Monitoring Ammassalik Vegetation Change 1968/69 – 2007 (MAVC) - Global Warming and Vegetation Change in the coastal low-arctic tundra of Southeast Greenland?

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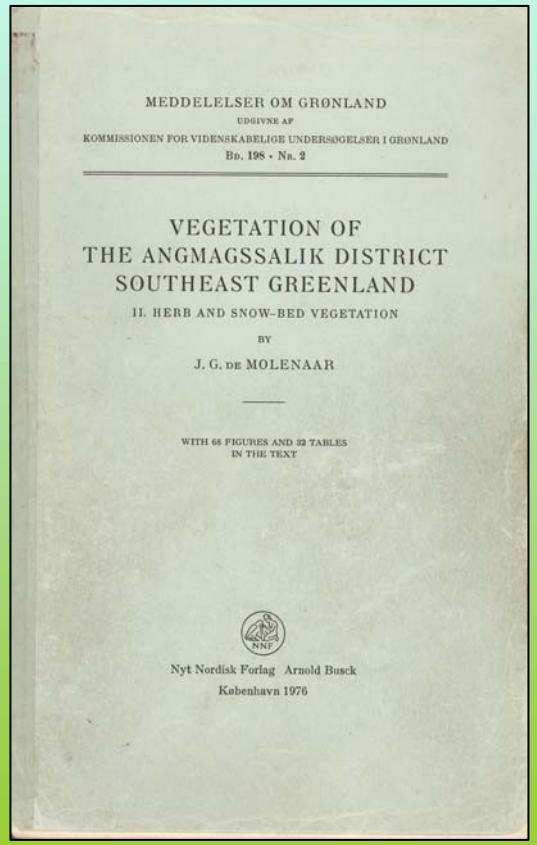
1. MAVC Project and aims
2. Introduction
3. Changes 1968/69 – 2007
4. Methods
5. Preliminary results and conclusions
6. Take home

1. The MAVC-Project Monitoring Ammassalik Vegetation Change

Internet http://www.polarjahr.de/MAVC.268.0html

Question: Change in key plant community types, if so, due to global warming?

Baseline is the phytosociological monographs by de Molenaar and Daniëls from the ends of the 60s published 1976 and 1982 in Meddelelser om Grønland


MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 198 · Nr. 2

VEGETATION OF
THE ANGMAGSSALIK DISTRICT
SOUTHEAST GREENLAND
II. HERB AND SNOW-BED VEGETATION
BY
J. G. DE MOLENAAR

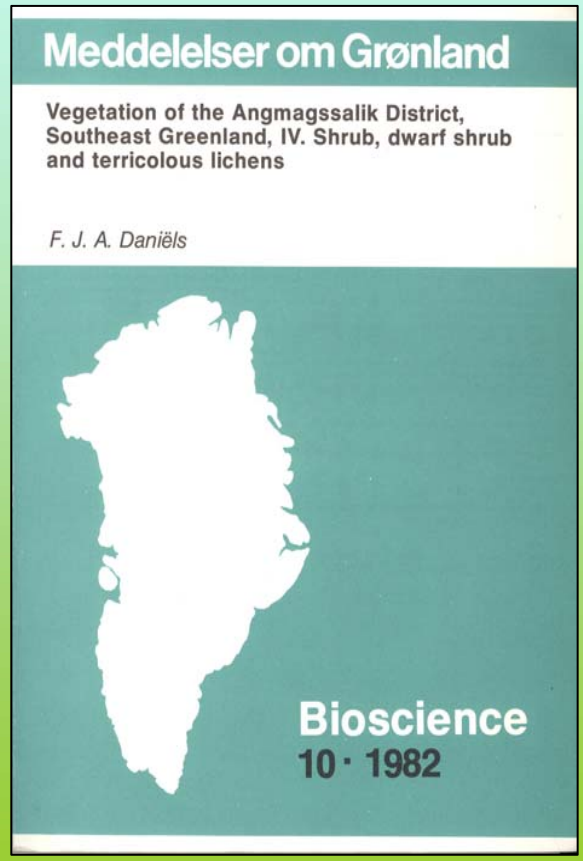
WITH 68 FIGURES AND 32 TABLES
IN THE TEXT

