VEGETATION OF THE ANGMAGSSALIK DISTRICT SOUTHEAST GREENLAND

I. LITTORAL VEGETATION

BY

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WITH 27 FIGURES AND 6 TABLES IN THE TEXT

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1974

Abstract

The present study deals with a part of the results of observations made during expeditions in 1968 and 1969 to the Angmagssalik District, the central and largest deglaciated area on the Southeast coast of Greenland; which journeys were preceded by a reconaissance in 1966.

The Angmagssalik District is a very mountainous area deeply cut by numerous fjords, and has a pronounced oceanic low-arctic climate. Its general physiography has no broad beaches and wide saline deltas where such extensive, luxuriant and very diversified littoral vegetation as those known from southern latitudes might develop. However, well-developed small stands are locally common in suitable, sheltered habitats and represent several clearly distinguishable vegetation types.

The occurrence and the composition of the littoral plant communities appear to depend on the physiography of the littoral, the climate, the properties of the open water, the substrate, and of course also on phytogeographical and historical factors. Although the environmental factors have not been studied in great detail, they are dealt with rather thoroughly, since they are in many respects different from conditions prevailing at lower latitudes as, for example, in the intensively studied western and southern parts Europe.

The littoral communities were described and classified according to the principles of the Zürich-Montpellier school.

Two exclusive arctic and subarctic groups of communities are represented in the area, viz. the order *Carici-Puccinellietalia* and the order *Honckenyo-Elymetalia arenarii*. The first comprises salt marsh communities which are mainly restricted to the lower beach and sandy to silty substrates, the second is chiefly confined to the upper part of coarse sandy to stony beaches in more exposed conditions.

A comparative study of the *Carici-Puccinellietalia* has led to a revision of the syntaxon, and shows that the associations grouped in this order form for the greater part pairs of vicarious, exclusively arctic and subarctic units at least in the northern Atlantic area. These pairs are differentiated by the absence or presence of a group of widely spread boreal taxa of which the common northern area limit coincides with the boundary between the arctic and subarctic regions, so that their areas are pararegional with respect to the area of the order and its two alliances.

All six associations of the *Carici-Puccinellietalia* are represented in the investigated area. Those of the *Puccinellion phryganodis*, which comprise the syntaxa that are as a rule confined to sheltered habitats on the lowest part of the beach in clayey to silty, sandy substrates poor in humus, are represented by lower units, except for the provisional new association *Sagino-Phippsietum algidae*. Those of the *Caricion glareosae*, which comprise the syntaxa restricted commonly to somewhat less sheltered habitats on the higher part of the lower beach in coarse, sandy, superficially strongly humic to peaty substrates, are represented by all known units.

The *Honckenyo-Elymetalia arenarii* is represented by two sociations, which are presumably local, impoverished representatives of the territorial Greenlandic association *Honckenyo diffusae-Elymetum mollis* or the widely spread, subarctic to arctic *Honckenyo diffusae-Elymetum arenarii*.

The results of the reclassification of the units of the *Carici-Puccinellietalia* in the northern Atlantic are summerized in a separate survey.

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ACKNOWLEDGEMENTS

The two journeys made in 1968 and 1969 on which this study is based were made possible through grants and other support from the Netherlands Organization for the Advancement of Pure Research (Z.W.O.), the Botanical Museum and Herbarium of the State University in Utrecht, the Rijksmuseum voor Natuurlijke Historie in Leiden, the U.S.Army Natick Laboratories, the Stichting Clementer et Auguster, and the Int. Flavors and Fragrances Holland N.V.

A graduate research fellowship of the Netherlands Organization for the Advancement of Pure Research and a temporary appointment at the State University in Utrecht provided the means for the working out of the field observations and collections since the summer of 1969. Technical facilities and hospitality during that period were extended by the above-mentioned Botanical Museum and Herbarium.

To all these institutions and to the persons who were instrumental in giving their support I want to express my sincere gratitude for their confidence.

Furthermore I want to thank everyone who has helped me, particularly the many good friends in the Angmagssalik District itself for their helpfulness and personal concern.

Manuscript received September 7th, 1972

Revised manuscript received February 6th, 1973

A. GENERAL COMMENTS

1. Introduction

1.1. Geographical Comments

1.1.1. Definition of the geographic regions

POLUNIN (1951) delimitates the Arctic as the region on the northern hemisphere that lies North of whichever of the following is situated farthest North: (1) a line 80 km (50 miles) north of the northern limit of coniferous forest or at least more or less continuous taiga; (2) North of the present-day northern limit of at least microphanerophytic growth, the northern extremities of tongues or outliers separated by not more than fifteen degrees of lóngitude; or (3) North of the northern Nordenskjöld line, which is determined by the formula V = 9–0,1K, where V is the mean of the warmest month and K is the mean of the coldest month, both in degrees centigrade.

The northern part of the temperate region bordering upon the Arctic is termed the Subarctic. When this term or its adjective are used hereafter, it is assumed that they comprise the transitional region between the northern limit of the continuous coniferous forests of the boreal zone, and the southern limit of the Arctic according to POLUNIN's concept. This zone includes the areas with microphanerophytic growth, isolated occurrences of conifer stands and open taiga or forest tundra. Accordingly, it includes areas often regarded as situated in the Arctic, such as southernmost Greenland, Iceland, northern Fennoscandia with the Kola peninsula and the coasts of the White Sea, the southeastern coasts of Siberia, the western coast of Alaska and the southern shores of Hudson Bay (cf. e.g. AHTI *et al.*, 1968, p. 201).

The Arctic is commonly subdivided in a high and a low-arctic part, based on climatological and floristic criteria; on the East coast of Greenland the borderline between these two zones is drawn at approximately 70° N.l.

1.1.2. The Angmassalik District

The Angmagssalik District constitutes the central part of the low arctic coast of East Greenland. It is situated opposite Iceland across the

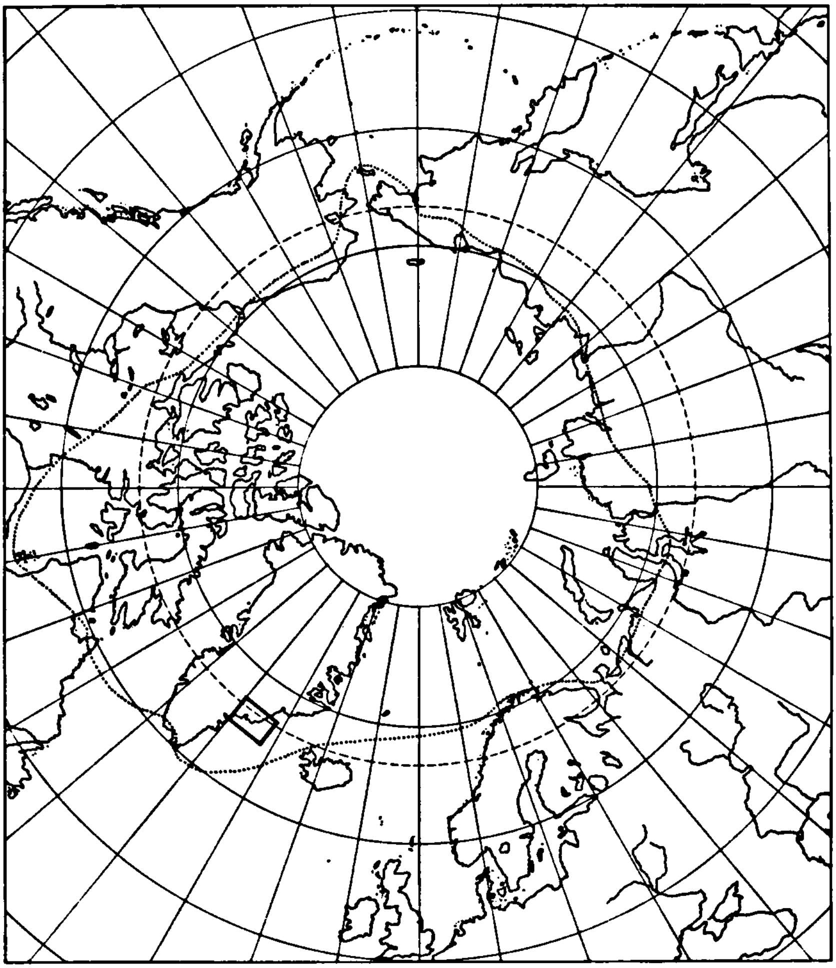


Fig. 1. Map of the central part of the northern hemisphere with the delimitation of the Arctic (dotted line; slightly modified after Polunin, 1951); the polar circle is indicated by an interrupted line, the investigated area by a square.

Denmark Strait, between 65° and 67°20′ N.l. When the term Angmagssalik District is used in this paper it applies to the area in stricter sense, to the deglaciated part of the Southeast coast between the Ikertivaq bay to the South and the K.J.V. Steenstrup Bræer (glaciers) to the North, thus ranging approximately from 65°30′ to 66°30′ N.l. Topographically it is a wild mountainous area, deeply cut by numerous fjords, and almost inaccessible except by boat during the ice-free period. Its ragged, steep mountaintops, with their corries and glacier-clad slopes, lend it a wild beauty, hardly surpassed by any other alpine landscape.

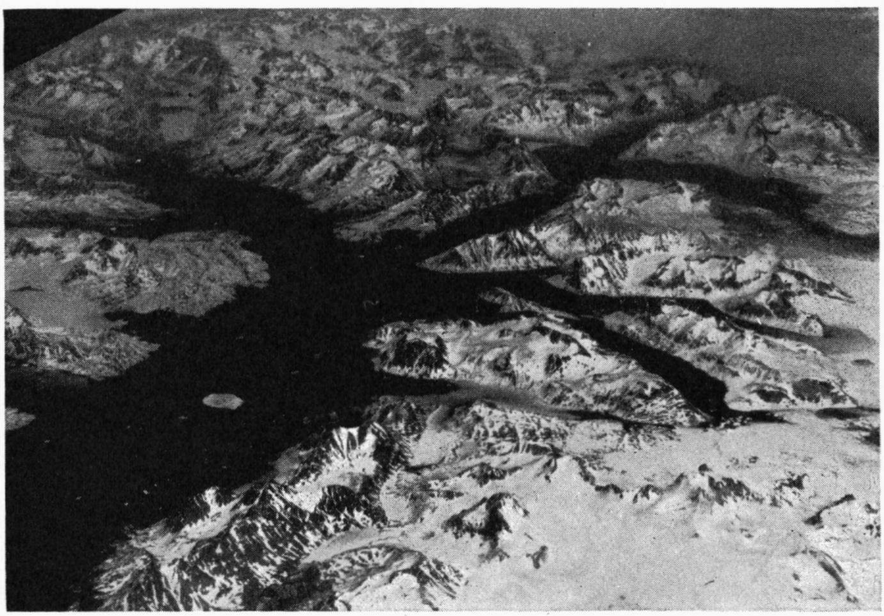


Fig. 2. Oblique aerial photograph of the central part of the Angmagssalik District: from the lower left curving to the upper left the Angmagssalik Fjord, branching in the innermost part in the Qíngertivaq (left) and Tasîlaq (right, still with ice); in the extreme upper right corner the misty Sermiligâq fjord, connected with the bend in the Angmagssalik Fjord by the Ikâsak fjord and its extension, the Íkáteq fjord (cf. fig. 3). JGdM phot. VI. 1969

1.2. Botanical Comments

1.2.1. General

Detailed publications on the littoral vegetation in the Arctic and the Subarctic, based on and illustrated by analyses of the vegetation, are scarce.

From the real Arctic, salt marshes have only been described in this way from the high arctic Spitsbergen archipelago, and from the Subarctic only from continental northern Europe and western Alaska. Brief descriptions and information of such vegetation are more common. These studies suggest that the plant communities of the shores of the Arctic Ocean constitute a circumpolar, homotonous group, which is poor in species and variation and physiognomically monotonous. The syntaxa, which are distinguishable, are characterized by usually one or only a very few faithful or differential, at the same time usually also physiognomically dominating taxa. The occurrence of these communities is restricted by physiographical conditions. Particularly along the rocky coasts in the real Arctic they are usually of limited extent; in the Subarctic they often cover far more extensive tracts and thus form marshes physiognomically comparable with the salt marshes of the temperate regions.

1.2.2. Previous Investigations

1.2.2.1. Southeast Greenland

The Angmagssalik District was reached for the first time by an expedition in 1883 (NORDENSKIÖLD, 1885). From that year until the turn of the century only incidental floristic investigations were carried out in the district.

Then, first in 1898–1899 as a member of an expedition lead by AMDRUP, and later in 1901–1902 accompanied by his family only, the district was intensively botanically investigated by CHR. KRUUSE, both floristically (KRUUSE, 1906) and ecologically according to the methods of that time (KRUUSE, 1912). In his botanical travel account he also mentions the floristic composition and, when present, the zonation of the vegetation of the sea shore, the "Strand-flora", which he finally subdivides in two large groups according to the substrate.

In 1932 TYGE W. BÖCHER visited the area as a participant in the Scoresby Sound Committee's 2nd East Greenland Expedition, studying the vegetation applying the Raunkiaer circling method (a method based on frequency and density analysis of individuals or shoots). However, he did not analyse the *Caricetum glareosae* he mentions (BÖCHER, 1933), but only says that he understands by this name littoral vegetation dominated by *Carex glareosa;* consequently this name must be regarded as a *nomen nudum.* This also holds true for his *Caricetum subspathaceae*, the name he designates to KRUUSE's enumeration of species present in the halophytic vegetation characteristically occurring on mud flats in the Angmagssalik District, but which as such does not constitute a syntaxonomical unit.

From the southern part of the Southeast coast, between 60°30′ and 64°30′ N.l. DEVOLD & SCHOLANDER (1933) present a brief floristic description of the halophytic beach vegetation in that area.

1.2.2.2. The remainder of Greenland

From the coasts of the remaining parts of Greenland littoral vegetation has frequently been described in the many botanical publications on local studies; sometimes only recording the predominating species, sometimes also mentioning some subdominating or because of other, usually phytogeographical reasons, conspicuous species. Most of these publications appeared in the series *Meddelelser om Grønland;* to avoid listing numerous publications I refer the reader to the index of this series. In this connection I will confine myself to mentioning as one of the first papers dealing with this subject the one by BERGGREN (1871), who already observed several zonations, and furthermore WARMING (1888), HARTZ (1894), KOLDERUP ROSENVINGE (1896), HARTZ & KRUUSE (1911) and BÖCHER (1933, 1954, 1963).

1.2.2.3. Jan Mayen

LID (1964) published several tables with analyses of some littoral vegetation types from the island of Jan Mayen, applying the Hult-Sernander scale (a scale based on the estimation of the abundancy or degree of cover, originally divided into 5 classes; see 1.2.3.1.). Unfortunately he does not supply additional data on the habitat. RUSELL & WELLINGTON (1940) give some brief information on this subject from this island.

1.2.2.4. Spitsbergen

In common with reports from Greenland, the numerous botanical publications concerning Spitsbergen contain many brief descriptions of and comments about the local littoral vegetation. The publication by HADAČ (1946) is fundamentally important to the syntaxonomy of arctic littoral vegetation. He describes and classifies several new syntaxa, and uses the Domin scale (a scale expressing the abundancy and degree of cover, divided into 11 classes) in coding the results of his analyses. But he, too, does not give detailed information on the synecology of the units.

Later on, HOFMANN (1969) gives a treatise on the *Puccinellietum phryganodis* HADAČ 1946 and its subunits, and a survey of the arctic-subarctic *Puccinellion phryganodis* HADAČ 1946. Worth mentioning are also the publications by WALTON (1922) and DOBBS (1939).

1.2.2.5. Iceland

The subarctic-boreal littoral communities of Iceland have been studied and described by STEINDÓRSSON (1936, 1954) and by TÜXEN (1970). They appear to be only partly connected with the circumpolar arctic-subarctic littoral vegetation group.

1.2.2.6. Continental northern Eurasia

The littoral vegetation of the subarctic part of continental northern Europe, ranging from northern Norway eastward to the eastern shores of the Kanin peninsula (Poluostrov Kanin), has attracted more detailed attention from botanists than most of the arctic-subarctic halophytic vegetation elsewhere, probably because of the extent of the salt marshes there and their economic importance.

Syntaxonomically the study of NORDHAGEN (1954) is of fundamental importance in this region. He presents a comprehensive and critical description of the salt marshes in Finmark, northern Norway, with analyses made by applying the Hult-Sernander scale.

Preceding that work KALELA (1939) published the results of a study of the meadow-like vegetation of the Fischerhalbinsel (Poluostrov Rybachiy) in Petsamo Lapland in former northern Finland, applying the slightly modified Norlinn scale (based on the estimation of the density, viz. the distance between the individuals of a certain species; HÄYRÉN, 1902; KALELA, 1939, pp. 53–54). REGEL (1923, 1928, 1941) has surveyed the vegetation of the Kola peninsula (Poluostrov Kol'skiy), including clear descriptions of the beach vegetation based on unfortunately for the greater part unpublished analyses according to the Drude method (based on an estimation of the abundancy, expressed in a scale divided in 5 not clearly defined classes). I may further mention for instance descriptions of the littoral vegetation in subarctic Scandinavia by RESVOLL-HOLMSEN (1916) and by GILLNER (1955).

The littoral vegetation along the shores of the Malozemel'skaya coast, arctic Russia, has been described by LESKOV (1936), and of the Mezenskaya Guba and the Chëshskaya Guba on both sides of the Kanin peninsula by KORCZAGIN (1937), on the basis of frequency-analyses (according to a scale divided in 6 classes). KORCZAGIN divides the Russian coastal areas along the Polar Sea in "Laidy", the coast of the eastern part of the Kola peninsula eastward to the coasts of the Kanin peninsula, roughly the subarctic White Sea area, and the "Tampy", the coast from the Kanin peninsula to the Bering Strait, the arctic Siberian area. Of the latter little is known with respect to detailed descriptions, but some brief floristic descriptions and particularities have been mentioned by various authors from different areas along that coast, for example in a publication dealing with the vascular plants of the Siberian North edited by TOLMACHEV (1966). In the light of the information from elsewhere, these give a fairly clear impression of the Tampy-vegetation.

1.2.2.7. North America

The littoral vegetation occurring in arctic and subarctic North America has been described or mentioned, among others, by HANSON (1951) from western Alaska, applying frequency analyses based on the point-contact method, JOHANSON (1924) from northern Alaska and neighbouring northwestern Canada, POLUNIN (1948) from northern Alaska (*in* CHAPMAN, 1960) and from the Canadian eastern Arctic, FERNANDEZ-GALIANO (1959) from subarctic eastern Canada.

1.2.2.8. Surveys

Recently CHAPMAN (1960) has paid attention to the data published about arctic and subarctic salt marshes, especially their zonation and succession, in a monograph on the salt marshes and salt deserts of the world.

Beeftink (1965, 1968) gives a survey of the syntaxonomy of the European salt marsh communities, including those from northern Norway and from Spitsbergen, within the scope of his study of the salt marshes of the southwestern Netherlands.

Finally Tüxen (1970) announced the publication of a survey of the subarctic beach communities with *Elymus* and *Hockenya.*

1.2.3. The Present Investigation

The present investigation was carried out during the summers of 1968 and 1969 in the Angmagssalik District on the Southeast coast of Greenland, as a part of a more comprising program.

1.2.3.1. Methods in the Field

I have described the littoral vegetation of the district on the basis of detailed analyses of homogeneous, representative and distinctly defined parts of well developed stands. These were carefully selected, after I had in the first instance acquired a general survey of the most important types of vegetation and their variation in the locality in question. Such a test area for analyses has been given various names in the literature: quadrate, sample plot, relevée, Aufnameflach, Probeflach. In this study I will refer to it arbitrarily by the term sample plot.

The fundamental importance of the homogeneity, the representativeness and the significance of the floristic minimum area, in connection with the choice of the place and the extent of the sample plot, is dealt with *in extenso* in various works (including Barkman, 1958; Braun-Blanquet, 1964; Dahl, 1956; Ellenberg, 1956). In the course of this study I found that the minimum area concerning both floristic composition and homogeneity was always considerably smaller than one square meter. Consequently I chose this area as the standard size of the sample plots. During recent investigations in Greenland and in Scandinavia this size is also in common use.

In contrast to most Scandinavian synecologists I did not analyse a series of 5 or 10 sample plots from each stand, but only one like Böcher (1954, 1959, 1963), Dahl (1957) and the synecologists of the Zürich-Montpellier school do. At the risk of loss of insight in the variability of the individual stands, this less time-consuming method yields more information on the variability of the collective stands of a vegetation type in a certain area as a whole. In this connection Nordhagen (1943) has introduced, analogous to the term homogeneity (heterogeneity) in respect to a single stand, the term homotony (heterotony) to apply to a single type as a whole; BARKMAN (1958) uses the terms intensive and extensive homogeneity, respectively.

I described the plant cover inside the sample plot qualitatively by listing the present taxa as completely as possible, quantitatively by assessing a combined estimate of the internal cover and the abundance for each taxon. For the coding of this estimation I have used the Hult-Sernander scale. Originally this scale has five classes, but like NORDHAGEN (1943), HANSON (1953), DAHL (1956) and GJAEREVOLL (1956) I found the class 5 too wide. Therefore I have followed HANSON (l.c.) and introduced a figure 6, so that 5 means cover $^1/_2$–$^3/_4$ and 6 means cover $^3/_4$–1. Furthermore I used the + sign to indicate the occurrence of only a very few, usually poorly developed individuals, as has become common use. The other classes are: 1 (cover less than $^1/_{16}$), 2 (cover $^1/_{16}$–$^1/_8$), 3 (cover $^1/_8$–$^1/_4$), and 4 (cover $^1/_4$–$^1/_2$). I preferred the Hult-Sernander scale to the Braun-Blanquet and the Domin scales to facilitate direct comparison of my results with the descriptions of the vegetation from elsewhere in Greenland and from Scandinavia, where it is generally used. These three scales are for that matter easily translatable into each other and a comparison is for instance given by DAHL (1956, pp. 44–45).

