MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 163 · Nr. 1

A SYNOPTICAL STUDY OF THE GREENLAND FLORA

BY

TYGE W. BÖCHER, KJELD HOLMEN
AND KNUD JAKOBSEN

WITH 4 FIGURES IN THE TEXT

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1959

CONTENTS

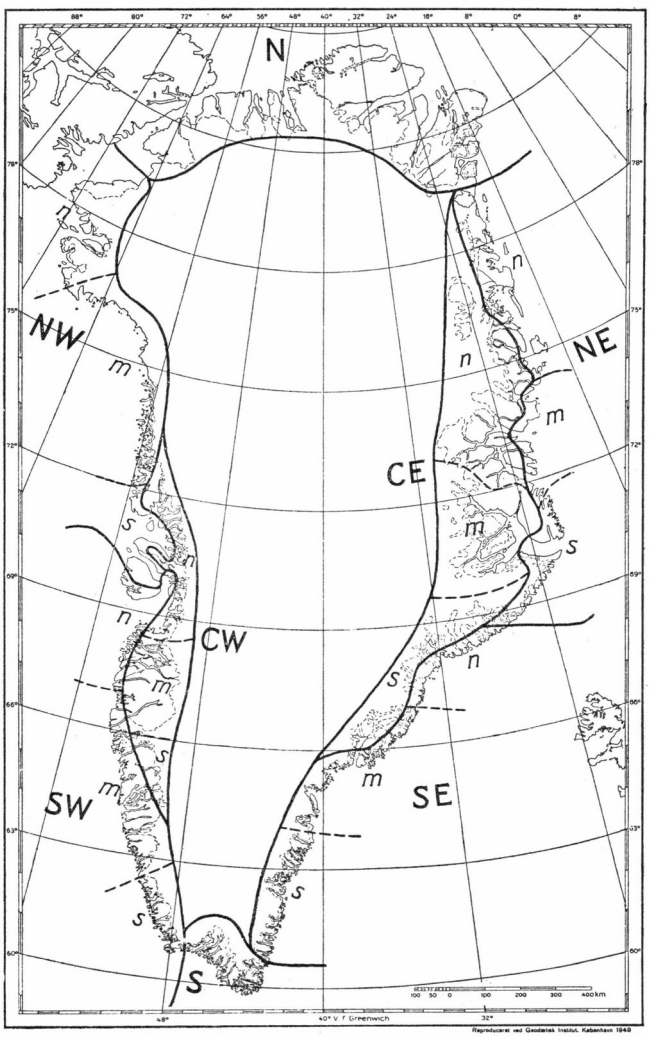

Fig. 1. Map showing floristic provinces and districts of Greenland. The boundaries of the provinces indicated by heavy lines those of the districts by broken lines.

1. Introduction.

The publication of the Greenland Flora (Grønlands Flora by Böcher, Holmen & Jakobsen 1957) made it possible to work out a number of statistical data concerning the Greenland flora as a whole. A material of this kind might be of interest to phytogeographers, and as it could not be included in the manual, it is published in the present paper.

All calculations mentioned in the tables are exclusively based upon facts mentioned in the Greenland Flora. Thus no account is taken of the most recent plant records or of other species concepts than those proposed in this manual. This, however, does not involve that the statistics are already out of date, since only very few important recent additions to the flora have been reported and since a considerable accordance with the species concept in the work of Jørgensen, Sørensen & Westergaard (1958) is present. Thus our treatment of *Calamagrostis hyperborea-neglecta*, *Papaver radicatum* coll. and the genus *Rhinanthus* relied on material or views mentioned by these authors.

2. Previous synoptical investigations.

More than 200 years ago the first botanical collections from Greenland were brought to Copenhagen by the Danish missionary Paul Egede, and nearly as old are the first reports in the literature concerning the flora of Greenland. Numerous Greenland plants were mentioned by Hornemann in his manual (1834—37) and described and illustrated in the *Flora Danica*. A rather extensive account of the vascular plants of Greenland was written more than 100 years ago by Johan Lange (1857). It was only a compilation of species. However, in 1880 Lange published a more comprehensive work: *Conspectus Florae Groenlandicae*, which in the years 1887—94 was completed by the addition of two supplements. In the 20th century few botanists have attempted an account of the whole flora. In 1902 Ostenfeld & Gelert published the vol. I of the *Flora Arctica* in which the vascular plants of Greenland were treated. Unfortunately that work was never finished, but in 1926 Ostenfeld published his important paper on the flora of Greenland and its origin which until now has served as the most recent account of the whole flora[1]).

[1]) Not published manuscripts have not been considered, thus e. g. Greenland Floras by F. C. Raben, J. Vahl and M. P. Porsild.

For East Greenland alone a list of the vascular plants was published by SEIDENFADEN & SØRENSEN in 1937. Table 1 shows the increase in number of reported species in the space of time between the paper by LANGE in 1857 and our recently published Greenland Flora (1957). All species introduced by human agency have been excluded from the table. The number of representative species rose considerably in the years just prior to LANGE's *Conspectus* as result of numerous collections made by several scientists. Another increase took place after 1926 due partly to the botanical activities during Danish expeditions and partly to the modern cytotaxonomical division of species.

Table 1. Number of species of native vascular plants.

	The whole of Greenland	West and South Greenland	East Greenland
Johan Lange 1857	311	308	98
Conspectus 1880—94	371	364	206
Ostenfeld 1926	382	371	256
Seidenfaden & Sørensen 1937			318
Böcher, Holmen & Jakobsen 1957	485	448	333

In the 19th and 20th century several studies on the phytogeographical position and the history of the Greenland flora have been published. HORNEMANN (1832) made comparisons between Greenland and other arctic regions. HOOKER (1861) divided Greenland into an arctic and a temperate part and considered the flora as being most related to the European one. LANGE (1880b) rejected HOOKER's suppositions by referring all Greenland to the arctic region and pointing out that the Greenland flora was equally related to European and American floras. Later WARMING (1888a, 1888b, 1890, 1891) and NATHORST (1890, 1891a, 1891b) treated the same subjects, their discussion being sometimes very sharp. WARMING considered that Greenland was a province of America and not Europe in a phytogeographical respect, whereas NATHORST considered that Southeast Greenland was most related to Europe. Other accounts on the same problems have been published by SIMMONS (1913), PORSILD (1921) and OSTENFELD (1926), who inter alia mentions that the Norse colonisation may have had a great bearing on the immigration of many eastern species, a point of view which later was modified by PORSILD (1932) and more intensely studied. Further accounts on the phytogeographical conditions of all Greenland have later been published by GELTING (1934), SEIDENFADEN & SØRENSEN (1937) and BÖCHER (1938). In all these accounts much valuable information and many suggestions

have been given with regard to the history of the flora and its affinities. Some of the authors also tried to divide Greenland into floristic provinces and the flora into various groups of distributional types. The highly increased knowledge in recent years of the flora of Greenland and other parts of the arctic regions may justify the present new synopsis, which, however, in spite of the better foundation hardly brings any revolutionary new points of view.

3. Floristic division of Greenland.

The Greenland Flora (1957) attempts to divide Greenland into natural floristic provinces and districts. The boundaries of the districts used by Ostenfeld (1926) roughly followed the latitudinal circles and were placed without much regard to ecological factors. Those used by the present writers (see fig. 1) have been placed along phytogeographical boundaries determined by a comparison of maps showing detailed distributions of a number of different species. The material of distributional maps is rather comprehensive. Species numbering 230 are found mapped in *Meddelelser om Grønland* (1933—57), particularly in the following issues: Vols. 101, Nos. 2—4, 104, No. 3, 106, Nos. 2—3, 136, Nos. 3 and 8, 147, Nos. 3, 7, 9, and 148, No. 1. Ten more are to be found in the *Journal of Ecology* Vol. 39 No. 2 (1951).

The boundaries of the provinces differ clearly in importance. A large number of species are distributed north or south of the northern limit of the provinces SW and SE, which together with district S may be termed the Atlantic or maritime part of Greenland. This boundary roughly coincides with the northern or southern area limits of 100 species and with the limits of frequent occurrence of another 100 species. Typical plants with northern area limits are e. g. *Lastraea phegopteris*, *Polystichum lonchitis*, *Ranunculus acris*, *Alchemilla filicaulis*, *Epilobium hornemanni*, *Viola palustris*, *Gnaphalium norvegicum*, *Hieracium hyparcticum*, *Leucorchis albida* var. *subalpina*, *Carex brunnescens*, *C. atrata*, and *Festuca vivipara* var. *hirsuta*. As examples of species distributed north of the provinces SW-S-SE the following may serve: *Potentilla rubricaulis*, *P. hookeriana* (sens. lat.), *Draba cinerea*, *Lesquerella arctica*, *Braya purpurascens*, *Stellaria ciliatosepala*, *Tofieldia coccinea*, *Carex misandra*, and *Arctagrostis latifolia*.

