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**11**	**13**	**14**	**16**	**17**
M a.s.l.	**1495**	**1550**	**1615**	**1640**	**1710**	**1765**	**1785**	**1840**	**1880**	**1950**	**2010**	**2050**	**2125**	**2137**
Beck gla	5	5	5	10	5	5	5		5	5	5	5	5	
Luz con	5	5	5	5	5		10	5	5	5				1
Poa fle		5	5	5	5	1	5	5	5	5	5	5	5	
Sal her	10	10	5	10	10	10	10	5	10	10	5	5	5	5

Sil aca	1	5				5						5
Eri uni						5						5
Cer alp												5
Car bel		5	5	5	5		5		5	5	1	5
Sib pro			5	5		5				5		
Tri spi		5		5		5			5	5		10
Fes viv	5	5		5	5	5			5	5		5
Rho ros		5				10						
Sax opp												5
Ant alp				5								5
Bis viv	5	5		5		10			5	5		
Sax cer												5
Des alp			5		5	5	1	5	5	5	5	5
Car big	5		5	5		5	10					
Cer cer												5
Har hyp	5	5	5	5								
Min bif				5								
Fes ovi		5										
Pot cra						5						
Emp nig	1	5										
Tarax						5				5		5
Sau alp		10				10			10	5		
Oxy dig	5	5		1		5			5	5		1
Luz spi	5	5	5	5		5			5	5		
Hie sub				1		5				1		
Ant nip						10						
Agr mer		5	5			5						
Oma sup		1	5	5		5			5	5	5	5
Sax ste	5	5	5	5	5	5			1	5	5	
Tha alp		5				5						
Ver alp									5			
Jun tri		5	5									
Ped oed		5				5						
Phle alp		1										
Poa viv		5								1		5
Car lac	5		1	5					5	5		5
Car vag						5						
Hup sel		5		5	5	5	5					
Jun big	5	1	1	5		1			5			
Ran pyg				5						5		5
Sal gla		1							1			
Sax riv				5								5
Ca atra						5						
Sax niv		5										
Sel sel						5						

"Knutsholstinden", 2341 m

31.07

1. UTM: 0475164 – 6810623. 1550 m. Ravine-ridge, dry, stony ground. Moist between the ridges, 260°SW.
2. Not found in 1998.
3. UTM: 0475303 – 6810897. 1680 m. Ledge in the rock face surrounded by large-stoned boulder field. Straight line from a stream and a green spot in the boulder field below. 210° S.
4. UTM: 0475583 – 6810891. 1760 m. Snow-bed boulder field with small stones and bare rocks. Wet from melting snow just above. 230° SW.
5. 6. (Recorded together). Deleted due to uncertain site, in 2014.
7. UTM: 0475817 – 6810904. 1880 m. Spot of lush vegetation 30 m south of boulder field, towards the pass. Bare rocks above. 230° SSW.
10. UTM: 0475879 – 6810931. 1930 m. Further up towards the pass. By the foot of moist rock crevice, rock crevice surrounded by boulder field. 260° W.
11. UTM: 0475943 – 6810977. 1995 m. Straight up from 10, same aspect. Moist ledges beneath a small mountain outcrop.
12. Not found in 1998.
13. Not found in 1998.
14. UTM: 0476123 – 6811084. 2135 m. The last slope towards the first top, "2185". Crevice in the rock, but the two species recorded here are also spread evenly up to about 2160 m.
15. Not found in 1998.
16. UTM: 0476288 – 6811227. 2185 m. The summit "2185".
8. Not found in 2014
9. Not found in 2014

Site	**1**	**3**	**4**	**7**	**10**	**11**	**14**	**16**
M a.s.l.	**1550**	**1680**	**1760**	**1880**	**1930**	**1995**	**2135**	**2185**
Beck gla	5		5	5	5	5	5	5
Luz con	5	5	5					
Poa fle		5		1	5	5	1	5
Sal her	5	5	10	5	5	5		
Sil aca	5	5		5		5		
Eri uni	5			5	5			
Cer alp		5						
Car bel		1	5		5	5		
Sib pro	5		5	5		1		
Tri spi		1	5	5	5	5		
Fes viv	5	10		5	5	5		
Rho ros	5	5	5	5	1			
Ant alp	5	5		5				
Bis viv	10	5	10	5	5	5		
Sax cer					5	5		
Des alp			5	5	5			
Car big	5	5						
Cer cer			5		1	5		
Min bif		5						
Fes ovi	5	1						
Pot cra	5	5		5				
Emp nig	5	1						
Tarax	5		10	5	5	1		
Sau alp	5	5		10				
Oxy dig			5		10	5		

Luz spi	5	5		5	1	5
Hie sub	5	5				
Ant nip	5	5			1	
Agr mer	5	5		5		
Eup wet	5	1				
Oma sup			5		5	5
Sax ste			5	5	5	1
Tha alp	5	5		5		
Sol vir		5				
Ver alp	5		5	5	5	
Jun tri	10	10				
Ped oed	5	5	1	5		
Phle alp			1			
Poa viv			5	5	5	5
Bar alp	5	5	5			
Cam rot	5	5	5			
Ave fle	5					
Car lac			5	5	5	5
Car rup		5				
Car vag	5					
Diph alp						5
Oma nor	5		5			
Phy cae		1				
Jun big			5	5	1	
Pul ver	5	5				
Poa arc				1		
Ran pyg			5		5	5
Sal gla		5				
Sax riv					5	1
Vac myr	5					
Vac vit	5	5				
Ca atra		1				
Epi ana			5			
Jun com		1				
Pyr min	5					
Sax niv					5	1
Vac uli	5					
Sil wahl				5		
Ath dis			5			

Galdhøpiggen, 2469 m

01.08

1. UTM: 0467175 – 6832949. 1570 m. 50 m north of the marked path to Galdhøpiggen. Rich, uneven grassy slope (20°). Medium large stones scattered, moist. 120° ESE. Sheep grazing close by.
2. UTM: 0467159 – 6833078. 1625 m. Continued straight uphill. More stones (large and medium large) in the steep slope of grazed grass heaths. Heather and Salix on the ridges. Moist. 130° E. Sheep on site.
3. UTM: 0466801 – 6833103. 1720 m. Gentle slope facing east/southeast. Rocky plateau and large stones give many good microhabitats. Permanent snow in the surroundings.
4. UTM: 0466754 – 6833251. 1780 m. Small, hill with stones, gravel and bryophytes on the ground. The only green spot in the area. Moist. 160° S.
5. Snow covered in 1998.
6. UTM: 0466135 – 6833346. 1905 m. Large, even plain with gravel, small stones and moist soaks, north of the path. Slight slope 160° S.

9 – 14. Not found in 1998.

15 – 16. Snow covered in 1998.

8. UTM: 0465101 – 6833328. 2125 m. On the way down, south east of Svellnosi. The only green patch between huge stones in the slope.
7. UTM: 0465225 – 6833178. 2050 m. Further down from 8. Steep ridge with huge stones. Just west and above a steep field of permanent snow.

Site	**1**	**2**	**3**	**4**	**6**	**7**	**8**
M a.s.l.	**1570**	**1625**	**1720**	**1780**	**1905**	**2050**	**2125**
Beck gla			5	5	5	5	
Luz con		5	5	5	5		
Poa fle			5	5	5	5	
Sal her	10	5	5	5	5	10	10
Sil aca	5						
Eri uni	5						
Cer alp	5	5	5	5	5		
Car bel			5	1	5		
Sib pro	5	5					
Tri spi	5		5	5			
Fes viv	1	5		5	5		
Rho ros	5	5					
Ant alp	5	5	5	5			
Bis viv	5	5					
Des alp	1						
Car big	5	5					
Har hyp	5	1	5				
Sax ces						5	
Fes ovi	5	5					
Pot cra	5						
Emp nig	5	5	5				
Tarax	5	5	5				
Sau alp	5	5					
Oxy dig	1						
Luz spi	5	5	5	5			
Hie sub	5	5		1			
Ant nip	10	10					
Agr mer	5						
Eup wet	5	5					

Oma sup	5	5	5		5
Sax ste		5			
Tha alp	5				
Sol vir			5		
Ver alp	5	5			
Jun tri	5		5		
Ped oed		5			
Phle alp	5				
Poa alp	5			5	
Poa viv					5
Bar alp	5	1			
Cam rot	5	5			
Ave fle	5	5			
Car lac	1				
Car vag		5			
Diph alp	5				
Gen niv	1				
Oma nor	5				
Hup sel		5			
Phy cae	5	5	5		
Loi pro	5				
Luz mul	5	5			
Sal gla			5		
Sal lap		5			
Sal ret	5				
Vac myr	5	5			
Vac vit	5	5			
Vio pal		5			
Nar str	10				
Ant dio	5				
Epi ana	5				
Ger syl	5				
Jun com	5				
Pyr min	1	5			
Rum acsa	1				
Tri eur		5			
Vac uli	5	5			
Sel sel	5				
Ste bor	5				
Agr cap	1				
Lyc ann			1		

Tverråtindan, 2302 m

03.08

1. UTM: 0465726 – 6831185. 1510 m. South of the path to Svellnosbreen, by the ascent of the ridge towards Tverråtindan. Stony slope covered by bryophytes. Patches of vascular plants. Moist. 150° SE.
2. UTM: 0465544 – 6831167. 1570 m. Rocky slope with ledges and sheltered corners. Stony and moist. 150° SE.
3. UTM: 0465515 – 6831209. 1600 m. Steeper slope with medium large stones and bare rocks. Bryophytes. 150° SE.
4. UTM: 0465438 – 6831242. 1650 m. Very rich slope. No brook, but moist soaks come from the rocks above. 150° SE.
5. Not found in 1998.
7. UTM: 0465301 – 6831335. 1760 m. Open stony ridge with bryophytes in the mountain slope. Flatter prior to the boulder field further up. 150° SE.
10. UTM: 0464943 – 6831414. 1885 m. In the boulder field between large stones. Dry.
12. UTM: 0464818 – 6831428. 1950 m. Ledges in the steep rock wall by the end of the ridge.
13. UTM: 0464823 – 6831459. 1960 m. Ledge in the rock wall facing 60° NE. UTM coordinates may be inaccurate because of what seems like GPS signal disturbance caused by the rock walls.
11. UTM: 0464749 – 6831345. 1910 m. On the way down and southwards. Moist patches along the steep rock wall facing south. Sprinkling water from above. Same GPS signal problems as on 13.
9. Not found in 1998.
8. UTM: 0464646 – 6831181. 1850 m. Stony ledge just beneath the steep wall. Moist from above. Same signal problems as on 13 and 11.
6. UTM: 0464631 – 6831106. 1790 m. Steep stony slope. Rich and moist. The steep rock wall just above.