I noted down the stratification in the plant cover when present; for each layer, including the litter layer, I estimated the cover in percentage. I also made notes on the stage of development of the various species and the general physiognomy.

After completing the analysis of the plant cover inside the sample plot I compared it with the rest of the stand to trace possible differences and zonations and then I made a brief description of the surroundings, usually illustrated by a sketch.

The position of the stands and the sample plots with regard to the level of mean high water is based on estimation, which I deduced from actually observed high tides and the situation of the normal and the stormtide marks on the beach.

Tidal levels are coded as follows:

MHW-MLW: mean high resp. low water level;
MHWS-MLWS: mean high resp. low water level at spring-tide;
EHWS-ELWS: extreme high resp. low water level at spring-tide.

Next a soil profile-pit was dug, as a rule to a maximum depth of −50 cm or else as deep as the ground water permitted. It is desirable in normal field work that the soil at the site is briefly described, since the soil and the vegetation which grow upon it are interdependent. The examination of the soil pit, as a means of studying the soil *in situ*, was done rather extensively, especially as facilities for studying the soil by samples *ex situ* were not available.

After the determination of the physical stability of the soil in general I divided it into its different layers by means of visible and tangible characteristics and then described each stratum as extensively as possible.

The vertical differentiation of the substrate and the texture of the different layers supply information on the genesis of the soil and the stability of the environment in time. The texture affects indirectly or directly structure and constitution and in consequence influences aeration, permeability, drainage and finally root development and root penetration. I determined the predominating grade in the proportions of the solid mineral constituents of the different strata in the field by comparison with a series of standard samples embedded in transparant plastic. This "particle size ruler" was divided as follows:

diameter smaller than 0,05 mm: silt;
0,05–0,105 and 0,105–0,21 mm: fine sand;
0,21–0,42 mm: medium fine sand;
0,42–1 and 1–2 mm: coarse sand.

I subdivided the finest grade in the field by the sense of touch and sight in silt and clay-loam.

This scale practically agrees with the system of texture grades of the U.S.Bureau of Soils and Public Roads Administration, with the understanding that the grade coarse sand in that system also comprises the grade medium fine sand from my "ruler".

If there was considerable admixture of material of a distinct other grade than the dominant one this was also noted. The terms I used in those cases, like clayey fine sand, coarse sandy peat, are my responsibility; consequently my terms are not the official ones based on mechanical analysis.

Below all sample plots I determined the pH of the rhizosphere by means of the colorimetric Hellige Pehameter. After some practice it permits an accuracy of determination of the nearest $^1/_4$pH unit. These values are rather rough, but the value of the determination depends to a great extent upon its interpretation. I consider it not as important to know the absolute values, as to know a series of comparative figures which permit an impression of the pH range for the various communities which may indicate differences in environment and possibly support differences in other respects. For this reason I consider this method sufficient. I obtained an impression of the water and air balance of the soil by combining the position of the stand in regard to MHW level and the ground water level at low tide with observations on the moisture, the texture, the structure and the constitution of the soil. I estimated the salinity of the flood water by taste tests; the classification in euhaline, mesohaline and polyhaline which I used is consequently a relative one. Superficial afflux and subterraneous influx of fresh water is easily discerned in the field.

1.2.3.2. Working up the data

In the classification I essentially followed the methods of the Zürich-Montpellier school (BRAUN-BLANQUET, 1963; ELLENBERG, 1956; BARKMAN, 1958), which is principally based on the fidelity concept. As regards the character of arctic and northern alpine types of vegetation I interpreted these classificatory principles in the same way as NORDHAGEN (1943) did in his famous synthesis of the Scandinavian and the Zürich-Montpellier schools, and applied the combined criterion of fidelity and dominance (cf. a.o. NORDHAGEN, 1954; DAHL, 1956; GJAEREVOLL, 1956; BEEFTINK, 1965).

The sample plot analyses are given in tables. Considering that such tables should serve to represent the communities I did not, as is often done, arrange the tables according to the different layers in the plant cover or to a taxonomical system, nor alphabetically. This would only facilitate looking up of individual taxa. Instead I arranged the taxa, to ecological criteria: the presence ("Stetigkeit") of the taxa, their according mutual ecological indicative similarity and the level of their syntaxonomical significance, so that it should be possible to take in the synqaxon at a glance.

Other quantitative data than the coded combined estimation of cover and abundance of the individual taxa are given at the top of the tables (– indicating (approximately) 0). With each phanerogamic taxon its phytogeographical distribution type is given, based on the publications of BÖCHER (1963) and HULTÉN (1958, 1962, 1968) and principally referring to the distribution in Greenland. The types are given in BÖCHER's coding (l.c.):

A: arctic widely distributed type;
L: low-arctic distributed type;
B: boreal distributed type.

A comparable detailed, parallel determination of the distribution of the various cryptogamic taxa not being possible is thus not given in the tables.

The Raunkiaer plant life-forms are mentioned in the text for each syntaxon.

For each unit described I have, to the best of my knowledge, cited the synonyms; this enumeration does not pretend to be exhaustive, and under the same heading I have stated which previously described communities at least from Greenland, Iceland and Fennoscandia belong to the same unit.

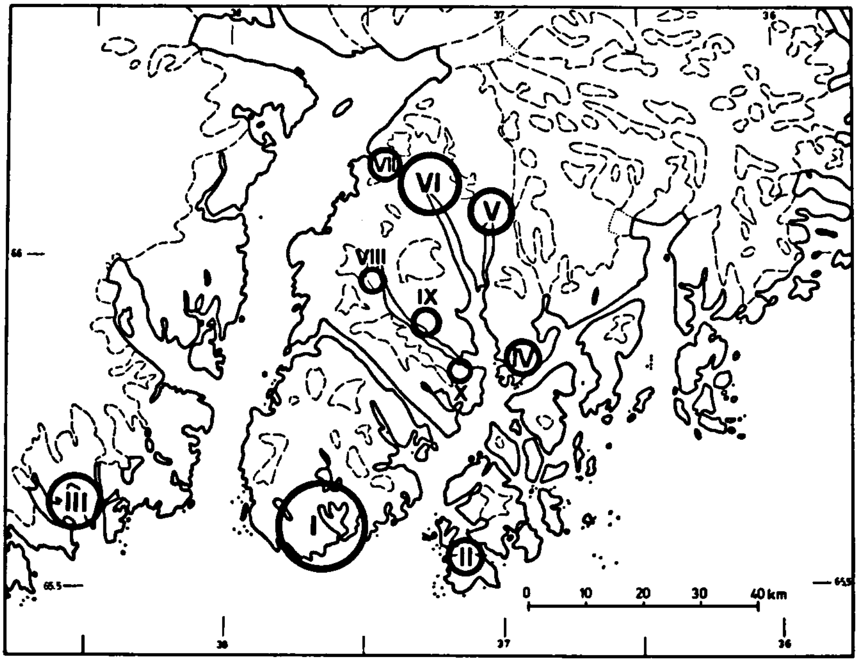


Fig. 3. Map of the localities investigated in 1968 and 1969. The interrupted line indicates the outline of the boundary between the deglaciated land and the ice cap, firn fields and glaciers.

2. The Localities

See fig. 3.

2.1. Locality I: Southern part of Angmagssalik Ø

2.1.1. Kong Oscars Havn or Tasîlaq (Konung Oscars hamn, Tasiusak or Tasiussaq on old maps; see fig. 4), a small, branched fjord in the centre of the locality.

2.1.1.1. Grønlænderpynten, 65°36′ N–37°36′ W, a small, rocky spit of land just inside the entrance to the fjord at Igtumît, an old habitation and camping site near the town of Angmagssalik. On its loose gravelly western slopes there is an open (aero)halophytic vegetation with for instance *Mertensia maritima* and *Sedum rosea.* Nearby there is a brackish marsh strongly manured by man (cf. KRUUSE, 1912, p. 101).

2.1.1.2. Sermilikvejen, 65°38$^1/_2$′ N–37°40$^1/_4$′ W, near the head of the northwestern branch of the fjord. The delta of the brook system draining the Sermilikvejen valley itself is stony and without vegetation; immediately northwest of it a crescent beach is found covered with a well-developed *Carex glareosa* meadow on the lower, peaty-sandy part, and

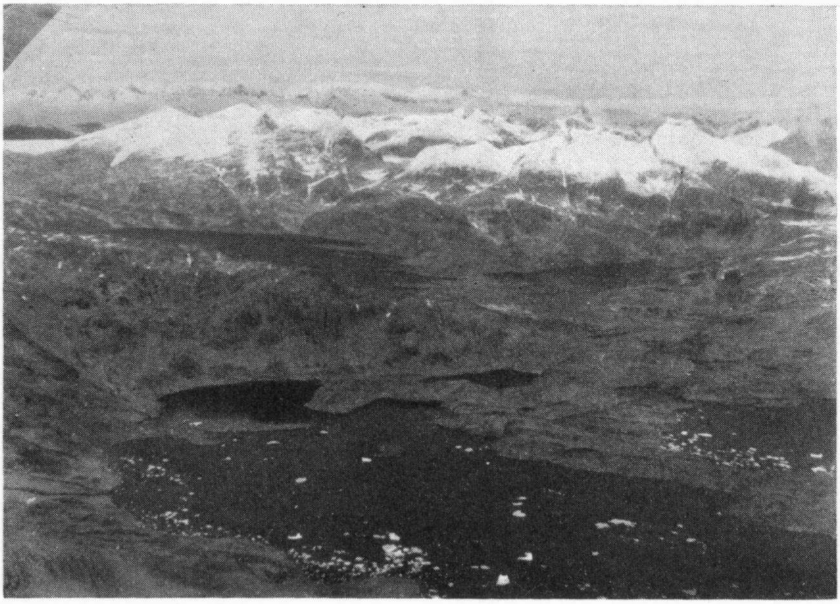


Fig. 4. Oblique aerial photograph of the northwestern branch of Kong Oscars Havn. To the lower left the crescent bay at the entrance to the Sermilikvejen valley and above this the almost circular Imîlâjiva; to the right the inner part of the northern, middle branch, Qortortup imîla; between these two branches the Amarqâq peninsula with several lakes. In the middle background the large, in the middle of the picture constricted lake Qordlortoq Sø. JGdM phot. VI. 1969

a closed *Honckenya peploides* cover on the upper, loose gravelly part, with in between and along the edge of the sedge meadow a narrow *Festuca rubra* zone (fig. 16).

2.1.1.3. Imîlâjiva, 65°39′ N–37°40′ W, the innermost crescent bay in the northwestern branch of the fjord. Along its shores *C. glareosa* meadows occur with patches dominated by *C. rariflora* (fig. 23), and open *Honckenya peploides* and *Mertensia maritima* stands, though the greater part of the beach is without vegetation.

2.1.1.4. Qortortup imîlâ, 65°38$^1/_2$′ N–37°36$^1/_2$′ W, the middle, northern branch of the fjord. Here, slightly east of the mouth of the Qortortoq river, a brook debouches into the bay through a marshy estuary. From the fjord inward are found to be dominating first *Festuca rubra*, then *Carex glareosa* without a moss layer, then *C. glareosa* with *Campylium polygamum*, and at last *C. glareosa* with *Drepanocladus uncinatus*. Along the western, steep slope of the estuary a snowdrift is found until late summer, with a very shallow tidal and meltwater puddle in front. On the wet, flat, muddy banks of this puddle a stand of *Carex subspathacea* with *Bryum salinum* occurs (fig. 15). Along the eastern slope *Bryum pseudotriquetrum* replaces patchwise *Campylium stellatum* in the *Carex glareosa* marsh.

2.1.1.5. Nordfjord, 65°37$^1/_2$' N–37°33$^1/_2$' W, the northeastern branch of the fjord. On the eastern shore of this bay there are found two very shallow, almost circular baylets. The largest is locally called "Kilitilik", because of the abundance of mussels there, in former times an important source of food during famines. Along the shores of these embayments occur small, well-developed stands of littoral vegetation dominated by *Carex glareosa*, *Festuca rubra* or *Honckenya peploides*.

2.1.2. Sarpakajik,, 65°38$^1/_2$' N–37°31$^1/_2$' W, a narrow, small fjord immediately east of Kong Oscars Havn. On its western shores in the inner part there are several small coves and bays with small stands of littoral vegetation dominated by *Puccinellia phryganodes* and *P. coarctata* on their beaches.

2.2. Locality II: Kap Dan on the island Kulusuk, 65°34' N–37°13' W,

directly northeast of the village. On a delta in the estuary of a brook covered with large boulders and blocks, there occur small patches of littoral vegetation dominated by *Carex subspathacea* (fig. 5), *Honckenya* and *Mertensia.*

2.3. Locality III: Tasîlâlik (Tasitalik), 65°39' N–38°31' W,

a small, L-shaped fjord on the eastern side of the Nagtivit kangertivat west of the Sermilik. The greater part of its shores is stony and rocky, without well-developed littoral vegetation. Along the outer shore of the bend in the fjord well-developed, rather extensive littoral vegetation occurs where a small brook debouches, draining the broad valley which runs southeast to the Siportôq fjord (fig. 18). The main vegetation type is a closed *C. glareosa* meadow at high tide level, on a sandy beach with here and there boulders and an occasional tidal pool. The upper part of the beach consists of loose, coarse gravel and shingle with an open cover of *Honckenya.* On a small rocky spit of land *Mertensia maritima* and *Plantago maritima* ssp. *borealis* var. *glauca* (Horn.) Fern. occur. A raised former beach nearby, at 3 m a.s.l., separated from the present beach by a low shingly ridge, is partly covered with a *P. phryganodes* stand. A little farther away there is a more extensive, flat, raised former beach at about 5 m a.s.l., partly covered with vegetation dominated by *Carex rariflora* and *Potentilla egedii* var. *groenlandica* Wormskj. (fig. 25).

Fig. 5. Patches of littoral vegetation (*Caricetum subspathaceae inops*, var. of *Bryum*) on a brook delta near Kap Dan on Kulusuk, which is protected against ice-scour and the waves by large boulders. JGdM phot. VII. 1968

2.4. Locality IV: Torssukåtak (Tunok), 65°52½′ N–36°54′ W,

a small branch of the Angmagssalik Fjord near Kûngmiut opposite the entrance of the Ikâsaulaq. In the inner part occur the best developed stands of *P. phryganodes* of the area; other littoral vegetation types also occur, particularly *C. glareosa* meadows and transitional types of these to other types, and *F. rubra* stands.

2.5. Locality V: Tasîlaq (Tasîssârssik), 66°2′ N–37°3′ W,

the eastern branch of the innermost ramification of the Angmagssalik Fjord. Most types of littoral vegetation found in the district are represented on the shores along this fjord, though they are often more or less fragmentary. Most common and best developed are the *F. rubra* stands on the upper part of bare, stony beaches (cf. fig. 21).

2.6. Locality VI: Qíngertivaq (Qingorssuaq),

the western branch of the innermost ramification of the Angmagssalik Fjord.

2.6.1. At the head of the fjord, 66°7′ N–37°16′ W. At the very head there is a vast outwash delta of glacier rivers with littoral vegetation types dominated by *C. subspathacea* on silt (fig. 14) and *Honckenya* on coarse sand. *C. rariflora* occurs on the narrow beaches along the tidal flat of this delta, and there are stands of *Puccinellia coarctata* and of *Phippsia algida* and *Sagina intermedia* on deltas of small brooks. In the middle part of the fjord the most common type is formed by belts of *F. rubra* on the upper part of stony beaches.

2.6.2. "Ujâjivdlutaleq", 66°1′ N–37°9′ W, on the eastern shore of the fjord near a huge, isolated boulder on the beach given this name by some local fishermen. Large, domed patches of *Honckenya* occur there on the very loose shingly beach.

2.7. Locality VII: Sermilik (Egede og Rothes Fjord), 66°10′ N–37°33′ W.

The Sermilik is the largest icefjord in the district. On its eastern shore, between Nûk and the entrance of Ilivnera valley (Itivdleq), there is a small bay with an islet as a cork in its bottleneck entrance. A *C. glareosa* meadow surrounds the bay and on the islet there are also some open stands dominated by *P. phryganodes* and by *Phippsia algida.* According to Nooter (in verb.), *C. glareosa* meadows also occur farther to the south in the Sermilik in the very sheltered Ikâsaulaq bay (Igdlerajik) between Paornakajît and Nûk. Near Nûk it was observed that the edge of the sedge meadow on the islet was strongly eroded and that large lumps of the turf were torn loose, sliding away into the water (fig. 17).

2.8 Locality VIII, X: Ikâsaulaq (Ikerasaussaq),

a long, narrow, western fjord-branch of the Angmagssalik Fjord, parallel to and in between the Ikâsartivaq (Ikerasagssuaq) and the Qíngertivaq. Fragmentary stands of nearly all the types of littoral vegetation observed in the district can be found along this fjord, but few of them are well-developed.

2.8.2. Locality VIII: At the head of the fjord, on the western shore just past a spit of land projecting far into the fjord, 65°59′ N–37°27′ W. On the upper part of the otherwise bare, stony beach occur narrow belts of littoral vegetation, dominated by *F. rubra* and *C. glareosa* (fig. 21). From a distance the beach on the extensive deltas at the very head of the fjord seems to be covered with *C. glareosa* and *C. subspathacea* meadows.

2.8.2. Locality X: Near Qârtulâjik, 65°51$^1/_2$′ N–37°10$^1/_2$′ W, at the entrance of the fjord about 2 km west of Maries Havn and Griseøen. Here there is an almost circular bay with stands of *F. rubra* and *C. gla-*

reosa on the upper part of the stony beach, and on the broad, low, sandy spit of land at the entrance of the bay extensive stands of *F. rubra*, *C. glareosa* and *Honckenya* occur on soil manured by man, as this site was and is still used as a camping place (fig. 27).

3. The Environment

3.1 The Physiography of the Littoral

The many islands along the coast of the mountainous Angmagssalik District and the numerous branched fjords, which cut deep into the deglaciated land, bring about a very long coastline. On the whole this coastline is formed by (steep) rocky cliffs, which come right out to the water. Narrow, stony beaches or sandy to silty brook deltas forming the transition from the land to the sea and the fjords occur only occasionally.

3.1.1. Along the Sea

The shore of the outer islands and along the wide entrances of the large fjords are mainly formed by rocky cliffs, which rise sheerly from the water. These are fully exposed to the wash of the waves and the scouring of the pack ice of the East Greenland Current during the summer; in the winter an ice foot of 1–2 m thickness is formed attached to the shore, offering protection against these forces, but eroding itself when it is broken loose occasionally from the shore by these actions. In consequence the littoral zone is nearly devoid of vegetation. There are only very few sites where patches of halophytic vegetation fragments can be found occurring in this zone. These are deltas of brooks covered with large boulders, which to some extent provide protection against the action of the ice and the waves. The soil in this habitat consists of material mixed according to origin and grade, and there is usually an influx of fresh water (cf. fig. 5).

3.1.2. Along the Middle and Inner Parts of the Fjords

There is no sharp border line between the physiography of the littoral zone at the entrances to the fjords, the seashore-type, and that of the middle and inner parts of the fjords. The latter is more diversified and requires a subdivision.

3.1.2.1. Along the Icefjords or "Sermiliks"

By this type of fjord is meant fjords in which abundantly calving active glaciers debouch. The discharge of these keep the "sermiliks" filled with icebergs and smaller pieces of ice almost the whole year round (fig. 6). The shores along these fjords are also mainly rocky, though in general less steep than along the seacoast, and exposed to the scouring

Fig. 6. Ice conditions in summer in the Sermilik fjord near Tiniteqilâq; icebergs and fragments, with in the background ice-polished roches moutonnées.
JGdM phot. VII. 1966

action of the ice. Consequently the littoral zone is nearly devoid of every vestige of vegetation. This is only seen in a few embayments, which are protected by a threshhold, ridge or spit of land at their entrance: this special physiography is described under 3.1.2.4.

3.1.2.2. Along the Large Deep Fjords

By this type of fjord is meant fjords in which no productive glaciers debouch. During the winter these fjords freeze over with an ice layer formed *in situ*. During the summer they are free of ice except for an occasional iceberg. Thus the littoral zone along these fjords is not exposed to the scouring action of the drift ice. In contrast it is usually unprotected against the wash of the waves and the eroding action of the ice foot in the winter and the spring, when this is broken loose and tears away lumps of vegetation and turf.

3.1.2.2.1. Along the Middle Parts of these Fjords

Here the shores are also usually formed by (precipitous) rocky cliffs (fig. 10), or by screes covered with heath, commonly fringed by a narrow stony beach of colluvial origin, with only a narrow belt of halophytic vegetation on its upper part. Conspicuous species in this belt are *Festuca rubra* ssp. *rubra* (fig. 21), *Honckenya peploides*, *Cochlearia groen-*

landica and *Calamagrostis neglecta*. The soil in this habitat consists of a commonly 10 to 20 cm thick peaty sod, distinctly separated from the underlying washed stony deposits. The influence of fresh water is variable, but there is often only seepage through the subsoil from the slopes above.

3.1.2.2.2. At the Head of these Fjords

At the innermost parts of these deep fjords there are vast outwash deltas of glacier rivers. These glaciofluviatile deposits continue subaquatic far into the fjords at only small depths. These shoals and the extensive tidal flats protect these deltas effectively against the eroding factors which affect the littoral zone in the middle parts of these fjords along deep water. Sedimentation is considerable and consists of coarse sand to clayey silt. The salinity of the water of the fjord is notably reduced and varies with the ebb and flow of the tide. The most common halophytic vegetation type on the central, outer, muddy parts of the deltas is dominated by *Carex subspathacea* (fig. 14). Less common and less extensive stands on the lateral, more sandy parts of these deltas, as well as along their tidal flats are dominated by *Honckenya peploides*, *Carex rariflora*, *Phippsia algida* and *Sagina intermedia*, or *Puccinellia coarctata*. Characteristic plants of the central, non-saline parts of these deltas in the Angmagssalik District are *Juncus arcticus* and *J. castaneus*.

3.1.2.3. The third type of large fjords notable in Greenland is the open, or stream fjord (strømfjord), which as a result of the strong current is open practically throughout the year, does not occur in the Angmagssalik District; consequently it is not dealt with here.