Nyt Nordisk Forlag Arnold Busck
København 1976

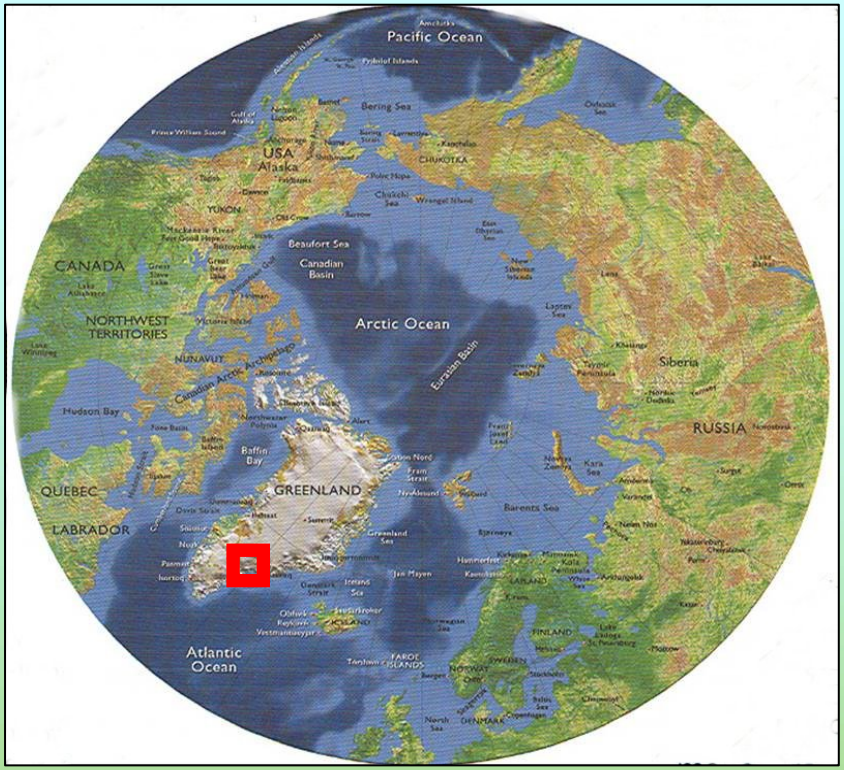
1968/69

2007

Deutsche Forschungsgemeinschaft
DFG



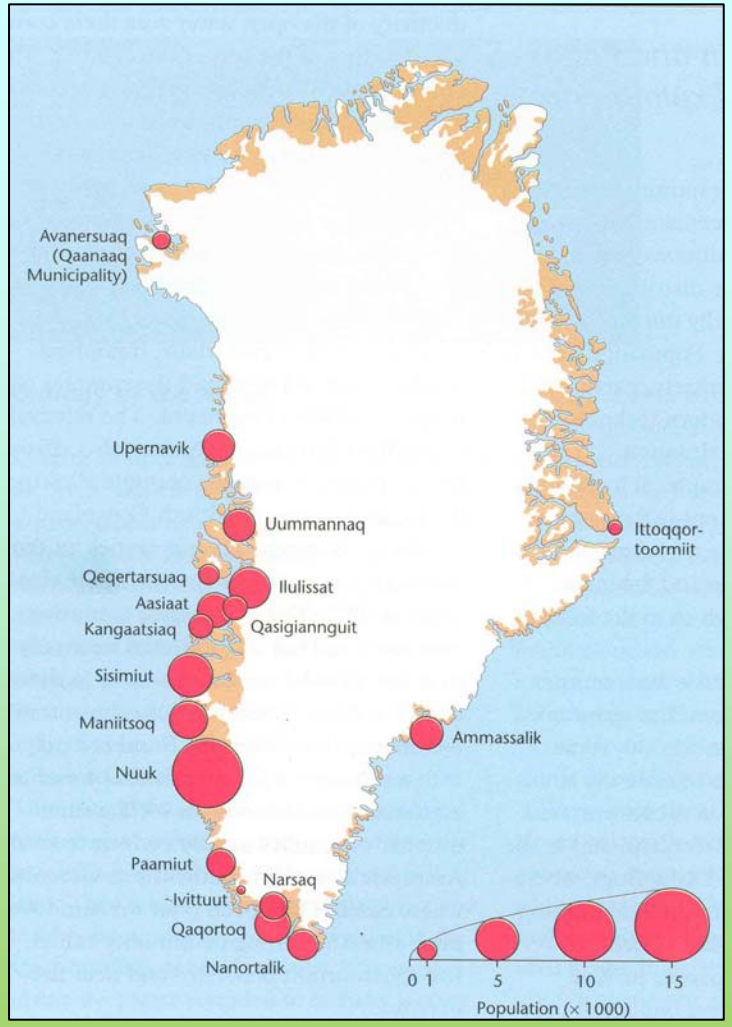
2. Introduction



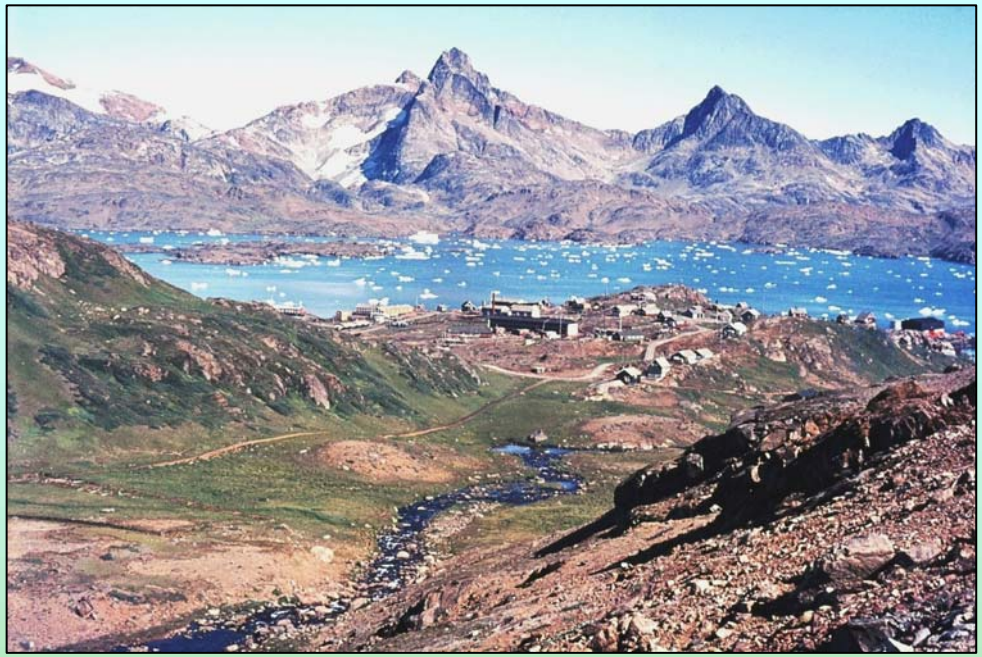
Ca. 65°36‘N, 37°37‘W

Inland Ammassalik, SE Greenland, 1968

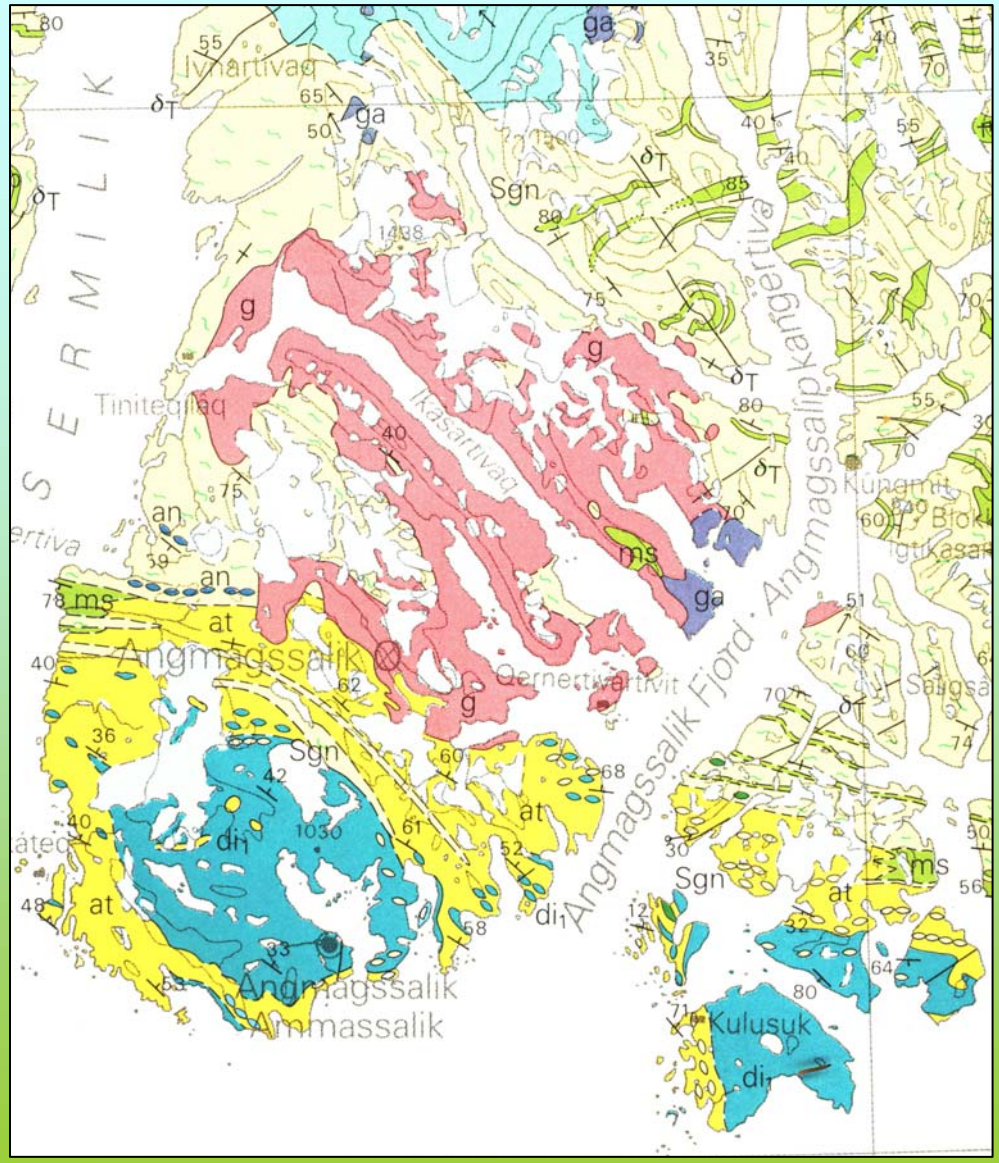
Glacier ice in Denmark Street, 2007



Towns in Greenland



Ammassalik 1968 and 2007



EARLY PROTEROZOIC

- g — GRANITE, GRANODIORITE and DIORITE
- ga — GABBRO

} Post-tectonic, zircon U-Pb age 1685 Ma

- di1 — DIORITE, GRANODIORITE and HYBRID ROCKS
- at — HIGH-GRADE ANATEXITES mainly derived from Sîportôq supracrustal association metasedimentary rocks

} Ammassalik Intrusive Complex, zircon U-Pb age 1885 Ma, patchy late-tectonic deformation, granulite facies

- δa — AMPHIBOLITE fragments of disrupted and altered basic dykes. Scattered occurrences, schematically indicated. Less deformed towards the northern margin of the mobile belt
- di2 — DIORTITE and TONALITE Sm-Nd model age 2200 Ma, locally in granulite facies
- c — MARBLE
- ms — SUPRACRUSTAL ROCKS garnet-sillimanite-graphite-kyanite paragneiss, undifferentiated amphibolites, ultramafic rocks and thin marbles

} Sîportôq supracrustal association, amphibolite facies

Mountainous landscape

Mainly acidic bedrock

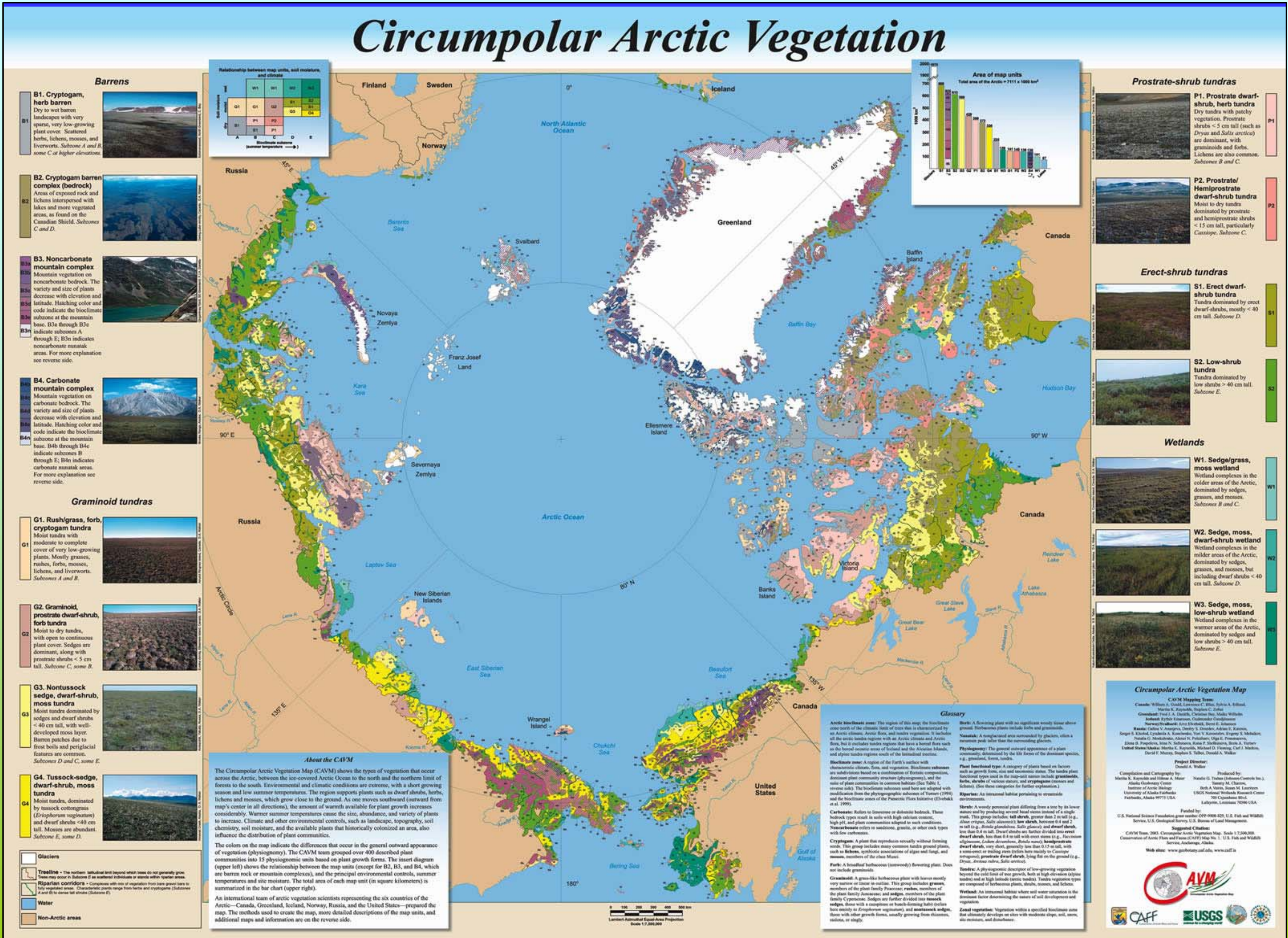
Poor wildlife, terrestric herbivorous mammals absent

Climate oceanic-lowarctic

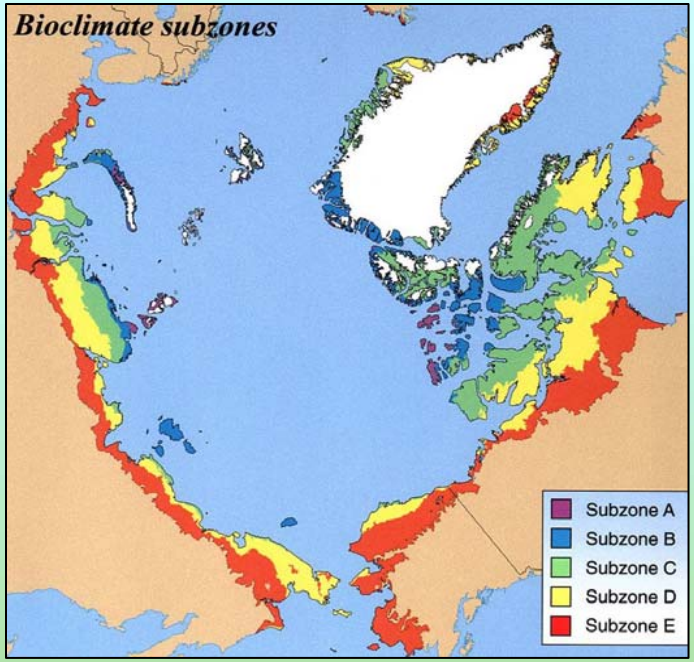
Sporadic, isolated permafrost

Coastal low arctic tundra vegetation complex

Blomsterdalen (Flower valley) in the backyard of Ammassalik 2007: southern exposed slope with Festuco-Salicetum chamaenerietosum, Phyllodoco-Salicetum, Alchemilletum alpinae, Cladonio-Viscarietum