Site	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**10**	**11**	**12**	**13**
M a.s.l.	**1510**	**1570**	**1600**	**1650**	**1790**	**1760**	**1850**	**1885**	**1910**	**1950**	**1960**
Beck gla	5	5		5	1	5		5	5	5	5
Luz con	5		1	1		5		1			5
Poa fle	5			5		5		5	5	5	5
Sal her	5	5		5	5	5		1	10	5	
Sil aca	5	5		5		5			5	5	5
Eri uni	5	5				5	1		5	5	
Cer alp					1		5				
Car bel	1	5				1			5	5	5
Sib pro	5	5			5	5			10	5	
Tri spi	5				5	5	1		10	5	5
Fes viv	5	5	5	5	1	10			5	5	1
Rho ros		5	5	5	5		5		5	5	
Sax opp		5		5						5	5
Ant alp	5	5	1	5	5	5	5		5	5	
Bis viv	5	5	5	5	5	5	5		5	5	
Sax cer							5				
Des alp					5		5		5	5	
Cer cer							5		5	5	
Har hyp	5							1			
Min bif				5	1		5		5	5	
Sax ces										5	
Fes ovi	5	5	5	5		5					
Pot cra	5	5		5	5				5		
Emp nig	5	10	10	10		5					
Tarax	1	5			5		5		5	5	
Sau alp	5	5	5	5	5	5	5		5		

Oxy dig	5				5		10		5	5
Luz spi	5	5		5	5	5			5	5
Hie sub	5	5	5	5	5	5			5	5
Ant nip	5	5	1		5				1	
Agr mer	5	5	5	5						
Eup wet		5	5	1					5	
Oma sup	5	5			5		5		5	5
Sax ste	5	5	1	5			5	1		5
Tha alp		5	5	5						
Sol vir	1	5	1						1	
Ver alp		5			5		5		5	1
Jun tri	5	5				5			1	
Ped oed	5	5	5	5	5				5	
Phle alp					5		5		5	
Ara alp					5		5		5	5
Poa alp					5		5		5	1
Poa viv							5		5	5
Bar alp	5	5	5	5	5	5				
Cam rot	5	5	5	5	5	5	5		5	
Ave fle	5	5			5					
Car lac							5		1	1
Car rup				5						
Car vag		1	5	1		5				
Diph alp	5									
Gen niv					5					
Oma nor		5			5		5		5	
Phy cae	5	1	5							
Poa gla			5		5				5	
Pul ver		5	1	5		5				
Ran pyg							1			5
Sal gla	5	1	5	5	5	1			5	
Sal lan		5		1						
Sal phy		1								
Sal ret		5	5	1	5					
Sax riv									5	
Vac myr		5								
Vac vit		5	5	5		5				
Ca atra	1	5	5	5	5				5	
Ver fru					5					
Alc spp.					5		10			
Ant dio			5							
Cry cri									1	
Epi ana							5		5	
Jun com		5	5	10		5				
Kob myo				5						
Poa pra					5					
Pyr min		5								
Rum					5		10			

acsa							
Sil dio					5		5
Vac uli	5	1	5	5			
Epi lac					5		
Arc uva		1		10		1	
Ath dis					1		1

Spiterhøi, 2033 m

05.08

1. UTM: 0468910 – 6831466. 1505 m. Left the path about 1 km from Spiterstulen, up the west slope towards Spiterhøi. Rich, steep slope. Moist with small stones. 300° W.
2. UTM: 0468975 – 6831465. 1555 m. Same slope further up. A small depression in the terrain within site. 340° N.
3. Not found in 1998.
4. Deleted due to uncertain site, in 2014.
5. Deleted due to uncertain site, in 1998.
6. Not found in 1998.
7. Not found in 1998.
8. UTM: 0469246 – 6831588. 1750 m. Steep mountain slope towards south west, just before the boulder field above. Moist. UTM coordinates may be inaccurate due to GPS signal problems.
9. Deleted due to uncertain site, in 1998.
10. Deleted due to uncertain site, in 1998.
11. UTM: 0469566 – 6831056. 1965 m. Various small patches of vegetation in the gentle stony south west slope. Fantastic view!
12. UTM: 0470216 – 6831158. 2033 m. Dry and even top plateau. Some large stones giving shelter.

Site	**1**	**2**	**8**	**11**	**12**
M a.s.l.	**1505**	**1555**	**1750**	**1965**	**2033**
Beck gla	5	1	5	10	5
Luz con	5			10	5
Poa fle			5	5	5
Sal her	5	5	5	5	5
Sil aca	5	5			
Eri uni	5	5	5		
Cer alp	5	5	5		
Tri spi	5	5	10		
Fes viv	5	5	5	5	
Rho ros	5	5	5		
Sax opp	1	5			
Ant alp	5	5	1		
Bis viv	5	5	5		
Des alp			1		
Car big	5				
Cer cer			5		
Fes ovi	10	5			
Pot cra	5	5			
Emp nig	5	1			
Tarax		1	5		

Sau alp	10	10	
Oxy dig	5	5	10
Luz spi	5	5	5
Hie sub	5	5	
Ant nip	5	5	
Agr mer	5	5	
Eup wet	5		
Sax ste		1	
Tha alp	5	5	
Sol vir			1
Ver alp	1		
Ped oed	5	1	1
Ara alp		5	5
Poa alp	1	5	5
Poa viv			5
Bar alp	5		
Cam rot	5	5	
Car lac		5	
Hup sel	5		
Phy cae	5	5	
Poa gla	1	5	
Luz mul	5		
Ran pyg			5
Sal gla	5	5	
Sal lan	5	10	
Sal ret	5		
Sax riv		5	1
Vac vit	5	5	
Ca atra	1		
Jun com	1		
Poa pra		5	5
Vac uli	10	1	

Skauthøi, 1993 m
06.08

1. UTM: 0470428 – 6834174. 1545 m. The first plateau from the northeast ascent. Stony plain with rocks and lots of mosses and lichens. 2 ° slope, 30° NE.
2. UTM: 0470376 – 6834008. 1565 m. Plain ridge in the north slope. Even terrain with lichens and medium large stones.
3. UTM: 0470412 – 6833614. 1690 m. Dry slope with rocks and medium large stones. 340° N.
4. Deleted due to uncertain site, in 1998.
5. Not found in 1998.
6. UTM: 0470195 – 6833256. 1745 m. Small barren ridge with bryophytes surrounded by a boulder field of medium large stones. 320° NW.
10. UTM: 0470267 – 6833187. 1795 m. Small patches of vegetation in the even boulder field. Bryophytes, gravel and stones. 340° N.
13. UTM: 0470438 – 6832952. 1895 m. Black, stony plain in the northwest facing slope, covered by lichens.
15. UTM: 0470504 – 6832861. 1920 m. Even plain with small and medium large stones. Easy to walk on. 340° N.

18. UTM: 0470561 – 6832508. 1980 m. In the west slope. Small patches of vegetation.
19. UTM: 0470668 – 6832524. 1992 m. Even stony plateau. Some rocks and large stones.
17. UTM: 0470606 – 6832439. 1965 m. Downwards, dry south slope just beneath the summit.
16. UTM: 0470526 – 6832373. 1930 m. Uneven slope with large and medium stones, some patches with bryophytes. 200° S.
14. UTM: 0470322 – 6832399. 1905 m. Steep part of the southwest slope down from the summit. Dry.
12. UTM: 0470268 – 6832335. 1880 m. Same slope as 14, further towards southwest. Boulder field. 210° SW.
11. UTM: 0470151 – 6832337. 1850 m. Same aspect as 12, but further to the southwest. Slope in a rugged terrain.
9. UTM: 0469807 – 6832395. 1760 m. Along the only coarse of a brook observed. 240° SW.
8. UTM: 0469798 – 6832455. 1770 m. Blocks, clefts and ledges. North of the cleft where the glacier might have ended in 1931. 340° N.
7. Deleted due to uncertain site, in 1998.

Site	**1**	**2**	**3**	**6**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
M a.s.l.	**1545**	**1565**	**1690**	**1745**	**1770**	**1760**	**1795**	**1850**	**1880**	**1895**	**1905**	**1920**	**1930**	**1965**	**1980**	**1992**
Beck gla		5	5	5	1	5	1	5	5	10	5	10	5		5	10
Luz con	5	1	10	10	10	5	10	10	10	10	10	5	10	10	5	5
Poa fle			5	5	5	5	1	10	5	5	5	5	5	5	5	1
Sal her	10	10	10	10	5	5	10	10	10	5	10		10	10		5
Sil aca	5	5														
Car bel					5	1	5	5	5		1		5			
Fes viv	10	5	5					5								
Rho ros	5															
Sax opp	1															1
Ant alp	5	5	5						5							
Bis viv	5	5														
Car big	10	5	10					5								
Har hyp	5	5			5											
Min bif	5	5														
Fes ovi	10	5						5								
Pot cra	1															
Emp nig	5	5	5		1											
Sau alp	5	5							5							
Luz spi	5	5														
Hie sub	5	5														
Agr mer	5															
Eup wet	1															
Tha alp	5															
Jun tri	5	5														
Ped lap		5														
Ped oed	5	1														
Cam rot	5	5														
Car lac	5															
Car rup		5														
Car vag	5															
Dry oct		5														
Gen niv	5															
Hup sel	5		5								5					
Phy cae	5		5				5		1		5				1	

Loi pro	5	5	1		
Sal gla	1				1
Vac vit	5	5			
Arc alp	1	5			
Bet nan	5	5			
Tof pus	5				
Vac uli	5	5			
Sed vil			5		
Car arc		1			

Hellstuguhøi, 2072 m

07.08

1. UTM: 0468727 – 6827789. 1500 m. Leave the path by the bridge crossing Heillstuguåi, crossing the west facing slope up towards 1500 m. Steep, uneven slope. Boulder fields, large stones scattered. Green patches in between. Moist. Soaks and small courses of brooks. Bare rocks. 320° NW.
2. UTM: 0468846 – 6827617. 1610 m. Continue up towards a mountain outcrop, same aspect as 1. Bare rocks, crevices and ledges covered by bryophytes and lichens. Gravel on the ground.
3. UTM: 0468944 – 6827453. 1695 m. Up and southwards. Steep boulder field with green, stony slopes in between. Lichens and bryophytes. 300° W.
4. UTM: 0469103 – 6827369. 1850 m. Steep rock face on the top of a pass, moist ledges and crevices. Block field and loose gravel beneath. 270° W.
5. UTM: 0469130 – 6827280. 1920 m. Up above the rocks to a huge boulder field of large stones. Huge boulder field above site. 310° W.
6. UTM: 0469169 – 6827215. 1930 m. Moist rock cleft at the transition to the more gentle part of the mountain. 280° W. UTM coordinates can be inaccurate because of GPS signal problems.
7. UTM: 0469199 – 6827075. 1995 m. Gentle plain. Small stones, lichens and bryophytes. 345° N.
8. UTM: 0469237 – 6826908. 2050 m. Gentle plain. Gravel and lichens in between numerous small stones. Small patches of vegetation. 320° NW.
9. UTM: 0469470 – 6826926. 2070 m. Even and stony top plateau. *Ranunculus glacialis* and *Luzula confusa* evenly scattered.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
M a.s.l.	**1500**	**1610**	**1695**	**1850**	**1920**	**1930**	**1995**	**2050**	**2070**
Beck gla	5		5	5	5	5	10	10	10
Luz con	5		5	5	10	5	10	5	5
Poa fle		5	5	5	10	5	5	5	5
Sal her	10	10	10	5	5	5	5		
Sil aca	5	5	1	5					
Eri uni	5	5	5	5					
Cer alp		5	5	5	5				
Car bel	1		5	5	5	1			
Sib pro	5								
Tri spi	5	5	5	5	5		5		5
Fes viv	5	10	10	10	5	5	5	1	5
Rho ros	5	5	5	10					
Sax opp	5	5	5	5					
Ant alp	5	5	5	5	5				
Bis viv	5	5	5	5					

Sax cer			5						
Des alp	5				5				
Car big	5								
Cer cer			1	1					
Har hyp	5								
Min bif			1	5					
Sax ces			5	5	5				
Fes ovi	5	1			1				
Pot cra	5	5	5	5					
Emp nig	1	5	1						
Tarax	5	5	5						
Sau alp	5	5	5	5	1				
Oxy dig	5	5	5	5					
Luz spi	5	5	5	5	5				5
Hie sub	5	5	1						
Ant nip	5	5							
Agr mer	5		1						
Eup wet	5								
Oma sup	5	5							
Sax ste	1								
Tha alp	5	5							
Ver alp	5	1							
Jun tri	5								
Ped lap	5								
Ped oed	5	5	5	5					
Ara alp			5						
Poa alp		5							
Bar alp	5								
Cam rot	5	5		1					
Ave fle	5								
Car lac	5		5						
Car vag	5								
Hup sel	1								
Phy cae	5								
Luz mul	1								
Ran pyg			5						
Sal gla	1	5	5	5					
Sal lan	5	5	5						
Sal lap			1						
Sal ret		5	5						
Sax riv			5		10	5			
Vac myr	5								
Vac vit	5	5							
Ca atra	5								
Pyr min	1								
Vac uli		1							

