Journal of Vegetation Science 5: 781-790, 1994

Vegetation classification in Greenland

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Abstract. An account of the description and classification of the vegetation of Greenland is presented. Four periods are recognized: the Physiognomic period, the Extension period, the Floristics-Dominance period, and the Syntaxonomic period. The approaches used in vegetation classification pertaining to Greenland are discussed. A first survey is presented of the higher syntaxa known from suboceanic-oceanic, subarctic-low arctic Greenland. 14 classes are dealt with. The syntaxa are floristically defined and their concept is discussed. The *Juncetalia trifidi, Caricetea curvulae*, are described for the first time.

Keywords: Arctic-alpine vegetation; Böcher approach; Higher syntaxa; History; *Juncetalia trifidi*; Low Arctic; Syntaxonomy.

Abbreviations: Ch-species = Character species; D-species = Differential species.

Nomenclature: Böcher et al. (1978) for vascular plants, but Hultén (1968), Lid (1963), and Oberdorfer (1990) for certain taxa, Corley et al. (1981) for mosses, Grolle (1983) for liverworts; Hawksworth et al. (1980) for lichens. Nomenclature of syntaxa is in accordance with Barkman et al. (1986).

Introduction

Greenland is almost entirely covered by a central icecap, leaving only narrow fringes of ice-free land for plant cover. Many botanists have explored the vegetation of these fringes during the last century. Thus, the vascular plant flora is very well known (e.g. Böcher et al. 1978; Feilberg 1984; Bay 1992). However, the intensity of vegetation research and the methods of investigation differ greatly. S, SW and W Greenland have been explored more often (i.a. Böcher 1954, 1963; Fredskild 1961; Knapp 1964; Vestergaard 1978; Stumböck 1993) than the remote, logistically difficult areas along the east and north coast of Greenland (i.a. Seidenfaden & Sörensen 1937; Holmen 1957; Raup 1971; de Molenaar 1974; Daniëls 1982; Bay 1992).

The present paper aims at summarizing the history of vegetation description in Greenland with emphasis on the different approaches used in vegetation classification (for a more complete bibliography, see Daniëls 1982). Moreover, it presents a first synopsis of higher syntaxa known from SW, S and SE Greenland, with a subarctic-low arctic, suboceanic-oceanic climate (Böcher 1954). This part of Greenland coincides with the ice-freeregion south of ca. 67 °N, except the vast inland areas around and south of Kangerdlussuaq (Söndre Strömfjord) in continental SW Greenland (Fig. 1). According to Aleksandrova (1980) most of the area belongs to the subarctic tundra part of the Tundra region, the Hemi-arctic zone (Elvebakk 1985), or the Low Arctic (Bliss 1979). According to these authors, the southernmost part of Greenland belongs to the Atlantic region of the boreal ericaceous heaths and meadows, the Northern boreal zone, and the Forest-Tundra zone, respectively. According to Yurtsev (1994) the whole area may be considered as an oceanic counterpart of some southern Hypoarctic tundras; floristically, however, the area is excluded from the Arctic floristic region proper.

History of vegetation classification in Greenland

Physiognomic period

This period (1888-1920), dominated by E. Warming (1851-1924) is characterized by a strictly deductive approach: the vegetation was described according to the dominant life form and physiognomy. The first publication on the vegetation of Greenland was by Warming (1888). Seven formations ('Vegetationsformen') were distinguished: willow scrub and herb vegetation, heathland, fell-field vegetation, fresh water vegetation, fens, seashore vegetation and vegetation of manured soil. Between 1895 and 1912 several parts of Greenland were described following Warming's approach (i.a. Rosenvinge 1896; Porsild 1902). In an English edition of the pioneer survey (Warming 1928) the knowledge was updated; again seven (roughly the same) plant formations were described.

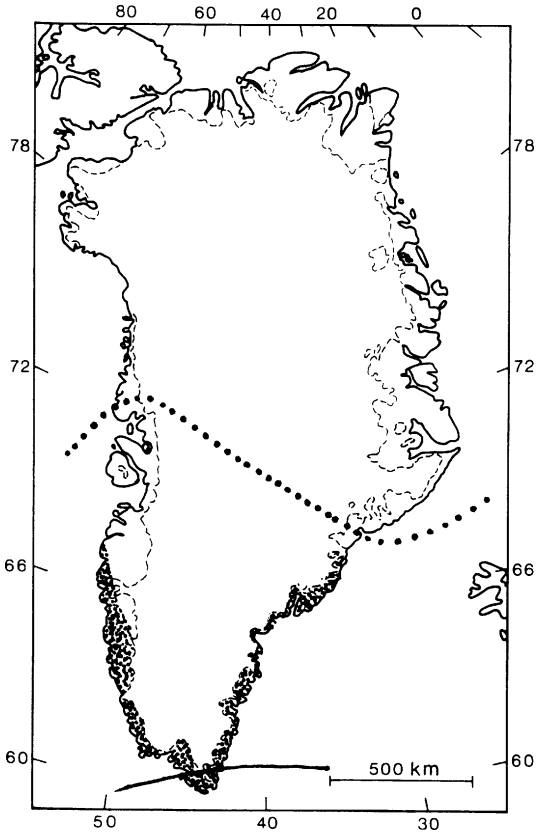

Fig. 1. Map of Greenland. The dotted area refers to the vegetation survey. The southern limit of the High Arctic is indicated by the dotted line, that of the Low Arctic by the solid line.

