

Vegetation mapping

of Zackenberg valley, Northeast Greenland



Christian Bay

**Danish Polar Center
&
Botanical Museum, University of Copenhagen**

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Abstract

Mapping of the major plant communities of the study area at Zackenberg was carried out from mid July to mid August 1997 at the peak of the development of the plant cover. A black and white aerial photos from 1987 in the scale 1:25.000 was used for the interpretation of the delimitation and distribution of the plant communities. After reconnaissances the vegetation was classified into 9 types of plant communities, which could be recognised on the aerial photo. The plant communities are characterised by the composition of the vascular plant species, their cover, the moss and lichen cover, and the relation to terrain and soil parameters.

The study area - Zone 1a - comprises a c. 6 km broad belt at sea level stretching towards northeast from the shore of Young Sund up the slopes of Aucellabjerg to an elevation of 600 m above sea level. Totally, c. 19 km² have been ground truthed and mapped. In each of the nine plant communities vegetation analyses giving detailed information on species composition, cover, and biomass have been carried out. The ITEX concept of vegetation analyses have been used making it possible to record changes of the vegetation structure and species composition by re-analysing the permanent marked plots in the future. The vegetation types depicted on the map p.4 are: Fen, grassland, three types of dwarf shrub heath - *Cassiope tetragona* heath, *Vaccinium uliginosum* heath, *Dryas* heath, *Salix arctica* snowbed, abrasion plateau, fell-field, and salt marsh.

East of the Zackenberg river the lowland is dominated by *Cassiope tetragona* heath intersected by grasslands and *Salix arctica* snowbeds in the low-lying depressions. On the west site of the river *Vaccinium uliginosum* heath is more abundant and the fens are richer and have a higher species diversity. On the slopes of Aucellabjerg the vegetation changes and grasslands, *Dryas*

1. Introduction

Studies of the changes of the distribution of plant communities and the floristical and structural changes of the vegetation units are important elements in monitoring the effects of climate changes on the arctic ecosystems. A vegetation map is a basic information on the present distribution of plant communities and is also of importance to studies of the relationship between herbivores and plants, the use of habitats by animals, and the spatial and temporal distribution of herbivores in the landscape.

The Zackenberg study area is situated in the northern part of the east coast of Greenland (74°28' N.), and has recently been referred to the Middle Arctic based on compilation of new floristical and vegetation data (Bay 1997).

2. Material and Methods

2.1. Floristics

The flora of the Zackenberg area in the Northeast Greenland flora province is well known as a recently published paper deals with the flora and phytogeography of Greenland north of 74° northern latitude (Bay 1992). Since then contributions dealing specifically with the flora and vegetation of the Zackenberg area have been published (Fredskild *et al.* 1992, Fredskild & Bay 1993, Fredskild 1996, 1998, Fredskild & Mogensen 1997). Fredskild (1996) gives a list of 150 species of vascular plant species using the taxonomy and nomenclature of Böcher *et al.* (1978).

During the field work in 1997 two species new to the area were found: *Colpodium vahliianum* (Liebm.) Nevski and *Carex stans* Drej., both high arctic species known from East Greenland.

As most of the *Dryas* material is the hybrid between the eastern taxon *Dryas octopetala* and the western taxon *D. integrifolia* this taxon will be mentioned only by the genus name.

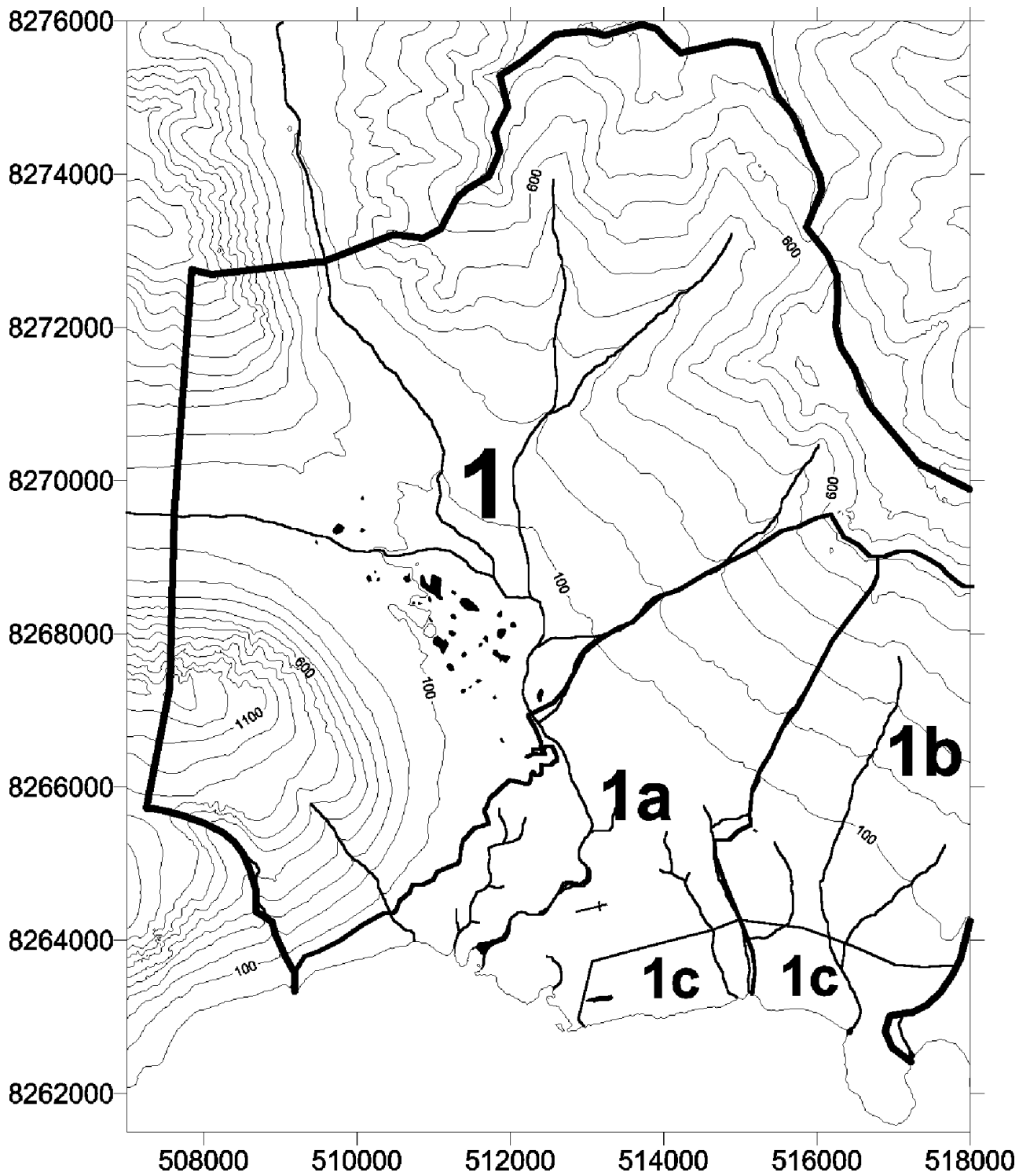


Figure 1. Study area. The vegetation map comprises Zone 1a of the research Zone 1 at Zackenberg (From Meltofte & Thing (eds.) 1997).