Circumpolar Arctic Vegetation
Barrens
B1. Cryptogam, herb barren
Dry to wet barren landscapes with very sparse, very low-growing plant cover. Scattered herbs, lichens, mosses, and liverworts. Subzone A and B, some C at higher elevations.
B2. Cryptogam barren complex (bedrock)
Areas of exposed rock and lichens interspersed with lakes and more vegetated areas, as found on the Canadian Shield. Subzones C and D.
B3. Noncarbonate mountain complex
Mountain vegetation on noncarbonate bedrock. The variety and size of plants decrease with elevation and latitude. Hatching color and code indicate the bioclimate subzone at the mountain base. B3a through B3e indicate subzones A through E; B3n indicates noncarbonate nunatak areas. For more explanation see reverse side.
B4. Carbonate mountain complex
Mountain vegetation on carbonate bedrock. The variety and size of plants decrease with elevation and latitude. Hatching color and code indicate the bioclimate subzone at the mountain base. B4b through B4e indicate subzones B through E; B4n indicates carbonate nunatak areas. For more explanation see reverse side.
Graminoid tundras
G1. Rush/grass, forb, cryptogam tundra
Moist tundra with moderate to complete cover of very low-growing plants. Mostly grasses, rushes, forbs, mosses, lichens, and liverworts. Subzones A and B.
G2. Graminoid, prostrate dwarf-shrub, forb tundra
Moist to dry tundra, with open to continuous plant cover. Sedges are dominant, along with prostrate shrubs < 5 cm tall. Subzone C, some B.
G3. Nontussock sedge, dwarf-shrub, moss tundra
Moist tundra dominated by sedges and dwarf shrubs < 40 cm tall, with well-developed moss layer. Barren patches due to frost boils and periglacial features are common. Subzones D and C, some E.
G4. Tussock-sedge, dwarf-shrub, moss tundra
Moist tundra, dominated by tussock cottongrass (Eriophorum vaginatum) and dwarf shrubs < 40 cm tall. Mosses are abundant. Subzone E, some D.
Glaciers
Treeline
Riparian corridors
Water
Non-Arctic areas
Relationship between map units, soil moisture, and climate
Bioclimate subzone (summer temperature)
Finland
Sweden
Norway
Iceland
Russia
Greenland
Canada
United States
North Atlantic Ocean
Barents Sea
Kara Sea
Laptev Sea
East Siberian Sea
Chukchi Sea
Bering Sea
Beaufort Sea
Baffin Bay
Hudson Bay
Arctic Ocean
Svalbard
Novaya Zemlya
Franz Josef Land
Severnaya Zemlya
New Siberian Islands
Wrangel Island
Ellesmere Island
Baffin Island
Banks Island
Victoria Island
Great Bear Lake
Great Slave Lake
Lake Athabasca
Reindeer Lake
Gulf of Alaska
Arctic Circle
80° N
0°
180°
90° E
90° W
45° E
45° W
135° E
135° W
Area of map units
Total area of the Arctic = 7111 x 1000 km²
Prostrate-shrub tundras
P1. Prostrate dwarf-shrub, herb tundra
Dry tundra with patchy vegetation. Prostrate shrubs < 5 cm tall (such as Dryas and Salix arctica) are dominant, with graminoids and forbs. Lichens are also common. Subzones B and C.
P2. Prostrate/Hemiprostrate dwarf-shrub tundra
Moist to dry tundra dominated by prostrate and hemiprostrate shrubs < 15 cm tall, particularly Cassiope. Subzone C.
Erect-shrub tundras
S1. Erect dwarf-shrub tundra
Tundra dominated by erect dwarf-shrubs, mostly < 40 cm tall. Subzone D.
S2. Low-shrub tundra
Tundra dominated by low shrubs > 40 cm tall. Subzone E.
Wetlands
W1. Sedge/grass, moss wetland
Wetland complexes in the colder areas of the Arctic, dominated by sedges, grasses, and mosses. Subzones B and C.
W2. Sedge, moss, dwarf-shrub wetland
Wetland complexes in the milder areas of the Arctic, dominated by sedges, grasses, and mosses, but including dwarf shrubs < 40 cm tall. Subzone D.
W3. Sedge, moss, low-shrub wetland
Wetland complexes in the warmer areas of the Arctic, dominated by sedges and low shrubs > 40 cm tall. Subzone E.
About the CAVM
The Circumpolar Arctic Vegetation Map (CAVM) shows the types of vegetation that occur across the Arctic, between the ice-covered Arctic Ocean to the north and the northern limit of forests to the south. Environmental and climatic conditions are extreme, with a short growing season and low summer temperatures. The region supports plants such as dwarf shrubs, herbs, lichens and mosses, which grow close to the ground. As one moves southward (outward from map's center in all directions), the amount of warmth available for plant growth increases considerably. Warmer summer temperatures cause the size, abundance, and variety of plants to increase. Climate and other environmental controls, such as landscape, topography, soil chemistry, soil moisture, and the available plants that historically colonized an area, also influence the distribution of plant communities.
The colors on the map indicate the differences that occur in the general outward appearance of vegetation (physiognomy). The CAVM team grouped over 400 described plant communities into 15 physiognomic units based on plant growth forms. The insert diagram (upper left) shows the relationship between the map units (except for B2, B3, and B4, which are barren rock or mountain complexes), and the principal environmental controls, summer temperatures and site moisture. The total area of each map unit (in square kilometers) is summarized in the bar chart (upper right).
An international team of arctic vegetation scientists representing the six countries of the Arctic—Canada, Greenland, Iceland, Norway, Russia, and the United States—prepared the map. The methods used to create the map, more detailed descriptions of the map units, and additional maps and information are on the reverse side.
Glossary
Lambert Azimuthal Equal-Area Projection
Scale 1:7,500,000
Circumpolar Arctic Vegetation Map
CAVM
CAFF
USGS

Bioclimatic subdivision of the terrestric Arctic biome



Subzone D: Southern arctic dwarf shrub Subzone

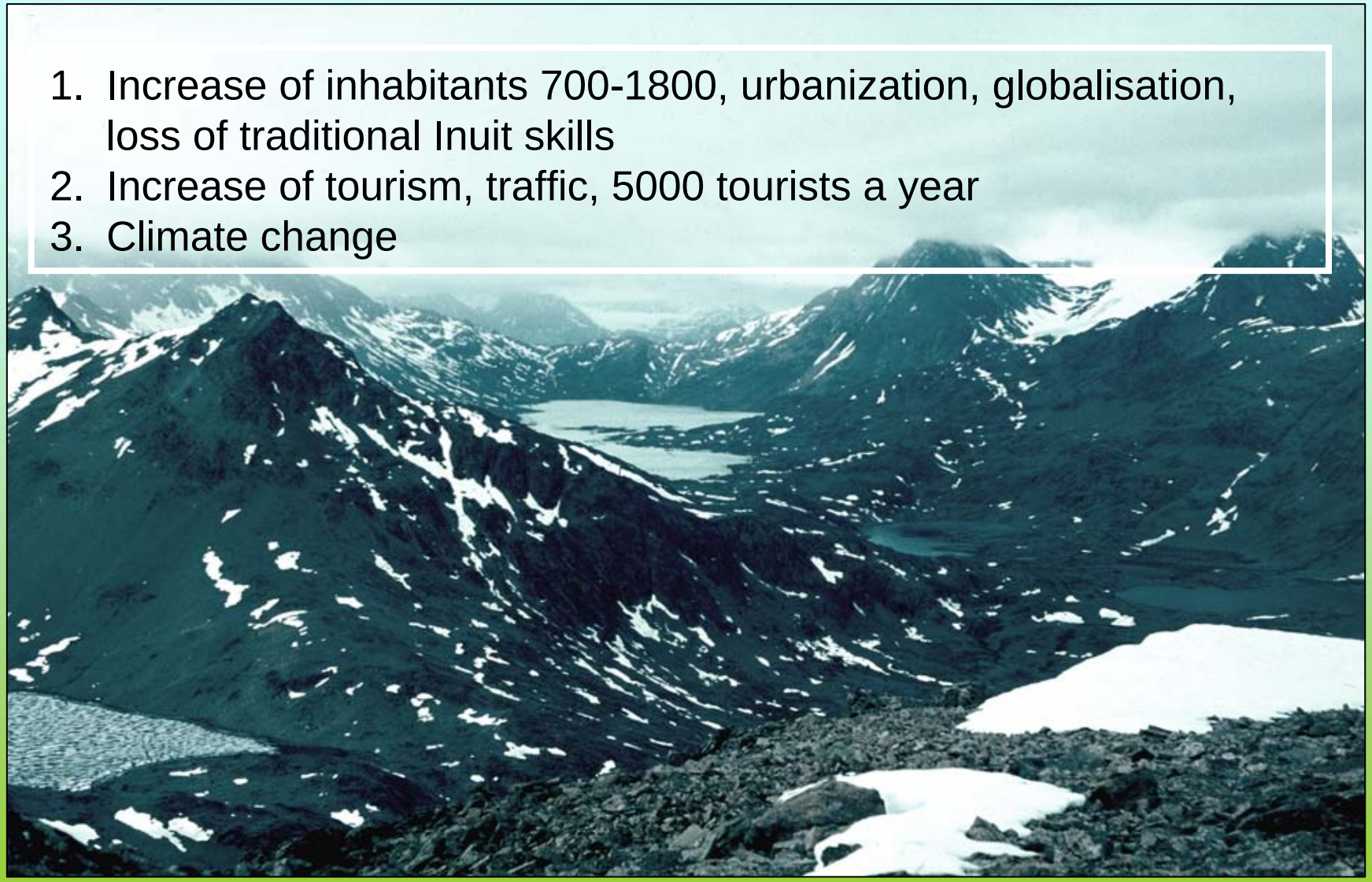
CAVM

Subzone	Mean July Temp[1] (°C)	Summer warmth index[2] (°C)	Vertical structure of plant cover[3]	Horizontal structure of plant cover[3]	Major plant growth forms[4]	Dominant vegetation unit	Total phyto-mass[5] (t ha^{-1})	Net annual production[6] (t ha^{-1} yr^{-1})	Number of vascular plant species in local floras[7]
A	1-3	<6	Mostly barren. In favorable microsites, 1 lichen or moss layer <2 cm tall, very scattered vascular plants hardly exceeding the moss layer	<5% cover of vascular plants, up to 40% cover by mosses and lichens	b, g, r, cf, of ol, c	<3	Units 1 and 2	<0.3	<50
B	4-5	6-9	2 layers, moss layer 1-3 cm thick and herbaceous layer, 5-10 cm tall, prostrate dwarf shrubs <5 cm tall	5-25% cover of vascular plants, up to 60% cover of cryptogams	npds, dpds, b, ns, cf, of, ol	Unit 4	5-20	0.2-1.9	50-100
C	6-7	9-12	2 layers, moss layer 3-5 cm thick and herbaceous layer 5-10 cm tall, prostrate and hemi-prostrate dwarf shrubs <15 cm tall	5-50% cover of vascular plants, open patchy vegetation	npds, dpds, b, ns, cf, of, ol, ehds* * in acidic areas	Unit 5	10-30	1.7-2.9	75-150
D	8-9	12-20	2 layers, moss layer 5-10 cm thick and herbaceous and dwarf-shrub layer 10-40 cm tall	50-80% cover of vascular plants, interrupted close vegetation	ns, nb, npds, dpds, deds, neds, cf, of, ol, b	Units 7 and 9	30-60	2.7-3.9	125-250
E	10-12	20-35	2-3 layers, moss layer 5-10 cm thick, herbaceous/ dwarf-shrub layer 20-50 cm tall, sometimes with low-shrub layer to 80 cm	80-100% cover of vascular plants, closed canopy	dls, ts*, ns, deds, neds, sb, nb, rl, ol *in Beringia	Units 8 and 10	50-100	3.3-4.3	200 to 500