3.1.2.4. Along the Smaller Sheltered Fjords or "Tasiussaqs"

The name tasiussaq, East-Greenlandic: tasîlaq, means a fjord, that makes the impression of being a lake because of its narrow, bottleneck entrance, while the fjord itself appears widened. In a broader sense I apply this term to small fjords of this physiography and to embayments of a similar form along fjords of other types (3.1.2.1–3).

Because of this physiography the "tasiussaqs" (plural in Greenlandic: tasiussat) are free of ice in the summer. Consequently the scouring action of drift ice is absent and the wash of the waves is limited. In contrast there may be observed lateral pushing action in the winter, caused by the expansion of the winter ice sheet *in situ*, as well as influence of tidal currents in these quiet fjords. The shores along these bays and fjords are constituded of almost bare stony cliffs with sandy and silty beaches in between, which are covered with different types of halophytic vegetation.

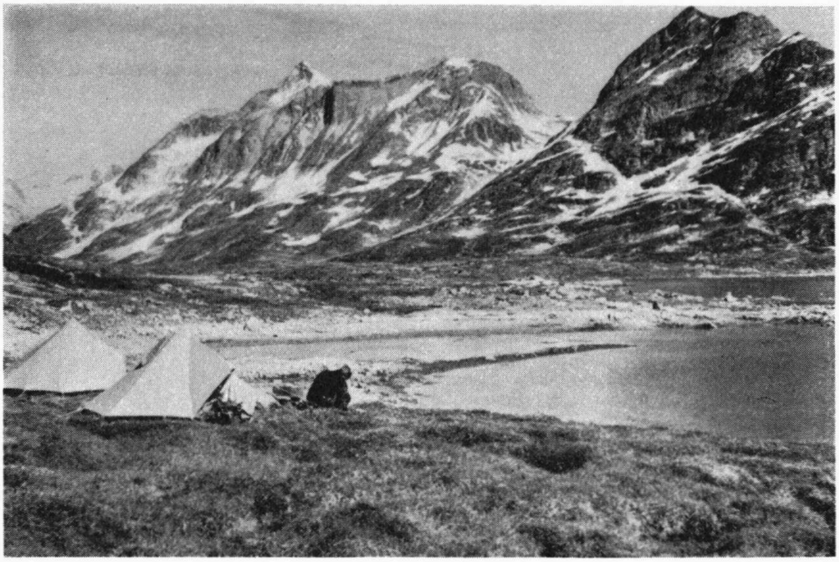


Fig. 7. Ice-pushed ridges along the outer margin of the tidal flat in a cove along the Torssukátak fjord, shortly before low tide.

FJAD phot. VII. 1969

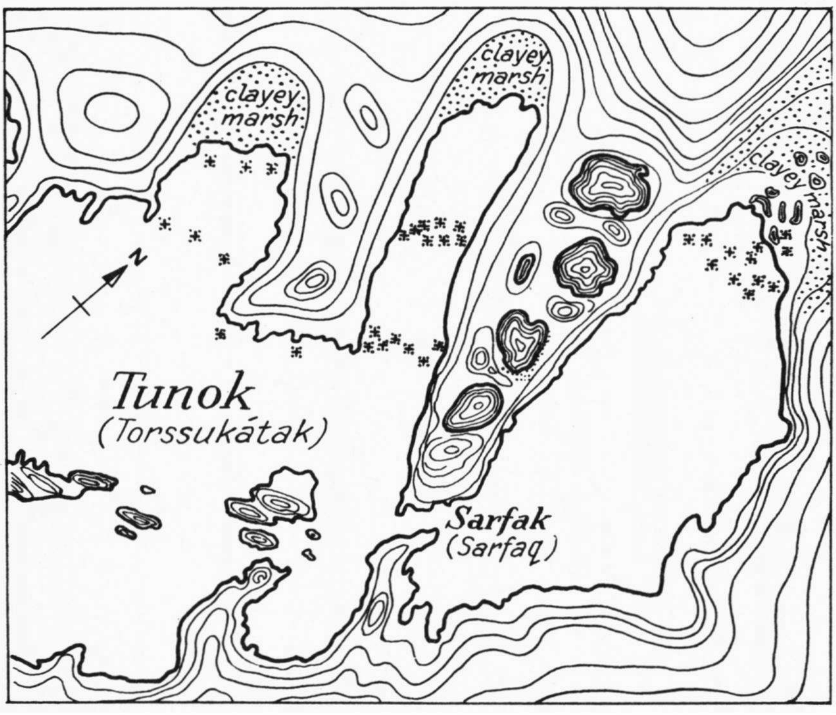


Fig. 8. Sketched map of the inner Torssukátak fjord after Kruuse (1912, table II), showing the ice-pushed, low, stony ridges along the outer margin of the tidal flats in the coves.

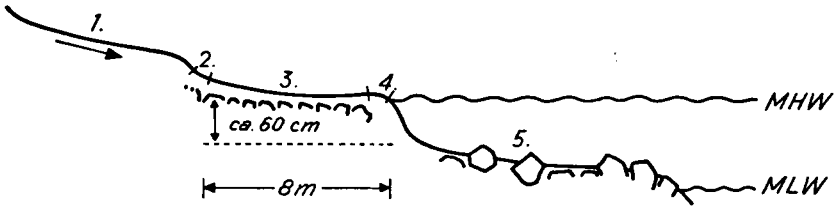
3.1.2.4.1. Along Small, Shallow, Deep Coves in "Tasiussaqs"

These embayments in "tasiussaqs" with a very irregular shoreline usually have well developed stands of halophytic vegetation on the beaches in their inner part. They often appear to be more or less dammed by low ridges of blocks and boulders, sometimes several behind one another, or anastomosic, at or immediately below MLW level (cf. figs 7 and 8). These ridges border the outer edge of the tidal flats in the bays and protect these and the beaches behind them against the wash of the waves. They are submerged at high tide and are usually covered with a dense growth of algae, mainly *Fucus*. These structures are formed by lateral ice sheet pressure in the winter, as it expands horizontally and pushes unconsolidated debris along the shore into irregular ridges. The finer material of this bottom material is washed out later on by the tide and partly sedimented in the quiet water of the regularly inundated tidal flats behind the ridges. Consequently the substrate in the inner parts of these baylets is clayey-silty, mixed with coarser colluvial and fluvial material. Beach and tidal flat are only slightly inclined and merge gradually. Afflux and influx of fresh water is more or less limited, often even absent. The plant cover in the littoral zone, if present, is characteristically dominated by *Puccinellia phryganodes*, which forms dense coherent swards within reach of high tide.

3.1.2.4.2. Along Small, Shallow Open Bights in "Tasiussaqs"

In the littoral zone of these open, crescent embayments in "tasiussaqs" with a more regular shoreline, well-developed stands of halophytic vegetation also often occur. The same kind of ice-pushed ridges as those described above are frequently found in front of these bights, protecting the beach along them. This beach and the tidal flat behind these low thresholds are in this case coarse-sandy, because of the partially longshore direction and the strength of the tidal currents. This phenomenon is caused by the spatial differentiation of these currents, due to either the width and general physiography of the "tasiussaq" in question, or by intensification of the non-differentiated tidal currents along sharp bends in the shoreline. The beaches are slightly inclined to almost level and at their outer edge they drop almost vertically 50 to 80 cm down to the also almost level tidal flat. Along this edge there is frequently found an up to 10 cm high ridgelet not unlike a diminutive marsh bar, at MHW level. This sudden drop at the transition beach-tidal flat, as well as the occurrence of the miniature ridge there, is caused primarily by the direction and force of the tidal currents and only to a far less degree by ice-push (figs 9, 17, 20 and 23).

Where the beaches along such crescent-shaped bays consist of unconsolidated gravel this physiognomic structure is less distinct and the



1. *Carex bigelowii-Salix glauca heath*
2. *accumulated dead Fucus*
3. *Potentillo-Caricetum rariflorae var. with mosslayer*
4. *Caricetum glareosae festucetosum rubrae*
5. *tidal flat*

Fig. 9. Sketch of the cross-section through a small salt marsh along the Imîlâjiva (Kong Oscars Havn); the arrow to the left indicates the seepage of fresh ground water.

plant cover is very open and formed by patches of *Honckenya peploides* var. *diffusa* or, more rarely, also by *Mertensia maritima.* Where the beaches are more consolidated and sandy, the upper layer of the substratum is peaty and the plant cover formed by dense salt marsh meadows dominated by *Carex glareosa*, sometimes patchwise replaced by *C. rariflora*, bordered along the outer edge on the ridgelet as well as along the inner, upper limit by almost pure belts of *Festuca rubra* ssp. *rubra.*

Sometimes an upper, gravelly, unconsolidated part of the beach is found above the meadow, partly covered with *Honckenya* (figs 16 and 18). Superficial afflux and subterraneous seepage of fresh water occur in various degrees.

3.1.3. Raised Former Beaches

At present a relative subsidence of the land is observed in Greenland. This phenomenon takes place at varying speeds in various parts of the island. During the period 1885–1950 the rate in the Angmagssalik District was 2.7 ± 0.5 mm per annum (Nielsen, 1952), but far greater measures have been observed elsewhere in Greenland (Bøgvad, 1940; Nielsen l.c.). The influence of this phenomenon on the physiography and plant cover of the littoral in the Angmagssalik District is negligible, but in areas where it happens at greater speed it has an erosive and denudating influence on the shore and its vegetation, especially along the large fjords, where there is little sedimentation.

Relatively recently, during the late quaternary period, this phenomenon was preceded by one of discontinuous relative upheaval of the land. In many coastal parts of the island this is demonstrated by the occurrence of series of raised former beaches at different levels (Kruuse, 1912; Vogt, 1933; Fredskild, verbal comm.). The lowest of these local terraces in the Angmagssalik District were formerly often beaches situated in fjords and bays of the "tasiussaq"-type and in some cases they are covered by vegetation syntaxonomically related to or belonging to vegetation types of the present littoral zone, both the *Puccinellietum phryganodis* and the *Caricetum glareosae*, especially the latters subass. *festucetosum* and the *Potentillo-Caricetum rariflorae*. This vegetation is frequently dominated by strongly nitrophilous species, owing to contamination of the soil by human agencies, since the physiography of these otherwise neither very common nor extensive sites in this mountainous area made them highly preferred as temporary or semi-permanent habitation sites by the originally very nomadic population. This semi-natural vegetation is left out of the present investigation.

3.2. The Climate

The climate will be dealt with in detail in a next publication in this series. Here I will confine myself to a brief characterization and the description of some factors of importance to littoral vegetation.

The climate of Southeast Greenland is low-arctic (HASTINGS, 1960; the series: Summaries of Weather Observations in Greenland). It is characterized in regard to more continental climates by a narrow temperature amplitude, high precipitation more or less evenly distributed over the entire year, and almost constant winds.

The mean annual temperature at Angmagssalik is −1,2°C; the mean temperature of the coldest month, February, is −8,3°C, of the warmest month, July, +6,9°C (1895–1970). The mean total amount of precipitation is 819,5 mm (1895–1970); most of this is snow. The mean relative humidity of the air varies monthly from 72 to 83 %, the mean cloudiness (percent sky cover) from 53 to 66 % (30 years; HASTINGS, l.c., table 8, 9). The mean surface windspeed is about 4MPH (about 6,4 km/hr); fresh gale force can be reached during any season of the year; gusts of 115MPH (ca. 185 km/hr) have been recorded from the coastal areas of the district (HASTINGS, l.c., p. 24).

The microclimate in littoral vegetation is little known and was not investigated in the course of this study. Extreme conditions regarding temperature and humidity fluctuations supposedly occur in the habitat of the *Honckenyo-Elymetea arenarii*, while conditions in the habitat of the *Asteretea tripolii* (*Carici-Puccinellietalia*) are supposed to be more moderate.

3.2.1. The East Greenland Current

The climate of this stretch of the coast is closely connected with the cold East Greenland Current, which slowly carries southwards a wide belt of pack ice along the coast. At the seacoast proper this ice continuously exerts its scouring action on the littoral zone. With certain wind directions large fields of pack ice may drift into the entrances to the fjords, sometimes considerably far inland (fig. 10), where they linger for some

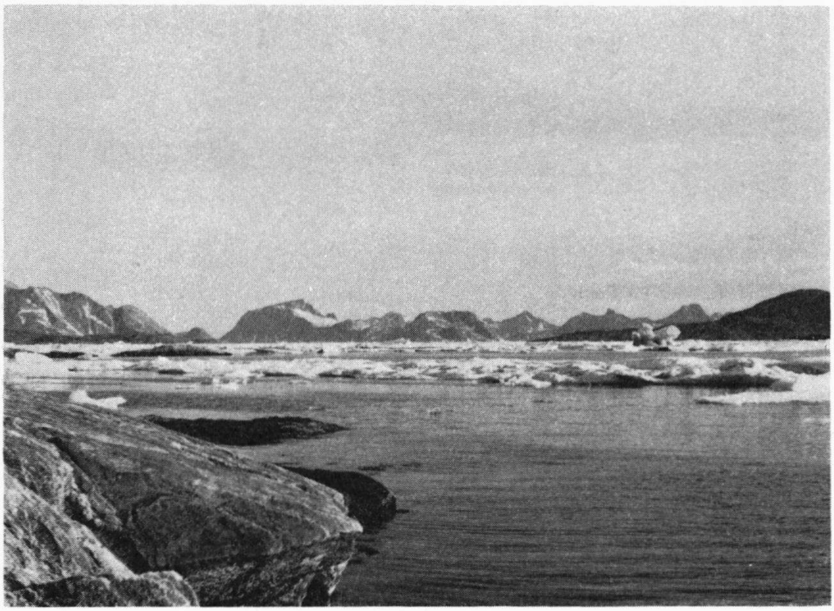


Fig. 10. The middle part of the Angmagssalik Fjord in early August, shortly North of Kûngmiut; view to the South.
JGdM phot. VIII. 1969

time, blocking the fjords and only slightly fluctuating in position with the movements of the tide, scouring the shores of the fjords until they are blown seaward again.

3.2.2. The Temperature

Because of the low winter temperatures characteristic of the low-arctic climate, the fjords freeze over completely during the winter except for a few "stream-places" or "sarfaqs". The influence of this phenomenon on the physiography and the vegetation of the littoral is discussed in section 3.1.

3.2.3. The Wind

The winds along the coast, with regularly strong gales, cause a continuous wash of the waves, which is often partly rapidly subdued by the ice. A true surf is not observed in the district because of the extensive pack belt along the coast (fig. 11). The wash of the waves exerts its influence mainly through ice scouring on the littoral zone, notably along the seacoast and along the exposed shores of the wide, deep fjords, where the windforce is even increased by the funneling effect of the physiography. The tidal levels and consequently the salinity of the water may deviate considerably from the norm now and then, owing to persistent wind in a single direction in long fjords, or in fjords with a narrow entrance.

Fig. 11. Pack along the coast of the Angmagssalik District in June, near the island Kulusuk (background); mainly floes of sea-ice.
JGdM phot. VI. 1966

Because of this instability of the environment, a certain levelling occurs and thus a qualitative impoverishment of the flora.

In spite of the often strong force of the wind, a distinct influence of salt-spray on the littoral vegetation could not be detected in any part of the District.

3.2.4. The Precipitation

The effect of the high precipitation on the vegetation of the littoral is intensified, as it piles up during winter in the form of snow, to be released first from the beginning of the vegetation season in a comparatively short time. This partly explains the occurrence of species characteristic of brackish habitats and especially of fluctuating contact situations between fresh and saline conditions in the littoral vegetation.

3.2.5. The Snow Cover

Little is known about the snow cover of the littoral zone in the Arctic. According to GELTING (1934), it appears that in East Greenland the depth and persistence of the snow cover vary considerably. Even all true halophytes there are constantly free of snow and often exposed to the most violent gales at the outer coast, while in contrast they are covered with snow throughout the winter and become free of snow comparatively late in more inland localities. Because of physiographic conditions it is likely that this indifference of the species with respect to the presence or absence of a snow cover during the winter, in general also applies to their occurrence in the Angmagssalik District. Thus, it seems that this factor is of less importance to the distribution of arctic halophytes than of arctic non-halophytes.

3.3. The Open Water

The vegetation occurring in the transitional zone from the land to the sea is highly determined by the immediate presence of the open water, namely by its physical and chemical properties.

3.3.1. Physical Properties

The most important physical property of the open water of the sea and the fjords, with respect to the littoral vegetation, is its dynamic character.

This dynamic character is expressed by two different types of phenomena, which primarily possess a temporal aspect, and secondarily a spatial one:

(a) the regular periodic fluctuations of tides, which result from cosmic forces and exhibit a high, constant frequency;

(b) the irregular episodic fluctuations, which are raised under the influence of climatological factors, and which are characterized by a very inconstant, low frequency of occurence, and are, as such, superimposed on the periodic fluctuations.

The periodic fluctuations present one temporal aspect, their frequency expressed by the tidal cycle, and two aspects in space, a vertical one, the amplitude of the tidal movements, and a horizontal one, the tidal currents.

The frequency of the periodic fluctuations as such represents a basically constant temporal feature; but correlated with a certain elevation it is subject to some variation, in dependence on the variation in the amplitude of the vertical aspect of these fluctuations.

The tidal cycle takes place twice daily in the Angmagssalik District; the difference there between high and low tide level is approximately 2 m and may under the influence of episodic fluctuations reach a maximum of 4 m (Fristrup, personal communication); in "tasiussaqs" this is less.

Independently of the episodic fluctuations in general, the amplitude of the tide is variable between certain limits due to the modifying and differentiating influence of the general and the local physiography, both spatial aspects, and of the complex climatological factors expressed in the different seasons of the year, a temporal aspect.

Because of the general physiography of the fjords and inlets, a transverse differentiation in the vertical amplitude of the tides develops. In fjords of the "tasiussaq" type an increase occurs at the bottleneck entrance, followed immediately by a decrease in the wide basin-like fjord itself. In the long fjords there is a slow increase in amplitude of the tide some distance from the more or less widened entrance, followed by a more gradual decrease, which is dependent on the counter pressure of the river water discharge at the innermost part of these fjords. The difference between high and low tide level also depends on the local physiography. Usually there is a direct relation between this phenomenon and the duration of submersion at each high tide, and the elevation of a certain site. Sometimes the local physiographical differentiation of the supralittoral may create a barrier, which leads to a certain spatial isolation of a site with respect to the open water. This results in a decrease in the frequency of inundation, and in stagnation. As a result of this the discharge is impeded when the tide recedes, the duration of submersion extends, and the direct relation between the normal frequency of the vertical tidal movements, the duration of flooding and the elevation of a certain site (in respect to MHW) is disturbed. In such situations only one or a few species characteristically occur, but then in great abundance: in saline conditions often *Puccinellia phryganodes*, in brackish conditions *Campylium polygamum*, *Carex rariflora*, and *Festuca rubra*.

The amplitude of the tidal fluctuations also varies somewhat in relation to the seasons. The amplitude and consequently the frequency of inundation of a certain site reach a maximum in the cold seasons, and a minimum in early summer.

The horizontal, spatial aspect of the periodical fluctuations, the tidal currents and to a far less degree the wash of the waves, exercise mechanical influence on the littoral vegetation, both directly and indirectly.

The action of the tidal currents is threefold: (1) directly: it influences the establishment of the littoral colonists, (2) indirectly: it influences the rate and nature of the sedimentation, and (3) also indirectly: it may lead to erosion of the substrate.

The effect of this action is intensified by the presence and subsequently by the quality and quantity of the drift ice carried along with it. The exposure to these factors depends primarily on the physiography of the littoral and differs considerably from place to place (cf. 3.1.).

3.3.2. Chemical Properties

The most important chemical property of the open water is without doubt its salinity, its total content of dissolved salts. In an area with a complicated coastline the salinity varies spatially and temporally, depending upon physiographical and climatological conditions.

As the physiographical conditions are constant they result in a more or less constant spatial macrogradient in salinity. In this connection the width and depth of the fjords are of importance. Wide, deep entrances to the fjords facilitate the penetration of the heavier saline water at high tide farther into the fjord than do the narrow entrances of "tasiussaqs" or entrances with a subaquatic threshold of fjords in general.

The complexity of the ramifications of the fjord systems regulates the mass and also the salinity of the water involved in the tidal movements, by local acceleration or extinction of the tidal currents. Furthermore, there may occur a spatial differentiation of the tidal movements, and thus also in the salinity, in wide inlets.

The climatological conditions are variable and cause a disturbance of this basic pattern. The varying discharge of the meltwater rivers is in this connection an important factor depending on rain, snowfall and temperature, as are the direction and persistence of the wind and also to a far lesser degree the discharge of the glaciers. Their interaction causes a shifting of this gradient, particularly in the inner parts of the fjords. The transition zone there between saline and non-saline, because of this instability, must be understood as an area of disturbance.

3.4. The Soil

3.4.1. Texture and structure

The texture of the soil, the geometrical aspects of the component particles including size, shape and arrangement, results from the process of sedimentation which is differentiated in time and space. It is of importance in respect to various soil factors such as water balance and salinity, which will be dealt with below.

The structure of the soil, including factors such as bedding, jointing and cleavage, is also vital as far as the vegetation is concerned. A local significant aspect of this is the superficial closer setting of the particles of the soil, accompanied by a decrease in porosity and an increase in density. This setting of the sedimenting soil particles occurs, for example, in shifting transitional situations.

3.4.2. Ground water

Water is found in the soil as free water in the pores between the macroscopic solid component particles, and as adsorbed water in a mantle around microscopical particles.

The occurrence and distribution of free water and air in the soil depends primarily on the structure and texture of the soil.

Secondarily this depends on the situation of the site in relation to MHW level. The important factors resulting from this feature are the frequency and duration of submersion at high tide. The soil in the eulittoral zone remains almost saturated with water also in the superficial layer during the period of emersion, so that the flood water penetrates only very little into the soil during the next submersion, and the environment remains homogeneous in this respect. More differentiation in the ground water regime occurs in the supralittoral. During the period of emersion capillary water is withdrawn from the surface layer of the soil owing to evaporation, transpiration and drainage, which results in aeration of this layer, followed by a more ready and deeper penetration of the floodwater during the next submersion. In relation to the situation of the site with respect to MHW, this will result in a differentiation of the depth of aeration and the influence of the flood water on the ground water pattern at low tide. The differentiation in the plant cover in this zone further modifies this pattern by its influence on the evaporation and its own transpiration.