The course of the boundary between SW and CW has been based upon the local distributions of many species in Godthaabsfjord, Søndre Strømfjord, and Nordre Strømfjord and was recently further established by investigations in Nordre Isortoq and the Sukkertoppen area (Trapnell 1933, Böcher 1952, 1959). The position of the boundary between SE and NE is due to observations and collections mentioned by Böcher

(1933). Concerning the boundary between SW and NW see PORSILD (1902, 1920). The two continental provinces CE and CW are clearly separated from the adjacent coastal districts. The floristic decline there from the coastal areas to the interior or *vice versa* is always large (for East Greenland see HARTZ 1895, SØRENSEN 1933, GELTING 1934, BÖCHER 1938) and corresponds to considerable climatic differences. In the provinces N and S similar climatic differences between coast and inland are present (see e.g. HOLMEN 1957, ROSENVINGE 1897), but they seem to affect the flora in somewhat a lesser degree; and although the inland areas in N and S are relatively continental in character when compared with the corresponding coastal areas, they may belong to the same climatic regime as these; thus the coastal areas of province N in spite of having colder and more foggy summers have been considered a part of the continental high-arctic climatic regime while the province S as a whole belongs to the north-atlantic climatic regime. The annual precipitation inland in South Greenland amounts 775 mm and the mean annual temperature range in C is only 17°, (see BÖCHER 1949).

Most of the provinces have been subdivided into a northern (n), a middle (m) and a southern (s) district (see fig. 1). This subdivision is based upon a number of important northern or southern species limits as they appear on distributional maps. These district boundaries are by no means unalterable and may be expected to change as the knowledge of species distribution becomes more complete.

4. The flora of the floristic provinces.

In *Grønlands Flora* all distributions in Greenland were indicated by means of a set of abbreviations which are explained in English. The world distribution of the species found in Greenland is not given, but the flora is divided into four geographical types: *Western* species, which have their main area in America—Greenland but which in some cases may have some few stations in Europe (see pp. 9—10), *eastern* species with their main area in Eurasia, but which may occasionally occur in Eastern North America as well (see pp. 10—11), *endemic* Greenland species (see p. 11), and the rest, which are either *circumpolar* or *amphi-Atlantic* but having an almost even distribution on both sides of the Atlantic. If we disregard 94 recently introduced species we find the 485 native ones are almost evenly divided into 257 circumpolar-amphi-Atlantic and 231 western, eastern or endemic species[1]). There are 114 western species including 7 species of the genera *Taraxacum* and *Hieracium*, 82 eastern species with

[1]) A species represented in Greenland by a western or eastern subspecies or variety only has been treated as western or eastern respectively. Species with two subspecies or varieties of different distribution are referred to both groups.

Table 2. The flora of the floristic provinces.

Floristic provinces	Number of native sp.	Circump. amph. Atl. sp.	Western sp.	Eastern sp.	Endemic sp.	Introd. sp.	Total
N	101	73 (73)	26 (26)	2 (2)	0	0	101
NW	230	148 (64)	59 (26)	17 (7)	6 (3)	4	234
CW	290	174 (60)	75 (26)	30 (10)	11 (4)	9	299
SW	334	191 (57)	79 (24)	47 (14)	17 (5)	81	415
S	307	168 (55)	62 (20)	57 (19)	20 (7)	42	349
SE	235	133 (57)	40 (17)	51 (22)	11 (5)	4	239
CE	228	151 (66)	39 (17)	35 (15)	3 (1)	1	229
NE	204	136 (67)	34 (17)	32 (16)	2 (1)	0	204

Figures in brackets: Per cent. of native species in the province.

18 species of *Taraxacum-Hieracium* and 35 endemic among which 15, however, belong to the genus *Hieracium* and are closely related to European species.

Western species (or lower taxa).

Figures in brackets indicate that the species are restricted to West Greenland (W), East Greenland (E), South Greenland (S) or North Greenland (N).

Selaginella rupestris (S)
Isoetes echinospora var. muricata (WS)
Coptis trifolia
Ranunculus cymbalaria (W)
— sabinei (WN)
Anemone richardsoni (W)
Dryas integrifolia
— chamissonis
Potentilla tridentata
— pulchella
— rubricaulis
— vahliana (W)
Parnassia kotzebuei (WS)
Saxifraga tricuspidata
Sorbus decora (WS)
Epilobium lactiflorum
— hornemanni
Myriophyll. spicatum ssp. exalbescens (W)
Draba groenlandica
— arctogena (WN)
— ostenfeldii (W)
— ovibovina (E)
— lanceolata (W)
— aurea
— crassifolia
— bellii
Lesquerella arctica
Braya thorild-wulffii
— novae-angliae (W)
— humilis (EN)
Arabis arenicola
— holboellii
Halimolobus mollis (W)
Erysimum pallasii (WN)
Viola labradorica
Callitriche anceps
Cornus canadensis (S)
Salix uva-ursi (WS)
— arctophila (WS?)
— glauca ssp. callicarpaea
Betula glandulosa
Alnus crispa (WS)
Sagina caespitosa
Stellaria monantha
— laeta (W)
— laxmanni
— calycantha
Arenaria humifusa (W)
Minuartia groenlandica
Melandrium triflorum
Primula stricta
— egaliksensis (WS)

Pyrola secunda var. obtusata (W)
Ledum groenlandicum (WS)
— palustre ssp. decumbens (W)
Rhododendron lapponicum
Lomatogonium rotatum (WS)
Mertensia maritima
Veronica wormskjoldi
Pedicularis groenlandica (W)
— capitata (W)
— labradorica (W)
— flammea
— arctica (W)
Rhinanthus groenlandicus
Plantago maritima ssp. borealis
Galium triflorum (WS)
— brandegei
Linnaea borealis var. americana
Campanula uniflora
Erigeron compositus
— humilis
Antennaria canescens
— ekmaniana (W)
— angustata (W)
Hieracium groenlandicum[1])
Taraxacum arctogenum (WN)
— lacerum (WS)
— umbrinum (W)
— pumilum (EN)
— phymatocarpum
— hyparcticum (WN)
Streptopus amplexifolius (WS)
Orchis rotundifolia (WS)
Platanthera hyperborea
Juncus subtilis
Luzula groenlandica (W)
Eriophorum spissum (W)
Carex nardina
— gynocrates (WS)
— macloviana
— praticola (WS)
— scirpoidea
— supina ssp. spaniocarpa
— deflexa
— stylosa
— norvegica ssp. inserrulata
— holostoma (W)
— viridula (S)
— microglochin
Danthonia spicata (S)
Festuca baffinensis
Poa hartzii
Puccinellia langeana (W)
— andersonii
— deschampsioides (W)
— laurentiana (W)
— vaginata
— phryganodes
Calamagrostis purpurascens
Hierochloë orthantha
Roegneria borealis var. hyperarctica
— violacea (WS)
Potamogeton alpinus ssp. tenuifolius (WS)

Eastern species (or lower taxa).
Figures in brackets, see western species.

Polypodium vulgare (S)
Ranunculus glacialis (E)
— auricomus (E)
Rubus saxatilis (ES)
Potentilla stipularis (E)
— crantzii
Alchemilla alpina
— vestita (S)
— filicaulis
— glomerulans
— wichurae (E)
Sedum villosum
— annuum
— acre (E)
Saxifraga stellaris
— aizoides
— aizoon (as coll. sp.)
Epilobium alsinifolium (W)
Draba fladnizensis (E)
— norvegica
— incana
— sibirica (E)
Braya linearis
Arabis alpina
Viola palustris
Geranium silvaticum (W)
Polygala serpyllifolia (E)
Callitriche intermedia

[1]) A Greenland species of eastern origin but radiating to North America.

Angelica archangelica
Salix herbacea
Betula nana
— pubescens (WS)
Cerastium cerastoides
— fontanum ssp. scandicum (WS)
Sagina procumbens
Arenaria pseudofrigida (EN)
Viscaria alpina
Armeria maritima (ES)
Diapensia lapponica
Gentiana nivalis
— detonsa
— aurea
— tenella
Thymus drucei
Veronica fruticans
— alpina
Rhinanthus minor
Bartsia alpina
Euphrasia arctica
Galium boreala (S)
Erigeron borealis
Antennaria porsildii
Gnaphalium norvegicum
— supinum
Hieracium alpinum
Taraxacum arcticum (EN)
— croceum
— brachyceras (ES)
— devians (E)
— pleniflorum (E)
— purpuridens (E)
— rhodolepis (E)
— davidssonii (E)
— curvidens (E)
— cyclocentrum (S)
— naevosum (S)
— atroglaucum (S)
— dilutisquameum (S)
— firmum (W)
— campylodes (W)
— islandiciforme (S)
— latispinulosum (S)
Leucorchis albida (as coll. spec.).
Juncus squarrosus (S)
— trifidus
Carex parallela (E)
— norvegica ssp. norvegica
— atrata (?)
Nardus stricta (ES)
Poa alpina var. vivipara (E)
Puccinellia maritima (WS)
Anthoxanthum odoratum (ES)

Endemic species (or lower taxa).
Figures in brackets, see western species.