Vegetation features of the subzones of the Arctic (CAVM)

3. Changes 1968/69 - 2007

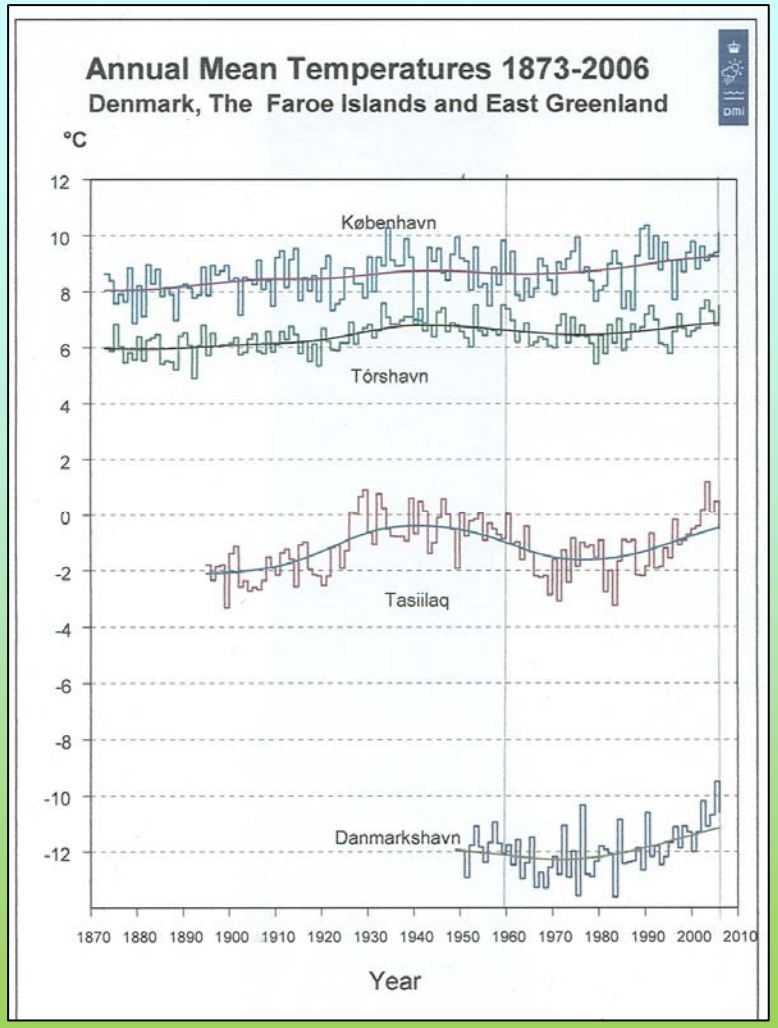
1. Increase of inhabitants 700-1800, urbanization, globalisation, loss of traditional Inuit skills
2. Increase of tourism, traffic, 5000 tourists a year
3. Climate change



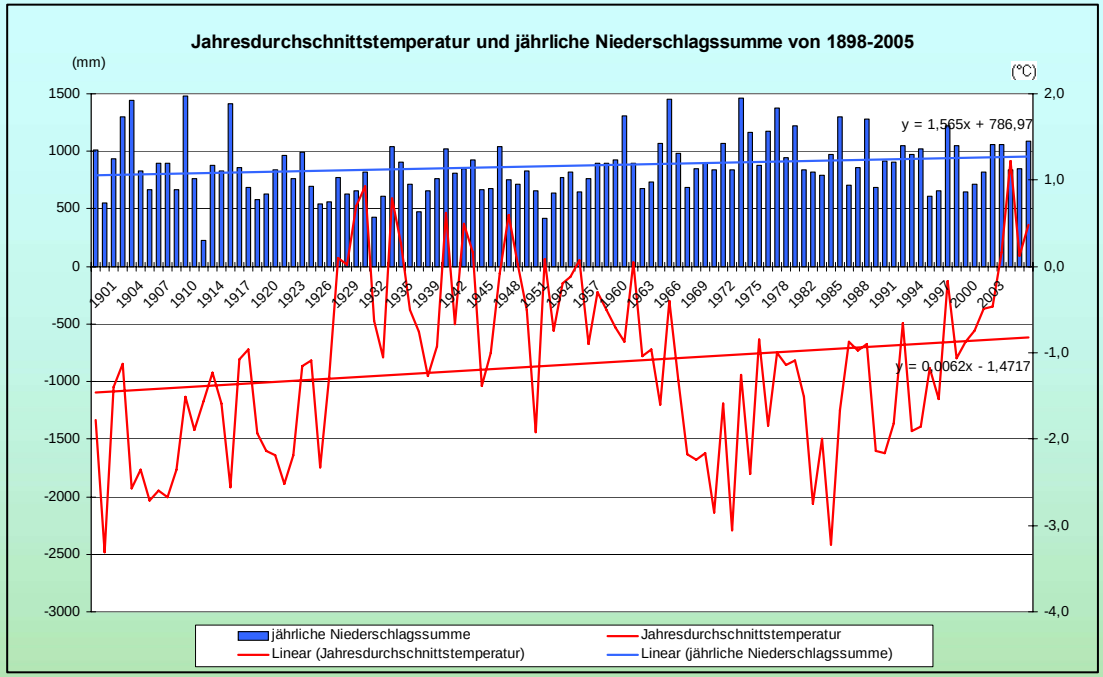
Sømandsfjeld near Ammassalik, 1969

Kajak, Isortoq, Southeast Greenland 1968

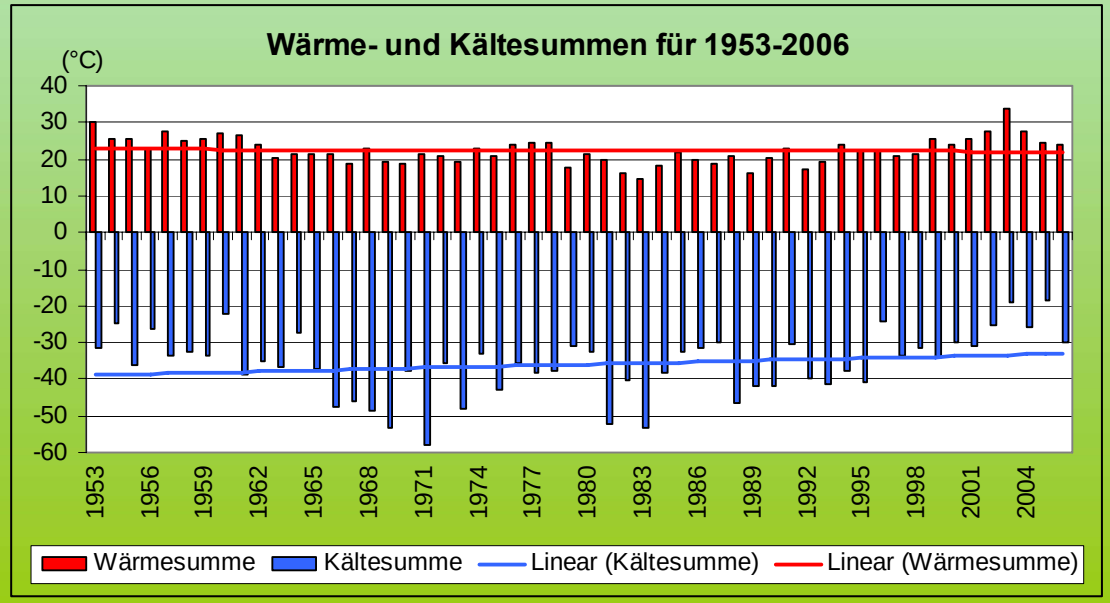
Annual mean T (°C) 1873-2006



Annual mean T (°C) and precipitation (mm) 1898-2006



Summer warmth and winter coldness indices 1953 -2006



Summary of meteorological data of respectively 5, 10 and 15 years preceding the fieldwork periods 1968/1969 and 2007

Number of years		5	5	10	10	15	15
Periods		1963-67	2002-06	1958-67	1997-06	1953-67	1992-06
	Mean annual T (°C)	-1,6	0,3	-1,1	-0,2	-0,9	-0,6
	Mean July T (°C)	6,9	7,5	6,9	7,0	6,8	6,7
	Mean January T (°C)	-7,3	-5,5	-7,3	-5,9	-7,2	-6,8
	Mean T of the warmest month	6,9	8,0	6,9	7,4	7,0	7,0
	Mean T of the coldest month	-9,2	-7,0	-9,4	-7,6	-9,1	-8,0
	Mean annual precipitation (mm)	1007,3	915,1	958,0	886,3	866,8	889,8
For months with mean monthly T > 0°C	Mean monthly T (°C)	4,1	4,6	4,1	4,5	4,4	4,4
	Summer warmth index (°C)	20,9	27,4	22,9	25,4	23,9	23,9
	Number of months with mean monthly T>0°C	5,2	6,0	5,6	5,7	5,6	5,5
	Sum of precipitation (mm) of months with mean T>0°C	289,2	320,1	342,7	320,7	327,4	320,4
For months with mean monthly T ≤0°C	Mean monthly T (°C)	-5,6	-3,9	-5,6	-4,2	-5,4	-4,8
	Winter coldness index (°C)	-39,2	-23,8	-36,6	-28,0	-34,6	-30,9
	Number of months with mean monthly T ≤°C	6,9	6,0	6,4	6,3	6,4	6,5
	Sum of precipitation (mm) of months with mean T≤0°C	718,1	564,6	602,2	571,3	560,1	573,2