Extension period

The period from 1920-1945 is characterized by a high diversity in methodology of the analysis and classification of the Greenlandic vegetation. Influences of the Physiognomic, British (Tansley), Northern (Raunkiaer) and Southern (Braun-Blanquet) approaches can be traced (see Whittaker 1978 for a survey of approaches).

Trapnell (1933), describing vegetation in SW Greenland, used a system of regional vegetation forms, based on characteristic species; subordinated local types are miniature replicas of the regional vegetation forms, which include: open vegetation, open mat, moss mat, lichen mat and heath mat. Open vegetation, for example, is subdivided into poppy herb barren, *Solorina* moss barren, *Oxyria* herb barren and *Luzula* moss barren; heath mat into *Vaccinium* mat and *Ledum-Betula* mat.

Considering the strong impact of the physical environment, Seidenfaden & Sörensen (1937) considered the plant communities of NE Greenland as ecotopes: localized concrete units within an ecosystem, connected by similarity in vegetation and observable physical conditions. 18 ecosystems or ecotope types were recognized, such as barren ground, bird places, snow-patches, polygon fields and seashore lagoons.

Böcher (1933), studying the east coast, was influenced by the general ideas of Raunkiaer, Braun-Blanquet and Rübel (1930), and the monographs on Greenland by Ostenfeld (1926) and Iceland by Mölholm Hansen (1930). He introduced a Raunkiaer-based small-scale frequency analysis as a basis for vegetation description and classification. On the other hand, his classification units were associations, distinguished according to frequency dominants in the sample plots and named according to the Braun-Blanquet approach. The geographical distributional types of Ostenfeld (1926) were also taken into account, but the classification was still based on a physiognomic life form system. Thus, associations were classified in ecologically and physiognomically defined formations derived from the system of Rübel (1930). As an example, four heath associations were distinguished, *Saliceto-Vaccinietum*, *Empetreto-Vaccinietum*, *Vaccinietum*, and *Cassiopetum tetragonae*, which were grouped in the *Ericifructiceta* (heath vegetation). The same approach was used later by de Lesse (1952) in W Greenland.

Böcher (1938) also considered the geographical aspects of vegetation classification in relation to the fidelity concept. Character species were considered valid only locally. He emphasized a synthesis of classification methods based on character species, life forms and distributional types.

Floristics-Dominance period

This period, from 1946-1964, is dominated by the later work of T.W. Böcher (1909-1983), with monumental monographs on SW and W Greenland (Böcher 1954, 1963), the first one being the most fundamental work on Greenlandic vegetation. In this monograph, (Böcher 1954), following Böcher (1938) rejected a classification based on character species only. His objection was based both on fundamental and practical arguments, including the subjective basis of fidelity estimation, the possible obscurity in the elaboration of a local plant community typology stemming from the local selectivity in certain species. Moreover, Böcher considered such classification of practical importance only, i.e. serving subsequent investigations of the autecology of the species involved and of plant geography; "communities are of little interest in themselves". Thus, Böcher's community concept is pragmatic, and individualistic rather than holistic. Moreover the Braun-Blanquet nomenclature was rejected, since "such complex names could not contribute to a clear survey".

Böcher (1954, 1959) distinguished between four

types of species to be used in vegetation classification:
1. Ar-species = Area-geographical differential species, differentiating related communities by their presence or absence in areas with related climatic and edaphic conditions.
2. Cl-species = Climatic indicator species, which through their association with a definite macroclimate give the vegetation in which they occur an ecological-climatic identity. A group of Cl-species forms a 'biological distribution type'.
3. Hb-species = Habitat indicator species, which in a certain area are linked to a definite combination of microclimate and soil or hydrospheric factors.
4. EG-species = Ecogeographical species, belonging to a definite biological type *sensu* Iversen (1936) as well as to a certain distribution type (Cl-species).

Böcher's vegetation classification scheme included the following levels:
1. Sociation individual: a vegetation patch with a given combination and frequency of occurring species.
2. Sociation: a plant community with definite dominants in all strata and a corresponding species composition.
3. Sociation group: A group of sociations linked by occurrence or dominance of certain Hb-species.
4. Vegetational type: Combinations of sociations with EG- and Cl-species in common and characterized by certain life forms and biological types, divided into regional, extra-regional and intermediate types.
5. Vegetational complex: a group of related vegetational types irrespective of their physiognomy or life form, but with the same or closely related types of EG- and Cl-species.
6. Vegetational region: a larger geographic unit comprising similar vegetational types.