Potentilla ranunculus[1])
— rubella (E)
Saxifraga nathorstii (E)
Draba gredinii (E)
Braya intermedia (E)
Gentiana cfr. amarella (S)
Antennaria brevistyla (W)
— glabrata (W)[2])
— affinis (WS)
— hansii
— intermedia (W)
Hieracium angmagssalikense (E)
— stelechodes (E)
— hyparcticum
— lividorubens (S)
— scholanderi (S)
— ivigtutense
— amitsokense (S)
Hieracium sylowii (S)
— devoldii (S)
— eugenii (W)
— nepiocratum (S)
— stiptocaule (S)
— musartutense (S)
— rigorosum
— acranthophorum (WS)
Sisyrinchium sp. aff. albidum (W)
Puccinellia rosenkrantzii (W)
— porsildii (W)
— groenlandica (W)
Calamagrostis poluninii
— hyperborea (WS)
— lapponica var. groenl. (W)
Roegneria doniana var. virescens
Potamogeton pusillus ssp. groenlandicus (WS)

[1]) Doubtful in N. America.
[2]) Now reported from two stations on Baffin Island.

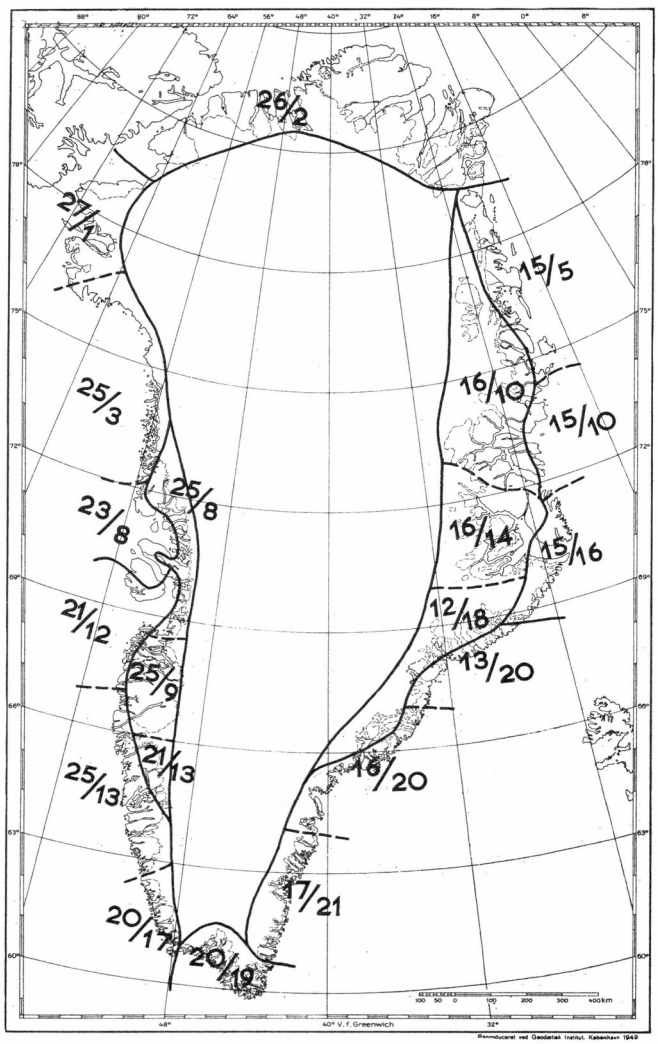

Fig. 2. Map showing the frequencies of western and eastern species indicated in per cent. of the total native flora of each district. The first figure indicates western, second figure eastern species.

The total number of species and the numbers of western, eastern, endemic, or introduced species in the provinces are enumerated in table 2. The SW province appears to be richest in species with the S province following. Introduced species are most abundant in these two provinces, where the main part of the Greenland population lives. The frequencies of eastern and western species are particularly interesting. On the map, fig. 2, the frequencies of these species are indicated in per cent. of the total native flora of each district. These two groups are almost equally

represented in S, CEm, and NEs, while in N, in NW-CW-SW, in NEm-n and CEn the western species clearly have the upper hand. Only in SE and CEs is there a majority of eastern species, this majority, however, being a result of a decrease in western species. The endemics are most abundant in South Greenland, decrease from S to N and perhaps also from West to East.

5. Species with restricted or disjunct areas in Greenland.

Species with disjunct or isolated areas are rather frequent in Greenland. In table 3 are shown all cases of isolations and disjunctions as calculated on the basis of the data contained in *Grønlands Flora*. They are rather easily divisible into the four groups, I—IV given in table 3.

In the first group with one restricted area we have counted species like *Luzula wahlenbergii* (CEn), *Chrysosplenium tetrandrum* (CEn—NEm), *Viola selkirkii* (SWs), and *Arctostaphylos uva-ursi* (CWm). A species like *Sedum acre* may be of particular interest. It is an eastern temperate species and not known outside Angmagssalik district (SEm). Its absence from South Greenland must be due to some historical factors, thus perhaps a rather recent immigration to Angmagssalik from Iceland. Other species in the group are restricted to South Greenland (S), which may be explained either ecologically, the species being dependent on the favourable climatic condition inland (e.g. *Galium boreale* and *Juncus gerardi*) or as a result of historical factors (recent origin as a result of mutation in groups of apomictic species, e.g. *Hieracium rigorosum* → *acranthophorum*). A species like the Asiatic *Potentilla stipularis* var. *groenlandica*, which is found on Clavering Ø only (NE), is a good example of a unicentric species (cp. GELTING 1934), which has a very limited range in Greenland owing to perglacial survival and recent non-ability of further spreading from its refugium.

The second group is well represented by a species like *Parnassia kotzebuei*, which is known from a few stations in the Nûgssuaq peninsula (NWs) and from one station in South Greenland; other interesting examples are *Primula egaliksensis* (CWm and S) and *Potentilla ranunculus* (NWs—SWn, S, and SEs).

Particularly good examples of the third group are *Sagina caespitosa*, *Dryopteris fragrans* and *Saxifraga tricuspidata*, which have a large continuous area in West Greenland but in East Greenland are restricted to a small area, in the case of *Sagina caespitosa* and *Dryopteris fragrans* a single locality at Hold with Hope (NEm) and Scoresbysund (CEm) respectively, and in the third case the coastal mountains on both sides of the entrance to Scoresbysund (NEs). This peculiar type of distribution is approached by two western species of *Arabis: A. arenicola*, which

Table 3. Number of species with restricted (I–III) or disjunct (IV) areas.

Provinces and disiricts	I	II	III	I—III	IV
	One small restricted area	Two or more small restricted areas	One or more small restricted areas isolated from large areas	Total number of isolations. Only small areas calculated	Occurrence in the districts of species having two or more large areas separated from each other
N	(0)[1]	(2)	(0)	(2)	(5)
n	5	1	2	8	16
m NW	0 (8)	0 (7)	0 (9)	0 (24)	11 (22)
s	3	6	7	16	22
n	2	9	4	15	22
m CW	6 (8)	14 (21)	3 (10)	23 (39)	11 (22)
s	0	5	3	8	7
n	5	8	4	17	13
m SW	7 (17)	7 (14)	5 (10)	19 (41)	6 (13)
s	5	3	2	10	2
S	(38)	(22)	(5)	(65)	(1)
s	5	3	4	12	0
m SE	4 (10)	3 (6)	8 (13)	15 (29)	1 (1)
n	1	0	2	3	1
s	0	0	0	0	6
m CE	1 (8)	2 (6)	2 (9)	5 (23)	17 (22)
n	7	5	7	19	22
s	3	4	6	13	16
m NE	5 (8)	1 (4)	3 (9)	9 (21)	21 (23)
n	0	0	0	0	17

[1]) Figures in brackets: Total number of species with isolated or disjunct areas being present in the province as a whole.

occurs only at Hurry Inlet in NEs but which has a discontinuous range in West Greenland, and *A. holboellii*, which has several stations inland at Scoresbysund and a single one at Turner Sund (NEs) besides one at Skjoldungen in SEs. Several of these odd distributions may be due to local extinction as a result of an uneven glacial activity in the past in different parts of Greenland. The case of *Saxifraga tricuspidata* is very striking. This American species is almost ubiquitous on dry rocks in West Greenland north of Godthaab and occurs there abundantly in the interior without being absent from maritime rocks and screes. In East Greenland, however, it is only found in coastal mountains on rocks or

in loose scree of basalt on capes facing the sea. In such places it is generally without flowers. The fact that this species is absent inland at Scoresbysund, which most likely swarms with suitable habitats, supports the idea that the species long ago was extinct inland during an advance of the Inland Ice and afterwards has not been able to recover its lost area.

