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Phytosociology of Beach and Salt Marsh Vegetation in Northern West Greenland

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Abstract: Beach and salt marsh vegetation of the Uummannaq District, northern West Greenland (c. 70°15' N – 72° N, 49° W – 54° W) was studied 1998 according to the Braun-Blanquet phytosociological approach. Habitat analyses included soil chemistry. Such vegetation locally occurs and is not developed over extensive areas. On gravely stony beaches a *Mertensia maritima* ssp. *maritima* community occurs, while a *Honckenya peploides* var. *diffusa* community is confined to sandy beaches. The association Honckenyo diffusae-Elymetum mollis Thannh. 1975 is confined to sandy shore walls and low dunes. All vegetation types are assigned to the alliance Honckenyo-Elymion arenariae Tx. 1966, which again is a unit of the order Honckenyo-Elymetalia arenariae Tx. 1966, which is sub ordered to the class Honckenyo-Elymetea arenariae Tx. 1966. On fine sediments along sheltered coasts salt marsh vegetation is locally developed mainly on fiord deltas and outwash plains of small rivers and streams. A distinct zonation pattern in vegetation can be observed from the lower to upper salt marsh: Puccinellietum phryganodis Hadač 1946 association, Caricetum subspathaceae Hadač 1946 association, Caricetum ursinae Hadač 1946 association (all assigned to the alliance Puccinellion phryganodis Hadač 1946) and Festuco-Caricetum glareosae Nordh. 1954 association (assigned to the alliance Armerion maritimae Br.-Bl. et de Leeuw 1936). Both alliances are units of the order Glauco-Puccinellietalia Beeftink et Westhoff in Beeftink 1965, which is assigned to the class Asteretea tripolii Westhoff et Beeftink in Beeftink 1962. TWINSPAN and CCA support the vegetation classification and the CCA with soil chemistry parameters shows that salinity (related to position above MHW) and N-content are strongly correlated with the floristical differentiation of the vegetation of the Honckenyo-Elymetea class. In the Asteretea tripolii class, position above MHW (negatively correlated with pH, conductivity and Cl-content) and fresh water supply are likely the main factors, which affect vegetation differentiation. A synoptic survey of vegetation types from Greenland based on published phytosociological tables is presented and distribution of the vegetation types is addressed, just as their position in a circumpolar context. Moreover a *Cochlearia groenlandica-Melandrium triflorum* community is described as a new vegetation type, occurring on shallow soil on cliffs influenced by salt spray.

Zusammenfassung: Die Strand- und Küstenvegetation des Uummannaq-Gebiets, nördliches Westgrönland (ca. 70°15'N – 72°N, 49°W – 54°W) wurde 1998 nach der pflanzensoziologischen Braun-Blanquet-Methode untersucht. Standortanalysen inklusive Bodenuntersuchungen wurden vorgenommen. Die untersuchte Vegetation tritt nur lokal auf und ist nicht großflächig verbreitet. An schotterig-steinigen Stränden findet man eine *Mertensia maritima* ssp. *maritima* Gesellschaft, während eine *Honckenya peploides* var. *diffusa* Gesellschaft an sandigen Strandbereichen auftritt. Die Assoziation Honckenyo diffusae-Elymetum mollis Thannh. 1975 ist beschränkt auf niedrige Dünen und sandige Strandwälle. Diese Vegetationstypen sind einzuordnen im Verband Honckenyo-Elymion arenariae Tx. 1966 der Ordnung Honckenyo-Elymetalia arenariae Tx. 1966, die zu der Klasse Honckenyo-Elymetea arenariae Tx. 1966 gehört. In geschützten Buchten und in Delta-Bereichen findet man auf feinem Ablagerungssubstrat Salzwiesenvegetation. Von der unteren zur oberen Salzwiese ist eine Vegetationszonierung zu beobachten: Puccinellietum phryganodis Hadač 1946, Caricetum subspathaceae Hadač 1946, Caricetum ursinae Hadač 1946 (alle drei Assoziationen des Verbandes Puccinellion phryganodis Hadač 1946) und die Assoziation Festuco-Caricetum glareosae Nordh. 1954, die zum Verband Armerion maritimae Br.-Bl. et de Leeuw 1936 gehört. Beide Verbände gehören zu der Ordnung Glauco-Puccinellietalia Beeftink et Westhoff in Beeftink 1965, die der Klasse Asteretea tripolii Westhoff et Beeftink in Beeftink 1962 zugeordnet werden. TWINSPAN und CCA unterstützten die vorgenommene Klassifikation. Die CCA mit Bodenparametern zeigt, dass die Salinität (korreliert mit der Höhe ü. NN) und der N-Gehalt wesentlich für die floristische Differenzierung der Honckenyo-Elymetea Vegetationstypen verantwortlich ist. Auch bei der Vegetation der Salzwiesen ist die Höhenposition üNN, die negativ korreliert ist mit pH-Wert, Leitfähigkeit und Salinität (Cl-Gehalt) sowie dem Einfluss von Süßwasser, ein wichtiger Differenzierungsfaktor für die Vegetation. Eine synoptische Tabelle stellt die bisher bekannten Vegetationstypen der grönländischen Küsten zusammen und die Verbreitung der Vegetationstypen, auch im zirkumpolaren Raum, wird angeführt. Des Weiteren wird eine *Cochlearia groenlandica-Melandrium triflorum* Gesellschaft beschrieben. Sie kommt in Steilküstenbereichen auf Klippen und Felsvorsprüngen vor und wird durch Spritzwasser des Meeres beeinflusst.

INTRODUCTION

Although Greenland's coastline is about 40000 km long phytosociological and ecological studies on coastal vegetation are scarce (cf. Bay 1992, Böcher 1954, 1963, Daniels & de Molenaar 1993, Feilberg 1984, Fredskild 1998, de Molenaar 1974, Vestergaard 1978). This might be due to conditions in past and present largely reducing the possibilities for development of extensive coastal ecosystems, such as recent glacial history, sheer coastline, narrow rocky shores, ice-foot in winter, drift-ice in summer and low temperatures (Fig. 1). Saline influences are also limited by winter ice conditions (no salt spray) and lower salinity in the fiords, leaching by meltwater and fresh groundwater (de Molenaar 1974). Therefore good conditions for halophytic plants are limited in particular in the most northern part of the island (Bay 1992). However in the southernmost part seashore vegetation is considered generally poor as well (Feilberg 1984). Thus beach and salt marsh vegetation is generally poorly developed

Fig. 1: Exposed steep rocky coast along the northern side of the Uummannaq Fiord without coastal vegetation. Photo F.J.A.D. July 1993.

Abb. 1: Exponierte, steile Felsküste ohne Küstenvegetation entlang der nördlichen Seite des Uummannaq-Fjords. Foto F.J.A.D. im Juli 1993.

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and its occurrence is restricted to more sheltered areas such as small bays, coves and fiord bottoms, often associated with outlets of streams and river deltas (Fig. 2). Phytosociological studies of coastal vegetation in West Greenland north of Disko (situated in the middle of the west coast) are completely lacking so far. The present paper focuses on the phytosociology of the unknown beach and salt marsh vegetation in the Uummannaq District, the area roughly between the peninsulas Nuussuaq and Svartenhuk, northern West Greenland (70°15'N and 72° N, 49° W – 54° W, Fig. 3). Moreover it addresses the global distribution of these vegetation types in Greenland and their position in a circumpolar context. DANIËLS & DE MOLENAAR (1993) globally surveyed the dry coastal ecosystems in Greenland. A survey of salt marsh vegetation does not exist so far.

STUDY AREA

The landscape in the Uummannaq District is mountainous and deeply cut by fiords with mainly sheer coasts. In the eastern inland parts Precambrian gneiss covers extensive areas, while bedrock in the western, more oceanic part, is mainly basalt. However locally granite, marble and cretaceous and tertiary sediments occur (PULVERTAFT 1990). The climate of the town of Uummannaq (70°41'N, 52°W) might be characterized as arctic-continental with mean annual temperature of minus 3,5 °C, precipitation 132 mm a^{-1} (1961-1967) and the sum of mean temperatures (°C) of months with mean temperature above 0 °C, being 22.2 degrees centigrade (DANIËLS et al. 2000). The coastal areas likely have an arctic, sub continental climate. Meteorological data are lacking. For a more detailed description of the Uummannaq District the reader is referred to

Fig. 2: Estuary of small river in the bottom of a sheltered fiord, Kangiussap qinguâ, on the Svartenhuk Peninsula with a salt marsh vegetation complex. Locality 2. Photo F.J.A.D. July 1998.

Abb. 2: Der Ästuar-Bereich eines kleinen Flusses am geschützten Ende des Fjords Kangiuassap qinguâ, Svartenhuk Peninsula, mit Salzwiesen-Vegetation. Lokalität 2. Foto F.J.A.D. im Juli 1998.

LÜNTERBUSCH & DANIËLS (2004). The vegetation was studied in the following localities (Fig. 3):

1 Illorsuit on Ubekendt Ejland,
2 Kangiussap qinguâ on Svartenhuk Peninsula,
3 Itsako on Svartenhuk Peninsula,
4 Naujât,
5 Nuugaatsiaq,
6 Ikerasak,

