

Experiences with *Nothofagus* in West-Norway and East-Denmark.

af

Poul Søndergaard

Den Kgl. Veterinær- og Landbohøjskole
Arboretet, 2970 Hørsholm

Erfaringer med *Nothofagus* i Vest-Norge og Øst-Danmark.

Keywords: *Nothofagus*, *species*, *plant-introduction*, *provenances*, *Bergen*, *Hørsholm*.

Abstract:

Species of southern beech, *Nothofagus*, were introduced to Scandinavia about 50 - 60 years ago. Descriptions are given for 9 species grown out of doors in the Nordic region including Denmark, The Faeroe Islands, Iceland, Norway and Sweden. New plant material was collected during the 1970es by joint Nordic Arboretum expeditions to the southern hemisphere and distributed to the milder parts of West-Scandinavia. The performance of *Nothofagus* in West Norway is compared to results from East-Denmark supplemented with a look to the Faeroe Islands. *N. antarctica* and *N. pumilio* seem to have the broadest potential in the Nordic climate and *N. betuloides* looks promising for shelter belt planting and production of greenery for decoration in the Faeroe Islands and along the coast of Southwest-Norway.

Introduction:

While the northern beeches form a homogenous group of only ten species of deciduous trees, the beeches of the southern hemisphere are mainly evergreen and belong to a larger and more varied group with about 35 species (Hill & Dettmann 1996). Nine species of *Nothofagus* are natives of the temperate parts of Chile and bordering Argentina, and six of these are deciduous; three are found in Tasmania and Australia of which one is deciduous (*N. gunnii*). The four species in New Zealand are all evergreen just as the remaining nineteen species from New Guinea and New Caledonia.

Earlier infrageneric classifications of *Nothofagus* spp. were based on the presence or absence of the deciduous or evergreen habit, cupule morphology and leaf vernation. This classification did not correspond very well with the pollen groupings found and used by palynologists (Hill & Read 1991). As a result of their own studies of cupule

morphology, leaf architecture and cuticular morphology, Hill & Read proposed a revised infrageneric classification of *Nothofagus*. They hypothesized that deciduousness is primitive in *Nothofagus* and that the evergreen habit has arisen more than once. The deciduous or evergreen habit is therefore considered invalid as a primary taxonomic character. Rbcl-studies by Martin & Dowd (1993) support the new classification as well as cladistic analysis by Hill & Jordan (1993) in which paper they also accept the classification of *Nothofagus* in its own monogeneric family, the Nothofagaceae.

The ancestors of the genus appeared during the Cretaceous, when South America, Antarctica, Australia and New Zealand were connected or close to one another. Fossil evidence indicate a more or less continuous distribution of *Nothofagus* spp. from South America via Antarctica to Australasia about 80-70 mill B.P., and the Antarctic Peninsula and South America were suggested as the Cretaceous centre of diversity for *Nothofagus* (Veblen, Hill & Read 1996). A second centre of diversity developed during the Tertiary in south-east Australia and New Zealand (Hill & Dettmann 1996), fig.1.

Pollen found in Oligocene and Eocene sediments in N. America (Gulf Coastal Plain and the Pacific NW) has been classified as belonging to *Nothofagus* and thereby suggest a former occurrence of the genus in the northern hemisphere (Elsik 1974).

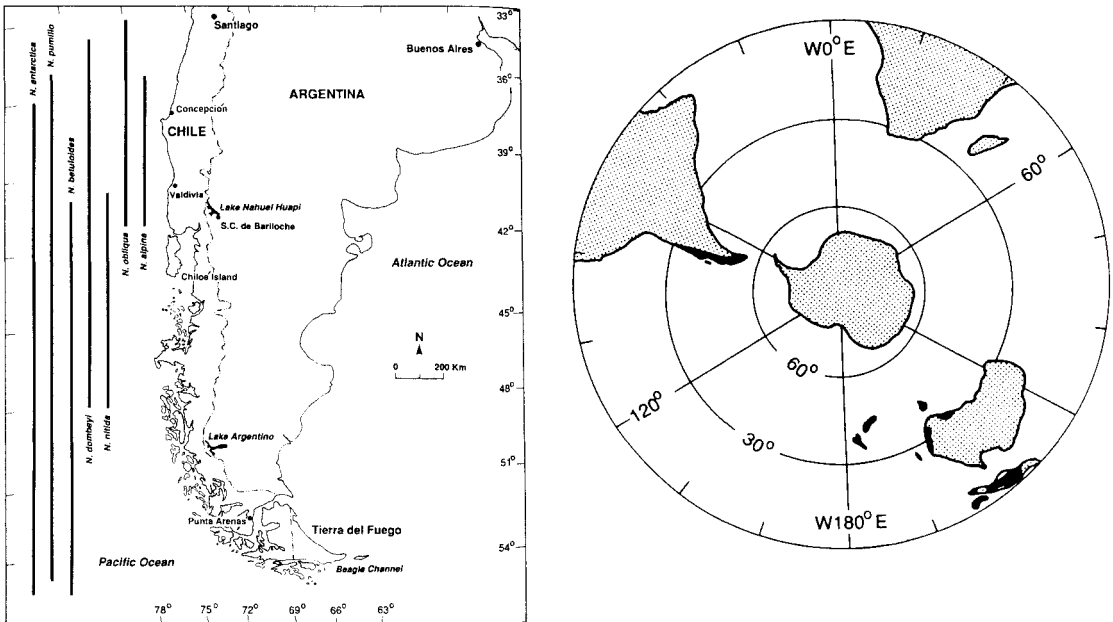


Fig.1 Distribution of *Nothofagus* /udbredelseskort for *Nothofagus* (after Humphries 1981 and Donoso 1987, p. 2 & 294 in Veblen, Hill & Read 1996: The Ecology and Biogeography of *Nothofagus* Forests).