The fourth group may be exemplified by species like *Pedicularis lapponica*, *Minuartia stricta*, and *Tofieldia coccinea* which are absent from N and S but have continuous areas on both sides of the Inland Ice. Such species were classified by GELTING (1934) as bicentric in Greenland and their ranges were compared with the so-called bicentric species of Scandinavia occurring in northernmost Scandinavia and in the Dovre-Lom-region in Southern Norway. In the case of the Greenland bicentric species, however, the disjunction is due to the presence of the Inland Ice, thus to physiographical conditions, and the northern and southern limits of many of these species may be ecologically explained as being responses of the species in question to environmental conditions. Of course this does not exclude the possibility that they, like *Saxifraga tricuspidata*, may have survived on both sides of the ice cap, but this is not evidenced by their present ranges.

In the first and second groups (I—II), which consist chiefly of very rare plants, the isolated species total 125 (of which 27 are species of *Hieracium* or *Taraxacum*); in the third group isolations total 51. Isolated occurrences seem to congregate in certain provinces or districts more than in others. The abundant number of isolations in CWm, SWm, S, and CEn is evident from table 3. In S, however, 15 out of 65 species belong to the genera *Taraxacum* and *Hieracium* and here as well as in CWm the high number of isolations may very well be a result of climatic or edaphic conditions not found elsewhere in Greenland.

The number of species restricted to West, East or South Greenland is given in table 4. The Inland Ice constitutes a great barrier between East and West Greenland. At present the two most important plant migration routes from east to west or *vice versa* are through the barrens in North Greenland (Province N) and across the narrow coastal country at Kap Farvel in S. Accordingly it is of great interest to calculate the number of species restricted to West or East Greenland. Table 4 also includes such species as are present in West or East Greenland and further extend into the N or S Provinces. Lastly it contains a summary of species restricted to South Greenland. It is remarkable that there are no species restricted to Province N. The table shows that 197 species, or only 2/5 of the total flora, are restricted to East, South, or West Greenland. Thus the majority of the species have areas on both sides of the Inland Ice. Of this majority 146 species have a continuous area including South Greenland and adjacent areas in West and East Greenland, while

51 species have ranges covering North Greenland and northern parts of East and West Greenland. Only a very limited number (31) are ubiquitous and circum-Greenlandic. With three exceptions the latter are circumpolar or wide-ranging, while those restricted to East or West Greenland, if not circumpolar or amphi-Atlantic, in most cases are eastern or western species. The single western species, which is only found in East Greenland is the imperfectly known *Draba ovibovina* Ekman. The largest number of species absent from East Greenland occurs in the districts S, SW, CWm, whereas species absent from West Greenland especially gather in the districts CEn, NEm-s. Among the species restricted to South Greenland ten are eastern (including 6 Taraxacum-species) and four western.

Table 4. Number of species restricted to W., E., or S. Greenland.

Number of species restricted to:	Circumpolar or amphi-Atlantic species	Western species (see pp. 9—10)	Eastern species (see pp. 10–11)	Endemic species (see p. 11)	Total
West Greenland (W) ..	17	25	4	9	55
West and North Greenland (W and N)	0	5	0	0	5
West and South Greenland (W and S)	31	17	3	4	55
Total:	48	47	7	13	115
East Greenland (E) ...	8	1	16	6	31
East and North Greenland (E and N)	1	2	2	0	5
East and South Greenland (E and S)	2	0	4	0	6
Total:	11	3	22	6	42
North Greenland (N) ..	0	0	0	0	0
South Greenland (S)...	16	4	10	9	39

6. Floristic comparison between West and East Greenland.

According to the data in tables 2 and 4 the West Greenland flora is somewhat richer than that of East Greenland. OSTENFELD (1926) associates this paucity of species on the East Coast with unfavourable external conditions (especially in SE Greenland), further with the longer distance from other countries and the fact that East Greenland escaped the Norse colonisation. The latter factor may, however, be of minor impor-

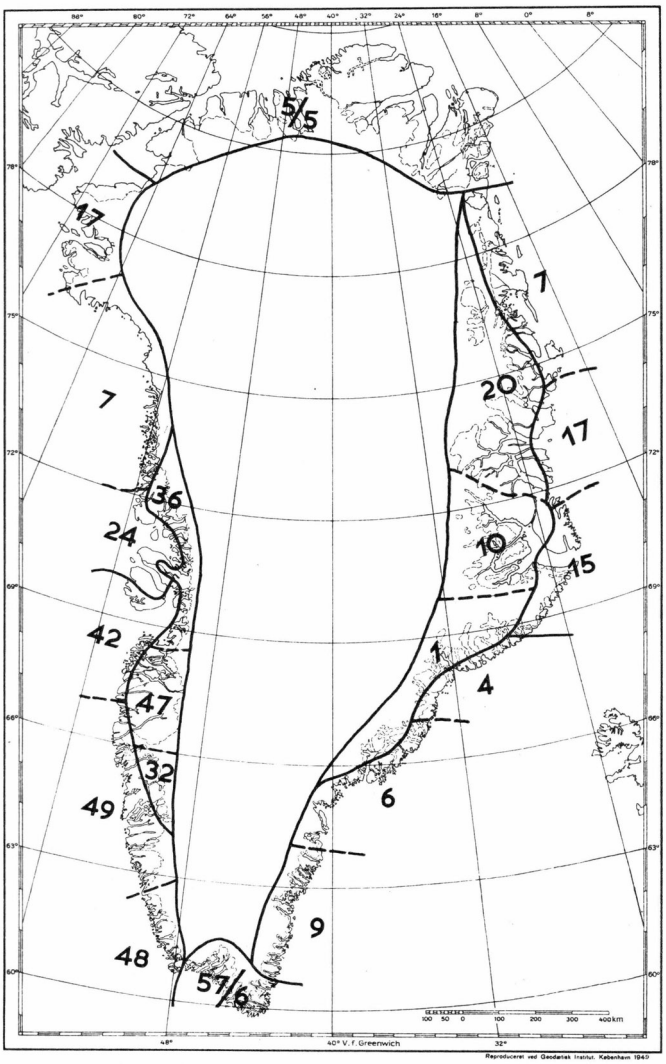

Fig. 3. The distribution of native species absent either from East Greenland (all figures west of the lines of fraction in N and S) or West Greenland (figures east of the lines of fraction in N and S). All species restricted to South Greenland are excluded.

tance, seeing that Porsild (1932) was able to reduce the Norse element in the flora of South and West Greenland to a few species. By comparison with West Greenland it may further be pointed out that many parts of East Greenland support a rich vegetation under conditions hardly surpassed in West Greenland at the same latitudes. Nor does the East Greenland polar current seem to have decisive influence on the plant distributions. A large number of southern species have northern limits almost at the same latitudes on both the east and west coasts, and some

species as e. g. *Sedum annum*, *S. rosea* and *Hieracium alpinum* even reach much higher latitudes in East Greenland. From the material in table 2, however, it appears that East Greenland still is relatively poor in species; as hinted also by OSTENFELD this sparsity, however, is mainly in Southeast Greenland, where the uncovered coastal area is very narrow, and where therefore many southern species with continental climatic requirements are excluded. The difference between West and East Greenland in number of species may primarily be caused by the multitude of climatic types in West Greenland. Thanks to the climatic measurements now available from both inland and coastal areas in Southwest Greenland it is possible there to distinguish five climatic types (cp. BÖCHER 1954), among which continental and subcontinental types most probably are absent from Southeast Greenland. OSTENFELD also mentioned the different facilities of migrations from countries west and east of Greenland to West and East Greenland respectively, the richness of the West Greenland flora partly being a result of the short distances across the waters between the Canadian Eastern Arctic and West Greenland. In accordance with this supposition the number of western species is larger than that of the eastern, and among the 114 western species 107 (94 per cent.) are present in West Greenland while only 63 (55 per cent.) occur in East Greenland. Among the 82 eastern species 65 (79 per cent.) are present here, whereas 50 (60 per cent.) reach West Greenland. The distribution of species absent either from West Greenland or from East

Table 5. Greenland distributions of Western and Eastern species.

		Area type within Greenland:											
		W	W+S	W+N	S	E	E+S	E+N	∪[1]	∩[1]	C[1]	()[1]	O[1]
Per cent. of Western species (114)		22	15	4	4	1	0	2	24	*11*	2	14	3
Per cent. of Eastern species (82)	Including Taraxacum	5	4	0	12	20	5	2	*44*	0	0	9	0
	Excluding Taraxacum	3	4	0	6	15	6	3	*53*	0	0	10	0

[1]) ∪: Distribution W-S-E; ∩: Distribution W-N-E; C: With a gap in East Greenland; (): W and E, not N and S; O: Circumgreenlandic distribution.