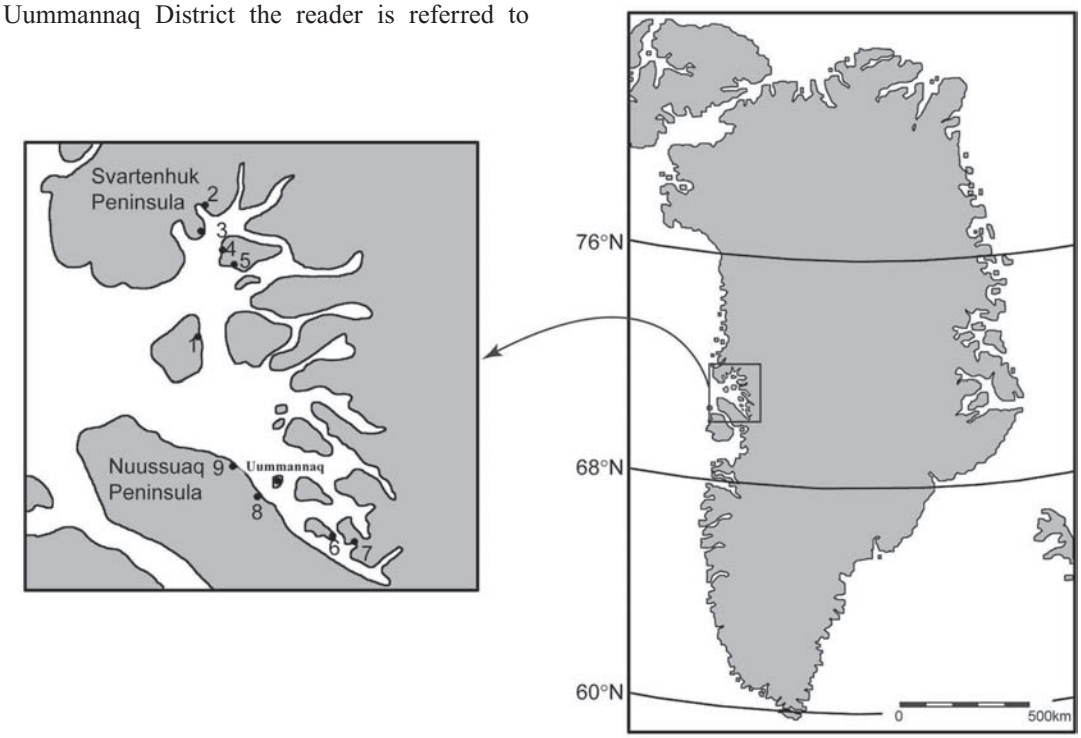

Fig. 3: Map of Greenland with the location of the Uummannaq District (right) and the research localities (left). 1 = Illorsuit, Ubekendt Eijland, 2 = Kangiussap qinguâ on Svartenhuk Peninsula, 3 = Itsako on Svartenhuk Peninsula, 4 = Naujât, 5 = Nuugaatsiaq, 6 = Ikerasak, 7 = Drygalski Peninsula, 8 = Kûk on Nuussuaq Peninsula, 9 = Qaarsut on Nuussuaq Peninsula.

Abb. 3: Karte von Grönland mit der Lage des Uummannaq-Distriktes (rechts) und die Lage der Untersuchungsgebiete (links). 1 = Illorsuit, Ubekendt Eijland, 2 = Kangiussap qinguâ auf der Svartenhuk Halbinsel, 3 = Itsako auf der Svartenhuk Halbinsel, 4 = Naujât, 5 = Nuugaatsiaq, 6 = Ikerasak, 7 = Drygalski Halbinsel, 8 = Kûk auf der Nuussuaq Halbinsel, 9 = Qaarsut auf der Nuussuaq Halbinsel.

7 Drygalski Peninsula,
8 Kûk on Nuussuaq Peninsula,
9 Qaarsut on Nuussuaq Peninsula, and
10 (in 1993) the bottom of Laksefiord in the Upernavik District (locality outside the map, 72° 30'N, 55° 30'W).

The localities are situated within the Southern Arctic Shrub Zone or Arctic Subzone D (Daniëls et al. 2000, CAVM Team 2003, Walker et al. 2005); the zonal vegetation in the lowlands is an erect dwarf shrub heath with a.o. *Empetrum hermaphroditum, Vaccinium uliginosum* ssp. *microphyllum, Cassiope tetragona, Ledum decumbens, Phyllodoce coerulaea and Salix glauca* ssp. *callicarpaea.*

MATERIAL AND METHODS

In the field 57 vegetation stands were analysed according to the Braun-Blanquet relevé method (Westhoff & van der Maarel 1973, Dierschke 1994). Sample plot size varied between 1 and 4 m^2 (once 8 m^2). Cover/abundance of species was recorded according to Wilmanns (1998). Comparisons of these 57 relevés in tables resulted in a vegetation typology based on similarities in presence/absence and cover/abundance values of the species. The syntaxonomical position of the vegetation types was identified by literature comparison. The hierarchical syntaxonomical vegetation classification system according to the Braun-Blanquet method (Westhoff & van der Maarel 1973, Dierschke 1994) consists of the units association, alliance, order and class. These syntaxa are mainly characterised by their diagnostic species, which include so-called character and differential species. Character species are either confined to or show an optimum of occurrence in one syntaxon, while differential species only differentiate by presence/absence between syntaxa of the same rank or differentiate within syntaxa. According to their degree of fidelity to a syntaxon, character species are classified as exclusive, selective or preferrent. Hierarchically the association is the lowest unit of the classification system, followed by the higher ranked alliance, which is assigned to the higher ranked order and this to the hierarchically highest ranked class. Based on differential species associations can be subdivided into subassociations and/or variants, alliances into suballiances, orders into suborders and classes into subclasses. Vegetation types lacking diagnostic species are called here "communities"; vegetation types only characterised by dominance of species are often named sociations (Westhoff & van der Maarel 1973, Dierschke 1994). Nomenclature and typification of syntaxa is in agreement with Weber et al. (2000). Nomenclature of vascular plants follows Böcher et al. (1978), lichens Santesson et al. (2004) and bryophytes Corley et al. (1981). In the vegetation tables lichens are indicated by (L), mosses and liverworts by (M). Biological distribution types are indicated in the tables 1-4 and 6 according to Fredskild (1996): A = arctic widespread, AC = arctic continental, B = boreal, L = low arctic, LO = low arctic, oceanic, LC = low arctic, continental, MA = middle arctic and HA = high arctic. Geographical distribution types are based on Hultén (1968) in Fredskild (1996): A = amphi-atlantic, C = circumpolar, E = eastern, W = western.

Nomenclature of tidal levels follows de Molenaar (1974). Scale for fresh water influence ranges from 1 (without) to 5 (strong). Soil samples from the mineral soil (depths 0-10 cm) were analysed by methods described in VDLUFA (1991): pH value and conductivity were determined in distilled water. Total nitrogen (N) and carbon (C)-contents were measured with an Elementar Analysator (CHN-O-Rapid, HEREUS); plant available phosphorus (P) was measured spectro-photometrically in calciumacetat-hydrate, calcium lactate and acetic acid (CAL-method) and K, Na, Ca, Mg flame-photometrically (AAS 939 Unicam) in ammoniumchlorid (0.05 mol l^{-1}) according to Trüby & Aldinger (1989); and Cl-content potentiometrically by a chloride-meter (Eppendorf). The relevés were analysed by TWINSPAN (Hill 1979) for Windows 2.3. Canonical Correspondence Analysis (CCA) (ter Braak & Smilauer 2002) was applicated with CANOCO for Windows 4.5 (using default options) to show relationships between relevés and soil parameters.

RESULTS AND DISCUSSION

V*egetation on beaches and dunes*

The vegetation of beaches and lower sand dunes are assigned here to alliance Honckenyo-Elymion arenariae Tx. 1966 (order Honckenyo-Elymetalia arenariae Tx. 1966; class Honckenyo-Elymetea arenariae Tx. 1966). This northern class substitutes the class Ammophiletea arenariae Br.-Bl. et Tx. 1943 north of 60 °N (Thannheiser 1987a). Drift mark vegetation of the therophytic class Cakiletea maritimae Tx. et Prsg. in Tx. 1950 is considered absent in Greenland and the Arctic, due to the short vegetation season in combination with the temporary habitat which is frequently disturbed by waves and drift ice. Such conditions do not allow therophytes to complete their life cycle.

Mertensia maritima ssp. maritima community

This open and species-poor community (Tab. 1, ref. numbers 1-2) is rather rare in the study area, since only two well-developed stands could be sampled (localities 2, 6). The vegetation occurs on gravely and stony beaches at the EHWS level and is subjected to irregularly flooding. Mean soil pH is 7.4, conductivity varies from 56 to 228 μS cm^{-1} and humus content of the substrate is comparatively high, in mean 5.3 % (Tabs.1, 4).

Mertensia maritima (L.) S.F. Gray ssp. *maritima* (Sea-Lungwort) is a mainly western, low arctic species and a neophyte in Greenland (Daniëls & de Molenaar 1970). In Greenland it has a spotty, rather disjunct, southern and western distribution ranging from SE via S to NW Greenland (Bay 1992, Fredskild 1996). In South Greenland the species is very rare (Feilberg 1984, Stumböck 1993). The community is described from northern Europe to Alaska (e.g., Nordhagen 1940, Möller 2000, Böcher 1954, 1963, de Molenaar 1974, Thannheiser 1974, 1975, 1981, Thannheiser & Hoffmann 1977, Bliss 1993 and Daniëls et al. 1998). The more robust *Mertensia maritima* ssp. *asiatica* Takeda is confined to northeastern Asia (Hultén 1968). It locally occurs in great abundance on sandy seashores with pebbles and driftwood along the Sea of Okhotsk (pers. observ. by F.J.A.D. 2006, see also Haase 1999).

		Biological, geographical distribution types													Thannheiser 1988, Tab. 2, relevé 10
Ref. number			1	2	3	4	5	6	7	8	9	10	11	12	13	
Field number			0	123	1	53	18	20	63	5	62	77	136	6	116	
Locality			2	6	2	3	2	2	3	1	3	4	8	1	7	
Total cover	(%)		30	35	25	20	10	45	70	80	65	15	55	90	80	
Cover mosses	(%)		<1	10	0	0	3	0	5	0	0	3	0	2	30	
Cover lichens	(%)		0	<1	<1	0	<1	0	0	0	0	0	0	0	0	
pH			7.2	7.5	-	6.5	7.4	7.3	7.0	8.3	7.5	7.8	7.7	7.3	7.2	
Conductivity	(µS/cm)		56	228	-	68	24	21	23	36	28	18	30	28	35	
Humus	(g/100g)		4.1	6.4	-	3.8	0.4	2.9	0.6	2.0	1.8	1.0	0.4	3.6	3.4	
N	(g/100g)		-	0.6	-	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	
C	(g/100g)		-	7.5	-	1.1	0.2	0.3	1.1	0.6	0.4	0.3	0.1	1.4	0.6	
Cl	(g/100g)		-	1.0	-	2.8	0.7	0.5	3.1	0.5	0.2	0.4	0.5	0.0	0.0	
Na	(mg/100g)		-	213	-	113	158	115	165	262	213	39	50	228	67	
K	(mg/100g)		-	36	-	81	7	13	17	87	36	25	24	179	41	
Ca	(mg/100g)		-	25	-	52	11	6	20	18	20	7	4	44	16	
Mg	(mg/100g)		-	58	-	51	6	5	21	36	21	8	6	67	34	
Mn	(mg/100g)		-	0.2	-	0.7	0.2	0.4	0.7	0.2	0.7	0.1	0.1	0.4	0.1	
Fe	(mg/100g)		-	0.4	-	0.0	0.0	0.0	0.7	0.0	0.7	0.4	0.2	0.3	0.7	
P	(mg/100g)		-	1.3	-	0.5	0.5	0.4	0.7	1.0	0.7	0.2	0.7	3.5	0.3	
Mertensia maritima ssp. *maritima* community																
Mertensia maritima ssp. *maritima*		L, W	2b	3	1	.	.	.	+	.	.	.	.	.	.	.
Honckenya peploides var. *diffusa* community																
Honckenya peploides var. *diffusa*		B, C	1	+	2b	2b	2a	3	3	3	2a	2a	3	.	.	1
Ch Honckenyo-Elymetum mollis association																
Elymus mollis		L, W	.	.	+	.	.	.	.	4	4	2a	3	3	2b	4
D Variant of *Festuca rubra*																
Festuca rubra coll.		L, C	.	.	.	.	.	.	.	.	.	.	1	4	2a	.
Pottia heimii (M)			.	.	.	.	.	.	.	.	.	.	.	+	+	.
Salix glauca ssp. *callicarpaea*		L, C	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Hymenostylium recurvirostrum (M)			.	.	.	.	.	.	.	.	.	.	.	+	1	.
Microlichen indet. (L)			.	.	.	.	.	.	.	.	.	.	.	1	+	.
Others																
Stellaria humifusa		A, C	+	2a	.	.	.	1	.	.	+	.	+	.	2a	.
Bryum salinum (M)			+	2a	.	.	.	.	2m	.	+	1	.	.	3	.
Cochlearia groenlandica		A, C	.	1	.	.	.	.	.	+	.	.	.	.	2b	.
Puccinellia phryganodes		A, C	.	.	.	.	.	1	2b	.	.	.	.	.	.	.
Psoroma hypnorum (L)			.	+	+	.	.	.	.	.	.	.	.	.	.	.
Stereocaulon glareosum (L)			.	r	.	.	r	.	.	.	.	.	.	.	.	.

