CHOICE OF SPECIES AND ORIGINS FOR ARBORICULTURE IN GREENLAND AND THE FAROE ISLANDS

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Arter og racer af vedplanter
egnet til dyrkning på Grønland og Færøerne.

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Abstract

In the North Atlantic the climatic conditions close to the shores of the Faroe Isles (62°N) and at the interior fiords of SW-Greenland (60°-61°N) indicate potential boreal forest zones. The results of arboriculture and afforestation attempts during a century in the Faroe Isles and 30 years in Greenland illucidate the phytogeographical position of these areas and suggest from which regions further species and origins should be introduced.

The extreme oceanic conditions of the Faroe Isles permit cultivation of an almost unlimited variety of species, origins and cultivars. Well adapting is, however, almost only plant material from the climatically corresponding cool oceanic forests of coastal Alaska (e.g. *Pinus contorta, Picea sitchensis, Tsuga heterophylla, Alnus sinuata*) and the Southern Hemisphere, particularly Tierra del Fuego (*Nothofagus betuloides, N. pumilio, N. antarctica*). New Zealand genera of shrubs such as *Hebe, Aristotelia, Coprosma,* and *Hoheria* are well suited for Faroese gardens. Also species originating from western C-European mountains adapt well (*Acer pseudoplatanus, Laburnum* spp., *Sorbus mougeottii*) and so do a number of cloud-forest species from Japan and S-China.

In Greenland the fluctuating winter-climate, the effect of the foehns and the occasional spells of very cool growing seasons limit the choice of adaptable species and origins to a very few. Most promising are *Picea glauca, Pinus contorta* var. *latifolia,* and *Abies lasiocarpa* from S-Alaska and adjacent Yukon-BC, and *Larix sibirica* var. *sukaczewii* from NW-USSR; at the most oceanic sites also *Pinus contorta* from Haines-Skagway and *Picea glauca* x *sitchensis* from Kenai-Tsaina. At interior fiords further north (to Søndre Strømfjord at the Arctic Circle) *Picea glauca* from treeline populations N of 64°N may adapt.

The best choices of origins for the extreme conditions in the Faroe Isles and Greenland are in general not available from seed dealers, nurseries or forestry seed-banks. Larger-scale planting of such material has to be based on repeated collecting of seed and saplings in the wild and/or generative and vegetative propagation of superior stands or individuals either locally or in more favourable situated seed orchards and nurseries.

Introduction

In forestry and horticulture it is a current challenge and task to search for, collect, and grow plants that are well or better adapted (the closer to treeline, the more so), and among them to select the superior and breed for improved qualities. As this is a never ending process, it is tempting and useful once in a while to try to survey the present stage and let the results guide the next steps. There is a long tradition for doing so in forestry in the Nordic countries, where exotic species in a large scale have added to a poor native dendroflora, and Nordic forestry literature is therefore rich in results from origin and provenance trials with economic important tree species. Papers updating general experiences from forestry in Iceland, UK, and Denmark (Blöndal 1982, Lines 1987, and Larsen 1983) pushed me to do an attempt in that direction for Greenland and the Faroe Islands, including also small trees and shrubs.

In the Faroe Islands and not least in Greenland, arboriculture is still in a pioneer phase and a majority of species and origins so recently introduced, that the present survey had to be based not least on what might be regarded as „early tests" with the main purpose of trying to encircle what is able to survive and grow at all. For some species the exact origin of especially early introduced material is unknown or uncertain, and numbers of origins and individuals are in many cases small. Owing to the in general complex and uneven plant material implied, and to the often patchwork-like conditions of sites where planted (often an ecological niche, where a plant might get a good start), the present paper is based primarily on general observations and reflection, not on statistically +/– proof designs of trials and calculations of measurements. Such might be considered in future projects if manpower and money permit and when adequate areas are found and preserved.

The fieldwork has emphasized repeated observations of growth, timing of flushing and ripening of annual shoots, injuries, flowering, fruiting, etc. during some weeks almost every year from 1976 to 1987. It was carried out in as well the older plantations and gardens as among the comprehensive material of species and origins collected mainly on arboretum-expeditions and planted 1976 ff.

The recommendations and suggestions are based primarily on this fieldwork and on a evaluation of the results so far, but also on observations of distribution patterns and growth of various species while collecting at or near treelines in North and South America and in boreal, subarctic, and subalpine forests elsewhere. They are also influenced by observations and discussions on the many excursions together with Nordic colleagues to natural forests, experimental plots and gardens in northern Fennoscandia and in Iceland (Nordic Arboretum Committee, Nordic Subarctic Birch Project, SNS working groups).

The close cooperation with Leivur Hansen, Faroe Isles, and Poul Bjerge, Greenland, while planting and recording, has learned me a lot, and their experience from decades of managing nurseries and plantations has contributed invaluably to the present knowledge of possibilities and practice.

The problems confined with the phytogeographical classification of the cool North Atlantic coastlands and their position in relation to actual and potential treelines are discussed in previous papers by Ødum (1979, 1990) and Tuhkanen (1984, 1987), considering the success of planted exotics a valuable tool in defining the relationships of areas which are poor in species and separated from neighbouring lands by powerful geographic barriers. This aspect is stressed further as a consequence of the evaluation of results.

In SW-Greenland as well as in the Faroe Isles the potential altitudinal treeline is apparently situated at approx. 150 m on favourable exposures, but except from that are the climatic and edaphic conditions, and hence the results of planting, so different that the two areas in the following are dealt with separately.

The botanical nomenclature is in accordance with Ødum (1990) and Ødum & al. (1989) in which authors are quoted, or with Bailey & al. (1976).

The Faroe Islands

Nature conditions

The Faroe Islands, a group of 18, are situated at 62°N, 7°W between Shetland and Iceland, covering an area of 1400 km². They are built up of tertiary basalt and tuff and during the Ice Age shaped by glaciers forming fiords and cirque-valleys. The highest plateaus reach altitudes of 500-882 m (Rasmussen 1963). The soils are in general continuously moist and highly acidic with thick organic horizons in which the silt-fraction of minerals is high and the clay-fraction low (Rutherford & al. 1981). The Gulf Current evens the temperature of the surrounding ocean to approx. 7°C the year round and thereby the air temperatures of the coastal lowlands. At the capital, Tórshavn, the average temperature for the coldest month, February, is 3.7°C, and for the warmest, August, 11.1°C. Abs. max. is 22.1°C, and abs. min. is −10.4°C. At low altitudes snowcovered ground and superficially frozen soil are shortlasting phenomena. The relative humidity is high all the year and fog is common. The annual precipitation is 1500 mm, lowest in April-July. Depending on topography and exposures it varies from 835 mm in the very South and West to 3020 mm at Klaksvik in the North (Lysgaard 1969). The islands are exposed to very strong winds and at coastline to saltspray.

A thousand years of sheep-grazing all over the islands has increased peatformation, erosion, and development of heath vegetation. Jóhansen (1975, 1985) and Hansen (1966) have studied the history, altitudinal zonation and composition of the natural and semi-natural vegetation of the islands, where scrub of *Betula nana* disappeared due to increasing oceanity prior to Landnam, and where scrub of *Salix* and *Juniperus* has been dramatically reduced by grazing. Recently, however, Jóhansen (1989) has recorded the find of a fossil stump and log of *Betula pubescens*, which in the present millenium must have formed at least a local scrub-forest on northern Eysturey.

For further details and discussion of ecoclimatical aspects, see Tuhkanen (1987) who draws attention to the convincing correspondance with the climates of outer coastal Alaska Panhandle, Tierra del Fuego, southern Patagonia, and Campbell and Auckland Islands S of New Zealand.

Introduction and planting of exotics

Fencing of gardens to keep out the sheep and attempts to grow some trees and shrubs were probably initiated in Tórshavn more than 200 years ago by

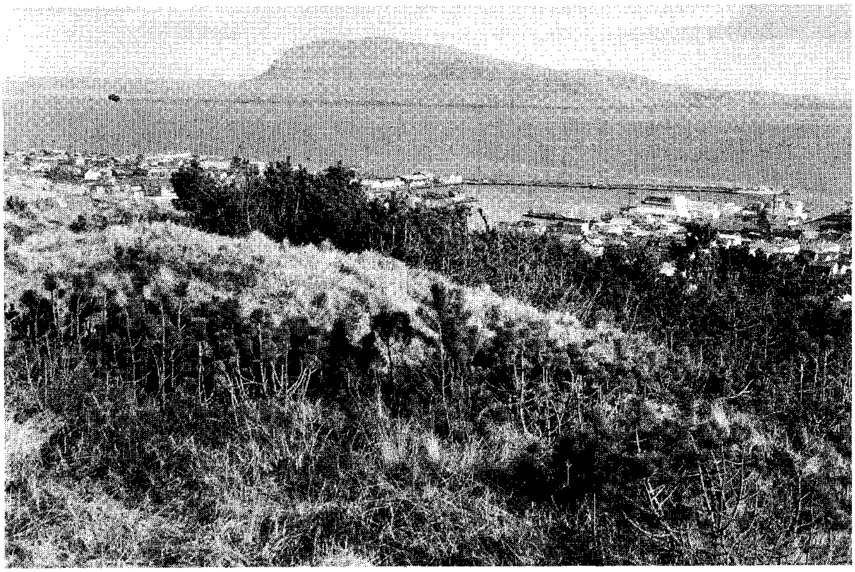

Fig. 1. The abrupt treeline in the plantation (here *Pinus contorta*) at Hotel Borg at 150 m a.s.l. View towards the SE over Tórshavn harbour to Nolsøy. S.Ø. phot., April 1986.

residents coming from Denmark and Norway (Svabo 1781-82), but it was not until a hundred years later the planting of trees, present in Tórshavn today, was started, and even later in other towns. Børgesen (1903, 1908) and Flensborg (1903) describe gardens with young trees of particularly *Sorbus aucuparia, S. intermedia, Acer pseudoplatanus,* and *Salix* spp. Larger scale establishment of ornamental gardens is a fairly recent phenomenon, escalating during the last 20-30 years with use of increasing numbers of species and cultivars.

Flensborg (1903, 1947) initiated, in cooperation with Faroese garden-pionéers and authorities, the oldest of the conifer plantations present today (fig. 2), using first *Pinus mugo* and *Picea glauca,* later with success *Picea sitchensis, Pinus contorta* and *Larix leptolepis*. He, and later Christensen (1967) and Nyholm (1970), transferred from the nurseries of Hedeselskabet, Jutland, an increasing number of species, among which *Abies* spp. Around 1950-60 cooperation between Leivur Hansen, Faroe Isles, Hakon Bjarnason, Iceland, S.A. Christensen, and Ivar Nyholm resulted in more determined and hence fruitful efforts in finding and producing climatically better adapted plant material originating particularly from coastal Alaska and British Columbia.

Fig. 2. Part of the plantation in Gundadal, Tórshavn, with 60-70-year old, 10-15 m high *Pinus contorta* and *Picea sitchensis*. Obs. the windbreaks. Major parts of this plantation was windfelled 1988. S.Ø. phot., 25 March 1984.

The collecting and introduction to the Faroe Isles of species and origins from homoclimatic areas in the southern hemisphere was initiated in 1972 with establishment of the Nordic Arboretum Committee (1977). From the coastal Alaska Leivsson and I collected further material for the Faroe Isles in 1981, particularly *Picea, Tsuga, Populus,* and *Alnus*.

More details about the history of gardens and plantations can be looked up in Hansen & Ødum (1982) and Højgaard & al. (1989). In the latter Leivsson (1989a, 1989b) is updating distribution, size and time of establishment of all Faroese plantations, and he describes in details one of the oldest plantations, Selatrað. In the same publication Søndergaard (1989) and Ødum (1989) are dealing with the introduction and growth of the southern hemisphere material collected by the Nordic Arboretum Expeditions 1974-75 (Søndergaard & al. 1977, Ødum & al. 1977).

Climatically matching geographical areas providing well adapting plant material

Exotic trees and shrubs meet challenges confined with the extreme oceanity of the islands: Fairly high temperatures in the autumn and early winter (8° - 7° - 5°C in average for Oct.-Nov.-Dec. with normally no frosts) being critical to inwintering processes. Winters and springs with fluctuating spells of mild weather and frosts being critical to early flushing plants, particularly the continental ones. Delayed and cool summers critical to the carbon budget of late flushing deciduous plants and their maturing of annual growth. Very humid, peaty soils poor in nutrients and oxygen being critical to establishment and stability. Rarely occurring very dry summers are hence a threat to big, superficially rooted individuals.

An up to date recording and scoring of as far as possible all lignoses in cultivation in the Faroe Isles (Ødum & al. 1989) creates the basis for the following grouping of species as being more or less successful. A classification as belonging to the top of the scale is primarily based on climatic matching, not on growth rate. Some taxa are slow growing in their natural environment and will normally remain so, when planted elsewhere. Fast growth in combination with a perfect matching is, of course, a quality of plants to be used in plantations, shelterbelts and as street-trees. Some of the climatically well adapted species demand improved soil conditions to establish at all or reasonably fast, and most species will benefit from draining, fertilizing, and shelter. Special attention is therefore paid to species and origins being superior pioneers.

Fig. 3. Trondur Leivsson cutting a 50-year old *Pinus contorta* in Selatrað plantation (see Leivsson 1989 b). S.Ø. phot., April 1986.

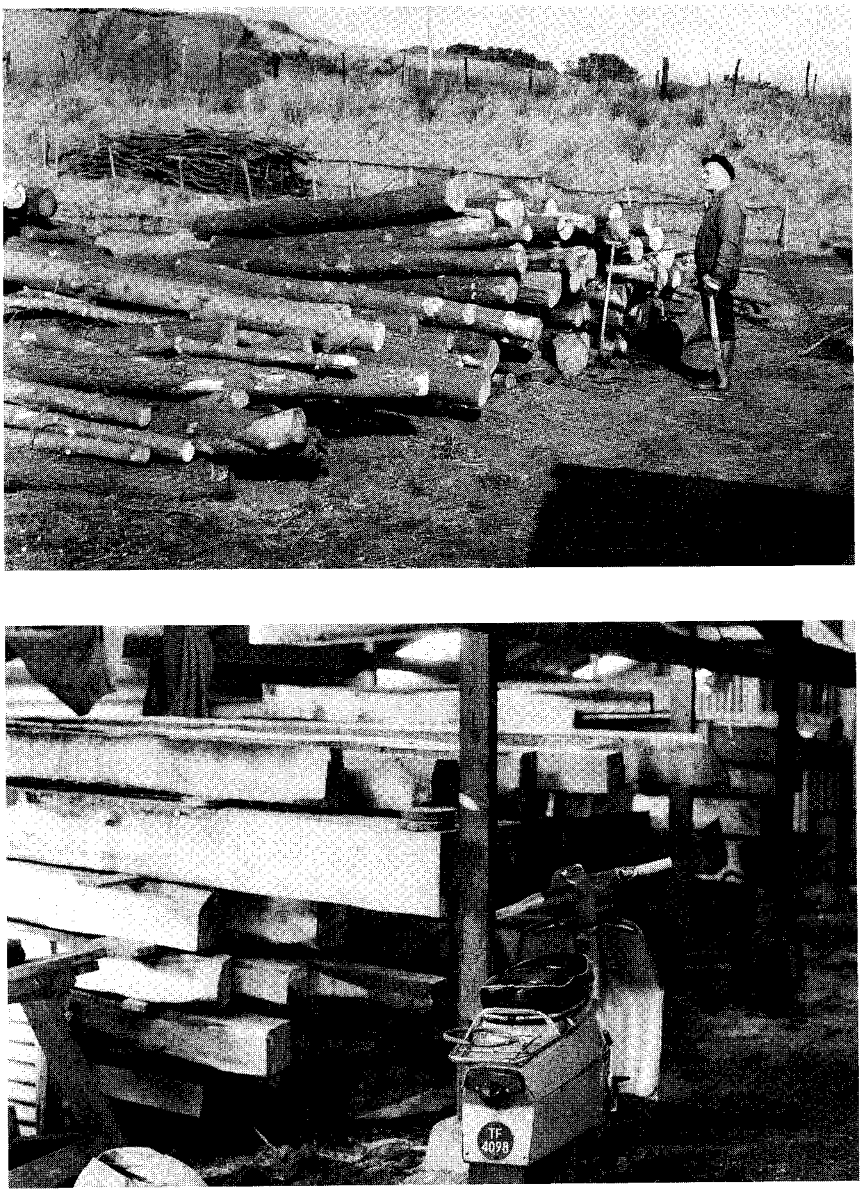

Fig. 4a and b. Logs and timber of *Pinus contorta* and *Picea sitchensis* from the Faroese Plantations. S.Ø. phot., April 1986.

The climatically matching trees and shrubs are identified by their proper timing of flushing and cessation of growth: No or minor damages of early growth in case of flushing earlier than normally occurring late frosts, and sufficient maturing of shoots and buds with no or only minor occasional diebacks (unless a semishrub, e.g. *Fuchsia*). Flowering every year and proliferously, if a normal habit. Maturing fruits and seed, if either wind pollinated, visited by pollinating insects (in the Faroes primarily flies and bugs), or apomictic.