Glittertinden, 2472 m

09.08

1. UTM: 0472529 – 6834134. 1500 m. Gentle, green plain with small brooks crossing. Some large and medium large stones around. Alternating between dry and moist. 260° W.
2. UTM: 0472817 – 6834621. 1585 m. Concave terrain close to the path. Dry and stony, but also moist patches. 280° W.
3. UTM: 0472997 – 6834687. 1605 m. The south slope in the same terrain. Rocks and stones close to the path. Alternating dry and moist. 250° SW.
4. UTM: 0474003 – 6834963. 1735 m. In the beginning of the steep boulder field. Stones in all sizes. Rocks. Patches of vegetation. Dry. 280° W.
5. UTM: 0474077 – 6834993. 1765 m. 3 m south of the path. Ledge and sheltered corner between rocks and stones.
7. UTM: 0474124 – 6835049. 1790 m. 5 m north of the path. Ledge beneath a steep rock wall. Just above the boulder field. 280° W.
8. UTM: 0474184 – 6835085. 1830 m. 2 m north of the path. Rocks. Dry ledge facing west.
11. UTM: 0474242 – 6835051. 1875 m. Dry ledge. Same aspect as 8.
14. UTM: 0474413 – 6835079. 1965 m. Reaching the plateau. The terrain becomes gentler and less stony. Snow-bed in the boulder field. Several small patches of vegetation.
16. UTM: 0474519 – 6835124. 2015 m. Follow the ridge. Snow-bed close to the path.
17. Not found in 1998.
20. UTM: 0474811 – 6835138. 2110 m. Follow the path. Snow-bed just south of boulder field.
19. UTM: 0474655 – 6835517. 2095 m. Cross the remnants (melting away) of field of permanent snow northwestwards towards Glitteroksli. Snow-bed north of the snowfield. 240° SW.
18. UTM: 0474507 – 6835487. 2050 m. On the way down. Towards the southern slope of Glitteroksli. Patches of vegetation.
15. UTM: 0474369 – 6835402. 2000 m. Further down towards the pass between Glitteroksli and Glittertind. Gentle stony slope.
13. Not found in 1998.
12. Deleted due to uncertain site, in 2014.
10. UTM: 0474102 – 6835268. 1880 m. Steep south facing slope on the way down the southern slope of Glitteroksli.
9. UTM: 0474060 – 6835223. 1840 m. Further down the same slope as 10.
6. UTM: 0473723 – 6835096. 1745 m. Further down, in the last rock cleft before the path to Spiterstulen. Moist.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**14**	**15**	**16**	**18**	**19**	**20**
M a.s.l.	1500	1585	1605	1735	1765	1745	1790	1830	1840	1880	1875	1965	2000	2015	2050	2095	2110
Beck gla	5	5	5	5	5	5	5	5	1	5	5	5	5	5	10	5	5
Luz con			1			1					5	5	5		5		
Poa fle				1	5	1	5	1		5	5	5	5	5	10	5	
Sal her	10	10	10	10	10	5	10	10	10	5	5	10	10	10	5		
Sil aca	5	5	10	5	5	5	5	5	5	10	1						
Eri uni		5	5	1	5	5			5	5							
Cer alp				5	5			5		5	5						
Car bel				1			5	5			5	5					
Sib pro	5	5	5						5				5				
Tri spi		5	5		5		5	1	5	5	1	5	5		5		
Fes viv		5		5	5	5	10	10	1	10	5	5	5				
Rho ros	5	5	5	5		5			5	5							
Sax opp								5		5	5	5					
Ant alp	5	5	5	5	5	5	5		5	5	5		5				
Bis viv	5	5	5	5	5	5	5	5	5	5							
Des alp		5							5								
Car big	5	5	5						5								

Cer cer									1						
Har hyp	5	5	5						5			5	1		
Min bif				5	5	5	5			5	1				
Sax ces								5							
Fes ovi	5	5	5	5	5	5	1		5	5					
Pot cra	1	5	5	5	5	5			5						
Emp nig	5	10	5	1					1			1			
Tarax		5	5		1	5	1		5				5		
Sau alp		5	5	5	5	10	10	5	5	10					
Oxy dig	5		5			5	5	5	5	5					
Luz spi	5	5	5	5	5	5	5	5	5	5	5		5		
Hie sub	5	1	5	5	5	5	1			5					
Ant nip	5	5	5	5	10	5			10	5					
Agr mer	5	5	5	1		5			5						
Eup wet		5	5	5		5			5	5					
Oma sup		5	5		1	5	1		5				5		5
Sax ste	5	1													
Tha alp		5	5			5			5	5					
Sol vir	1			5		5							1		
Ver alp						5			5				5		
Jun tri	5	5	10	5	5	5			5						
Ped oed		5		5		5			5	5					
Phle alp									5						
Poa alp		1			1				5	5					
Bar alp	5	5		5	5	5			5	5					
Cam rot	5	5	5	5	5	10			5	5					
Ave fle	5		5	5		5			5						
Car lac	5	5							5	5			5		
Car rup				5		5		5		5					
Car vag	1		5	5		5				1					
Gen niv						5			5						
Oma nor						5			1						
Hup sel	5	1	5	5			5					5			
Phy cae	5	5	1	5	1	5						1			
Jun big		5													
Poa gla				5						5					
Leo aut		5													
Pul ver		5		5	1										
Loi pro	5	5	1												
Luz mul	5						1								
Ran pyg							5		5						
Sal gla	5			5		5				1					
Sal lap	5														
Sal ret	1					1			1	1					
Sax riv							5								
Vac myr	5														
Vac vit	5	5	5	5	5										
Ca atra	1	5	5	5		5			5	5					

Car sax	5	5												
Alc spp.						5								
Ant dio	5	5		5										
Arc alp		1												
Bet nan	10	5	5											
Bet pub				1										
Ger syl						10								
Jun com	1	1	1											
Poa pra									5					
Vac uli	1	5		5										
Sel sel		5				1								
Arc uva				5						1				
Sax ten														5
Lyc ann		1												

Surtningstinden, 1997 m

11.08

1. UTM: 0456330 – 6821490. 1500 m. Just above a boulder field which starts at about 1300 m. Rich green ground, 30° slopes, with some medium large stones and bare rocks. Wet soaks from the mountain behind. 180° S.
2. UTM: 0456397 – 6821558. 1535 m. Uphill and a bit eastwards. Rich 35° slopes, with a few large stones on the ground. Wet soaks from rock faces above. 160° S.
3. UTM: 0456348 – 6821601. 1580 m. Further up in the same slope. More small and medium stones, still moist from wet slope of bare rock above.
4. Deleted due to uncertain site, in 2014.
5. UTM: 0456165 – 6821727. 1740 m. Up and westwards from 4. Rich ledge beyond a rock face. Moist. 180° S.
6. UTM: 0456014 – 6821780. 1770 m. Further west from 5. Rich spots in the boulder field. Bare rock above. 180° S.
7. UTM: 0455779 – 6821870. 1845 m. The last piece of vegetation before only bare rocks are visible. Steep crevice and ledges in the rock. Moist. 160° S.
8. UTM: 0455779 – 6821886. 1870 m. Small plateau, snow-bed, just before ascent to the highest ridge. 160 °S. UTM-coordinates may be inaccurate because of GPS signal problems.
9. Not found in 1998.

Site	**1**	**2**	**3**	**5**	**6**	**7**	**8**
M a.s.l.	**1500**	**1535**	**1580**	**1740**	**1770**	**1845**	**1870**
Beck gla	5	1	5	5	5	5	5
Luz con			5	5		5	5
Poa fle				5	5	5	5
Sal her	5	5	5	10	10	10	10
Sil aca	5				5		
Eri uni				5			
Car bel			1	1		5	
Sib pro	5	5	5	5	10	5	5
Tri spi							5
Fes viv	5	5	5	5	5	10	5
Rho ros	5	5	5	5	5		

Ant alp				1	5	5	1
Bis viv	1		5	5	5		1
Des alp	5	1		5	5	5	10
Car big		5	5				
Har hyp	5	5	1	1			5
Fes ovi	1						
Emp nig	5	10	5	1			
Tarax	5			5	5		
Sau alp	5	5	10	10	5		5
Oxy dig	5			5	5		
Luz spi			5	5	5	5	5
Hie sub	5	5	5	1	5		
Ant nip	10	5	10	10	5		5
Agr mer	5	5		5	5		5
Eup wet	5	5	5				
Oma sup	5	5	5	5	5	1	10
Sax ste		5	1	5	5	1	
Sol vir	10	10	10	5	5	5	5
Ver alp	5	5	5	5	5		5
Jun tri	5	5	5			5	
Ped lap		1	5				
Ped oed	5			5			
Phle alp			5	5	5		
Alch alp	5	5	5	1			
Poa alp				1	5		
Poa viv					5	1	5
Bar alp	5	5	5	5	5		
Cam rot	5	5	5				
Ave fle	10	10	10	1	5		5
Car lac				5	5		
Car vag	5		5				
Diph alp	5	5	5				1
Oma nor	5	5	5	5	5		
Hup sel			5	5			
Phy cae	5	5	5	5			
Jun big				5			
Leo aut	5	5			1		
Luz mul		5					
Ran pyg				1			
Sal gla	5						
Sal lan	5						
Sal lap	1						
Vac myr	10	5	5				
Vac vit		5	5				
Ca atra	5			5	5		
Vio pal	5	5	5				
Nar str	5	10	5				
Car sax	5	5					5

Ant dio	5	5			5
Cry cri					5
Epi ana				5	
Ger syl	5	5			
Jun com	1	1	5		
Pin vul	5	5			
Pyr min	5		5		
Rum acsa	5	5	5		1
Vac uli	5	5	5		
Sel sel	5				
Epi lac	5				5
Ath dis	5		1		5
Cir het		5	5		
Coe vir	1				
Tri ces		1			
Agr cap		5	10		
Des ces			5		