Some of Böchers sociation groups are equivalent to associations according to the Braun-Blanquet concept (cf. also Moravec 1993). They are defined by Hb-species, which are equivalent to regional association character species, while Ar- and Cl-species may be used as area-differential species (cf. Daniëls 1985). Many vegetational types are equivalent to alliances and vegetational complexes may comprise several alliances, orders or even classes. EG-species are often equivalent to character species of higher syntaxa.

In the second, phytogeographical monograph, Böcher (1963) did not use this elaborate classification system, but returned to the physiognomic approach for the higher units, while the lower units (sociations) were based on floristics and ecology.

Important studies in line with Böcher's include those by Iversen (1954), Gelting (1955) and Fredskild (1961), who all described sociations.

Syntaxonomic period

This fourth period, starting with Knapp (1964), differs from the former three periods by the predominance of the Braun-Blanquet approach (Westhoff & van der Maarel 1978). Later, during the sixties the vegetation of the Angmagssalik District, SE Greenland, was thoroughly studied in the same way by de Molenaar (1974, 1976) and Daniëls (1975, 1982), albeit that they used the Hult-Sernander-Du Rietz cover scale instead of the Braun-Blanquet cover-abundance scale. For the first time a syntaxonomical comparison was made between the low-arctic vegetation of SE Greenland and the vegetation of SW Greenland as described by Böcher (1954, 1963). Further phytosociological studies in Greenland include Daniëls & van Herk (1984), Dierßen (1984, 1992), de Molenaar (1987), Daniëls et al. (1985) and Daniëls & de Molenaar (1993).

In addition, some contributions following other traditions may be mentioned. They usually concentrate on local descriptions, often of physiognomic or dominance types (sociations) in relation to their local environment (e.g. Raup 1971; Böcher 1977; Vestergaard 1978; Feilberg 1984; Bay 1992; Stumböck 1993).

Syntaxonomical survey

General remarks

In view of the short history of the Braun-Blanquet approach in Greenland, this synopsis is preliminary. The distinction and comparison of higher syntaxonomic units is emphasized; notes on their ecology and distribution will be added. Diagnostic species mentioned are either character species, 'Ch-species', or differential species, 'D-species'. For some classes, comments are made on their delimitation and subdivision. The synopsis is based on own phytosociological research in SE Greenland in 1966, 1968, 1969 and 1981, and SW, W and NW Greenland in 1992 and 1993, as well as phytosociological literature mentioned above. For broader comparison some synopses of Scandinavian vegetation were used, notably Vevle (1983), Dahl (1987), and Dierßen (1992), which discussed Scandinavian concepts and also included related vegetation of the Alps, Iceland and some arctic regions. For a further comparison with alpine vegetation the recent plant community survey of Austria by Grabherr & Mucina (1993) was consulted. In this way the Greenlandic synopsis may be related to the ongoing European vegetation survey (Mucina et al. 1993).

Table 1 presents a survey of the phytosociological classes of Greenland, with their regional Ch-species.

While reading the table, note that acidic bedrock predominates in subarctic-low arctic suboceanic-oceanic Greenland.

Asplenietea trichomanis (Braun-Blanquet in Meier & Braun-Blanquet 1934) corr. Oberdorfer 1977

Chasmophytic vegetation, occurring in rock fissures, is distributed in Europe and North Africa, also in Asia and North America, and certainly occurs in Brazil, where Alves & Kolbek (1993) described syntaxa which they compared with European *Asplenietea* communities. In Greenland, this class is fragmentarily developed and difficult to separate from the next class (cf. also Böcher 1954). This vegetation needs to be studied in more detail. At present too few relevés are available for developing a clear concept of the class and its subdivision. It includes in part the *Veronica fruticans-Sedum annuum* Type (Böcher 1954) and the *Sedo-Thymion* de Molenaar 1976 .

Thlaspietea rotundifolii Braun-Blanquet 1948

This class is found on coarse sandy or stony debris on screes and alluvial plains in alpine areas. It includes the *Saxifrago stellaris-Oxyrion digynae* Gjaerevoll 1950 (*sensu* Dierßen 1992), the *Deschampsia alpina-Carex rufina* Type - the *Deschampsia alpina-Gnaphalium supinum-Cassiope hypnoides* Complex (Böcher 1954), which Dahl (1987) assigned to the *Salicetea herbaceae*. Thus, for the time being Dierßen's interpretation of the class can be accepted (Dierßen 1992), at least from an ecological viewpoint, but its floristical basis should be tested and the subdivision needs further study. *Luzula spicata* and *Juncus trifidus* are D-species towards the *Asplenietea*.