The inventory emphasizes approx. 330 cultivated species. These can be divided into 1/3 being well or very well adapted, another 1/3 as being less well adapted and of poor quality due to diebacks most years, to very slow growth compared with the normal habit, to poor or lacking flowering, etc. The last 1/3 can be divided into one half being very miserable and another half having been introduced too recently to be evaluated.

Western North America

Conifers

Many conifers of this region survived as oceanically adapted species or races during the Ice Ages due to the NS-orientated mountain ranges and have for the last hundred years contributed to forestry in more or less oceanic parts of NW-Europe, being superior to the few native ones, which hibernated in fairly continental refuges. Hence it is no surprise that NW-American species from coastal areas and W-facing mountains high in precipitation are among the best for Faroese conditions:

Abies grandis. This is the fastest growing *Abies* in the Faroe Isles, doing best as a second generation in sheltered openings in the old plantations. The origin of the plants provided by Hedeselskabet is uncertain, but most likely W Washington or E Vancouver Isl. (Larsen 1983).

Abies procera. A strong species in older plantations and in gardens (fig. 5), also where exposed to wind. Origin of material uncertain, but most likely Danish provenance (Barner & al. 1980).

Chamaecyparis lawsoniana and *C. nootkatensis* expose a promising development where planted in older plantations and gardens. Origins unknown, but *C. l.* has a very limited geographical area, and *C. n.* is hardly from seed of northern origins.

Fig. 5. *Abies procera* in a garden in Tórshavn having just started the new growth. S.Ø. phot., 22 June 1986.

Picea sitchensis. The only species of spruce growing well in the Faroe Isles, and since 1918 widely used in plantations and gardens. Older material is probably the same as used by Hedeselskabet in Denmark, most likely SW-B.C. and Wash. coast origins. This material is fast growing, in sheltered positions to 16-18 m in 70 years (fig. 2). In some years *Elatobium* breakouts cause massive loss of needles on some individual trees or in whole stands. This southern material is performing best when in mixture with e.g. *Larix leptolepis* and *Pinus contorta* and when planted in drained, fertilized sites. Later introductions of origins from Sitka Island, Cordova, Pigot Bay and Pt. Pakenham (Pr. William Sound) and Homer, all Alaska, are climatically better adapted and more tolerant to wind exposure and peaty soil, having stronger annual shoots with needles kept for several years. Similar qualities are exposed by additionally six recently introduced origins (dug up seedlings or seed) ranging from Juneau via Yacutat, Icy Bay, and English Bay to Kenai, now being tested as pioneers in exposed positions.

Picea sitchensis x *glauca* (*P.* x *lutzii*) of seed from Seward, Alaska, was planted 1970 and is well adapted, but slower growing than *P. sitchensis*.

Pinus contorta. For sixty years the coastal ssp. of this species has been the most important tree in the Faroese plantations, and is planted in gardens as well. In not too wet soil and with some phosphate added when started, it is a good pioneer. In all older plantations the material used was provided by Hedeselskabet and hence most likely all Wash. coast and SW-B.C. origins. Roger Lines (1983) identified it also as such, when visiting the plantations in 1982. This material grows to 16 m high trees in 50 years (fig. 3), producing approx. 7 m^3/ha/year (Leivsson 1989 b). However, 20 years old stands of Annette Island origin reveal that coastal Alaska material is climatically better adapted, a little slower growing with darker, densely set and longer persisting needles. It is a better pioneer on peat, better rooted, and hence more windfirm. In spite of a less good reputation in Scotland (Lines 1987) a Findon Forest provenance (Culbokie) of Fraser River, B.C. origin (S.A. Christensen 1967) has developed into a pretty stand in Tórshavn, less firm, however, than the Annette Island ones.

Thuja plicata. A specimen purchased in Aberdeen 1944 by Leivur Hansen has been propagated by cuttings planted in various plantations where performing well. Origins from Westminster, B.C., and Ketchikan, Alaska, have recently been introduced.

Fig. 6. Leivur Hansen at a 10-year old *Tsuga heterophylla* in Selatrað plantation. S.Ø. phot., April 1986.

Tsuga heterophylla. This species is probably the most oceanic of the NW-American conifers. Where planted during the last 20 years in the old plantations, it is growing vigorously (fig. 6). Probably of B.C. or Wash. coast origin. Various origins dug up in Alaska (e.g. Juneau and Yacutat) have recently been planted for comparison.

Broadleaves

Northern NW-American is poor in broadleaved tree species. Only *Alnus sinuata* and *Populus trichocarpa* are so far of interest. *Alnus rubra* which in warmer areas of W-Eur. is a high yielding species, fail to mature most of its late growth, even when of Alaska origin. In SE-Alaska it is common only in valleys with rich soil below 300 m alt. (Viereck & Little 1972) and does not enter the cool coastal forests W of Haines.

Alnus sinuata. The first introduction, seed and plants of Alaska coast origin, was received from Iceland 1956. It appeared to be a perfect pioneer (N-fixation), now being used in new plantations, in shelterbelts and gardens. Seed is being harvested locally for production of plants. In the frontier of the forest at Prince William Sound and on Kodiak Island it is a pioneer as well, outcompeting high grass and nursing advancing conifers.

Alaska origins from Haines, Yacutat, Girdwood, and Dillingham (Bering Sea coast), were collected 1981 and recently planted for comparison. All of them grow very well.

Populus trichocarpa. Alaska origins of this species are so far the only poplars adapting well in the Faroe Isles with hardening of tissue of annual shoots early enough to avoid dieback. Particularly one clone, distributed 1956 from Iceland, where introduced by Bjarnason from Kenai, is superior and now widely planted. Further Alaskan origins have been introduced for comparison.

A number of species of shrubs associated with the NW-American oceanic forests are very well adapted: *Gaultheria shallon, Lonicera ledebourii, Ribes bracteosum* (Yacutat), *Ribes sanguineum* (the pink-flowered wild-form superior to the dark red cultivars), *Rubus spectabilis* (where forming thickets, improving soil conditions markedly), *Spiraea douglasii, Symphoricarpos rivularis, Vaccinium ovalifolium* (Pr. Rupert, B.C.).

Eastern North America

Rhododendron catawbiense is native to cool valleys and cloudforests at the higher elevations of the Appalachian Mts. Hybrids with *R. ponticum* and other species, e.g. *R.* 'Grandiflorum' and *R.* 'Cunninghams White', grow well in Faroese gardens, flowering a month later than in Denmark. *Rosa virginiana,* having a wider range, is well adapted.

Iceland

The southcoast of Iceland is climatically not very different from the Faroe Isles. *Betula pubescens* or rather *B. p.* ssp. *tortuosa* from Iceland is often planted in Faroese gardens in spite of its slow growth. It is tolerant to the poor soils and being moved to a more southern latitude it stops growing early and gets as one of the few of the introductions bright autumn colours. The best adapted exotic willow for Faroese conditions is a female clone, 'Brekkuviður', from Iceland with native parents, *Salix glauca* x *phylicifolia.*

Europe

The most oceanic species and origins of the W-European ligneous flora are growing in the central and fairly southern mountains with high precipitation: the Pyrenees, the Alps and adjacent ranges, and to some extent Yugoslavia. A few oceanic evergreens (*Ilex, Taxus, Hedera*) spread in the Atlantic period northward to SW-Scandinavia (Iversen 1944, Fægri 1960, Ødum 1968). In general the Scandinavian trees and shrubs seem not yet to have developed extreme oceanic races along the Norwegian coast.

Conifers

Pinus mugo from the Alps and *P. m.* var. *rostrata* (syn. *P. uncinata*) from the Pyrenees (where together in W-Alps and in Danish plantations, introgression, cf. Christensen (1987, 1989)) are planted in gardens. Seed of Danish provenance much used. The latter has developed into a fine, 50 year old stand on Kunoy in the North. The Haut Conflent origin from the Pyrenees has been planted in many places since 1959.

Abies alba, probably of Danish provenance and C-European origin (Larsen 1983), was used in the plantations early in this century, but is hardly planted any more. It grows to fairly big trees with dense crowns, but is not as well adapted as the N-American *Abies*-species mentioned. In recent years attacked by *Dreyfusia* which seems to be favoured by the mild winters and humid summers, cf. Bejer-Petersen & al. (1974).

Broadleaves

Acer pseudoplatanus, a native of C-European mountain forests with high precipitation and widely planted and naturalized in the oceanic-suboceanic NW-European lowland, incl. coastal W-Norway. In the Faroe Isles many big trees can be seen in the streets and in old gardens of Tórshavn (fig. 10). Widely planted in gardens and in good soil in the plantations. Flowering and fruiting regularly, and occassionally self-sowing. Young plants may suffer from partial dieback of shoots, whereas older trees are unharmed. Most likely all plants are from seed of Danish provenance. To find out if any selection has taken place, material from trees doing well along the Norwegian coast was introduced a few years ago.

Sorbus. The old introductions from Denmark and maybe Norway of *S. aucuparia* and the apomictic *S. intermedia* have resulted in many big specimens in streets and gardens. Particularly is *S. intermedia,* produced by Hedeselskabet, often planted due to its resistance to strong winds. In spite of their ability to grow into big specimens they expose lack of perfect adaptation, being somewhat sparsely and irregularly leaved, often attacked by rust, and flowering and fruiting only some years (especially so *S. intermedia*).

On the contrary *S. mougeottii,* also an apomict, native to the Vosges and W-Alps, expose a dense, healthy foliage and regular and abundant flowering and fruiting. *S. intermedia* was fixed as subcontinental with parents in the Baltic after the last glaciation (Liljefors 1955), while *S. mougeottii* arose with maybe the same parent species, but of oceanic race. *Sorbus aria,* also native to

W-Europe S of Scandinavia, is similarly well adapted.

Other European trees doing fairly well are *Fagus sylvatica* (origin Risskov, Jutland, and also *F. s.* 'Atropunicea'), *Fraxinus excelsior, Ulmus glabra,* and *Alnus incana.*

Among the well adapted European shrubs or small trees (origins unknown) are *Taxus baccata, Buxus sempervirens, Clematis alpina, Cytisus* x *praecox* (hybrid with SW-European parents, *C. multiflorus* x *purgans* from cloud-zones), *Clematis alpina, Hedera helix* incl. the Irish clone 'Hibernica', *Ilex aquifolium, Laburnum alpinum, L. anagyroides, Lonicera periclymenum, Rhododendron ferrugineum, Ribes alpinum, Rosa pimpinellifolia, Viburnum lantana.* Rather well adapted are *Salix caprea, S. cinerea,* and *S.* x *smithiana.*

Kaukasus

The W-slopes of Kaukasus and adjacent Turkish mountains facing the Black Sea receive a high precipitation. *Abies nordmanniana* from here grows rather well, however slowly, forming a dense crown. Like *A. alba* in recent years suffering from *Dreyfusia*-attacks. *Rhododendron ponticum* from the same region and *Prunus laurocerasus* from here or Balkan are also doing well, when sheltered.

East Asian cloud forests

High mountains with temperate climate at higher elevations and influenced by monsoons and typhoons causing fogs and high rainfall in the summer, are obviously of interest when considering lignoses for Faroese conditions.

Japan

Larix leptolepis. For more than 50 years used in plantations and gardens, produced by Hedeselskabet from seed from Danish plantations. A strong species, even in poor soils, and rooting well as a pioneer. Has grown to 16 m in 50 years. Badly shaped if not in some shelter. Its hybrid with *L. decidua, L.* x *eurolepis,* produced in Danish seed-orchards, is well adapted but less vigorously growing. (*L. decidua* is not as valuable as the preceeding ones).

Alnus maximowiczii. Plants of Nikko-origin planted 1984 is growing perfectly well. Resembling its relative, *A. sinuata.*

Sorbus commixta. An origin from Mt. Tateyama collected by the Nord. Arb. Exp. 1976 is well adapted, getting bright crimson autumn-colour.

(Japanese species doing rather well are *Abies homolepis,* partly from comm. nurseries, partly from Odaigahara and Kamegamori, and *Cryptomeria japonica* of unknown origin, growing slowly in shelter and without damages. Also *Chamaecyparis pisifera* and *C. obtusa. Berberis thunbergii* to be seen in some gardens).

Korea

(Recently introduced material of *Abies koreana* collected by the Nord. Arb. Exp. in Cheju-do and Doe-kyu San starts well. Origins of *Sorbus commixta* are less promising than the Japanese material).

China

The southern central mountains in Sichuan and neighbouring provinces (trees from this region have not yet been tried). A number of shrubs, which are well adapted in spite of their very southern natural range, are all from commercial nurseries: *Juniperus squamata, Berberis candidula, B. verruculosa, Clematis montana, Cotoneaster bullata, C. dielsiana, C. horizontalis, C. salicifolia,* clones of hybrids such as *C.* 'Brændkjær', *C.* 'Skogholm', *Deutzia scabra* and hybrids (Chinese or Japanese), *Euonymus fortunei, Hydrangea petiolaris, Lonicera henryi, L. nitida, Rosa moyesii, Sinarundinaria murielae* (bamboo), *Sorbus vilmorinii* (apomictic, loaded with ripe fruits in Nov.)

South America

Nothofagus antarctica, N. betuloides (evergreen), and *N. pumilio* (forming treeline) were in 1975 together with other species from the southern Andes Mts. and Tierra del Fuego transferred as plants to the Arboretum in Hørsholm and in the following spring to Tórshavn. The Tierra del Fuego origins proved to be very well adapted, and 6000 plants of the three species were therefore collected 1979 by the „Danish Scient. Exp. to Patagonia and Tierra del Fuego" and transported directly to the Faroe Isles (Madsen & al. 1980, Ødum 1989). *N. antarctica* appears to be a good pioneer. So far the three species keep up in growth rate with the best conifers (fig. 8-9).

The following species of shrubs and small trees, most of them evergreen, are very well adapted: *Azara lanceolata, Berberis buxifolia, B. darwinii, B. empetrifolia, B. ilicifolia, B. linearifolia, Buddleia globosa* (flowering proliferously, pollinated by flies), *Chiliotrichum diffusum, Chusquea couleou* (bamboo), *Drimys winteri, Embothrium coccineum* (fig. 7), *Escallonia alpina, Fuchsia magellanica, Maytenus magellanica, Ovidia andina, Pernettya mucronata, Ribes cucullatum.*

Fig. 7. *Embotrium coccineum* (Proteaceae) from Bahia Inutil, Tierra del Fuego, flowering in Tórshavn. S.Ø. phot., 23 June 1986.

(Rather well adapted are the slow-growing conifers *Araucaria araucana, Fitzroya cupressoides, Pilgerodendron uviferum, Saxegothaea conspicua*).

Tasmania

Athrotaxis cupressoides (Taxodiaceae), *Drimys lanceolata, Eucalyptus coccifera,* and *Leptospermum humifusum* appear well adapted. *Athrotaxis cupr.* and *Eucalyptus cocc.* form treeline in Tasmania at 1200-1300 m alt. (Wardle 1974).

New Zealand

A number of evergreen or wintergreen broadleaves collected by the Nord. Arboretum Exp. (Søndergaard & al. 1977) at high altitudes on the South Island are very well adapted, rich in flowers, and some of them self-sowing: *Aristotelia fruticosa, Cassinia vauvillersii, Coprosma pseudocuneata, Hebe* spp. (e.g. *Hebe cockayniana, H. epacridea, H. odora, H. pauciramosa, H. petriei, H. rupicola*), *Hoheria glabrata, Neopanax colensoi, Olearia ilicifolia, O. moschata, O. nummulariifolia, Senecio bidwillii.* Giant perennial herbs native to New Zeland, may become a gain for Faroese gardens as *Aciphylla aurea* (Umbelliferae) and *Phormium cookianum* (Agavaceae), also collected by the Arb. Exp., in Tórshavn are undamaged and flowering. (Slow-growing but apparently hardy are *Libocedrus bidwillii* and *Podocarpus* spp., most promising the natural hybrid *P. nivalis* x *hallii*).

Exceptions

A few species, which are well adapted, are not clearly confined to oceanic climate zones or mountain cloud-zones: The disjunctly occuring and apparently climatically rather indifferent Eurasian *Hippophaë rhamnoides* and circumpolar *Potentilla fruticosa,* and the Eurasian continental *Lonicera ruprechtiana, Sorbaria sorbifolia,* and *Syringa josikaea.*

Species failing to adapt

Below is mentioned a number of species which have proved to be less well adapted and for that reason less valuable in plantations and gardens or complete disasters, though staying alive in some cases.

Rather bad adaptation

Europe. *Pinus sylvestris,* tried years ago in the plantations, has perished, while a few trees in gardens are not quite bad. The latter ones may bave been picked in W-Norway by garden-owners. A number of origins from Scotland and W-Norway are now being tested (e.g. Loch Maree, W-Scotl. and Vøringfos, V-Hardanger). *Picea omorika* grows extremely slowly, and so do *Aesculus hippocastanum, Tilia cordata,* and *T. europaea.* Some species do not stop growing in proper time and suffer from repeated diebacks: *Alnus glutinosa, Corylus avellana, Populus canescens* (and *Populus* hybrids with American-Eurasian parent material: *P. tremula* x *tremuloides, P. maximowiczii* x *trichocarpa* clone OP42, *P.* 'Berolinensis'), *Prunus cerasifera, Salix acutifolia, S. alba, S. fragilis, Sambucus nigra* (flowering Aug.-Nov.). Other species start growing too late and mature their shoots incomplete: *Acer platanoides, Quercus petraea, Q. robur*. Too continental and flushing much too early are *Larix sibirica* and *Lonicera coerulea*.