Tab. 1: Phytosociological table of beach vegetation: 1, 2 = *Mertensia maritima* ssp. *maritima* community, 3-7 = *Honckenya peploides* var. *diffusa* community and 8-13 = Honckenyo-Elymetum mollis association. (L) = lichens, (M) = mosses and liverworts. Biological distribution types: A = arctic widespread, B = boreal, L = low arctic; geographical distribution types: C= circumpolar, W= western.

Tab. 1: Pflanzensoziologische Tabelle der Strandvegetation: 1, 2 = *Mertensia maritima* ssp. *maritima*-Gesellschaft, 3-7 = *Honckenya peploides* var. *diffusa*-Gesellschaft, 8-13 = Honckenyo-Elymetum mollis-Assoziation. (L) = Flechten, (M) = Moose und Lebermoose. Biologische Verbreitungstypen: A = arktisch, B = boreal, L = südarktisch; geographische Verbreitungstypen: C = zirkumpolar, W = westlich.

Honckenya peploides var. diffusa community

This open and species-poor vegetation (Tab. 1, ref. numbers 3-7) is dominated by *Honckenya peploides* (L.) Ehrh. var. *diffusa* (Hornem.) Mattf. (Seabeach-Sandwort). It occurs on sheltered beaches and rarely on more extensive sandy river deltas, from MHWS to EHWS. It is irregularly flooded. Mean soil pH is 7.1. Mean soil conductivity (34 μS cm^{-1}) and humus content (1.9 %) are lower than in the *Mertensia maritima* ssp. *maritima* community (Tabs. 1, 4). The community was only observed in localities 2 and 3. This preponderantly boreal species and vegetation type are mainly restricted to low arctic Greenland being absent in North Greenland (Bay 1992, Daniëls & de Molenaar 1993). From SW and W Greenland *Honckenya peploides* var. *diffusa* vegetation is described by Böcher (1954), while de Molenaar (1974) reported a *Honckenya peploides* var. *diffusa* sociation from SE Greenland.

Association Honckenyo diffusae – Elymetum mollis Thannh. 1975

This mostly dense vegetation (Tab.1, ref. numbers 8-13, Fig. 4; *lectotypus hoc loco relevé* 10, Tab. 2 in Thannheiser 1988) has an upper field layer of *Elymus mollis* (American Lyme-Grass) and often *Festuca rubra* (Red Fescue). In the lower herbaceous field layer *Honckenya peploides* var. *diffusa* and *Stellaria humifusa* (Arctic Chickweed) occur. *Elymus mollis* is character species of the association. Mosses such as *Pottia heimii, Bryum salinum* and *Hymenostylium recurvirostre* are often present. The association occurs on sandy beaches and low dunes in several (five) localities. *Honckenya peploides* var. *diffusa* is confined to more mobile substrates (typical variant, Tab. 1, ref. numbers 8-11), while *Festuca rubra* is found in older, more stabilized low dunes (variant of *Festuca rubra* coll., Tab. 1, ref. numbers 12-13). Mean soil pH and humus percentage are 7.8 and 1.3, and 7.3 and 3.5 respectively, likely related to the differences in vegetation cover (54 % and 85 % respectively). In Greenland *Elymus mollis* has a distinct southern and western distribution and reaches its northernmost occurrence in the Uummannaq District (Ahokas &

Ref. number		1	2	3	4	5	6
Author		M74	LD	LD	M74	LD	B54
Area	Biol., geogr. dist.types	SE	NW	NW	SE	NW	SW
Table number		V	1	1	VI	1	23
Number of relevés		4	2	5	6	6	10
Mertensia maritima ssp. *maritima* community							
Mertensia maritima ssp. *maritima*	L, W	4	2	II	.	.	.
Rhodiola rosea	LO, E	3	.	.	I	.	.
Cerastium alpinum	A, A	2	.	.	.	.	.
Honckenya peploides var. *diffusa* community							
Honckenya peploides var. *diffusa*	B, C	.	2	V	V	IV	II
Ch/D Honckenyo-Elymetum mollis association							
Elymus mollis	L, W	.	.	.	.	V	V
Festuca rubra coll.	L, C	.	.	.	.	III	V
Others							
Pottia heimii (M)		.	.	.	.	II	.
Salix glauca ssp. *callicarpaea*	L, C	.	.	.	.	II	.
Hymenostylium revurvirostrum (M)		.	.	.	.	II	.
Microlichen indet. (L)		.	.	.	.	II	.
Artemisia borealis	LC, C	.	.	.	.	.	II
Stellaria longipes coll.		.	.	.	.	.	II
Stellaria humifusa	A, C	.	2	I	I	III	.
Bryum salinum (M)		2	2	I	.	III	.
Carex glareosa	L, C	2	.	.	I	.	.
Cochlearia groenlandica	A, C	.	1	.	.	II	.
Puccinellia phryganodes	A, C	.	.	II	II	.	.
Psoroma hypnorum (L)		1	.	.	.	.	.
Plantago maritima coll.		.	.	.	.	.	I
Carex maritima	A, C	.	.	.	.	.	I

Tab. 2: Synoptic table of beach vegetation with relevés from entire Greenland. LD = this publication, M74 = DE MOLENAAR (1974), B54 = BÖCHER (1954). Species occurring once with "+" or "r" are omitted. (L) = lichens, (M) = mosses and liverworts. Biological distribution types: A = arctic widespread, B = boreal, L = low arctic, LO = low arctic oceanic, LC = low arctic continental; geographical distribution types: A = amphi-atlantic, C = circumpolar, E = eastern, W = western. NW = Northwest Greenland, SE = Southeast Greenland, SW = Southwest Greenland.

Tab. 2: Synoptische Tabelle der Strandvegetation, zusammengestellt für Gesamt-Grönland. LD = diese Publikation, M74 = DE MOLENAAR (1974), B54 = BÖCHER (1954). Nur ein Mal mit „+" oder „r" vorkommende Arten sind weggelassen. (L) = Flechten, (M) = Moose und Lebermoose. Biologische Verbreitungstypen: A = arktisch, B = boreal, L = südarktisch, LO = südarktisch ozeanisch, LC = südarktisch kontinental; geographische Verbreitungstypen: A = amphi-atlantisch, C = zirkumpolar, E = östlich, W = westlich. NW = Nordwestgrönland, SE = Südostgrönland, SW = Südwestgrönland.

Fig. 4: Honckenyo-Elymetum mollis association on the higher parts of the sandy beach near the village Illorsuit. Locality 1. Photo O.L. July 1998.

Abb. 4: Honckenyo-Elymetum mollis-Assoziation auf dem höheren Sandstrand in der Nähe der Ortschaft Illorsuit. Lokalität 1. Foto O.L. im Juli 1998.

FREDSKILD 1991, FREDSKILD 1996). It is a western, low arctic, species. The same applies to the association. BÖCHER (1954) reported this association under the name *Elymus mollis-Festuca rubra* sociation from the coastal Godthaab region and from the inland near Söndre Strömfjord as *Elymus mollis* sociations (BÖCHER 1954: Tab. 23). TÜXEN (1970) reviewed the geographical variation of the northern *Honckenya-Elymus* vegetation types. He considered the Honckenyo diffusae-Elymetum mollis a Greenlandic association. However the first valid description of the association was from the Canadian Arctic by THANNHEISER (1975, 1988).

Synopsis

The CCA diagram of the beach vegetation (Fig. 5) shows that the x-axis seems strongly correlated with Cl- and K-contents of the soil, while the y-axis correlates with conductivity, humus-content, total N and total C (Tab. 4). Thus soil properties have a strong influence on the differentiation of the beach vegetation, apart from soil texture characters. *Honckenya peploides* var. *diffusa* community is the most saline, while the *Mertensia maritima* ssp. *maritima* community seems to prefer N-enriched sites. The synoptic table (Tab. 2) shows relevé-based beach communities from several parts of Greenland: from the Uummannaq District by the present authors (LD); from SE-Greenland (M74) by DE MOLENAAR (1974) and from SW-Greenland (B54) by BÖCHER (1954). The *Honckenya peploides* var. *diffusa* vegetation seems floristically rather similar, while the *Mertensia maritima* ssp. *maritima* vegetation from Southeast Greenland (M74) contains *Rhodiola rosea* (Arctic Roseroot) as a low arctic, oceanic species with eastern distribution, which is absent in the study area. The Honckenyo-Elymetum association from the study area (LD) contains e.g., *Stellaria humifusa* (Low Stitchwort), *Cochlearia groenlandica* (Polar Scurvy grass) and the moss *Bryum salinum,* which occur in the nearby well-developed salt marsh vegetation. The association in the inland near Kangerlugssuak (Söndre Strömfjord) (B54) occurs on higher dunes outside the reach of salt marshes and contains the low arctic-continental circumpolar species *Artemisia borealis* (Northern Wormwood).