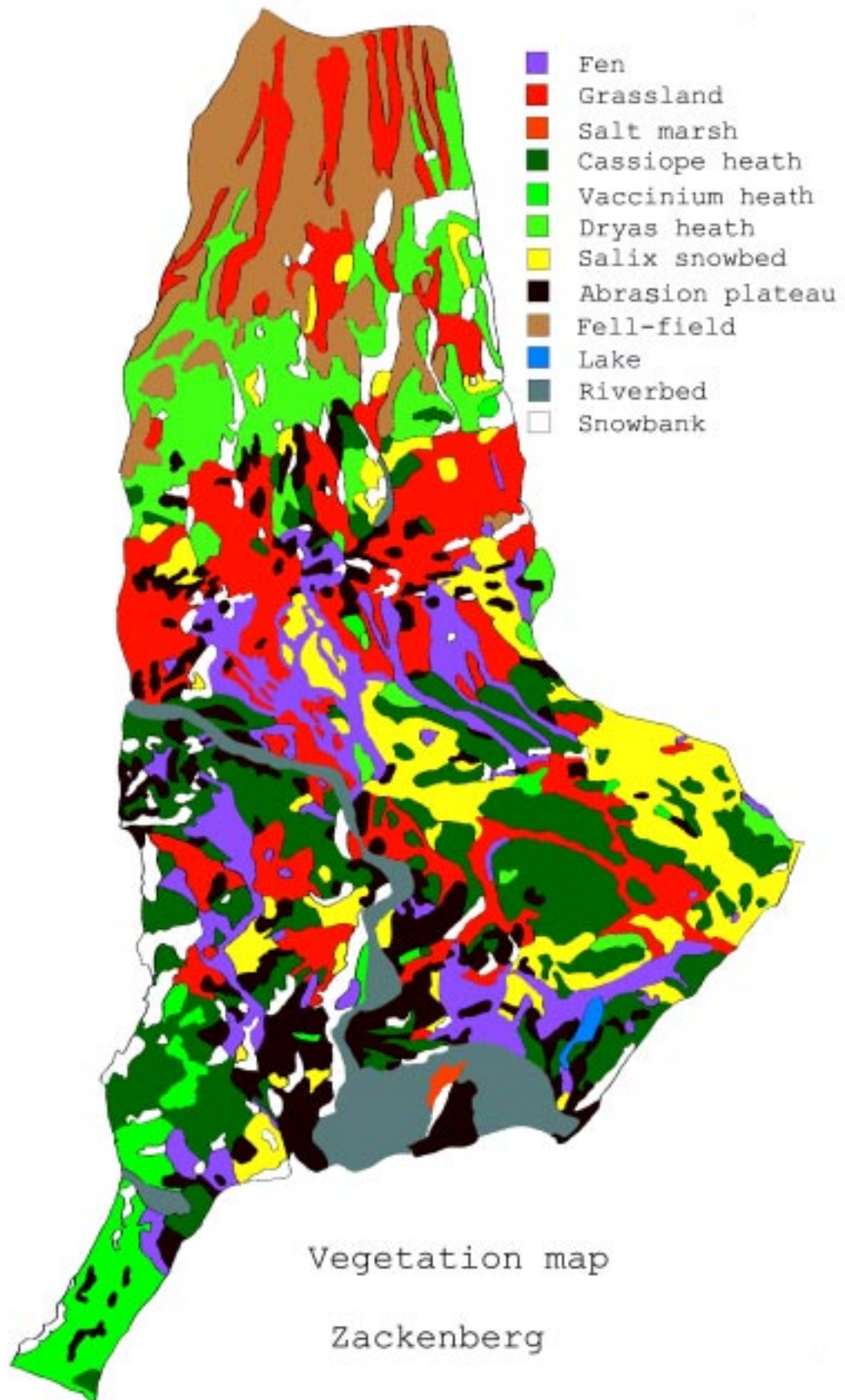


Figure 2. Vegetation map of the study area at Zackenberg.

2.3. Vegetation classification and mapping

Mapping of the major vegetation types of the study area at Zackenberg was carried out from mid July to mid August 1997 at the peak of the development of the plant cover. A black and white aerial photo from August 5, 1987 in the scale 1:25,000 was used in the ground truthing. The snow banks were of a reduced size in 1997, however, the vegetation map shows the distribution of the snow banks as they were distributed in 1987. The plant communities found on the sites covered by snow in 1987 were *Salix arctica* snowbed and late snowbed.

After initial reconnaissances the vegetation was classified into nine types of plant communities and three types of impediments, which are recognisable on the aerial photo. The plant communities are characterised by the composition and cover of vascular plant species, cover of mosses and lichens, in addition to their relation to terrain and soil parameters.

The main study area, Zone 1a, (Meltofte & Thing 1997) comprises a wedge shaped area c. 6 km broad at sea level stretching c. 6.6 km in a northeast direction from the shore of Young Sund up the slopes of Aucellabjerg to an altitude of 600 metres above sea level (Fig. 1). It is delimited to the east by "Grænseelv" and its extension up slopes to the 600 m above sea level. To the west the border is at the 50 metre elevation on the west bank of Zackenbergelven and it continues in Aucellaelv on the east bank of Zackenbergelven. The coast line is the southern border and the 600 m elevation on Aucellabjerg is the northern border.

The photo was ground truthed by crossing as many borders between different plant communities as possible. In the lowland *Cassiope tetragona* heath was easily mapped as this type appears very distinct on the photo and the border - determined by the duration of snow cover - is very distinct, whereas the plant communities on the slopes of Aucellabjerg were more difficult to delimit as the differences in grey colour were not that distinct and gradual transitions between some of the plant communities occur. Totally, c. 19 km² have been mapped (Fig. 2).



Figure 3. The set up of the vegetation analyses using an ITEX frame.

The study area consists of three major landscape units: 1) the lowland on the west side of Zackenbergelven, 2) the lowland between the east bank of Zackenbergelven and Aucellabjerg, and 3) the southwest facing slopes of Aucellabjerg. The distribution of the major plant communities is closely related to these landscape units, the soil conditions (type, moisture), and the elevation.

The vegetation is classified into the following nine plant communities: Fen, grassland, salt marsh, three types of dwarf shrub heath, snowbed, abrasion plateau, and fell-field. The types of impediments comprise river bed, snow bank, and lake.

Mosaic of two plant communities are mapped as the dominant type. Plant communities covering too small areas to be shown on the map are included in the neighbouring type, with which they are mostly related e.g. small fens are included in grasslands.

Other plant communities than the nine types mapped, were found, but their size was too small to be recognised on the aerial photo, and consequently, these are not depicted on the vegetation map. These comprise rich fen, *Betula nana* heath, herb-slope, late snowbed, early snowbed, and steppe.

The minimum size of the depicted polygons is c. 3 x 3 mm on the map which corresponds to just less than 10.000 m².

A minor revision of the classification of the vegetation types was carried out in connection with production of the final vegetation map. The delimitation of areas not ground truthed was checked by use of a stereoscope. The type characterised by a low plant cover originally named abrasion plateau/fell-field was split into two types because of differences in species composition and distribution in the landscape. This means that a vegetation analysis has to be carried out in the fell-field type in the upland of the slopes of Aucellabjerg. The *Dryas-Kobresia myosuroides* community turned out to have a very small distribution and as it is floristically closely related to the abrasion plateaus, it is mapped together with this type.

2.4. Vegetation analyses

Vegetation analyses giving detailed information on species composition, cover, and biomass of vascular plants have been carried out in nine plant communities. The ITEX concept of point-quadrat vegetation analyses have been used, making it possible to record changes of the species composition and vegetational structure by re-analysing the permanent marked plots in the future.

Vegetation analyses were carried out in homogeneous areas in the plant communities, which clearly appear with a distinct colour on the aerial photo. An analysis includes 5 plots, which were laid out along a line with a distance of c. 5 metres in the centre of the most homogenous part of the plant community. A description of the plant community is given, comprising the presence of all species of vascular plants, and the cover of the plant categories dwarf shrubs, herbs, mosses, and lichens (incl. organic crust) are given with specific data on the cover of the dominating vascular plant species (Appendix 1). All additional vascular plant species in the plant communities are recorded. The following physical parameters are noted: GPS position, altitude, exposure, inclination, soil moisture, and structure of the surface of the ground. The method follows the ITEX concept (Walker 1995) and is a modified "pinpoint" analysis. The vegetation frame consist of an aluminium frame of 70 cm x 70 cm with a distended nylon net in two layers, which have 100 intersections per layer (Fig. 3). The frame is placed horizontal by use of four spirit levels on the frame, which makes it possible to record the species perpendicular under the common intersections of the two layers. The holes left in the soil after removing the legs are permanently marked by a metal tube in the southwestern corner and by nails in the other corners. The frame is oriented by placing the A-corner in the southwestern direction (Appendix 3).