4. Methods

1. Resampling of key plant community types:

   Low shrub vegetation: Festuco-Salicetum callicarpaeae

   Lichen-rich grass-herb vegetation: Cladonio-Viscarietum alpinae

   Dwarf shrub heath: Empetrum hermaphroditum-Vaccinium microphyllum community, Phyllodoco-Salicetum callicarpaeae and Sphaerophoro-Vaccinietum microphylli

   Snow bed vegetation: Caricetum bigelowii, Alchemilletum alpinae, Alchemilletum glomerulantis, Polygono-Salicetum herbaceae lophozietosum and Hylocomio-Salicetum herbaceae

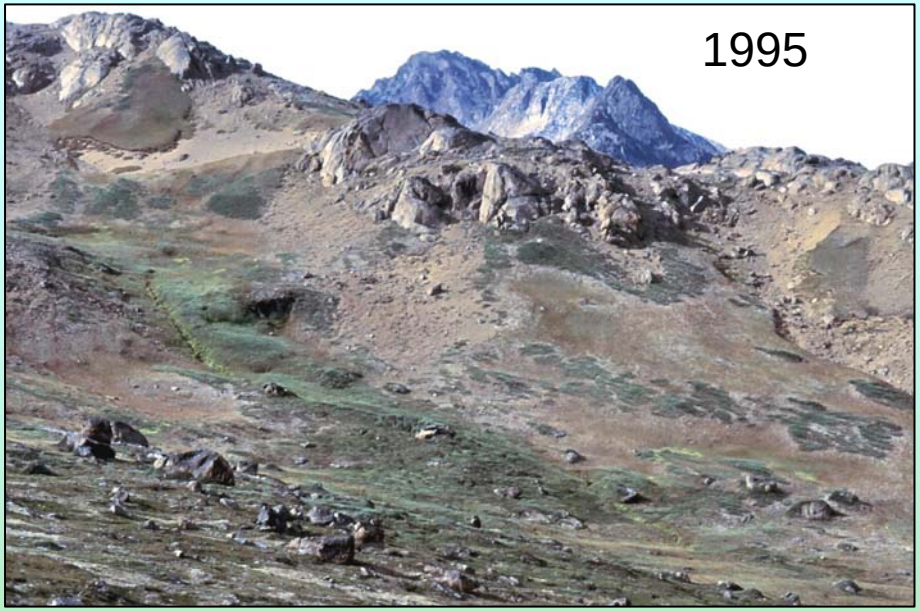
   Mire vegetation: Caricetum rariflorae

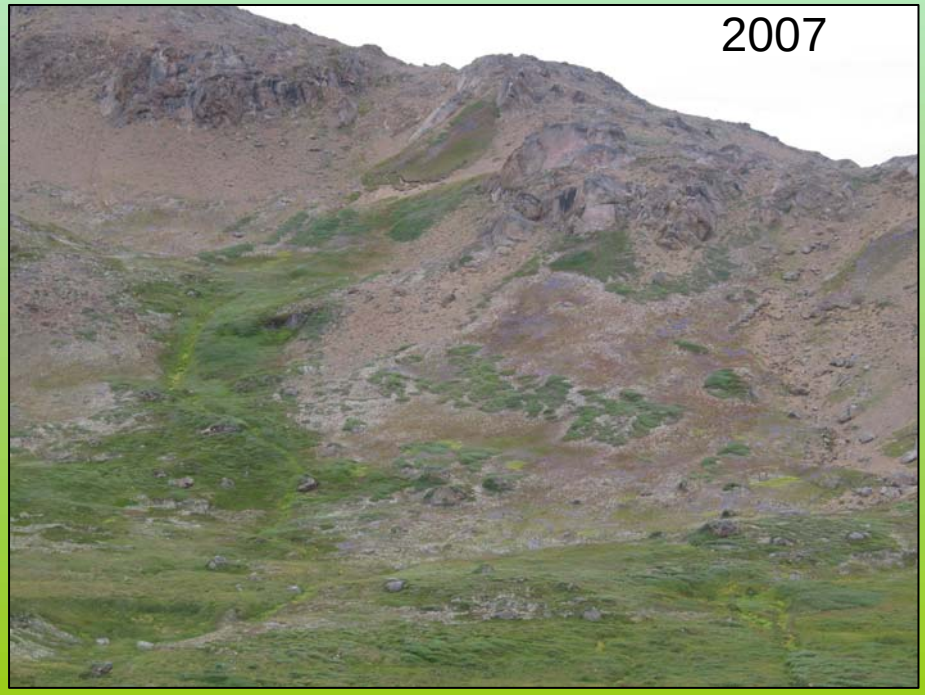
2. Checklist of plant communities from the end of the 60s

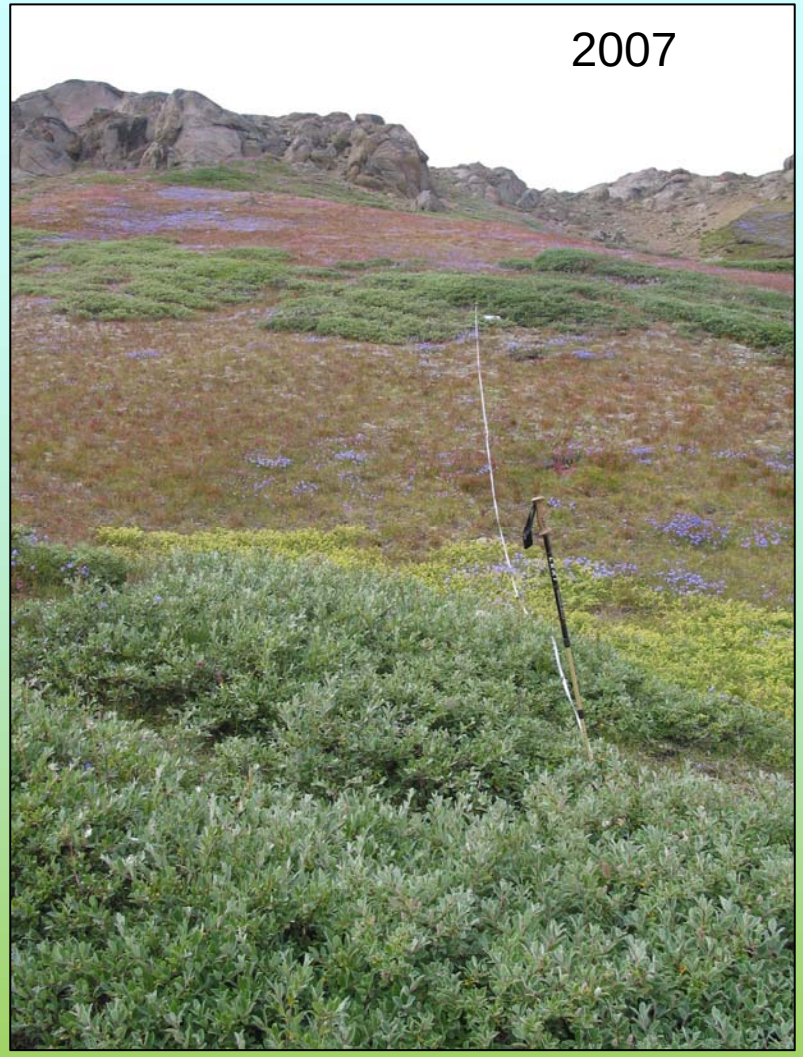
3. Transect studies of typical vegetation pattern on southern slopes (1981 and 2007)

4. Remapping of a small fresh water pond (1969, 2007, Subulariadammen)

Same team, same methods, same localities, if possible same stands and sample plots (at least 10), multivariate analysis of both data sets, incorporation of plant functional types and thermophily index of species, estimation of degree of direct human impact



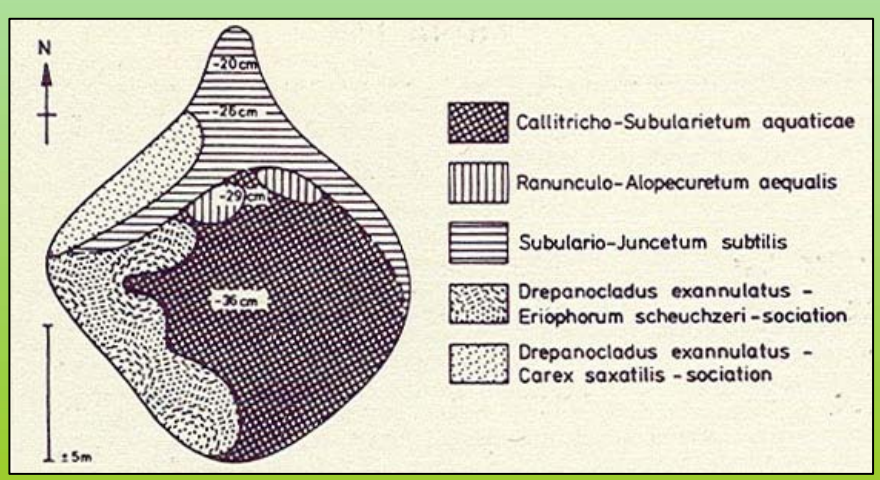




Transect on Praestefjeld 1981-2007

1995

Mapping of Subulariadam 1968 - 2007



Vegetation type map 1969

2007

Comparision of plant community types 1968/69 and 2007 by phytocoenological similarity

Sørensen: 2c / a + b + 2c

Jaccard: c / a + b + c

Dahl: (2 c / a + b) x 100

a= number of species in vegetation type a

b= number of species in vegetation type b

c= number of shared species of vegetation types a and b

Similarities calculated here with species with constancy III, IV and V

5. Preliminary results and conclusions

Cladonio-Viscarietum				
	FD		FD	
Year	6869		2007	
Number of releves	11		11	
Cladonia phyllophora	IV	+/1	V	+/2
Viscaria alpina	V	+/1	IV	+/1
Carex bigelowii	V	+/2	V	+/1
Cetraria islandica	V	+/1	V	+/1
Cladonia arbuscula ssp. mitis	V	+/3	V	1/5
Cladonia ecmocyna	V	+/2	V	+/2
Stereocaulon alpinum	V	+/5	V	1/5
Cladonia gracilis	V	+/1	V	+/1
Luzula spicata	V	+	V	r/1
Stereocaulon paschale	V	+/5	V	1/3
Campanula gieseckiana	V	+/1	V	+/2
Cladonia rangiferina	V	+/2	V	+/2
Cladonia uncialis	V	+/1	V	+/1
Cetraria ericetorum	V	+/1	V	+/1
Chamaenerion angustifolium	IV	+	V	r/1
Barbilophozia hatcheri	V	+/3	IV	+/2
Cerastium alpinum ssp. lanatum	IV	+	V	+/1
Juncus trifidus	IV	+/1	V	+/2
Dicranum scoparium	IV	+/2	IV	+/1
Peltigera malacea	IV	+/1	IV	r/1
Cladonia crispata	IV	+/1	IV	r/2
Salix herbacea	III	+/2	III	r/1
Cladonia macrophyllodes	III	+	III	+/1
Cladonia coccifera	III	+	II	r/+
Ptilidium ciliare	III	+/3	II	+/1
Lepraria neglecta s.l.	II	+	III	+/2
Poa arctica	II	+	II	+/1
Desmatodon latifolius	II	+	II	+/1
Drepanocladus uncinatus	II	+	I	+
Cephaloziella species	III	+		
Brachythecium species	II	+		
Cetrariella delisei	II	+		
Dicranum muehlenbeckii	II	+/1		
Rinodina species	II	+		
Hieracium alpinum	II	+/3	IV	r/1
Thymus drucei	II	+/1	IV	r/3
Trisetum spicatum	+	+	III	r/+
Empetrum nigrum ssp. hermaphroditum			II	r
Erigeron eriocephalus			II	r/1
Agrostis hyperborea			II	+
Veronica fruticans			II	r/1