Kyrkja, 2032 m

12.08

1. UTM: 0460821 – 6822475. 1520 m. The ridge between Leirvatn and Høgvagltjern. Gentle stony plain with both dry and moist patches. Marked path crosses straight through the site.
2. UTM: 0461259 – 6822362. 1570 m. Gentle, rugged slope with bare rocks and large stones. Course of a brook, but only some trickling water observed. 200° S.
3. UTM: 0461480 – 6822334. 1630 m. Steep slope with large stones and bare rocks. Look straight down at Høgvagltjern. Both dry and moist spots. 220° SW.
4. UTM: 0461580 – 6822404. 1690 m. Swampy, gentle slope with *Sphagnum.* Bare rocks and large stones. Drier spots in between. 210° SW.
5. UTM: 0462222 – 6822435. 1810 m. Plateau south of Kyrkja, close to the hill "1843". Flat and dry.
6. UTM: 0462400 – 6822974. 1790 m. In the southeast ascent of Kyrkja, straight east from the path. First green spot in the steep mountain side. Stony, bare rocks and gravel. 140° SE.
7. UTM: 0462374 – 6823056. 1850 m. Same aspect. Steep stony slope with bare rocks. Dry and moist vegetation covered patches. Bryophytes in between.
8. UTM: 0462370 – 6823100. 1880 m. Same exposition. Steep, huge boulder-field with more stones than in 7. Bare rock-faces and scattered patches of vegetation in between.
9. UTM: 0462355 – 6823138. 1915 m. Slope in the same exposition as 8. Ledge prior to the south-facing edge. Dry and stony. 140° SE.
10. UTM: 0462330 – 6823252. 1990 m. Crossed the south edge and then uphill. Steep stony slope. Ledges in the rock. Moist. 230° SW. UTM-coordinates may be inaccurate due to GPS signal problems.
11. UTM: 0462340 – 6823329. 2005 m. Same exposition. Clefts and ledges. Moist. Same signal problems as on 10.
12. UTM: 0462360 – 6823294. 2020 m. Moist mountain cleft facing 220° SSW.
13. UTM: 0462376 – 6823296. 2032 m. Summit. Stony and rocky. Small plateau with gravel on the ground, frequently trampled by tourists.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
M a.s.l.	**1520**	**1570**	**1630**	**1690**	**1810**	**1790**	**1850**	**1880**	**1915**	**1990**	**2005**	**2020**	**2032**
Beck gla	5	5	1	5	5	5	5		1	5	5	5	
Luz con	5	5	5	5	10				5				

Poa fle	5	1		5	5	5		5	5	5	5	5	5
Sal her	10	10	10	10	10	10	10	10	10	5	5		
Sil aca			1	5			5	5		5		1	
Eri uni				1		5	5	5	1	5	5		
Cer alp						1		5	5	5	5	10	5
Car bel	5				5								
Sib pro	5	5	5	5		5	5	5	5		5		
Tri spi			1	5		10	10	5	5	5	5	5	5
Fes viv			5	5	1	5	5	5	5	5	1		1
Rho ros		5	5	5		10	10	10	5	10	5		
Sax opp								5	5	5	5	5	5
Ant alp		5	5	5		5	5	5		5			
Bis viv	1	5	5	5		5	5	5					
Sax cer										5	5		
Des alp	5	5	5	5			5						
Car big	5	5	5	5									
Cer cer				1		1							
Har hyp	5			1									
Min bif										5			
Sax ces										5	5	5	5
Fes ovi			1										
Pot cra								5		5			
Emp nig	1	1											
Tarax		5	5	5		5	5	5					
Sau alp		5	5	5		5	5	5		5	5		
Oxy dig		5	5			5	5			5	5	5	1
Luz spi			1	5		1	5			5	5		
Hie sub		5	5			5	1	5					
Ant nip		5	10			5							
Agr mer	5	5	5	5									
Eup wet			5					1					
Oma sup	5	5	5	5		5	5	5	5				
Sax ste	5		5										
Tha alp			5										
Sol vir		5	5				1						
Ver alp		5	5	5		5	5	5					
Jun tri		5	5	5									
Ped lap		5											
Ped oed		5					1						
Phle alp			5										
Poa alp		5				5	5	5					
Poa viv	5	5		5		5	5	5		5	5	5	5
Bar alp		5	5			5	5	5					
Cam rot			5			1		5					
Ave fle		5	10	5			5						
Car lac	5	5		5		5							
Car vag			5										
Diph alp			5	5									

Oma nor		5	5			5							
Hup sel												5	
Phy cae	1	5	5		1								
Jun big				5									
Poa gla										5			
Sal gla		1	5										
Sax riv												5	5
Vac myr			5										
Vac vit			5	5									
Ca atra			5					5					
Car sax	5												
Vahl atr		10		5									
Dra fla											5		
Epi ana		5											
Ger syl			5										
Poa pra	5												
Pyr min			1										
Rum acsa			5										
Vac uli			1										
Ath dis		5											
Gym dry						1							

Tverbotnhorn, 2084 m

14.08

1. UTM: 0460002 – 6824391. 1415 m. The terrain just north of Leirvassbu, before the hills further northwest. Stony, gently plains, slightly falling , 160° S. Moist.
2. UTM: 0460007 – 6825273. 1475 m. In the lee-side southeast to the hills called “Presten” (map). Grass slopes with many large stones. Alternating dry and wet (snow-beds). 170° S.
3. UTM: 0460432 – 6825211. 1555 m. At the start of the ascent to the mountain, greenest parts of the south-facing slopes. Bare rocks and small stones. Dry. The exposition is directly towards Leirvassbu, 200° S.
4. UTM: 0460532 – 6825250. 1610 m. Same aspect as 3, but further east. Rich green slope with wet soaks and stones in between. Concave terrain.
5. UTM: 0460556 – 6825305. 1660 m. Uphill in the same slope as 5. Large stones and water from a mountain outcrop. UTM-coordinates may be inaccurate due to GPS signal problems.
6. UTM: 0460722 – 6825301. 1705 m. Uphill and eastwards across a small pass. Drier, but still moist. Bryophytes and lichens on the ground, medium large stones and bare rocks. 190° S. Same GPS signal problems as on 5 (steep mountain slopes/precipices).
7. UTM: 0460832 – 6825366. 1785 m. Steep cleft with both wet and dry patches. Stony ground. 180° S.
8. UTM: 0460853 – 6825423. 1830 m. Broad ledge by the foot of a slope of bare rock. Moist and stony. 200° S. Same signal problems as on 5 and 6.
9. UTM: 0460792 – 6825512. 1890 m. Sheltered ledge. Dry. Bare rocks and many small and medium stones. 190° S.
10. UTM: 0460656 – 6825608. 1905 m. Large, broad cleft in the mountain. Moist. Bare rocks and small stones on the ground. 180° S.
11. UTM: 0460694 – 6825643. 1950 m. Same cleft as 10. Ledges in the rock. Moist.
12. Not found in 2014.
13. Not found in 2014.
14. Not found in 2014.
15. UTM: 0461074 – 6825671. 2050 m. Downhill, south of the summit. First patch of vegetation found. Snow-bed beyond the field of permanent snow that was once covering the summit.

Site	1	2	3	4	5	6	7	8	9	10	11	15
M a.s.l.	**1415**	**1475**	**1555**	**1610**	**1660**	**1705**	**1785**	**1830**	**1890**	**1905**	**1950**	**2050**
Beck gla		5					5	5	5	5	5	5
Luz con												5
Poa fle					1		5	5	5	5	5	10
Sal her	10	5		5	5	5	10	10	10	5	10	10
Sil aca	5	5	1			5	5		5	1		
Eri uni							5	5	5	5		
Cer alp									5		5	
Car bel								5				
Sib pro	5	5		5	5	1	5	5	5	5	5	5
Tri spi		1			1		5	5	5	5	5	
Fes viv	1	5		1	5	5	5	5	5	1	5	10
Rho ros	5	5	5	5	5	5	5	5	5	5	5	
Ant alp		5				5	5	5	5	5	5	
Bis viv	5	5	5	5	5	5	5	5	5	5	5	
Sax cer										1		
Des alp	5	5		10	10		10	10		10	5	5
Car big	5	5	5	5	5							
Cer cer				1	5		5	5			5	
Har hyp	5	5										
Min bif				5	5		5	1	5	5		
Fes ovi		5	5	1	5	5						
Pot cra		5	5		5	1	5					
Emp nig	10	5	5									
Tarax	5	5	5	5	5		5	5	5	5	5	
Sau alp		5	5	5	5	5	5	5	5	5	5	
Oxy dig	5	5		5	5		5	5	5	5	5	
Luz spi	5	5	5	5	5	5	5	5	5	5	1	1
Hie sub	5	5	5			5	1	5	5			
Ant nip	5	5	10	10		5	5	5				
Agr mer	5	5	5	5	5	5	5	5			5	
Eup wet	5	5	5	5	5	5						
Oma sup	5	5	1	5	5	1	5	5	5	5	5	1
Sax ste	5	1	5	5	5		5	5		5	5	
Tha alp		5	5		5	1						
Ver alp	5	5	5	5	5	1	5	5	5	5	5	
Jun tri	5	5	5		5	5						
Ped oed		5	5			5	5	1	5			
Phle alp		5		10	10		5					
Poa alp		5			1			1	5			
Poa viv					5		5	5	5	5	5	5
Bar alp	5	5	5	5	5	1	5					
Cam rot		5	5	5	5	5	5		5			
Ave fle	5	5	5	5	5	5	5					
Car lac	5				5		1	5		5	5	1
Car vag		5				5						

Diph alp		5										
Eri ang	5											
Gen niv		5		5			5					
Hie hie						1						
Oma nor		1		5	5		5	5		1	1	
Hup sel	5	5					1	5				
Phy cae	5	5	5									
Jun big					1							
Leo aut	10	10										
Pul ver			5			5	5		1			
Loi pro	5											
Luz mul		1	5		5							
Ran acr		5	5	5	5							
Poa arc											5	
Ran pyg		1								5		
Sal gla		1	5	1	5	5	5	1				
Sal lan			10	5	5		1			1		
Sal lap	5											
Sal ret			5	5			5					
Sax riv										1	1	
Vac myr	5	5	5			5						
Vac vit	1		5			5						
Ca atra			1		5							
Nar str	1	5										
Car sax	5	5										
Vahl atr	10	10										
Alc spp.		5	5	10	10		5					
Ant dio			5			5						
Epi ana	5	5		5	5		5	5		5	1	
Eri sch	5											5
Ger syl			5	10	5							
Jun com						5						
Vis alp			5		5		1	5		1		
Pin vul			5									
Poa pra				5	5							
Pyr min		5										
Rum acsa		5	1	5	5							
Sil dio				5								
Tof pus			5									
Vac uli		5	5									
Sel sel		5	5			1						
Epi lac				5								
Ath dis		5		1	1	1						
Coe vir			5									
Equ arv	5											

Steindalsnosi, 1936 m

15.08

1. UTM: 0439214 – 6820493. 1435 m. In the upper part of the plateau just before the ascent to Steindalsnosi. Rich slopes surrounded by boulder field. Dry, 190° S.
2. UTM: 0439248 – 6820573. 1475 m. Next plateau. Stony ground with bare rocks. Moist and dry areas. 220° SW.
3. UTM: 0439685 – 6820695. 1645 m. Getting steeper. Green spot or ledge in the boulder field of small and medium large stones. UTM-coordinates may be inaccurate due to GPS signal problems.
4. UTM: 0439666 – 6820857. 1700 m. Sheltered plateau/corner. Mountain outcrops, medium large stones, snow-bed. 220° SW.
5. UTM: 0439706 – 6820889. 1735 m. The only spot of vegetation visible in the huge boulder field. 210°SW.
6. UTM: 0439755 – 6820918. 1775 m. Rock crevice and ledges. 170° S.
7. UTM: 0439833 – 6820961. 1845 m. Gentle stony slopes in the boulder field. Patches of mosses, gravel. 210° SW.
8. Deleted due to uncertain site, in 2014.
9. UTM: 0440213 – 6821255. 1936 m. Flat, stony top plateau.

Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**
M a.s.l.	**1435**	**1475**	**1645**	**1700**	**1735**	**1775**	**1845**	**1936**
Beck gla		5	5	5	5	5	5	5
Luz con		5		5	5	5	5	
Poa fle		5	5	5	5	5	5	5
Sal her	5	5	10	10	10	5	10	1
Sil aca		5						
Eri uni						1		
Car bel			5	5		5		
Sib pro	5	5	5	5		5	5	
Tri spi			5	5	5	5		
Fes viv	5	5	5	5	5	5	10	5
Rho ros	5		5					
Ant alp	5			5	1	5		
Bis viv	5	5	5					
Des alp			5	5		5	5	
Car big	5	5						
Cer cer						5		
Har hyp		5			1			
Emp nig	5	5						
Tarax	5		1			5		
Sau alp			5			5		
Oxy dig			5					
Luz spi	5	5	5	5		1		5
Hie sub	5	5		1				
Ant nip	5	5	5					
Agr mer	5	5	5					
Eup wet	5							
Oma sup	5	5	10	5		5		
Sax ste	1		5					
Sol vir	5		5					
Ver alp			5			5		
Jun tri	5	10		5				
Ped lap	5							

Ped oed	5					
Alch alp	5					
Poa viv			5			5
Bar alp	1					
Cam rot	5	1			1	
Ave fle	10	5	1			
Car lac		5	1			5
Diph alp		5				
Oma nor	5		5			
Hup sel		5				
Phy cae	5	5		1		
Poa gla				1		
Leo aut	5					
Loi pro		5				
Luz mul	5					
Ran pyg						5
Sal gla	1					1
Sal lap	5					
Sax riv						5
Vac myr	10	5				
Vac vit		5				
Vio pal	5					
Nar str	5					
Vahl atr		5	5			
Bet pub	1	1				
Cry cri			5			
Epi ana			5			
Ger syl	5					
Jun com	5					
Vis alp	1	1				
Pyr min	5					
Rum acsa	5					
Vac uli	5	5				
Ath dis	5		5			
Car bru		1				

Fannaråki, 2068 m

16.08

1. UTM: 0442220 – 6819851. 1485 m. Left the path Turtagrø- Skogadalsbøen prior to Illvatnet. Rich slope just above the mid-point of the water. Small and medium large stones, trickling water from the rocks above. 180° S.
2. UTM: 0442341 – 6819918. 1535 m. Same aspect but further to the east. Concave terrain with large stones, drier than 1. UTM-coordinates may be inaccurate because of GPS signal problems.
3. UTM: 0442450 – 6820099. 1680 m. Further to the east. Stony and rocky. Moist. 180° S.
4. UTM: 0442149 – 6820219. 1765 m. Further to the west, same aspect as 3, but somewhat steeper. Bare rocks and stones. Moist. 180° S.
5. UTM: 0441848 – 6820222. 1830 m. Westwards and towards the summit. Just above the outlet of Illvatnet. Before a mountain outcrop facing south. Ledges in the rocks, moist site. GPS signal problems as on 2.
6. UTM: 0441869 – 6820295. 1895 m. In the upper part of the bare rocks, just in front of the large boulder field towards the summit. Small mountain clefts, stony. 140° SE.
7. Not found in 1998.
8. Not found in 1998.
9. UTM: 0441645 – 6820458. 1995 m. Terrain is gentler. Snow-bed facing southwest, surrounded by the large boulder field covering the summit. Just east of path.
10. UTM: 0441836 – 6820772. 2050 m. New site. Stony plain north and west of DNT's Fannaråkhytta. No vascular plants found.

Site	1	2	3	4	5	6	9	10
M a.s.l.	**1485**	**1535**	**1680**	**1765**	**1830**	**1895**	**1995**	**2050**
Beck gla			5	1	5	5	5	
Luz con				5	5	5		
Poa fle			5	5	5	5	5	
Sal her	5	5	10	10	5	10	5	
Eri uni		1						
Cer alp					5			
Car bel			5		5			
Sib pro	5	5	5	5	5	5		
Fes viv		5	5	5	5	5	5	
Rho ros	5	5			5	1		
Ant alp					5			
Bis viv	5	5	5	5	5			
Des alp	5	5	5	5	5	5	5	
Car big	5	5	5	10	5			
Cer cer				5	5	5		
Har hyp			1					
Emp nig			5					
Tarax	5	5			5			
Sau alp	5				5			
Oxy dig	5	5				5		
Luz spi	1	5	5	5	5	5	5	
Hie sub	1	1	5	1				
Ant nip	5	10	1	1				
Agr mer	1	5						
Eup wet	5	5						
Oma sup	5	5	5	5	5	5		
Sax ste	5		5	5	5			
Sol vir	5							

Ver alp	1	5			5	1	
Phle alp	1	5					
Poa alp		5					
Poa viv	1			5	5	5	5
Bar alp	5	1					
Cam rot	5	5					
Ave fle	5	5	5				
Car lac	5	5	5	5	5	5	
Oma nor	5	5		5			
Hup sel			5				
Leo aut	5						
Luz mul	1						
Ran acr	5	5					
Ran pyg					5		
Sal gla	5	5			1		
Sal lan	5	1					
Sax riv					5	5	
Vac myr	5						
Vio pal	5	5					
Alc spp.	5	5					
Epi ana	5	5			5		
Eri sch				5			
Ger syl	5	5					
Jun com	1						
Pyr min	5						
Rum acsa	5	5					
Vac uli	5						
Epi lac		5					
Ath dis	5	5					
Cal pur	5	5					
Cir het	5	5					
Cha ang	5	5					
Myu dec		1					
Phe con		5					

Appendix 2

This is a continuation of Appendix 2 from Klanderud (2000). It contains species names, total number of observations per species in 1930/31, 1998 and 2014, and the difference in number of observations between 1998 and 2014. It also shows each species' highest altitude observation in 1998 and 2014, and compares with the Norwegian altitudinal limits in Lid & Lid (2005). Where new altitudinal limits have been registered in 2014, altitude is written in bold numbers, and the site is mentioned.

Species names		Total number of observations				Highest observations (m)		Altitudinal limit (m) (Lid and Lid, 2005)	Site of new altitudinal limit
		1930-1931	1998	2014	Diff 1998-2014	1998	2014		
Agr cap	*Agrostis capillaris*	0	0	3	3	-	***1580***	1340	Surtningstinden (3)
Agr mer	*Agrostis mertensii*	2	27	87	60	*1840*	***1950***	1600	Tverbotnhorn (11)
Alc alp	*Alchemilla alpina*	5	13	14	1	*1610*	*1740*	1760	
Alc spp	*Alchemilla* spp.	21	23	24	1	*1790*	*1880*	-	
Ang arc	*Angelica Archangelica*	3	3	2	-1	*1560*	*1515*	1600	
Ant alp	*Antennaria alpina*	110	121	138	17	*2050*	*2130*	2240	
Ant dio	*Antennaria dioica*	14	25	20	-5	*1770*	*1770*	2000	
Ant nip	*Anthoxanthum nipponicum*	67	77	93	16	*1880*	*1930*	2130	
Ara alp	*Arabis alpina*	9	11	8	-3	*1950*	*1950*	1980	
Ara pet	*Arabidopsis petraea*	1	0	1	1	-	*1590*	1730	
Arc alp	*Arctous alpinus*	11	11	7	-4	*1790*	***1670***	1620	Surtingssue/Rau (4)
Arc uva	*Arctostaphylos uva ursi*	18	16	11	-5	*1850*	***1880***	1840	Glittertinden (10)
Asp vir	*Asplenium viride*	0	1	0	-1	*1560*	-	1700	
Ast alp	*Astragalus alpinus*	2	5	3	-2	*1700*	*1620*	1775	
Ath dis	*Athyrium distentifolium*	3	13	19	6	*1790*	*1850*	1870	
Ave fle	*Avenella flexuosa*	27	48	57	9	*1950*	*1880*	1900	
Bar alp	*Bartsia alpina*	40	53	65	12	*1915*	*1880*	1960	
Beck gla	*Beckwithia glacialis*	204	208	204	-4	*2185*	*2185*	2370	
Bet nan	*Betula nana*	5	8	10	2	*1745*	***1605***	1570	Glittertinden (3)
Bet pub	*Betula pubescens*	0	1	8	7	*1540*	***1740***	1580	Sikkildalshøa (8)
Bis viv	*Bistorta vivipara*	108	126	133	7	*2010*	*1995*	2280	
Bot bor	*Botrychium boreale*	0	1	1	0	*1525*	*1500*	1690	
Bot lun	*Botrychium lunaria*	0	1	2	1	*1650*	***1750***	1650	Surtingssui/Rau (7)
Cal pur	*Calamagrostis purpurea*	2	1	2	1	*1485*	***1535***	1430	Fanaråken (2)
Cam rot	*Campanula rotundifolia*	59	56	87	31	*2050*	*1950*	2060	
Car bel	*Cardamine bellidifolia*	71	87	102	15	*2050*	*2130*	2200	
Car arc	*Carex arctogena*	0	2	3	1	*1730*	***1750***	1720	Rasletinden/Rau (9)
Ca atra	*Carex atrata*	25	26	42	16	*1910*	*1910*	1920	
Ca atro	*Carex atrofusca*	3	2	0	-2	*1560*	-	1880	
Car big	*Carex bigelowii*	65	89	88	-1	*1880*	*1910*	1950	
Car bru	*Carex brunnescens*	0	0	1	1	-	*1475*	1550	
Car cap	*Carex capillaris*	0	1	2	1	*1560*	***1670***	1570	Surtingssui/Rau (4)
Car dio	*Carex dioica*	0	2	0	-2	*1560*	-	1500	

Car lac	*Carex lachenalii*	47	50	69	19	*2010*	***2050***	2000	Svartdalspiggan (14)
Car rup	*Carex rupestris*	13	51	19	-32	*2020*	*1990*	2100	
Car sax	*Carex saxatilis*	4	6	10	4	*1620*	***1870***	1750	Surtningstinden (8)
Car vag	*Carex vaginata*	20	57	43	-14	*1880*	***1880***	1830	Bukkhammaren (13)
Cer alp	*Cerastium alpinum*	109	103	84	-19	*2032*	*2050*	2220	
Cer cer	*Cerastium cerastoides*	28	28	32	4	*2010*	***2050***	2040	Svartdalspiggan (14)
Cha ang	*Chamerion angustifolium*	15	9	5	-4	*1675*	*1571*	1780	
Cir het	*Cirsium heterophyllum*	3	4	5	1	*1580*	*1580*	1680	
Coe vir	*Coeloglossum viride*	2	6	3	-3	*1740*	*1555*	1740	
Cry cri	*Cryptogramma crispa*	1	2	3	1	*1485*	***1910***	1660	Tverråtindan (11)
Cys fra	*Cystopteris fragilis*	1	2	0	-2	*1700*	-	1700	
Des alp	*Deschampsia alpina*	50	93	93	0	*2050*	*2050*	2230	
Des ces	*Deschampsia cespitosa*	0	0	1	1	-	***1580***	1470	Surtningstinden (3)
Diph alp	*Diphasiastrum alpinum*	12	21	18	-3	*1625*	***1995***	1740	Knutsholstinden (11)
Dra fla	*Draba fladnizensis*	14	12	5	-7	*1930*	*2005*	2300	
Dra niv	*Draba nivalis*	5	2	5	3	*1880*	*1778*	2100	
Dra nor	*Draba norvegica*	1	5	0	-5	*1760*	-	2020	
Dry oct	*Dryas octopetala*	6	6	3	-3	*1775*	*1670*	1830	
Emp nig	*Empetrum nigrum*	9	68	91	23	*1845*	***1965***	1770	Glittertinden (14)
Epi ana	*Epilobium anagallidifolium*	5	5	29	24	*1785*	***1950***	1840	Tverbotnhorn (11)
Epi lac	*Epilobium lactiflorum*	0	0	8	8	-	***1790***	1660	Tverråtindan (6)
Equ arv	*Equisetum arvense*	1	6	4	-2	*1585*	*1510*	1600	
Eri uni	*Erigeron uniflorus*	111	82	86	4	*2020*	*2050*	2120	
Eri ang	*Eriophorum angustifolium*	0	9	8	-1	*1830*	***1715***	1700	Tjørnholstinden (5)
Eri sch	*Eriophorum scheuchzeri*	2	3	6	3	*1540*	***2050***	1840	Tverbotnhorn (15)
Eri vag	*Eriophorum vaginata*	2	3	1	-2	*1710*	*1705*	1720	
Eup wet	*Euphrasia wettsteinii*	10	23	63	40	*1850*	***1910***	1800	Tverråtindan (11)
Fes ovi	*Festuca ovina*	50	64	80	16	*1880*	***1920***	1900	Nordre Hellstuguhøi (5)
Fes viv	*Festuca vivipara*	110	160	179	19	*2095*	*2080*	2300	
Gen niv	*Gentiana nivalis*	5	7	26	19	*1830*	*1840*	1880	
Ger syl	*Geranium sylvaticum*	15	17	18	1	*1675*	*1745*	1750	
Gym con	*Gymnadenia conopsea*	0	1	0	-1	*1560*	-	1560	
Gym dry	*Gymnocarpium dryopteris*	0	1	2	1	*1620*	***1790***	1600	Tverråtindan (6)
Har hyp	*Harrimanella hypnoides*	33	65	66	1	*1880*	***2000***	1870	Glittertinden (15)
Hie sub	*Hieracium sect. subalpina*	80	90	111	21	*1915*	*2010*	-	
Hie hie	*Hieracium sect. hieracium*	1	3	3	0	*1560*	*1705*	-	
Hup sel	*Huperzia selago*	44	61	55	-6	*2020*	***2020***	1940	Kyrkja (12)
Jun big	*Juncus biglumis*	23	26	24	-2	*1760*	*1930*	1970	
Jun tri	*Juncus trifidus*	58	88	94	6	*1860*	***1910***	1850	Tverråtindan (11)
Jun com	*Juniperus communis*	30	34	38	4	*1760*	***1880***	1730	Bukkhammaren (13)
Kob myo	*Kobresia myosuroides*	0	3	3	0	*1760*	*1710*	1960	
Leo aut	*Leontodon autumnalis*	1	1	21	20	*1495*	***1775***	1600	Besshø (6)
Loi pro	*Loiseleuria procumbens*	20	20	20	0	*1765*	*1700*	1920	
Luz con	*Luzula confusa*	151	165	149	-16	*2095*	*2137*	2250	
Luz mul	*Luzula multiflora*	17	24	27	3	*1740*	*1790*	1800	
Luz par	*Luzula parviflora*	4	1	0	-1	*1735*	-	1750	
Luz spi	*Luzula spicata*	82	154	170	16	*2050*	*2080*	2220	