E-Asia. *Rosa rugosa* grows well but flowers sparsely and much too late to develop heps.

E-North American species such as *Kalmia latifolia* and *Vaccinium corymbosum* need warmer summers and grow poorly.

W-American *Alnus rubra* does not stop growing in the fall.

Southern Hemisphere. Low latitude/low altitude material and material from the transition zone between forest and steppe (rainshelter) in S-America and New Zealand may require warmer summers and/or less wet soil conditions. This is discussed and exemplified in Ødum (1989). Trees such as *Nothofagus procera* (S-Am.), *N. menziesii* (Tasm.), and *N. solandri* var. *cliffortioides* (N.Z., where forming treeline) suffer from diebacks.

Very bad adaptation

Eurasia. Some continental and/or mediterranean species demanding much warmer summers expose hardly any growth and/or severe dieback: *Acer campestre, Cornus alba, Corylus colurna, Fraxinus ornus, Pterocarya fraxinifolia, Ulmus carpinifolia.*

N-America, similarly: *Acer negundo, Cornus stolonifera* (not from the West), *Larix laricina, L. occidentalis, Picea pungens, Thuja occidentalis.*

Discussion and suggestions

Plant geographical aspects

From the results of introduction and cultivation of exotic trees and shrubs, it is evident that the lowest altitudes of the Faroe Isles have very much in common with the ecoclimatic conditions prevailing in the cool temperate forest zones of coastal NW North America and Tierra del Fuego, as described by Tuhkanen (1987), maybe less with those of southern New Zealand and Tasmania, as the *Nothofagus* spp. from there are less well adapting. Discussing the composition of native floras, Tuhkanen (1984) states that a considerable mixing of zonal floristic elements is commonly observed in highly oceanic areas (incl. the Faroes): Northerly species due to the absence of high max. temps. in summer, and southerly species due to the mild winters and a long growing season.

The exotic species hitherto in cultivation in the Faroe Isles expose a similar mixtum compositum of flora-elements from various geographical areas. And so do the cultivated herbs (Rasmussen 1989). Or to put it the opposite way: The extreme oceanic conditions favour the possibilities of growing a tremendous variety of exotics because climatic extremes simply do not occur. In the older gardens and plantations it is almost impossible to get even a badly thriving plant killed unless it is drowned or eaten up.

It is, however, primarily plant material from homoclimatic coastal areas which is really well adapted to the cool summers and fluctuating spring conditions. Skre (1988), reviewing a comprehensive literature on frost resistance, concludes that coastal plant material is characterized by its adaptation to changing climate in the spring. The successful establishing of the temperate Southern Hemisphere species is a consequence of the Faroe Isles being unique to the Northern Hemisphere in having so mild winters and modest abs. min. temp. in spite of the high latitude. Most of the evergreens from S-America, New Zealand, and Tasmania growing well in the Faroes have been killed or are repeatedly being cut down by frost and desiccation in Bergen (Søndergaard 1989) and Denmark (Ødum 1986). The high humidity the year round is, of course, also favouring survival and growth of such species.

Another interesting feature is the abrupt shift from the treeline at 150 m alt., as indicated by a small plantation at Hotel Borg, Tórshavn (fig. 1), to the fastgrowing, fairly big trees in Gundadal plantation 100 m below (fig. 2). In the humid forests of Tierra del Fuego and Patagonia the transition from tall *Nothofagus pumilio* forest over a narrow band of krumholz of the same species to alpine tundra is similarly abrupt. In coastal Alaska, e.g. on Kodiak Isl. and at Valdez, the sudden altitudinal shift from big, fast growing *Picea sitchensis* to a scrub zone (*Alnus sinuata*) or alpine meadows is evident as well. The duration of snow-cover may influence the position of such strongly marked treelines, but hardly in the Faroe Isles where the temperature-sum, influenced also by exposure to wind and sun, seems to be the only factor responsible.

Pioneer species

100-150 years ago it must have been somewhat easier to get a tree started in a garden on the naked islands than in the areas laid out later for plantations. With centuries of accumulation of manure and waste around the houses and with some shelter from buildings and stonefences, only draining and weeding may have been needed. In the new plantation-areas all problems confined with impoverished wet soil and wind-exposure had to be overcome. Today the problems when planting outside the inhabited areas and old

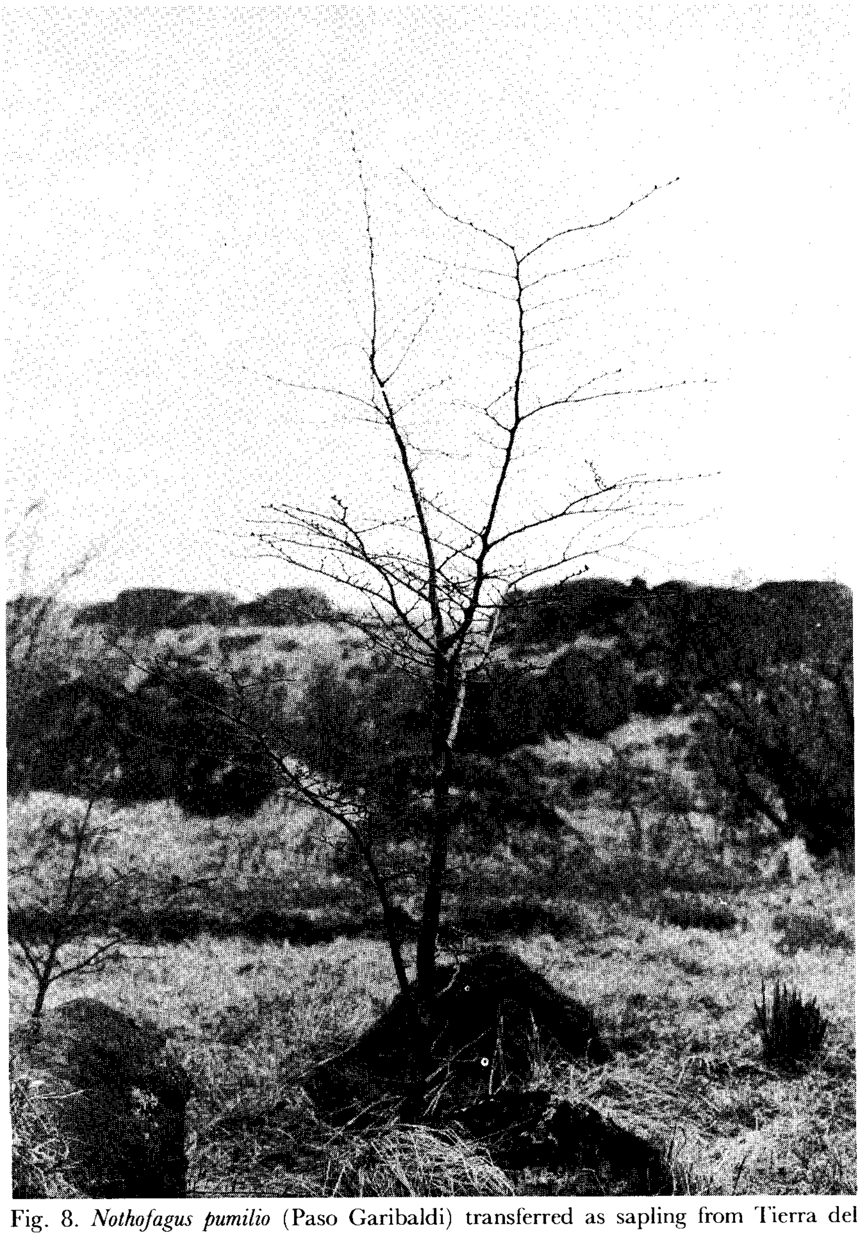

Fig. 8. *Nothofagus pumilio* (Paso Garibaldi) transferred as sapling from Tierra del Fuego to Hørsholm 1975, and to Tórshavn 1976. Obs. the 70 cm topshoot from 1983. S.Ø. phot., 26 March 1984.

plantations with improved conditions are exactly as bad as previously. In new gardens outside the old towns conditions are often being improved right away with rich soil from excavations downtown, incl. mineral soil, whereas the success of new plantations primarily depends on the right choice of origins of a very few possible species.

The species and origins to be recommended today for pioneer planting are limited to: *Alnus sinuata, Pinus contorta,* and *Picea sitchensis* (all Alaska-origins, the best choices to be encircled), *Larix leptolepis* (origin experiments should be carried out), and probably *Nothofagus antarctica* (Tierra del Fuego). In Alaska, e.g. at Cedar Bay W of Valdez, *Chamaecyparis nootkatensis* grows in very wet soils, and Alaska-origins of this species hence deserve to be tried as pioneers in the Faroes. *Nothofagus betuloides* and *N. pumilio* are being tested as such in a new plantation at Klaksvik (phot. and prel. results in Ødum (1989)).

Where soil conditions in new built-up areas are somewhat improved, additional species might contribute to the pioneer-shelterbelts, e.g. *Populus trichocarpa* (Alaska), *Acer pseudoplatanus, Sorbus intermedia, S. mougeottii, Laburnum* spp., *Betula pubescens* (Iceland), *Cotoneaster bullata, Rubus spectabilis, Ribes sanguineum,* and – in spite of some diebacks – *Salix* x *smithiana.*

North America

In the work with establishing and maintaining the Faroese plantations, the NW-American forests yield outstanding material. The results on species-level and the obvious gains when using very northern origins suggest further testing of particularly Alaska-origins. Of all the species with a wide N-S range of distribution, the northern material should be preferred in plantations as well as in gardens: *Chamaecyparis nootkatensis, Pinus contorta, Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla, Alnus sinuata, Populus trichocarpa,* and associated shrub species. Northern origins of *Abies amabilis* and *Tsuga mertensiana* might be included as well as the locally occurring northernmost coastal *Abies lasiocarpa* on Prince of Wales Isl. and Dall Isl. in the archipelago W of Ketchikan (Harris 1965, Worley & Jaques 1973).

In spite of slower growth (*Pinus, Tsuga, Populus*) and broader crowns and thicker branches (*Picea sitchensis*), the very northern origins of these species should be recommended as they adapt faster and are more resistant to stress-factors and pests (cf. the qualities of *Picea sitchensis* of Alaska-origin in W-Jutland shelterbelts (Nielsen 1988)). As the origins of *Abies grandis* and *A. procera* are uncertain, a testing of well defined origins is desirable. Results from Scotland may serve as a guideline (Lines 1987).

The SNS-expeditions 1987-88 to Alaska and NW-Canada made further collecting possible, also in coastal Alaska (Aug.-Sept. 1988, T. Leivsson, A.

Fig. 9. The evergreen *Nothofagus betuloides* (Lago Escondido, Tierra del Fuego) among *Pinus contorta* (Annette Island, Alaska) in Hoydal plantation, Tórshavn. Topshoot 40 cm. Transplanted directly 1979. S.Ø. phot., April 1986.

& S. Ødum) and resulted in seed and saplings of most of the above-mentioned tree species (and a broad spectrum of shrubs), e.g. some of the northernmost *Tsuga heterophylla* (Elfin Cove and Cordova), *T. mertensiana* (Valdez, Girdwood and N of Seward), *Chamaecyparis nootkatensis* (Cedar Bay, W of Valdez), *Abies lasiocarpa* Mt. Calder, Pr. of Wales Isl.), and a number of origins of *Populus trichocarpa* and *Alnus sinuata* from a broad zone between Copper R. Delta – Anchorage region – Kodiak. According to the distribution maps in Viereck & Little (1972, 1975) and Lines (1987) the natural range of *Tsuga heterophylla* should include parts of the Kenai Peninsula lowland. During the fieldwork in 1981 and 1988 we have, however, only met *Tsuga mertensiana* in Valdez, Portage, Girdwood, and Kenai Peninsula in a dark green form, which might have been mistaken for *T. heterophylla*.

The plantations in Iceland may undoubtedly be another good source for Alaska-material for Faroese plantations and gardens (and for W-Norway and the Scottish Highlands as well). Around 1940-1950 Hakon Bjarnason (1951, 1967) initiated collecting in coastal Alaska for forestry in Iceland, and a number of stands of well-defined origins are producing seed rather regularly. In 1985 T. Benedikz, Mogilsá Exp. St., provided seed of *Picea sitchensis* from plots of e.g. Prince William Sound origins, which might be difficult and expensive to hit in the wild in a good seed year, and the plants, produced in the Arboretum, were placed in Tórshavn 1988.

Other sources of Alaska-material of well defined origin might be the seed bank of the US Forest Service nursery in Eagle River and US Forest Service in Juneau. Provenances of Alaska origin to be tried might also be suggested by NISK, Stend (Bergen) and the Forestry Bureau in Mosjøen, N-Norway. Further NW-American material worth testing might be obtained from UK-Forestry Commission, Bush, Scotland, either from their seed bank or from stands doing well in the Highlands or along the NW-coast.

Europe and West Asia

On a species level the results so far suggest a strategy just opposite the above mentioned: Southern material native to mountains with high precipitation is apparently much better adapted in the Faroe Isles than northern material from Scandinavia (as indicated by *Acer pseudoplatanus, Laburnum alpinum, L. anagyroides, Sorbus mougeottii, Viburnum lantana,* a.o.). It would therefore be tempting to introduce more species and origins from the SW and to test various origins of a number of species for comparison, e.g. *Betula pubescens, Fagus* and *Fraxinus* from W-Norway, N-Jutland, Scotland, the Alps, and the Pyrenees. In the *Fagus*-forest at Lygrefjord, N of Bergen, originally planted 1000 years ago (Fægri 1954), selection may have resulted in a climatic race worth trying in the Faroes. The Calabrian *Abies alba,* genetically wider coded and adaptable elsewhere than the C-European origins (Larsen 1986), might be tried. The origins of the planted *Ilex* and *Taxus* are not known, but Norwegian and more southern origins should be planted for comparison.

East Asia

The cloud forest zones of SE-Asia are extremely rich in species which have avoided or escaped tertiary mountain foldings and subsequent glaciations at higher altitudes. In gardens in the temperate NW-Europe are grown a large number of species and cultivars originating from particularly the collecting carried out in S-China by Augustine Henry, Ernest H. Wilson, and Joseph Rock during the period of 1880-1930 (cf. Bean 1976). Even though the first selection in most of this material took place in England and the Arnold Arboretum, and further decrease in genetic span must have happened to it on its way through nurseries in S-England (e.g. Hillier), Holland and Denmark, surprisingly many species do well also in the Faroe Islands.

Information about the zonation of the W-Sichuan forests on the mountain slopes towards Sikiang (Tibet) and their main components has been compiled by Wang (1961). From his climatic maps (after Lu) it is obvious

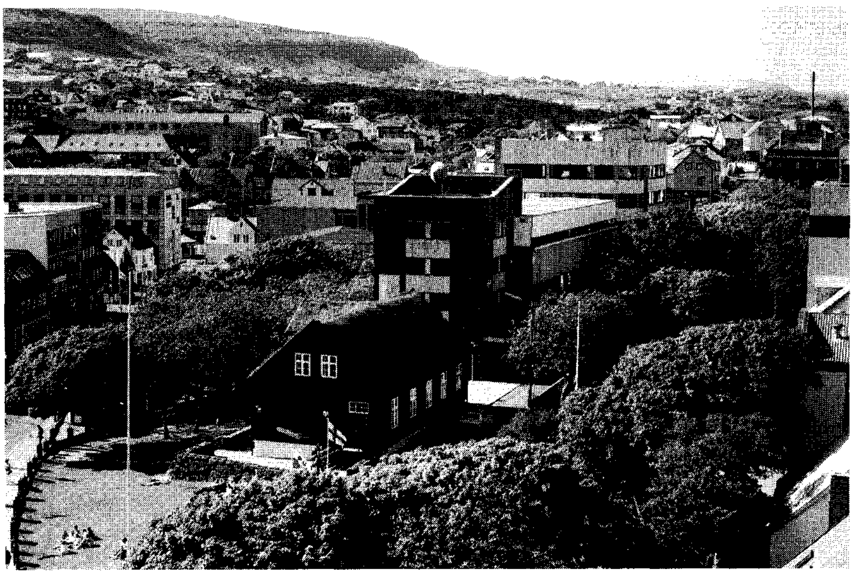

Fig. 10. View from the roof of Hotel Hafnia over downtown Tórshavn with old trees (in front) of *Acer pseudoplatanus* towards Gundadal plantation. S.Ø. phot., 22 June 1986.

that the ecoclimatic gradients of these mountain slopes must emphasize niches with rather Faroe-like climate, indicated by overlapping zones with: 1000 mm mean annual precipitation, 175 annual days with precipitation, mean Jan.-temp. and annual temp. curves of 4°C and 7°C almost congruent, mean annual rel. humidity 80% and foggy days 70 (more than elsewhere in interior China, and also higher cloudiness index), and little frost, even at higher elevations (drop-winds from N and W).