Slight increase of xerophytic and thermophytic vascular plants

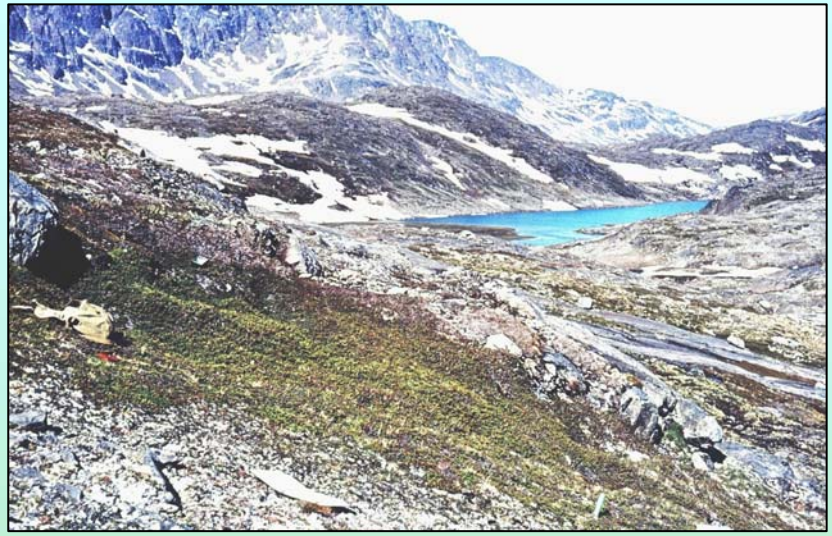
Festuco-Salicetum				
	FD		FD	
Year	6869		2007	
Number of releves	12		11	
Salix glauca ssp. callicarpaea	V	4/6	V	5/6
Chamaenerion angustifolium	V	+/1	V	+/2
Carex bigelowii	V	+/2	V	r/2
Campanula gieseckiana	IV	+/2	V	r/1
Cerastium alpinum	IV	+/1	IV	r/+
Festuca rubra coll.	IV	+/1	IV	r/1
Thalictrum alpinum	IV	+/1	IV	r/1
Taraxacum croceum	III	+/1	IV	r/1
Empetrum nigrum ssp. hermaphroditum	III	+/4	III	1/3
Pyrola minor	III	+/1	III	r/3
Poa arctica	III	+/1	III	+/1
Polygonum viviparum	III	+/2	II	+/2
Cetraria islandica	III	+	II	+
Thymus drucei	II	+/1	II	r/2
Tortula ruralis	II	+	I	+
Rhodiola rosea	II	+	I	1/2
Coptis trifolia	II	+	I	+/1
Poa glauca	II	+	I	+
Luzula spicata	II	+	I	+
Stereocaulon species	III	+		
Cladonia species	II	+		
Cladonia chlorophaea s.l.	II	+		
Vaccinium uliginosum ssp. microphyllum	II	+/4		
Bryum species	II	+		
Poa alpina	I	+/1	III	+/1
Hieracium hyparcticum			II	+/1

1969

2007

Festuco-Salicetum chamaenerietosum
Slight increase of a few vascular plants

Empetrum-Vaccinium community				
	FD		FD	
Year	6869		2007	
Number of releves	10		10	
Empetrum nigrum ssp. hermaphroditum	V	4/6	V	4/6
Salix herbacea	V	+/2	V	+/1
Vaccinium uliginosum ssp. microphyllum	IV	2/4	III	+/4
Carex bigelowii	V	+/1	IV	+/1
Ptilidium ciliare	V	+/3	IV	+/4
Psoroma hypnorum	V	+/1	IV	+/2
Stereocaulon alpinum	IV	+/4	V	+/4
Drepanocladus uncinatus	IV	+/2	V	+/2
Polygonum viviparum	IV	+	V	+/1
Cladonia arbuscula ssp. mitis	IV	+/2	IV	+/1
Cladonia rangiferina	IV	+/2	IV	+/1
Barbilophozia hatcheri	IV	+/4	III	+/2
Cladonia gracilis	IV	+/2	II	+/1
Cladonia ecmocyna	III	+/1	IV	+/1
Dicranum scoparium	III	+/4	IV	+/2
Pohlia nutans	III	+/1	IV	r/1
Cetraria islandica	III	+/1	IV	+/1
Peltigera scabrosa	III	+/1	III	+
Cetraria ericetorum	III	+/1	III	+/1
Cetrariella delisei	III	+	II	+
Cladonia coccifera s.l.	II	+	II	+/1
Lophozia ventricosa	II	+	II	1/2
Cladonia crispata	III	+	I	+
Ochrolechia frigida	II	+	+	+
Cladonia uncialis	II	+	+	+
Dicranum fuscescens	II	+/4	IV	+/2
Salix glauca ssp. callicarpaea	I	+/1	III	+/3
Peltigera malacea	I	+	III	+
Solorina crocea			III	+
Peltigera aphthosa			III	+/1
Stereocaulon paschale	+	1	II	+/1
Juncus trifidus			II	r/+
Poa arctica			II	+
Silene acaulis			II	+
Polytricum alpinum			II	+



1968

2007

Increase of Salix glauca ssp. callicarpaea and some cryptogams

Sphaerophoro-Vaccinietum microphylli

Spaerophoro-Vaccinietum					
Year		6869		2007	
Number of releves		10		10	
Sphaerophorus globosus		V	+ / 1	V	+ / 1
Empetrum nigrum ssp. hermap	L	V	3 / 4	V	1 / 4
Ochrolechia frigida		V	+ / 2	V	+ / 3
Ptilidium ciliare		V	+ / 2	V	+ / 3
Cladonia amaurocraea		V	+ / 1	V	+ / 1
Cladonia gracilis		V	+ / 1	V	+ / 1
Vaccinium uliginosum ssp. mic	L	V	3 / 4	V	1 / 4
Pohlia nutans		V	+	V	+ / 1
Salix herbacea	LO	IV	+ / 3	V	+ / 1
Racomitrium lanuginosum		IV	+/5	V	+ / 5
Cladonia arbuscula ssp. mitis		IV	+ / 1	V	+ / 2
Cladonia coccifera		IV	+	V	+
Cladonia rangiferina		IV	+ / 1	V	+ / 1
Psoroma hypnorum		V	+ / 2	IV	+ / 2
Barbilophozia hatcheri		IV	+ / 1	IV	+ / 1
Cetraria muricata		IV	+	IV	+ / 1
Dicranum fuscescens		IV	+ / 4	IV	1 / 3
Solorina crocea		IV	+	IV	+
Cladonia uncialis		III	+ / 2	V	+ / 1
Stereocaulon alpinum		III	+ / 1	V	+ / 4
Carex bigelowii	L	III	+	IV	+ / 1
Gymnomitrion corallioides		IV	+ / 1	III	+ / 1
Drepanocladus uncinatus		III	+ / 1	IV	+ / 1
Anastrophyllum minutum		IV	+ / 1	III	+ / 2
Dicranum scoparium		IV	+ / 4	III	1 / 2
Polygonum viviparum	A	II	+	IV	+
Peltigera malacea		III	+	III	+
Cetraria islandica		III	+ / 1	III	+
Salix glauca ssp. callicarpaea	L	II	+	III	+
Cetraria ericetorum		III	+ / 1	II	1
Aulacomnium turgidum		III	+	II	+ / 1
Diapensia lapponica	L	III	+	II	+ / 1
Cladonia bellidiflora		II	+	II	+ / 1
Pertusaria oculata		II	+ / 1	III	+ / 1
Polytrichum juniperinum		II	+	II	+
Cladonia crispata		II	+ / 1	II	+
Thamnolia vermicularis		II	+	II	+
Lophozia ventricosa		III	+ / 1		
Alectoria nigricans		III	+	I	1
Cephaloziella species		III	+	I	+
Peltigera aphthosa		III	+ / 1	I	+ / 1
Polytrichum piliferum		III	+	I	+
Lepraria neglecta s.l.		III	+		
Tritomaria quinquedentata		II	+		
!Microlichen indet.		II	+		
Pannaria praetermissa		II	+		
Stereocaulon paschale		II	+ / 2	I	+
Dicranum elongatum		II	1 / 4	I	2 / 3
Cetraria nivalis		II	+ / 2	+	1
Luzula spicata	LO	II	+	+	r
Cynodontium strumiferum		II	+ / 1	+	+
!Microlichen black				IV	+ / 2
Luzula confusa	LO			IV	+
Cetraria crispa				III	+ / 1
Peltigera scabrosa		I	+ / 1	III	+
Cladonia pyxidata				III	+
Crocynia neglecta				II	+
Polytrichum alpinum				II	+
Buellia geophila				II	+
Cladonia lepidota var. stricta				II	r / +
Orthocaulis kunzeanus				II	+ / 1
Stereocaulon species		I	+	II	+ / 1
Huperzia selago	A	+	+	II	+
Nephroma arcticum		+	2	II	+ / 1
Polytrichum hyperboreum		+	+	II	+
Cetrariella delisei		I	+	II	+ / 2