Thirdly, the water and air balance of the soil is in general influenced by the occurrence and vicinity of creeks and rills, which act upon the drainage and irrigation of the site. True local drainage systems do not exist in the Angmagssalik District owing to the limited extent of the salt marshes there. As these marshes are usually developed on the deltas of rivers and brooks, the draining of the marshes is taken over by these existing meltwater courses. Their discharge irrigates the marshes at low tide, and thus limits the influence of the factor situation in respect to MHW by diminishing the penetration of flood water in the soil, as it reduces the depth of desiccation of the upper layer during the period of emersion.

3.4.3. Salinity

This environmental factor is closely connected with the ground water regime, upon which various factors act in dependence on the local climate and physiography.

The evaporation and transpiration tend to increase the salinity of the soil, but they are of only minor importance to the salinity and the ground water regime in general in the Angmagssalik District, as a consequence of the pronounced oceanic character of the climate of SE Greenland with its high amount of rainfall, which is evenly distributed throughout the year.

In contrast, the precipitation reduces the salinity by eluviation. This leaching effect is differentiated in space, mainly as a result of the local relief.

The submersion by saline or brackish flood water acts contrarily to the precipitation. As the annual precipitation by far exceeds the annual evaporation and transpiration, the flood water acts as practically the only source of supply of soluble salts to the soil. This supply depends on the frequency and duration of submersion and the salinity of the flood water.

Afflux of fresh water from elsewhere is of importance especially in spring and early summer. The diluting effect is thus temperally differentiated, and, in relation to physiography and texture and structure of the soil, also in spatial respect.

As a consequence of the interaction of the factors mentioned a local equilibrium develops, resulting in a final degree or range of salinity to which plant life responds.

3.4.4. Organic Matters

The nitrates are considered very important constituents of the organic matter in the soil in respect to plant life. An indication of the content of available nitrates in the soil is given by the rates of supply and humification and the origin of the organic matter.

The autochtonous component consists of rests of roots and dead overground parts of the vegetation on the spot, which are partly held by the process of sedimentation of solid mineral material. The spatial origin of this component implies no substansial enrichment of the soil in nitrates. Most of the organic matter in the soil below the *Caricion glareosae* is of autochtonous origin. The rate of production of organic matter by this vegetation type usually exceeds the rate of humification, which will result in the common occurrence of a thin deposit of peat below the plant cover.

The allochtonous component of the organic matter consists of small suspended particles of partly decomposed material, which deposits are spread over comparatively extensive areas together with other small, solid constituents in the flood water, and of larger, floating parts of not or hardly decomposed large *Phaeophyceae*, mainly *Fucus* species, which are deposited in a limited zone of the littoral as a tidal mark. This spatially concentrated accumulation of rests of large seaweeds, and their quantity make this component of the allochtonous matter by far the more important of the two as a source of enrichment in nitrates of the soil.

The *Puccinellia phryganodes* stands immediately above MHW are sometimes covered by extensive, considerable deposits of dead *Fucus*. These dry out during long periods and the rate of humification is consequently very slow, which sometimes will result in the formation of a peaty layer to which autochtonous material also contributes. However, these accumulations are still within reach of higher tides and if they are not yet partly interwoven and thus held by the living plants, they are often carried off again to be re-deposited elsewhere.

Fucus deposits situated higher up in the littoral zone are more permanent. Owing to prolonged periods of desiccation the rate of humification of the seaweed is very low; locally only these accumulations remain continually moistened by the afflux of fresh water and the rate of humification is consequently higher there.

The highest situated flood marks are usually deposited on loose, coarse-sandy to gravelly soils, which are subjected to drift. Patches of *Honckenya peploides* var. *diffusa* and *Mertensia maritima* characteristically develop here. A supply of nitrates may also result from human activities. In that case the matter is of allochtonous, largely animal origin. The effect of these activities in the Angmagssalik District is very conspicuous in the vegetation, but localized in limited areas and the vegetation of these sites is omitted from this investigation.

B. DESCRIPTION OF THE LITTORAL VEGETATION

1. Occurrence

Littoral vegetation occurs locally and is of limited extent in the Angmagssalik District, because of the topography and the soil conditions in this mountainous area.

In the first instance, to some extent the stands of this vegetation give the impression of being fragmentary, rather than, apparently, of constituting well-developed, distinct, and both homogenous and homotonous units governed by their own laws in regard to their floristic-phytogeographic composition and relation to and dependence on the environment.

2. Zonation and succession

Littoral vegetation in general often displays a zonation in belts parallel to the coastline, particularly where the littoral zone is wide and sloping very gradually. On account of the limited spatial extent of the suitable habitats in the Angmagssalik District, only a limited number or commonly even only one single vegetation type occur in one and the same location in this area.

A general view of a sequence of vegetation types, according to the change in situation in respect to MHW level, to an increasing particle-size of the substratum or to decreasing salinity of the ground and flood water can consequently only be obtained by comparison of observations from different localities. Some observed zonations are represented in figs 9, 16, 20 and 23, others are mentioned in the text. In fig. 12 the relative connections of the vegetation units with the factors: situation of the habitat in respect to MHW level, soil particle size and salinity are shown in a diagram.

As early as 1870 Berggren (1871) observed zonations in the littoral vegetation in West Greenland. From the lower to the upper beach he first noted a zone dominated by *Puccinellia phryganodes*, then one with *Carex glareosa*, and above that belt a zone with *Elymus arenarius* (ssp. *mollis*) or a *Puccinellia vaginata* and a *Plantago borealis-Cochlearia fenestrata* (*C. groenlandica*) zone. This description outlines the zonations

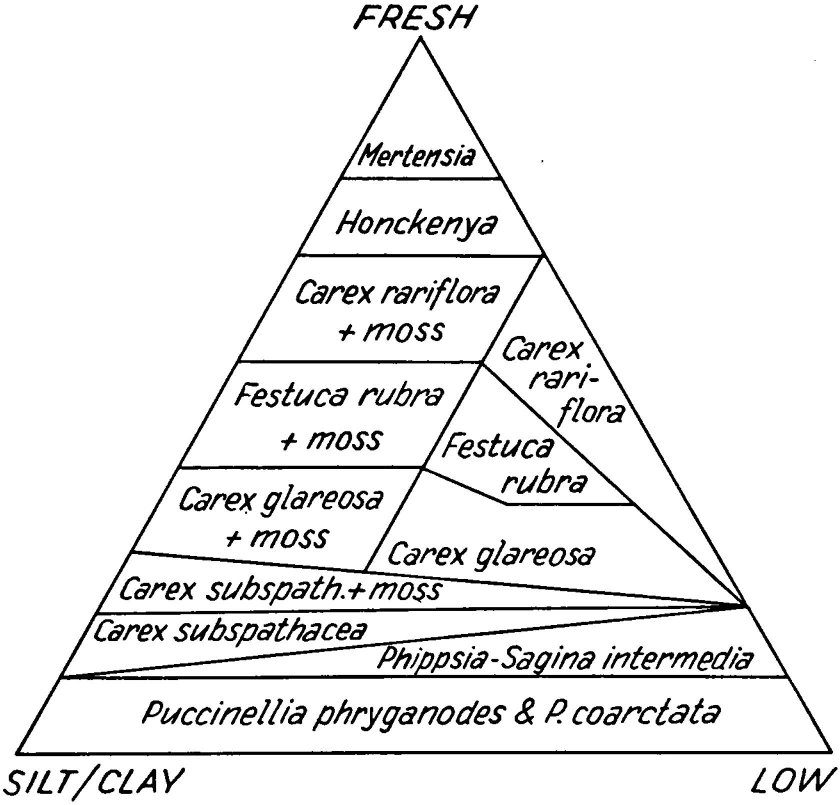


Fig. 12. Relation of the littoral vegetation types (indicated by the dominant taxa) which occur in the Angmagssalik District, to the factors of elevation, texture of the substrate, and the relative salinity of the floodwater.

as observed everywhere in the Arctic. CHAPMAN (1960) recently compiled all the literature data on zonation in the littoral vegetation in the Arctic and the Subarctic. Fig. 13 shows the interrelations and the probable pathways of succession of the littoral vegetation units in the Angmagssalik District.

It must be mentioned here that it is difficult in some cases to obtain some certainty on this process. In this connection the danger of interpreting the observed actual zonation as representing the spatial expression of the temporal succession is rightly emphasized in many publications. The only conclusive methods of studying sucession in the vegetation are observation on permanent squares, which takes very much time, and, which also often proves impossible for practical reasons, paleobotanical study of the recognizable macro- and microscopical plant rests in the soil layers below the present vegetation.

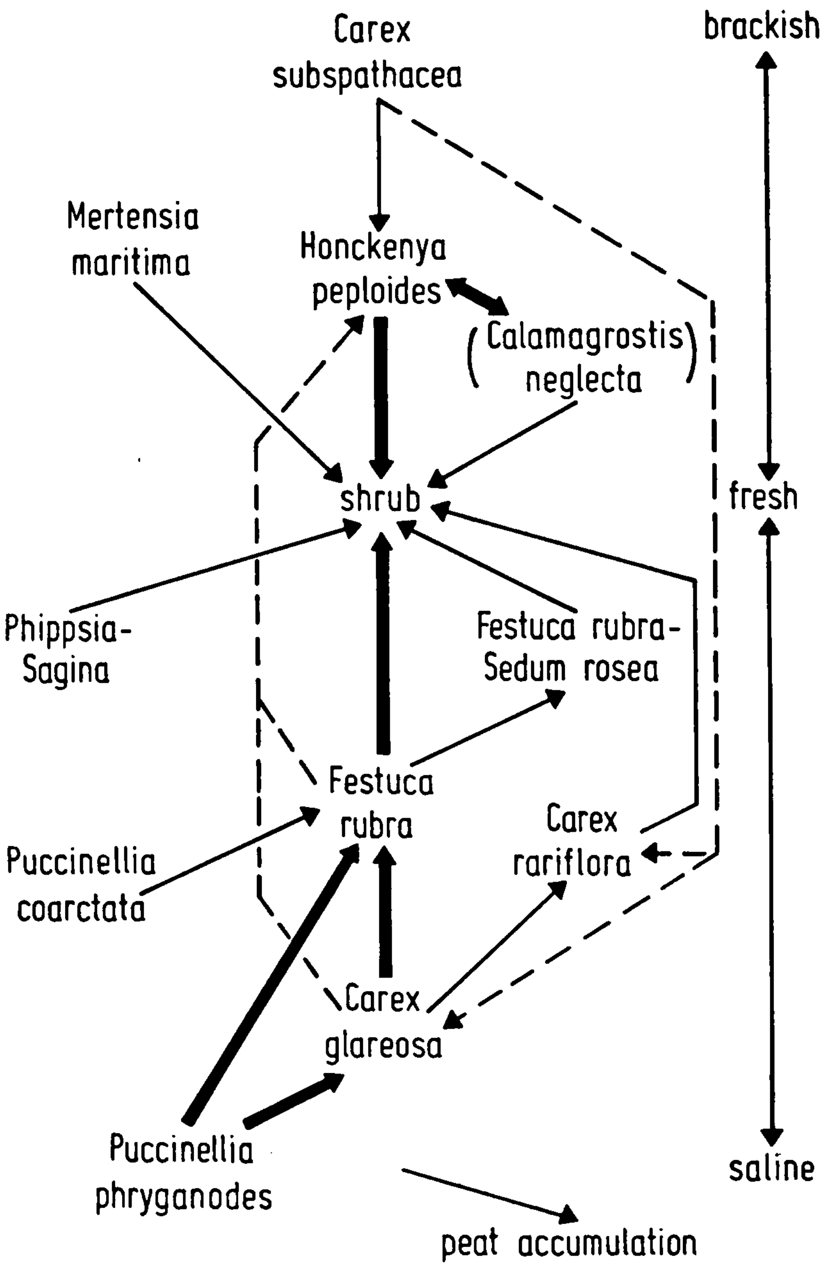


Fig. 13. Presumed succession of the littoral vegetation types in the Angmagssalik District; types indicated by the dominant taxa.

I recognize two main series in the succession in the district. One series starts from a brackish habitat, mud flats on extensive river deltas, where a rapid raising of the substratum by sedimentation of mineral material of increasing particle-size takes place, later on involving drift and decreasing salinity of the soil, and, during a certain period, by a supply of allochtonous organic matter. The other series starts from a saline environment, local clayey-sandy to gravelly beaches, where a slow raising of the substratum takes place, in which process autochtonous vegetable matter plays an increasing part. This process involves a gradual decrease in salinity and an increase in the acidity of the soil, only now then interrupted by a sudden rapid raising with coarse sandy-gravelly material in consequence of unusually heavy inundation by meltwater. In all cases I consider the *Salix glauca* shrub, possibly locally replaced by *Empetrum-Vaccinium* heath, to be the final stage in the succession in the Angmagssalik District.

Evidence of the proposed diagram is partly based on the macroscopic composition and the consistency of buried peaty layers below the analyzed stands, with regard to the series of *Puccinellia phryganodes-Carex glareosa-Festuca rubra* communities and the alternating stages of *Honckenya peploides* var. *diffusa-Calamagrostis neglecta* communities, partly based on the interpretation of observations on the present vegetation, "snapshots" of the gradual transitions and the spatial and floristic differentiation in general in the vegetation, correlated with environmental and physiographical characteristics.

3. Class *Asteretea tripolii* WESTHOFF & BEEFTINK 1962

syn.: *Juncetea maritimi* BR.–BL. 1931 p.p., *Puccinellio-Salicornietea* TOPA 1939 p.p., *Astereto-Salicornietea* WESTHOFF *et al.* 1942 prov. p.p., *Salicornietea* BR.–BL. & R. TÜXEN 1943, p.p.

faithful taxa: *Aster tripolium* L. s.l., *Plantago maritima* L. s.l., *Triglochin maritimum* L.

3.1. Order *Carici-Puccinellietalia* BEEFTINK & WESTHOFF 1965

composition: differential taxa combination is *Stellaria humifusa* ROTTB., *Potentilla egedii* WORMSKJ., *Plantago maritima* L. ssp. *borealis* (LGE.) BL. et D., *Bryum salinum* HAG.

S. humifusa is general, exclusive faithful; *P. egedii* is also general, exclusive faithful and has its ecological optimum in the *Caricion glareosae.* In particular, these two taxa indicate by favouring contact and disturbance situations (e.g. between saline and fresh water) the affinity of the order to the *Agropyro-Rumicion crispi* NORDH. 1940 em. R. TÜXEN

1950 (*Plantaginetalia majoris* R. Tüxen (1947) 1950). *P. maritima* ssp. *borealis* (= *P. juncoides* Lam. var. *glauca* (Hornem.) Fern.) is local, viz. in the northern amphi-atlantic area, exclusive to selective faithful, just as *Br. salinum.*

physiognomy: The communities are made up of open to closed swards, which consist of only a graminoid field layer or of such a field layer and a bottom layer of bryophytes (acrocarpous and pleurocarpous musci). They are dominated by reptant hemicryptophytes; reptant chamaephytes and geophytes also occur frequently.

synecology & habitat: The high to subarctic, halophytic and tropohydrophytic, eutrafent to somewhat mesotrafent, more or less nitrophytic, medium acidophytic to neutrophytic communities of the order are indifferent to depth and persistence of the snow cover. They occur characteristically in contact situations between saline and fresh water influences, also between poor and rich and dry and wet substrates, in relatively dynamic, unstable environments. They are found on sheltered beaches from half a meter below MHW up to EHWS level, rarely up to several meters above EHWS. The substrate is silty to coarse sandy, more or less consolidated and poor in humus to peaty.

distribution: The syntaxon is exclusively high to subarctic and presumably circumpolar. It is vicarious with the western european, atlantic and west to southern baltic *Glauco-Puccinellietalia* Beeftink & Westhoff 1962 and the southeastern european, pontic-pannonic *Puccinellietalia* Soó 1940 em. Vicherek 1962.

3.1.1. All *Puccinellion phryganodis* Hadač 1946

composition: general, transgressive faithful taxon is *Puccinellia phryganodes* (Trin.) Scribn. et Merr. (= *Glyceria reptans* (Laest.) Krok, *G. vilfoidea* Lge.).

synecology & habitat: The halophytic and tropohydrophytic, eutrafent and neutrophytic communities of the alliance occur on the shores along local, sheltered, small and shallow bays and on deltas of streams, in a zone from about half a meter below MHW up to shortly above MHW level (exceptionally up to EHWS) in clayey to silty, sandy soil poor in humus. The syntaxon is vicarious a.o. with the *Puccinellion maritimae* Christiansen 1927 em. R. Tüxen 1937 (*Glauco-Puccinellietalia*).

3.1.1.1. Ass. *Pucinellietum phryganodis* Hadač 1946 em. Hofmann 1969

syn.: incl. *Caricetum ursinae* Hadač 1946; non *Puccinellietum phryganodis* Nordh. 1954.

composition: regional (Arctic), selective to exclusive faithful taxon is *Puccinellia phryganodis* (Trin.) Scribn. et Merr.

distribution: The syntaxon is exclusively arctic, presumably circumpolar.

See further 3.1.1. and the survey on p. 73.

3.1.1.1.1. Subass. *inops* HOFMANN *1969* (sub nom. *Typische Subassoziation*)

table 1: 1–7.

composition: As indicated by the epitheton *inops* the syntaxon is negatively characterized by the absence of differential taxa with respect to the other syntaxa of the association. Besides the dominant *P. phryganodes Stellaria humifusa* is the only other more or less constant taxon. The syntaxon is on the whole very poor in taxa; it is not even rare that *P. phryganodes* is the only taxon in the stands of this syntaxon. On an average 2.5 taxa occur in one sample plot in the Angmagssalik District. There is no more or less well-developed bottom layer.

Most taxa belong to the widely spread arctic element.

physiognomy: The hemicryptophytic, partly also chamaephytic community consists of a low, closed field layer. It forms dense, coherent swards, sometimes of considerable extent. These are green below, where the water most frequently reaches, and of a characteristic reddish hue higher up near the tidal mark. Many stands are often found to be partly covered by dark, blackish, red-brown deposits of recently accumulated dead seaweed, chiefly Fucus sp.

synecology & habitat: See 3.1. and 3.1.1. The community occurs in the Angmagssalik District along the shores of small, sheltered coves and bays in small fjords with a deeply incised coastline, where there is no beating of the surf nor ice-scour (cf. A 3.1.2.4.1., p. 24). It represents the lowest situated littoral vegetation type in the district and is found from about half a meter below MHW up to the tidal mark. It is subjected to regular flooding at each tide by saline, viz. euhaline to occasionally mesohaline water. Exceptionally it is also found slightly below EHWS level in shallow depressions very close to the shore, where temporary salt or slightly brackish tidal pools are formed with high tides (far) exceeding MHW. This habitat is subjected to irregular but prolonged inundation.

The substrate consists of more or less consolidated, predominantly silty to clayey deposits with coarser grades, sand, gravel and stones. It is often covered with a mat of remains of partly decomposed seaweeds. Near the surface it is frequently slightly humic and brown, deeper down it is purely mineral. When emerged it is poorly aerated and moist; the ground water level at low tide is found at a depth between 0 and −20 cm.

The colorimetric pH of the rhizosphere ranges from 6 to 7 and averages 6.5.

distribution: The community is not uncommon in the Angmagssalik District (Torssukâtak, Nûk, Tasîlâlik, Kap Dan); it is especially common and well-developed along the Torssukâtak fjord. It is also more or less common elsewhere in Greenland (cf. A 2.2.2.) and presumably circumpolar (cf. HULTÉN, 1968, p. 155).

syntaxonomy & discussion: HOFMANN (1969), in a publication on the *Puccinellietum phryganodis* in Spitsbergen, discusses the alliance, and arrives at a survey in which he distinguishes an arctic *Puccinellietum phryganodis* HADAČ 1946 and a vicarious, subarctic-northern Fennoscandian *Triglochino-Puccinellietum phryganodis* (NORDH. 1954) HOFMANN, 1969.

HADAČ's description is based on a single sample plot from Spitsbergen. HOFMANN's additional data enabled him to propose a subdivision of the syntaxon in four types: a typical subassociation or subass. *inops*, a subass. *drepanocladetosum*, a subass. *bryetosum* and a subass. *caricetosum ursinae* (see p. 73). HOFMANN's subass. inops corresponds to the description of HADAČ, and the *P. phryganodes* marshes from the Angmagssalik District belong without doubt to the same syntaxon. HOFMANN also places the *Caricetum ursinae* HADAČ 1946 in the subass. *caricetosum ursinae*, which seems a correct re-classification in view of HOFMANN's additional data. Moreover, *Carex ursina* has a middle-arctic area, which is local (intraregional sensu MEYER DREES, cf. BARKMAN, 1958, p. 227) with respect to the area of the alliance. This syntaxon is also described

Table I

reference number		1	2	3	4	5	6	7	8	9	10
total cover plants (in %)		100	80	60	95	100	40	40	70	20	15
cover phanerogams –		100	80	60	95	100	40	35	70	20	15
– cryptogams –		–	–	–	–	–	–	10	–	(1	(1
– litter –		–	–	–	10	5	40	–	10	–	–
– open soil –		10	30	40	–	–	40	60	25	90	90
pH rhizosphere		$6^1/_4$	$6^1/_4$	7	$6^1/_4$	$6^1/_2$	7	6	7	7	7
ground water table (in -cm)		–	20	30	50	30	60	2	20	15	9
Stellaria humifusa	L	..	..	1	2	2	+	3	1	+	+
Puccinellia phryganodes	A	6	6	5	6	6	4	2	..	..	+
Puccinellia coarctata	L	..	..	..	..	..	..	..	5	3	2
Carex glareosa	L	..	..	..	1	..	+	..	..	..	+
Bryum salinum		..	..	..	..	..	..	2	..	..	+
Plantago maritima ssp. *borealis*	L/B	..	..	..	..	..	+	..	..	..	..
Cochlearia groenlandica	A	..	..	..	..	..	+	..	..	..	..
Bryum argenteum		..	..	..	..	..	..	..	..	+	..
Carex subspathacea	L	..	..	..	..	..	..	..	..	..	+

from NE Canada (POLUNIN, 1948) and NE Greenland (GELTING, 1934; HARTZ & KRUUSE, 1911) and can be regarded as the northern subunit of the association, whereas the other three subassociations are widespread in the Arctic.