Caricetea curvulae Braun-Blanquet 1948

This class comprises circumpolar dry grass heath vegetation on acid, mineral soil in arctic and alpine regions of the northern hemisphere. The various concepts of this syntaxon and its nomenclature were discussed by Dierßen (1992). Both Dahl (1987) and Dierßen (1992) group the achionophytic dwarf shrub heath and grass heath together into one syntaxon, albeit not the same: *Juncetea trifidi* and *Cetrario-Loiseleurietea* respectively.

On the basis of the Greenland material, I cannot support this view for Greenland. Contrary to Dierßen, I am not in favour of uniting the northern dry grassland vegetation - the '*Juncion trifidi scandinavicum*' from Scandinavia and the *Cladonio-Viscarion* Daniëls 1982 from SE Greenland - and the achionophytic acidophytic dwarf shrub vegetation in one class, the Holarctic *Cetrario-Loiseleurietea* Suzuki-Tokio & Umezu in Suzuki-Tokio 1964. This class should comprise achionophytic and weakly chionophytic dwarf shrub heath and dry grassland vegetation of northern alpine and sub-low arctic regions. Important species for this class are according to Dierßen (1992): *Dicranum elongatum, Gymnomitrion corallioides, Hieracium alpinum* aggr., *Juncus trifidus, Loiseleuria procumbens, Luzula spicata, Prasanthus suecicus* and *Viscaria alpina,* and lichens such as *Alectoria nigricans, Cetraria cucullata, C. nivalis, Cladonia amaurocraea, Pertusaria dactylina* and *Sphaerophorus globosus*. Floristically this class is heterogeneous and very weakly characterized. Moreover it is impossible to separate the class in Greenland from the chionophytic dwarf shrub heath vegetation - *Phyllodoco-Vaccinion myrtilli* - and the classes *Carici-Kobresietea* and *Thlaspietea*.

Dahl (1987) grouped the South Scandinavian chionophytic *Juncus trifidus* vegetation and the chionophytic dwarf shrub heath in the *Vaccinio-Piceetea*. Both on floristical and ecological grounds this solution does not apply for treeless low arctic Greenland. As Daniëls (1982) argued, the acidophytic subalpine-alpine and subarctic-arctic dwarf-shrub heath vegetation should be separated on the class level from the montane and boreal coniferous forests.

I agree with Dierßen (1992) in separating the central-European 'Krummseggenrasen' (*Carex curvula* grasslands) from the northern dry grassland vegetation rich in *Juncus trifidus*. However, I propose to keep them together in one class, *Caricetea curvulae* Braun-Blanquet 1948, but in two different orders. The central-European communities are assigned to the *Caricetalia curvulae* Braun-Blanquet in Braun-Blanquet & Jenny 1926. There are many Ch-species which do not occur in Scandinavia and the Arctic. The northern and low-arctic communities are grouped into the *Juncetalia trifidi ordo nov.*; type alliance *Carici-Juncion trifidi* Nordhagen (1936) 1943 *nom. nov.*; type association *Cladonio stellaris-Juncetum trifidi* (Nordhagen 1943) Dierßen 1992. Renaming of *Juncion trifidi* Nordhagen (1936) 1943 is necessary since the *Juncion trifidi* Krajina 1933 of the Tatra is a younger homonym. Ch-species are *Campanula gieseckiana, Festuca ovina* (absent from Greenland), *Juncus trifidus, Luzula spicata, Viscaria alpina*; D-species towards the *Caricetalia curvulae* are *i.a. Carex bigelowii, Poa arctica, Salix glauca* ssp. *callicarpaea, Stereocaulon paschale* and *Thymus praecox* ssp. *arcticus*.

The order comprises two alliances. The achionophytic *Carici-Juncion trifidi* from Scandinavia and SW Greenland - including the '*Juncus trifidus-Hierochloë orthanta* Verband' (Knapp 1964) - and most of the *Juncus trifidus-Minuartia groenlandica* Type (Böcher 1954), is clearly

Table 1. Survey of classes with their character species for Greenland; important species indicated with *; Ch = character species.

Asplenietea trichomanis
Rock vegetation

Cystopteris fragilis ssp. *dickieana*
Rhodiola rosea
Saxifraga paniculata
Woodsia alpina
W. glabella
W. ilvensis

Thlaspietea rotundifolii
Herb vegetation of screes and alluvial plains

Chamaenerion latifolium
Draba aurea
Oxyria digyna
Papaver radicatum
Polystichum lonchitis
Ranunculus glacialis
Sedum annuum
Veronica fruticans

Caricetea curvulae
Dry grass heath vegetation on acid, mineral soil

Campanula gieseckiana
Juncus trifidus
Luzula spicata
Viscaria alpina

Loiseleurio-Vaccinietea
Dwarf shrub vegetation on acid soil

Arctostaphylos uva-ursi
**Betula nana*
Diapensia lapponica
Empetrum nigrum ssp. *hermaphroditum*
Loiseleuria procumbens
Phyllodoce coerulea
Salix uva-ursi
**Vaccinium uliginosum* ssp. *microphyllum*