Subgenus			
<i>Nothofagus</i>	<i>Fuscaspora</i>	<i>Lophozonia</i>	<i>Brassospora</i>
South America	South America	South America	New Caledonia
Section <i>Nothofagus</i> <i>antarctica</i> (fl, pl) <i>betuloides</i> (fl,p) <i>dombeyi</i> (fl, p) <i>nitida</i> (fl,pl)	<i>alessandri</i> (f2, ?)	<i>alpina</i> (m, pl) <i>glauca</i> (m, p) <i>obliqua</i> (m, pl)	<i>aequilateralis</i> (b,c) <i>baltansae</i> (b, ?) <i>baumanniae</i> (b,c) <i>codonandra</i> (b, c) <i>discoidea</i> (b, ?)
South America	Australia	Australia	New Guinea
Section <i>Pumiliae</i> <i>pumilio</i> (fl, pl)	<i>gunnii</i> (f2,r)	<i>cunninghamii</i> (m,p) <i>moorei</i> (m,p)	<i>pseudoresinosa</i> (b, ?) <i>pullae</i> (b,c) <i>stylosa</i> (b,?) <i>resinosa</i> (b,c) <i>starkenborghii</i> (b,?) <i>rubra</i> (b,?) <i>womersleyi</i> (b,?)
	New Zealand	New Zealand	
	<i>fusca</i> (f2,r) <i>solandri</i> (f2,r) <i>truncata</i> (f2,r)	<i>menziesii</i> (m,p)	

Table 1. Proposed infrageneric classification of *Nothofagus*, slightly modified after Hill & Read (1991) and Hill & Jordan (1993). In brackets after each species is the pollen type (b = *N. brassii* type, fl = *N. fusca* type 1, f2 = *N. fusca* type 2, m = *N. menziesii* type) and the vernation type (c = conduplicate, p = plane, pl = plicate, r = revolute).

Continental drift broke up the Gondwanaland and different lineages of *Nothofagus* developed on the separated southern landmasses, but still with closely related taxa on different continents, table 1.

Description of species grown out of doors in Denmark, The Faeroe Islands and Norway

Nothofagus alpina (Poepp. & Endl.) Ørst. (syn. *N. procera*, *N. nervosa*). Rauli. (Fig. 2).

A deciduous tree (35-40 m in S. America, in Denmark up to 15 m). Normally single-stemmed with a straight bole. Bark grey-brown, at first smooth with fine horizontal bands of lenticels, later cracked and peeling. Buds ovate, pointed, spreading, resembling those of the common beech, 6-10 x 3-4 mm. Leaves symmetrical, ovate, shallowly lobulate with small triangular teeth on the lobes; 40-100 x 10-30 mm with 12-15 pairs of secondary veins. Petioles 3-5 mm. Base rounded or slightly cordate. *N. alpina* is extremely rare in Scandinavia. All of the mature trees died during the bad winters of the 1980es (Ødum 1986), and only young trees seem to be left in collections of West Scandinavia.

Nothofagus antarctica (Forst.) Oerst.
Nirre. (Fig. 2).

A deciduous tree to 16 m high (in Danish and Norwegian collections), variable in growth form and often multi-stemmed with curved stem bases. Bark grey-brown with horizontal lines of lenticels; peeling in vertical bands at an early age (10 - 15 years). Shoots divaricate, often in a graceful fishbone design. Leaves 10-40 x 10-25 mm, broadly ovate, cuneate, truncate or cordate at base, often unequal sided, 3-5 pairs of secondary veins (normally 4); margins irregularly dentate, with a varying number of teeth between adjacent secondary veins (normally 5-6). Buds ovate to globular about 2 mm. Flowering is regular in Denmark and Norway from the age of 10, and seed is often abundant. Husk of fruit with four linear valves. *N. antarctica* is found along the Andes over a distance of more than 3000 km and grows from sea level in the Tierra del Fuego to timber line at about 2000 m elevation in the north. Among South American *Nothofagus* it is the species that displays the greatest morphological variation, from well formed trees to small shrubs. A number of morphotypes can be distinguished, but genetic differences have not yet been investigated (Veblen, Donoso, Kitzberger and Rebertus 1996). The plant material introduced to Scandinavia displays a similar variation, both with regard to leaf morphology, growth form and size. *N. antarctica* is found in many Danish parks and gardens and is not uncommon in

West Norway and South Sweden. In The Faeroe Islands it is expected to become an important species in future afforestation.

Nothofagus betuloides (Mirbel) Blume.

Guindo. (Fig. 2).

An evergreen tree (to 30 m in S. America). Leaves coriaceous, upper surface shining green, ovate 15-25 x 10-20 mm, finely serrate, rounded or cuneate at base. Petioles ca 2 mm; 5-6 pairs of secondary veins. Barely hardy in Denmark. In Bergen and the Faeroes it grows single-stemmed to 6 m in 15 years, when sheltered. Exposed to winds (only seen in the Faeroes) it makes a broad and dense shrub, like in S. America, when it grows without protection from Pacific gales.

Nothofagus cunninghamii (Hook.) Oerst.

Myrtle beech.

An evergreen tree (to 30 m in Tasmania and S.E. Australia). Leaves coriaceous, ovate deltoid, with irregularly crenate margin, very shortly petiolate; 10-25 x 7-18 mm. High altitude populations have genetically fixed smaller leaf size (sometimes less than 5 mm long) and are more frost tolerant (Hill 1997). It is only grown out of doors (as a small shrub) in the Faeroe Islands, where it is repeatedly damaged by frost (Ødum, Hansen & Rasmussen 1989).

Nothofagus dombeyi (Mirb.) Blume.

Coigüe.

An evergreen tree (to 40 m in S. America). Leaves coriaceous with shining green upper surface, ovate - lanceolate, finely serrate, 20-25 x 7-15 mm, cuneate at base. Petiole 1-2 mm. 5-6 pairs of secondary veins. It is not hardy in Denmark and West Norway, but makes a nice shrub in shelter in the Faeroes (Ødum 1989). It is best distinguished from *N. betuloides* by its often narrow-lanceolate leaves. Romero (1980) and Gandolfo & Romero (1992) distinguish the two species respectively by the presence or absence of glands on the leaves and by a different ramification of secondary veins near the margins of leaves. These distinctions proved difficult to verify on herbarium material collected in S. America 1975 (Ødum, Hjerting & Sjøgaard 1977).

Nothofagus menziesii (Hook. F.) Oerst.

Silver beech.