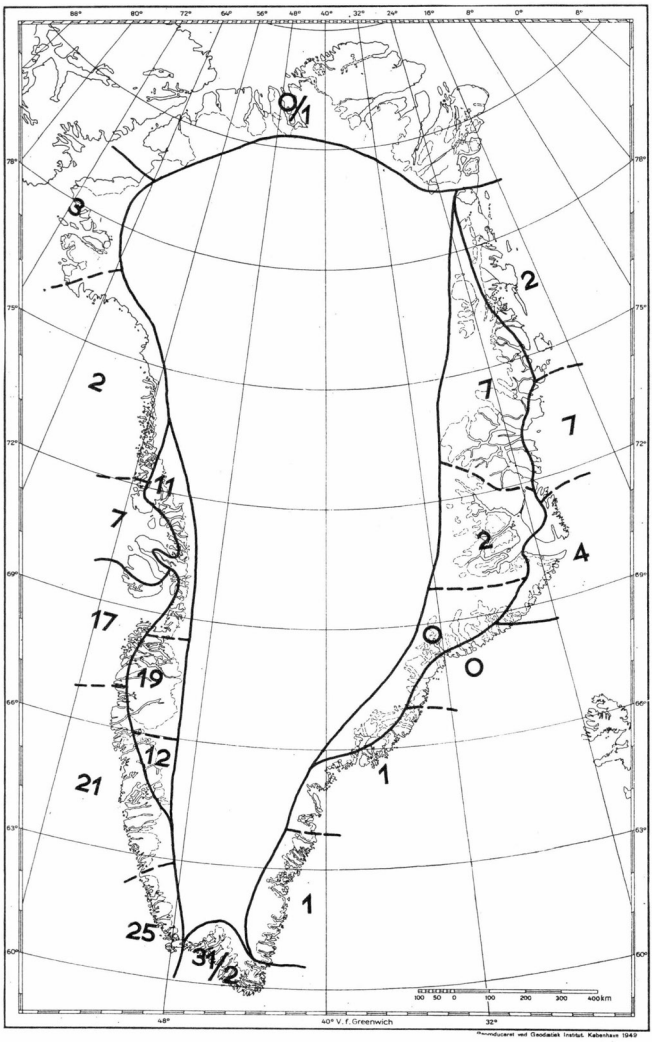

Fig. 4. The distribution of native circumpolar or amphi-Atlantic species absent either from East Greenland (all figures west of the lines of fraction in N and S) or West Greenland (figures east of the lines of fraction in N and S). All species restricted to South Greenland are excluded.

Greenland appears from the map fig. 3. The high number of species absent from East Greenland is due not only to an accumulation of western species in West Greenland but to a fairly large extent also to a limitation of many circumpolar—amphi-Atlantic species to the provinces CW and SW (—S), see fig. 4.

The different behaviour of western and eastern species in Greenland is evidenced through the calculations summarized in table 5. Most important is the fact that U-distributions (W-S-E) are most frequent among

the European species and ∩-distributions (W-N-E) among the American species. Most of the European species have obviously used the north-Atlantic islands (the Faroes and Iceland) during their immigration to Greenland. They must therefore be more or less adapted to oceanic-arctic climatic conditions and consequently they occur now in the Atlantic parts of Greenland (see p. 7). On the other hand the American species mostly came from arctic continental areas and hence many of them were unable to penetrate to South Greenland with its maritime climate. Some of them (11 per cent.) were high-arctic and able to reach East Greenland through the North Greenland barrens.

7. Plant distribution in relation to climate and soil.

The area of very many species in Greenland seems to be limited by climatic conditions. In several cases the area is not only a result of the state of temperature (summer heat, length of the period of vegetation), but often seems to a greater extent to depend on the amount of precipitation and the humidity of the air, which varies greatly from one part of the country to another. Generally the southern parts of Greenland have greater precipitation than the northern parts and coastal areas are moister than inland. *Alchemilla alpina* and *Minuartia groenlandica* are examples of species restricted to the most humid districts, SW, S, and SE; they are completely absent from the arid districts CW and CE. On the other hand *Puccinellia deschampsioides* and *Calamagrostis purpurascens* are examples of species which in the south will be found in the arid continental areas.

A. Climatic distributional patterns in Greenland. HULTÉN in his work on the distribution of vascular plants in NW-Europe (1950) divides the Nordic flora into 48 geographical groups. These groups are area-types but many of them are climatic types as well, thus e.g. the Atlantic and sub-atlantic group and the six continental groups (Nos. 34—39). The majority of Greenland plants may be referred to one of the following climatic types, which at the same time are area types or are composed of a number of closely related area types.

1. *Arctic montane ubiquitous element.* Widely distributed species able to inhabit continental as well as oceanic, high-arctic or low-arctic regions, and also in many cases mountains south of the arctic regions. Some few of them are even able to occur in suitable places in northern temperate (boreal) regions. The majority of the plants belong to HULTÉN's arctic circumpolar plants with continuous range and his circumpolar, arctic montane species lacking or occurring in European mountains. Calciphilous species have been marked by the letters Ca. V indicates western species.

Woodsia glabella (Ca)
Ranunculus hyperboreus
Dryas integrifolia (V. Ca)
Saxifraga hyperborea
— nivalis
— cernua
— caespitosa
— oppositifolia
Chamaenerion latifolium
Papaver radicatum, coll.
Cochlearia groenlandica
Cardamine bellidiflora
Draba nivalis
Polygonum viviparum
Oxyria digyna
Koenigia islandica
Silene acaulis
Cerastium arcticum (V)
Minuartia rubella
Sagina intermedia
Juncus biglumis
— triglumis
Luzula confusa
Kobresia myosuroides (Ca)
Eriophorum scheuchzeri
Phippsia algida
Poa glauca coll.
Trisetum spicatum

2. *High-arctic element.* Species inhabiting the high-arctic regions, thus areas with very low temperature, low precipitation and very long (continuous) days during the summer. They are probably unable to grow in the southern part of Greenland where e.g. the temperature may be too high or the day length too short. Many of the species are absent from Scandinavia or restricted to northern Norway and the Kola peninsula; they are further lacking in Iceland. Most of the species are calciphilous but they are not found on calcareous soils in the southern part of Greenland or in Iceland, where such soils are abundant. Many of the species are hygrophytic or hydrophytes, others are high arctic xerophytes. In the list Ca means calciphilous, V western, Ø eastern species, X xerophytic and H hygro—hydrophytic.

Ranunculus sabinei (H)
— sulphureus (H. Ca)
Potentilla vahliana (V. X. Ca)
— rubricaulis (V. X. Ca)
— hyparctica
— pulchella (V. X. Ca)
Saxifraga flagellaris ssp. platysepala (cp. A. E. Porsild 1955) (Ca)
Draba subcapitata (Ca. X)
— oblongata (V? Ca)
— bellii (V. Ca)
Eutrema edwardsii (H. Ca)
Braya thorild-wulffii (V. Ca)
— purpurascens (Ca)
— humilis arctica (X. Ca)
Lesquerella arctica (V. X. Ca)
Erysimum pallasii (Ca)
Salix arctica
Cerastium regelii (H. Ca)
Minuartia rossii (H. Ca)
Arenaria pseudofrigida (Ø. Ca)
Melandrium apetalum arcticum (H)
Pedicularis arctica (V. Ca?)
Taraxacum arcticum (Ø)
— pumilum (V. Ca)
— arctogenum (V. Ca)
— phymatocarpum (V. Ca)
— hyparcticum (V)
Eriophorum triste (cp. A. E. Porsild 1955) (H)
Carex stans (H)
Festuca baffinensis (V. X. Ca).
— hyperborea (X. Ca)
Poa abbreviata (X. Ca)
— hartzii (V. X)
Puccinellia andersonii (V. H. Ca)
— angustata (H. Ca)
Colpodium vahlianum (H. Ca)
Pleuropogon sabinei (H)
Arctogrostis latifolia (H)

Dupontia fisheri (H)
Deschampsia brevifolia (H. Ca)
Alopecurus alpinus (H)[1])
Roegneria borealis hyperarctica

3. *Widely distributed arctic continental element.* This element consists of species with wide and frequently continuous areas in the arid tundra regions and in mountains in the south where the climate has not a maritime character. In Greenland the species are mainly associated with the CW-NW-N-NE-CE. The species mostly keep clear of the outer coastal areas in Greenland south of about 65° n-lat. and are with a single exception absent from Iceland. Many are western (V) and some calciphilous (Ca).