Lyc ann	*Lycopodium annotium*	1	7	3	-4	*1765*	***1720***	1600	Galdhøpiggen (3)
Min bif	*Minuartia biflora*	31	56	52	-4	*2010*	*1990*	2210	
Myo dec	*Myosotis decumbens*	0	1	1	0	*1485*	*1535*	1550	
Nar str	*Nardus stricta*	0	0	14	14	-	*1590*	1750	
Oma nor	*Omalotheca norvegica*	18	31	42	11	*1910*	***1950***	1780	Tverbotnhorn (11)
Oma sup	*Omalotheca supina*	32	87	116	29	*2010*	***2050***	2000	Svartdalspiggan (14)
Oxy dig	*Oxyria digyna*	100	86	99	13	*2032*	*2050*	2160	
Par pal	*Parnassia palustris*	0	2	3	1	*1560*	*1670*	1750	
Ped lap	*Pedicularis lapponica*	10	12	9	-3	*1610*	*1580*	1700	
Ped oed	*Pedicularis oederi*	60	77	67	-10	*1950*	*1910*	2050	
Pet fri	*Petasites frigidus*	2	2	0	-2	*1555*	-	1960	
Phe con	*Phegopteris connectilis*	0	0	1	1	-	*1535*	1560	
Phle alp	*Phleum alpinum*	22	26	32	6	*1790*	***1910***	1800	Tverråtindan (11)
Phy cae	*Phyllodoce caerulea*	43	68	76	8	*1880*	***1980***	1850	Skauthøi (18)
Pin vul	*Pinguicula vulgaris*	2	10	9	-1	*1700*	***1670***	1570	Surtingssui/Rau (4)
Poa alp	*Poa alpina var. alpina*	25	41	59	18	*2005*	*1950*	2000	
Poa viv	*Poa alpina var. vivipara*	7	7	53	46	*1990*	*2050*	2140	
Poa arc	*Poa arctica*	5	0	4	4	-	*1950*	2050	
Poa fle	*Poa flexuosa*	178	167	176	9	*2135*	*2185*	2350	
Poa gla	*Poa glauca*	13	13	32	19	*2005*	*1990*	2160	
Poa pra	*Poa pratensis*	3	3	10	7	*1650*	*1840*	1950	
PoaXjem	*Poa x jemtlandica*	1	0	0	0	-	-	1760	
Pol lon	*Polystichum lonchitis*	0	1	1	0	*1515*	***1515***	1500	Surtningssui/Rau (1)
Pseu sta	*Pseudorchis staminea*	3	3	0	-3	*1560*	-	1800	
Pot cra	*Potentilla crantzii*	70	76	75	-1	*2005*	*1990*	2000	
Pot niv	*Potentilla nivea*	1	4	3	-1	*1790*	***1790***	1700	Tverråtindan (6)
Pul ver	*Pulsatilla vernalis*	38	45	37	-8	*1880*	***1890***	1840	Tverbotnhorn (9)
Pyr min	*Pyrola minor*	7	21	21	0	*1660*	***1630***	1620	Kyrkja (3)
Ran acr	*Ranunculus acris ssp. pumilus*	11	18	19	1	*1720*	***1880***	1870	Bukkhammaren (13)
Ran pyg	*Ranunculus pygmeaeus*	38	35	25	-10	*2010*	*2050*	2230	
Rho ros	*Rhodiola rosea*	123	132	121	-11	*2095*	*2005*	2280	
Rum acla	*Rumex acetocella*	0	1	0	-1	*1525*	-	1840	
Rum acsa	*Rumex acetosa*	24	31	30	-1	*1790*	*1850*	1880	
Sal gla	*Salix glauca*	13	29	65	36	*1830*	***1950***	1900	Surtningssui/Rau(15)
Sal her	*Salix herbacea*	185	198	219	21	*2125*	*2137*	2170	
Sal lan	*Salix lanata*	10	13	30	17	*1660*	***1905***	1750	Tverbotnhorn (10)
Sal lap	*Salix lapponum*	16	37	16	-21	*1790*	*1695*	1750	
Sal myrs	*Salix myrsinites*	5	7	2	-5	*1670*	*1620*	1750	
Sal phy	*Salix phylicifolia*	6	33	8	-25	*2000*	*1655*	1760	
Sal ret	*Salix reticulata*	20	27	24	-3	*1905*	*1880*	1940	
Sau alp	*Saussurea alpina*	110	141	125	-16	*2095*	*2005*	2130	
Sax aiz	*Saxifraga aizoides*	2	2	0	-2	*1560*	-	1700	
Sax cer	*Saxifraga cernua*	25	20	15	-5	*2020*	*2050*	2350	
Sax ces	*Saxifraga cespitosa*	52	42	20	-22	*2050*	*2050*	2280	
Sax cot	*Saxifraga cotyledon*	0	2	3	1	*1590*	***1590***	1490	Veslefjellet (3)
Sax niv	*Saxifraga nivalis*	25	22	9	-13	*2060*	*1995*	2250	
Sax opp	*Saxifraga oppositifolia*	31	56	44	-12	*2032*	*2130*	2350	

Sax riv	*Saxifraga rivularis*	23	19	23	4	*2000*	*2050*	2350	
Sax ste	*Saxifraga stellaris*	45	38	70	32	*1950*	***2010***	1970	Svartdalspiggan (13)
Sax ten	*Saxifraga tenuis*	0	0	1	1	-	*2015*	2250	
Sed vil	*Sedum villosum*	0	0	4	4	-	*1700*	1880	
Sel sel	*Selaginella selaginoides*	0	0	15	15	-	***1790***	1520	Surtningssui/Rau(10)
Sib pro	*Sibbaldia procumbens*	97	117	116	-1	*2010*	*2080*	2130	
Sil aca	*Silene acaulis*	117	138	131	-7	*2032*	*2130*	2210	
Sil wahl	*Silene wahlbergella*	6	3	1	-2	*1850*	*1880*	1970	
Sil dio	*Silene dioica*	9	11	6	-5	*1790*	***1850***	1780	Tverråtindan (8)
Sol vir	*Solidago virgaurea*	30	47	51	4	*1880*	***2000***	1800	Glittertinden (15)
Ste bor	*Stellaria borealis*	0	0	1	1	-	***1570***	550	Galdhøpiggen (1)
Tarax	*Taraxacum spp.*	56	89	101	12	*2010*	*2050*	-	
Tha alp	*Thalictrum alpinum*	36	62	56	-6	*1880*	*1880*	1920	
Tof pus	*Tofieldia pusilla*	2	12	6	-6	*1700*	***1750***	1700	Surtningssui/Rau (7)
Tri ces	*Trichophorum cespitosum*	0	3	1	-2	*1605*	*1535*	1600	
Tri eur	*Trientalis europaea*	3	11	4	-7	*1625*	***1625***	1600	Galdhøpiggen (2)
Tri spi	*Trisetum spicatum*	124	106	126	20	*2032*	*2080*	2220	
Vac myr	*Vaccinium myrtillus*	18	35	33	-2	*1700*	***1705***	1700	Tverbotnhorn (6)
Vac uli	*Vaccinium uliginosum*	13	45	49	4	*1765*	***1750***	1730	Rasletinden/Rau (9)
Vac vit	*Vaccinium vitis-idaea*	40	62	55	-7	*1855*	*1775*	1800	
Vah atr	*Vahlodea atropurpurea*	0	0	18	18	-	***1715***	1600	Tjørnholstinden (5)
Val sam	*Valeriana sambucifolia*	1	0	0	0	-	-	1540	
Ver alp	*Veronica alpina*	52	74	82	8	*1910*	***2000***	1920	Glittertinden (15)
Ver fru	*Veronica fruticans*	10	5	6	1	*1850*	***1880***	1800	Bukkhammaren (13)
Vio pal	*Viola palustris*	7	16	7	-9	*1680*	*1625*	1750	
Vis alp	*Viscaria alpina*	28	26	27	1	*1890*	***1905***	1900	Tverbotnhorn (10)
Total number of species		125	138	140					

Appendix 3

The table shows the results of the randomization test, with species names, p-values and change in number of observations between 1998 and 2014. Bold letters and numbers indicate significant changes.