Evergreen tree (to 30 m in New Zealand). Leaves coriaceous, ovate, doubly serrate, cuneate at base; 6-15 x 5-15 mm, 3 pairs of obscure secondary veins. Only grown out of doors (as a shrub) in the Faeroes, where it is damaged in most winters (Ødum, Hansen & Rasmussen

1989). It is close to *N. cunninghamii*, from which it can be distinguished by the more pronounced and deeper serration of the leaves.

Nothofagus obliqua (Mirb.) Blume,
Roblé. (Fig. 2)

A deciduous tree (to 40 m in S. America), single-stemmed if not resprouting after frost-damage. Bark grey-brown with dense horizontal lines of lenticels, scaling on mature trees. Buds pointed, appressed 4-5 x 2 mm. Leaves ovate - oblong, margin finely lobed, set with small irregular teeth or doubly serrate, 20-70 x 10-25 mm, base rounded or cuneate and more or less unequal sided, blunt or slightly acute at apex. 10-12 pairs of secondary veins. Petioles 2-5 mm. Husk of fruit with four ovate valves. *N. obliqua* is extremely rare in Scandinavia. One mature tree planted around 1955 is known from the Knuthenborg estate in Denmark.

Nothofagus pumilio (Poepp. & Endl.) Krasser.
Lenga. (Fig. 2).

A deciduous tree (to 35 m in S. America). Often multi-stemmed (probably due to frost damage on young plants). Bark greyish brown to copper-coloured, with fine horizontal lines of lenticels and remaining smooth even on 40 year old trees, eventually peeling and cracking like birch. Buds ovate to globular 2-3 mm. Leaves ovate, rounded at apex, rounded or slightly cuneate at base, 15-40 x 8-30 mm, finely and regularly crenate, with 5-6 pairs of secondary veins ending in sinuses and with two lobes on the margin between adjacent veins. Petioles 1-5 mm. Husk of fruit with two linear valves (Hill & Read 1991). Flowering and fruiting has not been observed in Scandinavia.

Distinction between *N. antarctica* and *N. pumilio*:

	<i>N. antarctica</i>	<i>N. pumilio</i>
Husk of fruit	4 valves	2 valves
Secondary veins	3-5	5-6
Toothing of leaf in middle part between adjacent secondary veins	More than two small irregular teeth (5-6)	Two large, blunt regular teeth.

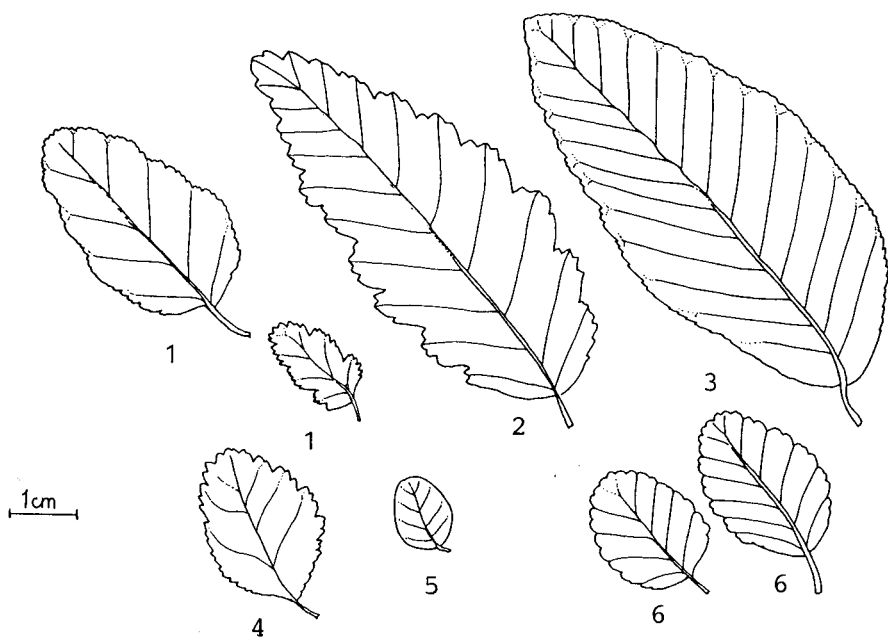


Fig. 2 Leaves of *Nothofagus* spp./Blade af *Nothofagus*-arter. 1= *antarctica*, 2= *obliqua*, 3= *alpina*, 4= *betuloides*, 5= *solandri* var. *cliffortioides* and 6= *pumilio*. Drawing by Beate Helle Ingvartsen.

Nothofagus solandri var. *cliffortioides* (Hook. f.) Poole.

Mountain beech. (Fig. 2).

Evergreen tree (to 15 m in N. Zealand); in W. Norway to 4 m after 20 years. Leaves coriaceous with entire margins, ovate, subacute and obliquely rounded at base; 10-15 x 7-10 mm (in Scandinavia 10-12 x 5-6 mm) with 6-7 pairs of obscure secondary veins. In Copenhagen (Forest Bot. Garden) 2 plants 20 years old and about 1 m high; 4 plants in Bergen to 4 m high, a few small plants in the Faeroes.

Hybridization in *Nothofagus*.

Hybrids have been observed in *Nothofagus*, e.g. between *N. fusca* and *N. solandri* (Cockayne & Turner 1967 and Søndergaard, Benedikz & Vedel 1977). In S. America hybrids have been observed between *N. alpina* and *N. obliqua* and between *N. obliqua* and *N. glauca*, known as *N. leonii* (Donoso 1996). However, much of the data on hybridization between S. American spp. of *Nothofagus* seem to be anecdotal (Hill & Read 1991). Where *N. antarctica* and *N. pumilio* meet, plants with leaf forms intermediate between the two species have been found (Pre-

moli 1997 and Veblen, Donoso, Kitzberger and Rebertus 1996), but hybridization between the two species has not yet been formally investigated. In a stand of *Nothofagus pumilio* near Køge the author found three deviating individuals. They resembled *N. antarctica* and two of the three were the tallest in the stand, see Schlätzer 1997 and further discussion in this article.

History of introduction to Denmark and Norway.