More material from the cloud forest zones of Japan, S-Korea, and Sichuan should be worth trying in the Faroe Isles. The results with a very limited number of species and individuals (e.g. *Sorbus commixta, Abies homolepis, A. koreana)* from the Nordic Arboretum Exp. to Japan and Korea (Nitzelius & al. 1978, Hagman & al. 1978) show that more material from these expeditions and other sources ought to be tried, e.g. *Abies sikkokiana, A. mariesii, A. firma, A. veitchii, A. holophylla, Chamaecyparis pisifera, Rhododendron* spp., *Weigela* spp.

From China it would be most interesting, of course, if a sufficient number of plants from new introductions of known origin could be grown on the spot exposed to the selective effect of the local climate. Material originating from the old introductions and not being available in Danish collections and nurseries due to lack of hardiness, might be obtained from botanical gardens and nurseries in Scotland, e.g. many of the Rhododendrons. As the genus *Abies* in general performs well in oceanic climates, the many attractive S-Chinese species should be tried, e.g. *A. sutchuenensis, A. faxoniana, A. squamata.*

In 1989 I got the opportunity to collect in the cloud forests and treeline zones (between 2000 and 4000 m alt.) in Taiwan and to rob the seed bank of Taiwan Silvicultural Inst. (thanks to the chief, Dr. J.C. Yang and taxonomist S.Y. Lu), thereby being able to bring back for testing in primarily the arboreta in Hørsholm, Bergen, and Tórshavn a fairly large number of species. Many of them are endemics, e.g. the treeline forming *Abies kawakamii* and species such as *Picea morrisonicola, Chamaecyparis formosensis, Shefflera taiwaniana, Sorbus randaiensis, Rosa transmorrisonensis, Deutzia pulchra, Gaultheria itoana, Pieris taiwanensis,* and several *Rhododendron* species with *R. pseudocrysanthum* and *R. rubropilosum* reaching altitudes far above treeline and therefore maybe of particular interest for Faroese gardens. According to Liu (1987) the subalpine *Abies*-forest of Taiwan has a mean annual precipitation of 4000 mm and an annual mean temp. of 5.7°C with 7.5°C for the warmest month and 0.6°C for the coldest.

Southern hemisphere

From the collecting expeditions 1975 more than 70% of the species introduced to the Faroe Isles adapted well. This encouraging result might inspire to introduction of additional species and origins not least because a number of the best growing and flowering species are represented by only a single or a few individuals (some now multiplied by cuttings). Based on the results with the South American material so far in cultivation it can be recommended to use Tierra del Fuego origins of all species of trees and shrubs distributed that far south, and to use origins from high latitudes and altitudes of species with a more northern range. The morphological and physiological variation from south to north seems to be stronger in *Nothofagus antarctica* than in any of the other species (Ødum 1989).

Further introductions from South America may not result in many more species, but from particularly the Chilean archipelago, from Chiloë to the western part of Tierra del Fuego, it is very likely that valuable origins of already cultivated species might be obtained. *Nothofagus nitida* (evergreen), not yet tried, should be collected at the southern limit of its range, 48°-49° S (Godley 1964) and the pretty, big-leaved *Podocarpus salignus* as well. It would be fun also to try to grow tree-ferns (*Dicksonia*) in Faroese gardens, if material from very cool localities could be obtained.

The good results with *Athrotaxis cupressoides* and the few other Tasmanian species indicate that further material from the higher altitudes of this island should be tried. The Tasmanian forester and commercial seed dealer, T.G. Walduck, Kingston, issues a seed list with many native species and might be consulted for special wishes.

Additional species and origins should similarly be introduced from the South Island of New Zealand (Søndergaard 1989). And then, of course, a special collecting tour should be made to the Snares, Auckland and Campbell Islands south of New Zealand, as they by Tuhkanen (1987) are regarded as being ecoclimatically almost identical to the Faroe Islands. No plants from these islands have been tried so far. Fraser's (1986) descriptions and photos from the islands give a good impression of the nature-conditions and the flora and some idea of how physiognomy of vegetation (not species composition) and soils might have been like in the Faroe Isles without influence of grazing and trampling. Windswept scrub-forests of species adapted to the cool summers and deep peat are composed by e.g. *Olearia lyallii* with big leathery leaves, *Metrosideros* sp. (Myrtaceae, red flowers), *Myrsine divaricata* and species of *Cassinia, Hebe, Coprosma,* and *Fuchsia.* From the strange flora of perennial herbs, some with enormous leaves and inflorescenses, should be collected for the gardens as well: *Pleurophyllum speciosum, Stilbocarpa* spp., *Bulbinella rossii, Anisostome,* o.a. According to Fraser a *Picea sitchensis* planted on Campbell Island, 52°30'S, has grown to 6 m in 60-80 years.

Fig. 11. Airplanes and plastic-bags have caused a revolution in transplanting possibilities. A Hercules from the Danish Airforce has just landed on the Faroe Isles with Alaskan plants. S.Ø. phot., April 1984.

In addition to the introduction of material from the wild it might be worthwhile trying more of the material from the Southern Hemisphere already in cultivation in the NW of the British Isles, particularly species and cultivars of shrubs originating from the high elevations of New Zealand and Tasmania. On the contrary there will probably be less gain from imports of the older South American material, which in most cases originate from central Chile, e.g. the Valdivia-region and northward on the mountain slopes towards the Central Valley, where summers are long and fairly warm (Bean 1976, Elwes & Henry 1913, Morley 1979).

Greenland

Nature conditions

From a tree-planting point of view only Southwest Greenland between 60°N and the Polar Circle is to be considered, and here first and foremost the subarctic zone at 60°-61°15'N. In this southernmost region the landmass between the icecap and the ocean is mountainous with 1000-2000 m ridges separated by glacier-eroded valleys and deep fiords oriented mainly NE-SW and declining towards a coastal archipelago. Owing to the polar icedrift the climate of the outer coastal areas is cool and foggy in summer with av. temp. for the warmest months around 5°-6°C, whereas the valleys at the heads of the fiords not far from the icecap have av. temp. for July and August of 10°-11°C. Accordingly a fairly steep climatic gradient is evident over a 50-100 km zone, markedly influencing the distribution of native species, the formation of vegetation, and the possibilities for tree-growth.

In a phytogeographical interpretation of this region Feilberg (1984) divides the region into climatic-vegetational zones ranging from lowarctic-oceanic to subcontinental-subarctic, the latter with scrub-forest of *Betula pubescens* (fig. 13-14). The precipitation within the region varies much depending on topography, exposure, and distance to the ocean with an annual av. from 700 to 1100 mm, lowest in March-May. Particularly critical to tree-growth are the frequently occuring desiccating foehns and sequences of cold summers, or just a single cold summer preceeding a severe winter. Various biological and ecological aspects of the subarctic birch forest zone in SW-Greenland are dealt with in further details in Fredskild & Ødum. 1990.

The Norse Landnam resulted in cutting and grazing, and sheep-farming has been re-introduced in the present century. Until 1950 boat-expeditions from the coastal towns to the interior fiords for cutting of scrub for fuel were a normal practice. The past and present impact on vegetation and soil (low water-retaining capacity: erosion) is described and discussed by Oldendow (1935), Jacobsen (1987), and Fredskild (1988). Evidently conditions favouring presence and dispersal of natural scrub have deteriorated over vast areas, and so have, as a consequence, the better sites for possible afforestation.

The climatic and edaphic conditions in the Godthåbsfjord-region are rather similar, whereas in Søndre Strømfjord they are highly different. In the interior Godthåbsfjord the precipitation is still fairly high, and with an av. temp. of 9.7°C for June and Aug., and 10.9°C for July (recorded at Kapisigdlit E of Qorqut) the valleys carry a rich natural vegetation with scrub of *Salix glauca,* in moist sites with *Alnus crispa* and *Ledum groenlandicum,* and in dry sites with *Betula nana.* The growing season is a little shorter than in Narssarssuaq. The favourable climatic and vegetational conditions resulted in the other Norse settlement in this region, likewise causing changes in the vegetation (Fredskild 1981). Sheepfarming re-introduced in Qorqut and other places during the first half of this century was given up 1950-60.

In the region of interior Søndre Strømfjord, separated by mountain ranges from the distant outer coast, the environmental conditions very much resemble those of the transition-zones between arctic-subarctic semi-deserts and treelines at high latitudes in interior N-America, e.g. on the Yukon plateau. The growing season is short, lasting from first week of June till last week of August, with av. temp. for July just above 10°C, but due to the high latitude with daily max. temps. in mid-summer often getting up around 20°C. This results in a heat-sum just above the 600 degree-days (treshold 5°C) normally correlated with treeline (Sarvas 1966). With a low humidity and an annual precipitation below 250 mm, the S-facing slopes carry a very sparse vegetation, and only because of permafrost preventing or delaying drainage, the outwash-plains and N-exposures carry a closed vegetation with low scrub of *Salix glauca* and *Betula nana.* Salt lakes are present in the area (Böcher 1949). *Alnus crispa* is found in more humid areas further West (Fredskild & al. 1990). The top-soil is loess rich in slowly decomposing leaves, etc.

Where bordering roadsides and gravelpits (surplus water) and where receiving melt-water from above, the normally 1 m high *Salix*-scrub grows to 2-4 m, indicating that water deficit besides low temperatures is a factor markedly limiting tree growth, but also illustrating potential forest- or treeline conditions, provided drought resistant origins adapted to a very short season and with a proper timing of growth could immigrate or be introduced. *Salix glauca* simply does not have the genes to grow to bigger dimensions. Similar localities with unusual high willow scrub-forest indicating a forest climate are described from a valley SW of Søndre Strømfjord (Secher & al. 1987) and from far north of the present treeline in Labrador (Maycock & al. 1966).

The different immigration routes of *Betula, Alnus,* and *Sorbus* and the local geographical barriers complicate the definition of the subarctic zone and potential treelines, cf. Böcher (1979). Also Tuhkanen (1984) has trouble with a proper ecoclimatic classification of SW-Greenland due to the very great local climatic differences in the region. He concludes that limited areas belong to the northern boreal zone. In a recent paper I have discussed the treeline-aspects further (Ødum 1990), suggesting particularly *Sorbus* as being a convincing indicator of a potential coniferous forest-zone, and concluding that the treeline conditions in SW-Greenland resemble alpine treelines and not the polar-treelines of the eastern continents.

Introduction and planting of exotics

In the above-mentioned paper the epochs of planting initiatives and their main results are surveyed. Summarized they can be divided as follows:

1846-1952: Scattered planting or sowing of *Picea abies* at Lichtenau fiord (Herrnhut missionaries 1846: C-Eur. origin?), no trees remain. On initiative of L.K. Rosenvinge sowing 1892 of *Picea abies* and *Pinus sylvestris* (origin N-Norway) at the head of Tunugdliarfik fiord near Narssarssuaq, 6 pines and 1 spruce remain, 4-5 m (fig. 15). Around 1930 C. Syrach-Larsen sent seed and plants of various northern boreal species of known origin to the Agric. Sta. in Julianehåb, where probably all material soon perished (lowarctic outer coast); maybe except from a *Picea abies* (Finland?) planted in Qingua valley (suboceanic-subarctic), 2.4 m, repeated diebacks. *Picea glauca* and *Abies balsamea* (Battle Harbour, Labrador, 53°N) transferred 1944 as saplings by R. Bang-Christensen to Ivigtut (61°12'N), where now 3 m, tops dying back.

1947: C.H. Bornebusch, C.A. Jørgensen, and C. Syrach-Larsen suggest larger-scale planting, and Bornebusch and Jørgensen carry out a planning tour choosing future sites for planting (interior fiord-landscapes, W-exposures). Planting initiated 1953 with northern boreal species and origins and the plantations since 1956 extended and maintained by Poul Bjerge, settling in Upernaviarssuk and establishing a nursery. Seed and plants in the first years received via the Danish State Forest Nursery and the Arboretum (P. Chr. Nielsen involved), later mainly from the State Forestry of Iceland (*Larix sibirica, Pinus contorta* of coastal Alaska-origin). 1976 ff planting of material from the arboretum-expeditions to the Rocky Mts. 1971 and Alaska-Yukon 1981, of *Pinus contorta*-origins from Yukon-B.C. (via NISK, Norway), and of Fennoscandian material. The experiments were at that time extended northward to Qorqut, Godthåbsfjord (suboceanic-subarctic, 64°15'N) and Søndre Strømfjord (extreme continental lowarctic or subarctic, Arctic Circle (fig. 12)).

On the 1971-expedition (L. Feilberg, S. Ødum) and the 1981-exp. (J. Dietrichson, T. Leivsson, S. Ødum) seed was collected from in general several individuals of a population. Of the main conifers cones were collected from 10-20 well spaced trees. In Alaska-Yukon 1981 additional material of small, selfsown plants (of the conifers in most cases 100-400 from each population) were pulled or dug up, preferably on slopes or roadsides with loose soil making it easy to lift an intact, dense root-system. The plants

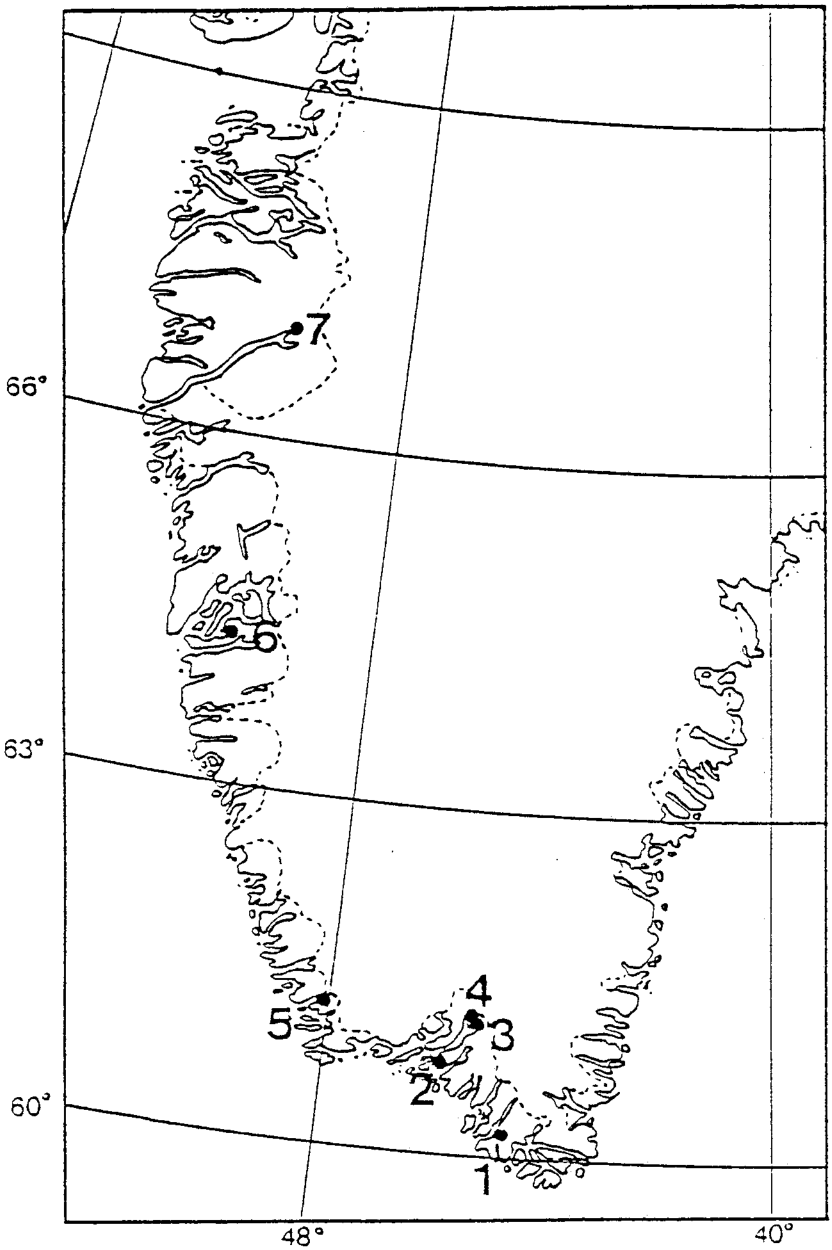

Fig. 12. The main planting localities in SW-Greenland. 1: Kugssuak. 2: Upernaviarssuk. 3: Narssarssuaq. 4: Qanagssiassat and „Rosenvinge's Trees". 5: Ivigtut. 6: Qorqut. 7: Søndre Strømfjord.

were bundled with moss around the roots and wrapped tightly in plastic bags with tops free. In this way material was secured from stands with no seed and from treeline-stands with doubtful seed-quality. Furthermore, this procedure made it possible to start a testing of the origin in the following year. The same method was used when collecting at treelines in Fennoscandia. Reports from the expeditions are kept in the Arboretum.

At the Upernaviarssuk Exp. St., Bjerge maintains archives with records of all activities, incl. introduction, sowing and planting, and similar records and maps covering the activities from 1976 ff are kept at the Arboretum as well.