The distance from the top side of the frame to the ground below the plant cover is measured by all 100 records and by the legs. The vascular species are given in addition to the categories moss, lichen, organic crust (prothallus of mosses, lichen, and algae), and litter. The accuracy of the measurements is given by 0.5 cm. In most of the analyses two layers are recorded, as a moss layer is common in the moist and wet habitats. This method ensures that changes in the species composition and the vegetation structure can be detected by placing the frame in the exact same position and re-analyse the plots with intervals of years.

The five plots are permanently marked by a 30-40 cm plastic stick painted red at the top. They are placed ca. 50 cm south of each plot except for the northernmost plot, the stick was placed on the north side. All the data are compiled in Appendix 3.

2.5. Biomass measurements

Along a line c. 2 metres from the plots of the vegetation analysis the above ground biomass of vascular species was harvested in 5 plots of a quarter square metre. The biomass from the salt marsh was harvested from 1/16 m², as this type is very homogeneous. The plant material was sorted by species and dried in an oven at 100° C for 12 hours immediately after harvesting in order to avoid respiration loss and weighed. The analyses are presented in Appendix 2.

3. Results

3.1. General description of the vegetation

The vegetation at Zackenberg has been studied intensively in the period prior to the establishment of the scientific station (Fredskild *et al.* 1992, Fredskild & Bay 1993, Fredskild 1996, 1998). The study area can be divided into two different areas based on different geology and soil conditions. The border line is Zackenbergelven which dissect the area into a western part dominated by gneissic bedrock and an eastern part with soils originating from sedimentary and basaltic bedrock. On the west site of the river *Vaccinium uliginosum* heath is more abundant and the fens are richer and have a higher species diversity. Although the bedrock is gneiss local deposits of marine clay give rise to rich fens.

The key species are *Kobresia simpliciuscula*, *Carex atrofusca*, *C. marina* ssp.. *pseudolagopina*, and *Juncus triglumis*. The dwarf shrubs *Rhododendron lapponicum*, *Salix herbacea*, and *Empetrum nigrum* and the herb *Tofieldia coccinea* have a higher frequency on the west side than on the east side.

East of Zackenbergelven the lowland is dominated by *Cassiope tetragona* heaths mixed with *Salix arctica* snowbeds, grasslands, and fens; the latter occurring in the low-lying depressions, often surrounded by grassland. On the transition from the level lowland and the slopes of Aucella-bjerg (50-100 m a.s.l..) the vegetation is dominated by grassland. Between 100 and 300 metres *Dryas* heath is dominating, and gradually the vegetation becomes more open with increasing altitude and fell-fields with an open plant cover of *Salix arctica* and *Dryas* as the important dwarf shrubs dominate the uplands, where another type of grassland rich in species occurs along the wet stripes from the snow banks.

3. 2. Detailed description of the plant communities and the impediments

For each of the mapped plant communities the species composition, species number, biomass, and the distribution in the study area is given in Table 1, 2, and Appendix 1.

3.2.1. Fen

Fens occur on level terrain in the lowland, where the soil is saturated by water throughout the growing season. They are often related to semipermanent snow banks which support the low-lying areas with water, or to watercourses. The key species are *Dupontia psilosantha* and *Eriophorum scheuchzeri*, which do not occur as a dominant element in the neighbouring community grassland. In addition *Carex saxatilis* and *Arctagrostis latifolia* occur, and the total number of vascular species was 6 in the analysis (Table 2). The cover of vascular species and mosses are on an average 25% and 63%, respectively. The biomass of 134 g/m² is the largest among the plant communities dominated by monocotyledones.

In few places another type of fen was found. The species composition indicates that the soil is rich in nutrients, but as it covers only a few square metres it is not depicted on the vegetation map. The frequency of these rich fen fragments was more abundant on the west side of Zackenbergelven where marine deposits occur. The key species in the rich fens are: *Carex atrofusca*, *Eriophorum callitrix*, *Juncus trifidus* and *Kobresia simpliciuscula*.



Figure 4. Fen in a depression south of the research station.

3.2.2. Grassland

This type is dominated by graminoids, i.e. plants species belonging to the monocotyledon families Cyperaceae, Juncaceae, and Poaceae. The content of dwarf shrubs varies and in some places *Salix arctica* is an important element - especially in tussocky areas and on the lower parts of the slopes of Aucellabjerg. The type occurs mostly on slightly sloping terrain with adequate supply of water early in the season, but later the available soil water changes from wet to moist. The key species in the lowland are *Arctagrostis latifolia*, *Eriophorum triste*, and *Alopecurus alpinus*. In tussocky sites below snow banks in the eastern part of the study area *Salix arctica*, *Pedicularis*

hirsuta, and *Polygonum viviparum* occur on the tussocks. Moss cover is nearly 100%, whereas the cover of vascular species is 15%. An average biomass of 37 g/m² is among the smallest of the plant communities.

In the upland, especially above c. 200 metres, along the wet stripes another type of grassland-like plant community occurs. The species diversity is among the highest, and several rare species are mostly found in this type: *Deschampsia brevifolia*, *Saxifraga hieracifolia*, *Carex capillaris*, *Kobresia simpliciuscula*, *Epilobium arcticum*, and *Juncus castaneus*. Dominating and common are *Carex misandra*, *Carex saxatilis*, *Saxifraga oppositifolia*, *Polygonum viviparum*, *Saxifraga hirculus*, *Eriophorum triste*, *Melandrium apetalum*, *Alopecurus alpinus*, and *Salix arctica*.

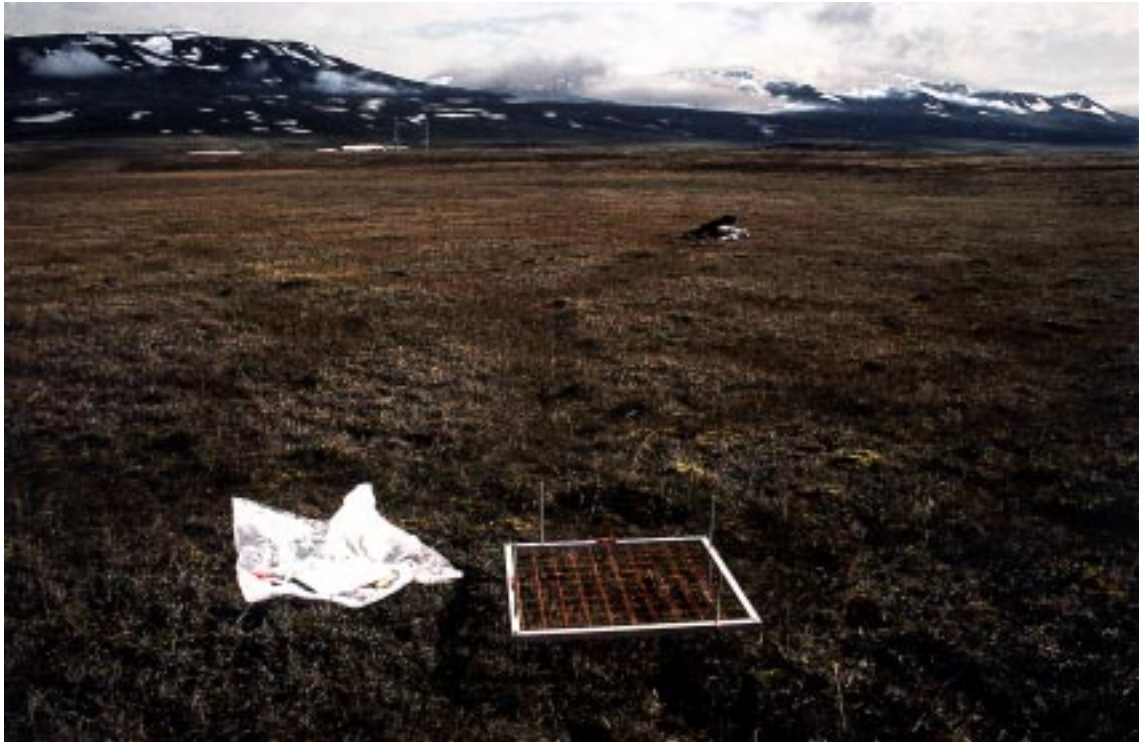


Figure 5. Grassland in depression east of air strip.