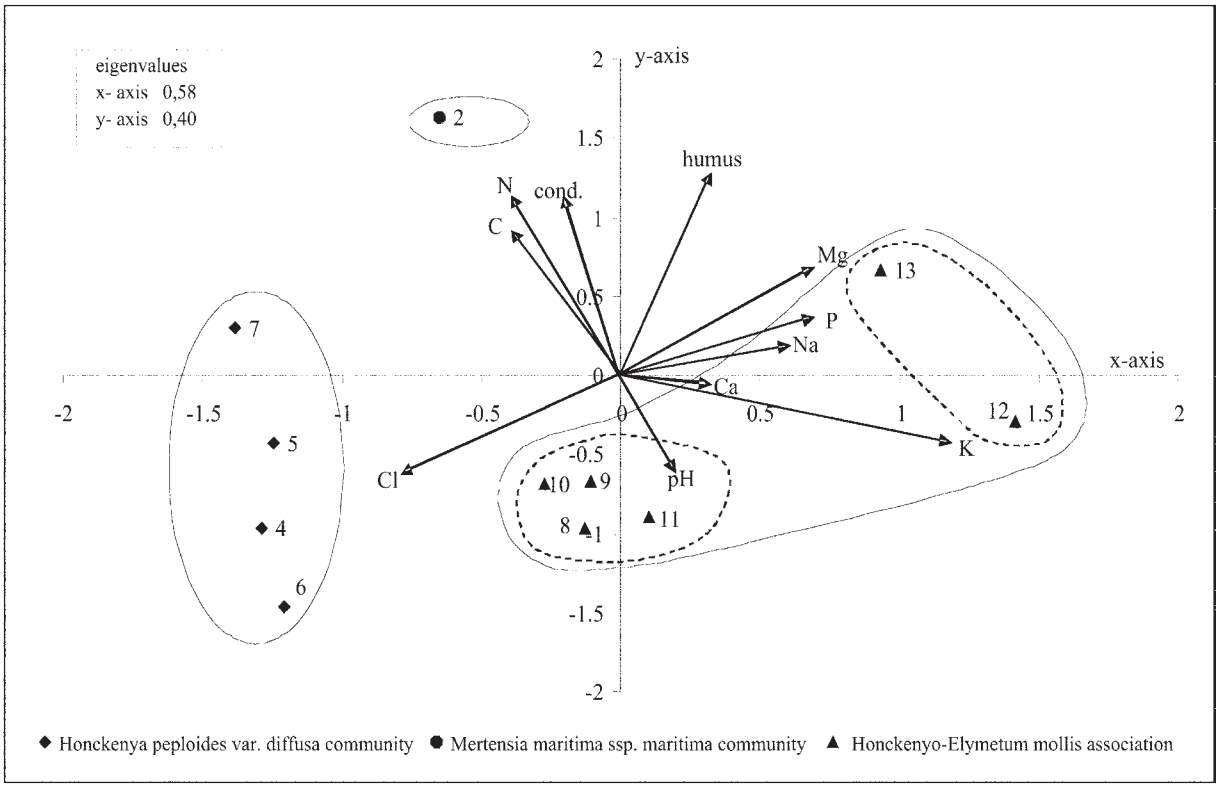

Fig. 5: CCA-biplot of eleven relevés of the class Honckenyo-Elymetea (without ref. numbers 1 and 3) and soil parameters.

Abb. 5: CCA-Analyse von elf Aufnahmen aus der Klasse Honckenyo-Elymetea (ohne Ref.-Nummern 1 und 3) und den Bodenparametern.

Vegetation on salt marshes

Coastal salt marshes mainly develop well on flat coasts, thus in Greenland with its generally rocky, steep coastline they are not developed over extensive areas. Because of the sheer rocky coast, low tidal range, strong waves and ice-drift in winter, conditions for sedimentation of fine-textured material, e.g., mud, are generally unfavourable. However fine marine deposits are locally found in protected bays, coves, and fjord bottoms, often associated with outlets or outwash plains of small rivers and streams (Fig. 2). Thus salt marshes are mostly found as small patches. If more extensive zonation of salt marsh communities can be observed according to their position towards MHW level and soil gradients like salinity. The associations Puccinellietum phryganodis, Caricetum subspathaceae and Caricetum ursinae are assigned to the alliance Puccinellion phryganodis Hadač 1946 and the association Festuco-Caricetum glareosae to the alliance Armerion maritimae Br.-Bl. & de Leeuw 1936. Both alliances are assigned to the order Glauco-Puccinellietalia Beeftink et Westhoff in Beeftink 1965, which belongs to the class Asteretea tripolii Westhoff et Beeftink in Beeftink 1962.

Association Puccinellietum phryganodis Hadač 1946

The Puccinellietum phryganodis association (Tab. 3, ref. numbers 1-10) occupies the lowest part of the salt marsh. Character species is *Puccinellia phryganodis* (Creeping Salt marsh Grass), which is a widely distributed, mainly arctic, circumpolar species (e.g., Hultén 1968, Porsild & Cody 1980 and Fredskild 1996). In the Arctic, also in Greenland, the Puccinellietum phryganodis probably is the northernmost distributed salt marsh association. Southwards its distribution area reaches into the northern boreal zone (Dierßen 1996). The low and rather dense association was mainly observed from about 30 cm below MHW up to 50 cm above MHW along sheltered bays and deltas on silty and clayey soil. The mean soil pH is 7.4, conductivity 358 μS cm^{-1} and, as expected, the contents of Na (359 mg 10^{-2} g) and Cl (0.98 g 10^{-2} g) are very high (Tab. 4). The association is widely distributed in northern West Greenland, however mostly as small stands. Below MHW level the association only contains the character species *Puccinellia phryganodes;* such stands are considered as initial stage of the association (Tab. 3, ref. numbers 1-2). Above MHW *Stellaria humifusa* occurs (ref. numbers 3-7), while moss species (presumably *Bryum salinum,* ref. numbers 8-10) are found in higher elevated stands. Fredskild (1998) described – in conformity with de Molenaar (1974) – *Puccinellia phryganodes* as the only representative species of the association, sometimes accompanied by *Stellaria humifusa.* Vestergaard (1978) mentioned *Stellaria humifusa* and *Potentilla egedii* (Pacific Silverweed) as companions. Based on the dominance of the species, Böcher (1954) described pure *Puccinellia phryganodes* patches as a sociation (Tab. 3, ref. numbers 1-10). Furthermore he divided his *Puccinellia phryganodes-Stellaria humifusa*-sociation in two sociation groups: a) a "northern, arctic-continental", differentiated by *Carex ursina* (Polar Bear Sedge) and b) a "southern" especially characterised by *Potentilla egedii.* The first group seems to be similar to the association Caricetum ursinae (Tab. 3, ref. numbers 14-18). De Molenaar (1974) described from the Angmassalik District, SE-Greenland, Puccinellietum phrygan-