Carici rupestris-Kobresietea bellardii
Dwarf shrub and grass heath vegetation on weakly acid-basic soil

Carex glacialis
C. misandra
C. nardina
C. rupestris
C. scirpoidea
Kobresia myosuroides
Lesquerella arctica
Pedicularis lanata
Saxifraga oppositifolia
Silene acaulis
many crustose lichens

Salicetea herbaceae
Snowbed vegetation

Anthelia juratzkana
Conostomum tetragonum
Gnaphalium supinum
Harrimanella hypnoides
Kiaeria falcata
K. starkei
Marsupella brevissima
Pleuroclada albescens
Pohlia drummondii
Polytrichum sexangulare
Ranunculus pygmaeus
Salix herbacea
Sibbaldia procumbens
Solorina crocea
Taraxacum croceum
Veronica alpina

Mulgedio-Aconitetea
Tall herb, shrub and open low woodland vegetation on moist soil by laterally moving groundwater

Alchemilla glomerulans
Alnus crispa
Angelica archangelica
Athyrium distentifolium
Betula pubescens ssp. *tortuosa*
Chamaenerion angustifolium
Geranium sylvaticum
Hieracium hyparcticum
Salix glauca callicarpaea
Sorbus groenlandica
Streptopus amplexifolius

Montio-Cardaminetea
Spring vegetation

Brachythecium rivulare
Bryum weigelii
Cardamine pratensis
Cerastium cerastioides
Cratoneuron commutatum
C. filicinum
Dicranella palustris
Epilobium hornemannii
Montia fontana
Philonotis fontana
P. seriata
P. tomentella
Pohlia wahlenbergii
Rhizomnium pseudopunctatum
Saxifraga stellaris
Scapania uliginosa
S. undulata
Stellaria calycantha

Scheuchzerio-Caricetea
Vegetation of mires and rich fens

***Ch Scheuchzerio-Caricetea*:**
Calamagrostis neglecta
Carex nigra
Comarum palustre
Eriophorum angustifolium
Menyanthes trifoliata
Scirpus caespitosus
Scorpidium scorpioides

***Ch Scheuchzerietalia*:**
Carex rariflora
Sphagnum lindbergii
S. riparium

***Ch Caricetalia nigrae, Caricion nigrae*:**
Calliergon sarmentosum
C. stramineum
Drepanocladus badius
D. exannulatus
Eriophorum scheuchzeri
Paludella squarrosa
Sphagnum teres

***Ch Caricetalia davallianae, Caricion atrofuscae-saxatilis*:**
Bryum pseudotriquetrum
Carex bicolor
C. microglochin
C. rufina
Homalothecium nitens
Juncus arcticus
J. biglumis
J. castaneus
J. triglumis

Oxycocco-Sphagnetea
Bog vegetation

**Betula nana*
Calypogeia sphagnicola
**Empetrum nigrum* ssp. *hermaphroditum*
Sphagnum fuscum
S. russowii

Honckenyo-Elymetea
Vegetation of sandy-stony beaches

Elymus arenarius ssp. *mollis*
Honckenya peploides ssp. *diffusa*
Mertensia maritima

Asteretea
Littoral salt-marsh vegetation

Bryum salinum
Carex glareosa
Plantago maritima ssp. *borealis*
Potentilla egedii
Puccinellia phryganodes
Stellaria humifusa

Littorelletea
Amphibious vegetation

Isoetes echinospora
I. lacustris
Juncus subtilis
Myriophyllum alterniflorum
Ranunculus reptans
Subularia aquatica

Potametea
Aquatic vegetation

Callitriche
Hippuris vulgaris
Myriophyllum exalbescens
Potamogeton alpinus ssp. *tenuifolius*
P. filiformis
P. gramineus
P. pusillus ssp. *groenlandicus*
Ranunculus confervoides
Sparganium angustifolium
S. hyperboreum.

distinguished from the more chionophytic and thermophytic *Cladonio-Viscarion alpinae* Daniëls 1982 from SE Greenland by many achionophytic lichen species. The latter alliance is differentiated towards the *Carici-Juncion trifidi* by a number of chionophytic species such as *Chamaenerion angustifolium*, *Poa alpina*, *Salix herbacea*, and *Cladonia ecmocyna*. Ch-species of class, order and alliances are listed in Table 1.

Loiseleurio-Vaccinietea Eggler 1952 em. Schubert 1960

This class includes dwarf shrub vegetation on acid soil in alpine and arctic regions of the northern hemisphere. It is very common in and typical of the coastal regions of subarctic-low arctic Greenland (Böcher 1954; Daniëls 1982). See Table 1. The vegetation is rich in lichens (*Cetraria, Cladonia, Peltigera, Stereocaulon*), mosses (*Dicranum, Drepanocladus*) and liverworts (*Lophozia* s.l.) (Schubert 1960; Daniëls 1982).