NORDHAGEN (1954, table 1, 2) described a *Puccinellietum phryganodis* from Finmark, northern Norway, which differs from the arctic syntaxon of the same name in the occurrence of the constant *Triglochin maritimum*, as well as several other accessory taxa which are absent in the Arctic, such as *Juncus bufonius*, *Aster tripolium* f. *arcticus*. These are widely spread boreal taxa, of which the areas are pararegional with regard to the area of the alliance. Therefore HOFMANN proposed to distinguish this community as a separate association, the *Triglochino-Puccinellietum phryganodis*. The *P. phryganodes* meadows which Regel (1928, nr. 955) studied in Kola and which KALELA (1939, table 63) studied on the Fischerhalbinsel (Poluostrov Rybachiy) in Petsamo Lappland also belong to this vicarious syntaxon. The western Alaskan *P. phryganodes* marshes described by HANSON (1951) presumably belong also to this subarctic unit, possibly as a geographical subassociation.

In contradiction to HOFMANN's opinion I do not group the *Puccinellietum retroflexae* NORDH. 1954 in this syntaxon, but maintain it as a separate unit (see 3.1.1.2).

3.1.1.2. Ass. *Puccinellietum coarctatae* ass. nov.

syn.: *Puccinellietum retroflexae* NORDH. 1954 pro min. p.; *Puccinellia coarctata-synedria* LID 1964.

composition: regional (Arctic), exclusive faithful taxon is *Puccinellia coarctata* FERN. et WEATH. (= *P. retroflexa* ssp. *borealis* var. *virescens* HOLMB.). See also p. 74.

distribution: The syntaxon is low-arctic, amphi-atlantic.

3.1.1.2.1. Variant *inops* var. nov.

table 1: 8–10.

composition: The community is negatively differentiated from the other units of the association (cf. 3.1.1.1.1.). *Puccinellia coarctata* and *Stellaria humifusa* are the only constant taxa. In the district nearly 4 taxa occur on an average in one sample plot. A more or less well-developed bottom layer is absent.

The phytogeographical composition emphasizes the low-arctic character of the variant.

physiognomy: The predominantly hemicryptophytic, partly also chamaephytic community consists of a rather open to a comparatively closed field layer. It forms variously developed stands. In open stands the nondescript greyish colour of the substrate dominates, in closed ones the dull greyish-green of the grass. In favourable conditions, where the substrate is manured by seaweed accumulation or human litter, it forms tussocky marshes.

synecology & habitat: See 3.1. The community occurs in the Angmagssalik District along the shores of calm, shallow bays in the fjords, without beating of the surf or ice-scour. It occurs, as does the *Puccinellietum phryganodis*, from about half a meter below MHW up to near the tidal mark, and is subjected to regular flooding by saline, viz. euhaline to mesohaline water at each high tide.

The substrate below this variant, as well as below other stands of the association, consists of rather mobile–unconsolidated, partly clayey-silty deposits of coarse sand and gravel with stones. Fines are less well presented than in the more stable and compact substrate below the *Puccinellietum phryganodis*. The uppermost part of the substrate is not or only slightly humic and brown. The substrate is at low tide somewhat better aerated; the ground water level is then found at a depth between −9 and −20 cm. The colorimetric pH of the rhizosphere is about 7.

distribution: The community is rare in the district (Sarpakajik, Qíngertivaq) and probably also elsewhere in southern Greenland. The general area will coincide with the northern, low-arctic half of the amphi-Atlantic distribution of *P. coarctata* (cf. SØRENSEN, 1953, fig. 110; HULTÉN, 1958, map 262).

syntaxonomy & discussion: The descriptions of the *P. coarctata* communities in the literature are quite heterogeneous. Some of these are very closely related to the *Puccinellietum phryganodis* HADAČ 1946 and particularly the *Triglochino-Puccinellietum phryganodis* (NORDH. 1954) HOFMANN 1969, because of the high constancy of *P. phryganodes* and boreal *Triglochin maritimum*, and the general phytogeographic composition. Consequently, HOFMANN (1969) classified the *Puccinellietum retroflexae* NORDH. 1954 from northern Norway in the *Triglochino-Puccinellietum phryganodis*. However, in my opinion comparison with other publications confirm NORDHAGEN's supposition that the *P. coarctata* communities constitute separate syntaxa taxonomically equal to the *P. phryganodes* associations. The two stands which NORDHAGEN (1954) studied are situated in areas which are quite far away from each other. On closer examination his analyses appear to be mutually quite different, which is related to this geographical (latitudinal-climatological) difference.

In the ten sample plots, represented in relevée 7 in his table 2, which he studied in the extreme northern, sub to low-arctic part of Norway (Båtsfjord), the two species of the differential taxa combination of the *Triglochino-Puccinellietum phryganodis* occur but sporadically; *P. phryganodes* in two of the ten quadrates; *T. maritimum* is completely absent. The only other recorded species are, apart from *P. coarctata*, *Stellaria humifusa* (constant) and *Cochlearia officinalis* (constant). This floristic-phytogeographical composition agrees with one of the descriptions of the *P. coarctata-synedria* given by LID (1964, table 9) from the low-arctic island of Jan Mayen. Phytogeographically these two communities appear to be closely related to the second synedria from Jan Mayen (LID, l.c., table 8) and the *P. coarctata* analyses from the Angmagssalik District. Hence I propose to unite these low-arctic communities in one association, the *Puccinellietum coarctatae* ass. nov.

NORDHAGEN'S relevée 8, (l.c. table 2) represents 10 sample plots studied in a stand in Jarfjord, SE Finmark, subarctic northern Norway. It shows a close relationship to the *Triglochino-Puccinellietum phryganodis* because of the high constancy of *P. phryganodes*, *T. maritimum* and its boreal-sub/low-arctic phytogeographical composition. In these respects it is similar to KALELA'S *P. retroflexa*—WIESE from Poliostrov Rybachiy (Fischerhalbinsel), Russian Lapland (KALELA, 1939). I propose to unite these *P. coarctata* communities in a vicarious, subarctic association, the *Triglochino-Puccinellietum coarctatae* NORDH. 1954 em. nov., which is vicarious with the low-arctic *Puccinellietum coarctatae*, as does the *Triglochino-Puccinellietum phryganodis* with the *Puccinellietum phryganodis*. The differential taxa combination is composed of *Puccinellia coarctata* and the boreal *Triglochin maritimum;* accompanying boreal taxa are *Aster tripolium* f. *arcticus*, *Agrostis stolonifera*, *Juncus gerardi*, *Atriplex patula*.

The *Puccinellietum coarctatae* can be subdivided into three communities of lower order. This is based on the shifting (co-) dominance of a single species only, which depends chiefly on one ecological factor, the nitrogen-content of the substrate. Consequently, I propose for these units the rank of variant. Thus, I recognize a variant *inops* (table I:8–10, without differentiating characteristics), a variant of *Mertensia* (LID, 1964, table 9, subdominant to dominant taxon *Mertensia maritima*) and a variant of *Cochlearia* (NORDHAGEN, 1954 table 2:7; LID, 1964 table 9; subdominant to dominant presence of *Cochlearia officinalis* and *C. groenlandica*), in this sequence arranged according to increased nitrophily. Finally, STEINDÓRSSON (1954) describes a *Atriplex patula-Puccinellia retroflexa*- and a *Polygonum aviculare- Puccinellia retroflexa*-sociation from northern Iceland, in which *P. retroflexa* also refers to *P. coarctata* (STEINDÓRSSON, in litt.). These two sociations constitute a separate, distinct community with only quantitative differences between the two. It is most closely related to the *Triglochino-Puccinellietum coarctatae* inops, but because of the absence of *Stellaria humifusa* and *Triglochin maritimum* and the presence of *Polygonum aviculare*, I prefer to regard it as a separate association, the *Atriplo-Puccinellietum coarctatae* ass. nov. prov., subdivided in two variants corresponding to STEINDÓRSSON'S sociations. The absence

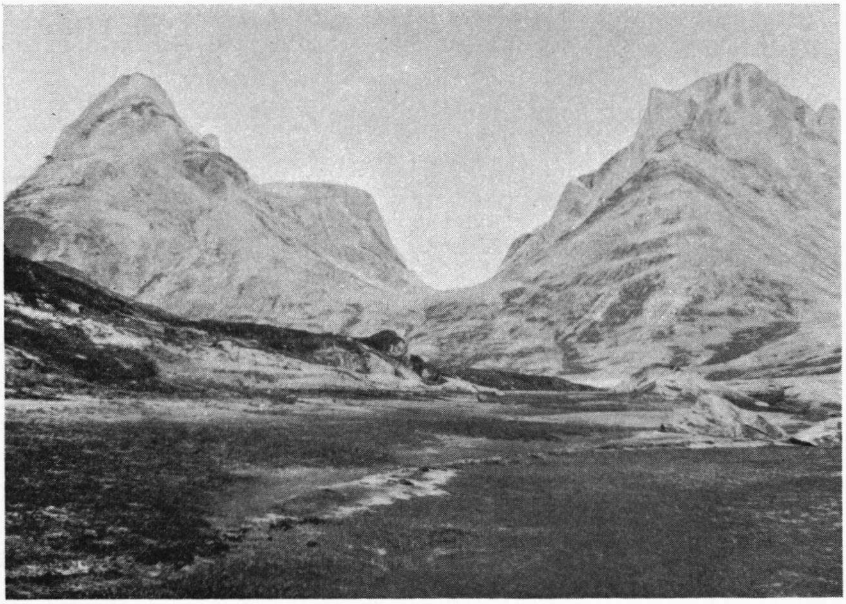


Fig. 14. Stand of the variant *inops* of the *Caricetum subspathaceae inops* on the delta at the head of the Qingertivaq fjord; to the left a closed phase, to the right an initial phase. JGdM phot. VII. 1969

also of *Potentilla egedii*, *Plantago maritima* ssp. *borealis* and *Bryum salinum* led me to suspect that this association had better be placed in the temperate, NW European *Puccinellio-Spergularion salinae* Beeftink 1965 or the related *Puccinellion maritimae* Christiansen 1927 em. R. Tüxen 1937.

3.1.1.3. Ass. *Caricetum subspathaceae* Hadač 1946 em. nov.

syn: non *Caricetum subspathaceae* Nordh. 1954, non *Carex subspathacea*-Wiese Kalela 1939.

composition: regional (arctic), exclusive faithful taxon is *Carex subspatacea* Wormskj.

distribution: The syntaxon has an arctic, probably circumpolar area.

3.1.1.3.1. Subass. *inops* subass. nov.

table 2; figs. 5, 14, 15.

composition: The community is negatively differentiated from the other units of the association (cf. 3.1.1.1.1.). The only constants are *C. subspathacea* and *Stellaria humifusa*. The community is relatively rich in taxa; in the Angmagssalik District an average of 5 taxa occur in one sample plot. Several of the accessory taxa indicate a contact situation between fresh and saline conditions (the cryptogams, *Carex rariflora*, *Potentilla egedii*). Phytogeographically it is pronounced low-arctic.

physiognomy: The in particular quantitatively predominantly geophytic community consists of a field layer or is stratified in both a field and a bottom layer. It forms very low, dense or comparatively open, wet sedge meadows or small patches of vegetation, which are of a characteristic dull, dark red-brown.

synecology & habitat: See 3.1. The community occurs in the Angmagssalik District on the sea and fjords shores on mudflats near the oulets of rivers and brooks, in general near MHW level, viz. between about 20 cm below and maximum about 50 cm above this level. It is subjected to infiltration of fresh water through the substrate and to more or less regular inundation with saline to brackish, more or less mesohaline water at high tide.

The substrate consists of clayey, silty or silty-sandy deposits, which are often more or less graded. At low tide it is wet as a result of irrigation and poor drainage. The ground water level is then usually not found deeper than −10 cm, though exceptionally also considerably deeper.

The colorimetric pH of the rhizosphere ranges from 5 to 7 and averages 6.5.

distribution: The community is not common in the Angmagssalik District (Kap Dan, Qortortup imîlâ, Qíngertivaq). The general area presumably coincides with the area of the association (distribution map of *C. subspathacea* in HULTÉN, 1964, map 184 and 1968, p. 252).

subdivision: The syntaxon can be subdivided in two variants:

a) Variant *inops* (table 2:1–3), characterized by the absence of differential taxa, the absence of a well-developed bottom layer and a relatively unstable habitat. This instability is due to the irregular fresh water supply: during spring and early summer the discharge of meltwater is often so much increased that the habitat is inundated, which involves sedimentation and sometimes erosion. The subsequent period of emerging, before saline (brackish) influences reassert themselves, appears to be most favourable for the germination of *C. subspathacea* (initial phase illustrated in fig. 14 and in table 2:1). Later the saline influences gradually increase, while the infiltration of fresh water through the mineral substrate further diminishes.

b) Variant of *Bryum* (table 2:4–7), characterized by the presence of a well-developed bottom layer dominated by *Bryum* (in the District *Br. salinum*, elsewhere also *Br. pseudotriquetrum* = *Br. ventricosum*) and the constancy of *Stellaria humifusa*. It is comparatively rich in taxa and occurs higher up on the beach. The influx of fresh water varies less throughout the vegetation period and is rather abundant.

Table II

reference number		1	2	3	4	5	6	7
total cover plants (in %)		5	)25	50	)80	)90	75	80
cover phanerogams –		5	)25	50	75	60	50	45
– cryptogams –		–	–	3	(15	70	60	50
– litter –		–	–	–	1	2	–	–
– open soil –		95	90	50	20	10	25	20
pH rhizosphere		7	6½	5	6¾	6¾	7	6½
ground water table (in -cm)		9	)50	0	8½	8½	6½	20
Carex subspathacea	L	2	4	5	5	5	4	4
Stellaria humifusa	L	..	+	..	3	1	1	1
Bryum (cf.) *salinum*		..	..	..	2	5	5	4
Potentilla egedii	L	..	..	..	..	..	3	..
Carex glareosa	L	..	1	..	..	..	3	+
Drepanocladus uncinatus fo.		..	..	+	..	..	+	+
Bryum (cf.) *pallens*		..	..	1	..	..	+	+
Cephaloziella spec.		..	..	..	..	..	2	+
Campylium polygamum		..	..	..	..	1	..	..
Carex rariflora	L	..	..	..	..	..	..	1
Calliergon stramineum		..	..	+	..	..	..	..
Philonotis tomentella		..	..	+	..	..	..	..
Ochrolechia spec.		..	..	..	..	..	..	+
Inocybe spec.		..	..	..	..	..	..	+

This variant presumably succeeds the variant inops. The upper layer of the substrate is usually slightly humic and brown-coloured.

syntaxonomy & discussion: Similar communities are commonly described in the literature. *C. subspathacea*-vegetation or -sociations which correspond to the subass. *inops* are described by various authors from low to middle-arctic Greenland (cf. e.g. BÖCHER (1963) and earlier publications).

In middle to high-arctic regions a related *C. subspathacea* community occurs; this is also characterized by the occurrence of *Carex ursina*, *Dupontia fisheri* and *D. fisheri* ssp. *psilosantha* (Greenland: HARTZ & KRUUSE, 1911; LAGERKRANZ, 1950; Spitsbergen: WALTON, 1922; DOBBS, 1939; HADAČ, 1946; northern Russia: LESKOV, 1936; northern Siberia: TIKHOMIROV *et al.*, 1966).

These arctic *C. subspathacea* communities, characterized by the absence of boreal taxa, can be grouped in a single association, which can be subdivided conform to the subdivision of the *Puccinellietum phryganodes* in a low to middle (-high) arctic subass. *inops* and a middle to high arctic subass. *dupontietosum* (see p. 74). It is likely that the subass.

Fig. 15. Stand of the variant of *Bryum* of the *Caricetum subspathaceae inops* below a snowdrift and around a muddy pool on a brook delta near Qortortup imîlâ; the lighter plant cover on the delta in the lower right is a *Carex glareosa* marsh.
JGdM phot. VII. 1969

dupontietosum can be subdivided in variants conform to the subdivision of the subass. *inops*.

C. subspathacea also occur as a characteristic dominant species in littoral vegetation farther south, in the Subarctic. From the publications dealing with the salt marshes from that region it appears that these involve typical subarctic communities (northern Iceland: STEINDÓRSSON, 1954; Finmark, Northern Norway: NORDHAGEN, 1954; the Kola peninsula: REGEL, 1923, 1941; Poluostrov Rybachiy, Petsamo Lappland: KALELA, 1939; Mezenskaya Guba and Cheshskaya Guba, northern Russia: KORCZAGIN, 1937), otherwise in the same type of habitat as the arctic *Caricetum subspathaceae*. NORDHAGEN (l.c.) expressed his doubts concerning the typical arctic nature of the northern Norwegian *C. subspathacae* meadows, but as exact analyses of its composition in the Arctic were lacking, he did not express a conclusive opinion. All these subarctic communities are distinguished from the arctic ones by their relative wealth of species, mainly attributable to the occurrence of boreal and temperate widespread taxa such as *Triglochin maritimum*, *Juncus bufonius*, *Agrostis stolonifera*, which are pararegional with respect to the area of the alliance (cf. p. 42). Floristically they are furthermore more closely related to other subarctic littoral communities such as the *Tri-*

glochino-Puccinellietum phryganodis, while the arctic *Caricetum subspathaceae* forms a more isolated community in this respect. Considering these floristic and phytogeographical differences I propose to unite these subarctic *C. subspathacea* communities in a vicarious subarctic association, the *Triglochino-Caricetum subspathaceae* (REGEL 1923 em. NORDH. 1954) ass. nov. (see p. 75).

3.1.1.4. Ass. *Sagino-Phippsietum algidae* ass nov. prov.

table 3.

composition: Differential taxa combination is *Phippsia algida* (SOL.) R. BR. and *Sagina intermedia* FENZL. (= *S. nivalis* BLYTT & DAHL). Constant accessory taxa are *Stellaria humifusa*, *Bryum salinum*. The mentioned taxa, as well as most of the other accessory taxa, indicate a contact situation between brackish-saline and fresh water influences, a prolonged, deep snow cover, and a certain enrichment of the substrate with organic, allochtonous material. The widespread arctic and low-arctic elements are equally represented in the flora.

physiognomy: The chamaephytic and hemicryptophytic community consists properly only of a field layer, the bottom layer is scarcely developed. It forms small, open stands, physiognomically dominated by the bare substrate, for as a rule the plants cover less than 15 $^0/_0$ of the total surface.

synecology & habitat: See 3.1. The chionophytic, more or less nitrophytic community occurs in the Angmagssalik District on the sea and fjord shore along sheltered deltas of brooks, where the local physiography offers possibilities for the accumulation of snow in the winter. It is found around MHW level and in consequence is subjected to irregular inundation. The flood water is more or less brackish (mesohaline) and penetrates only superficially into the substrate, which is particularly early in the vegetation period practically saturated with (nearly) fresh water.

The substrate consists of ungraded sediments, the particle size ranging from clay-silt to coarse sand and stones. It is little consolidated and shows neither stratification nor differentiation. At low tide it is wet; during that period the depth of the ground water is between 0 and −10 cm.

The colorimetric pH of the rhizosphere is about 7.

distribution: The community is rare in the Angmagssalik District (Qíngertivaq, Kap Dan). Presumably it also occurs elsewhere in Greenland, but rarely, and probably has a circumpolar area (distribution maps of *Ph. algida* and *S. intermedia* in HULTÉN, 1964, map 2, and 1968, pp. 92 and 427).

syntaxonomy & discussion: There is a number of arctic plant taxa, which is not strictly confined to the seashore, but which nevertheless

Table III

reference number		1	2	3	4
total cover plants (in %)		(10	5	(15	5
cover phanerogams –		(10	5	(15	5
– cryptogams –		(1	1	1	(1
– litter –		–	–	–	–
– open soil –		95	95	95	95
pH rhizosphere		7	7	7	$6^1/_2$
ground water table (in -cm)		10	2	5	0–1
Stellaria humifusa	L	+	+	+	1
Bryum salinum		+	+	+	+
Phippsia algida	A	2	2	2	1
Sagina intermedia	A	+	+	+	..
Puccinellia coarctata	L	+	..	+	..
Carex glareosa	L	..	+	..	..
Cochlearia groenlandica	A	+	+	..	..
Campylium polygamum		..	+	+	..
Drepanocladus uncinatus		..	+	+	+
Cerastium cerastoides	L	..	..	..	1
Philonotis tomentella		..	..	..	+
microlichen indet. (sterile)		..	..	..	+

appears to have a certain affinity with the shore vicinity. These taxa often show a more or less clear combination which is not so very rare in the Arctic, of being apparently at the same time facultative halophytic, nitrophytic and/or ornithocoprophytic and more or less chionophytic. This applies for instance to *Cochlearia* and *Phippsia algida*, and also to *Puccinellia coarctata*, *Festuca rubra* ssp. *rubra*, *Sagina intermedia*.

SEIDENFADEN & SØRENSEN (1937) describe from NE Greenland a "kind of shore snowpatch vegetation" at the margins of the shore of salt to brackish lagoons. Together with *Stellaria humifusa* there occur in this community *Sagina intermedia*, *Phippsia algida* and a special ecotype of *Saxifraga rivularis* as facultative halophytes. This community corresponds to the one described here as observed in the Angmagssalik District. With some reserve I describe it as a separate association, as only four sample plots were studied. This provisional syntaxon presumably belongs to the *Carici-Puccinellietalia*, on account of the constant occurrence of *Stellaria humifusa* and *Bryum salinum*, and the occurrence of other obligate and facultative halophytes characteristic of it. Synecologically it is more closely related to the *Puccinellion phryganodis* than to the *Caricion glareosae*, and therefore I group it in the first alliance.