Only the *Pinus contorta* origins (the NISK-material) were planted in mixed groups. Almost all other numbers (origins) have been planted in alternating rows or groups (e.g. *Pinus-Picea-Abies-Picea*) oriented in the same direction from a well defined baseline, where labelled in recent years with alu-rings of the type used for geese and ducks. If some labels disappear in the wilderness, the system is easily reconstructed. Planting has in general taken place in not too humid soil in openings in not too windswept scrub of *Salix glauca, Betula pubescens,* and *B. glandulosa* (at Qorqut and Sdr. Strømfjord *Salix glauca* and *Betula nana*).

Scribing has been preferred when planting, due to the small-sized plants used and to prevent erosion around the plant (wind, water) and desiccation of soil and plant. When planting in August the plants will root in the soil the same autumn and flush in proper time next spring. Bare-root plants have been preferred, if from sowing in the Arboretum or Upernaviarssuk normally as 3/0 or 3/1 plants. If picked at treelines, the plants may be 5-10 years old but still very small and with more dense tops and roots. In the Arboretum most *Pinus*-plants were potted in the spring prior to planting.

Results in the South

The situation of Upernaviarssuk Exp. St. and the three main localities for planting are shown on the map (fig. 12). Qanagssiassat plt. from 1953 and Kugssuak plt. from 1959 are fenced due to the presence of sheep. In Narssarssuaq, where no sheep are allowed (because of the airport), the plantings from 1976 and 1982 ff have been scattered to favourable sites over a fairly large area.

The topographic and climatic complexity of the region makes it difficult to evaluate the results very detailed. Over short distances there exist abrupt shifts in conditions such as drainage, wind-exposure (foehns as well as cold fiord-winds), occasional flow of cold airmasses through even minor depressions, distribution of either protecting or destructing snowdrifts, position of piling-up masses of ice from meltwater after foehns in winter, o.a. In general

Fig. 13. Qingua Valley, 10 km from the plantation in Kugssuak. View towards the North. Scrub of *Salix glauca* and (the dark on the slopes) *Betula pubescens* s.l.
S.Ø. phot., 3 August 1984.

the distribution and development of the natural scrub, where not destroyed by grazing, will indicate areas where it is worthwhile planting trees. Only the results in the plantations established in such more favourable situations are therefore considered in the following evaluation. To learn about their capacity, some species and origins (e.g. *Pinus contorta, Picea glauca, Larix sibirica*) have, of course, been tested in more harsh environments.

As Upernaviarssuk is located beyond the treeline towards the icefilled ocean (prostrate *Betula pubescens*, if any, and 30-40 years old 1-2 m krumholz of planted conifers (Feilberg 1985, Ødum 1979, 1990)) it does not make sense to incorporate in the present evaluation the great number of species, origins and cultivars which died after one or a few years in the nursery.

Only material known to have started growing after transplantation to the interior is considered of interest (casualties due to drought first summer after planting out are omitted).

The criterium for being placed in the better end of the hardiness-scale is a continued height-growth without damage of apical shoots most years or with only occasional dieback of no more than annual growth after unusual cold summers or in connection with a severe frost or foehn shortly after flushing. The best adapted species will hence be those not flushing too early

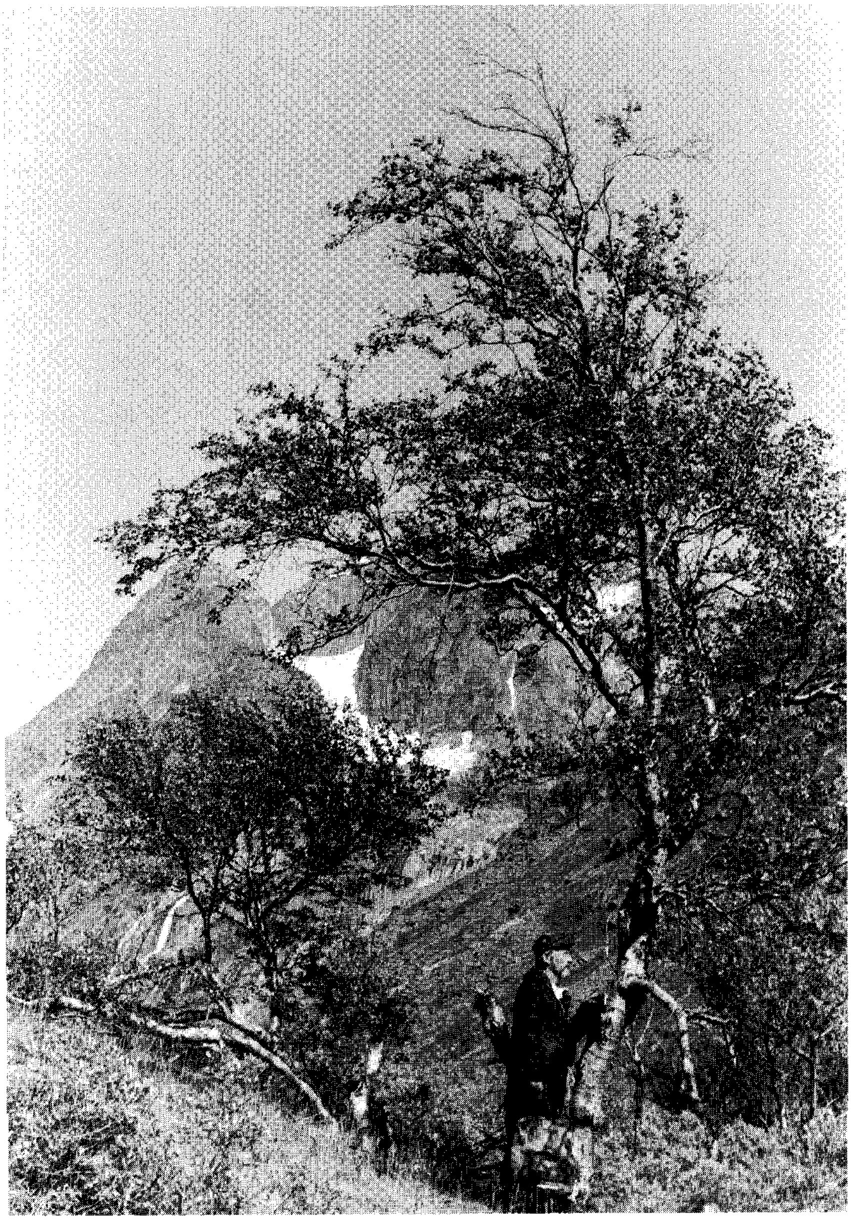

Fig. 14. Matti Sulkinoja (Kevo, Finland) studying a Mountain birch in Qingua (see Sulkinoja 1990). S.Ø. phot., 3 August 1984.

and finishing growth pretty fast, having hardened the tissue no later than early August.

For seedlings of many tree species growing in subarctic and subalpine environments it is normal with a 10-15 years period to get established and start increasing height-growth markedly. When planted in SW-Greenland under rather similar conditions, the start will be slow as well. *Pinus contorta* is the only conifer taking off pretty fast, while e.g. *Picea glauca* is fairly slow, *P. engelmannii* very slow, and *Abies lasiocarpa* quite unpredictable, maybe adding 1-2 cm to the height for 10 years without exposing any sign of not being well adapted. Hence slow growth the first many years, if a normal habit, will be no disqualification in comparison with other species.

In most northern boreal and subarctic/subalpine regions a long-lasting snowcover protects small trees, and may delay a proper evaluation of their hardiness until they have grown above normal snowdepth. In Greenland, where the foehns may melt the snow any time during winter and spring and expose soil and small plants to frost and desiccation, the planted material can be rather reliably evaluated from an early stage.

North America

Abies lasiocarpa. A promising species, but a very slow starter. A few plants of 8 origins from the central Rocky Mts. ranging from Utah and Colorado to Idaho and Montana were planted in Narssarssuaq and some of them in Kugssuak. Two northern origins, Cold Springs (Laramie Mts., Wyoming) and Stanley (Idaho) are best. Plants collected 1981 on Keno Hill, 64°N, 1100 m, Yukon, appear perfectly well adapted with good colour, fat buds and earlier cease of growth. Keno Hill is the northernmost known locality for *Abies lasiocarpa,* which here, together with *Picea glauca,* forms the subalpine forest at 1000-1300 m and is reaching 1550 m as scattered krumholz.

Picea engelmannii. The growth and hardiness of this species (Colorado origins) in Hallormstað, E-Iceland (Blöndal 1982) encouraged the planting of it in Greenland 1976 ff. Owing to a very dry summer after spring-planting in Narssarssuaq 1976 only a few plants survived. They started extremely slowly (like in Iceland) but have grown steadily with still longer and fatter topshoots, the best one being a specimen of Red Mtn. Pass origin, Colorado (top 1986: 7 cm, 1987: 14 cm).

Picea glauca. In Kugssuak stands of an origin from Knik River valley, N of Anchorage, Alaska, planted 1959, had in 1987 grown to 2.6 m (max. 3.4 m) with 10-25 cm topshoots. The cool test-summers 1982-84 caused damaged

Fig. 15. Poul Bjerge at the „Rosenvinge's Trees", *Picea abies* and *Pinus sylvestris* (N-Norway), sown 1892 at Qanagssiagssat. Obs. the effect of the foehns (flagged crowns). S.Ø. phot., August 1983.

tops on 2/3 of the trees (details and photos in Ødum 1990). The origins from Alaska-Yukon dug up 1981 and planted 1982-83 expose similar or better adaptation with earlier cessation and ripening of shoots if from slightly higher latitudes and higher altitudes (table 1). The low altitude-southern origins look a little better in suboceanic Kugssuak than in subcont. Narssarssuaq. The longday-adapted origins from 64°-67°N are extremely slow-growing. The origin, so far best adapted, seems to be Broad Pass (E of Mt. McKinley), 63°15'N, 550 m, with annual height-growth increasing from 10 cm 1986 to 20 cm 1988 (fig. 19). In comparison origins from Saskatchewan, Ontario, and Labrador are regularly damaged, obviously demanding warmer late summers for hardening. The Sask. and Ont. origins, approx. of the same age as the Knik R. origin, had in 1987 grown to 0.9-1.7 m and 0.9-1.3 m respectively. A few specimens originating from seed collected at 1500 m alt. in Black Hills, S-Dakota (44°20'N), were planted in Narssarssuaq 1976 and are surprisingly hardy in spite of late hardening shoots.

Picea sitchensis x *glauca* (*P.* x *lutzii*). Stands of this hybrid, from seed from a population in Kenai peninsula, were also planted 1959 in Kugssuak (fig. 16), next to the Knik R. material of *Picea glauca* (see above). Morphologically

Fig. 16. *Picea glauca* x *sitchensis* (Kenai) and at left margin a *Larix sibirica* planted 1959 at Kugssuak. S.Ø. phot., 14 July 1987.

the individuals vary from rater *sitch.*-like to rather *glauca*-like. Cones are *glauca*-like. They have grown faster than *P. glauca,* to 2.8 m (max. 4.1), but exposed a higher percentage of and more severe damages after the cool test-summers 1982-84, with the more *glauca*-like individuals in the hybrid-swarm being hardiest (fig. 20). In 1987 almost all trees had recovered, forming one or more new leaders. Older forkings caused by previous damages were to be seen as well.

From a more interior population at Tsaina R., N of Valdez (*P. sitchensis* entering along Copper R.), was in 1981 collected plants at 550 m alt. just below treeline N of Thompson Pass. They are so far undamaged (planted 1982-83) and may be hardier than the Kenai-material traditionally cultivated.

Pinus contorta. The first plantings of material of this species were made in Kanagssiassat 1968. The seed was from a Danish stand (Klosterheden, plot 617, Wash. origin). The plants grew fast until 1983 with 5-40 cm topshoots, exposing only occasional dieback of some lateral twigs and some dead needles after foehns. But after the severe winter 1984 the trees looked just miserable with damages as exposed in Danish plantations of coastal *Pinus*

Fig. 17. *Picea glauca* x *sitchensis* (Kenai) planted approx. 1965 in Qorqut. Compare with fig. 16. S.Ø. phot., 4 August 1986.

Fig. 18. Young *Picea glauca* in Arctic Village, Brooks Range, 68°07'N, where the species forms forest close to treeline. The growth is comparable with that of the young *Picea glauca* transplants in Greenland. S.Ø. phot., 2 September 1988.

contorta originating from S of 52°N (Wellendorf & Feilberg 1984). Later introductions from Iceland of Alaska coast origins, ranging from around Hollis to Haines and Skagway (fig. 21), are so far unharmed and are starting rather fast with Skagway and Haines as the obviously best adapted.

Some *Pinus contorta* var. *latifolia* from various localities in the Rocky Mts., USA, were planted in Narssarssuaq 1976. They started very slowly and had in 1986 without major damages grown to max. 110 cm with topshoots of max. 13 cm (Highwood Mts., Montana).

The origins of *Pinus contorta* var. *latifolia* from Yukon-B.C., of which 900 plants were planted in Narssarssuaq 1982, are better adapted (fig. 22). They finish growth approx. two weeks earlier than the above-mentioned material and with a faster hardening of the shoots. 1986-88 their height-growth in favourable sites increased from 10-15 cm to 15-25 cm, and the formation of lateral buds and shoots increased from 1-3 to 3-4(5). Any convincing variation in hardiness and growth rate has not been observed. The only variation among the origins observed so far is for how many years they keep the needles. The origins are (from Yukon): Rusty Creek A, B, C, Carmacks East, Little Salmon Lake, McCabe Creek, Whitehorse East, Champagne, S-Canol Rd., and (from B.C.): Cassiar, Muncho Lake, Fireside. They range from 59°-63°28'N and 420-1150 m alt. The seed was collected by Gisle Skaret (1979), and the plants were provided by Jon Dietrichson, NISK. These origins are all from within the range of the well-defined northernmost race of the var. *latifolia*, mapped and discussed by Cheng & al. (1986). According to Wheeler & Guries (1982) this genetically distinct northern race survived the last (Wisconsin) glaciation in an unglaciated region of west-central Yukon. According to Lindgren & al. (1985) only Yukon-origins from N of 62°N tend to perform satisfactorily in northernmost Sweden and Finland due to their photoperiod-controlled early growth-cessation. The authors suggest Carmacks as the best choice.

Populus. Some species, origins, and clones tend to be able to grow to some size with only occasional diebacks. A plant of a *Populus trichocarpa* clone of Alaska-origin received from Iceland was transplanted from Upernaviarssuk to Ivigtut (61°12'N, NW of Julianehåb), where in approx. 10 years it grew to 5 m (1984). This and other clones perished in Upernaviarssuk 1982-84. Cuttings from the Ivigtut-tree together with a new input from Iceland and Alaska of various origins of *P. trichocarpa, P. balsamifera* and intermediate types have been multiplied and planted in Narssarssuaq, Upernaviarssuk, and at some sheep-farms in the district. In the natural scrub the soil is in general too poor in nutrients and in periods too dry for balsam-poplars. Where fertilized and watered (at habitations) some of them grow rather

Fig. 19. *Picea glauca* (Broad Pass) dug up 1981 and transferred from Hørsholm to Narssarssuaq 1982. S.Ø. phot., 29 July 1986.

Fig. 20. *Picea glauca* x *sitchensis* (Kenai), *P. glauca*-like with modest height-growth and obviously well adapted. Kugssuak. The prolongation of the uppermost shoots has not yet finished. S.Ø. phot., 14 July 1987.

well, but it is too early to predict their development and use.

Some Alaska origins of *Populus tremuloides* have been planted in Narssarssuaq and Kugssuak (Seward, Fairbanks, Steese Hwy., Ambler). Only the Fairbanks-plants (dug-up seedlings) tend in Narssarssuaq to grow to some size. When first established they might, like in interior Alaska and Yukon, be able to colonize very dry slopes from suckering roots.

Salix. Clones of some Alaska origins of *Salix alaxensis, S. arbusculoides, S. hookeriana,* and *S. borealis,* males and females, received from Bot. Gard., Akureyri, Iceland, and the Agric. Univ., Ås, Norway, have after a promising start in Upernaviarssuk been transplanted 1986-87 to localities in the inland, at some sheepfarms for shelterbelt-tests and elsewhere. They are also being planted in gardens in coastal towns. It is too early to predict the results.

Other species. In Upernaviarssuk *Potentilla fruticosa* (Montana-origin, prostrate, flowering) and *Shepherdia canadensis* (Fort Yukon, Alaska) have grown for some years without any damages. Both species are in Alaska found above and N of present treelines (Viereck & al. 1972, 1975).

Species and origins failing to improve, or passed away

In the following (+), (–), and –, indicate the better end of the bad, the worse, and the dead, respectively. Dead material is only included if having stayed alive for more than one season.

Abies balsamea, New Foundl. –; *Larix laricina,* Fairbanks (+), New Brunswick (–), Quebec –; *Picea mariana,* Steese Hwy. (+), Fairbanks (+), Ambler –, Ontario –, Labrador, Goose Bay –, New Fdl. –; *Picea pungens,* Colorado and Utah (+), *Picea sitchensis,* Valdez (–), Pr. William Sound –; *Pinus banksiana,* Ontario (–); *Pseudotsuga menziesii,* Upper Fraser R., prov. Mustila (–); *Tsuga heterophylla, Yacutat* (–); *Betula papyrifera,* West Lake, New Fdl. –; *B. p.* var. *neoalaskana,* Alaska –; *Populus tremula* x *tremuloides,* Danish material –.