3.2.3. Salt marsh

Along the outlet of Zackenbergelven in Young Sund fragments of salt marsh occur level wet soils. The dominant species are *Carex subspathacea* and *Puccinellia phryganodes*. Other species are *Carex glareosa*, *Carex ursina*, *Sagina intermedia*, and *Saxifraga rivularis*. Although the lowest species diversity was recorded in this type, the cover is the largest among the graminoid dominated communities.

3.2.4. *Cassiope tetragona* heath

Cassiope tetragona heath occurs only in the lowland on moist, level ground and is abundant below an elevation of 50 metres. The *Cassiope* plants are between 5-10 cm, and they cover c. 50% of the ground. The most common herbs are *Luzula arctica* and *L. confusa*. The moss and lichen cover are lower than 10% and 5%, respectively. 13 species of vascular plants was recorded in the analysis. The biomass is the largest of all the analysed types: 266 g/m². The *Cassiope tetragona* heath in the western part of the mapped area on the west side of Zackenbergelven is more open and the average cover is low, because the terrain consists of eroded gneiss and the vegetation is restricted to the areas, where fine textured soil is deposited.



Figure 6. Salt marsh at the old river outlet at Young Sund.

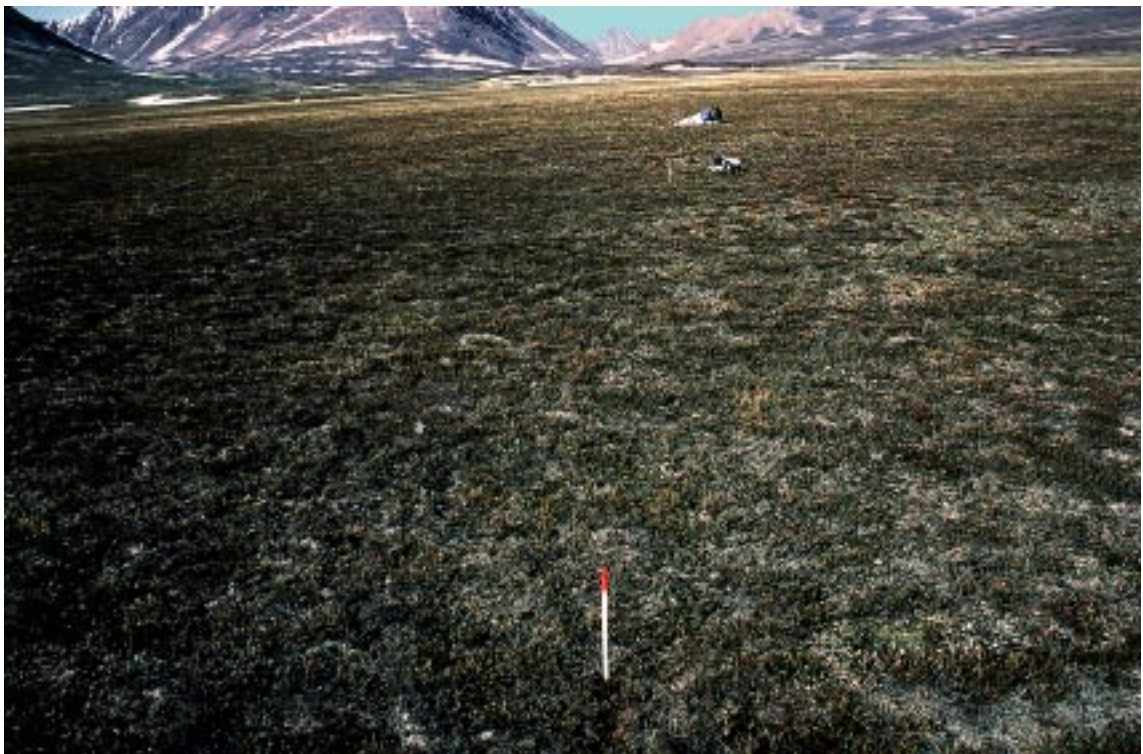


Figure 7. *Cassiope tetragona* heath northeast of the research station.



Figure 8. *Vaccinium uliginosum* heath on the west side of Zackenbergelven.

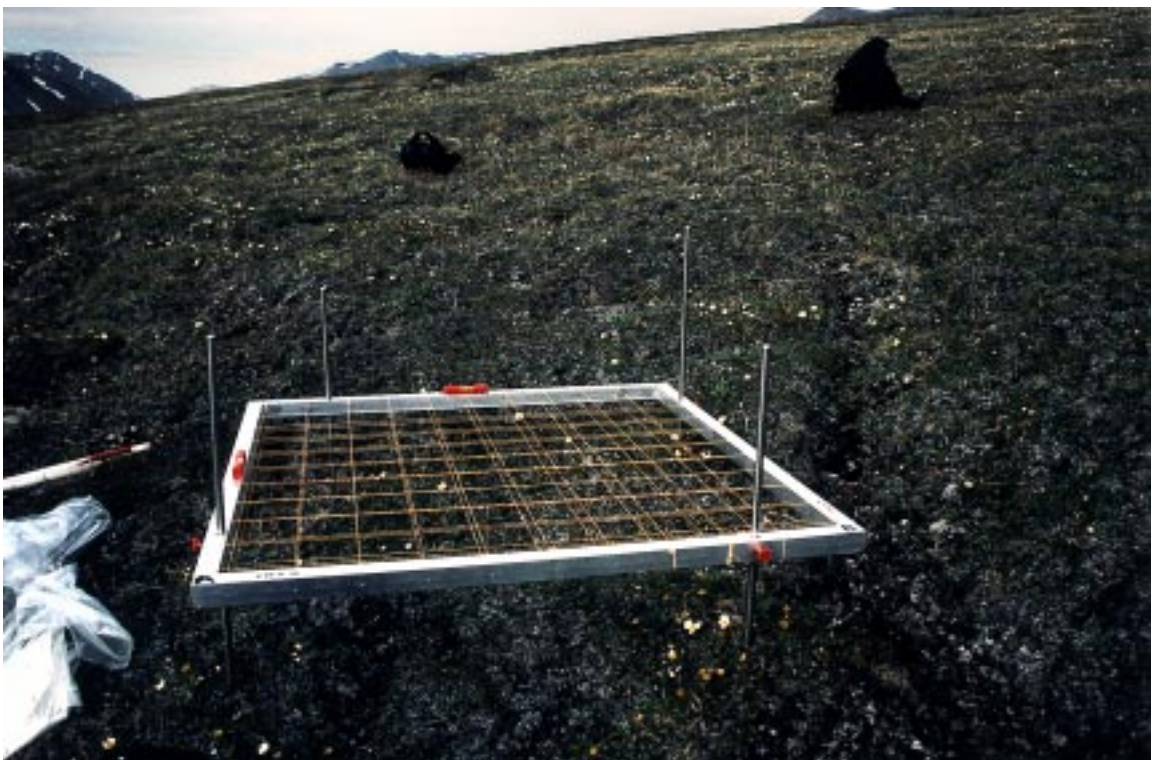


Figure 9. *Dryas* heath on southwest facing slope of Aucellabjerg.