		Biological, geographical distribution types																																	
Ref. number			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Field number			17	128	Q20	16	22	50	57	25	140	26	39	105	139	58	138	19	38	137	43	44	37	104	129	LF 5	40	59	15	21	24	23	84	73	36	60
Locality			2	6	9	2	2	2	3	2	8	2	2	5	8	3	8	2	2	8	2	2	2	5	6	10	2	3	2	2	2	2	5	4	2	3
Distance to sea shore	(m)		5	4	-	1	3	0.7	5	0.5	1	8	3	-	4	6	4	6	6	16	6	3	4	8	3	-	8	10	10	8	5	5	10	6	5	12
Position above MHW	(m)		0.0	0.2	-	0.0	0.3	0.3	0.1	0.3	0.6	0.3	0.6	-	1.0	0.3	0.6	1.0	1.0	1.0	1.0	0.6	0.6	1.0	0.6	-	1.0	1.0	1.0	0.8	0.8	0.7	1.5	1.0	0.8	1.3
Fresh water influence			1	1	-	1	3	1	1	2	2	5	2	-	5	2	5	3	2	2	2	1	2	3	2	-	1	2	3	3	3	3	2	2	2	2
Total cover	(%)		60	65	85	20	50	10	40	45	80	35	40	75	55	55	75	20	35	80	35	40	40	40	95	95	25	65	70	35	40	95	100	45	65	95
Cover mosses	(%)		0	0	0	0	0	0	0	10	30	12	0	10	20	5	25	1	1	20	0	10	2	3	85	10	15	15	15	10	10	80	25	20	55	70
Cover lichens	(%)		0	0	0	0	0	0	0	0	0	<1	0	1	1	0	0	0	0	0	0	0	0	1	8	2	0	<1	3	3	3	<1	<1	<1	0	0
pH			6.5	6.5	6.8	7.4	6.8	7.7	7.2	7.9	8.2	8.2	5.9	5.9	6.6	7.1	7.9	7.0	7.1	8.3	6.8	7.3	6.5	6.1	6.3	-	5.9	6.8	5.7	6.8	6.2	6.9	5.7	6.8	6.8	6.1
Conductivity	(µS/cm)		593	731	208	184	582	151	426	273	160	135	604	-	92	488	172	123	948	195	556	333	517	165	91	-	699	109	253	475	97	311	106	187	124	136
Humus	(g/100g)		4.4	6.7	5.5	1.2	3.0	1.4	5.0	3.5	2.4	2.9	1.9	-	8.5	6.4	7.1	0.6	3.5	3.8	1.5	2.6	2.9	6.6	10.6	-	4.4	6.6	3.7	5.1	6.0	4.3	11	2.5	2.8	5.3
N	(g/100g)		0.2	0.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.1	-	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.6	0.3	-	0.1	0.2	0.1	0.1	0.2	0.1	0.8	0.0	0.1	0.2
C	(g/100g)		2.7	3.1	2.6	0.3	0.6	0.3	2.5	0.6	0.5	1.1	0.8	-	4.4	2.6	1.9	0.3	1.3	0.9	0.6	0.9	1.3	9.6	6.2	-	1.8	2.3	1.6	1.4	2.6	1.1	11.2	0.5	1.0	2.1
Cl	(g/100g)		1.4	2.0	-	0.5	1.5	1.1	1.1	0.8	0.3	0.3	0.9	-	0.2	1.2	0.2	0.2	3.0	0.7	1.5	0.8	1.3	0.3	0.2	-	1.2	1.2	0.7	0.6	0.2	0.6	0.2	0.4	0.4	0.3
Na	(mg/100g)		365	309	544	255	435	319	274	516	201	375	123	-	143	201	89	154	172	132	112	86	195	110	35	-	339	86	387	402	339	447	39	147	80	10
K	(mg/100g)		37	25	180	57	79	58	38	144	61	127	36	-	20	45	30	13	24	60	19	30	16	14	7	-	24	33	34	96	40	85	28	54	25	15
Ca	(mg/100g)		2.2	18	-	14	12	31	39	75	39	79	23	-	29	39	22	14	55	63	22	27	63	51	26	-	29	64	29	30	26	14	52	39	101	91
Mg	(mg/100g)		50	46	95	36	11	54	80	74	30	80	37	-	33	96	29	7	59	33	30	43	34	72	31	-	43	93	40	10	27	20	77	49	47	73
Mn	(mg/100g)		0.6	0.8	0.2	0.5	0.3	0.4	0.7	0.3	0.5	0.4	0.6	-	0.2	0.2	0.2	0.3	0.2	0.3	0.6	0.3	0.6	0.2	0.0	-	0.4	1.8	0.1	0.2	0.2	0.6	0.3	0.2	0.2	0.2
Fe	(mg/100g)		0.2	0.8	0.4	0.2	0.0	0.3	0.1	0.2	0.2	0.2	0.7	-	0.7	0.0	0.1	0.0	0.5	0.2	0.2	0.1	0.2	0.5	0.7	-	0.4	0.0	0.0	0.0	0.0	0.0	1.4	0.2	0.3	0.8
P	(mg/100g)		0.6	1.5	2.2	0.4	0.5	0.2	0.4	0.8	0.8	0.6	0.4	-	0.5	0.4	0.7	0.2	0.4	1.1	0.3	0.3	0.5	0.7	1.3	-	0.1	0.6	0.3	0.4	0.5	0.5	5.5	0.3	0.5	0.5
Ch Puccinellietum phryganodis association and Puccinellion phryganodis alliance																																				
Puccinellia phryganodes		A, C	4	4	5	2b	3	2a	3	2b	4	+	.	+	1	1	1	.	.	2b	1	1	+	+	1	1	1	.	.	1	.	.	.	.	.	.
Ch Caricetum subspathaceae association																																				
Carex subspathacea		L, C	.	.	.	.	.	.	.	.	.	.	3	3	3	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ch/D Caricetum ursinae association																																				
Carex ursina		MA,C	.	.	.	.	.	.	.	.	+	.	.	.	.	2a	4	2b	2b	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Pottia heimii (M)			.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ch/D Festuco-Caricetum glareosae association																																				
Carex glareosa		L, C	.	.	.	.	.	+	.	+	2a	.	.	2b	+	2a	.	.	2b	3	2a	2b	3	2b	4	5	1	4	4	2a	2b	5	5	3	2b	3
Cochlearia groenlandica		A, C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	+	.	.	.	.	2a	.	+	+	.	.
Equisetum arvense		L, W	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Honckenya pepl. var. *diffusa*		B, C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.
D Variant of Potentilla egedii																																				
Potentilla egedii		L, W	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	1	2a	2b	.	.	.	.	.	.	.	.	.	.	.	.
D Variant of Sanionia uncinata																																				
Sanionia uncinata (M)			.	.	.	.	.	.	.	.	2a	.	.	.	.	r	.	.	.	.	.	.	.	.	4	1	.	1	2a	r	1	.	.	1	1	1
Stereocaulon glareosum (L)			.	.	.	.	.	.	.	.	.	+	.	r	r	.	.	+	.	.	.	.	.	.	.	1	.	+	+	+	+	.	+	.	.	.
Microlichen indet. (L)			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	1	.	.	1	1	1	r	.	.	.	.
Polytrichum alpinum (M)			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	1	.	2m	.	.	1	.	.
Festuca rubra coll.		L, C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2a	2b
Ch/D Asteretea tripolii class																																				
Stellaria humifusa		A, C	.	.	2a	r	2m	1	r	2b	2a	2b	+	+	+	2b	2a	+	+	2a	.	2b	2m	1	1	1	2b	2m	1	2a	1	2m	.	2a	1	2m
Bryum (cf.) *salinum* (M)			.	.	.	.	.	.	.	2a	2b	2a	+	2a	1	1	2b	1	.	2a	.	2a	1	1	3	.	2b	2b	2b	2a	2a	5	2b	3	3	3
Others																																				
Distichium capillaceum (M)			.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Cladonia spec. (L)			.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.

Tab. 3: Phytosociological table of the salt marsh vegetation: 1-10 = Puccinellietum phryganodis association, 11-13 = Caricetum subspathaceae association, 14-18 = Caricetum ursinae association, 19-34 = Festuco-Caricetum glareosae association. (L) = lichens, (M) = mosses and liverworts. Biological distribution types: A = arctic widespread, B = boreal, L = low arctic, MA = middle arctic; geographical distribution types: C = circumpolar, W = western.

Tab. 3: Pflanzensoziologische Tabelle der Salzwiesen-Vegetation: 1-10 = Puccinellietum phryganodis-Assoziation, 11-13 = Caricetum subspathaceae-Assoziation, 14-18 Caricetum ursinae-Assoziation, 19-34 = Festuco-Caricetum glareosae-Assoziation. (L) = Flechten, (M) = Moose und Lebermoose. Biologische Verbreitungstypen: A = arktisch, B = boreal, L = südarktisch, MA = mittelarktisch; geographische Verbreitungstypen: C = zirkumpolar, W = westlich.

Name of vegetation type Number of soil analyses		Me 1	Ho 4	H-El 6	Pu 10	Csub 2	Curs 5	F-Cgl 15	VPe 4	VSu 11	CM 10
Soil texture		gr-st	st-sa	sa	si-cl	si-sa	si-cl	si-sa	si	si-sa	st-sa
pH		7.4	7.1	7.6	7.3	6.0	7.5	6.5	6.7	6.4	6.8
Conductivity	(µS/cm)	142	34	29	358	348	385	277	393	235	149
Humus	(g/100g)	5.3	1.9	2.0	3.6	3.5	4.3	5.1	3.4	5.6	22.5
N	(g/100g)	0.6	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.9
C	(g/100g)	7.5	0.7	0.6	1.4	2.6	1.4	2.9	3.1	2.9	11.3
Cl	(g/100g)	1.0	1.8	0.3	1.0	0.6	1.0	0.7	1.0	0.5	0.1
Na	(mg/100g)	213	138	143	359	133	150	188	126	216	111
K	(mg/100g)	36.0	29.5	65.3	80.6	28.0	34.4	34.7	19.8	40.0	30.3
Ca	(mg/100g)	25.0	22.2	18.2	36.5	25.7	38.3	44.2	40.8	45.5	80.2
Mg	(mg/100g)	58.0	20.8	28.4	55.5	35.0	44.8	45.9	44.8	46.4	76.4
P	(mg/100g)	1.3	0.5	1.1	0.8	0.5	0.6	0.8	0.5	1.0	9.9

Tab. 4: Mean values of soil parameters of the vegetation types. Me = *Mertensia maritima* ssp. *maritima* community, Ho = *Honckenya peploides* var. *diffusa* community, H-El = Honckenyo-Elymetum mollis association, Pu = Puccinellietum phryganodis association, Csub = Caricetum subspathaceae association, Curs = Caricetum ursinae association, F-Cgl = Festuco-Caricetum glareosae association, VPe = Festuco-Caricetum glareosae association variant of *Potentilla egedii,* VSu = Festuco-Caricetum glareosae association variant of *Sanionia uncinata,* CM = *Cochlearia groenlandica-Melandrium triflorum* community. Soil texture: gr = gravel, st = stones, sa = sand, si = silt and cl = clay.

Tab. 4: Mittelwerte der Bodenparameter für die Vegetationstypen. Me = *Mertensia maritima* ssp. *maritima* Gesellschaft, Ho = *Honckenya peploides* var. *diffusa* Gesellschaft, H-El = Honckenyo-Elymetum mollis Assoziation, Pu = Puccinellietum phryganodis Assoziation, Csub = Caricetum subspathaceae Assoziation, Curs = Caricetum ursinae Assoziation, F-Cgl = Festuco-Caricetum glareosae Assoziation, VPe = Festuco-Caricetum glareosae-Assoziation, Variante von *Potentilla egedii,* VSu = Festuco-Caricetum glareosae-Assoziation, Variante von *Sanionia uncinata,* CM = *Cochlearia groenlandica-Melandrium triflorum* Gesellschaft. Bodentextur: gr = Kies, st = Steine, sa = Sand, si = Lehm and cl = Ton.

Fig. 6: Salt marsh vegetation complex of the associations Caricetum subspathaceae (in the middle) and Festuco-Caricetum glareosae (foreground) in Kangiussap qinguâ on Svartenhuk Peninsula. Locality 2. Photo O.L. July 1998.

Abb. 6: Salzwiesen-Vegetationskomplex mit den Assoziationen Caricetum subspathaceae (in der Mitte) und Festuco-Caricetum glareosae (im Vordergrund) in Kangiussap qinguâ auf der Svartenhuk-Halbinsel. Lokalität 2. Foto O.L. im Juli 1998.

odis without *Carex ursina* and *Potentilla egedii* as subassociation inops. Table 3 – as well as the vegetation surveys of Nielsen (1969) and Vestergaard (1978) – show that *Puccinellia phryganodes* is confined to the area up to 40 cm above MHW level. This level seems a critical limit for the distribution of the *Puccinellia phryganodes* vegetation. The same seems to apply to *Puccinellia maritima* and *Salicornia* vegetation in temperate areas.

Association Caricetum subspathaceae Hadač 1946

This association was sampled three times in a small zone behind the Puccinellietum phryganodis association in shallow depressions in the lower salt marsh area on mudflats near outlets of small rivers and brooks up to 50 cm above MHW (Tab. 3, ref.-numbers 11-13; Fig. 6). The sites are influenced by irregular inundation with saline or brackish water and infiltration of fresh water. The substrate is silt or clay. The mean soil pH-value is 6.0; the contents of the ions K^+, Na^+, Mg^{2+}, Ca^{2+} are rather low, especially Cl^- (0.6 g 10^{-2} g) (Tab. 4). *Carex subspathacea* (Arctic Salt marsh Sedge) is the character species of the association. Constant species are *Stellaria humifusa* and *Bryum salinum.* Vegetation with dominance of *Carex subspathacea,* which is considered low arctic, circumpolar (Fredskild 1996), is commonly reported from Greenland south of about 78 °N (Böcher 1963, Vestergaard 1972, de Molenaar 1974, Fredskild 1996, 1998) and other northern regions (Thannheiser 1974, 1975, 1987a, Möller 2000). The association has a circumpolar distribution (Fredskild 1996), but is not strictly arctic (Thannheiser 1987b).