Dryopteris fragrans[3])
Potentilla hookeriana ssp. chamissonis
Saxifraga tricuspidata[3]) (V)
Draba cinerea (Ca)
— groenlandica (V)
— lactea[2])
— hirta[3])
Melandrium triflorum (V. Ca)
Armeria scabra ssp. sibiria (?)
Pirola grandiflora[3])
Cassiope tetragona[2])
Rhododendron lapponicum[3]) (V)
Pedicularis lanata[3]) (Ca)
— hirsuta
Erigeron compositus (V. Ca)
Antennaria ekmaniana[3])
Arnica alpina coll.[3])
Tofieldia coccinea[3]) (V)
Luzula arctica[2])
Carex nardina[4]) (V)
— misandra[2])
Calamagrostis purpurascens (V. Ca)
Hierochloë alpina

4. *Medium-arctic montane element.* Species rare or missing in northernmost and southernmost Greenland and in the south alpine and frequently selective. Also often in certain alpine areas south of the arctic regions. They are absent or very rare in arid continental tundra areas as well as in markedly oceanic low—sub-arctic areas and mountains with similar climatic conditions. Many of them are chionophilous (Chi) or calciphilous (Ca), and belong to HULTÉN's circumpolar arctic montane plants.

Ranunculus nivalis (Chi)
— glacialis (Ø. Chi)
Saxifraga hieraciifolia
Epilobium arcticum (Ca)
Draba fladnizensis (Ø)
— crassifolia (Chi. Ca)
— alpina (Ca)
— gredinii
Arabis arenicola (V. Ca)
Sagina caespitosa (V. Chi)
Arenaria humifusa (V. Ca)
Melandrium affine
Campanula uniflora (V)
Erigeron humilis (V. Chi)
— eriocephalus
Antennaria porsildii (Ø. Chi)
— glabrata (Chi)
— angustata (Chi)
Taraxacum brachyceras (Ø. Chi)
Juncus castaneus

[1]) Occurring in Scotland.
[2]) Alpine in the southern inland areas in Greenland.
[3]) Missing in province N.
[4]) Rare in Iceland.

Carex ursina
— holostoma (V)
— atrofusca (Ca)
Poa alpina var. vivipara (Ø) (Greenland race)
Puccinellia vaginata (V)
Dupontia psilosantha

5. *Low-arctic or medium-arctic widely distributed element.* Species widespread in middle and southern Greenland but mostly missing in the high arctic areas and highly exclusive to favourable habitats in the north. Some of the species reach far to the south in boreal regions. Although occurring in continental as well as in oceanic-influenced areas some of the species are clearly more abundant in maritime stations (m), while others seem to prefer the inland (i). The element includes calcicphilous (Ca) as well as acidophilous (Ox) species.

Woodsia ilvensis
— alpina (Ca)
Equisetum variegatum (Ca. i)
Ranunculus pygmaeus
Saxifraga rivularis
Minuartia biflora
Cardamine pratensis (C. nymanii)[1])
Salix arctophila (V)
— glauca ssp. callicarpaea (V)
Betula nana (Ø. i)
Stellaria longipes — monantha (V)
Honckenya peploides var. diffusa
Arctostaphylos alpina
Vaccinium vitis idaea ssp. minus (i. Ox)
Vaccinium uliginosum ssp. microphyllum
Empetrum hermaphroditum (m. Ox)
Diapensia lapponica (Ø. Ox)
Mertensia maritima
Lomatogonium rotatum
Pedicularis flammea
Euphrasia arctica (Ø)
Campanula rotundifolia (arctic races)
Tofieldia pusilla
Juncus arcticus
Kobresia myosuroides (i)
Carex arctogena
— glareosa
— lachenalii (m)
— scirpoidea (V)
— bicolor (Ca)
— subspathacea
— bigelowii
— norvegica ssp. inserrulata (V)
— rariflora
— capillaris s.str.
— saxatilis
Festuca brachyphylla

6. *Low-arctic oceanic montane element.* Species with their main distribution in the provinces SW, S, SE and other arctic areas with a maritime climate as well as in mountains where the precipitation and the humidity of the air are high enough. This element is abundant in the Scottish mountains, the Faroes and in Iceland. It is also frequent in most parts of Scandinavia and occurs in the Pyrenees, the Alps and continues represented by many species further to the east (cp. the montane branch according to Hultén 1937); on the other hand the arctic branch is not developed or it is defective with large gaps. The majority of the species belong to the groups 7—11 in Hultén 1950 (Circumpolar arctic montane or amphi-Atlantic plants). Many of them are eastern (Ø). As occurring in maritime or humid montane climates many of the plants can grow on acid soils and some of them are typical oxylophytes (Ox). Several are markedly chionophilous (Chi).

[1]) cfr. Lövkvist 1956.

Lycopodium alpinum (Chi)
Selaginella selaginoides
Botrychium lanceolatum
Athyrium alpestre (Chi)
Polystichum lonchitis
Asplenium viride (Ca)
Anemone richardsonii (V. Chi)
Potentilla crantzii (Ø)
— tridentata (V)
Sibbaldia procumbens (Chi)
Alchemilla alpina (Ø)
— glomerulans (Ø. Chi)
— filicaulis (Ø. Chi)
— wichurae (Ø. Chi)
Sedum rosea
— annum (Ø)
— villosum (Ø)
Saxifraga stellaris (Ø. Chi)
— aizoides (Ø)
— aizoon
Epilobium anagallidifolium (Chi)
— lactiflorum (V)
— hornemanni (V)
Draba norvegica (Ø)
— incana (Ø)
Arabis alpina (Ø. Chi)
Angelica archangelica (Ø)
Salix herbacea (Ø. Chi)
— uva-ursi
Sagina saginoides
Cerastium cerastoides (Ø. Chi)
Minuartia groenlandica (V)
Viscaria alpina (Ø)
Harrimanella hypnoides (Chi)
Loiseleuria procumbens (Ox)
Phyllodoce coerulea (Ox)
Gentiana nivalis (Ø)
Veronica fruticans (Ø. Ca)
— alpina (Ø. Chi)
— wormskjoldi (V)
Bartsia alpina (Ø)
Erigeron borealis (Ø)
— uniflorus (Chi)
Antennaria canescens (V)
— intermedia
Gnaphalium norvegicum (Ø. Chi)
— supinum (Ø. Chi)
Hieracium alpinum (Ø)
Taraxacum croceum (Ø. Chi)
Leucorchis albida coll. (Ø)
Platanthera hyperborea (V)
Juncus trifidus (Ø. Ox)
Luzula spicata
Carex macloviana (V)
— rufina (Chi)
— atrata
— stylosa (V)
Festuca vivipara var. hirsuta
Poa alpina
Deschampsia alpina (Chi)
Vahlodea atropurpurea
Agrostis borealis
Phleum commutatum (Chi)
Hierochloë orthantha (V)
Anthoxanthum odoratum ssp. alpinum (Ø)

7. *Low-arctic continental element.* Arctic species absent from high-arctic regions and mostly associated with inland areas where they occur in the low-arctic belt. Wide ranging in the continents but very scarce or absent in Iceland and the Faroes. Many species are western and calciphilous.

Equisetum scirpoides (Ca)
Ranunculus lapponicus
— pedatifidus var. leiocarpus
Potentilla hookeriana ssp. hookeriana
Draba lanceolata (V. Ca)
— aurea (V)
Braya linearis (Ø. Ca)
— novae-angliae (V. Ca)
Arabis holboellii (V. Ca)
Halimolobus mollis (V. Ca)
Primula stricta
Ledum palustre ssp. decumbens (V)
Pedicularis lapponica
— labradorica (V)
Antennaria affinis
Artemisia borealis
Taraxacum lacerum (V)
Luzula groenlandica (V)

Kobresia simpliciuscula (Ca)
Carex gynocrates (V)
— microglochin
— amblyorhyncha
Carex supina ssp. spaniocarpa (V)
— capillaris ssp. robustior (= C. boecheri Löve, Löve and Raymond) (Ca)
Puccinellia deschampsioides (V. Ca)
Calamagrostis lapponica var. groenlandica
Roegneria violacea (V)

8. *Boreal widely distributed element.* Species with a very wide distribution in the boreal region but reaching far into the arctic regions; in Greenland not connected with either oceanic or continental parts. To this element belong several hydrophytes. Most species belong to groups Nos. 16, 29, and 33 in HULTÉN 1950.

Lycopodium selago
Isoëtes echinospora coll.
Botrychium lunaria
Equisetum arvense coll.
Ranunculus reptans
— confervoides
Rubus chamaemorus
Comarum palustre
Myriophyllum spic. ssp. exalbescens (V)
Hippuris vulgaris
Subularia aquatica
Rorippa islandica
Rumex acetosella coll.
Arctostaphylos uva-ursi
Oxycoccus quadripetalus var. microphyllus
Menyanthes trifoliata
Limosella aquatica
Utricularia minor
— intermedia
Pinguicula vulgaris
Juncus ranarius
— filiformis
Eriophorum angustifolium
Scirpus pauciflorus
Heleocharis acicularis
Carex canescens
Poa pratensis coll.
Agrostis canina
Calamagrostis neglecta
Alopecurus aequalis
Potamogeton filiformis
— gramineus
— alpinus ssp. tenuifolius
Triglochin palustre
Sparganium angustifolium

This element is further approached by some few species missing in the arctic regions proper and therefore in Greenland associated with the inland region in the southernmost part (S) or the dry and subarctic inland districts CWm-s. This element is very poor in species. Among the few examples the species of *Sisyrinchium* is imperfectly known, it may be an endemic Greenland subspecies of *S. albidum.* Most of the species are continental in their climatic requirements.