3.2.5. *Vaccinium uliginosum* heath

Locally on south or west exposed slopes *Vaccinium uliginosum* is the dominating species in some heaths. This type of heath is rare on the east side of Zackenbergelven, but more abundant on the west side and is the dominating type in the westernmost part of the mapped area. Here the heath is fragmented by eroded bedrock.

On the slopes of Aucellabjerg this type occurs typically on south exposed slopes just below the *Dryas* heath and above the *Salix arctica* snowbed. In these zones the snow cover is thinner and the plants are snow-free earlier in the season than in the below-lying snowbeds. In the analysis the cover of shrubs is c. 50%, whereas the moss cover is c. 30%. The biomass is the lowest among the heath types: 168 g/m².

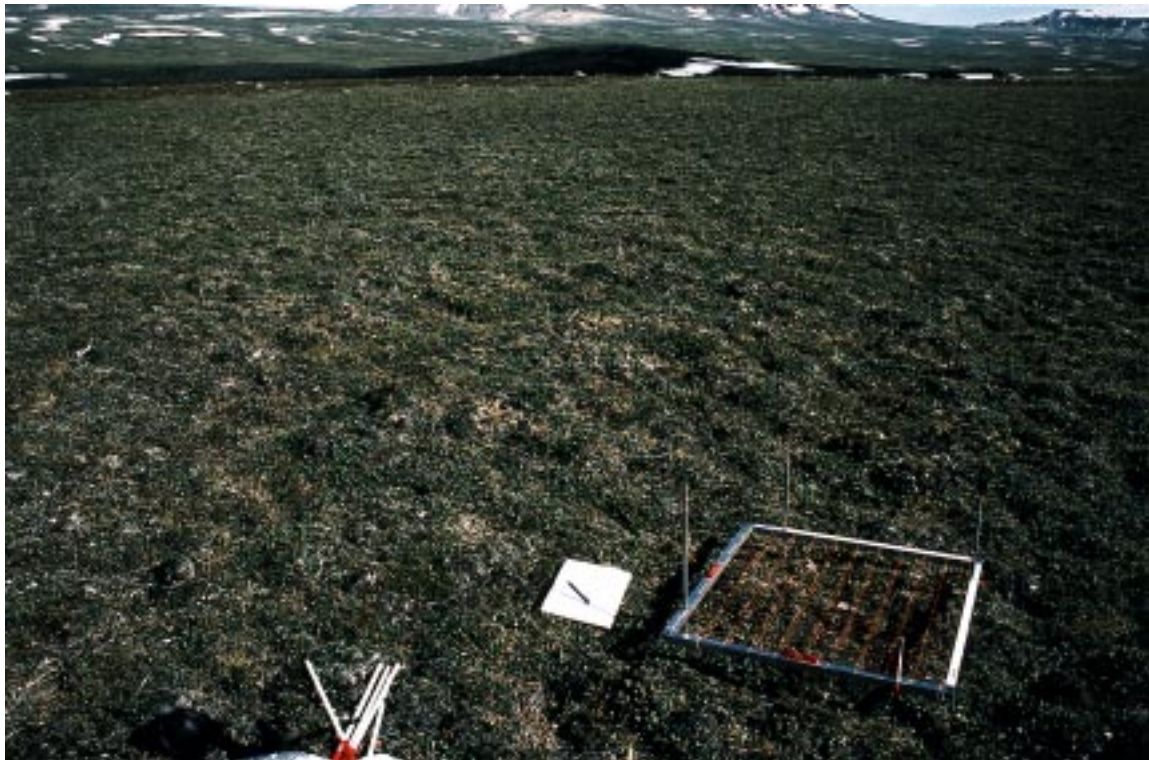


Figure 10. *Salix arctica* snowbed on hummocky soil east of the research station.

3.2.6. *Dryas* heath

Dryas occur as a dominating element in three types of vegetation. 1) On wind exposed places, where the soil is dry, and *Dryas* occurs together with *Kobresia myosuroides*, *Carex rupestris*, and *Poa glauca*. 2) On more snow protected places in the upland above c. 200 metres, where the soil is moist during the season, *Dryas* heath occurs together with *Salix arctica*, *Silene acaulis*, and *Polygonum viviparum*. 3) Above c. 300 metres the plant individuals of *Salix arctica* and *Dryas* become very scarce and this type is mapped as fell-field, because of the low cover of plants.

The cover of vascular plants and mosses in the *Dryas* heath analysis was c. 60% and 5%, respectively. The biomass was among the largest: 214 g/m².

3.2.7. *Salix arctica* snowbed

This type of snowbed, which is unique for East Greenland, occurs mostly on sloping terrain often below the *Cassiope tetragona* belt on the slopes, where the snow cover is more prolonged. The dominating species is *Salix arctica*, and the number of vascular species in the analysis was 9. Accompanying species are *Pedicularis hirsuta*, *Luzula arctica*, *Arctagrostis latifolia*, and *Eriophorum triste*. A cover of mosses or organic crust occur, where the *Salix arctica* cover is open and here follows *Alopecurus alpinus*, *Stellaria crassipes*, *Luzula confusa*, *L. arctica*, and *Poa arctica*. An average biomass of 76 g/m² is among the lowest recorded.



Figure 11. Abrasion plateau on top of a moraine hill northeast of the research station.

In addition to the widely distributed *Salix arctica* snowbed two snowbed types known from other parts of Greenland - early and late snowbed - were found in few places and always only occupying few square metres. The early snow-free type was found on west, south and east facing slopes. The characteristic species are: *Erigeron humilis*, *Taraxacum arcticum*, *Oxyria digyna*, *Salix herbacea*, *Ranunculus pygmaeus*, and *Salix arctica*. Late snow-free snowbeds are more rare and have a low cover of *Carex lachenalii*, *Phippisia algida*, and *Salix arctica*.

3.2.8. Abrasion plateau

This plant community is characterised by a low plant cover, less than 5%, on extremely dry soils. Abrasion plateaus occur in wind exposed sites and are either snow-free or have a very thin snow

cover during winter. Floristically they are characterised by species associated with dry soils and a low snow cover: *Kobresia myosuroides*, *Potentilla rubricaulis*, *Poa abbreviata*, *Potentilla hookeriana*, and *Carex nardina*. They are mostly found in the lowland especially on ridges and tops of the moraine hills (Oksebakkerne). The largest vascular diversity and the smallest biomass are found in this type: 14 and 20 g/m², respectively.

3.2.9. Fell-field

In the upland above 300 m a.s.l. on moist soils the landscape is dominated by another type of open plant community with a vascular plant cover less than 5%. These areas are presumably covered by a thicker snow cover than abrasion plateaus. *Dryas*, *Salix arctica*, and *Cerastium arcticum* are the most frequent species, but several special occur mostly by single individuals in the study area: *Potentilla hookeriana*, *Papaver radicum*, *Luzula confusa*, and *Melandrium triflorum*.



Figure 12. Fell-field at 600 m elevation on the slopes of Aucellabjerg (Photo: B. Fredskild)

3.2.10. Lake

This type comprises only one big lake by the coast on the east side of Zackenbergelven. Only three aquatic vascular plant species are found in the study area: *Pleuropogon sabinei*, *Hippuris vulgaris*, and *Ranunculus hyperboreus*.

3.2.11. River bed

Only Zackenbergelven and a small river bed in the western part are big enough to be depicted on the vegetation map. The delta by the outlet in Young Sund is included in this type.

3.2.12. Snow bank

The prevailing northerly wind direction during the season where the precipitation falls as snow is reflected by the dominant direction of the snow banks (Meltofte & Thing 1997). The snow is accumulated in lee as narrow bands in a east-west direction on the south facing slopes of Aucellabjerg and the moraine hills.

4. Acknowledgements

I am indebted to Fiona Danks, University of Alaska, Fairbanks, for assisting by the time consuming vegetation analyses and the ground truthing of the aerial photo.

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Table 1. Mapped plant communities. Key and associated vascular plant species are given.