Association Caricetum ursinae Hadač 1946

At higher elevations on the salt marsh the Caricetum ursinae association (Tab. 3, ref.-numbers 14-18) follows the association Caricetum subspathaceae. The association is physiognomicaly easily recognized by the round tufts of the character species *Carex ursina* (Polar Bear Sedge, Fig. 7), which is considered a middle arctic, circumpolar species (Fredskild 1996). Cover/abundance and vitality of *Puccinellia phryganodes* and *Carex subspathacea* are reduced. Soil parameters are as follow: pH 7.5, humus content 4.3 %, conductivity 385 μS cm^{-1} and Cl-content (1 g 10^{-2} g) just as in the Puccinellietum phryganodis (Tab. 4). The flooding by seawater is less as in the Puccinellietum phryganodis and Caricetum subspathaceae associations, however there is some influence of fresh water from rivulets. Soil aeration is better and the redoxpotential of the soil with less available Fe- and Mn-ions is higher compared with the soils of the previous salt marsh associations. The Caricetum ursinae association is the only salt marsh

Fig. 7: Caricetum ursinae association on the outlet of the river Kûk, Nuussuaq Peninsula. Locality 8. Photo O.L. August 1998.

Abb. 7: Caricetun ursinae-Assoziation an der Mündung des Flusses Kûk, Nussuaq-Halbinsel. Lokalität 8. Foto O.L. im August 1998.

association bound to the coast of the Arctic. It is not common in the study area; we found it in three localities only.

Association Festuco–Caricetum glareosae Nordh. 1954

In a survey of northern vegetation the circumboreal-arctic *Carex glareosa* salt marsh vegetation is classified by Dierßen (1996) as Festuco-Caricetum glareosae Nordh. 1954. We follow his association concept and consequently vegetation types with *Carex glareosa* (Gravel Salt marsh Sedge) described before from Greenland under different names (a.o. Böcher 1954, de Molenaar 1974, Vestergaard 1978) are all assigned here to this association (Tab. 3, ref.-numbers 19-34; Fig. 6). The sedge *Carex glareosa* is the dominant species in the upper salt marsh from 30 cm up to 1 m above MHW level and character species of the association. In sharp contrast with the lower salt marsh associations this association forms a densely tufted yellow sward. It occurs on sandy to fine gravely deposits on low beach terraces along fiords and on banks of streams in deltas. Fresh water influence from small streams and rivulets from the higher land is considerable.

Mean soil pH is 6.4, conductivity is 277 μS cm^{-1}, while Na-, K- and Cl-contents are 188 mg 10^{-2} g, 35 mg 10^{-2} g, and 0.6 g 10^{-2} g respectively (Tab. 4). *Stellaria humifusa, Puccinellia phryganodes* and mosses *Bryum salinum* and *Sanionia uncinata (Drepanocladus uncinatus)* are the most common companions. In stands bordering the lower salt marsh *Potentilla egedii* and *Cochlearia groenlandica* occur (Tab. 3, ref.-numbers 19-22; variant of *Potentilla egedii*). Festuco-Caricetum stands with mosses such as *Sanionia uncinata* and *Polytrichum alpinum* (Tab. 3, ref.-numbers 23-34; variant of *Sanionia uncinata*) occur on slightly higher sites. The grass *Festuca rubra* appears only in the northern region of the Uummannaq District (locality 2-5) and is confined to the upper part (>50 cm above MHW level) of the salt marsh (Tab. 3, ref.-numbers 31-34). Species number is distinctly higher (4-17, mean 8.6) as in the lower salt marsh communities (1-7, mean 3.5). In well-developed stands the association forms nearly closed, graminoid meadows with about 30 % cover of cryptogams. In the lower salt marsh they cover in mean 7.5 %.

This circumpolar association is the most common type of salt marsh vegetation in the research area and in Greenland, where it is confined to the southern, low arctic regions (Thannheiser 1987a). In comparison with stands in boreal regions the low arctic stands are poor in species.

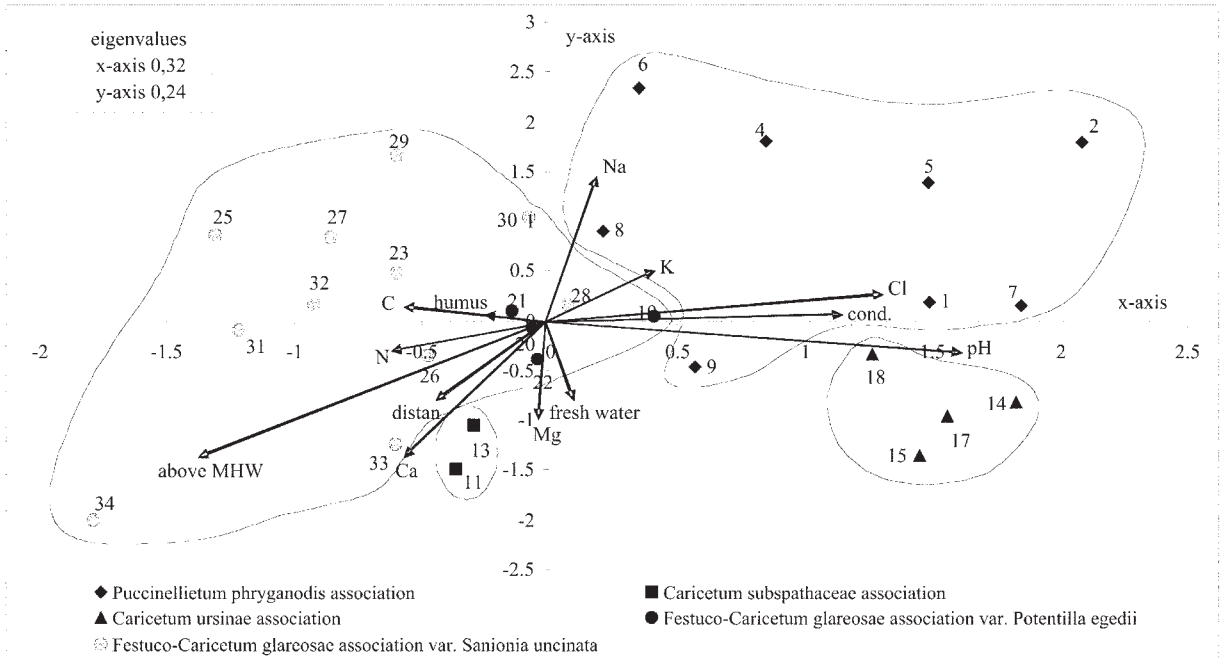

Fig. 8: CCA-biplot of 29 relevés of the class Asteretea tripolii (without ref. numbers 3, 10, 12, 16, 24) and soil parameters.

Abb. 8: CCA-Analyse von 29 Aufnahmen aus der Klasse Asteretea tripolii (ohne Ref.-Nummern 3, 10, 12, 16, 24) und den Bodenparametern.

Synopsis

The CCA diagram of the salt marsh vegetation (Fig. 8) shows that the x-axis (eigenvalue 0.32) rather strongly correlates with altitude, pH, conductivity and Cl-content. These factors are supposed to contribute strongly to the differentiation of the vegetation. Puccinellietum phryganodis association at MHW level is characterized by pH 7.4, conductivity 358 μS / cm^{-1} and Cl-content 0.98 g 10^{-2} g and is situated in the right part of the diagram. The association Festuco-Caricetum glareosae is characterized by pH 6.4, conductivity 277 μS cm^{-1} and Cl-content of only 0.6 g 10^{-2} g (Tab. 4) and is situated in the left part of the diagram. Its variant of *Potentilla egedii* in the centre has an intermediate position. The variant with the moss *Sanionia uncinata* in the left part is characterized by lower conductivity (138 μS cm^{-1}), and Cl-content (0.4 g 10^{-2} g). Moreover Na- and K-contents are less too. In contrast, humus content and Ca-content increase with distance from MHW level. The association Caricetum ursinae is often found in contact with the Puccinellietum phryganodis association since both seem to have a more or less similar ecology. However, the former association is clearly stronger influenced by fresh water, just as the Caricetum subspathaceae, which is floristically more related to the Festuco-Caricetum glareosae. The survey of the Greenlandic salt marsh associations (Tab. 5) shows that *Puccinellia phryganodes* and *Carex glareosa* are