Denmark. The first introductions of *N. antarctica*, *N. alpina* and *N. obliqua* took place during the 1930es (Nord. Ill. Havebrugsleks. 1946), fig.3A og B. Trees of *N. alpina* and *N. obliqua* did survive in a few collections for several years (20 - 40) but were repeatedly damaged in cold winters and only one of the first introductions is known to be alive, *N. obliqua* in Knuthenborg Park, which was 16 m high and 160 cm in circumference at breast height (CBH) in Sept. 1996. *N. pumilio* was introduced in 1947 by Myndel Petersen (Lange 1994), in 1958 (Schlätzer 1997) and again in 1960 to the Copenhagen Botanical Garden and 1961 to the Forest Botanical Garden in Charlottenlund (the latter, 11,5 m high and 50 cm in circumference 1996, is a Coihayque-provenance from Chile). *N. antarctica* is found as a mature tree (40 -50 years old) in a few Danish collections, e.g. Geografisk Have, Kolding, plan-



Fig. 3 A= *N. antarctica* (Balestrand 1994) and B= *N. pumilio* (Milde 1985), Phot. P. Søndergaard (P.S.).

ted 1949 (Schlätzer 1997), Knuthenborg Park, Lolland, planted c. 1955 and about 14 m high, Forsthaven, Århus, planted c. 1960 and Øregårdsparken, Hellerup, probably planted c. 1970.

Norway. Seed was imported in 1956 from Chile of *N. obliqua*, *N. alpina*, *N. dombeyi* and *N. antarctica* (Hiorth 1956). It is uncertain if any plants have survived from this probably first introduction of *Nothofagus* to Norway. *N. antarctica* was introduced again in the middle of the 1950es via the Botanical Garden, Bergen and in the beginning of the 1970es via the Institute of Dendrology at the Agricultural University, Ås. One specimen in the Bergen Botanic Garden from 1956 was 13,2 m high and 152 cm in circumference in August 1997. A tree the same age in the adjacent Nygårdsparken was 17,2 m high and 159 cm CBH. Three specimens planted at the same time at Stend Jordbrukskole were 14,8 m, 13,8 and 13,5 m high and the biggest stem 142 cm in circumference. A tree planted 1972 in Balestrand (approx. 100 km NE of Bergen) was 10,5 m high and had a circumference of about 100 cm in August 1994. The tree in Nygårdsparken is probably the highest specimen of *Nothofagus antarctica* and of the genus *Nothofagus* in the Nordic countries.

Recent introductions to Scandinavia.

Since 1974 Nordic seed collecting expeditions have brought home seed and plants of a wide range of provenances of *Nothofagus* species from southern South America and from New Zealand and Australia. This material was distributed in West Scandinavia and is now being tested in a number of plant collections. The main expeditions to S. America were the following: Larsen and Schlätzer 1974 (Schlätzer 1976), Hjerting, Søegaard and Ødum 1975 (Ødum et al. 1977), Ødum and Leivsson 1979 (Madsen et al. 1980), Benedikz, Bergstedt, Leivsson and Ødum 1992. The main expedition to New Zealand and Australia was accomplished by Benedikz, Søndergaard & Vedel in 1974/75 (Søndergaard et al. 1977).

Seed of 9 provenances of *N. obliqua* and 14 provenances of *N. alpina* were obtained by the Arboretum in 1977 from the British Forestry Commission; most of the seed was collected in Chile, but some samples came from first and second generation stands in Scotland and England.

The Faeroe Islands, in particular, received an important number of living plants (several thousands) dug up in areas with natural regeneration (the expeditions 1975, 1979 and 1992).

The number of *Nothofagus* species surviving out of doors in Denmark and Norway is so far limited to six: *N. alpina*, *N. antarctica*, *N. betuloides*, *N. obliqua*, *N. pumilio* and *N. solandri* var. *cliffortioides*. In

addition *N. cunninghamii*, *N. dombeyi* and *N. menziesii* have been in cultivation in the Faeroe Islands since 1976 (Ødum, Hansen & Rasmussen 1989).

Performance of the different species and provenances introduced 1974, 1975, 1977 and 1979:

In Denmark the 1995/1996-winter was characterized by an unusually long period of frost, which began in the middle of December and continued nearly uninterrupted till the end of March. Reduced rainfall during the same period added to the unfavourable conditions for growth and development of *Nothofagus*. Shoots were damaged on most of the species in Copenhagen (particularly 1992-plants in the nursery). The damage was restricted to the outermost parts of the annual shoots in *N. antarctica* and *N. pumilio*, while die back was more widespread in the remaining species. However, past winters and particularly 1981/82 caused much damage to both *N. antarctica* and *N. pumilio* (Ødum 1986). Many plants of *N. pumilio* were killed, without apparent correlation to provenance, while there was a clear tendency to higher mortality in the northern provenances of *N. antarctica* compared to provenances from Tierra del Fuego (Ødum 1997).

The 1995/96 winter in Bergen was also relatively cold and dry, but caused only little visible damage. The 1986/87 winter, on the other hand, inflicted cambial damage on *N. pumilio*, while *N. antarctica* was only slightly cut back on previous years growth.

Nothofagus antarctica

Four provenances from the 1975 collection and one from the 1979 collection were planted both in Hørsholm (9 plants) and in the Milde Arboretum (13 plants), see table 2.

There are too few plants to permit statistically founded conclusions, and there are not clear differences in growth and development of *N. antarctica* between Bergen and Copenhagen, except the number 112-79, for which height and diameter in Bergen are nearly double compared to Copenhagen.

However, there is a big variation between provenances in Copenhagen, both between the 1975 collections and the 1979 collections. The fastest growing provenance is 626-75 with heights of 13,5 m and 11,7 m. The slowest growing is 26-79 with only 4,3 m in May 1996. This was on the other hand one of the most ornamental and least damaged provenances after the 1995/96 winter (fig. 4).