Plant communities	Key vascular plant species	Associated vascular plant species
Fen	<i>Dupontia psilosantha</i> <i>Eriophorum scheuchzeri</i>	<i>Salix arctica</i> / <i>Polygonum viviparum</i> / <i>Arctagrostis latifolia</i> / <i>Saxifraga cernua</i>
Grassland	<i>Arctagrostis latifolia</i> <i>Eriophorum triste</i>	<i>Carex bigelowii</i> / <i>Carex saxatilis</i> / <i>Alopecurus alpinus</i> / <i>Salix arctica</i> / <i>Polygonum viviparum</i> / <i>Pedicularis</i> <i>hirsuta</i>
Salt marsh	<i>Carex subspathacea</i> <i>Puccinellia phryganodes</i>	<i>Stellaria humifusa</i>
<i>Cassiope tetragona</i> heath	<i>Cassiope tetragona</i>	<i>Salix arctica</i> / <i>Luzula arctica</i> / <i>Dryas</i> spp. / <i>Luzula confusa</i> / <i>Poa arctica</i> / <i>Polygonum viviparum</i> / <i>Stellaria</i> <i>longipes</i> / <i>Pedicularis hirsuta</i> / <i>Cardamine bellidifolia</i> / <i>Hierochloë</i> <i>alpina</i> / <i>Cerastium arcticum</i>
<i>Vaccinium uliginosum</i> heath	<i>Vaccinium uliginosum</i>	<i>Cassiope tetragona</i> / <i>Dryas</i> spp. / <i>Salix</i> <i>arctica</i> / <i>Poa arctica</i> / <i>Tofieldia</i> <i>coccinea</i> / <i>Carex rupestris</i> / <i>Carex</i> <i>capillaris</i> / <i>Luzula confusa</i> / <i>Luzula</i> <i>arctica</i> / <i>Stellaria longipes</i> / <i>Cerastium</i> <i>arcticum</i>
<i>Dryas</i> heath	<i>Dryas</i> spp.	<i>Carex rupestris</i> / <i>Salix arctica</i> / <i>Polygonum viviparum</i> / <i>Poa arctica</i> / <i>Luzula confusa</i> / <i>Polygonum viviparum</i> / <i>Papaver radicum</i> / <i>Silene acaulis</i> / <i>Alopecurus alpinus</i> / <i>Hierochloë alpina</i> / <i>Stellaria longipes</i> / <i>Minuartia biflora</i> / <i>Potentilla hyparctica</i>
<i>Salix arctica</i> snowbed	<i>Salix arctica</i>	<i>Dryas</i> spp. / <i>Arctagrostis latifolia</i> / <i>Eriophorum triste</i> / <i>Luzula arctica</i> / <i>Luzula confusa</i> / <i>Pedicularis hirsuta</i> / <i>Alopecurus alpinus</i> / <i>Stellaria longipes</i> / <i>Poa arctica</i> / <i>Potentilla hyparctica</i>
Abrasion plateau	<i>Dryas</i> spp. <i>Kobresia myosuroides</i>	<i>Carex rupestris</i> / <i>Salix arctica</i> / <i>Kobresia myosuroides</i> / <i>Carex supina</i> / <i>Arenaria pseudofrigida</i> / <i>Saxifraga</i> <i>nivalis</i> / <i>Potentilla rubricaulis</i> / <i>Potentilla hookeriana</i> / <i>Poa glauca</i> / <i>Melandrium triflorum</i> / <i>Draba nivalis</i> / <i>Lesquerella arctica</i> / <i>Cerastium</i> <i>arcticum</i>
Fell-field	<i>Salix arctica</i> <i>Dryas</i> spp.	<i>Cerastium arcticum</i> / <i>Potentilla</i> <i>hookeriana</i> / <i>Poa abbreviata</i> / <i>Luzula</i> <i>confusa</i> / <i>Papaver radicum</i> / <i>Poa</i> <i>glauca</i> / <i>Melandrium triflorum</i> / <i>Festuca</i> <i>brachyphylla</i>

Table 2. Classification of the vegetation. For each plant community the following is listed: key vascular plant species, cover, biomass, and the relation to landscape parameters.

Type no.	Plant community	Key vascular plant species	Number of vascular plant species	Cover (%) of vascular plants / mosses / lichens	Biomass of vascular plants (g/m ²)	Low/Upland	Soil moisture	Terrain
1	Fen	<i>Dupontia psilosantha</i> <i>Eriophorum scheuchzeri</i>	6	25 / 63 / 0	134	Lowland	Wet	Level terrain
2	Grassland	<i>Arctagrostis latifolia</i> <i>Eriophorum triste</i>	7	15 / 98 / 1	37	Lowland	Wet - moist	Level and sloping terrain
3	Salt marsh	<i>Carex subspathacea</i> <i>Puccinellia phryganodes</i>	3	73 / 0 / 0	102	Lowland	Wet	Level terrain
4	<i>Cassiope tetragona</i> heath	<i>Cassiope tetragona</i>	13	57 / 8 / 3	266	Lowland	Moist	Level and sloping terrain
5	<i>Vaccinium uliginosum</i> heath	<i>Vaccinium uliginosum</i>	12	57 / 31 / <1	168	Lowland	Moist	South facing slopes
6	<i>Dryas</i> heath	<i>Dryas</i> spp.	13	62 / 5 / <1	214	Mostly upland	Dry - moist	Sloping and level terrain
7	<i>Salix arctica</i> snowbed	<i>Salix arctica</i>	9	27 / 14 / <1	76	Lowland and upland	Moist	Level and sloping
8	Abrasion plateau	<i>Kobresia myosuroides</i>	14	3 / <1 / <1	20	Lowland	Extremely dry	Level terrain
9	Fell-field	<i>Salix arctica</i>	-	-	-	Upland	Dry - Moist	Sloping terrain

6. Appendix 1. Plot data

Vegetation analysis: 97-1

Plant community: *Cassiope tetragona* heath

Dato: 29.7.97

Position: Zackenberg, northeast of station, 35 m.a.s.l.

GPS-position: 74°28'26'' N; 20°33'07.1'' W.

Level ground, moist soil

Average vegetation height: < 5 cm.

Photo: Film # 3/22 - 23

Recorder: CB + FD

Vascular species in the plot: *Cassiope tetragona*, *Salix arctica*, *Luzula arctica*, *Dryas*, and *Luzula confusa*.

Other species in the community: *Poa arctica*, *Polygonum viviparum*, *Stelaria longipes*, *Pedicularis hirsuta*, *Cardamine bellidifolia*, *Hierochlo' alpina*, *Draba* sp., and *Cerastium arcticum*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Cassiope tetragona</i>	35	60	40	70	60	53 %
<i>Salix arctica</i>	5	2	3	4	2	3 %
<i>Dryas</i>			<1	<1	1	< 1 %
Total of woody species						57 %
<i>Luzula arctica</i>	<1		<1	<1		< 1 %
<i>Luzula confusa</i>					<1	<1 %
Total of herbs						< 1 %
Total of mosses	5	10	5	10	10	8 %
Total of lichens	2	2	2	5	5	3 %

Vegetation analysis: 97-2Plant community: *Salix arctica* snowbed

Dato: 30.7.97

Position: Zackenberg, eastnortheast of station, 45 m.a.s.l.

GPS-position: 74°28'18.0'' N; 20°32'39.1'' W.

Level ground; moist, micro-hummucky soil

Average vegetation height: < 5 cm.

Photo: Film # 3/17 - 18

Recorder: CB + FD

Vascular species in the plot: *Salix arctica*, *Dryas*, *Cassiope tetragona*, *Luzula arctica*, *L. confusa*, *Poa arctica*, *Arctagrostis latifolia*, and *Alopecurus alpinus*.