Selaginella rupestris (V)
Botrychium boreale (even inland in SEs)
Galium boreale
Sisyrinchium aff. albidum (V)
Carex praticola (V)

9. *Boreal or low-arctic montane sylvicolous element.* These species are connected with woods (or sometimes muskegs) where the humidity of

the air is high. Hence in Greenland they occur along with the oceanic low-arctic montane plants (6). Some few, however, which are calcicolous or demand a high summer temperature, are mainly found inland in Greenland in the southern part (i). Very many of them are included in HULTÉN's boreal circumpolar montane groups (16, 17, 24, and 29).

Equisetum silvaticum (i)
Cystopteris montana (i. Ca)
Lastraea phegopteris
— dryopteris
Dryopteris dilatata
Polypodium vulgare (Ø. i)
Coptis trifolia (V)
Rubus saxatilis (Ø)
Sorbus decora (V)
Chamaenerion angustifolium
Geranium silvaticum (Ø)
Viola selkirkii
Cornus canadensis (V)
Betula pubescens var. tortuosa (Ø)
Alnus crispa (V)
Pirola minor
— secunda var. obtusata (V)
Ledum groenlandicum (V)
Galium triflorum
Linnaea borealis var. americana (V)
Streptopus amplexifolius var. americanus (V)
Orchis rotundifolia (i. Ca. V)
Listera cordata
Corallorhiza trifida (i)
Carex deflexa (V)
Poa nemoralis
Deschampsia flexuosa
Calamagrostis langsdorfii

10. *Boreal suboceanic element.* Species missing in continental areas. Frequent in Iceland and the Faroes. In Greenland mainly outer coastal areas in the south. Most of the species are eastern.

Polygala serpyllifolia (Ø. Ox)
Cornus suecica (Ox)
Ligusticum scoticum
Armeria maritima s. str. (Ø)
Thymus drucei (Ø)
Juncus squarrosus (Ox)

This element is further approached by some Eurasiatic southern species:

Ranunculus acris (Ø)
Viola palustris (Ø)
Nardus stricta (Ø. Ox)

B. Distributional patterns mainly governed by edaphic conditions. As pointed out, many high-arctic and continental species are more or less calciphilous or depend on a high content of nitrates and phosphates in the soil. Other mainly low arctic or subarctic species clearly prefer acid and poor soils. As a rule the distribution in Greenland of species exclusive to certain soil types is determined by climatic as well as edaphic conditions and thus the species may be classified according to the above mentioned system of climatic distributional types. In some cases, however, the area limits in Greenland are in clear accordance with the limit of certain edaphic conditions, which again depend on the geological structure. For instance it is evident that oxylophytes like *Loiseleuria procumbens*, *Diapensia lapponica* and *Carex arctogena* avoid the areas of mesozoic sediments and basalts at Disko—Nugssuaq—Svartenhuk in

West Greenland and the basaltic area in Knud Rasmussen Land in East Greenland. A counterpart is found in species like *Draba alpina* and *Colpodium vahlianum* which are abundant on calcareous rocks but very rare or missing on gneiss. Locally, however, the soil formation is greatly influenced by the climate. Thus leaching of the uppermost layer of basic soils and peat formation in oceanic climates makes it possible for *Loiseleuria* and other oxylophytes to occur there, and lack of leaching under extremely arid conditions in continental West Greenland (CWm) makes the soils formed by disintegration of gneiss slightly acid or even neutral, thus making it possible for many calciphilous species to grow there. The aridity in this area may locally be so extreme that genuine saline ultrabasic soils are formed especially in the surroundings of depressions with salt lakes. In such places plants exclusive to saline soils are abundant (e.g. *Gentiana detonsa*, *Puccinellia deschampsioides*, *Plantago maritima juncoides* and others, see details in Böcher 1949, 1954, and 1959). A species like *Halimolobus mollis* is clearly favoured by soils with a high content of nitrates and phosphates. It is therefore abundant on bird cliffs and in villages, but it is not able to grow on similar soils in South Greenland, presumably because the climate is unfavourable. A species like *Alopecurus alpinus* behaves in a similar way.

8. The boundary in Greenland between the West-arctic and the East-arctic floristic region.

As already pointed out, the most important floristic boundary in Greenland is that which separates the oceanic provinces SW, S, SE from the northern and continental provinces. However, if we consider only the occurrence of eastern and western species (Table 2 and Fig. 2), it is evident that a boundary also exists between a west-arctic and an east-arctic floristic region in Greenland. Hooker (1861) placed this boundary in the Davis Strait, Nathorst (1890) on the Inland Ice, and Warming (1888a, p. 245) and Kruuse (1912) in the Denmark Strait. The acrimonious discussion between Nathorst and Warming is summarized by Ostenfeld (1926, pp. 7—11). In the present day, due to a more complete knowledge of the Greenland flora and the world ranges of its species, we favour Nathorst's view. No doubt the SE province and the CEs district belong to the Eurasian floristic region, and the boundary between it and the American region cuts through S and NE-CE, where the numbers of west- and east-arctic species are almost equal (see Fig. 2). Good in his Geography of Flowering Plants (1953) divides the arctic region into three provinces, viz. the Eurasian, the Neoarctic, and the Greenlandic. Of course, Greenland being an island, has been inaccessible for species with heavy seeds (e.g. species of *Oxytropis* and *Astragalus*, or

seeds which very soon lose their germinability (e.g. *Salix reticulata*), and its flora is therefore a little impoverished; but apart from the apomictic genera *Hieracium* and *Antennaria*, it has very few endemic species (table 2), and the rest of its flora is either circumpolar, amphi-Atlantic, or west- or east-arctic. Thus it seems most adequate to divide Greenland into a small Eurasian sector in SE and a large American (or Neoarctic) part as already suggested.

9. Age and immigration routes of the Greenland Flora.

Although the question of the age of the flora has been greatly discussed, it cannot be answered with any certainty. Discussions mainly centre around the number of perglacial survivors, this number being assumed variously as to be almost nil (NATHORST 1890, SIMMONS 1913, PORSILD 1922), rather small (OSTENFELD 1926, SEIDENFADEN & SØRENSEN 1937, IVERSEN 1953) or even high (EBERLIN 1887, WARMING 1888a, GELTING 1934, BÖCHER 1938). Species with disjunct areas or highly isolated stations in Greenland support the theory of survival, but it is probable that in many cases such disrupted ranges are the remnants of more continuous late-glacial distributions, or that some of the isolated stations represent accidental landing places of recent immigrants. The fact that isolations or area limits of Greenland plants, as evidenced even by the southern species, correspond to areas or limits of alpine mountain structure, seems to give new support to the theory of survival of many species, at least during the last Glacial period (see discussion in BÖCHER 1951, 1956).

The number of recently introduced plants is high (table 2), but it is very difficult to estimate to what extent this number was affected by the old Norse colonisation. According to OSTENFELD about 13 per cent. of the total flora was brought into the country by the Norsemen from Europe. As already mentioned this percentage, however, is undoubtedly much too high (see the discussion in PORSILD, 1932). A few species may have been brought to Greenland from Canada by Eskimos travelling along the arctic coasts (see e.g. SØRENSEN, 1953).

Whether postglacial, interglacial or preglacial, the immigration to Greenland must have proceeded over more than one route. Arctic western plants like *Pedicularis capitata* probably utilised the route from Ellesmere Island via Smith Sound and Kennedy Channel, while boreal American species like *Orchis rotundifolia* may have crossed Davis Strait. The low-arctic alpine Eurasian element (e.g. *Sedum annuum*) may be presumed to have come to the SE province from Iceland. Finally, the small group of arctic continental Eurasian or purely Asiatic species (e.g. *Potentilla stipularis*, *Draba sibirica*) most probably reached Greenland

long ago via the Arctic Ocean, in most cases using the Svalbard archipelago as an intermediate landing place.

10. Future work on the Greenland flora.

The recent account of all chromosome countings made on Greenland flowering plants by JØRGENSEN, SØRENSEN and WESTERGAARD (1958) gives a valuable foundation for further cytogenetic and biosystematic work on the Greenland species. Several of these are very complex and their cytogenetic structure deplorably little known. Among the defectively explored species or species groups may be mentioned *Ranunculus pedatifidus — auricomus*, *Potentilla nivea — hookeriana — chamissonis*, *P. crantzii — ranunculus*, *Cerastium alpinum — arcticum*, *Stellaria longipes — monantha*, *Campanula rotundfolia — giesekiana*, *Erigeron compositus*, *Arnica alpina*, *Leucorchis albida — straminea*, *Platanthera hyperborea* and *Trisetum spicatum*, *Festuca vivipara* and *F. rubra*. In all these cases more chromosome countings would be of great interest, but the investigations ought to be made to include experimental cultivations and crossings as well as embryological studies in all such groups which may contain apomicts.