Ref. number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Author	Biol., geogr. dist. types	F98	LD	M74	LD	F98	M74	F98	LD	LD	M74	LD	M74	M74	M74
Area		NE	NW	SE	NW	NE	SE	NE	NW	NW	SE	NW	SE	SE	SE
Table number		35	2	I	2	35	II	35	2	2	IV	2	IV	I	IV
Number of relevés		3	10	7	5	3	7	3	3	4	4	12	21	3	5
Ch Puccinellietum phryganodis association															
Puccinellia phryganodes	A, C	3	V	V	V	3	.	1	2	4	2	II	+	1	.
Ch Caricetum ursinae association															
Carex ursina	MA, C	1	.	.	V	3	.	.	.	.	.	.	.	.	.
Ch Caricetum subspathaceae association															
Carex subspathacea	L, C	.	.	.	I	2	V	3	3	.	.	.	I	1	.
Ch/D Festuco-Caricetum glareosae association															
Carex glareosa	L, C	.	II	II	III	.	III	1	2	4	4	V	V	1	III
Potentilla egedii	L, C	.	.	.	.	.	I	.	.	4	4	.	I	.	V
Sanionia uncinata (M)		.	.	.	I	.	III	.	.	.	.	IV	III	.	III
Festuca rubra coll.	L, A	.	.	.	.	.	.	.	.	.	2	II	III	.	.
Ch Puccinellietum coarctatae association															
Puccinellia coarctata	L, C	.	.	.	.	.	.	.	.	.	.	.	.	3	.
D Potentillo-Caricetum rariflorae association															
Carex rariflora	A, C	.	.	.	.	.	I	.	.	.	.	.	.	.	V
Ch Asteretea class, Glauco-Puccinellietalia order															
Stellaria humifusa	L, W	2	IV	IV	V	3	IV	1	3	3	4	V	V	3	IV
Bryum cf. *salinum* (M)	B, C	.	II	I	I	.	III	.	2	3	.	V	III	1	.
Plantago maritima ssp. *borealis*	A, C	.	.	I	.	.	.	.	.	.	2	.	.	.	.
Cochlearia groenlandica	B, C	.	.	I	.	.	.	.	.	2	.	III	.	.	.
Others															
Bryum spec. (M)		.	II	.	III	.	III	.	2	.	.	.	.	.	.
Stereocaulon glareosum (L)		.	.	.	I	.	.	.	1	.	.	III	.	.	.
Cladonia spec. (L)		.	.	.	.	.	.	.	1	.	.	.	.	.	I
Cetrariella delisei (L)		.	.	.	.	.	.	.	.	.	.	I	.	.	II
Polytrichum alpinum (M)		.	.	.	.	.	.	.	.	.	.	III	.	.	.
Ochrolechia spec. (L)		.	.	.	.	.	I	.	.	.	.	.	I	.	I
Phippsia algida	A, C	1	.	.	.	.	.	1	.	.	.	.	.	.	.
Koenigia islandica	A, C	.	.	.	.	1	.	1	.	.	.	.	.	.	.
Campylium polygamum (M)		.	.	.	.	.	I	.	.	.	.	.	III	.	.
Rhodiola rosea	LO, E	.	.	.	.	.	.	.	.	.	.	.	II	.	II
Cephaloziella spec. (M)		.	.	.	.	.	II	.	.	.	.	.	.	.	.
Equisetum arvense	B, C	.	.	.	.	.	.	.	.	1	.	I	.	.	.
Mosses (M)		.	.	.	.	2	.	3	.	.	.	.	.	.	.
Microlichens (L)		.	.	.	.	.	.	.	.	.	.	III	.	.	.
Pottia heimii (M)		.	.	.	III	.	.	.	.	.	.	.	.	.	.
Bryum pseudotriquetrum (M)		.	.	.	.	.	.	.	.	.	.	.	I	.	.
Pseudocalliergon turgescens (M)		.	.	.	.	.	.	.	.	.	.	I	.	.	.
Melandrium triflorum	AC, W	.	.	.	.	.	.	.	.	.	.	I	.	.	.
Oncophorus wahlenbergii (M)		.	.	.	.	.	.	.	.	.	.	.	.	.	II

Tab. 5: Synoptic table of salt marsh relevés of the entire Greenland. F 98 = FREDSKILD (1998), M 74 DE MOLENAAR (1974), LD = this publication. Species occurring once or twice with "+" or "r" are omitted. (L) = lichens, (M) = mosses and liverworts. Biological distribution types: A = arctic widespread, AC = arctic continental, B = boreal, L = low arctic, LO = low arctic oceanic, MA = middle arctic. Geographical distribution types: A = amphi-atlantic, C = circumpolar, E = eastern, W = western. NE = Northeast Greenland, NW = Northwest Greenland, SE = Southeast Greenland.

Tab. 5: Synoptische Tabelle der Salzwiesen-Vegetation, zusammengestellt für Gesamt-Grönland. F98 = FREDSKILD (1998), M74 = DE MOLENAAR (1974), LD = diese Publikation. Ein oder zwei Mal mit „+" oder „r" vorkommende Arten sind weggelassen. (L) = Flechten, (M) = Moose und Lebermoose. Biologische Verbreitungstypen: A = arktisch, AC = arktisch, kontinental, B = boreal, L = südarktisch, LO = südarktisch ozeanisch, MA = mittelarktisch; geographische Verbreitungstypen: A = amphi-atlantisch, C = zirkumpolar, E = östlich, W = westlich. NE = Nordostgrönland, NW = Nordwestgrönland, SE = Südostgrönland.

Ref. number			1	2	3	4	5	6	7	8	9	10
Field number			97	119	55	51	52	54	76	122	74	75
Locality			5	6	3	3	3	3	4	6	4	4
Position above MHW	(m)		4	1	3	2	4	10	10	4	5	4
Distance to shore	(m)		8	10	2	4	3	6	2	6	8	10
Size of stands	(m^2)		30	120	80	180	120	32	24	40	100	60
Aspect	(degrees)		90	0	180	315	0	180	90	0	180	135
Slope	(degrees)		6	0	1	2	0	1	5	3	2	2
Total cover	(%)		40	50	80	100	70	80	85	75	95	95
Depth of soil	(cm)		8	5	15	16	17	12	10	4	5	7
pH			7.2	7.9	6.4	6.2	6.5	6.3	7.0	7.5	6.4	6.7
Conductivity	(µS/cm)		45	59	314	210	324	178	72	139	91	107
Humus	(g/100g)		4.9	3.2	36	35	31	19	15	21	18	22
N	(g/100g)		0.1	0.1	1.9	2.3	1.0	0.8	0.6	0.7	0.7	0.7
C	(g/100g)		1.2	1.1	24	28	15	9.6	4.9	10	8.9	9.6
Cl	(g/100g)		0.0	0.0	0.2	0.1	0.3	0.2	0.0	0.0	0.0	0.0
Na	(mg/100g)		24	35	197	166	166	112	169	234	5.5	7.2
K	(mg/100g)		13	12	47	14	40	40	61	40	11	26
Ca	(mg/100g)		11	7	62	79	46	37	50	34	188	287
Mg	(mg/100g)		10	8	136	173	113	77	76	58	53	61
Mn	(mg/100g)		0.2	0.0	0.1	0.1	0.0	0.1	0.2	0.1	1.2	0.4
Fe	(mg/100g)		0.7	0.1	1.4	0.7	1.0	0.3	0.6	0.4	1.1	0.7
P	(mg/100g)		0.6	0.6	15	3.8	5.3	4.7	0.9	1.8	21	45
Characteristic species combination *Cochlearia-Melandrium* community												
Melandrium triflorum		AC,W	1	2a	1	+	1b	3	3	2a	+	.
Cochlearia groenlandica		A, C	1	.	1	2m	2a	2b	2a	2a	.	1
D Variant of *Elymus mollis*												
Elymus mollis		L, W	.	.	3	3	2b	.	.	.	.	.
Carex glareosa		L, C	.	.	.	1	2b	.	.	.	.	.
D Variant of *Candelariella terrigena*												
Candelariella terrigena (L)			.	.	.	.	.	+	1	1	.	.
Caloplaca tiroliensis (L)			.	.	.	.	.	1	r	+	.	.
Cladonia pyxidata (L)			.	.	.	.	.	+	r	+	.	+
Caloplaca cerina (L)			.	.	.	.	.	r	1	.	.	.
Lecanora epibryon (L)			.	.	.	.	.	1	+	.	.	.
Caloplaca jungermannia (L)			.	.	.	.	.	1	1	.	.	.
Cetraria muricata (L)			.	.	.	.	.	r	1	.	.	.
Bryonora pruinosa (L)			.	.	.	.	.	1	.	r	.	.
Ochrolechia frigida (L)			.	.	.	.	.	.	+	r	.	.
Physconia muscigena (L)			.	1	.	.	.	.	2a	+	.	.
Cetraria islandica (L)			.	.	.	.	.	.	2a	r	+	.
Cladonia macroceras (L)			.	.	.	.	.	.	1	+	.	.
D Variant of *Aulacomnium palustre*												
Aulacomnium palustre (M)			.	.	.	.	.	.	.	.	2a	2a
cf. *Ceratodon purpureus* (M)			.	.	.	.	.	1	.	.	1	+
Peltigera didactyla (L)			.	.	.	.	.	.	+	.	1	+
Tetraplodon mnioides (M)			.	.	.	.	.	.	1	.	2a	1
Draba glabella		AC, C	.	.	.	.	.	.	.	.	+	+
Others												
Puccinellia cf. *vaginata*		MA,W	3	3	1	1a	2a	2a	2b	2a	3	4
Bryum pallescens (M)			2a	.	3	+	4	4	4	3	2b	2a
Cerastium alpinum		A, A	.	+	r	2b	r	.	.	1	3	.
Sanionia uncinata (M)			.	.	.	5	2a	1	.	.	3	2a
Stellaria humifusa		A, C	+	.	.	+	.	.	.	1	.	.
Micarea crassipes (L)			2b	.	.	.	.	.	.	2a	.	.
Potentilla hookeriana		AC, C	+	.	.	.	.	.	.	.	+	.
Microlichen indet. (L)			.	1	.	.	.	.	.	1	.	.
Polytrichum alpinum (M)			.	.	.	.	.	.	1	.	1	.
Cetraria ericetorum (L)			.	.	.	.	.	.	1	.	+	.
Bryum argenteum (M)			.	.	.	.	.	.	1	.	.	1
Bryum cf. *capillare* (M)			.	.	.	.	.	.	.	1	.	1

Biological, geographical distribution types

Tab. 6: Phytosociological table of the *Cochlearia groenlandica-Melandrium triflorum* community. (L) = lichens, (M) = mosses and liverworts. Biological distribution types: A = arctic widespread, AC = arctic continental, L = low arctic and MA = middle arctic; geographical distribution types: A = amphi-atlantic, C = circumpolar, W = western.

Tab. 6: Pflanzensoziologische Tabelle der *Cochlearia groenlandica-Melandrium triflorum*-Gesellschaft. (L) = Flechten, (M) = Moose und Lebermoose. Biologische Verbreitungstypen: A = arktisch, AC = arktisch, kontinental, L = südarktisch, MA = mittelarktisch; geographische Verbreitungstypen: A = amphi-atlantisch, C = zirkumpolar, W = westlich.

the most prominent species. Although both species can be found together, they have different ecological and sociological ranges. As character species of the Puccinellion phryganodis alliance, *Puccinellia phryganodes* is mainly confined to the lower part of the salt marshes, while *Carex glareosa* as character species of the Armerion maritimae alliance, has its optimum in the higher salt marsh (cf. also Böcher & Laegaard 1962). The latter species has a low constancy (I-III) in the associations of the Puccinellion phryganodis alliance. All associations are poor in species and they are mainly characterized by a preferential character species as is common in extreme habitats with stress and disturbance (Grime 1977). *Stellaria humifusa* and the moss *Bryum salinum* are constant species in all vegetation types. The presented classification system of the salt marsh vegetation types is supported by a TWINSPAN analysis (not shown), which first separates the association Puccinellietum phryganodis from the associations Caricetum ursinae, Caricetum subspathaceae and Festuco-Caricetum, then the association Festuco-Caricetum from the associations Caricetum ursinae and Caricetum subspathaceae and finally the associations Caricetum ursinae and Caricetum subspathaceae and the two variants of the Festuco-Caricetum glareosae association. The association Puccinellietum coarctatae (within the alliance Puccinellion phryganodis) and the association Potentillo-Caricetum rariflorae (within the alliance Armerion maritimae), described by de Molenaar (1974) from Southeast Greenland, have not been observed during our studies in northern West Greenland (Tab. 5).