Other species in the community: *Potentilla hyperctica*, *Hierochlo' alpina*, and *Stellaria longipes*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Salix arctica</i>	30	35	25	25	20	27
<i>Dryas</i>	<1	<1	<1			<1
<i>Cassiope tetragona</i>			<1			<1
Total of woody species						29
<i>Luzula arctica</i>	<1		<1		<1	<1
<i>Luzula confusa</i>				<1		<1
<i>Alopecurus alpinus</i>				<1		<1
<i>Arctagrostis latifolia</i>		<1				<1
<i>Poa arctica</i>					<1	<1
Total of herbs						<5
Total of mosses	5	15	10	20	20	14
Total of lichens	<1	<1	<1	<1	1	<1

Vegetation analysis: 97-3

Plant community: Grassland

Dato: 2.8.97

Position: Zackenberg, northeast of air strip, 45 m.a.s.l.

GPS-position: 74°28'14.9'' N; 20°33'28.5'' W.

Level ground, moist soil

Average vegetation height: 7 cm.

Photo: Film # 3/5-6

Recorder: CB + FD

Vascular species in the plot: *Salix arctica*, *Arctagrostis latifolia*, *Eriophorum triste*, *Alopecurus alpinus*, *Equisetum arvense*, and *Polygonum viviparum*.

Other species in the community: *Juncus biglumis* and *Saxifraga cernua*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Salix arctica</i>	<1	<1		<1	1	<1
Total of woody species	<1	<1		<1	1	<1
<i>Arctagrostis latifolia</i>	10	10	15	20	15	14
<i>Polygonum viviparum</i>	<1	<1	<1			<1
<i>Eriophorum triste</i>	<1					
<i>Alopecurus alpinus</i>	<1					
<i>Equisetum arvense</i>	<1					
Total of herbs	<11	<11	<16	20	15	<15
Total of mosses	95	100	100	95	100	98
Total of lichens					<1	<1

Vegetation analysis: 97-4

Plant community: Fen

Date: 4.8.97

Position: Zackenberg, south of air strip, 30 m.a.s.l.

GPS-position: 74°28'04.9'' N; 20°33'55.5'' W.

Level ground, wet soil

Average vegetation height: 20 cm.

Photo: Film # 3/1-3

Recorder: CB + FD

Vascular species in the plot: *Dupontia psilosantha*, *Eriophorum scheuchzeri*, and *Salix arctica*.Other species in the community: *Arctagrostis latifolia*, *Saxifraga cernua*, and *Polygonum viviparum*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Salix arctica</i>	<1	<1	<1	<1	<1	<1
Total of woody species	<1	<1	<1	<1	<1	<1
<i>Dupontia psilosantha</i>	25	25	20	20	20	22
<i>Eriophorum scheuchzeri</i>	1	5	2	3	2	3
Total of herbs	26	30	22	23	22	25
Total of mosses	60	75	50	50	80	63
Total of lichens	-	-	-	-	-	-

Vegetation analysis: 97-5Plant community: Open *Dryas* vegetation

Date: 8.8.97

Position: Zackenberg, east of air strip, 30 m.a.s.l.

GPS-position: 74°28'33.5'' N; 22°31'74.4'' W.

Southeast facing (0-2%) ground; moist, hummocky soil.

Average vegetation height: 2-5 cm.

Photo: Film # 3/10-15

Recorder: CB + FD

Vascular species in the plot: *Dryas* spp., *Salix arctica*, and *Kobresia myosuroides*.Other species in the community: *Alopecurus alpinus*, *Carex rupestris*, *Poa glauca*, *Melandrium triflorum*, *Potentilla hyparctica*, *Festuca brachyphylla*, *Pedicularis hirsuta*, *Luzula confusa*, *Draba* sp., *Papaver radicum*, and *Cerastium arcticum*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Salix arctica</i>	<1	4	5	3	3	3
<i>Dryas</i> spp.	10	12	25	2	45	19
Total of woody species	10	16	27	5	48	22
<i>Kobresia myosuroides</i>	4	3	1	5	<1	<3
Total of herbs	4	3	1	5	<1	<3
Total of mosses	1	1	2	4	<1	2
Total of lichens	<1	<1	<1	1	<1	<1

Vegetation analysis: 97-6Plant community: *Vaccinium uliginosum* heath

Dato: 10.8.97

Position: Zackenberg, northwest of Zackenberghytten, 10 m.a.s.l.

GPS-position: 74°28'7.1'' N; 20°38'34.7'' W.

Moist soil on south facing (0-5°) ground.

Cover of stones and boulders: 20%

Average vegetation height: <5 cm.

Photo: Film # 5/29, 30

Recorder: CB + FD

Vascular species in the plot: *Vaccinium uliginosum* ssp. *microphyllum*, *Cassiope tetragona*, and *Dryas* spp.

Other species in the community: *Poa arctica*, *Salix arctica*, *Tofieldia coccinea*, *Carex capillaris*, *C. rupestris*, *C. misandra*, *Luzula confusa*, *L. arctica*, *Stellaria longipes*, and *Cetraria nivalis*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Vaccinium uliginosum</i>	35	65	15	60	50	45
<i>Cassiope tetragona</i>	3	1	15	10	20	10
<i>Dryas</i> spp.	2	<1	5		<1	<1
<i>Salix arctica</i>				2		<1
Total of woody species	40	66	35	72	70	57
Total of mosses	10	25	50	40	30	31
Total of lichens	1	1	<1	1	<1	<1

Vegetation analysis: 97-7

Plant community: Abrasion plateau

Dato: 12.8.97

Position: Zackenberg, northeast of air strip, hill east of "Kamelen", 80 m.a.s.l.

GPS-position: 74°29'13.9'' N; 20°31'47.7'' W.

Top of morain hill, level ground, dry soil

Average vegetation height: 3 cm.

Photo: Film # 5/18, 19

Recorder: CB + FD

Vascular species in the plot: *Salix arctica*, *Dryas* spp., *Kobresia myosuroides*, *Potentilla hookeriana*, *Carex nardina*, and *C. supina* ssp. *spaniocarpa*.

Other species in the community: *Carex rupestris*, *Arenaria pseudofrigida*, *Saxifraga nivalis*, *Poa glauca*, *Melandrium troflorum*, *Draba nivalis*, *Lesquerella arctica*, and *Cerastium arcticum*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Dryas</i> spp.		1		<1	<1	<1
<i>Salix arctica</i>	<1					<1
Total of woody species	<1	1		<1	<1	<1
<i>Carex supina</i>			3	1	2	1
<i>Kobresia myosuroides</i>	<1					<1
<i>Carex nardina</i>	2	2				<1
<i>Potentilla hookeriana</i>			1			<1
Total of herbs	2	2	2	2	2	2
Total of mosses	<1	<1		<1	<1	<1
Total of lichens	<1	<1	<1	<1	<1	<1

Vegetation analysis: 97-8

Plant community: Salt marsh

Dato: 13.8.97

Position: By the outlet of Zackenbergelven, at sea level.

GPS-position: 74°27'43.9'' N; 20°34'37.1'' W.

Level ground, wet soil

Average vegetation height: 2 cm.

Photo: Film # 5/14-16

Recorder: CB + FD

Vascular species in the plot: *Carex subspathacea* and *Puccinellia phryganodes*.Other species in the community: *Stellaria humifusa*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Carex subspathacea</i>	55	60	50	65	60	58
<i>Puccinellia phryganodes</i>	25	10	20	10	10	15
Total of herbs	80	70	70	75	70	73

Vegetation analysis: 97-9Plant community: *Dryas* heath

Dato: 16.8.97

Position: Zackenberg, foodhill of Aucellabjerg, 150 m.a.s.l.

GPS-position: 74°29'25.2'' N; 20°29'47.3'' W.

Level ground, moist soil

Average vegetation height: <5 cm.

Photo: Film # 6/18-19

Recorder: CB + FD + LI

Vascular species in the plot: *Dryas* spp., *Salix arctica*, *Carex rupestris*, and *Polygonum viviparum*.Other species in the community: *Poa arctica*, *Luzula confusa*, *Papaver radicum*, *Silene acaulis*, *Alopecurus alpinus*, *Hierochloa alpina*, *Stellaria longipes*, *Minuartia biflora*, and *Potentilla hyparctica*.