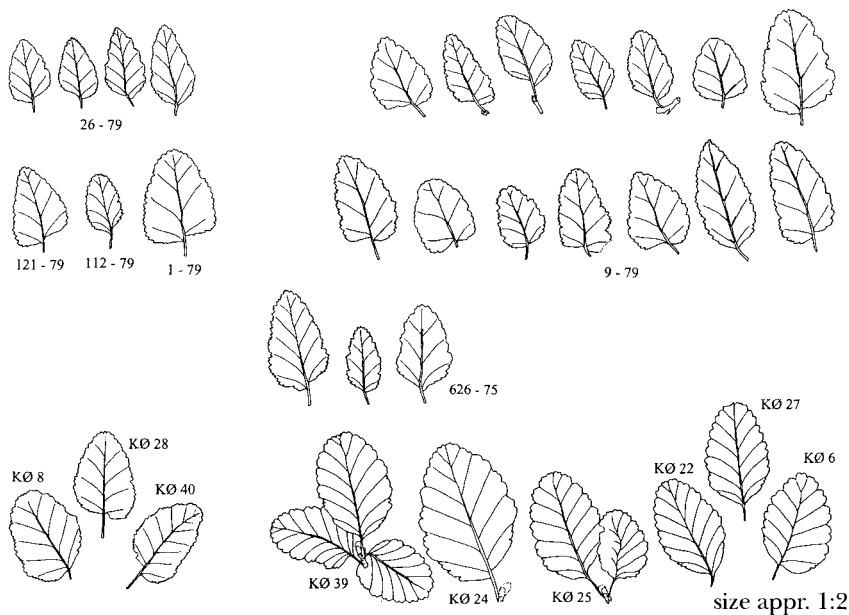


Fig. 4 *N. antarctica* (Hørsholm). 26-79: leaves from 4 single trees , 9-79: from 14 single trees, 626-75: from 3 single trees, 121-79, 112-79 and 1-79 from single trees. *N. pumilio* leaves from single trees in Køge: Kø 6, 22, 24, 25, 27 and 39. Leaves of deviating trees in Køge: Kø 8, 28 og 40. (Blade af *N. antarctica*, 9-79 fra 14 enkelttræer, 26-79 og 626-75 fra 3 enkelttræer, 1-79, 112-79 og 121-79 fra enkelttræer. *N. pumilio* fra Gammelkjøgegård, Kø 6, 22, 24, 25 og 27 og 39. Afvigende træer Kø 8, 28 og 40). Drawing by Beate Helle Ingvarsen.

Table 2. *Nothofagus antarctica* in Copenhagen and Bergen

S = collected as seed; P = collected as plants

DK = Denmark (measured May 1996), N = Norway (measured April 1996)

BH = Breast Height (1,3 m)

	382-75		626-75		640-75		642-75		112-79	
	DK	N	DK	N	DK	N	DK	N	DK	N
Average height m	9,8	9,8	12,6	10,5	8,1	10,8	8,8	10,8	4,3	7,4
Average BH-circumference cm	42	51	58	50	49	57	53	46	17	35
Number of plants	1	6	2	1	4	4	2	2	3	4
Average number of stems	5	2	6	5	4	3	5	2	4	4
	1-79		9-79		26-79		121-79		641-75	
	DK		DK		DK		DK		DK	
Average height m	8,0		6,8		4,3		7,0		7,7	
Average BH-circumference cm	33		29		22		25		37	
Number of plants	2		23		7		2		3	
Average number of stems	1		3,4		3,1		2,5		7	

382-75: 54 S, 67 W, 50 m Rio Fuego (S) 1-79: 44 S, 71 W, 700 m Techka Chubut (S)
 626-75: 41 S, 71 W, 800 m Colonia Suiza(P) 9-79: 43 S, 72 W, 550 m Corcovada/Trevelin (S)
 640-75: 54 S, 67 W, 100 m Rio Grande (P) 26-79: 42 S, 71 W, 1100 m Esquel/Chubut (S)
 641-75: 54 S, 67 W, 100 m Lago Fagnano (P) 112-79: 54 S, 67 W, 150 m Kaiken (P)
 642-75: 54 S, 67 W, 150 m C. San Pablo (P) 121-79: 55 S, 68 W, 100 m Ushuaia (P)

Table 3. *Nothofagus pumilio* in Copenhagen and Bergen

DK = Denmark (May/June 1996); N = Norway (April 1996)

BH = Breast Height (1,3 m)

	390-75 N	643-75 DK	644-75 DK	645-75 N	122-79 N	123-79 DK	124-79 DK N
Average height m	9,9	9,2	7,7	9,8	6,8	4,8	4,0 6,4
Average BH-circumf. cm	58	33	30	64	20	14	13 27
Number of plants	2	1	2	3	2	1	2 3
Average number of stems	1	10	6,5	1,7	2	2	8,0 2,7
	77.2901 N	77.2902 N	77.2903 N	77.2903* N	77.2904 N	KØGE DK	77.2906 N
Average height m	9,3	8,2	10,3	9,0	9,9	10,3	8,7
Average BH-circumf. cm	45	45	57	30	69	49	42
Number of plants	5	6	4	14	3	39	1
Average number of stems	2,4	1,5	2,3	1,5	1,3	1	2,0

390-75: 55 S, 67 W, 100 m Lago Fagnano (S) 77.2904: 40 S, 71 W, 1000 m. Co. Chapelco (S)
 643-75: 55 S, 67 W, 100 m Lago Fagnano (P) 77.2906: 54 S, 68 W, 150 m. Est. Carmen (S)
 644-75: 55 S, 68 W, 50 m W of Ushuaia (P) 122-79: 55 S, 68 W, 100 m Ushuaia (P)
 645-75: 55 S, 68 W, 450 m Paso Garibaldi (P) 123-79: 55 S, 68 W, 200 m Rte Olivia (P)
 77.2901: 43 S, 71 W, 1300 m Cdo de Esquel (S) 124-79: 55 S, 68 W, 300 m Lago Escondido (P)
 77.2902: 43 S, 71 W, 1500 m Paso del Cordoba (S) 77.2903* (14 plants near Svartediket, Bergen)(S)

Observations of *Nothofagus antarctica*.

Die back of last years growth was general in Copenhagen, but was normally less than 10 - 20%. The trees in Bergen were measured at the beginning of bud-break. Only insignificant visible damage on shoots of *N. antarctica* was recorded in Bergen except for a few withered topshoots. Flowering was observed in Copenhagen for 9-79 and 26-79, and has in earlier years been observed in other provenances of *N. antarctica*. Fully developed seed has been collected in both Copenhagen and Bergen.