The distribution of the species is probably better known within Greenland than in any other arctic area of a similar size. Nevertheless, many parts are deficiently explored. Thus most parts of the N-province with the exception of Peary Land and Independence Fjord are defectively known, and the same may be said about the adjacent northernmost part of district NWn. Gaps in our floristic exploration of Greenland are further found in the surroundings of Sukkertoppen and Fiskenæs in district SWm, and in many parts of the districts SEs, SEn, NEs as well as the northern branches of Scoresby Sund in CEm. Exploration of the last mentioned area and the Sukkertoppen fjord system in West Greenland is planned during the summer of 1958 by Danish botanists. No doubt the number of deficiently known areas will soon decrease. In the near future, therefore, more and more stress should be laid upon detailed floristic or ecological investigations in representative areas within the various districts. At present such investigations have been carried out only in Southern Disko, the head of Søndre Strømfjord, Ella Ø and Clavering Ø in NE-Greenland and some few other areas.

LITERATURE

Böcher, T. W. 1933. Phytogeographical studies of the Greenland Flora. — Medd. om Grønl. 104, No. 3.

— 1938. Biological distributional types in the flora of Greenland. — Medd. om Grønl. 106, No. 2.

— 1949. Climate, soil and lakes in continental West Greenland in relation to plant life. — Medd. om Grønl. 147, No. 2.

— 1951. Distributions of plants in the circumpolar area in relation to ecological and historical factors. — Journ. of Ecology 39.

— 1952. Contributions to the flora and plant geography of West Greenland III. Vascular plants collected or observed during the botanical expedition to West Greenland 1946. — Medd. om Grønl. 147, No. 9.

— 1954. Oceanic and continental vegetational complexes in Southwest Greenland. — Medd. om Grønl. 148, No. 1.

— 1956. Area-limits and isolations of plants in relation to the physiography of the southern parts of Greenland. — Medd. om Grønl. 124, No. 8.

— 1959. Floristic and ecological studies in Middle West Greenland. — Medd. om Grønl. 156, No. 5.

Böcher, T. W., Holmen, K. and Jakobsen, K. 1957. Grønlands Flora. — København.

Eberlin, P. 1887. Blomsterplanterne i dansk Østgrønland. — Archiv f. Math. og Naturvidsk. 12. Kristiania.

Florae Danicae Iconum 1761—1883. Fasc. 1—51, suppl. fasc. 1—3. — Hauniae.

Gelert, O. and Ostenfeld, C. H. 1902. Flora Arctica I. — Copenhagen.

Gelting, P. 1934. Studies on the vascular plants of East Greenland between Franz Joseph Fjord and Dove Bay. — Medd. om Grønl. 101, No. 2.

Good, R. 1953. The geography of the flowering plants. — New Edition. London.

Hartz, N. 1895. Fanerogamer og Karkryptogamer fra Nordøstgrønland ca. 75°—70° N. Br. og Angmagssalik o. 65° 40′ N. Br. — Medd. om Grønl. 18.

Holmen, K. 1957. The vascular plants of Peary Land, North Greenland. — Medd. om Grønl. 124, No. 9.

Hooker, J. D. 1861. The 1. part of the outlines of the distribution of arctic plants. — Trans. Linn. Soc.

Hornemann, J. W. 1832. Bemærkninger om Forholdet af de i Grønland fundne Vegetabilier, sammenlignet med Forholdet i andre især Polarlande. — Overs. V. S. Fhd. 1831—32.

— 1834—37. Dansk oeconomisk Plantelære. — København.

Hultén, E. 1937. Outline of the history of arctic and boreal biota during the Quaternary period. — Stockholm.

Hultén, E. 1950. Atlas över växternas utbredning i Norden. Fanerogamer och ormbunksväxter. Atlas of the distribution of vascular plants in NW. Europe. — Stockholm.

Iversen, J. 1953. The origin of the flora of Western Greenland in the light of pollen analyses. — Oikos 4, fasc. 2.

Jørgensen, C. A., Sørensen, Th. and Westergaard, M. 1958. The flowering plants of Greenland. A taxonomical and cytological survey. — Biol. Skr. Dan. Vid. Selsk. 9, No. 4.

Kruuse, C. 1912. Rejser og botaniske Undersøgelser i Østgrønland samt Angmagsalikegnens Vegetation. — Medd. om Grønl. 49.

Lange, J. 1857. Oversigt over Grønlands Planter. — In H. Rink: Grønland geografisk og statistisk beskrevet 2, Tillæg nr. 6. — København.

— 1880a. Conspectus Florae Groenlandicae. Pars prima. — Medd. om Grønl. 3, No. 1.

— 1880b. Studier til Grønlands Flora. — Bot. Tids. 12.

— 1887. Conspectus Florae Groenlandicae. Pars secunda. — Medd. om Grønl. 3, No. 2.

Lövkvist, B. 1956. The Cardamine pratensis complex. Outlines of its cytogenetics and taxonomy. — Symb. Bot. Upsalienses 14, No. 2.

Nathorst, A. G. 1890. Kritiska anmärkningar om den grönländska vegetationens historia. — Bih. t. K. Svenska Vet.-Akad. Hand. 16, Afd. III, No. 6.

— 1891a. Kritische Bemerkungen über die Geschichte der Vegetation Grönlands. — Engler's bot. Jahrb. 14.

— 1891b. Fortsatta anmärkningar om den grönlandska vegetationens historia. — Öfvers. af K. Svenka Vet.-Akad. Förh. 4.

Ostenfeld, C. H. 1926. The flora of Greenland and its origin. — Biol. Medd. Dan. Vid. Selsk. 6, No. 3.

Porsild, A. E. 1955. The vascular plants of the Western Canadian Arctic Archipelago. — Nat. Mus. Canada Bull. 135.

— 1957. Illustrated flora of the Canadian Arctic Archipelago. — Nat. Mus. Canada Bull. No. 146.

Porsild, M. P. 1902. Skildring af Vegetationen på Øen Disko. — Medd. om Grønl. 25.

— 1920. The flora of Disco Island and the adjacent coast of West Greenland. — Medd. om Grønl. 58. No. 1.

— 1921. In "Grønland i Tohundredaaret for Hans Egedes Landing". — Medd. om Grønl. 60.

— 1922. The flora of Greenland: its affinities and probable age and origin. — Torreya 22.

— 1932. Alien plants and apophytes of Greenland. — Medd. om Grønl. 92, No. 1.

Rosenvinge, L. K. 1892. Andet Tillæg til Grønlands Fanerogamer og Karsporeplanter. — Medd. om Grønl. 3.

— 1897. Det sydligste Grønlands Vegetation. — Medd. om Grønl. 15.

Seidenfaden, G. and Sørensen, Th. 1937. The vascular plants of Northeast Greenland from 74°30′ to 79°00′ N. lat. — Medd. om Grønl. 101, No. 4.

Simmons, H. G. 1913. A survey of the phytogeography of the Arctic American Archipelago. — Lunds Univ. Årsskr. Afd. 2, Bd. 9, No. 19.

Trapnell, C. G. 1933. Vegetation types in Godthaab Fjord. — Journ. of Ecol. 21.

Sørensen, Th. 1933. The vascular plants of East Greenland from 71°00′ to 73°30′N. lat. — Medd. om Grønl. 101, No. 3.

SØRENSEN, TH. 1953. A revision of the Greenland species of Puccinellia Parl. with contributions to our knowledge of the arctic Puccinellia flora in general. — Medd. om Grønl. 136, No. 3.

VAHL, J. Nomenclatura Florae Groenlandicae. Hafnia (about 1840).

WARMING, E. 1888a. Om Grønlands Vegetation. — Medd. om Grønl. 12, No. 1.

— 1888b. Tabellarisk Oversigt over Grønlands, Islands og Færøernes Flora. 1887. — Vidensk. Medd. fra den naturh. Foren. 1887.

— 1890. Grønlands Natur og Historie. Antikritiske Bemærkninger til Prof. Nathorst. — Vidensk. Medd. fra den naturh. Foren. 1890.

— 1891. Geschichte der Flora Grönlands. Antikritische Bemerkungen zu A. G. Nathorst's Aufsatz. — Engler's bot. Jahrb. 14.

Postscript.

After concluding this paper we received ERIC HULTÉN: The amphi-Atlantic plants and their phytogeographical connections (Kungl. Svenska Vetenskabsakad. Hdl. 4 ser. 7 No. 1, 1958) and EILIF DAHL: Amfiatlantiske planter. Problems of Amphiatlantic Plant Distribution (Blyttia 16, pp. 93—121, 1958). Unfortunately these important papers appeared to late to be considered in the present paper.

Færdig fra trykkeriet den 9. april 1959.