Species	P-value	Change number of observations 1998 – 2014
Agrostis capillaris	0.255	3
Agrostis mertensii	**0.001**	**60**
Alchemilla spp.	1	1
Alchemilla alpina	1	1
Angelica Archangelica	1	-1
Antennaria alpina	0.056	17
Antennaria dioica	0.382	-5
Anthoxanthum nipponicum	**0.016**	**16**
Arabis alpina	0.435	-3
Arabidopsis petraea	1	1
Arctous alpinus	0.452	-4
Arctostaphylos uva ursi	0.376	-5
Asplenium viride	1	-1
Astragalus alpinus	0.712	-2
Athyrium distentifolium	0.259	6
Avenella flexuosa	0.15	9
Bartsia alpina	**0.037**	**12**
Beckwithia glacialis	0.644	-4
Betula nana	0.617	2
Betula pubescens	0.056	7
Bistorta vivipara	0.281	7
Botrychium boreale	1	0
Botrychium lunaria	1	1
Calamagrostis purpurea	1	1
Campanula rotundifolia	**0.001**	**31**
Carex arctogena	1	1
Carex atrata	**0.006**	**16**
Carex atrofusca	0.525	-2
Cardamine bellidifolia	0.093	15
Carex bigelowii	1	1
Carex brunnescens	1	1
Carex capillaris	1	1
Carex dioica	0.509	-2
Carex lachenalii	**0.02**	**19**
Carex rupestris	**0.001**	**-32**
Carex saxatilis	0.392	4
Carex vaginata	**0.034**	**-14**
Cerastium alpinum	**0.034**	**-19**
Cerastium cerastoides	0.632	4
Chamerion angustifolium	0.282	-4
Cirsium heterophyllum	1	1
Coeloglossum viride	0.364	-3
Cryptogramma crispa	1	1
Cystopteris fragilis	0.468	-2
Deschampsia alpina	1	0
Deschampsia cespitosa	1	1
Diphasiastrum alpinum	0.635	-3
Draba fladnizensis	0.066	-7
Draba nivalis	0.373	3
Draba norvegica	0.066	-5
Dryas octopetala	0.483	-3
Empetrum nigrum	**0.001**	**23**
Epilobium anagallidifolium	**0.001**	**24**
Epilobium lactiflorum	**0.013**	**8**
Equisetum arvense	0.632	-2
Eriophorum angustifolium	1	-1
Eriophorum scheuchzeri	0.478	3
Erigeron uniflorus	0.686	4
Eriophorum vaginata	0.624	-2
Euphrasia wettsteinii	**0.001**	**40**
Festuca ovina	**0.019**	**16**
Festuca vivipara	**0.036**	**19**
Gentiana nivalis	**0.001**	**19**
Geranium sylvaticum	1	1
Gymnadenia conopsea	1	-1
Gymnocarpium dryopteris	1	1
Harrimanella hypnoides	1	1
Hieracium sect. hieracium	1	0
Hieracium sect. subalpina	**0.005**	**21**
Huperzia selago	0.516	-6
Juncus biglumis	0.858	-2
Juniperus communis	0.61	4
Juncus trifidus	0.42	6
Kobresia myosuroides	1	0

Leontodon autumnalis	**0.001**	**20**
Loiseleuria procumbens	1	0
Luzula confusa	0.056	-16
Luzula multiflora	0.72	3
Luzula parviflora	1	-1
Luzula spicata	**0.043**	**16**
Lycopodium annotium	0.328	-4
Minuartia biflora	0.654	-4
Myosotis decumbens	1	0
Nardus stricta	**0.001**	**14**
Omalotheca norvegica	**0.044**	**11**
Omalotheca supina	**0.002**	**29**
Oxyria digyna	0.132	13
Parnassia palustris	1	1
Pedicularis lapponica	0.532	-3
Pedicularis oederi	0.136	-10
Petasites frigidus	0.498	-2
Phegopteris connectilis	1	1
Phleum alpinum	0.332	6
Phyllodoce caerulea	0.331	8
Pinguicula vulgaris	1	-1
Poa alpina var. alpina	**0.019**	**18**
Poa arctica	0.12	4
Poa flexuosa	0.333	9
Poa glauca	**0.004**	**19**
Poa pratensis	**0.042**	**7**
Poa alpina var. vivipara	**0.001**	**46**
Poa x jemtlandica	1	0
Polystichum lonchitis	1	0
Potentilla crantzii	1	-1
Potentilla nivea	1	-1
Pseudorchis staminea	0.274	-3
Pulsatilla vernalis	0.271	-8
Pyrola minor	1	0
Ranunculus acris ssp. pumilus	1	1
Ranunculus pygmeaeus	0.149	-10
Rhodiola rosea	0.098	-11
Rumex acetocella	1	-1
Rumex acetosa	1	-1
Salix glauca	**0.001**	**36**
Salix herbacea	**0.002**	**21**
Salix lanata	**0.001**	**17**
Salix lapponum	**0.001**	**-21**
Salix myrsinites	0.118	-5
Salix phylicifolia	**0.001**	**-25**
Salix reticulata	0.731	-3
Saussurea alpina	**0.034**	**-16**
Saxifraga aizoides	0.494	-2
Saxifraga cernua	0.404	-5
Saxifraga cespitosa	**0.001**	**-22**
Saxifraga cotyledon	1	1
Saxifraga nivalis	**0.005**	**-13**
Saxifraga oppositifolia	0.083	-12
Saxifraga rivularis	0.584	4
Saxifraga stellaris	**0.001**	**32**
Saxifraga tenuis	1	1
Sedum villosum	0.132	4
Selaginella selaginoides	**0.001**	**15**
Sibbaldia procumbens	1	-1
Silene acaulis	0.399	-7
Silene dioica	0.171	-5
Silene wahlbergella	0.625	-2
Solidago virgaurea	0.673	4
Stellaria borealis	1	1
Taraxacum spp.	0.138	12
Thalictrum alpinum	0.37	-6
Tofieldia pusilla	0.134	-6
Trichophorum cespitosum	0.624	-2
Trientalis europaea	**0.029**	**-7**
Trisetum spicatum	**0.039**	**20**
Vaccinium myrtillus	0.833	-2
Vaccinium uliginosum	0.606	4
Vaccinium vitis-idaea	0.388	-7
Vahlodea atropurpurea	**0.001**	**18**
Valeriana sambucifolia	1	0
Veronica alpina	0.365	8
Veronica fruticans	1	1
Viola palustris	**0.01**	**-9**
Viscaria alpina	1	1

Appendix 4

The three indicator values: values from Gottfried et al. (2012), Nordic Indicator values and Ellenberg Temperature indicator values. The “x” means that an indicator value does not exist or has not been found.

Species	Gottfried et al. 2012	Nordic Indicator values	Ellenberg Temperature values
Agrostis capillaris	6	5	x
Agrostis mertensii	3	2	x
Alchemilla alpina	5	1	2
Alchemilla spp.	x	x	x
Angelica archangelica	x	5	6
Antennaria alpina	3	2	x
Antennaria dioica	5	5	x
Anthoxanthum nipponicum	x	2	3
Arabidopsis petraea	x	1	2
Arabis alpina	4	1	3
Arctostaphylos uvaursi	5	4	x
Arctous alpinus	4	1	2
Asplenium viride	x	4	4
Astragalus alpinus	4	1	2
Athyrium distentifolium	x	1	3
Avenella flexuosa	5	5	x
Bartsia alpina	4	1	3
Beckwithia glacialis	1	1	1
Betula nana	5	2	3
Betula pubescens	6	5	x
Bistorta vivpara	4	2	2
Botrychium boreale	x	2	x
Botrychium lunaria	5	5	x
Calamagrostis purpurea	6	4	4
Campanula rotundifolia	6	5	5
Cardamine bellidifolia	2	1	1
Carex arctogena	x	1	4
Carex atrata	4	2	2
Carex atrofusca	x	1	x
Carex bigelowii	2	1	3
Carex brunnescens	x	4	2
Carex capillaris	4	2	1
Carex dioica	x	2	4
Carex lachenalii	x	1	x
Carex rupestris	3	1	2
Carex saxatilis	x	1	x
Carex vaginata	x	2	3
Cerastium alpinum	x	1	1
Cerastium cerastoides	x	1	1
Chamerion angustifolium	6	5	x
Cirsium heterophyllum	x	4	4
Coeloglossum viride	5	4	x

Cryptogramma crispa	x	4	3
Cystopteris fragilis	x	3	x
Deschampsia alpina	x	2	x
Deschampsia cespitosa	x	3	x
Diphasiastrum alpinum	4	1	3
Draba fladnizensis	2	1	2
Draba nivalis	x	2	x
Draba norvegica	x	1	x
Dryas octopetala	3	1	2
Empetrum nigrum	5	2	x
Epilobium anagallidifolium	x	1	2
Epilobium lactiflorum	x	2	x
Equisetum arvense	x	3	x
Erigeron uniflorus	2	x	1
Eriophorum angustifolium	x	3	x
Eriophorum scheuchzeri	x	2	2
Eriophorum vaginata	x	2	x
Euphrasia wettsteinii	5	1	3
Festuca ovina	5	5	x
Festuca vivipara	3	2	x
Gentiana nivalis	x	1	1
Geranium sylvaticum	6	4	4
Gymadenia conopsea	6	5	x
Gymnocarpium dryopteris	x	5	4
Harrimanella hypnoides	2	2	x
Hieracium sect. hieracium	x	x	x
Hieracium sect. subalpina	x	x	x
Huperzia selago	4	2	3
Juncus biglumis	3	1	x
Juncus trifidus	3	1	2
Juniperus communis	5	5	x
Kobresia myosuroides	2	1	2
Leontodon autumnalis	x	5	x
Loiseleuria procumbens	4	1	2
Luzula confusa	2	x	1
Luzula multiflora	5	3	x
Luzula parviflora	x	2	x
Luzula spicata	2	1	2
Lycopodium annotinum	x	2	4
Minuartia biflora	2	1	x
Myosotis decumbens	x	2	3
Nardus stricta	5	5	x
Omalotheca norvegica	x	1	3
Omalotheca supina	3	1	2
Oxyria digyna	3	1	2
Parnassia palustris	5	5	x
Pedicularis lapponica	4	2	x
Pedicularis oederi	3	2	2
Petasites frigidus	x	2	x
Phegopteris connectilis	x	5	4
Phleum alpinum	4	2	3

Phyllodoce caerulea	4	1	x
Pinguicula vulgaris	x	4	x
Poa alpina	3	1	3
Poa alpina var. vivipara	3	1	3
Poa arctica	x	x	x
Poa flexuosa	x	1	1
Poa glauca	x	2	x
Poa pratensis	x	x	x
Poa X jemtlandica	x	x	x
Polystichum lonchitis	x	4	4
Potentilla crantzii	4	2	2
Potentilla nivea	x	1	x
Pseudorchis albida	5	4	4
Pulsatilla vernalis	3	5	x
Pyrola minor	5	4	x
Ranunculus acris	x	x	x
Ranunculus pygmaeus	x	2	1
Rhodiola rosea	4	1	4
Rumex acetosa	6	5	x
Rumex acetosella	x	6	5
Salix glauca	x	4	x
Salix herbacea	3	1	2
Salix lanata	5	1	x
Salix lapponum	x	2	x
Salix myrsinites	x	1	x
Salix phylicifolia	5	2	x
Salix reticulata	3	1	2
Saussurea alpina	3	1	1
Saxifraga aizoides	5	1	3
Saxifraga cernua	x	1	x
Saxifraga cespitosa	2	1	x
Saxifraga cotyledon	x	4	3
Saxifraga nivalis	x	1	x
Saxifraga oppositifolia	1	1	2
Saxifraga rivularis	x	1	x
Saxifraga stellaris	x	1	3
Saxifraga tenuis	x	2	x
Sedum villosum	x	2	5
Selaginella selaginoides	4	4	3
Sibbaldia procumbens	3	1	2
Silene acaulis	2	1	1
Silene dioica	x	5	x
Silene wahlbergella	x	2	x
Solidago virgaurea	5	5	x
Stellaria borealis	x	4	x
Taraxacum spp.	x	x	x
Thalictrum alpinum	3	1	x
Tofieldia pusilla	4	1	2
Trichophorum cespitosum	x	4	4
Trientalis europaea	6	4	5
Trisetum spicatum	2	1	1

Vaccinium myrtillus	6	4	x
Vaccinium uliginosum	5	2	x
Vaccinium vitis-idaea	5	2	x
Vahlodea atropurpurea	x	2	x
Valeriana sambucifolia	x	5	6
Veronica alpina	2	1	2
Veronica fruticans	4	1	2
Viola palustris	x	5	x
Viscaria alpina	x	2	x

Appendix 5

The species with their lower and upper distribution in vegetation zones in Norway (Lid & Lid, 2005). "Species range" is the vegetation zones where a species can be found, and "Species optimum" is the median of "Species range". Zones: Nem = 1, BNem = 2, SBor = 3, MBor = 4, NBor = 5, LAlp = 6, MAlp = 7, HAlp = 8.