N. antarctica often develops many stems and coarse branches, and there is much variation in growth form between provenances, fig. 5. Some are growing straight upright, while others have a sinuous or tortuous appearance. In some cases (and provenances) stems start growing along the ground, eventually arching upwards, so that the trees end up looking like many-branched candelabra. This "krummholz" growth-form, which may be genetically determined, is a most attractive quality from a garden- and landscape point of view. There is also much variation in the size of leaves, from very attractive small-leaved forms (and often slow-growing shrubs) to forms with bigger and more coarse leaves, fig. 4.

Nothofagus pumilio

Only one provenance (124-79) of *N. pumilio* of the 1975 and 1979 collections is found both at Milde and at Hørsholm, table 3. Plants from the 1974 collection (Schlätzer 1976) were in 1977 distributed from the Danish Tree Improvement Station, Humlebæk, to forest



Fig. 5 *N. antarctica* (Hørsholm 9-79). Phot. P.S. Jan. 1997.

districts in Denmark and to the Norwegian Arboretum, Milde. Five provenances have survived at Milde (77.2901, 77.2902, 77.2903, 77.2904 and 77.2906). 14 plants of 77.2903 are growing in a clear cut area in mountain-forest near Svartediket, Bergen (110 m asl), and 87



Fig. 6 Bark of *N. pumilio* (143-67 Hørsholm, 30 years old) at 0,5 m height. Phot. P.S. Jan. 1997.

plants of the 5 provenances are found in a plantation of Norway Spruce (*Picea abies*) and Western Hemlock (*Tsuga heterophylla*) at Skjørsand, Fusa, about 40 km SE of Bergen and 60 m a.s.l. (measured in April 1994). In 1977 a plantation was established with the same provenances in the Gammel-Kjøgegård Forest District, 2 km W of Køge Denmark. This stand was measured in June 1996. We do not know to which of the 6 provenances the remaining 41 plants belong. They are remnants of a former much bigger plantation.



Fig. 7 Bark of *N. antarctica* (Hørsholm 26-79, 17 years old) 0,5 m height. Phot. P.S. Jan. 1997.

During the inventory of this stand the author became aware of an unusual variation in bark characters; most of the trees having the usual smooth bark of *N. pumilio* (fig. 6), while some had a bark that was cracking in vertical ridges, such as *N. antarctica* does at an early age (fig. 7). A closer examination of shoots from the canopy disclosed that three of the specimens were not *N. pumilio*, but had leaves that could hardly be distinguished from leaves of *N. antarctica*, fig. 4. The three specimens were also among the 5 tallest trees in the stand.

Plants of *N. antarctica* could have been mixed with *N. pumilio*, either when the plants were delivered from the Danish Tree Improvement Station, or when they were planted at the Gammelkjøgegaard Forest District. However, G. Schlätzer (who collected the seed in S. America) finds it most unlikely that a mistake could have been made in any of the two places, and he rules out the possibility of a mistake or mixing of samples during the collecting of seed (Schlätzer 1997). Isozyme- or DNA studies of the trees from Køge might answer the question, if this is a mixture of the two species or if hybridization has occurred.

Comparison of 33 trees in the Bergen area (Milde and Svartediket) with 37 trees from Køge, all from the 1974 collection and all planted 1977 (measured spring 1996).

	Bergen	Køge
Average height m	9,2	10,2
Average Circumference C	44	47
Number of plants	33	37
Average number of stems/plant	1,71	

Diverging trees in the Køge plantation

		Height m	Circumference cm
Tree nbr.	8	14,0	72
- -	28	12,3	71
- -	40	15,5	108

Observations of *Nothofagus pumilio*

Only little damage due to frost and draught was recorded on *N. pumilio* in the Copenhagen area (incl. Køge) after the 1995/96 winter. In most cases between 0 and 10 % die back and only a few cases of up to 20 % reduction of last years growth. In the Bergen area no damage was observed, and as a rule the trees looked healthy and vigorous.

N. pumilio often develops many stems, when planted at wide spacing. By more dense spacing, or protected against frost, it tends to develop single stems, but most of the trees start forking from a few meters height and they often develop a number of coarse side-branches.

No flowering has been observed in *N. pumilio* either in Denmark or, as far as known, in Norway.

The little stand of *Nothofagus pumilio* 77.2903* (Svartediket) was planted on newly cleared forest land in November 1977. They grew up together with the natural vegetation of birch (*Betula pubescens*) and rowan (*Sorbus aucuparia*) and nothing was done to suppress competition from the native species. When the *N. pumilio* plants were measured in April 1996, the ten tallest birches in the stand were measured as well (fig. 8).

Comparison, April 1996, of the 10 tallest *N. pumilio* trees at Svartediket with the 10 tallest birch trees in the same stand. The rowans were overtaken by both birch and *Nothofagus*.

	Birch	<i>N. pumilio</i>
Average height m	9,9 (8,9-11,2)	9,9 (8,2-11,1)
Average BH-Circumf. cm	32 (26-43)	38 (28-59)

This indicates that *N. pumilio* is able to compete with a natural vegetation of birch, an important quality if the species is going to be used in afforestation.

The stand at Svartediket was measured several times between 1982 and 1997. The graph, fig. 8, shows the development of heights during the 15 year period. Even if there is a gap between 1987 and 1994 nothing indicates serious disruptions in growth rythm during this period, except for a single tree, which seems to have been suppressed from c. 1990.

A comparison of the 1974-provenances (77.2901 - 2906) at Milde, Fusa and Svartediket shows a relatively small variation between provenances except for 77.2906, which appears to be slower growing than any of the others. It was collected in the southernmost part of the Argentinian Tierra del Fuego. 77.2905 was collected in Southwest Chile (52° 10' S, 72° 00' W, 450 m asl). 30 plants were sent to Bergen (10 planted at Milde and 20 planted at Fusa). None of these have survived. Compared to the plants at Svartediket and Fusa the plants at Milde have had a much stronger growth (30 - 40 % bigger circumference). This is probably due to less competition from other trees (more space) and to yearly cuttings of the ground vegetation. Height development has been the same at Milde and at Svartediket, while the trees at Fusa are lacking behind, even when the slow growing 77.2906 is left out. From the 241 plants in 1977, 121, or 50

%, did survive. 77.2901 had the best survival rate with 50 living of 61 planted, or 82 %.