1969

2007

Decrease and increase of different lichens

Polygono-Salicetum loph.	196869		2007	
Salix herbacea	V	1-5	V	4-5
Polygonum viviparum	V	+-3	V	2-3
Drepanocladus uncinatus	V	+-4	V	2-5
Cladonia mitis	V	+-2	V	+-1
Stereocaulon alpinum	V	+-2	V	+-3
Polytrichum alpinum	IV	+-3	V	+-4
Carex bigelowii	IV	2-4	V	1-3
Cladonia rangiferina	IV	+-1	IV	+-1
Cladonia ecmocyna	V	+-2	III	+-1
Barbilophozia hatcheri	III	3-4	V	2-5
Lophozia alpestris/wenzelii	III	+-3	V	+-3
Cetraria islandica	III	1-2	V	+-2
Peltigera aphtosa	III	+-1	V	+-1
Polytrichum juniperinum	III	+	IV	+-1
Cetraria crispa	III	+-1	IV	+-1
Barbilophozia lycopodioides	III	4-5	III	+-3
Ptilidium ciliare	III	+-2	III	+-2
Aulacomnium palustre	III	+-2	III	+
Psoroma hypnorum	III	+-2	III	+-2
Peltigera canina	II	+-2	IV	+-2
Dicranum scoparium	III	+-4	II	+-4
Solorina crocea	III	+	II	+
Bryum cf. elegans/spec.	II	+	III	+
Empetrum hermaphroditum	II	+-1	III	+-2
Hieracium alpinum	II	+-2	III	+-1
Racomitrium lanigunosum	II	+	II	+
Cladonia chlorophea	II	+	II	+
Cetraria delisei	II	+	I	1
Hylocomium splendens	II	+	I	+
Bartramia ithyphylla	I	+	II	+
Oncophorus wahlenbergii	I	+	II	+
Thalictrum alpinum	II	+	I	+
Campanula gieseckiana	I	1	II	+
Trisetum spicatum	I	+	II	+
Cerastium alpinum	III	+	I	+
Cladonia gracilis	III	+-2		
Poa glauca	II	+		
Taraxacum croceum	II	+		
Dicranum elongatum	II	+-1		
Poa arctica	II	+-2	V	+-1
Dicranum fuscescens			V	2-4
Pleurozium schreberi	I	2	III	+-1
Peltigera malacea			III	+-1
Peltigera scabra			III	+-1
Euphrasia frigida			II	+
Oxyria digyna			II	+-1
Orthocaulus kunzeanus			II	2-3
Bartramia ithyphylla/pomif.			II	+
Dicranoweisia crispula			II	+

Polygono-Salicetum herbaceae lophozietosum (7)

2007

Slight increase of mesophytes, xerophytes

Alchemilletum alpinae (11)

Alchemilletum alpinae					
		1968/69		2007	
Alchemilla alpina	LO	V	3/6	V	4/6
Taraxacum croceum	LO	V	+/2	V	+/2
Campanula gieseckiana	L	IV	+/1	V	+/1
Carex bigelowii	L	IV	+/1	V	+/2
Salix herbacea	LO	III	1/4	IV	+/3
Luzula spicata	LO	III	+	IV	+
Chamaenerion angustifolium	BS	V	+/1	III	+
Poa arctica		II	+/1	IV	+/1
Polygonum viviparum	A	II	+/4	III	+/2
Poa alpina	LO	II	+	III	+
Cladonia mitis		III	+	II	+
Desmatodon latifolius		II	+	II	+
Peltigera malacea		II	+	II	+
Thymus drucei	BO	II	1	II	+
Juncus trifidus	LO	II	+/2	II	+/1
Phleum commutatum	LO	II	+	II	+
Polystichum lonchitis	LO	II	2/3	II	2/3
Poa glauca	A	II	+		
Viola palustris	BO	II	+/2		
Sibbaldia procumbens	LO	I	2/4	III	+/3
Bryum cf elegans				II	+
Barbilophozia hatcheri				II	+
Stereocaulon spec.				II	+
Cetraria crispa				II	+
Cladonia chlorophea				II	+
Cladonia ecmocyna				II	+
Cladonia phyllophora				II	+/1
Thalictrum alpinum	LO	II	+/2	I	2
Cystopteris fragilis		II	+	I	+
Cetraria islandica		I	1	II	+
Trisetum spicatum	A	I	+	II	+
Sedum annuum	LO	I	+	II	+
Empetrum hermaphroditum	L	I	+	II	+/1
Cerastium alpinum lanatum	A	I	1	II	+

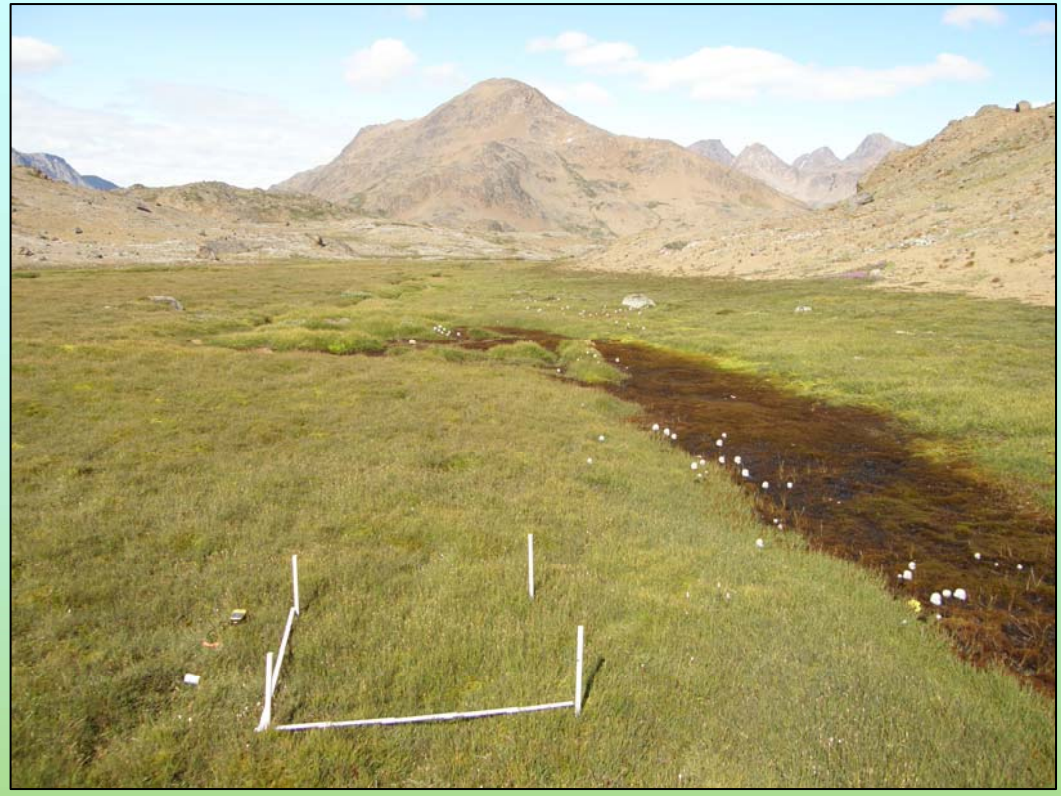
2007 Blomsterdalen

Some increase of mesophytic and xerophytic vascular plant species

Phyllodoco-Salicetum					
Year		1968/69		2007	
Number of releves		13		14	
Empetrum nigrum ssp. h	L	V	3/6	V	3/6
Polygonum viviparum	A	V	+/1	V	+/2
Carex bigelowii	L	V	+	V	+/1
Salix herbacea	LO	V	+/3	V	+/3
Salix glauca ssp. callicar	L	IV	+/1	V	r/4
Bartsia alpina	LO	IV	+/1	IV	+/1
Phyllodoce coerulea	LO	V	+/2	IV	+/3
Vaccinium uliginosum ss	L	IV	1/5	V	2/5
Juncus trifidus	LO	III	+	IV	r/1
Poa arctica		II	+	IV	+
Loiseleuria procumbens	LO	IV	+/1	II	+/1
Cetraria islandica		III	+	III	+/1
Cladonia mitis		III	+	III	+
Stereocaulon alpinum		III	+	III	r/1
Pyrola minor	BS	II	+	III	r/+
Hieracium alpinum	LO	II	+/1	III	+
Thalictrum alpinum	LO	II	+/1	III	+/1
Campanula gieseckiana	L	II	+	III	+
Taraxacum croceum	LO	II	+	III	+/1
Rhodiola rosea	LO	II	+/1	III	+/1
Diphasiastrum alpinum	LO	II	+/2	III	+/2
Cladonia ecmocyna		II	+	III	r/+
Coptis trifolia	BS	II	+	II	+
Sibbaldia procumbens	LO	II	+	II	1
Veronica alpina	B	II	+	II	+
Viola palustris	BO	II	+	II	+/1
Dicranum scoparium		II	+	II	+/1
Peltigera rufescens		II	+	II	+
Poa alpina	LO	II	+	II	+
Trisetum spicatum	A	II	+	II	r/+
Festuca vivipara	LO	II	+	II	r/+
Barbilophozia hatcheri		II	+	I	+/2
Listera cordata	BS	II	+	I	+
Phleum commutatum	LO	II	+	I	r/+
Polytrichum juniperinum		II	+	I	r
Peltigera aphthosa		II	+	I	+/1
Luzula spicata	LO	II	+	I	r/+
Drepanocladus uncinatus		II	+	I	+
Tofieldia pusilla	L	II	+	+	r
Brachythecium species		II	+	+	+
Cetrariella delisei		II	+	+	+
Harrimanella hypnoides	LO	II	+/1		
Gymnomitrion concinnatum		II	+		
Chamaenerion angustifo	BS	I	+	III	+/1
Sphagnum teres		I	+/1	II	+/3
Peltigera malacea		I	+	II	+
Euphrasia frigida	L	I	+	II	r/+
Agrostis borealis		I	+	II	+
Peltigera canina		+	+	II	+
Psoroma hypnorum		+	+	II	+

Phyllodoco-Salicetum callicarpaeae, Blomsterdalen, Ammassalik
2007
Increase of forbs

Caricetum rariflorae		
Number of releves	9	9
	1968/69	2007
Carex rariflora	V.2-4	V.2-5
Salix herbacea	IV.+-2	V.+-3
Paludella squarrosa	V.3-6	V.4-6
Calliergon stramineum	V.2-5	V.+-4
Sphagnum teres	IV.1-4	V.+-4
Polytrichum juniperum	II.+	III.+-3
cf Cephalozia spec.	II.+-1	III.+
Oncophorus wahlenbergi	III.+-2	II.+
Calliergon sarmentosum	II.+-1	II.+-1
Scapania cf uliginosa	II.+-2	II.+
Drepanocladus exannulatus	I.+	II.+-1
Polygonum viviparum	I.+	V.+-1
Drepanocladus uncinatus	I.1	IV.+-3
Calamagrostis neglecta		II.+-1
Empetrum hermaphroditum		II.+



2007

Appearance of mesophytes

Mire vegetation with Caricetum rariflorae

Caricetum bigelowii (12)