The syntaxon is possibly vicarious with the *Puccinellio-Spergularion salinae* BEEFTINK 1965 (closely related to the *Puccinellion maritimae;* see 3.1.1.).

In irrigated snow-beds in northern alpine areas a *Phippsietum algidae-concinnae* NORDH. 1943 occurs. This non-halophytic, boreal-alpine (to arctic?) syntaxon has only *Ph. algida* in common with the *Sagino-Phippsietum algidae* (cf. NORDHAGEN, 1943, table 48; GJAEREVOLL, 1956, table 54), whereas an other *Caryophyllaceae* taxon, *Cerastium cerastoides* (= *C. trigynum*) replaces *S. intermedia* as a constant. Sample plot 4 in table 3 is in this respect related to the *Phippsietum algidae-cincinnae.*

Distinctly nitrophytic *Phippsia algida* communities, often with *Sagina intermedia*, *Cochlearia*, *Puccinellia* species and other taxa, found in strongly manured sites usually in the vicinity of the coast (at the foot of birdcliffs, in former Eskimo habitation sites etc.) seem to be common in many parts of the Arctic and are presumably closely related to or belong to the *Sagino-Phippsietum algidae.*

3.1.2. All. *Caricion glareosae* NORDH. 1954

composition: General, transgressive faithful taxon is *Carex glareosa* WBG. incl. var. *amphigena* FERN.; selective differential taxon as regards the *Puccinellion phryganodis* is *Festuca rubra* L.

synecology & habitat: The halophytic to meso(oligo)halophytic, more or less tropohydrophytic, eutrafent to mesotrafent and medium acidophytic to neutrophytic communities of the syntaxon occur on often comparatively more or less exposed shores along bays and fjords, in a zone from a few decimeters below MHW up to EHWS level, above the zone characterized by the *Puccinellion phryganodis;* exceptionally also higher on low raised beach terraces. The substrate is coarse sandy and strongly humic to peaty in the upper part.

The area is presumably sub- to middle-arctic, semi-circumpolar (absent in central, northern Canada and Siberia).

The syntaxon is presumably vicarious with the *Armerion maritimae* BR.-BL. & DE LEEUW 1936 (*Glauco-Puccinellietalia;* see 3.1.), presumably partly also with the *Agropyro-Rumicion crispi* (see 3.1.2.2.). See further 3.1. and the survey on p. 75.

3.1.2.1. Ass. *Caricetum glareosae* ass. nov.

syn.: *Festuceto-Caricetum glareosae* NORDH. 1954 pro min. p.; *Caricetum glareosae* BÖCHER 1933 n.n.; non *Carex glareosa*-WIESE KALELA 1939, non *Caricetum glareosae* REGEL 1923.

table: 4:1–25; figs. 9, 16–23.

composition: regional (Arctic), selective faithful taxon is *Carex glareosa* WBG. incl. var. *amphigena* FERN. *Festuca rubra* and *Campylium polygamum* have, within the *Carici-Puccinellietalia*, their optimum in this syntaxon in the Arctic.

Fig. 16. Littoral vegetation on a crescent beach in Kong Oscars Havn near the entrance to the Sermilikvejen valley. From left to right *Carex glareosa* marsh (*Caricetum glareosae typicum*), recent tidal mark (*Fucus* rests, driftwood), *Honckenya peploides* var. *diffusa* sociation and steeply sloping dwarf shrub heath with an old tidal mark at its base. JGdM phot. VIII. 1968

In the Angmagssalik District on an average about 5.5 taxa occur in one sample plot. *Potentilla egedii* and possibly also *Plantago maritima* ssp. *borealis* seem to prefer dynamic habitats, where a certain setting of the superficial substrate layers occurs, in saline-fresh and eutrophic-oligotrophic contact situations. The bryophytes in particular seem to prefer less dynamic, somewhat disturbed habitats regarding the saline-fresh contact, where the development of the soil is less, or not at all disturbed by displacement of material. The rhizosphere below stands with a moss layer is noticeably, viz. on an average one pH unit lower than below stands without a bottom or moss layer. Most taxa belong to the low-arctic flora element.

physiognomy: The predominantly hemicryptophytic, partly also geophytic and chamaephytic community consists of a single field layer or of a field and a bottom or moss layer. It forms closed, graminoid meadows of sometimes relatively considerable extent and of a very homogeneous appearance; see further the subunits.

synecology & habitat: See 3.1. and 3.1.2. The community occurs in the Angmagssalik District on more or less sheltered, flat, or slightly concave, slightly sloping, to almost level crescent beaches along "tasiussaqs" (cf. A. 3.1.2.4.2.), on the upper part of exposed, otherwise bare, gravelly to stony beaches along deep fjords (cf. A. 3.1.2.2.1.), and rarely locally on sandy banks in brook deltas, from 20 cm below MHW to 60 cm (exceptionally more than 1 m) above MHW at MHWS level. It also occurs locally on raised former beaches at an elevation of 2 to 3 m above MHW.

The community is more or less regularly flooded with saline, viz. euhaline to mesohaline, exceptionally polyhaline water. The direct relation between elevation of the site and the duration of inundation is sometimes disturbed by physiographical structures. Fresh water supply can occur and vary both spatially and temporally, as does the ground water level at low tide.

The substrate consists of peaty, coarse sandy to fine gravelly deposits. The soil development may go on undisturbed by displacement of

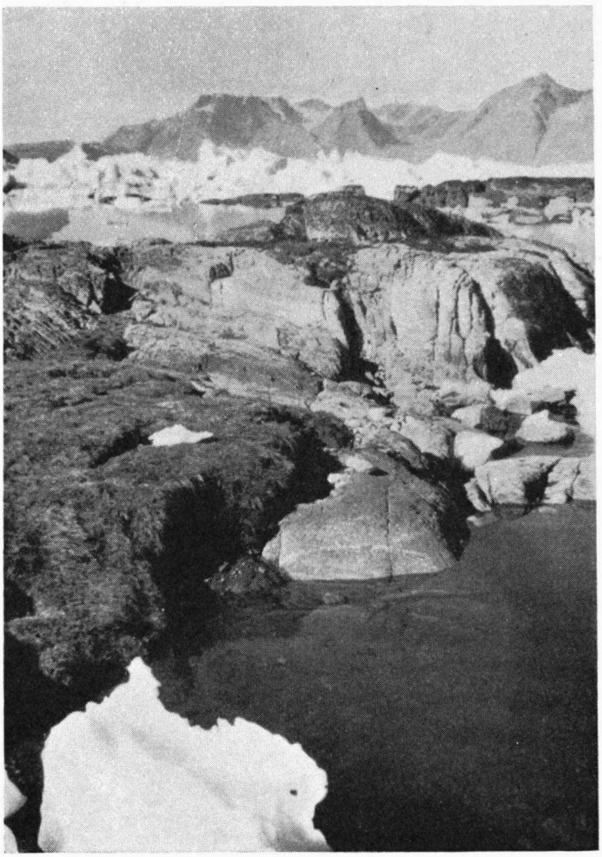


Fig. 17. Eroding *Carex glareosa* marsh (*Caricetum glareosae typicum* var. *inops*) near Nûk along the Sermilik fjord. JGdM phot. VII. 1969

material, or be interrupted by discontinuous sedimentation. There may also occur locally closer bedding of the soil particles in the upper layers.

The substrate is in various degrees enriched by allochtonous organic material, viz. either finely dispersed vegetative and animal matter or coarse, floating, vegetative material in the form of dead, large *Phaeophyceae;* excrements of birds rarely contribute to the enrichment.

The colorimetric pH of the rhizosphere ranges from 5 to 7 and averages about 5,8.

distribution: This community represents the most common type of littoral vegetation in the Angmagssalik District (all localities except Kap Dan); it also commonly occurs elsewhere in middle and low-arctic Greenland (cf. A. 1.2.2.1. and 2.). Its general area is low to middle-arctic, presumably semi-circumpolar (cf. B. 3.1.2.).

3.1.2.1.1. Subass. *typicum* subass. nov.

table 4:1–14; fig. 16–20, 23.

composition: As indicated by the epitheton the community is not characterized by differential taxa, but, in contrast to the syntaxa defined by the term *inops*, not noticeably less rich in taxa then the equivalent units grouped in the same higher syntaxon. *Potentilla egedii* and to a lesser degree *Stellaria humifusa* have their ecological optimum within the association in this unit.

physiognomy: The community forms rather low, dense, yellowish-green swards of a sometimes considerable extent (fig. 16).

synecology & habitat: See 3.1.2.1. The community occurs in the district along small, shallow, open bights in the "tasiussaqs" (A.3.1.2.4.2.) between 20 cm below to more than 20 cm above MHW, more rarely also on sandy banks in funnel-shaped estuaries on the deltas of brooks, where the tidal amplitudes are more variable.

The habitat is more or less regularly flooded with saline, viz. euhaline to mesohaline water and is sometimes subjected to an influx of fresh water.

The substrate consists of more or less distinctly stratified, graded, coarse sandy deposits and is usually peaty in the upper part to a maximum depth of at least −15 cm. It is apparently rather discontinuously deposited and exposed to erosion at the steep outer edge (cf. A. 3.1.2.4.2., fig. 17). Setting of the soil particles in the superficial layers occurs frequently. Enrichment of the soil by finely dispersed, allochtonous organic matter seems to be common, but accumulation of allochtonous, coarse organic material in the form of partly decomposed large seaweeds (tidal mark) does not occur.

Fig. 18. Stand of the variant *inops* of the *Caricetum glareosae typicum* along the Tasîlâlik fjord, with an open *Honckenya peploides* var. *diffusa* stand in the foreground.
JGdM phot. VII. 1968

The salinity of the substrate varies with the amount of infiltration of fresh water. At low tide the ground water level usually is not found deeper than −20 cm, though exceptionally also deeper down.

The colorimetric pH of the rizosphere ranges from 5 to 7 and averages about 5.75.

distribution: See 3.1.2.1.

subdivision: Two local variants can be distinguished:

a) Variant *inops* (table 4:1–4; figs. 17, 18, 23), characterized by the differential taxa *Potentilla egedii* (optimum) and *Plantago maritima* ssp. *borealis*, and by the absence of a well-developed bottom layer. On an average 5 taxa are found in one sample plot.

The appearance of this variant is enlivened by the abundant, conspicuous, bright yellow flowers of the *Potentilla*.

The variant occurs along small, open bights in "tasiussaqs", where the crescent beach is not bordered by a low ridglet at the outer edge (fig. 16). The habitat is characterized by a stable dynamic in time, caused by the regular flooding with saline water; there is no perceptible infiltration of fresh water. The process of soil development is, judging from the often noticeable stratification of the substrate,

Fig. 19. Detail of a patch of vegetation of the variant with a moss layer of the *Caricetum glareosae typicum*. JGdM phot. VII. 1969

disturbed by discontinuous sedimentation. At low tide the ground water level is found from −20 to below −50 cm depth. The colorimetric pH of the rhizosphere ranges from $5^3/_4$ to 7 and averages about 6.5.

b) Variant with a moss layer (table 4:5–14; fig. 19, 23), differentiated by the presence of a well-developed moss layer with *Campylium polygamum*, *Drepanocladus uncinatus*, *Bryum pseudotriquetrum* and *Br. salinum*. On an average 6 taxa occur in one sample plot.

The variant occurs along small, open bights in "tasiussaqs", where the often more or less slightly concavely sloping beach is usually bordered by a low ridglet before it steeply drops off to the tidal flat (figs 20, 23); it also occurs on flat to slightly concave, low sandbanks in river deltas in funnel-shaped estuaries. The habitat is characterized by a dynamic, temporally unstable contact situation between fresh and saline conditions, caused by the interaction of the more or less regular flooding with saline water, a from spring onwards gradually diminishing influx of fresh water, and a somewhat impeded local drainage. Judging from the non-stratified or hardly stratified substrate, the process of soil development is more continuous than below the variant inops. At low tide the ground water level occurs at a depth of 0 to −20 cm. The pH of the rhizosphere ranges from 5 to 6 and averages about 5.5.

3.1.2.1.2. Subass.. *festucetosum rubrae* subass. nov.

table 4: 15–25; figs 9, 20–23.

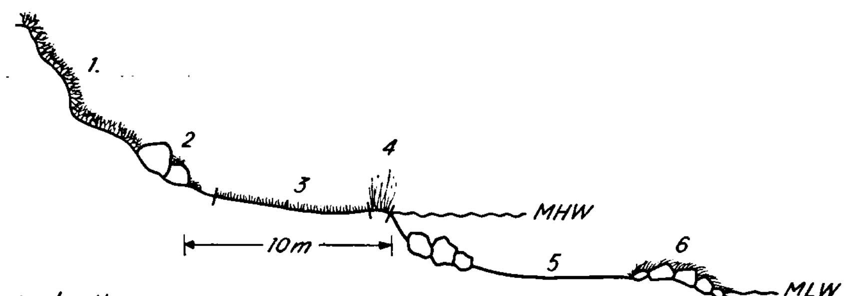
composition: Differential, exclusive faithful taxon is *Festuca rubra* L. ssp. *rubra*. The abundance of *C. glareosa* is quite variable.

physiognomy: The community forms high, dense, graminaceous stands of a glaucous colour with a characteristic purplish hue. The area of these stands is usually rather small. See also p. 61.

synecology & habitat: See 3.1.2.1. The community occurs in the district in belts or narrow strips of vegetation on the upper beach along the base of the talus slopes along the fjords, where the middle and lower part of the stony beaches are without any vegetation (cf. A. 3.1.2.2.1.), and also commonly on very low ridges along the outer edge of, as well as halfway up on the beaches above *C. glareosa* marshes (subass. *typicum*, see 3.1.2.1.1.), in both habitats more or less at MHWS level, viz. (0-)30 to 60 cm above MHW. It is also found more rarely along the outer edge of sandbanks in estuaries of brooks at about the same level, and on raised former beaches at 2 to 3 m a.s.l. immediately adjacent to the present shore.

The habitat is irregularly flooded with saline, viz. more or less euhaline to mesohaline water. Influx of fresh water is hardly perceptible.

The substrate is often more peaty in the upper part than below the subass. *typicum* and not noticeably stratified. The peaty material originates partially from accumulated dead *Fucus;* supply and accumulation of this allochtonous organic material varies, but is often locally considerable, forming thick tidal marks. Setting of the soil does not seem to occur. The development of the soil is relatively continuous; erosion often occurs but only affects the outer or lower edges of the sod.



1. *heath*
2. *accumulated dead Fucus*
3. *Caricetum glareosae typicum*
4. *Caricetum glareosae festucetosum rubrae*
5. *tidal flat*
6. *ice-pushed ridge with Fucus*

Fig. 20. Sketch of the physiography and zonation in the plant cover on a crescent beach along Kong Oscars Havn, Imîlâjiva.

Table IV

reference number		1	2	3	4	5	6	7	8	9	10	11	1[illegible]
total cover plants (in %)		100	95	70	90	100	100	100	100	100	100	80	10[illegible]
cover phanerogams –		100	95	70	90	65	40	35	15	90	40	30	2[illegible]
– cryptogams –		–	(1	–	–	65	100	100	100	35	90	65	9[illegible]
– litter –		–	50	5	–	–	10	–	5	–	1	–	[illegible]
– open soil –		–	–	30	10	–	–	–	–	–	–	20	[illegible]
pH rhizosphere		$5^3/_4$	$6^1/_4$	7	$6^3/_4$	$5^1/_2$	$5^1/_4$	5	5	6	$5^3/_4$	6	$5^3/$[illegible]
ground water table (in -cm)		20	22	–	±20	13	3	6	0	9	10	20	2–[illegible]
elevation (in m a.s.l.)		–	–	–	–	–	–	–	–	–	1	–	[illegible]
Plantago maritima ssp. *borealis*	L/B	..	..	1	1	..	..	..	..	..	..	..	[illegible]
Puccinellia phryganodes	A	..	..	+	3	..	..	..	..	..	1	1	[illegible]
Potentilla egedii	L	4	2	2	4	5	..	..	..	3	..	..	[illegible]
Stellaria humifusa	L	+	1	+	1	2	2	2	+	1	1	3	[illegible]
Carex glareosa	L	6	6	5	6	4	4	4	3	6	4	3	[illegible]
Festuca rubra	B	..	+	+	..	+	..	..	..	..	..	..	[illegible]
Carex rariflora	L	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Bryum (cf.) *salinum*		..	..	..	..	..	+	2	..	2	..	4	[illegible]
Campylium polygamum		..	+	..	..	5	6	6	6	..	2	..	[illegible]
Drepanocladus uncinatus fo.		..	..	..	..	..	..	..	1	3	6	4	[illegible]
Bryum pseudotriquetrum		..	..	..	..	..	..	..	..	..	..	1	[illegible]
Carex subspathacea	L	..	..	..	..	..	..	..	..	+	..	..	[illegible]
Sedum rosea	L	..	..	+	..	..	..	..	..	1	..	..	[illegible]
Ochrolechia (sterile)		..	..	..	..	..	..	..	..	..	..	1	[illegible]
Oncophorus wahlenbergi		..	..	..	..	..	..	..	..	..	..	..	[illegible]
Cetraria delisei		..	..	..	..	..	..	..	..	..	..	..	[illegible]
Cladonia spec.		..	..	..	..	..	..	..	..	..	..	..	[illegible]
Polytrichum alpinum		..	..	..	..	..	..	..	..	1	..	..	[illegible]
Cephaloziella cf. *divaricata*		..	..	..	..	..	..	..	..	+	..	..	[illegible]
Salix herbacea	L	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Honckenya peploides ssp. *peploides* var. *diffusa*	L	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Poa alpina	L	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Empetrum hermaphroditum	L	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Philonotis tomentella		..	..	..	..	..	+	..	..	..	..	..	[illegible]
Pohlia spec.		..	..	..	..	..	+	..	..	..	..	..	[illegible]
Phippsia algida	A	..	..	..	..	..	..	..	+	..	..	..	[illegible]
Inocybe spec.		..	..	..	..	..	..	..	..	..	..	+	[illegible]
Subularia aquatica	B	..	..	..	..	..	..	..	..	..	..	..	[illegible]
Polytrichum norvegicum		..	..	..	..	..	..	..	..	..	..	..	[illegible]
Anthelia juratzkana		..	..	..	..	..	..	..	..	..	..	..	[illegible]

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
100	70	90	80	60	65	75	100	100	100	100	100	100	95	70	100	90	85
45	35	90	80	60	65	75	90	95	90	90	80	85	95	70	60	75	65
90	45	–	–	–	$7^1/_2$	1	20	40	20	20	40	30	–	–	60	25	40
2	–	80	60	–	50	15	5	5	$2^1/_2$	–	–	10	80	60	5	30	40
–	30	–	–	40	5	15	–	–	2	2	–	–	–	–	–	–	–
$5^1/_2$	5	6	$6^1/_2$	$6^3/_4$	6	$6^1/_2$	5	5	$5^1/_4$	$5^1/_2$	$5^3/_4$	$5^3/_4$	$6^1/_4$	$5^1/_4$	5	$4^3/_4$	$4^3/_4$
9	7	–	–	–	–	–	–	–	–	–	44	20	–	27	7	–	–
1	–	–	–	(3	(3	–	–	–	–	–	–	–	–	–	1	5	5
..	..	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	+	..	..	..	..	..	4	2	4	4	4	4
1	2	..	+	1	..	1	..	+	2	2	3	2	..	..	..	..	1
4	3	+	+	3	2	3	3	5	3	3	5	4	..	..	2	2	2
..	..	6	6	4	5	2	5	5	5	5	4	3	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	6	5	4	5	4
..	..	..	..	..	+	+	..	+	+	2	..	..	..	..	..	..	..
3	..	..	..	..	..	..	..	..	3	3	4	4	..	..	..	..	} 4
2	2	..	..	..	..	..	3	4	..	..	..	..	..	..	5	3	
5	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1	+	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..
..	..	..	+	..	1	3	2	..	..	..	..	..	..	..	+	..	1
..	+	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	+
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	+	+
..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	+
..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	+	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	1	..
..	..	..	+	..	..	3	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+

The salinity of the substrate is presumably variable and often rather low. At low tide the ground water level is found below –20 cm depth, as a rule even below –50 cm (the maximum depth of the profile pits).

The colorimetric pH of the rhizosphere ranges from 5 to $6^3/_4$ and averages about 5.8.

distribution: See 3.1.2.1.

subdivision: Two local variants can be distinguished:

a) Variant *inops* (table 4:15–19), characterized by the absence of a moss layer and by the rare occurence of *Plantago maritima* ssp. *borealis*. The average number of taxa in one sample plot is 5.4.

The variant occurs on very low ridges along the outer edge of, as well as halfway up on crescent beaches in "tasiussaqs", more rarely on the level outer part and on very low ridges along the outer edges of raised former beaches immediately adjacent to the present shore (see the subass.). The habitat is somewhat unstable-dynamic, due to irregular flooding with saline (euhaline to polyhaline) water and a certain disconnection of the relation between elevation and duration of inundation. The flood water stagnates more or less behind the often somewhat elevated sites, to drain away slowly through the substrate; this prolonged saline influence also occurs when the stands occur on level soil near MHWS, where often considerable quantities of dead seaweed accumulate and retard the drainage. Infiltration of fresh water is not perceptible. The salinity of the substrate is in consequence less variable and higher than below the following variant. At low tide the ground water level occurs below –50 cm depth. The pH of the rhizosphere ranges from 6 to $6^3/_4$ and averages about 6.4.

b) Variant with a moss layer (table 4:20–25), differentiated by the presence of a rather well developed moss layer with *Campylium polygamum* and *Drepanocladus uncinatus* (the more halophytic *Bryum salinum* is less common). The average number of taxa in one sample plot is 5.3.