Plants from the 1974 collection were tested in a few other places in Denmark (Schlätzer 1997). Schlätzer considers *N. pumilio* to be a new and promising species for both horticulture and forestry in Denmark, and he recommends that new provenance trials should be established. A similar suggestion can be made for West- and South Norway, where one would expect a similar or even better performance.

Comparison of plantings of *N. pumilio* at Milde, Svartediket and Fusa (planted 1977, recorded April 1994). Initial number of plants in brackets.

	Nbr of plants	Average height m	Average Circumf. cm	Aver. nbr stems/plant
Milde				
77.2901	(10) 5	8,4	38	2,4
77.2902	(10) 6	7,3	37	1,5
77.2903	(10) 4	8,3	48	2,3
77.2904	(10) 5	8,0	53	1,3
77.2905	(10) 0			
77.2906	(10) 1	7,5	36	2,0
Average		7,9	43	1,8
Svartediket				
77.2903*	(30) 14	7,8	29	1,5
Fusa				
77.2901	(51) 45	6,8	27	1,4
77.2902	(20) 7	6,5	25	1,1
77.2903	(10) 7	6,5	23	1,0
77.2904	(10) 4	5,6	26	1,3
77.2905	(20) 0			
77.2906	(40) 23	4,9	16	1,7
Average		6,1	23	1,4
- 77.2906 left out		6,6	26	1,3

Tree height (m)

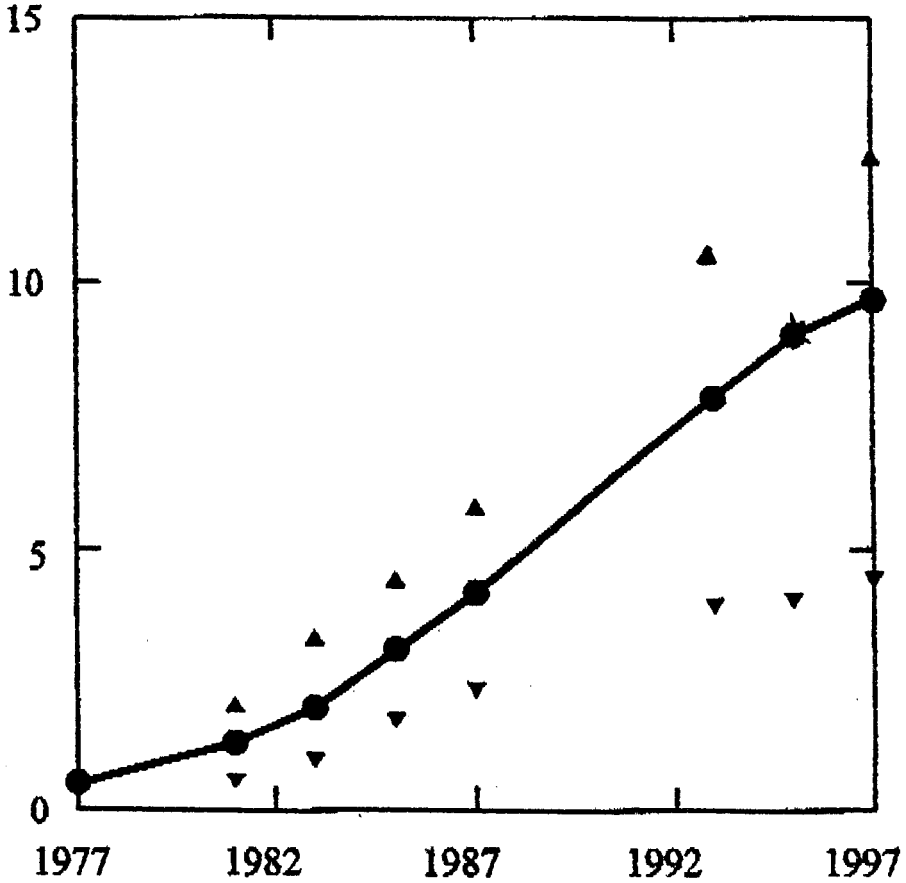


Fig. 8 Average height/gennemsnitshøjde 1977-1997 for *N. pumilio* at Svartediket, Bergen.

***Nothofagus alpina (procera)* and *N. obliqua*.**

N. alpina and *N. obliqua* (fig. 9 and 10) are the most interesting species of *Nothofagus* from a foresters point of view. They have both been introduced to Denmark several times and except for the latest introductions, after 1977, only a single individual of the former introductions have survived (*N. obliqua* at Knuthenborg). The two species have also been introduced to West Norway since 1970 with more or less the same results. Both species were tested by the Forest Services in England, Scotland and Wales. They have shown high growth rates and good qualities as timber trees (Tuley 1980). However, both species are tricky with regard to climate, and there are clear differences in



Fig. 9 *N. obliqua* (Hørsholm 1284-77). Photo P. S. May 1996.

frost resistance between different provenances (Deans, Billington & Harvey 1992). In freezing chamber tests with *N. alpina* the authors found patterns of alternate hardening and dehardening during win-



Fig. 10 *N. alpina* (Hørsholm 1283-77). Leaves damaged by frost near bud break. Phot. P.S. April 7th 1996.

tertime, which make this species susceptible to damage, when mild spells are succeeded by cold periods (fig. 10). Provenance tests in Wales (Danby 1991) showed that trees from some provenances of the two species were severely affected by frosts in areas further than 20 km from the coast and in cold valleys (cambial damage). The trials suggested that only *N. alpina* is likely to be of commercial value in Welsh Forestry, and that the most cold hardy provenance is Central Chile (38° - 40° S). In similar trials near Rouen, France, the authors (du Cros, E.T., Duval, H, & Teissier du Cros, E. 1985) found that both species were damaged by severe frost, but that *N. obliqua* apparently was more frost resistant than *N. alpina*.

A trial in Nordrhein-Westfalen in Germany with *N. alpina* (11 provenances), *N. obliqua* (7 provenances) and *N. pumilio* (3 provenances) was started 1979 and given up in 1987, when 90 % of the plants were completely destroyed and the rest severely damaged (Heymann 1988). Among the provenances with best survival before the fatal 1986-winter, were *N. obliqua* and *N. alpina* from West Scotland 55°-56° N (1st generation of Chilean origin).

Danish experiences after 1977

In 1977 the Hørsholm Arboretum received seed from the British Forestry Commission of the following species.