(*Nothofagus pumilio,* Tierra del Fuego, planted 1982 in Kugssuak, died the first or second winter).

Eurasia

Larix sibirica. From the very beginning of the afforestation efforts considered a main species. The first seedlots were of prov. Sorsele and of a source Bograd, the latter provided by Finland. Of the many introductions of plants and seed following, I have not been able to sort out which of them are from native populations, from planted stands of known origin, or to what extent

Fig. 21. *Pinus contorta* (Skagway) with *Lupinus nootkatensis* sown for N-fertilization (no marked effect). Kugssuak. S.Ø. phot., 14 July 1987.

the source indicated actually is a stand in USSR or rather the railway station from where the seed was shipped (Krasnojarsk, Askiz, Haskaskoyo, Sagonar). Obviously all this material originate from the region between Baikal Lake and Novosibirsk, around 51°-54°N, 90°-92°E. Thousands of plants produced in Upernaviarssuk have been planted by Poul Bjerge during the last 30 years.

Their climatic adaptation is good with the var. *sukaczewii* from the Ural Mts. (58°50'N, 60°07'E) as the obviously best matching (fig. 23-24), and being without needles in the winter and early spring when the foehns are most damaging, is certainly an advantage. The older trees have now grown to 4-6 m. In the early summer new foliage is often somewhat yellow due to cold nights and fiord-winds, but as the terminal buds flush later than the

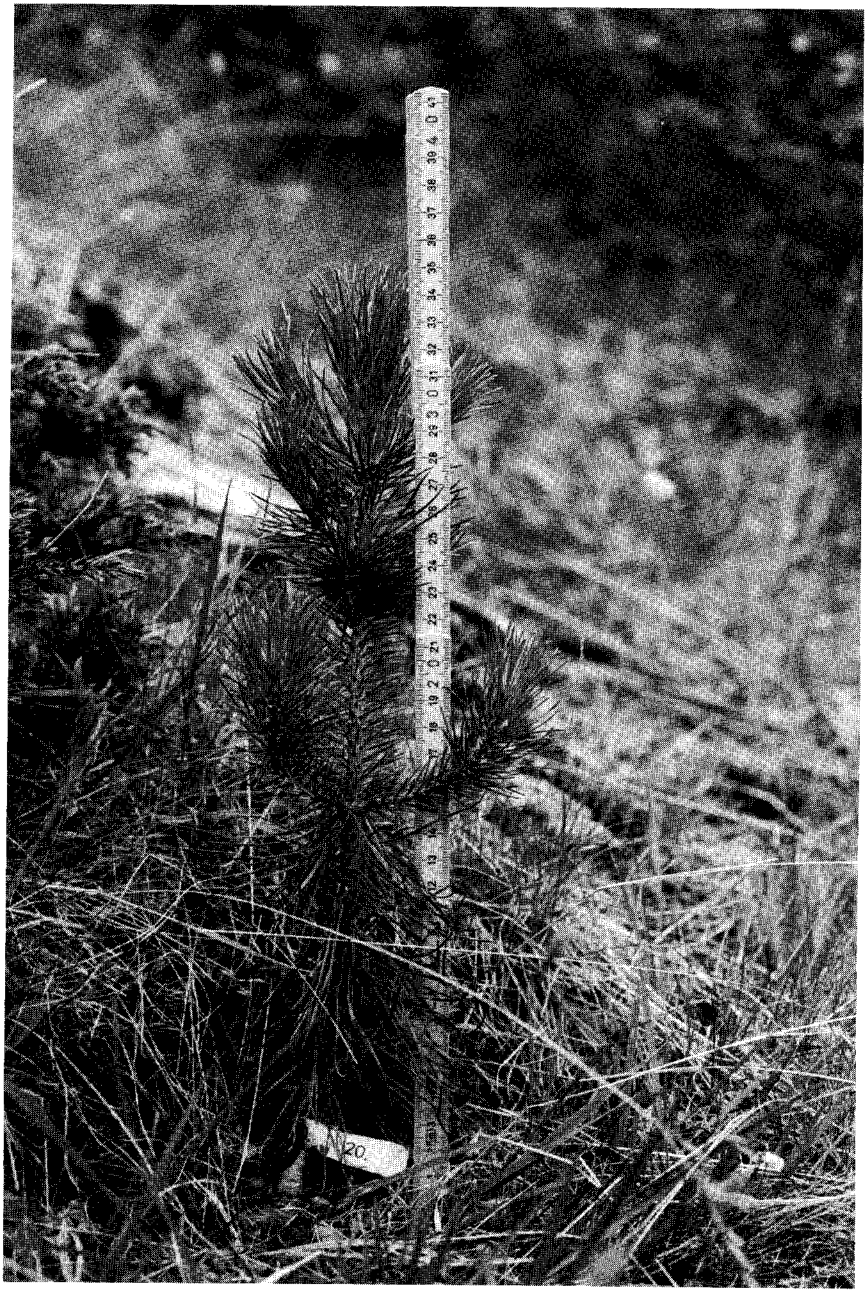

Fig. 22. *Pinus contorta* var. *latifolia* (left: Rusty Creek A, right: Muncho Lake), planted in Narssarssuaq 1982. Obs. the early cessation of growth. S.Ø. phot., 29 July 1986.

spur-buds, the new shoots are normally undamaged. Warm summers are strongly reflected by much wider annual rings and hence the increment: From approx. 1 mm width of annual rings in normal years to 5 mm in a year (1977) with av. temp. for the growing season 2°C above the av. for a period of 28 years, cf. phot. in Ødum (1990). The response is much stronger than in the native birch (Kuivinen & al. 1982) and in the planted spruces and pines. This can only be explained by the heat-sum controlled secondary growth of the terminal shoots. Accordingly the increment of even-aged trees in Narssarssuaq and Kugssuak is higher in Narssarssuaq, where summers are warmer. Even where planted in gravel and sand on the outwash-plain in Narssarssuaq, it grows quite well and may not least in such places depend on mycorrhiza with *Suillus grevillei* (Knudsen 1983).

An experiment with grafting of twigs from 10 trees, selected for hardiness and other qualities in Finland by Max Hagman, were carried out 1st June by K. Næss-Schmidt (1983), the Arboretum, on some of the larches in Narssarssuaq. The material emphasized: *Larix sibirica* var. *sukaczewii* Nos. (Finland) P.40, K.301, E.403, all Raivola; E.390, E.395, Pinega; K.319, SU.2956, Archangelsk; E.665, Nishnij-Tagilsk; and *L. sibirica* Nos. E.383, Novosibirsk; SU.2949, Voronesk. Each No. was grafted on 3 or 4 individuals, and some of all nos. succeeded, half of them 100%, in av. 82%. Two nos. seemed to be better climatically adapted than all other *Larix*-material with their thick shoots, earlier growth cessation and darker green needles: No. P.40 and No. E.390, both var. *sukaczewii*.

Larix sibirica from seed received from Iceland, with origins indicated as Altai, Sagonar, and Krasnojarsk, has been planted in recent years (Iceland reg. Nos. 577, 581, 579, and 576).

The imperfect stage of larch-cancer, *Potebniamyces coniferarum*, has occured scattered in the plantations over the last 20 years, particularly infesting young trees damaged by snowbreaks. The climatically severe 1982-84 period may have weakened the trees. At least the larch-cancer turned epidemic, killing 80-90% of the trees in the dense stands in Qanagssiassat and Kugssuak. To Narssarssuaq, where the trees so far have been very scattered, the disease has not yet spread. Similarly *Armillaria* appeared 1983-84 for the first time as a parasite with killing effect in a few spruces and pines.

Picea abies. The presence of the single remaining spruce (1983 4.8 m, girth bh 33 cm) of N-Norway origin among the „Rosenvinges Trees“ (fig. 15) may have inspired C.A. Jørgensen to try similar material. At least approx. 2000 trees, origin Helgeland, were planted in Qanagssiassat 1953-54. Very few remain, producing rather strong shoots but suffering from desiccation on the

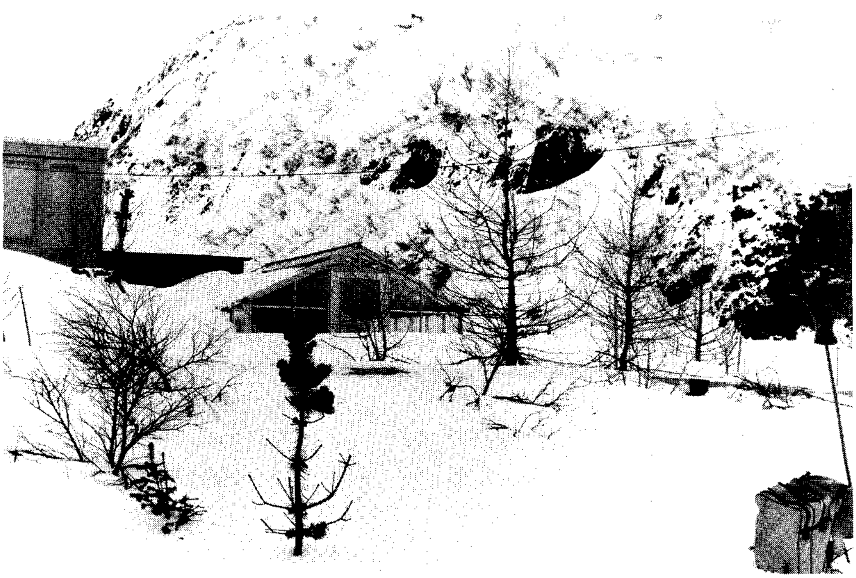

Fig. 23. Narssarssuaq 7 March 1984. In the foreground left a native *Salix glauca*, a frost- or foehn-injured *Picea sitchensis* x *glauca*, and a severely injured *Pinus contorta* (Alaska coast 55°-58°N). Behind some well adapted *Larix sibirica*. S.Ø. phot.

foehn-exposed side, from breaking under heavy snow, and from diebacks after cold summers. They have not grown higher than 2-3 m.

Plants dug up in N-Sweden (Teletöisen and Kiruna) and N-Finland (Inari, *obovata*-like), and from near treeline in eastern Hardanger Mts., 60°N, Norway, have been planted in Narssarssuaq. The Hardanger plants seem to adapt best. The others are hardy but slow-growing due to their high latitude origin.

Pinus cembra var. *sibirica*. Two plants of two origins, Son, Hakasska, 54°N, 90°10'E, and Turan, Tuvinskaja, 52°10'N, 94°E, were planted in Narssarssuaq 1976. The first origin is well adapted, now growing approx. 15 cm per year after a very slow start. According to Max Hagman (pers. comm.) who looked into the Russian seed certificate, the Son-material was rather collected at Biritsulsk, 53°27'N, 89°30'E. – Next to these trees was planted a *Pinus pumila* (Kamtchatka) apparently hardy, but growing very slowly. This shrubby 5-needled pine is confined to treelines in NE-Asia.

Pinus sylvestris. The remaining „Rosenvinges Trees", a Troms Fylke origin (Oldendow 1935), measured in 1983 when 90 years old 3.7-4.8 m, the biggest with 52 cm girth at bh (fig. 15). Annual growth in top of the flagged crowns (foehn-effect) were only 2 cm per year, probably due to a combined influence of day length and too moist soil conditions (looking like muskeg-pines). Similar N-Norway material (Kvenangen, Storefjord, and Aust Finmark) were planted in Qanagssiassat 1954-61. They grow slowly but steadily, having reached approx. 3 m, with topshoots now 15-25 cm. 1982-84 were planted some additional origins from Swedish and Finnish Lapland (Abisko, Teletöisen, Luleå, Lipakka, Peltovuomi, and Kevo: hardy, strong daylength-control), from treeline localities in Hardanger (Vøringfos, Vågslid, Uvdal), and from Scotland (Breamar). The Hardanger origins are best adapted. Luleå (lowland with high heat-sum) died in Narssarssuaq but has improved in Kugssuak. Breamar died rather soon. *Pinus sylvestris* var. *mongolica* (Ulan Ude and Hailar), tried in recent years, stops growing much too late and does not harden sufficiently.

Salix. From Bot. Gard., Akureyri, the following promising clones were transfered: *Salix glauca* x *phylicifolia* (female) 'Brekkuviður' (parents from Iceland), and cuttings of Icelandic *S. nigricans, S. lanata, S. myrsinites, S. phylicifolia,* and a *S. viminalis* selected in Kiruna, Sweden. All perform well in Upernaviarssuk, the latter being tried in shelterbelts in the inland, the others mainly in gardens.

Other species. *Lonicera alpigena* (W-Alps) is well adapted and flowering in Upernaviarssuk and Narssarssuaq. *Lonicera coerulea* (E-Alps), *Ribes rubrum* (no fruits) and *Sorbus aucuparia* (N-Norway: Alta and Porsanger fiords 69°N) have grown for many years in Upernaviarssuk without being severely damaged. *S. aucuparia* is here doing much better than *S. groenlandica*.

Species and origins failing to improve, or passed away

For explanation of signs, see p. 48. *Abies sibirica,* Sibiria and prov. Mustila, (–); *Larix gmelinii* var. *dahurica* (–), *L. g.* var. *koraiensis* (–), *L. g.* var. *kurilensis* (–), all three from seed harvested in stands planted at Tartu, Estonian SSR; *Picea asperata,* prov. Hørsholm Arboretum, –; *Populus tremula* x *tremuloides,* made in Denmark, –. Of *Abies sibirica* were planted 2800 plants in Qanagssiassat 1954-61, and only a few miserable specimens remain.

Results in the North

From the early introductions remain some *Larix sibirica* and *Picea glauca* x *sitchensis* (fig. 17) planted in Qorqut around 1960 and a few *Larix sibirica* in Søndre Strømfjord. In Sdr. Strømfjord *Larix* is repeatedly cut back, in some years almost to the ground, and most of the new growth has not hardened in

Fig. 24. Twigs with cones on *Larix sibirica* var. *sukaczewii* (Ural) in the phenological garden in Narssarssuaq, planted 1960 and 5 m high 1987. S.Ø. phot., 23 July 1987.

mid-August. In Qorqut the plants have grown to krumholz-like mounds not tending to grow much higher than 1.5 m. They were severely damaged 1984.

Of the Rocky Mts. species surviving a dry sommer after planting in Qorqut 1976 remain a few *Pinus contorta, Picea engelmannii,* and *Abies lasiocarpa,* having grown to 30-65 cm (1986), with only an *A. lasiocarpa* (Hungry Horse, Montana) undamaged. Some thousand plants of a broad spectrum, representing most species and origins of the conifer-material collected in the Rocky Mts. 1971, were planted in Sdr. Strømfjord 1976-78. Today I regret not having spent at least half of this material in Narssarssuaq, as almost all plants were killed 1982-84. Nevertheless, this fact reveals how limited the possibilities are. A few remaining *Picea engelmannii, P. glauca,* and hybrids from Idaho-Alberta grow extremely slowly (IUFRO Nos. 7004, Stanley, Idaho, 7017 Elpoco and 7018 Highwood Smt., both Alberta).

The material from Alaska-Yukon planted in Qorqut 1983 is in general better adapted with only the most coastal origins killed or repeatedly cut back (tabel 1).

In Søndre Strømfjord only the northernmost *Picea glauca* from treeline-localities (or close to) and *Abies lasiocarpa* from Keno Hill expose increasing undamaged height-growth. Arctic Village, Brooks Range, is the origin of *Picea glauca* finishing growth earliest and hence the most promising. The importance of obtaining material from close to treeline is evident from two collections of *Picea glauca* from 64°N, W of Dawson, Yukon: Plants from 370 m alt. are repeatedly cut back, while plants from treeline at 1000 m alt. (Boundary) are undamaged.

In both localities the northernmost origins of *Picea mariana* (Ambler and Steese Hwy.), *Populus balsamifera* (Steese Hwy. and Boundary), *P. tremuloides* (Steese Hwy. and Fairbanks), *P. tremula* (N-Finland) and *Pinus sylvestris* (Abisko and N-Finland) are improving (fig. 25).

Betula pubescens s.l. (Kiruna), which has not been tried in the South, grew in both localities with only minor cut-backs, whereas S-Greenland *B. pubescens* s.l. died. According to Sulkinoja (1990) the S-Greenland *Betula pubescens* has similarly proved less hardy than N-Fennoscandian origins when planted in N-Finland.

Discussion and suggestions

The results so far of the afforestation experiments in Greenland reveal that only origins from rather limited areas of a very few tree species are to be considered for planting purposes. With a few exceptions northern boreal material from the NE-lowlands of the continents flushes too early (*Larix gmelinii*) and/or requires warmer late summers for inwintering processes (most species, *Pinus banksiana* pronouncedly). Even though only a limited number of origins and provenances have been tried, it does not seem worth while to put much effort in obtaining and planting further *Abies sibirica, Larix gmelinii,* and *Pinus sylvestris* from Siberia or *Abies balsamea, Larix laricina, Pinus banksiana, Picea mariana,* and *Picea glauca* from central and eastern Canada. Even when from Alaska, *Larix laricina* and *Picea mariana* do not adapt well to SW-Greenland conditions. They do not enter the cool coastal areas of S-Alaska or compose forests at treeline, and their main distribution is confined to the – in summer very warm – interior riverplains and valleys. Furthermore, in Greenland *Abies sibirica, A. balsamea, Picea abies,* and *P. mariana* are apparently less resistant to the desiccating foehns than other species tried.