The class contains one order: *Rhododendro-Vaccinietalia* Braun-Blanquet in Braun-Blanquet & Jenny 1926 em. Daniëls 1982; nomenclatural type *Rhododendro-Vaccinion* Braun-Blanquet in Braun-Blanquet & Jenny 1926, *lectotypus hoc loco*.

In Greenland two alliances occur: the achionophytic *Loiseleurio-Diapension* (Braun-Blanquet, Sissingh & Vlieger 1939) Daniëls 1982 - including the *Loiseleuria-Salix uva-ursi* Type (Böcher 1954), the *Empetrum-Deschampsia* Ass. (Knapp 1964) p.p.-, and the chionophytic *Phyllodoco-Vaccinion myrtilli* Nordhagen 1936 - including the *Phyllodoce coerulea-Lycopodium alpinum* Type (Böcher 1954) and the *Empetrum-Deschampsia* Ass. p.p. (Knapp 1964).

Ch-species of the *Loiseleurio-Diapension* are *Arctostaphylos uva-ursi, Diapensia lapponica, Loiseleuria procumbens,* and *Salix uva-ursi* (confined to continental regions); in oceanic regions *Harrimanella hypnoides, Polygonum viviparum* and *Salix herbacea* are common. D-species towards the *Phyllodoco-Vaccinion myrtilli* are many achionophytic lichens such as *Alectoria nigricans, A. ochroleuca, Cetraria cucullata* and *C. nivalis,* species of *Coelocaulon, Sphaerophorus, Thamnolia,* and bryophytes such as *Gymnomitrion corallioides* and *Racomitrium lanuginosum* (see further Daniëls 1982). Ch-species of the *Phyllodoco-Vaccinion myrtilli* is *Phyllodoce coerulea*; D-species towards the *Loiseleurio-Diapension* are many mesophytic herbs: *Bartsia alpina, Coptis trifolia, Diphasium alpinum, Hieracium alpinum, Pyrola minor* and *Rhodiola rosea,* and chionophytic mosses and lichens such as *Hylocomium splendens, Pleurozium schreberi,* and *Cladonia ecmocyna*.

Carici rupestris-Kobresietea bellardii Ohba 1974

This is achionophytic, mainly xerophytic dwarf shrub and dry grass-heath vegetation on weakly acid, neutral or basic soil. The distribution is circumpolar, Arctic-alpine. This widely accepted class is well represented in Greenland, however with only one order and alliance: *Kobresio-Dryadetalia* Ohba 1974 and *Dryadion integrifoliae* Ohba ex Daniëls 1982. This vegetation type is more commonly distributed in continental areas and in the northern parts of Greenland. Ch-species of alliance, order, and class are listed in Table 1.

Salicetea herbaceae Braun-Blanquet in Braun-Blanquet et al 1947

This class comprises arctic and alpine snowbed vegetation and related communities of the northern hemisphere. The class is widely distributed in Greenland (e.g. Böcher 1954; de Molenaar 1976; Daniëls 1982). The subdivision of the class in Southeast Greenland was discussed by Daniëls (1982), who distinguished only two alliances, the *Cassiopo-Salicion herbaceae* and the *Ranunculo-Oxyrion* (*Salicetalia herbaceae*).

Dierßen (1992) discussed the status of the class in Scandinavia. Among other things, he united these two alliances into one, the *Salicion herbaceae* and excluded the European *Arabidion coeruleae* from the class. I agree with this concept and with the subdivision of the class into one order with three alliances: *Salicetalia herbaceae* Braun-Blanquet in Braun-Blanquet & Jenny 1926, *Salicion herbaceae* Braun-Blanquet in Braun-Blanquet & Jenny 1926, *Saxifrago-Ranunculion nivalis* (Nordhagen 1943) Dierßen 1984 and *Luzulion arcticae* (Nordhagen 1936) Gjaerevoll 1956. Ch-species of class and order are *Gnaphalium supinum, Ranunculus pygmaeus, Salix herbacea, Sibbaldia procumbens, Veronica alpina, Anthelia juratzkana, Pohlia drummondii,* and *Marsupella brevissima* (see Table 1).

Communities of the *Salicion herbaceae* are very common in subarctic-low arctic, suboceanic-oceanic Greenland (cf. de Molenaar 1976; Daniëls 1982; Dierßen 1984). Ch-species are *Harrimanella hypnoides, Taraxacum croceum, Conostomum tetragonum, Kiaeria falcata, K. starkei, Pleuroclada albescens, Polytrichum sexangulare,* and *Solorina crocea* (Table 1). The alliance includes most of the *Deschampsia alpina-Gnaphalium supinum-Cassiope hypnoides* Complex, viz. the *Cerastium cerastioides-Veronica alpina* Type, *Salix herbacea-Cassiope hypnoides* Type, and *Alchemilla vulgaris-Phleum commutatum* Type of the *Alchemilla-Phyllodoce-Scirpus austriacus* Complex (Böcher 1954).