Degree of cover

Taxon	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
<i>Dryas</i> spp.	65	55	50	70	50	58
<i>Salix arctica</i>	5	2	3	1	2	3
Total of woody species	70	57	53	71	52	61
<i>Carex rupestris</i>	<1		<1	<1	<1	<1
<i>Polygonum viviparum</i>		2	<1	2	2	1
Total of herbs	<1	2	<1	2	2	1
Total of mosses	3	5	2	10	3	5
Total of lichens	1	<1	1	3	1	1

7. Appendix 2. Biomass data

The above ground live vascular plant biomass has been recorded by harvesting from 1/16 m². The results are given as g/m².

Biomass analysis 97-1

Cassiope tetragona heath

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Cassiope tetragona</i>	182.0	312.8	105.2	270.0	286.4	252.4
<i>Salix arctica</i>						
leaves	4.8	3.6	2.4	3.6	2.4	3.2
twigs	12.0	14.0	5.2	9.6	7.6	9.6
<i>Luzula arctica</i>	5.6	2.4			2.0	2.0
<i>Stellaria longipes</i>	2.0					<1
<i>Poa arctica</i>	<1	<1		<1	<1	<1
<i>Hierochloë alpina</i>		2.0				<1
<i>Luzula confusa</i>			<1	<1		<1
<i>Cardamine bellidifolia</i>					<1	<1

Biomass analysis 97-2

Salix arctica snowbed

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Salix arctica</i>						
leaves + catkins	14.0	26.0	24.8	18.0	16.0	19.6
twigs	24.4	40.8	50.4	33.2	37.2	37.2
<i>Polygonum viviparum</i>	<1	<1	<1		<1	<1
<i>Luzula arctica</i>	5.2	<1	4.0	4.0		<1
<i>Luzula confusa</i>	<1	8.0	4.8	<1	<1	<1
<i>Arctagrostis latifolia</i>	<1				<1	<1
<i>Dryas octopetala</i>	<1			8.0		<1
<i>Poa arctica</i>	<1	<1	3.2	<1		<1
<i>Stellaria longipes</i>	<1	<1	<1	<1		<1
<i>Cardamine bellidifolia</i>	<1					<1
<i>Potentilla hyparctica</i>	<1	<1				<1
<i>Alopecurus alpinus</i>		<1	<1	<1	<1	<1
<i>Saxifraga cernua</i>			<1			<1
<i>Pedicularis hirsuta</i>				<1		<1
<i>Hierochloë alpina</i>				<1		

Biomass analysis 97-3

Grassland

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Salix arctica</i>						
leaves	4.4	6.0	<1	<1		<1
twigs	2.4	3.2	<1			<1
<i>Arctagrostis latifolia</i>	25.6	19.2	19.2	16.8	22.0	20.4
<i>Polygonum viviparum</i>	4.0	<1	<1	<1	<1	<1
<i>Eriophorum triste</i>	<1	<1	<1	<1	<1	<1
<i>Equisetum arvense</i>	<1	<1	<1	<1	<1	<1
<i>Alopecurus alpinus</i>	3.6	4.4	4.4	<1	<1	<1
<i>Equisetum arvense</i>			<1			<1
<i>Saxifraga cernua</i>				<1		<1
<i>Dupontia psilosantha</i>				2.4	<1	<1

Biomass analysis 97-4

Fen

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Dupontia psilosantha</i>	112.0	100.4	130.0	147.2	134.0	124.8
<i>Eriophorum scheuchzeri</i>	4.4	8.0	4.4	8.8	3.6	6.0
<i>Saxifraga cernua</i>	<1		<1	<1	<1	<1
<i>Polygonum viviparum</i>		<1	<1			<1
<i>Stellaria longipes</i>	<1					<1

Biomass analysis 97-5Open *Dryas* vegetation

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Dryas</i> spp.	76.8	360.4	160.8	64.4	140.8	160.6
<i>Salix arctica</i>						
leaves	35.2	<0.5	20.4	10.8	15.6	16.4
twigs	32.4	<0.5	28.0	11.2	18.8	18.1
<i>Kobresia myosuroides</i>	19.6	<0.5	7.2	14.8	14.8	11.3
<i>Alopecurus alpinus</i>	<0.5	<0.5		<0.5	<0.5	<0.5
<i>Festuca brachyphylla</i>	<0.5	<0.5	<0.5	<0.5		<0.5
<i>Poa glauca</i>		5.2			<0.5	1.0
<i>Cerastium arcticum</i>		<0.5				<0.5
<i>Stellaria longipes</i>			<0.5			<0.5
<i>Carex rupestris</i>			<0.5		<0.5	<0.5
<i>Luzula confusa</i>				<0.5	<0.5	<0.5

Biomass analysis 97-6*Vaccinium uliginosum* heath

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Vaccinium uliginosum</i>	65.6	102.4	162.8	36.4	30.8	79.6
<i>Cassiope tetragona</i>	61.6	109.2	46.4	65.2	120.8	80.8
<i>Dryas</i> spp.		<1	<1	<1		<1
<i>Salix arctica</i>						
leaves	3.2			<1	2.4	<1
twigs	3.2			<1	2.8	<1
<i>Poa arctica</i>	<1	<1	<1			<1
<i>Luzula arctica</i>	<1	<1			<1	<1
<i>Stellaria longipes</i>	<1	<1	<1			<1
<i>Carex misandra</i>					<1	<1

Biomass analysis 97-7

Abrasion plateau

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Carex nardina</i>	10.8				2.8	
<i>Poa glauca</i>	<1					<1
<i>Cerastium arcticum</i>	<1					<1
<i>Carex rupestris</i>	<1	<1		<1	<1	<1
<i>Drapa nivalis</i>	<1	<1			<1	<1
<i>Saxifraga nivalis</i>	<1	<1				<1
<i>Melandrium triflorum</i>	<1					<1
<i>Dryas</i> spp.		41.2	<1	<1		8.0
<i>Arenaria pseudofrigida</i>		<1			<1	<1
<i>Potentilla hookeriana</i>		<1			<1	<1
<i>Carex supina</i>		<1	<1	<1	<1	<1
<i>Papaver radicum</i>					<1	<1

Biomass analysis 97-8

Salt marsh

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Carex subspathacea</i>	84.8	32.0	54.4	72.0	131.2	74.9
<i>Puccinellia phryganodes</i>	28.8	62.4	30.4	27.2	12.8	32.3

Biomass analysis 97-9*Dryas* heath

Plant species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
<i>Dryas</i> spp.	187.6	147.6	192.8	219.6	198.0	189.1
<i>Salix arctica</i> leaves	2.4	7.2	<0.5	5.2	5.2	4.0
twigs	12.0	11.6	<0.5	9.2	9.2	10.5
<i>Polygonum viviparum</i>	3.2	6.8	<0.5	3.6	4.8	3.7
<i>Carex rupestris</i>	<0.5	<0.5	<0.5	<0.5		<0.5
<i>Alopecurus alpinus</i>			<0.5	<0.5	<0.5	<0.5
<i>Hierochloë alpina</i>		<0.5	<0.5			<0.5
<i>Poa arctica</i>			<0.5		<0.5	<0.5
<i>Draba</i> sp.		<0.5		<0.5		<0.5
<i>Stellaria longipes</i>			<0.5			<0.5
<i>Luzula confusa</i>				<0.5		<0.5
<i>Carex bigelowii</i>					<0.5	<0.5
<i>Kobresia myosuroides</i>		<0.5			<0.5	<0.5
<i>Potentilla hyparctica</i>					<0.5	<0.5
<i>Silene acaulis</i>		<0.5				<0.5
<i>Minuartia rubella</i>		<0.5				<0.5