Cochlearia groenlandica-Melandrium triflorum community

This community described here for the first time (Tab. 6, ref.-numbers 1-10; Fig. 9) occurs on shallow soil on rocky plateaus near the sea at 1-10 m above MHW level. The cliffs are exposed to the sea and influenced by salt spray in particular during EHW conditions. The species combination of *Melandrium triflorum* (Three-flowered Lychnis) and *Cochlearia groenlandica* (Polar Scurvy grass) is characteristic for this community. *Puccinellia* cf. *vaginata* (Sheeted Alkali-grass) and the moss *Bryum pallescens* are constant species. The community occurs in several localities. A typical variant (Tab. 6, ref.-numbers 1-2) occurs on poor soil, while another variant with *Elymus mollis* and *Carex glareosa* was found on rocks with sand cover, very close to the sea and 2-4 m above sea level. The sites are surrounded by beach and salt marsh vegetation. Soil depth, humus layer, salinity and conductivity are fairly high (Tab. 4). A lichen-rich variant of *Candellariella terrigena* occurs on the top surface of steep cliffs situated 4-10 m above sea level. Due to dry soil conditions many terricolous lichens like *Candellariella terrigena, Caloplaca tiroliensis, C. cerina* and *C. jungermannia* occur (Tab. 6, ref.-numbers 6-8). *Puccinellia* cf. *vaginata* is dominant in the variant of the moss *Aulacomnium palustre* (Tab. 6, ref.-numbers 9-10). *Melandrium triflorum* and *Cochlearia groenlandica* are less abundant. The moss *Aulacomnium palustre* indicates wet habitat conditions, whereas the moss *Ceratodon purpureus* and the lichen *Peltigera didactyla* indicate some eutrophication and disturbance. The moss *Tetraplodon mnioides* reflects the high nutrient content (Ca and P) of the soil due to the activities of birds. The variant is considered ornithocoprophytic preferring bird perches. The floristical composition of this community is quiet different from those influenced by birds described from elsewhere, e.g., Svalbard (Elvebakk 1994, Möller 2000). The syntaxonomical assignment of this vegetation type needs further study.

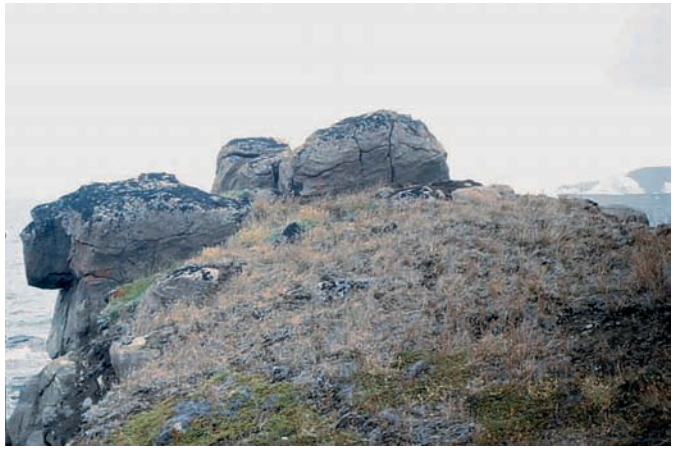

Fig. 9: *Cochlearia groenlandica-Melandrium triflorum* community on a cliff near the sea at Naujât. Locality 4. Photo O.L. July 1998.

Abb. 9: *Cochlearia groenlandica-Melandrium triflorum* Gesellschaft auf einem Felsvorsprung am Meer bei Naujât. Lokalität 4. Foto O.L. im Juli 1998.

GREENLANDIC BEACH AND SALT MARSH VEGETATION IN CIRCUMPOLAR CONTEXT

A number of publications (e.g., Batten & Murray 1993, Daniëls & de Molenaar 1993, Bliss 1993, 1997, Chapman 1977, Dierßen 1996, Elvebakk 1994, Möller 2000 and Talbot & Talbot 1994, Thannheiser 1991) survey or deal with vegetation of coastal ecosystems of the North. They allow an assessment of the Greenlandic coastal beach and salt marsh vegetation, however, without considering arctic Russia, from where phytosociological information could not be traced. Within the relatively young Arctic landscapes the similarity of these azonal vegetation types exposed to stress and disturbance, is fairly high. Contrary to zonal vegetation types, geographical variation seems poorly expressed. A global comparison reveals that beach vegetation in Greenland is rather poor and fragmentary developed. There are only a few vegetation types (*Mertensia maritima* ssp. *maritima* community, *Honckenya peploides* var. *diffusa* community and the Honckenyo-Elymetum mollis association), poor in species and the extension of their stands is very limited and local, due to the preponderantly strongly exposed sheer rocky coast with narrow rocky shores (see Fig. 1, also introduction). Many beaches in the northern Greenland are devoid of any vegetation. Beach vegetation of Greenland and arctic (Eastern) Canada are rather similar. These areas belong to the same floristic, Canada-Greenland province (Yurtsev 1994). The arctic beach vegetation of Alaska in the Beaufort–Chukchi and Bering Sea regions as well as of the more southern (boreal) Aleutian Islands–Alaska Peninsula, are richer in species. Here we additionally find the mainly boreal, North American, amphi-pacific *Senecio pseudo-arnica* (Seaside Ragwort), and the circumboreal *Lathyrus maritimus* (Beach Pea), which is only found in the beach vegetation of southernmost Greenland (Böcher et al. 1978, Feilberg 1984). Moreover richer backshore vegetation is developed (Batten & Murray 1993, Bliss 1993). The northern salt marsh vegetation types from Svalbard, Greenland, East and West Canada are rather similar as

well. They share the associations Caricetum ursinae, Puccinellietum phryganodis, Caricetum subspathaceae and Festuco-Caricetum glareosae. However, the Canadian arctic salt marshes are enriched by the associations Caricetum mackenziei (amphi-pacific) and Puccinellietum pauperculae (syn. Puccinellietum langeanae) (THANNHEISER 1991). In more southern arctic-boreal regions beach and salt marsh communities are richer in species as can be shown even for Greenland, where *Carex lynbyei* (Lyngbye's sedge), *C. mackenziei* (Mackenzie's sedge), *C. salina* (Salt marsh sedge) and *Puccinellia maritima* (Common Salt marsh Grass) are reported from salt marsh habitats in its southernmost part (BÖCHER et al. 1978, FEILBERG 1984). The extensive and high productive salt marsh vegetation of the western Canadian and Alaskan coasts is often associated with estuaries of large rivers causing more brackish soil conditions. Such areas, also along the Russian arctic coast, have an important ecosystem function being of considerable importance for wildlife; especially goose (CHAPMAN 1977, BLISS 1993). Comparable situations are not found in Greenland. Consequently the small and spotty Greenlandic salt marshes are not reported as important grazing grounds for birds and other wildlife (BORN & BÖCHER 2000). Finally haline vegetation types also occur around some lakes in continental inland areas with a dry and warm summer climate (BÖCHER 1954), even at relatively high elevation, most often in the vicinity of fiords. They show some similarities with salt marsh and steppe vegetation. However, their phytosociology is still poorly known and needs urgently studied.

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Appendix

Species occurring once or twice in Tables 1, 3 or 6 (ref. number, cover/abundance value in brackets). (L) = lichens, (M) mosses and liverworts. Biological distribution types: A = arctic widespread, AC = arctic continental, L = low arctic, LC = low arctic continental and HA = high arctic; geographical distribution: A = amphi-atlantic, C = circumpolar, W = western.

Tab. 1: *Carex glareosa* L, C (7, +), *Agrostis mertensii* L, C (8, +).

Tab. 3: *Mertensia maritima* ssp. *maritima* L, W (6, 2b), *Triglochin palustre* L, C (9, 2m), *Pottia heimii* (M) (17, +), *Triglochin palustre* L, C (20, +), *Polygonum viviparum* A, C (22, r), 27: *Cephaloziella* cf. *rubella* (M) (27, 1), *Ditrichium flexicaule* (M) (27, 1), *Mertensia maritima* ssp. *maritima* L, W (28, +), *Arctomia delicatula* (L) (29, 1), *Biatora vernalis* (L) (29, 1), *Caloplaca cerina* (L) (29, +), *C. tiroliensis* (L) (29, 1), *Catapyrenium cinereum* (L) (29, 1), *Cetrariella delisei* (L) (29, r), *Minuartia biflora* L, C (29, r), *Ochrolechia frigida* (L) (29, +), *Stereocaulon* spec. (L) (29, +), *Cerastium alpinum* A, A (31, 1), *Melandrium triflorum* AC, W (31, 2a), *Saxifraga tricuspidata* AC, W (31, +), *Stereocaulon* cf. *condensatum* (L) (31, +), *Cetrariella delisei* (L) (32, +), *Melandrium triflorum* AC, W (32, +), *Salix glauca* ssp. *callicarpaea* L, C (32, +), *Carex stans* HA, C (33, 2a), *Polygonum viviparum* A, C (33, +), *Pseudocalliergon turgescens* (M) (33, +), *Scorpidium revolvens* (M) (33, r), *Campylium stellatum* (M) (34, 2b), *Ditrichium flexicaule* (M) (34, 1), *Koenigia islandica* A, C (34, +), *Pseudocalliergon trifarium* (M) (34, 1), *P. turgescens* (M) (34, 2b), *Straminergon stramineum* (M) (34, +).

Tab. 6: *Artemisia borealis* LC, C (1, +), *Bryum salinum* (M) (3, +), *B. capillare* (M) (6, 2a), *Pottia heimii* (M) (6, 1), *Caloplaca ammiospila* (L) (6, +), *Cladonia* cf. *macrophyllodes* (L) (6, +), *Buellia geophila* (L) (7, 2a), *Leptogium* cf. *lichenoides* (L) (7, 2a), *Catapyrenium cinereum* (L) (7, 1), *Cladonia pocillum* (L) (7, +), *Salix glauca* ssp. *callicarpaea* L, C (8, +), *Leproloma vouxii* (L) (8, r), *Hypnum revolutum* (M) (9, +).

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