The variant occurs in belts of vegetation along the basis of talus slopes along the fjords at about 30 to 60 cm above MHW (near or at MHWS; cf. A. 3.1.2.2.1.); rarely also in front of stands of the variant *inops* halfway on the beaches along crescent bays in "tasiussaqs" and along the outer margin of level to slightly concave sandbanks in the estuaries of brooks, shortly above MHW. The habitat represents a somewhat more unstable, dynamic contact situation between fresh and saline conditions, being subjected to more or less irregular flooding with saline (euhaline to polyhaline) water, a variable though limited supply of fresh (seepage)water and a comparatively poor drainage of the site. Accumulation of allochtonous organic material is considerably less, but peat development is more pronounced than below the variant

Fig. 21. Stand of the *Caricetum glareosae festucetosum rubrae* along the shore of the inner Ikâsaulaq fjord. JGdM phot. VIII. 1969

inops. The ground water level at low tide occurs from −20 to below −50 cm depth. The colorimetric pH of the rhizosphere ranges from 5 to $5^3/_4$ and averages about 5.4.

3.1.2.1.2.A. Note: *Sedum rosea*-facies

table 4: 19, 20; fig. 22.

Sedum rosea (L.) Scop. occurs occasionally in most littoral vegetation types in small numbers. But in the *Caricetum glareosae festucetosum rubrae* it may occur in such numbers as to become sub- to co-dominating. The facies is a typical tidal mark community, which is found as a narrow belt along the base of the talus along the fjords, above a usually bare, stony beach. It is characteristic for the parts of the fjords with abundant *Fucus* growth, along the shores of shallow, sheltered bays. The soil consists of a more or less coherent, at the most 10 cm thick, very humic turf which rests without any transition immediately upon the overgrown stony-shingly beach. The two colorimetric pH's of the rhizosphere measured 5 and $6^1/_2$. The facies displays a characteristic physiognomy due to the growth form of the rose root. The tussocks of this plant are already conspicuous from afar because of their beautiful, large, semi-globular form, which may reach a diameter of more than 40 cm, and the rich simultaneous flowering of the stems. *Carex glareosa*, too, shows a tussocky growth, which the sedge also does in other manured habitats, such as

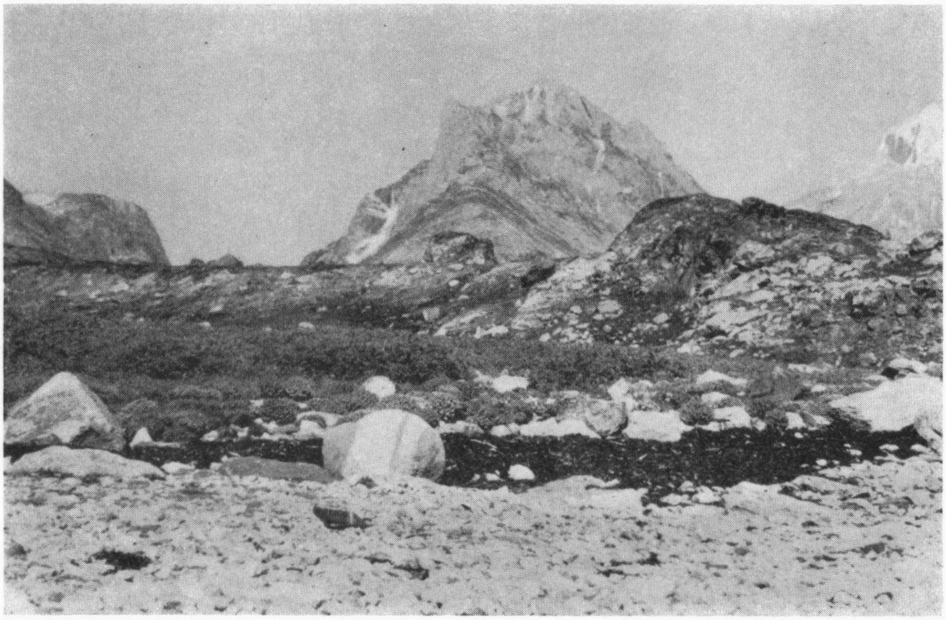


Fig. 22. *Sedum rosea* facies of the *Caricetum glareosae festucetosum rubrae* on a stony brook delta in the inner Qíngertivaq fjord. In front of the stand a dark recent tidal mark of *Fucus* rests, behind it a *Salix glauca* shrub.

JGdM phot. VII. 1969

bird islands and former and recent human habitation sites. In true littoral marshes it does not grow this way but forms dense, closed swards. The floristic composition is heterogenous. Several species do not belong to the halophytic element, but are typical non-halophytic heath-plants. The community apparently forms a stage of succession or transition, and in many places it may indeed be observed to shade off into the heath vegetation on the talus. It is floristically related to the vegetation on "gull-tufts" as described by KRUUSE (1912) from the Angmagssalik District. The community is not a very common one in the inner fjord ramifications in the District. A similar facies occurs in the vicarious, subarctic-Fennoscandian *Agrosto-Caricetum glareosae* (KALELA, 1939, p. 340).

syntaxonomy & discussion: NORDHAGEN (1954) groups the subarctic, northern Fennoscandian and the low to middle-arctic, Greenlandic, mutually closely related *Carex glareosa*, *Festuca rubra*, *Agrostis stolonifera* and *Carex marina* (= *C. glareosa* var. *amphigena* FERN.) salt marsh communities in a single association, the *Festuceto-Caricetum glareosae* NORDH. 1954 (see p. 75–76).

The subarctic communities of this syntaxon (cf. REGEL, 1923, 1927, 1928, 1941; KALELA, 1939; NORDHAGEN, 1954; ± HAVAS, 1961; ± SJÖRS,

1967) appear on closer examination to differ from the arctic ones (cf. Kruuse, 1912; Böcher, 1933, 1963; Devold & Scholander, 1933; Fredskild, 1961; Igoshina, 1966; see also the publications cited by Nordhagen, 1954, p. 384 and the present publication, part C) conform the difference between the vicarious pairs of subarctic and arctic syntaxa grouped in the *Puccinellion phryganodis* (3.1.1., cf. a.o. 3.1.1.1.), viz. by the occurrence of a group of more or less constant taxa of which the northern area limits coincide with the transition between the Subarctic and Arctic. The areas of these essentially boreal taxa (*Agrostis stolonifera*, *Triglochin maritimum*, *Primula sibirica* incl. *finmarchica*, *Juncus bufonius*, *Parnassia palustris*, *Juncus gerardi*, *Atriplex patula*) are thus pararegional regarding the area of the alliance and the order. Therefore I propose, corresponding with the division of for example the *Puccinellietum phryganodis* Hadač 1946 *sensu* Nordh. 1954 and the *Caricetum subspathaceae* Hadač 1946 *sensu* Nordh. 1954, to divide the *Festuceto-Caricetum glareosae* in two vicarious associations, an arctic *Caricetum glareosae* and a subarctic *Agrosto-Caricetum glareosae* (see Part C).

3.1.2.2. Ass. *Potentillo-Caricetum rariflorae* ass. nov.

syn.: ? *Carex rariflora*-sociation Nordh. 1954 n.n.; ? *Carex rariflora*-Wiese Kalela 1939.

table 4: 26–30; figs. 9, 23–25.

composition: Differential taxa combination is *Carex rariflora* Wbg. (exclusive faithful within the alliance) and *Potentilla egedii* Wormskj. (optimum). In the Angmagssalik District on an average 6 taxa occur in one sample plot. See further the corresponding paragraph with 3.1.2.1.

physiognomy: The hemicryptophytic and geophytic community consists of a single field layer or of both a field and a bottom or moss layer. It forms rather low, dense, graminoid patches of a dull grayish-green, sprinkled with the numerous bright yellow flowers of *P. egedii* (cf. 3.1.2.1.1.a.).

synecology & habitat: See 3.1. and 3.1.2. The community occurs in the Angmagssalik District patch-wise in *Carex glareosa* salt marshes along embayments in "tasiussaqs" (cf. 3.1.2.1.) at about 20 to 40 cm above MHW, as well as along shallow, temporary pools on raised former beaches at about 5 m a.s.l. at most.

It is characteristic of (more or less) unstable environments in comparatively extreme contact situations between dry and wet, poor and rich (oligotrophic and eutrophic) and to some extent between fresh and saline conditions, sometimes forming a transition to real mire communities. The habitat is subjected to a variable, in the course of the summer diminishing percolating of fresh water through the soil, and to irregular

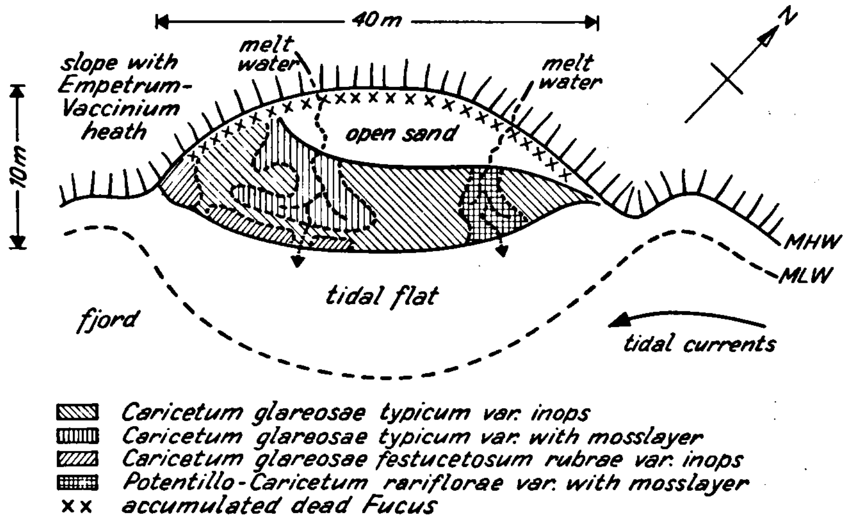


Fig. 23. Sketch of the pattern in the littoral vegetation on a small beach in Kong Oscars Havn, Imîlâjiva.

flooding with saline (more or less mesohaline) water, or is completely out of reach of the tides.

The substrate consists of an up to 20 cm thick layer of sedge peat over a sandy, gravelly or stony subsoil. The humidity fluctuates considerably in the course of the vegetation period, as to a far less degree the salinity, which is presumably very low, does. In early summer the ground water moves feebly and is found at or near the surface. Later, as the substrate dries out superficially, it becomes nearly stagnant.

Supply and accumulation of allochtonous vegetative matter was not observed. Guanotrophy occurs at least in the habitat on raised former beaches, whereas the water movements involve a certain mineral enrichment of the soil and closer setting of the soil particles in the upper layers.

The colorimetric pH of the rhizosphere ranges from $4^3/_4$ to $6^1/_4$ and averages about 5.2.

distribution: The community is rare in the Angmagssalik District (Tasîlâlik, Kong Oscars Havn-Imîlâjiva, inner Qíngertivaq); it also occurs elsewhere in Greenland and possibly in northernmost Fennoscandia and Russia (BÖCHER, 1938, p. 232; DEVOLD & SCHOLANDER, 1933, p. 156, 123; KALELA, 1939, p. 354; NORDHAGEN, 1954, p. 392). Its area is possibly circumpolar.

subdivision: Conform the subdivision of the two subassociations of the *Caricetum glareosae* two local variants can be distinguished:

a) Variant *inops* (table 4: 26, 27; fig. 24), characterized by the absence of a bottom or moss layer and of *Carex glareosa*, *Stellaria humifusa*, *Sedum rosea*. It is very poor in taxa.

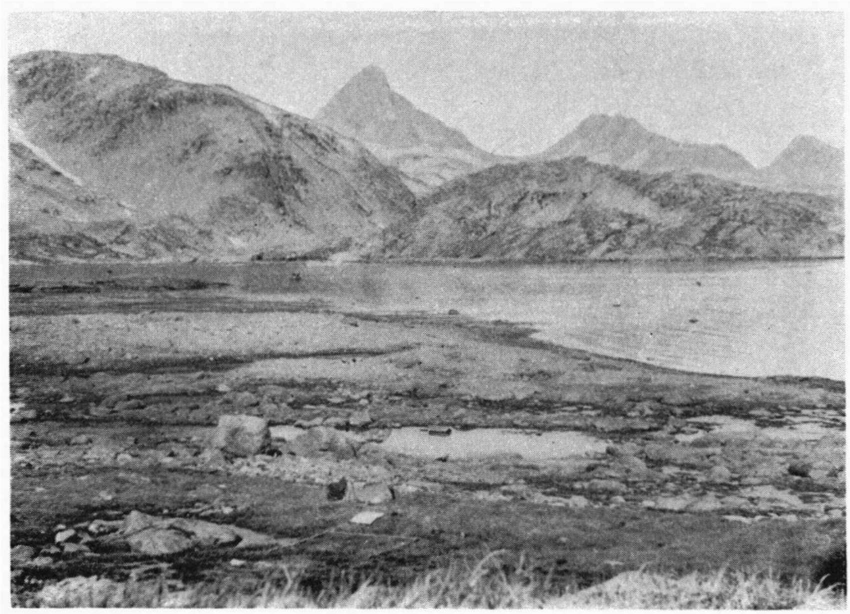


Fig. 24. Small patch of vegetation of the *Potentillo-Caricetum rariflorae* (variant *inops*; in and around the square) in surrounding *Caricetum glareosae typicum* on the shore of Kong Oscars Havn, at Imîlâjiva, at low tide.

JGdM phot. VII. 1969

The variant occurs on slightly concave, crescent beaches along embayments in "tasiussaqs", as patches in surrounding *C. glareosa* communities. The habitat presents a temporally somewhat unstable dynamic contact situation between fresh and saline conditions, in which the relation between elevation and duration of inundation is somewhat disturbed: the drainage is to some extent impeded by the physiography, so that part of the brackish flood water stagnates, to become gradually diluted in the upper zone of the soil with fresh ground water, which in limited quantities percolates from the slopes above. Sedimentation of mineral material is limited and more or less continuous. Two pH measurements of the rhizosphere gave $5^1/_4$ and $6^1/_4$.

b) Variant with a moss layer (table 4: 28–30; figs 9, 23, 25), differentiated by the presence of a well-developed moss layer dominated by *Drepanocladus uncinatus*, and of *C. glareosa*, *St. humifusa* and *S. rosea*, as well as of some non-halophytic taxa such as *Salix herbacea*, *Oncophorus wahlenbergii*, *Cetraria delisei*. It is comparatively (though very variably) rich in taxa.

The variant occurs in similar habitats such as the variant inops, when there is a greater supply of fresh water and/or a more impeded local drainage, and along temporary pools on raised former beaches

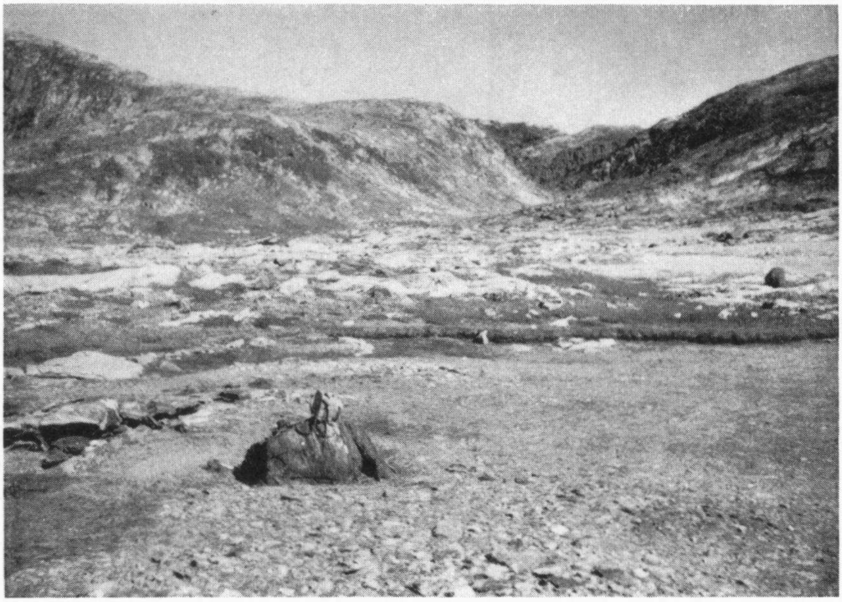


Fig. 25. Stand of the *Potentillo-Caricetum rariflorae* (variant with a moss layer; in the middle of the picture) along a dried up, very shallow pool (lower half of the picture) on a raised former beach along the Tasîlâlik fjord, 5 m a.s.l. The bottom of the pool is covered with a community of *Alopecurus aequalis*.

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(fig. 25); intermediate communities occur along the tidal flats at the head of fjords, at MHW level. The habitat is characterized by a comparatively often less dynamic, more unstable contact situation between wet and dry, poor and rich, and fresh and saline conditions, caused by a greater variation in the supply of fresh water and in the wetness of the substrate, a more pronouncedly impeded drainage, irregular or no supply of saline (brackish) water and a very limited influence of saline spray which involves a very low salinity of the substrate mainly restricted to the upper layers, frequent closer setting of the upper layers of the substrate, and an enrichment of the substrate due to the supply of soluble minerals and bird excrements. Sedimentation of mineral material is minimal. The pH of the rhizospehere ranges from $4^3/_4$ to 5.

syntaxonomy & discussion: Littoral *Carex rariflora* communities, though frequently mentioned in the literature, are little studied.

However, from the published data and the present study it appears that they constitute a distinct group clearly different from mire communities with *C. rariflora* in non-saline conditions. On account of its floristic composition, viz. the occurence of *Potentilla* *egedii* (constant), *Stellaria humifusa* and *Carex glareosa*, and its synecology, this group should be placed in the *Caricion glareosae*. Because of the floristic and synecological differences between the *Caricetum glareosae* (and the *Agrosto-Caricetum glareosae;* cf. table 4 and 3.1.2.1.) and this unit. I propose to distinguish it as a separate association.

Of all syntaxa of the *Carici-Puccinellietalia* this association seems to be the one synecologically most closely related to the *Agropyro-Rumicion crispi* NORDH. 1940 em R. TÜXEN 1950 (*Plantaginetea majoris* R. TÜXEN & PREISING 1950), in particular because of its characteristic occurrence in more or less unstable, complex contact situations.

Low-arctic, Greenland communities apparently belonging to this association have been described by KRUUSE (1912, p. 126), DEVOLD & SCHOLANDER (1933, p. 123, 156), BÖCHER (1963, p. 84, 92) and several other authors cited by KALELA (1939, p. 354). Related communities occur in subarctic northern Europe (KALELA, 1939, p. 352–354; NORDHAGEN, 1954, p. 392). The scarce data referring to these suggest that they represent a vicarious, equivalent syntaxon; the arctic and subarctic *C. rariflora* salt marshes thus probably form two separate syntaxa, conforming to the general pattern in the syntaxonomy of the *Carici-Puccinellietalia.*

4. Class *Honckenyo-Elymetea arenarii* R. TÜXEN 1966

With the characteristics of the alliance.

4.1. Order *Honckenyo-Elymetalia arenarii* R. TÜXEN 1966

See 4.

4.1.1. *Honckenyo-Elymion arenarii* (FERNANDEZ-GALIANO 1959) R. TÜXEN 1966

syn: incl. *Arenarion robustae* prov. FERNANDEZ-GALIANO 1959, *Honckenya diffusa-Mertensia maritima* Type BÖCHER 1954.

composition: Regional, selective to exclusive faithful taxa are *Elymus arenarius* L. incl. ssp. *mollis* (TRIN.) HULT., *Honckenya peploides* (L.) EHRH. incl. ssp., *Ligusticum* (= *Haloscias*) *scoticum* L. et *hultenii* FERN., *Mertensia maritima* (L.) GRAY, *Senecio pseudo-arnica* LESS. and possibly also *Lathyrus maritimus* (L.) BIGEL. (= *L. japonicus* WILLD. s.l.).

physiognomy: The communities of this syntaxon form open to usually closed communities, which consist as a rule of a low, herbaceous lower field layer and a high, graminaceous upper field layer with some tall herbaceous taxa; a bottom or moss layer is absent. They are dominated by hemicryptophytes and rhizome-geophytes.

synecology & habitat: The northern boreal-subarctic to arctic, halophytic and more or less tropohydrophytic, eutrafent and nitrophytic, xerophytic and psammophytic communities of the alliance are indifferent to depth and persistence of the snow cover in winter. They occur characteristically as pioneer communities in dynamic conditions, in somewhat consolidated, beneath the dry surface moist, loose sandy to gravelly substrates rich in organic nutrients and as a rule subjected to drift, rarely also to creep. They are found on beaches along more or less exposed shores of bays and fjords, in usually brackish conditions where they are subjected to irregular flooding with saline, (mesohaline to) euhaline water, namely on the upper beach between MHW and EHWS level but occasionally also at higher altitudes some distance from the coast.

distribution: The area of the syntaxon is northern-boreal to arctic, semi-circumpolar with wide gaps in central arctic Asia. It replaces the boreal *Cakiletea maritimae* R. TÜXEN & PREISING 1950 and the boreal *Ammophiletea* BR.-BL. & R. TÜXEN 1943 in northern regions, and is related to the boreal *Agropyro-Rumicion crispi* NORDH. 1940 em. R. TÜXEN 1950 (*Plantaginetea majoris* R. TÜXEN & PREISING 1950; see also TÜXEN, 1966 and HADAČ, 1970).

4.1.1.1. *Mertensia maritima* seciation

syn: *Mertensietum* NORDH. 1940 n.n.; *Mertensia maritima-synedria* LID 1964.

table 5; fig. 26.

composition: Dominant taxon is *Mertensia maritima* (L.) GRAY ssp. *maritima*. The nitrophytic and facultative halophytic *Sedum rosea* (cf. 3.1.2.1.2.A.) occurs with a high frequency; for the rest the composition is rather variable. In habitats where the mobility of the substrate is reduced *Bryum* cf. *salinum* can occur abundantly, sometimes partly overgrown by *Psoroma hypnorum*, on tussocks of dead or not particularly vital *Carex glareosa*. Non-halophytic taxa such as *Salix herbacea* occur only in stands comparatively high above sea level.