The other alliances are common in more northern arctic regions.

Mulgedio-Aconitetea Hadač & Klika in Klika & Hadač 1944

This class comprises tall herb, shrub and open low woodland vegetation on moist, nutrient-rich soil influenced by laterally moving groundwater. It occurs in high montane, subalpine-alpine, and subarctic-arctic regions of the western part of the northern hemisphere, and is characterised by many boreal-montane species

such as *Adenostyles alliaria, A. alpina, Cicerbita alpina, Cirsium heterophyllum, Milium effusum, Myosotis sylvatica, Polygonatum verticillatum, Ranunculus platanifolius, Salix hastata, S. lanata, S. lapponum, S. phylicifolia, Tozzia alpina, Trollius europaeus* and *Viola biflora* (cf. Kalliola 1939; Nordhagen 1943; Braun-Blanquet 1948; Dahl 1957; Ellenberg 1978; Daniëls 1982; Oberdorfer 1990).

Communities, which fit into the ecology of the class are commonly distributed in southern Greenland, particularly in southernmost Greenland; however they lack many Ch-species of the class, its order (*Adenostyletalia* G. Braun-Blanquet & J. Braun-Blanquet 1931) and its northern alliance *Lactucion alpinae* Nordhagen 1943. Only *Geranium sylvaticum, Athyrium distentifolium* and *Streptopus amplexifolius* reach South Greenland. Such communities are found in relatively warm, moist, sheltered sites, mainly in S Greenland. They include *Betula pubescens* ssp. *tortuosa* woodland in the extreme south (see Fredskild & Odum 1990; Knapp 1964), *Salix glauca* ssp. *callicarpaea* scrub, and thickets, including *Festuco-Salicetum callicarpaeae* (Daniëls 1982) in addition to tall herb vegetation of *Angelica archangelica* in subarctic-low arctic Greenland, which were grouped by Böcher (1954) in the *Alchemilla-Phyllodoce-Scirpus austriacus* Complex, especially as the *Streptopus-Lastrea phegopteris* Type. Probably these communities constitute an own group (alliance) of Greenlandic and North American associations, which might be named *Pyrolo-Salicion callicarpaeae*. Ch-species are listed in Table 1. D-species towards the Scandinavian *Lactucion alpinae* are i.a. *Coptis trifolia* and *Pyrola grandiflora* (area-differential species, cf. Daniëls 1985).

Montio-Cardaminetea Braun-Blanquet & Tüxen 1943

Azonal communities rich in helophytes and usually very rich in bryophytes. They occur in eustatic springs and shallow spring brooks with clear, oxygen-rich water and are known from lowland and alpine areas, as well as subarctic-low arctic areas of the Eurosiberian region.

The syntaxonomy of the class has recently been discussed by Hinterlang (1992) who recognized two orders. The *Cardamino-Chrysosplenietalia* Hinterlang 1992 comprise spring vegetation in woodlands. Thus this order is absent from Greenland. The *Montio-Cardaminetalia* Pawłowski 1928 comprise subalpine-alpine and subarctic-arctic vegetation.

Spring vegetation is very common in the southern part of Greenland. As acidic rocks predominate the acidophytic *Montio-Epilobion hornemannii* Nordhagen (1936) 1943 is well-represented and well-developed. The alliance is equivalent to the *Epilobium hornemannii-Saxifraga stellaris* Type of Böcher's *Alchemilla-Phyllodoce-Scirpus austriacus* Complex (Böcher 1954). *Scheuchzerio-Caricetea nigrae* (Nordhagen 1936) Tüxen 1937.

These are azonal communities of depressions in bogs and intermediate mires, of the lagg zone, and of oligotrophic-eutrophic pools and marshes. Most are rich in mosses and occur on wet, commonly peaty but sometimes also mineral soil with stagnant or fluctuating high groundwater. They are minerotrophic, oligotrophic-eutrophic, acidophytic-basiphytic, occasionally calciphytic. Their distribution is Holarctic-circumpolar (cf. Bressoud 1989; Daniëls 1982; de Molenaar 1976; Dierßen 1982, 1992). The class is widely distributed in the southern part of Greenland and consists of three orders, which, contrary to my earlier statement (Daniëls 1982), all occur in Greenland.

The *Scheuchzerietalia palustris* Nordhagen 1936 comprise wet ombrotrophic and minerotrophic communities of depressions in bogs and mires.

The *Caricetalia nigrae* (Koch 1926) Nordhagen 1936 comprise minerotrophic-oligotrophic, mostly mesotrophic, non-calciphytic, acidophytic-neutrophytic, and hygrophytic-hydrophytic communities on shallow peat, and is typical of sites with running water, in so-called intermediate fens, where the water contains a minor amount of dissolved electrolytes, or in flooded places along springs, rivulets, brooks, and lakes.