Species	Lower zone	Upper zone	Species range	Species optimum
Agrostis capillaris	Nem	Nbor	1,2,3,4,5	3
Agrostis mertensii	NBor	MAlp	5,6,7	6
Alchemilla alpina	MBor	MAlp	4,5,6,7	5,5
Alchemilla spp.				
Angelica archangelica	MBor	MAlp	4,5,6,7	5,5
Antennaria alpina	NBor	HAlp	5,6,7,8	6,5
Antennaria dioica	Nem	HAlp	1,2,3,4,5,6,7,8	4,5
Anthoxanthum nipponicum	NBor	MAlp	5,6,7	6
Arabidopsis petraea	MBor	Lalp	4,5,6	5
Arabis alpina	NBor	HAlp	5,6,7,8	6,5
Arctostaphylos uvaursi	Nem	MAlp	1,2,3,4,5,6,7	4
Arctous alpinus	Nbor	MAlp	5,6,7	6
Asplenium viride	BNem	MAlp	2,3,4,5,6,7	4,5
Astragalus alpinus	Nbor	MAlp	5,6,7	6
Athyrium distentifolium	NBor	MAlp	5,6,7	6
Avenella flexuosa	Nem	MAlp	1,2,3,4,5,6,7	4
Bartsia alpina	Mbor	Malp	4,5,6,7	5,5
Beckwithia glacialis	MAlp	HAlp	7,8	7,5
Betula nana	SBor	LAlp	3,4,5,6	4,5
Betula pubescens	Nem	MBor	1,2,3,4	2,5
Bistorta vivpara	BNem	HAlp	2,3,4,5,6,7,8	5
Botrychium boreale	MBor	LAlp	4,5,6	5
Botrychium lunaria	Nem	MAlp	1,2,3,4,5,6,7	4
Calamagrostis purpurea	Nem	LAlp	1,2,3,4,5,6	3,5
Campanula rotundifolia	Nem	MAlp	1,2,3,4,5,6,7	4
Cardamine bellidifolia	LAlp	HAlp	6,7,8	7
Carex arctogena	LAlp	MAlp	6,7	6,5
Carex atrata	NBor	MAlp	5,6,7	6
Carex atrofusca	NBor	MAlp	5,6,7	6
Carex bigelowii	NBor	HAlp	5,6,7,8	6,5
Carex brunnescens	BNem	MAlp	2,3,4,5,6,7	4,5
Carex capillaris	SBor	MAlp	3,4,5,6,7	5
Carex dioica	Nem	LAlp	1,2,3,4,5,6	3,5
Carex lachenalii	NBor	HAlp	5,6,7,8	6,5
Carex rupestris	NBor	HAlp	5,6,7,8	6,5
Carex saxatilis	NBor	MAlp	5,6,7	6
Carex vaginata	NBor	Malp	5,6,7	6
Cerastium alpinum	NBor	HAlp	5,6,7,8	6,5

Cerastium cerastoides	NBor	MAlp	5,6,7	6
Chamerion angustifolium	Nem	LAlp	1,2,3,4,5,6	3,5
Cirsium heterophyllum	Nem	LAlp	1,2,3,4,5,6	3,5
Coeloglossum viride	BNem	MAlp	2,3,4,5,6,7	4,5
Cryptogramma crispa	Mbor	MAlp	4,5,6,7	5,5
Cystopteris fragilis	Nem	LAlp	1,2,3,4,5,6	3,5
Deschampsia alpina	LAlp	HAlp	6,7,8	7
Deschampsia cespitosa	Nem	LAlp	1,2,3,4,5,6	3,5
Diphasiastrum alpinum	NBor	MAlp	5,6,7	6
Draba fladnizensis	LAlp	HAlp	6,7,8	7
Draba nivalis	LAlp	HAlp	6,7,8	7
Draba norvegica	NBor	MAlp	5,6,7	6
Dryas octopetala	Mbor	MAlp	4,5,6,7	5,5
Empetrum nigrum	Mbor	MAlp	4,5,6,7	5,5
Epilobium anagallidifolium	NBor	MAlp	5,6,7	6
Epilobium lactiflorum	MBor	LAlp	4,5,6	5
Equisetum arvense	LAlp	MAlp	6,7	6,5
Erigeron uniflorus	LAlp	HAlp	6,7,8	7
Eriophorum angustifolium	Nem	MAlp	1,2,3,4,5,6,7	4
Eriophorum scheuchzeri	NBor	HAlp	5,6,7,8	6,5
Eriophorum vaginata	Nem	MAlp	1,2,3,4,5,6,7	4
Euphrasia wettsteinii	Mbor	MAlp	4,5,6,7	5,5
Festuca ovina	Nem	HAlp	1,2,3,4,5,6,7,8	4,5
Festuca vivipara	Sbor	HALp	3,4,5,6,7,8	5,5
Gentiana nivalis	NBor	Malp	5,6,7	6
Geranium sylvaticum	Nem	Lalp	1,2,3,4,5,6	3,5
Gymadenia conopsea	Nem	LAlp	1,2,3,4,5,6	3,5
Gymnocarpium dryopteris	Nem	LAlp	1,2,3,4,5,6	3,5
Harrimanella hypnoides	LAlp	HAlp	6,7,8	7
Hieracium sect. hieracium				
Hieracium sect. subalpina				
Huperzia selago	Mbor	Malp	4,5,6,7	5,5
Juncus biglumis	LAlp	HAlp	6,7,8	7
Juncus trifidus	NBor	MAlp	5,6,7	6
Juniperus communis ssp. alpina	NBor	MAlp	5,6,7	6
Kobresia myosuroides	NBor	MAlp	5,6,7	6
Leontodon autumnalis	NBor	MAlp	5,6,7	6
Loiseleuria procumbens	NBor	HAlp	5,6,7,8	6,5
Luzula confusa	MAlp	HAlp	7,8	7,5
Luzula multiflora	NBor	MAlp	5,6,7	6
Luzula parviflora	NBor	MAlp	5,6,7	6
Luzula spicata	NBor	HAlp	5,6,7,8	6,5
Lycopodium annotinum	NBor	MAlp	5,6,7	6
Minuartia biflora	NBor	HAlp	5,6,7,8	6,5
Myosotis decumbens	MBor	LAlp	4,5,6	5
Nardus stricta	Nem	MAlp	1,2,3,4,5,6,7	4
Omalotheca norvegica	MBor	MAlp	4,5,6,7	5,5

Omalotheca supina	NBor	HAlp	5,6,7,8	6,5
Oxyria digyna	NBor	HAlp	5,6,7,8	6,5
Parnassia palustris	Nem	MAlp	1,2,3,4,5,6,7	4
Pedicularis lapponica	NBor	MAlp	5,6,7	6
Pedicularis oederi	NBor	MAlp	5,6,7	6
Petasites frigidus	NBor	MAlp	5,6,7	6
Phegopteris connectilis	Nem	LAlp	1,2,3,4,5,6	3,5
Phleum alpinum	MBor	Malp	4,5,6,7	5,5
Phyllodoce caerulea	NBor	HAlp	5,6,7,8	6,5
Pinguicula vulgaris	Nem	MAlp	1,2,3,4,5,6,7	4
Poa alpina	BNem	HAlp	2,3,4,5,6,7,8	5
Poa alpina var. vivipara	LAlp	HAlp	6,7,8	7
Poa arctica	NBor	HAlp	5,6,7,8	6,5
Poa flexuosa	MAlp	HAlp	7,8	7,5
Poa glauca	MBor	HAlp	4,5,6,7,8	6
Poa pratensis	Mbor	Malp	4,5,6,7	5,5
Poa X jemtlandica	MAlp	MAlp	7	7
Polystichum lonchitis	Nem	Lalp	1,2,3,4,5,6	3,5
Potentilla crantzii	BNem	MAlp	2,3,4,5,6,7	4,5
Potentilla nivea	LAlp	MAlp	6,7	6,5
Pseudorchis staminea	NBor	Malp	5,6,7	6
Pulsatilla vernalis	SBor	Malp	3,4,5,6,7	5
Pyrola minor	Nem	LAlp	1,2,3,4,5,6	3,5
Ranunculus acris ssp. pumilus	LAlp	HAlp	6,7,8	7
Ranunculus pygmaeus	LAlp	HAlp	6,7,8	7
Rhodiola rosea	NBor	HAlp	5,6,7,8	6,5
Rumex acetosa	MBor	LAlp	4,5,6	5
Rumex acetosella	Nem	LAlp	1,2,3,4,5,6	3,5
Salix glauca	MBor	Malp	4,5,6,7	5,5
Salix herbacea	NBor	HAlp	5,6,7,8	6,5
Salix lanata	MBor	Lalp	4,5,6	5
Salix lapponum	MBor	MAlp	4,5,6,7	5,5
Salix myrsinites	MBor	Lalp	4,5,6	5
Salix phylicifolia	MBor	Lalp	4,5,6	5
Salix reticulata	NBor	HAlp	5,6,7,8	6,5
Saussurea alpina	MBor	HAlp	4,5,6,7,8	6
Saxifraga aizoides	NBor	MAlp	5,6,7	6
Saxifraga cernua	LAlp	HAlp	6,7,8	7
Saxifraga cespitosa	NBor	HAlp	5,6,7,8	6,5
Saxifraga cotyledon	SBor	LAlp	3,4,5,6	4,5
Saxifraga nivalis	NBor	HAlp	5,6,7,8	6,5
Saxifraga oppositifolia	NBor	HAlp	5,6,7,8	6,5
Saxifraga rivularis	LAlp	HAlp	6,7,8	7
Saxifraga stellaris	NBor	MAlp	5,6,7	6
Saxifraga tenuis	LAlp	HAlp	6,7,8	7
Sedum villosum	NBor	Lalp	5,6	5,5
Selaginella selaginoides	BNem	MAlp	2,3,4,5,6,7	4,5
Sibbaldia procumbens	NBor	MAlp	5,6,7	6

Silene acaulis	NBor	HAlp	5,6,7,8	6,5
Silene dioica	Nem	Lalp	1,2,3,4,5,6	3,5
Silene wahlbergella	LAlp	MAlp	6,7	6,5
Solidago virgaurea	NBor	MAlp	5,6,7	6
Stellaria borealis	MBor	LAlp	4,5,6	5
Taraxacum spp.				
Thalictrum alpinum	MBor	MAlp	4,5,6,7	5,5
Tofieldia pusilla	SBor	MAlp	3,4,5,6,7	5
Trichophorum cespitosum	Nem	Lalp	1,2,3,4,5,6	3,5
Trientalis europaea	Nem	LAlp	1,2,3,4,5,6	3,5
Trisetum spicatum	NBor	HAlp	5,6,7,8	6,5
Vaccinium myrtillus	Nem	MAlp	1,2,3,4,5,6,7	4
Vaccinium uliginosum	Nem	MAlp	1,2,3,4,5,6,7	4
Vaccinium vitis-idaea	Nem	MAlp	1,2,3,4,5,6,7	4
Vahlodea atropurpurea	NBor	MAlp	5,6,7	6
Valeriana sambucifolia	Nem	LAlp	1,2,3,4,5,6	3,5
Veronica alpina	NBor	HAlp	5,6,7,8	6,5
Veronica fruticans	NBor	Malp	5,6,7	6
Viola palustris	Nem	MAlp	1,2,3,4,5,6,7	4
Viscaria alpina	NBor	MAlp	5,6,7	6

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