Exceptions from the central and eastern boreal Eurasia are *Larix sibirica* and probably *Pinus cembra* var. *sibirica.* The reason why *Larix sibirica* var. *sukaczewii* is the obviously best *Larix* for the SW-Greenland conditions may be the influence within its range of occasional oceanic airflows from the Barents Sea.

The more successful or promising species and origins are hence from the cool coastal and/or alpine forests and treelines of the northwestern parts of the continents. The winters of the very South of SW-Greenland are not extremely cold (in Narssarssuaq the average for the coldest month is –9.5°C and abs. min. –33°C), but cold enough to kill or injure even the northernmost origins of true oceanic species such as *Picea sitchensis* and *Tsuga heterophylla*. Hence these and probably other species confined solely to coastal regions are not adapted to the combination of rather short growing-seasons often followed by sudden drops to low extremes in the autumn or early winter, and they are sensitive to the desiccating foehns as well.

Skre (1988) concludes that coastal material is adapted to changing climate in the growing season, and that northern and alpine populations stop their growth earlier and at shorter nights than southern and lowland populations. The results obtained in Greenland are in accordance with this statement. The majority of the best developing species and origins are from the NW of N-America, particularly from populations at or close to alpine treelines and from the northernmost suboceanic transition zones towards the Pacific: *Picea glauca, P. engelmannii, Pinus contorta,* and *Abies lasiocarpa,* plus the northern hybrid swarms between *Picea glauca* and *P. sitchensis*. From NW-Europe *Pinus sylvestris* from treeline populations in Fennoscandia and *Larix sibirica* from the NW (see above) are best.

Even though some very southern origins of e.g. *Abies lasiocarpa, Picea engelmannii,* and *Pinus contorta* var. *latifolia* can survive and grow in Narssarssuaq, it is obvious that material originating from about the same latitude perform best. If from a slightly higher latitude, a stable development due to an earlier growth-cessation and hardening may appear to be an advantage in spite of a somewhat reduced annual increment, as experienced in e.g. N-Finland with *Pinus sylvestris*. As an example, all the above-mentioned criteria for a perfect adaptation in Narssarssuaq (61°15'N) seem to be combined in the superior Broad Pass origin of *Picea glauca*: It is collected at 63°15'N, 550 m alt. (close to treeline), in the transition zone between the continental interior and the oceanically influenced lowlands towards Anchorage (indicated by the northernmost populations of *Oplopanax horridus* and *Sambucus callicarpa* below the pass).

Major injuries among native birch trees and 20-year-old planted conifers caused by the 1982-84 spell of cool summers (Ødum 1990) illustrate that fluctuations in vigour and mortality must be considered in SW-Greenland as well as at treelines elsewhere, e.g. in the Scandes (Kullman 1981, 1988; Kullmann & Hofgaard 1987), N-Finland (Mikola 1971), and Iceland (Pálsson 1981). Such events warn against too optimistic large scale planting of short-term introductions. Guidelines have to be derived primarily on the basis of results on the spot since the conditions are much more severe, not least due to the foehn-effect, than in most other places in the North, where arboriculture is practiced. Thus the broad spectrum of species and origins cultivated in the lowlands of northernmost Norway (Reisæter 1955) and

Fig. 25. *Populus tremuloides* and *P. balsamifera* (Steese Hwy., 64°30'N, 850 m a.s.l., close to treeline), planted 1983 at Søndre Strømfjord (67°N) and tending to adapt. S.Ø. phot., 6 August 1986.

Iceland reflect far more favourable local climates, where e.g. old gardens in Reykjavik with *Sorbus intermedia, Ulmus glabra,* and *Acer pseudoplatanus* are resembling those in Tórshavn.

As a guideline for extended afforestation at the interior fiords of the very Southwest of Greenland it can at present be recommended to plant preferably *Picea glauca, Abies lasiocarpa,* and *Pinus contorta* var. *latifolia* originating from populations at or close to treeline in South Alaska and adjacent Yukon-Northern Brit. Columbia. *Larix sibirica* var. *sukaczewii* from central Ural Mts. can be recommended as well, even though considerable reductions in numbers of individuals can be expected due to the larch-cancer. The best would probably be to use the Siberian larch in mixed stands. Also Alaskan *Picea sitchensis* x *glauca* might still be used in spite of the possible loss of less hardy *sitchensis*-like individuals, at least in the suboceanic region of Tasermiut fiord, where also *Pinus contorta* from Haines and Skagway can be recommended.

To encircle the possibilities and the best choice of origins, further trials are needed. The SNS-expeditions to Alaska and NW-Canada 1987-88 resulted in an extensive material of population samples of all major species of trees and shrubs for this and similar purposes in the other Nordic countries. In addition it would be of interest to test more origins of *Picea engelmannii,* particularly from the northern part of its range, incl. the zone of introgression with *P. glauca.* Even though the E-Canadian origins of *Picea glauca* tried do not adapt well, material from its treeline-forming populations at Ungava Bay and the adjacent NE-coast of Labrador deserve to be collected and tested. Also the particularly foehn(chinook)-resistant *Pinus flexilis* should be obtained from its northernmost localities in the Rocky Mts. for testing.

General conclusions

The results of arboriculture in SW-Greenland and the Faroe Islands (and Iceland) reveal that the development of the vegetation of these geographically isolated lands obviously not is „in equilibrium" with their present state of climate. The results of introduction of a broad variety of species and origins as well as of afforestation attempts elucidate the presence of a potential subarctic-boreal forest zone and treeline in the North Atlantic and to which extent it relates to corresponding phytogeographical areas. There are hence convincing accordances between the situation of the Faroe Islands, coastal S-Alaska and southern Tierra del Fuego, and between SW-Greenland at 60°-61°N and treelines at about the same latitude in Alaska. The Faroes, however, do also expose similarities with oceanic alpine forests and even continental cloud forest zones at much lower latitudes.

The spectrum of species which are successful in gardens and plantations in the Faroe Islands shows that the arboricultural conditions to some extent are intermediate between Ireland-W Scotland and W Norway-S Iceland. The summers are, however, more cool in the Faroes.

The Greenland trials expose some similarities with the development of exotic conifer plantations in NE-Iceland and N-Fennoscandia, but the extremely limited choice of species and origins stresses how marginal and climatically complex the Greenland conditions are. The marked phenological response to climatical events among the various species and origins of planted conifers in Greenland make these appropriate indicators of climatic fluctuations. *Larix sibirica,* e.g., would promptly double its increment as a result of even a slight natural or artificial global heating (greenhouse-effect).

With the potential treeline in SW-Greenland and the Faroe Isles situated at approx. 150 m a.s.l., it is not surprising that origins from close to treeline in appropriate climatic zones expose the best adaptation. However, commercial seed from wild or planted stands especially fitted for the extreme and/or marginal conditions in question, is in general not available. Commercial forest seed dealers are preferably collecting in valleys and lowlands, where the heat-sum and length of growing-season secure a sufficient crop and seed quality. Similarly forest research stations and forestry nurseries, which may offer a broad variety of origins of economically important tree species, very rarely keep in stock seed from treeline localities.

On the Nordic Arboretum expeditions to e.g. Alaska-Yukon and Tierra del Fuego it was accordingly our experience that seed from populations of e.g. *Nothofagus* spp., *Picea glauca,* and *Abies lasiocarpa* close to or at treelines

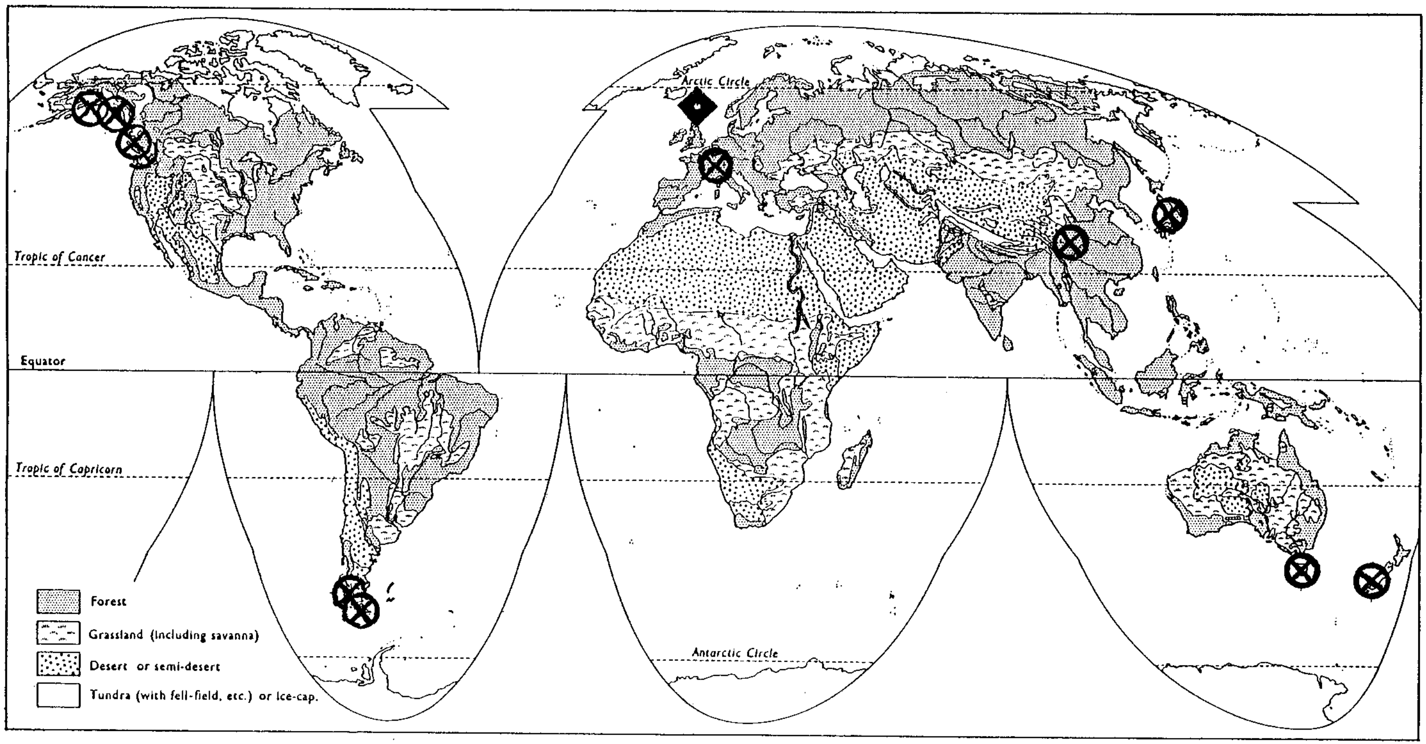

Fig. 26. The position of the Faroe Isles ◆, and main regions for adaptable plant material ⊗. Map after Polunin.

was either lacking, empty or of bad quality. For early tests with material from marginal or remote localities it has therefore proved to be a satisfactory strategy to transfer selfsown saplings, which may even represent a screening of the hardiest genotypes. As an additional gain their mycorrhiza is simultaneously transferred.

Future supply of well adapting material originating from such marginal localities has to be based either on repeated imports or on seed orchards established with likewise transferred saplings or with grafts or cuttings from successful individuals selected in the plantations. Seed orchards for Greenland purposes have to be established at proper latitudes in the Fennoscandian lowland, while seed orchards of *Nothofagus*, if the species and origins desired fail to produce seed in the Faroes, might be established in the British Isles. Vegetative propagation by cuttings for supply of local gardens is now taking place in the Faroe Isles (*Hebe, Fuchsia, Cassinia, Chiliotrichum* a.o.). Once in the future it should be considered to establish a new or additional forest-nursery for Greenland purposes „below" treeline, e.g. in the region of Narssarssuaq.

The plantations and the arboretum-nursery areas in Tórshavn and the young plantations in Narssarssuaq-Qanagssiagssat function as national arboreta of the Faroe Isles and Greenland, respectively, and the adaptation and development of their increasing collections of species and weel-defined origins serve as a valuable guidance for further introductory work and future use of the material.

In areas which are new or climatically marginal for growing trees, it does not make sense to classify the activities at a too early stage as being forestry, agroforestry, recreational planting, shelter-planting, ornamental horticulture, or whatsoever. Experimental arboriculture and the establishment of arboreta s.l. in such marginal areas may lead in either direction and yield material and knowledge for multiple as well as special purposes.

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My wife Astrid participated in seed-collecting in the Americas and in recording. Particular thanks are due to Poul Bjerge and Leivur Hansen for many years of inspiring cooperation, and to Trondur Leivsson for good discussions and company during our collecting work in Tierra del Fuego and Alaska. Gregers Andersen, The Comm. f. Scient. Res. in Greenland, and Bent Søegaard, the Arboretum, have in many years encouraged the expeditions and research. The staff of gardeners at the Arboretum, in particular Ole Byrgesen, has done a tremendously good job in handling the complex material of seed and plants, and Lissie Christiansen has carefully managed the technical preparation of the manuscript.

Dansk sammendrag

Afhandlingen udbygger og sammenfatter tidligere publicerede arbejder omhandlende plantningsforsøg på Færøerne og Grønland, herunder de i den foranstående litteraturliste nævnte (Ødum 1979, 1989, 1990 og Ødum & al. 1989). Den er baseret dels på studier af ældre plantninger og information herom, dels – og ikke mindst – på eget arbejde med tilvejebringelse, udplantning og vurdering af plantemateriale fra potentielt egnede indsamlingsområder, især det sydlige Patagonien og Ildlandet (1975 og 1979) samt Alaska-Yukon (1981 og 1988).

Indledningsvis redegøres der for Færøernes og Grønlands specielle situation i Nordatlanten, hvor geografiske barrierer i form af udstrakt hav samt fjeldkæder og sommerkolde yderkyster (Grønland) er en hindring for naturlig spredning af boreale vedplanter til lavlandsområder, hvor lokale klimaforhold og floraelementer indicerer potentiel skov. Fåregræsning på Færøerne i 1000 år og fåregræsning og hugst af brænde i birke- og pilekrat i Grønland, både i Nordbotiden og i dette århundrede, har forstærket indtrykket af de for trævækst mulige områder som værende mere subarktiske end de i realiteten er, samt forringet vilkårene for evt. naturligt koloniserende eller plantede træers etablering. Udover de gevinster for et have- og skovbrug, som plantede, klimaegnede træer og buske måtte indebære i hidtil skovløse områder, er de velegnede til at påvise hvilke eventuelt fjerntliggende plantegeografiske områder, der er beslægtet med hhv. Færøerne og Grønland, samtidig med at de indicerer, hvilke lokaliteter og arter, det især er værd at satse på i indsamlingsarbejdet.

Nogle ældre plantager på Færøerne og de naturlige krat af Fjeldbirk og Røn i Sydvestgrønland markerer, at den potentielle trægrænse for nåletræer på gunstige eksponeringer (syd og vest) begge steder befinder sig ca. 150 m o.h. Trægrænsen sættes primært af den for træernes tilvækst og skudmodning nødvendige varmesum i vækstsæsonen. Den i begge områder lavt beliggende trægrænse er derfor udtryk for en særdeles beskeden sum af sommervarme, som i Grønland bliver en for trævækst stærkt begrænsende faktor på grund af vintrenes længde og dramatiske temperatursvingninger mellem streng frost og udtørrende, relativt varme føhnvinde fra indlandsisen, mens Færøernes ekstremt oceaniske klima med længere vækstsæson og meget milde vintre muliggør overlevelse og tilvækst for et bredt spektrum af arter og provenienser.