Caricetum bigelowii	1968 1969		2007	
Carex bigelowii	V	3-5	V	3-6
Campanula gieseckiana	V	+-4	V	1-4
Cerastium alpinum	V	+-2	V	+-1
Taraxacum croceum	V	+-4	V	1-4
Chamaenerion angustifolium	IV	1-4	V	+-4
Cetraria islandica	IV	+-2	V	+-2
Bryum elegans	IV	+-1	V	+-1
Luzula spicata	IV	+-3	IV	+-3
Barbilophozia hatcheri	III	+-4	V	+-3
Dicranum scoparium	III	+-1	IV	+-3
Stereocaulon alp./paschale	III	+-2	IV	+-2
Cladonia mitis	III	+	IV	+-1
Erigeron uniflorus	II	+	III	+
Hieracium alpinum	II	+	III	+-2
Thymus drucei	II	1	III	+-4
Peltigera 'canina'***	II	+	III	+
Cladonia ecmocyna	II	+-2	III	+-1
Poa alpina	II	+-2	II	+-1
Salix herbacea	II	+-2	II	+-2
Polygonum viviparum	II	+-2	I	1-3
Phleum commutatum	I	+	II	+-1
Viscaria alpina	I	+-1	II	+-1
Veronica fruticans	I	3	II	+
Tortula norvegica	I	+	II	+-1
Thalictrum alpinum	III	+-4	I	2
Poa arctica	I	+	IV	+-1
Desmatodon latifolium	I	+	IV	+-3
Trisetum spicatum	I	+	III	+-1
Cetraria crispa	I	+-2	III	+-2
Cladonia chlorophaea	I	+	III	+-1
Cladonia phyllophora			III	+-1

Increase of xerophytes and thermophytes

Alchemilletum glomerulantis					
		1968/69		2007	
Alchemilla glomerulans	LO	V	4/6	V	4/6
Taraxacum croceum	LO	V	+/4	V	1/3
Phleum commutatum	LO	V	+/1	V	+/1
Polygonum viviparum	A	V	+/3	IV	+/2
Rhodiola rosea	LO	V	+/4	IV	+/4
Bryum capillare		IV	+/2	IV	+/4
Carex bigelowii	L	III	1/2	V	+/2
Ranunculus acris	B	II	+/2	IV	+/2
Thalictrum alpinum	LO	III	1/4	III	+/3
Poa alpina	LO	II	+/2	III	+
Cystopteris fragilis		IV	+/1	II	+
Salix herbacea	LO	III	+/2	II	+/1
Sibbaldia procumbens	LO	II	2	II	+/1
Epilobium anagallidifolia	LO	II	+/3	II	+/1
Bartsia alpina	LO	II	+/1	II	+/2
Gnaphalium norvegicum	LO	II	+	II	+
Marchantia alpestris		II	+/3	II	3/4
Campanula gieseckiana	L	IV	+/1	I	+
Chamaenerion angustifolium	BS	IV	+/3	I	1
Plagiothecium denticulatum		V	+/3		
Desmatodon latifolius		IV	+/1		
Agrostis borealis		II	+		
Alchemilla alpina	LO	II	+		
Erigeron uniflorus	LO	II	+		
Gentiana nivalis	LO	II	+		
Juncus trifidus	LO	II	+		
Luzula spicata	LO	II	+/1		
Polystichum lonchitis	LO	II	+/1		
Potentilla crantzii	LO	II	+/1		
Lophozia alpestris		II	+		
Pyrola minor	BS	I	+	V	+/2
Viola palustre	BO			III	+/2
Brachythecium reflexum				II	
Philonotis tomentella				II	
Empetrum hermaphroditum	L			II	
Epilobium hornemanni	LO			II	
Carex scirpoidea	L	II	1/2	I	+
Epilobium lactiflorum	LO	II	+/1	I	+
Oxyria digyna	A	II	+/3	I	1
Stellaria calycantha	BS	II	+	I	+
Veronica alpina	B	II	+	I	+
Polytrichum juniperinum		II	+	I	+
Poa arctica		I	2	II	+
Chamaenerion latifolium	A	I	+	II	+/1
Salix glauca ssp. callicarpea	L	I	+	II	+
Eurphrasia frigida	L	I	+	II	+
Gymnocarpium dryopteris	BS	I	3	II	

Alchemilletum glomerulantis (8)

2007

Decrease and increase of several boreal herb species

Salix herbacea	V	V
Hylocomium splendens	V	V
Drepanocladus uncinatus	V	V
Peltigera canina	V	IV
Pleurozium schreberi	IV	III
Carex bigelowii	IV	IV
Polygonum viviparum	III	V
Festuca vivipara	III	IV
Oxyria digyna	III	IV
Polytrichum alpinum	IV	II
Ptilidium ciliare	III	V
Stereocaulon spec.	III	V
Polytrichum commune	II	IV
Dicranum fuscescens	II	IV
Barbilophozia hatcheri	II	IV
Cerastium alpinum	III	III
Luzula spicata	III	III
Cetraria crispa	III	II
Cladonia rangiferina	III	II
Aulacomnium turgidum	II	III
Dicranum scoparium	II	III
Timmia austriaca	II	III
Cladonia mitis	II	III
Peltigera aphtosa	II	III
Lophozia cf ventricosa	II	II
Empetrum hermaphroditum	II	II
Silene acaulis	II	II
Tortula ruralis	II	I
Vaccinium microphyllum	I	II
Taraxacum croceum	I	II
Salix glauca callicarpea	I	II
Cladonia gracilis	I	II
Tritomaria quinquedentata	I	II
Climacium dendroides	II	
Poa glauca	II	
Luzula confusa	II	
Barbilophozia lycopodioides	II	V
Polytrichum juniperinum	I	IV
Racomitrium lanigunosum	I	IV
Cetraria islandica	I	III
Cladonia ecmocyna	I	III
Psoroma hypnorum	I	III
Campanula gieseckiana	I	III
Trisetum spicatum	I	III
Lycopodium selago	I	III
Poa alpina	I	III
Lophozia alpestris/wenzelii		III
Bryum spec.		III
Cetraria delisei		III
Solorina crocea		III
Peltigera malacea		II
Cladonia pyxidata		II

Hylocomio-Salicetum herbaceae (8)

Increase of many mesophytic vascular plant species and bryophytes, and lichens

Phytocoenological similarities between the plant community types recorded 1968/1969 and 2007

Similarity index 1968/69 and 2007 Associations ranked according similarity 1968/69-2007	Jac	Sør	EDa							
Cladonio-Viscarietum alpinae	0,30	0,46	86.8			1	1	1	3	
Festuco-Salicetum callicarpaeae chamenerietosum	0,30	0,46	84.6			1	1	2	4	
Empetrum-Vaccinium microphyllum community	0,29	0,45	81.8			2	2	3	7	
Sphaerophoro-Vaccinietum microphyllae	0,27	0,43	76.7			3	3	4	10	
Polygono-Salicetum herbaceae lophozietosum	0,27	0,43	74.5			3	3	5	11	
Alchemilletum alpinae	0,27	0,29	73.7			3	6	6	15	
Phyllodoco-Salicetum callicarpaeae	0,25	0,41	68.6			4	4	7	15	
Caricetum rariflorae	0,25	0,40	66.7			4	5	8	17	
Caricetum bigelowii	0,25	0,26	66.7			4	8	8	20	
Alchemilletum glomerulantis	0,23	0,38	61.5			5	6	9	20	
Hylocomio-Salicetum herbaceae	0,21	0,34	50			6	7	10	23	

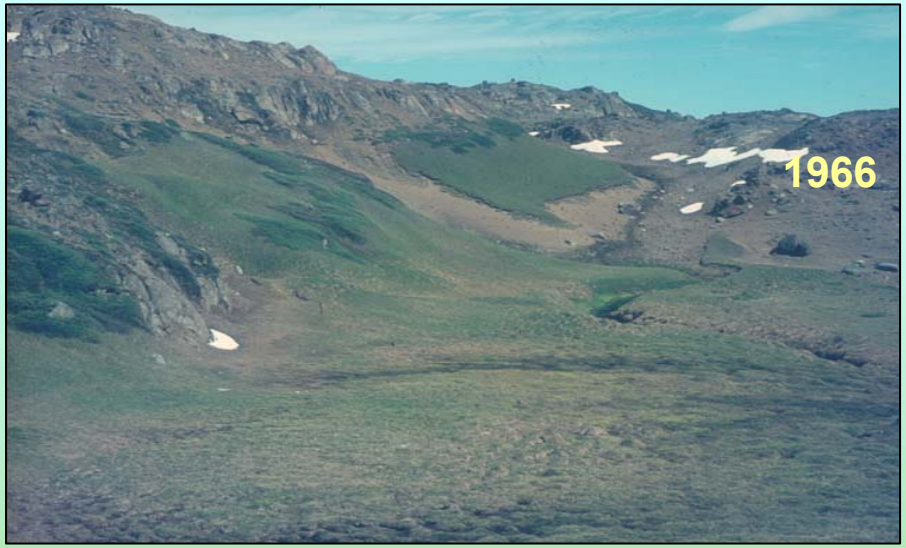
Species	Veg-Type	1968/9	2007
Salix callicarpaea LO	Fes-Sal	V4/6	V5/6
	Emp-Vac	I+/1	III*/3
	Sph-Vac	II+	III+
	Phy-Sal	IV+/1	Vr/4
	Hyl-Sal	I+	II+
Pyrola minor BS	Fes-Sal	III+/1	IIIr/3
	Phy-Sal	II+	IIIr/+
	Alc glo	I+	V+/2
Thymus drucei BO	Cla-Vis	II+/1	IVr/1
	Car big	II1	III+/4
	Alc alp	II1	II+
Chamaenerion angustifolium BS	Cla-Vis	IV+	Vr/1
	Fes-Sal	V+/1	V+/2
	Phy-Sal	I+	III+/1
	Car big	IV1/4	V+/4
	Alc alp	V+/1	III+
	Alc glo	IV+/3	I1

Thus

Hardly any changes in characteristic species combination of sheltered thermo-xerophytic Cladonio-Viscarietum, Festuco-Salicetum callicarpaeae chamenerietosum and mesophytic zonal dwarf shrub vegetation, *Empetrum-Vaccinium* community. Dry sites

More changes in plant community types of mires (Caricetum rariflorae) and snowpath – and snowbed habitats such as herb-rich dwarfshrub heath (Phyllodoco-Salicetum), Caricetum bigelowii, Hylocomio-Salicetum herbaceae and Alchemilletum glomerulantis. Moist-wet sites

6. Take Home



Human impact is confined to the immediate surroundings of the town.

Impact of climate change is difficult to assess.

Magnitude of climate change in the last 40 years appears insufficient to change tundra plant community types of Ammassalik significantly!

Plant community types of dry sites appear rather stable in characteristical species composition, structure and distribution.

More changes in plant community types of moist soil possibly due to drier soil conditions due to shorter snow cover period and longer and warmer summers.

***Salix callicarpaea* is more frequent now.**

Thank you for your attention!