The *Caricetalia davallianae* Braun-Blanquet 1949 comprise hygrophytic-tropohydrophytic, neutrophytic-basiphytic, often calciphytic, eutrophic and minerotrophic communities, and is generally rich in taxa, mainly bryophytes and *Cyperaceae*. In Greenland all communities of this latter order belong to the *Caricion atrofuscae-saxatilis* Nordhagen 1943. This alliance is rare in southern Greenland, but very common in more continental and northern regions in Greenland with basic soil (own observations, see also Bay 1992).

Oxycocco-Sphagnetea Braun-Blanquet & Tüxen 1943

This class comprises oligotrophic communities from the drier parts of bogs (and mires), and some floristically related dwarf shrub communities on moist, humic soils. Its distribution is circumpolar. Communities of this class are predominantly found in cool, humid atlantic, boreal, and montane regions (cf. Dierßen 1982). Thus they are not common in the Arctic.

However, dwarf shrub heath in suboceanic-oceanic SE Greenland with *Empetrum nigrum* ssp. *hermaphroditum, Betula nana, Calypogeia sphagnicola, Sphagnum fuscum*, and *S. russowii* - including the *Sphagnum rubellum-Vaccinium microphyllum* community (Daniëls 1982) and part of the *Phyllodoco-Salicetum callicarpaeae* (Böcher 1933) em. Daniëls 1982 - should be

classified as *Empetro-Sphagnetum fusci* Du Rietz 1921 em. Dierßen 1982, which I suggest be assigned to the *Oxycocco-Empetrion hermaphroditi* Nordhagen 1936, *Sphagnetalia magellanici* (Pawłowski 1928) Kästner & Flössner 1933, *Oxycocco-Sphagnetea* (Daniëls 1992).

Honckenyo-Elymetea arenarii Tüxen 1966

This class is represented on sheltered, dry sandy or stony beaches in Greenland. The distribution is mainly subarctic-low arctic, boreal (cf. Daniëls & de Molenaar 1993; Thannheiser 1991). They are well-developed in the southernmost part of S and SE Greenland and along the west coast up to 72° N. (Daniëls & de Molenaar 1993), and belong to the *Honckenyo-Elymion* Fernandez-Galiono 1959 em. Géhu & Tüxen in Géhu 1975, *Honckenyo-Elymetalia* Tüxen 1966 em. Géhu & Tüxen in Géhu 1975. They include the *Honckenya diffusa-Mertensia maritima* Type (Böcher 1954).

Asteretea tripolium Westhoff & Beeftink in Beeftink 1962

This class of littoral salt-marsh vegetation which is characterized by *Aster tripolium, Triglochin maritimum* (both absent in Greenland), and *Plantago maritima borealis*, is represented in Greenland by the order *Carici-Puccinellietalia* Beeftink & Westhoff in Beeftink 1965, which has a mainly circumpolar, subarctic-arctic distribution (de Molenaar 1974).

Two alliances occur: the *Puccinellion phryganodis* Hadač 1946 em. Hofmann 1969 occurs from about 50 cm below MHW up to shortly above MHW level on fine-textured soil and is characterized by *Puccinellia phryganodes*. The *Caricion glareosae* Nordhagen 1954 occurs from a few dm below MHW up to EHWS level above the *Puccinellion phryganodis* zone on more coarse soil. Ch-species is *Carex glareosa*; D-species is *Festuca rubra* (see Daniëls & de Molenaar 1993; de Molenaar 1974; Vestergaard 1978). See further Table 1.

The Greenlandic littoral salt-marsh vegetation is grouped by Böcher (1954) into the *Puccinellia phryganodis-Stellaria humifusa* Type.

Amphibious and aquatic vegetation

This azonal vegetation is syntaxonomically very poorly studied in Greenland (see de Molenaar 1976). However, several limnophytes are common (Fredskild 1992) and they build up distinct communities in the amphibious class *Littorelletea* Braun-Blanquet & Tüxen 1943, and the aquatic class *Potametea pectinati* Tüxen & Preising 1942 corr. Oberdorfer 1977, with a *Myriophyllum alterniflorum-Subularia* Type Böcher (1954) .

Conclusion

This survey emphasizes the strong syntaxonomical similarity between this part of Greenland and subalpine-alpine temperate and boreal Europe, especially Scandinavia, as a result of many common features in their floras and flora histories.

Acknowledgements. I thank Christian Bay, Klaus Dierßen and two unknown reviewers for their critical remarks. The fieldwork in 1992 and 1993 was supported by the Deutsche Forschungsgemeinschaft.

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Received 13 October 1993;
Revision received 7 March 1994;
Accepted 20 March 1994;
Final revision received 22 October 1994.