Phytogeographically the sociation is distinctly low-arctic.

physiognomy: The predominantly hemicryptophytic community usually forms open and low, not distinctly stratified herbaceous stands, which are dominated by the conspicuous glaucous patches of the fleshy, procumbent *Mertensia*, with open ground in between.

synecology & habitat: See 4.1.1. The sociation occurs in the Angmagssalik District as a usually more or less fragmentary pioneer community on more or less exposed beaches along bays, particularly in "tasiussaqs", and more rarely near the outlets of brooks, in gravelly

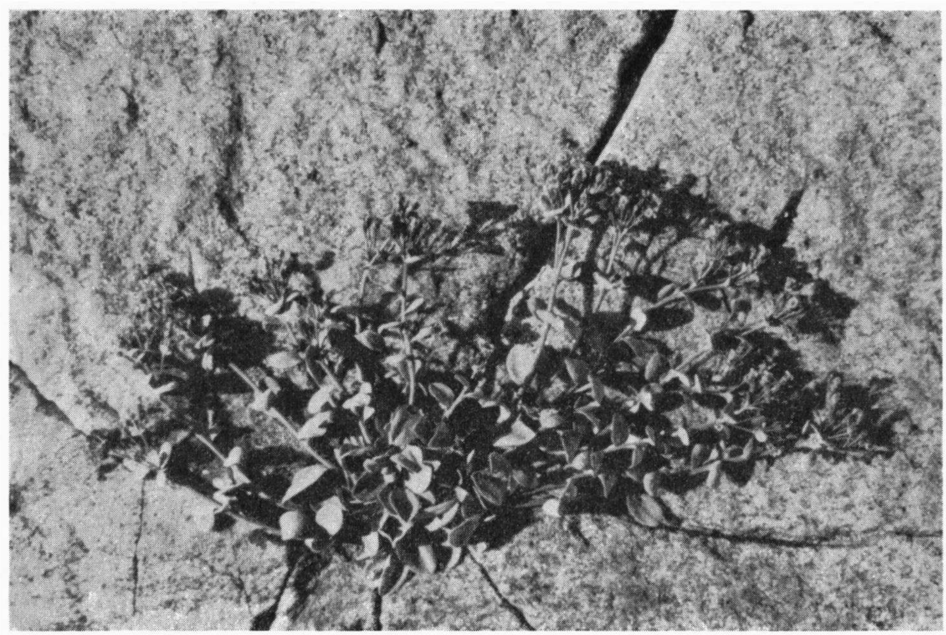

Fig. 26. *Mertensia maritima* in fissure of the rocky cliffs along the Tasîlâlik fjord. JGdM phot. VII. 1968

places from MHW level to 15 m a.s.l.; it is usually best developed near EHWS level.

The community is thus as a rule at least within reach of saline spray and often subjected to irregular flooding with saline, viz. euhaline to mesohaline water.

The substrate consists of loose coarse gravel, and shows no differentiation.

The colorimetric pH of the rhizosphere ranges from 5 to $6^1/_2$ and averages about 5.6. Increase of acidity is correlated with increase in elevation and distance from the shore, and with decreasing mobility of the substrate.

Mertensia does not suffer from the mobility of the substrate; burial even seems to favour the growth of the plant, which is capable of forming shoots from dormant buds.

The sociation usually forms an indistinct belt associated with, or above *Honckenya* stands (see 4.1.1.2.).

Distribution: The sociation is not common in the Angmagssalik District (Tasîlâlik, Grønlænderpynten, the island Kulusuk, Imîlâjiva). The sociation presumably has a wide distribution, more or less coinciding with the area of the alliance.

Mertensia seems to be a recently arrived neophyte, which is spreading in the coastal areas of the district (cf. Daniëls & de Molenaar, 1970).

Table V

reference number		1	2	3	4
total cover plants (in %)		75	$7^1/_2$	2	2
cover phanerogams –		55	5	2	2
– cryptogams –		30	$2^1/_2$	–	(1
– litter –		–	–	–	1
– open soil –		25	95	98	98
pH rhizosphere		$6^1/_2$	$5^3/_4$	5	5
ground water table (in -cm)		–	–	–	–
elevation (in m a.s.l.)		2	1	8	15
Mertensia maritima	L/B	4	1	1	+
Sedum rosea	L	..	+	+	+
Cerastium alpinum	L	..	+	+	..
Carex glareosa	L	2	+	..	..
Bryum cf. *salinum* (sterile)		3	1	..	..
Psoroma hypnorum		3	..	..	..
Salix herbacea	L	..	..	..	+
Silene acaulis	A	..	..	..	+
Ceratodon purpureus		..	..	..	+
Polytrichum alpinum		..	..	..	+

syntaxonomy & discussion: *M. maritima* is a little variable taxon; the ssp. *asiatica* TAKEDA occurs only in East Asia, whereas the ssp. maritima has a semi-circumpolar distribution more or less coinciding with the area of *Honckenya peploides* var. *diffusa* (see HULTÉN, 1968, p. 781).

LID (1964) has published twenty analyses of two stands dominated by *M. maritima* on Jan Mayen (LID, l.c., table 31, 32). *Oxyria digyna* is the only constant taxon besides the dominant oysterleaf in them.

Sub- to middle-arctic *M. maritima* ssp. *maritima* communities are otherwise frequently mentioned in the literature from various areas (NORDHAGEN, 1940, p. 72; TÜXEN, 1966, p. 362 and 1970, p. 267; POLUNIN, 1948; BÖCHER, 1938, p. 168; the literature cited by these authors), but the general composition of these is, in spite of their general poverty in taxa, apparently rather variable.

4.1.1.2. *Honckenya peploides* var. *diffusa* sociation

table 6; figs 16, 18, 27.

composition: The dominant taxon is *Honckenya peploides* ssp. *peploides* var. *diffusa* (HORNEM.) MATTF.

The main floral element is the low-arctic one; the widely spread arctic element is also of importance.

Table VI

reference number		1	2	3	4	5	6
total cover plants (in %)		60	80	20	20	45	3
cover phanerogams –		60	80	20	20	45	3
– cryptogams –		–	–	–	–	–	(1
– litter –		–	–	–	–	–	3
– open soil –		40	50	90	80	55	95
pH rhizosphere		6½	7	7	7	7	6
ground water table (in -cm)		–	–	–	–	–	–
Honckenia peploides ssp. *peploides* var. *diffusa*	L	5	6	3	3	4	1
Puccinellia phryganodes	A	..	..	..	+	1	..
Stellaria humifusa	L	..	..	..	..	1	..
Carex glareosa	L	..	..	..	..	..	1
Oxyria digyna	A	..	..	..	..	..	+
Bryum cf. *salinum* (sterile)		..	..	..	..	..	+
Calamagrostis neglecta	B	..	..	1	..	..	..
Trisetum spicatum	A	..	+	..	..	..	..
Poa alpina	L	..	+	..	..	..	..
Plantago maritima ssp. *borealis*	L/B	..	..	..	+	..	..
Sedum rosea	L	..	..	..	..	+	..
Cerastium cerastoides	L	..	..	..	..	..	+
Anthelia juratzkana		..	..	..	..	..	+

physiognomy: The predominantly hemicryptophytic sociation consists as a rule of an usually well developed low field layer; sometimes a differentiation in this (lower) field layer and a very open higher field layer with grasses and tall herbs can be distinguished. It forms dense patches, which are already easily discerned at a distance by the fresh bright-green colour of the fleshy, dominant taxon.

synecology & habitat: See 4.1. The sociation occurs in the Angmagssalik District in gravelly places over thin, buried old tidal marks, namely on beaches along coves and near the outlets of brooks, more rarely also on extensive sandy river deltas, between (MHW-)MHWS and EHWS level.

It is occasionally subjected to flooding with saline, viz. euhaline to mesohaline water and to limited drifting, and it is found as a rule above *Carex glareose* marshes (figs 16, 18), or on otherwise bare, stony beaches.

The substrate consists of more or less stabilized deposits of loose coarse sand and gravel, which were previously very mobile and subjected to drift and displacement by the tides. It usually contains some quantities of buried, partially decomposed vegetative material.

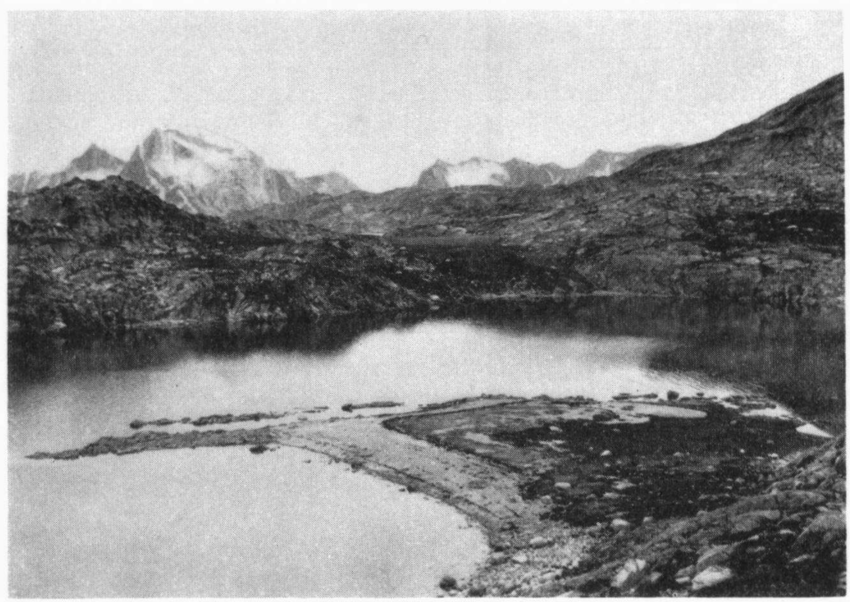

Fig. 27. Littoral vegetation on a spit of land at the entrance to the Ikâsaulaq fjord near Qârtulâjik. On top of the gravelly ridge *Honckenya peploides* var. *diffusa;* on the lower marshy area behind the ridge *Carex glareosa* vegetation, in the lower right of the picture with dominant occurrence of *Festuca rubra.*

JGdM phot. VIII. 1969

The colorimetric pH of the rhizosphere ranges from 6 to 7.

Occasional drift may partly bury *Honckenya*, but since the plant is capable of vegetative propagation by means of long, branched runners, it does not seem to suffer from limited drifting.

distribution: The sociation is not uncommon in the Angmagssalik District (Kong Oscars Havn: Sermilikvejen, inner and middle Qíngertivaq, Tasîlâlik, the island Kulusuk). Its distribution probably coincides with the area of the dominant taxon (cf. HULTÉN, 1958, p. 13).

syntaxonomy & discussion: The sociation of *H. peploides* var. *diffusa* as described above is undoubtedly closely related to TÜXEN's territorial association *Honckenyo diffusae-Elymetum mollis* R. TÜXEN, 1970. This syntaxon exclusively occurs in Greenland. It is also closely related to the *Honckenyo diffusae-Elymetum arenarii* (REGEL, 1928), R. TÜXEN 1968, which has a much wider distribution, occurring in Iceland, and elsewhere along the shores of the Arctic Ocean (TÜXEN, 1970).

C. SURVEY OF THE *CARICI-PUCCINELLIETALIA* IN THE NORTHERN ATLANTIC AREA

1. **Order *Carici-Puccinellietalia*** BEEFTINK et WESTHOFF 1965 *apud* BEEFTINK 1965. Differential taxa combination: *Stellaria humifusa* ROTTB., *Potentilla egedii* WORMSKJ., *Plantago maritima* L. ssp. *borealis* (LANGE) BL et D., *Bryum salinum* HAG. Distribution: arctic to subarctic, presumably circumpolar.

1.1. Alliance ***Puccinellion phryganodis*** HADAČ 1946. General transgressive faithful taxon: *Puccinellia phryganodes* (TRIN.) SCRIBNet. MERR.

1.1.1. Association ***Puccinellietum phryganodis*** HADAČ 1946 em. HOFMANN 1969. Synonyms: non *Puccinellietum phryganodis* NORDH. 1954; incl. *Caricetum ursinae* HADAČ 1946. Exclusive regional faithful taxon: *Puccinellia phryganodes* (TRIN.) SCRIBN. et MERR. Distribution: arctic, presumably circumpolar.

1.1.1.1. subass. *inops* HOFMANN 1969 (sub nom. *Typische Subassoziation*). Distribution: arctic, presumably circumpolar. Composition: HADAČ (1946) table p. 142; HOFMANN (1969) table p. 226; table I:1–7.

1.1.1.2. subass. *drepanocladetosum* HOFMANN 1969 (sub nom. Subassoziation von *Drepanocladus uncinatus*). Differential taxon: *Drepanocladus uncinatus* (HEDW.) WARNST. Distribution: arctic, Spitzbergen and probably also elsewhere. Composition: HOFMANN (1969) table p. 226:2–6.

1.1.1.3. subass. *bryetosum argentei* HOFMANN 1969 (sub nom. Subassoziation von *Bryum argenteum*). Differential taxa combination: *Bryum argenteum* HEDW. and *Desmatodon suberectus* (HOOK.) LIMPR. Distribution: arctic, Spitsbergen and probably also elsewhere. Composition: HOFMANN (1969) table p. 226:7–11.

1.1.1.4. subass. *caricetosum ursinae* (HADAČ 1946) HOFMANN 1946 (sub nom. Subassoziation von *Carex ursina*). Synonym: *Caricetum ursinae* HADAČ 1946. Differential taxon: *Carex ursina* DEW. Distribution: middle to high-arctic, Spitsbergen, NE Greenland, NE Canada; probably more or less circumpolar. Composition: HADAČ (1946) table p. 141; HOFMANN (1969) table p. 226:12,13.

1.1.2. Association ***Triglochino-Puccinellietum phryganodis*** (REGEL 1928 em. NORDH. 1954) HOFMANN 1969. Synonyms: *Glycerietum reptantis* REGEL 1928; *Puccinellietum phryganodis* NORDH. 1954. Differential taxa combination: *P. phryganodes* (TRIN.) SCRIBN. et MERR. and *Triglochin* *maritimum* L. Distribution: subarctic, northern Fennoscandia and Kola. Composition: REGEL (1928) No. 955; KALELA (1939) table 63:I.; NORDHAGEN (1954) table 1:1–3 and 2:1–6.

1.1.3. Association ***Puccinellietum coarctatae*** ass. nov. Synonyms: *Puccinellietum retroflexae* NORDH. 1954 pro min.p.; incl. *Puccinellia coarctata-synedria* LID 1964. Exclusive regional faithful taxon: *Puccinellia coarctata* FERN. et WEATH. Distribution: low arctic, amphi-atlantic.

1.1.3.1. variant *inops*. Distribution: low-arctic, SE Greenland (probably also elsewhere). Composition: table I:8–10.

1.1.3.2. variant of *Mertensia maritima*. Synonym: *Puccinellia coarctata-synedria* LID. 1964. Differential, (co-) dominant taxon: *Mertensia maritima* (L.) GRAY. Distribution: low-arctic, Jan Mayen (and probably also elsewhere). Composition: LID (1964) table 8.

1.1.3.3. variant of *Cochlearia*. Synonyms: *Puccinellietum retroflexae* NORDH. 1954 pro min.p.; *Puccinellia coarctata-synedria* LID 1964. Differential taxon: *Cochlearia* L. Distribution: low-arctic (?and the extreme northern part of the Subarctic), Jan Mayen and northernmost Fennoscandia (probably also elsewhere). Composition: NORDHAGEN (1954) table 2:7; LID (1964) table 9.

1.1.4. Association ***Triglochino-Puccinellietum coarctatae*** (NORDH. 1954) em. nov. Synonyms: *Puccinellietum retroflexae* NORDH. 1954 p.p.; *Puccinellia retroflexa*-WIESE KALELA 1939. Differential taxa combination: *P. coarctata* FERN. et WEATH. and *Triglochin maritimum* L. Distribution: subarctic, northern Fennoscandia. Composition: KALELA (1939) table 63:II; NORDHAGEN (1954) table 2:8.

1.1.5. Association ***Caricetum subspathaceae*** HADAČ 1946 em. nov. Synonyms: non *Caricetum subspathaceae* NORDH. 1954; non *Carex subspathacea*-WIESE KALELA 1939. Exclusive regional faithful taxon: *Carex subspathacea* WORMSKJ. Distribution: arctic, probably circumpolar.

1.1.5.1. subass. *inops* subass. nov. Distribution: (low)arctic.

1.1.5.1.1. variant *inops*. Composition: table II:1–3.

1.1.5.1.2. variant of *Bryum*. Differential taxon: *Bryum* HEDW. Composition: table II:4–7.

1.1.5.2. subass. *dupontietosum* (HADAČ 1946) subass. nov. Synonym: *Caricetum subspathaceae* HADAČ 1946. Differential taxa combination: *Dupontia fisheri* R. BR. incl. ssp. *psilosantha* (RUPR.) HULT. and *Carex ursina* DEW. Distribution: middle to high-arctic, Spitsbergen, Yakutia, NW and NE Greenland; probably circumpolar. Composition: HADAČ (1946) table p. 142.

1.1.6. Association ***Triglochino-Caricetum subspathaceae*** (REGEL 1923 em. NORDH. 1954) ass. nov. Synonyms: *Caricetum subspathaceae* REGEL 1923; *Carex subspathacea*-WIESE KALELA 1939. Differential taxa combination: *C. subspathacea* WORMSKJ., *Triglochin maritimum* L. and *Agrostis stolonifera* L. Distribution: subarctic, northern Fennoscandia and Kola (probably semi-circumpolar). Composition: REGEL (1923) no. 251, id. (1927) no. 765, 770, id. (1928) no. 1179; KORCZAGIN (1937) table 4; KALELA (1939) table 63:IV; NORDHAGEN (1954) table 1:4–8; (? STEINDÓRSSON (1954) table E:I,II).

1.1.7. **Association *Caricetum salinae*** REGEL 1928 em. NORDH. 1954. Exclusive (-selective ?) faithful taxon: *Carex salina* WBG. Distribution: subarctic (-northern boreal ?), northern Fennoscandia, the Faroe islands (cf. REGEL, 1941 p. 348), probably amphi-atlantic. Composition: REGEL (1928) no. 1190; KALELA (1939) table 66:II ?; NORDHAGEN (1954) table 3:9–11.

1.1.8. **Association *Sagino-Phippsietum algidae*** ass. nov. prov. Differential taxa combination: *Phippsia algida* (SOL.) R. BR. and *Sagina intermedia* FENZL. Distribution: arctic, (S)E Greenland (probably circumpolar?). Composition: table III.

1.2. **Alliance *Caricion glareosae*** NORDH. 1954. General transgressive faithful taxon: *Carex glareosa* WBG. incl. var. *amphigena* FERN. Distribution: middle to subarctic, probably semi-circumpolar (absent in central northern Canada and Siberia).

1.2.1. **Association *Caricetum glareosae*** ass. nov. Synonyms: *Caricetum glareosae* BÖCHER 1933 nom. nud.; *Festuceto-Caricetum glareosae* NORDH. 1954 pro min.p.; non *Caricetum glareosae* REGEL 1923, non *Carex glareosa*-WIESE KALELA 1939, etc., vide 1.2.2. Exclusive regional faithful taxon: *Carex glareosa* WBG. Distribution: low and middle-arctic, Greenland and probably elsewhere.

1.2.1.1. subass. *typicum* subass. nov.

1.2.1.1.1. variant *inops*. Differential taxa combination: *Potentilla egedii* WORMSKJ., *Plantago maritima* ssp. *borealis* (LANGE) BL. et D., weakly also *Puccinellia phryganodes* (TRIN) SCRIBN. et MERR. and *Festuca rubra L.* Composition: table IV:1–4.

1.2.1.1.2. variant with a moss layer. Differential taxa combination: *Bryum salinum* HAG., *Campylium polyganum* (B.S.G.) C. JENS., *Drepanocladus uncinatus* (HEDW.) WARNST., *Carex subspathacea* WORMSKJ. Composition: table IV:5–14.

1.2.1.2. subass. *festucetosum rubrae* subass. nov. Differential (exclusive faithful) taxon: *Festuca rubra* L. ssp. *rubra*.

1.2.1.2.1. variant *inops*. Composition: table IV:15–19.

1.2.1.2.2. variant with a moss layer. Differential taxa combination: cf. the corresponding variant of the subass. *typicum* (excl. *Carex subspathacea*). Composition: table IV:20–25.

1.2.2. **Association *Agrosto-Caricetum glareosae*** REGEL 1923 em. NORDH. 1954 em. nov. Synonyms: *Caricetum glareosae* REGEL 1923; incl. *Caricetum subspathaceae-glareosae* REGEL 1923, *Cariceto-Agrostidetum maritimae* id., *Festucetum rubrae salinae* REGEL 1927; *Festuceto-Caricetum glareosae* NORDH. 1954 pro max. p.; incl. *Carex glareosa*, *Festua rubra*, *Agrostis stolonifera* and *Carex marina*-WIESE KALELA 1939. Differential taxa combination: *Carex glareosa* WBG. and *Agrostis stolonifera* L. Distribution: subarctic, northern Fennoscandia and Kola; fragmentary in the inner part of the Gulf of Bothnia. Composition: REGEL (1923) no. 14, 164, 252, 297, 298, id. (1927) no. 540, 543, 544; id. (1928) no. 958, 959; KALELA (1939) table 64:I, 65:I–III,V; NORDHAGEN (1954) table 1:9–12 and 4; also HAVAS (1961) and SJÖRS (1967).

1.2.3. Association ***Potentillo-Caricetum rariflorae*** ass. nov. Synonym: ? *Carex rariflora*-sociation NORDH., 1954 n.n.; ? *Carex rariflora*-WIESE KALELA 1939. Differential taxa combination: *Carex rariflora* WBG. and *Potentilla egedii* WORMSKJ. Distribution: arctic and, possibly, subarctic, more or less circumpolar; SE Greenland and probably elsewhere. Composition: table IV:26–30; ? KALELA (1939) table 67:II,III.

1.2.3.1. variant *inops*. Composition: table IV:26,27.

1.2.3.2. variant with a moss layer. Differential taxa: *Drepanocladus uncinatus* (HEDW.) WARNST., *Carex glareosa* WBG. Composition: table IV:28–30.

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