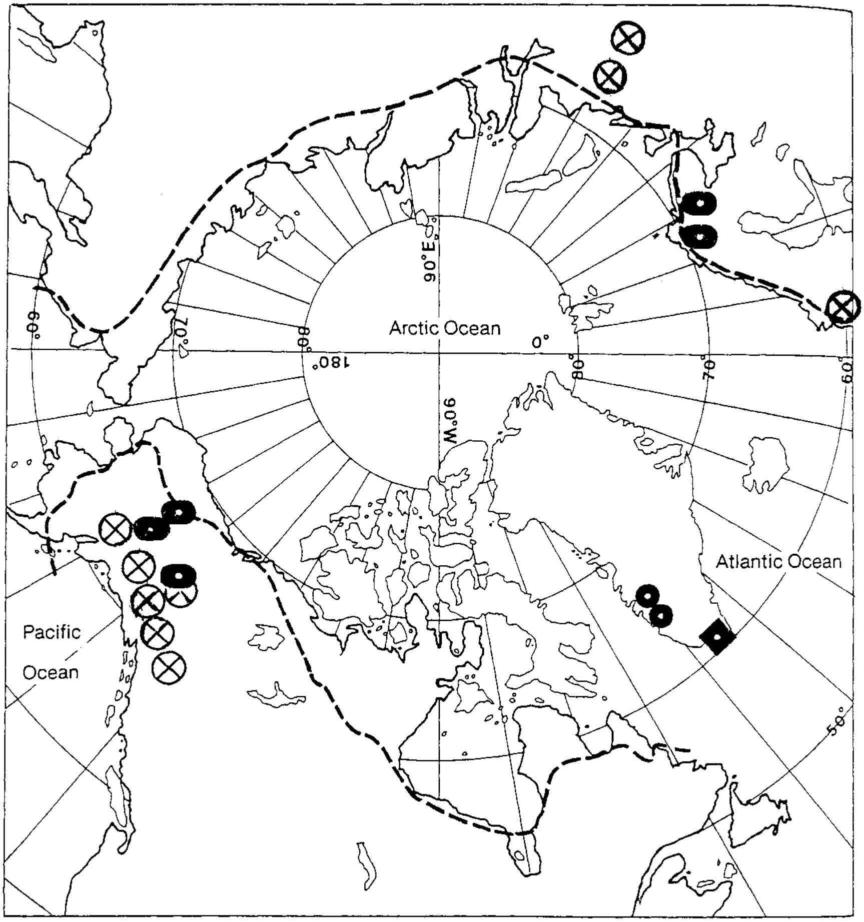

Fig. 27. Main areas ⊗ for plant material adaptable in Narssarssuaq ◆. Main areas ● for plant material adaptable in Qorqut and Søndre Strømfjord ●. Map after Arno & Hammerly. The dashed line indicates the general concept of the arctic treeline.

Færøerne
Plantning af træer og buske i byernes haver påbegyndtes for ca. 200 år siden med nok Pil, Røn og frugtbuske. De ældste i dag tilstedeværende træer i gamle haver i Tórshavn er ca. 140 år gamle og omfatter især Ær, Bornholmsk Røn og Storbladet Elm. Både ældre og nyere haver er domineret af de arter og kulturformer, som gennem tiderne har været handelsvarer i danske planteskoler.

Også de første plantager, initieret af C.E. Flensborg, Hedeselskabet, i århundredets begyndelse, var baseret på de i danske hede- og klitplantager traditionelt anvendte nåletræarter og -provenienser, hvoraf de i starten benyttede Hvidgran og Skovfyr var uegnede. Bedre egnet var Bjergfyr og især de siden 1918-1928 plantede Sitkagran, Contortafyr og senere hen Japansk Lærk. Samarbejde efter 1950 mellem Færøernes Plantagenævn, det Islandske Skovvæsen og Hedeselskabet udmøntede sig i en mere målrettet og resultatrig afprøvning af flere og nordligere provenienser af de vestamerikanske træarter og andet materiale af træer og buske, som skønnedes bedre egnet til Færøernes klima- og jordbundsforhold.

Dannelsen i 1972 af Nordisk Arboretudvalg resulterede i et tæt samarbejde de nordiske lande imellem om indsamling og afprøvning af nyt materiale, således fælles indsamlingsekspeditioner 1974-76 til bl.a. New Zealand, Tasmanien og det sydlige Sydamerika (igen 1979), og i en afprøvning på Færøerne af et omfattende plantemateriale fra disse egnes koldt tempererede skove og skovgrænser. Endvidere blev indsamlingsekspeditioner i Alaskas kystegne efter materiale til især Færøerne gennemført 1981 (og igen 1988).

En gennemgang af bevoksningerne i haver, plantager og arboretforsøg resulterede i en evaluering af tilpasning og udvikling hos de konstaterede ca. 330 arter af træer og buske, hvoraf ca. 1/3 kunne klassificeres som godt eller særligt godt egnede til det stedlige klima (ingen eller kun ubetydelige tilbagevisninger af årsskud; blomstring, frugtsætning o.a.). En gruppering af de særligt klimaegnede arter og oprindelser viser, at de bedre tilpassede hidrører fra det vestlige Nordamerikas nordlige kystegne og/eller vestvendte, nedbørrige bjerge samt det sydligste af Andeskæden, Ildlandet og den vestvendte, alpine del af Sydøen, New Zealand. Også de vestvendte bjergområder i Mellemeuropa (i højere grad end Skandinavien) er hjemsted for velegnet materiale. Interessant er det, at arter fra tågeskove i det centrale Japan og i Sydkina også trives på Færøerne. De mindre egnede eller helt uegnede arter er overvejende hjemmehørende i mere kontinentale, sommervarme områder og springer enten for tidligt eller meget sent ud, afmodner dårligt, blomstrer sparsomt og ofte for sent til at udvikle/modne frugt etc.

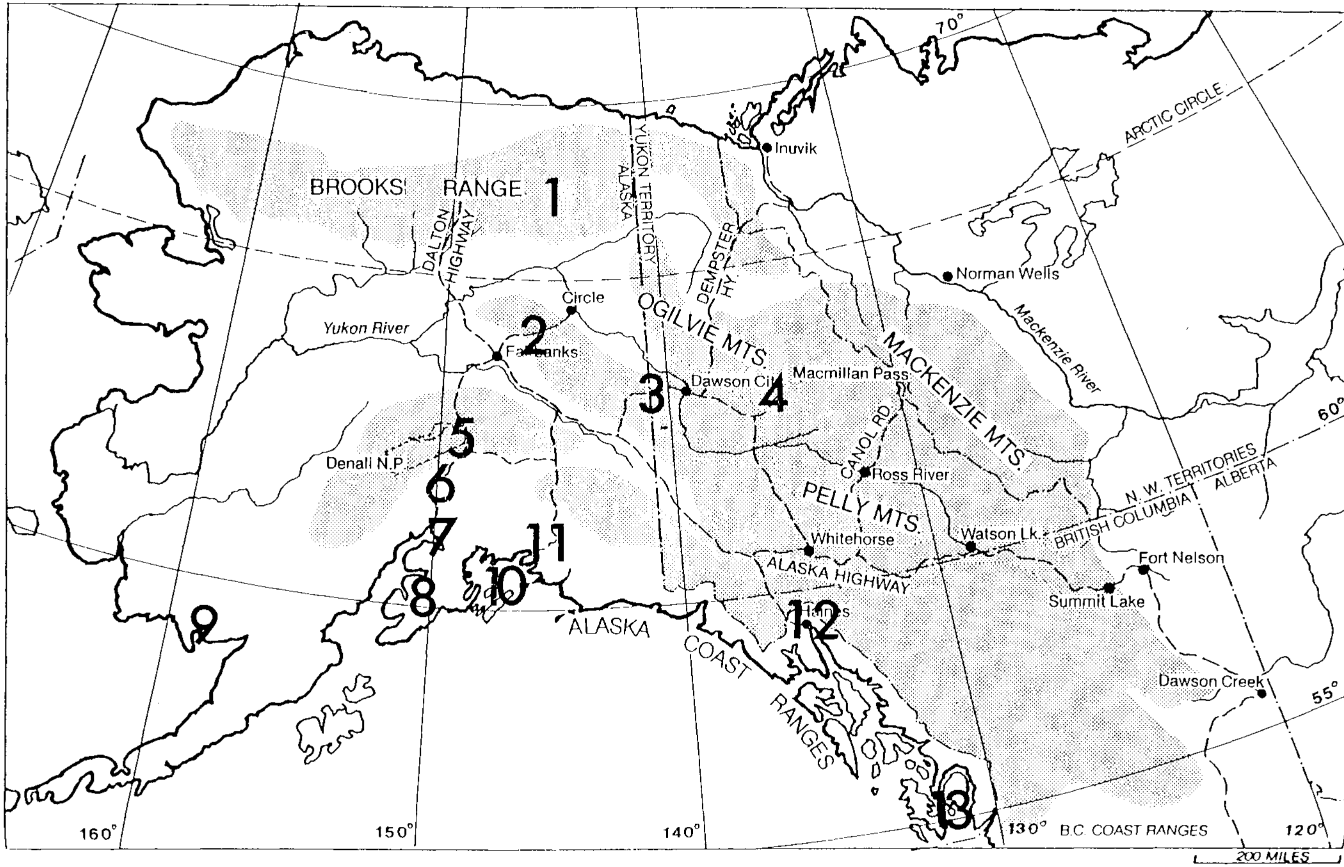

Fig. 28. Areas of important NW-American origins referred to in text and table 1 and 2 (gray zone indicates the boreal Rocky Mts.): 1. Arctic Village. 2. Steese Hwy. 3. Boundary. 4. Keno Hill (next to the northernmost stands of *Pinus contorta* var. *latifolia* at Rusty Creek, Stewart Crossing). 5. Broad Pass. 6. Talkeetna. 7. Knik River. 8. Kenai s.l. and Saxton. 9. Dillingham. 10. Prince William Sound. 11. Tsaina – Thompson Pass. 12. Haines and Skagway. 13. Annette Island. Map after Arno & Hammerly.

På baggrund af gennemgangen af de hidtidige resultater anbefales nogle arter og geografiske områder som værende af særlig interesse i forbindelse med yderligere indsamling.

Mens udvalget af arter og oprindelser, der dyrkes og trives i de lidt ældre havers og plantagers forbedrede lokalklima og jord, er stærkt stigende, er startvilkårene for ny trævækst i åbent landskab og klæg tørvejord nu som før særdeles vanskelige. De bedre egnede pionerer har indtil nu vist sig at være Sitka-El (*Alnus sinuata*), Contortafyr og Sitkagran, alle af Alaska-herkomst samt Japansk Lærk og sydbøge-arter fra Ildlandet, især *Nothofagus antarctica*. Også Bornholmsk Røn, Vogeser-Røn (*Sorbus mougeottii*), Vestamerikansk Balsampoppel (*Populus trichocarpa*) og buske som *Rubus spectabilis* og vildformen af Blodribs (*Ribes sanguineum*) har pionerkvalitet.

Grønland

Forekomsten af naturlige krat af Fjeldbirk og et enkelt vellykket forsøg fra 1892 med såning af Skovfyr og Rødgran fra Nordnorge („Rosenvinges Træer") inspirerede 1947 til mere indgående undersøgelser (Landbohøjskolen og Det forstlige Forsøgsvæsen) af skovplantningsmuligheder og siden 1953 til et fortløbende arbejde med tilvejebringelse af materiale og med plantning (Upernaviarssuk Forsøgsstation, Arboretet, Statsskovenes Planteavlsstation).

Efter en epoke med optimistisk afprøvning af et bredt udvalg af nordligt boreale arter, provenienser og oprindelser, blandt hvilke klimaet bortselekterede næsten alt bortset fra Sibirisk Lærk, Skovfyr fra Nordnorge og Hvidgran og Hvidgran x Sitkagran fra det sydlige Alaska, har hovedvægten siden 1981 været lagt på tilvejebringelse og udplantning af materiale fra Alaska-Yukon. Sideløbende er plantning af Sibirisk Lærk (materiale leveret af især Island) blevet fortsat.

En periode med særligt kolde somre 1982-84 resulterede i en selektion også i dette nyere materiale, hvorefter følgende kan sluttes: Kun få, begrænsede områder, hovedsagelig på tilsvarende eller nordligere breddegrader og nær skovgrænsen, yder materiale, der har muligheder for at vokse til træstørrelse i Sydvestgrønland uden eller med kun lejlighedsvise, moderate klimaskader. De arter og oprindelser, som særligt kan anbefales til hvilke lokaliteter, fremgår af tabel 1 og 2. Der er således baggrund for især at satse på indsamling og afprøvning af materiale fra fortrinsvis trægrænse-lokaliteter af Hvidgran fra Alaska, Klippegran (*Abies lasiocarpa*) og Indlandscontorta (*Pinus contorta* var. *latifolia*) fra Yukon (hvilket er gjort 1987-88) samt Sibirisk Lærk fra de nordvestlige egne af udbredelsesområdet (*Larix sibirica* var. *sukaczewii*).

Den marginale situation for plantet trævækst i Sydvestgrønland indebærer, at plantagernes tilstand, tilvækst og især tykkelsesvæksten hos Sibirisk Lærk er velegnede til at afspejle selv små klimaændringer, herunder en naturlig eller menneskeskabt drivhuseffekt.

Nogle generelle erfaringer og konklusioner

Uanset at færøsk skov- og havebrug i dyrkning af vedplanter kan nyde godt af erfaringer og materiale fra nabolandene og især Skotland, Vestnorge og Sydisland, er der med øernes ekstremt oceaniske, sommerkolde og vintermilde klima betydelige gevinster at opnå gennem indsamling i specielt koldt tempererede kystegne og skovgrænseområder i Alaska, på Ildlandet og sydøen af New Zealand. Der er også visse lighedspunkter mellem skovdyrkningssituationen i det nordlige Fennoskandien og det nordøstlige Island, men forholdene på Grønland er så ekstreme, at der kun er begrænset vejledning og materiale at hente i forsøgene her. Det har vist sig, at de væsentligste fremskridt i tilvejebringelse af bedre tilpasset materiale er sket gennem direkte indsamling til formålet nær trægrænsen. Kommercielt frø fra sådanne områder er stort set ikke indsamlet, da der normalt er langt mellem frøår med mulighed for høst af større mængder frø af god kvalitet.

I det fortsatte arbejde med indsamling fra for trævækst marginale klimaområder er det derfor en hensigtsmæssig strategi ikke blot at samle frø hvor og når dette er muligt, men også at sikre sig en repræsentation af populationerne ved at optage større antal småplanter til udplantning. Derved vindes tid i en „early test" af herkomsten og materiale til etablering af en eventuel frøhave på en lettere tilgængelig lokalitet med et for blomstring og frøsætning bedre egnet klima.

Table 1. Variation in adaptation of some origins of important conifers at SW-Greenland localities. Tendencies scored: ++ best; + good; *(+)* not promising; *(–)* repeated diebacks; – dead.

Species and origins (tl.: Material from close to treeline)	Kugssuak 60°15'N subarct.-subocean	Narssarss. 61°10'N subarct.-subcont.	Qorqut 64°15'N subarct.-suboccan.	S. Strømfj. 67°N low-arct.-cont.
Abies lasiocarpa				
Rocky Mts., USA (several origins)	+	+	(+)	–
Keno Hill, 64°N, 1100 m, tl.	++	++	+	+
Larix sibirica s.l.	+	++	(–)	(–)–
Picea engelmannii, Rocky Mts., USA (few origins)		+	(–)	(–)
Picea glauca				
Arctic Village, 68°N, 750 m, tl.	(+)	(+)	+	+
Steese Hwy. 64°30'N, 850 m, tl.	+	+	+	+
Boundary, 64°N, 1000 m, tl	+	+	+	+
Dawson, 64%N, 370 m	+	+	+	(–)
Broad Pass, 63°15'N, 550 m, tl.	++	++	+	+
Talkeetna, 62°N, 60 m	++	+	(+)	(–)
Knik River, 61°30'N, low alt.	++			
Saxton, 60°30'N, 180 m	++	++	(+)	(–)
Dillingham, 59°N, 50 m	+	+	(+)	(–)
Picea glauca x *sitchensis*				
Tsaina-Thompson Pass, 61°N, 550 m, tl.	++	(+)	(+)	
Kenai, approx. 60°N, low alt.	+	(+)	(–)	
Pinus contorta				
Skagway	++	+	(–)	–
Yukon – N.BC (several origins)	+	++	(+)	(–)–
Rocky Mts., USA (Several origins)		+	(–)	–
Pinus sylvestris				
Fennoscandia 67°-69°N, tl.	+	+	(+)	(+)
Hardanger, Norway, 60°N, tl.		+		

Table 2. The at present most important or promising tree species and origins.

Faroe Islands	Origins	Area recommended
Abies grandis	?	NW-Washington
Abies procera	?	NW-Washington
Picea sitchensis	Pr. Will.Sound	Alaska coast
Pinus contorta	Annette Island	Alaska coast
Tsuga heterophylla	?	Alaska coast
Alnus sinuata	Kenai	Alaska coast
Populus trichocarpa	Kenai	Alaska coast
Acer pseudoplatanus	?	W-Alps
Sorbus mougeottii		W-Alps
Larix leptolepis	?	C-Japan
Nothofagus antarctica	Entre Rios	Tierra del Fuego
Nothofagus betuloides	Lago Escondido	Tierra del Fuego
Nothofagus pumilio	Paso Garibaldi	Tierra del Fuego
Greenland, Kugssuak		
Abies lasiocarpa	?	SE-Alaska-Yukon
Picea glauca	Saxton and Broad Pass	S-Alaska
Picea glauca x *sitchensis*	Tsaina	S-Alaska
Pinus contorta	Skagway	North. SE-Alaska
Greenland, Narssarssuaq		
Abies lasiocarpa	Keno Hill	Yukon
Picea glauca	Broad Pass	S-Alaska
Pinus contorta var. *latifolia*	?	Yukon
Larix sibirica var *sukaczewii*	C-Ural	NW-USSR
Greenland, Qorqut		
Abies lasiocarpa	Keno Hill	Yukon
Picea glauca	Steese Hwy.	C-Alaska
Greenland, S-Strømfjord		
Picea glauca	Arctic Village	N-Alaska

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