N. alpina: 11 provenances collected in Chile between latitude 36° and 40° S and 500 - 800 m asl, and 3 provenances collected in Scotland and England on 1st and 2nd generations of Chilean origin. (Table 4).

N. obliqua: 5 provenances collected in Chile at the same latitudes and elevations, and 2 provenances from Scotland and England collected in 1st and 2nd generations of Chilean origin. (Table 5).

The same provenances were used in the Nordrhein-Westfalen trials, which were given up in 1987 (see above).

N. alpina and *N. obliqua* were collected again 1979 in Argentina (Rio Aluminé and Lago Tromen) about 39° S, at 800 - 900 m elevation by The Danish Scientific Expedition to Patagonia and Tierra del Fuego 1978-1979 (Madsen, Nielsen & Ødum 1980).

Surviving plants from the two collections (a total of 19 provenances and 55 plants) were transplanted from the nursery to the Arboretum 1983 after a heavy selection had taken place during the very cold 1982-winter. Most of the plants were cut back, many nearly to the ground, during the following cold winters 1983 -1987 (Ødum 1986 and Søndergaard 1989). About 30 plants of 13 provenances were still alive in July 1996, and many looked promising (e.g. 1273.77, 1282.77, 1283.77 and 166.79 of *N. alpina* and 1270.77, 1284.77 and 167.79 of *N. obliqua*), tables 4 and 5. It is interesting to note that among the seven best performing provenances of the two species four were either 1st or 2nd generation offspring from England or Scotland and two were from Argentina (collected in a drier and more continental climate than prevails in adjacent Chile).

N. alpina and *N. obliqua* in Bergen.

At present one 10-15 year old tree of *N. alpina* is growing in the Bergen Botanical Garden (8,2 m high and 44 cm CBH in August 1997). Plants of *N. obliqua* have all perished, the last during the 1986/87 winter.

Table 4. *Nothofagus alpina* (recorded at Hørsholm July 1996). All collected as seed.

Provenance	Nbr of plants	Height m	Circumf. cm	Av. nbr stems	Die back of crown	Remarks
1272.77 Las Tablas, Chile, 36°40' S	1	2,9	5	4	98 %	no good
1273.77 Puesco, Chile 39° S	3	5,0	21	3,1	15-30 %	good and healthy, green to the top
1279.77 Pemehue, Chile 38° S	1	3,7	13	3	60 %	Recovering, green to the top.
1280.77 Temuco, Chile 39°40 S	3	4,9	16	3	80-99 %	Very bad condition
1282.77 England (South) 2nd gener. (origin Chile) 51°N	1	4,7	16	2	20 %	Good and healthy green to the top
1283.77 England (West) 1st gen. (origin Chile) 52°N	2	5,9	24	4	15-20 %	Good and healthy green to the top
166.79 Lago Tromen, Argentina 39°34'S 71°-26'W 900m	3	4,1	16	1,7	25-30 %	Healthy, green to the top

Table 5. *Nothofagus obliqua* (recorded at Hørsholm July 1996). All collected as seed.

Provenance	Nbr of plants	Height m	Circumf. cm	Aver nbr of stems	Die back of crown	Remarks
1265.77 Los Guindos, Chile 37°50' S 71°40'W 700-800 m	1	5,2	20	2	35 %	Good. Green to the top.
1266.77 Las Trancas, Chile 38°50'S 72°10'W 500-600 m	3	6,4	28	1	50-98 %	Very bad, dying?
1267.77 Mahuidanche, Chile 39°30'S 72°00'W 650-700 m	2	5,2	20	1,5	60 %	Healthy looking and recovering
1270.77 England (South) 2nd gen.	3	6,7	30	1,7	15-30 %	Good, green to the top and recovering well
1284.77 Scotland (West) 55°N	1	7,6	34	1	15 %	Completely recovered and with full crown
167.79 Rio Aluminé Argentina 39°30'S 70°58'W 800 m	2	4,6	25	2,5	25-40 %	Healthy and green to the top

Evergreen *Nothofagus* species

Only two of the evergreen species of *Nothofagus* have survived in Bergen and Copenhagen, *N. betuloides* from S. America and *N. solandria* var. *diffortoides* from New Zealand. The first introductions of *N. betuloides* 1975 and 1979 were all killed by the very cold winters between 1977 and 1983. New introductions from the Faeroe Islands to Bergen in 1982 have obtained heights of more than 7 m and were relatively little damaged by the 1995/96 winter (fig. 11, fig. 12).



Fig. 11 *N. betuloides* (Milde 82.0153) at Milde. Phot. P.S. April 26, 1996.



Fig. 12 *N. betuloides* exposed to wind, near Klaksvik, Faeroe Islands. Phot. P.S. August 1996.

***Nothofagus betuloides* in Bergen (measured April 1996).**

Measured in April	113-79			119-79		
	1996	1994	1988	1996	1994	1988
Average height m	4,9	3,7	1,1	6,2	4,7	1,1
Average circumf. cm	16			16		
Number of plants	4	4	4	2	2	2
Average nbr stems/plt	2,5			2		

15 % of the leaves in 113-79 were brown (April 1996) compared to 7 % in 119-79. They grow in relatively good shelter and they all have an open lanky growth.

113-79: 55° S, 69° W, 300 m Tierra del Fuego

119-79: 55° S, 68° W, 100 m Tierra del Fuego

Nothofagus betuloides in Denmark.

One plant of *Nothofagus betuloides* (119-79) was planted in the Garden of the Royal Veterinary- and Agricultural University in 1987. It was completely healthy and undamaged in 1997, when the largest of its three stems had obtained a height of 2,0 m. Two were planted in Forstbotanisk Have (1988 one plant from the 1974-expedition) and 1992 one of no. 113-79. More than 90 % of the leaves and shoots were killed by the 1995/96-winter on the plant from 1988, which was only 1,3 m high. The plant from 1992 was 3,5 m high with an open and irregular growth and cut back by about 30%.

Nothofagus solandri var. *cliffortioides*.

Bergen.

Four plants from the 1975 - collection survived the very cold winter 1978/79 at Milde. They seem to be well established and have been growing steadily since they in 1982 were transplanted from a frost exposed area to more favourable places.

75.1616: Broken Hill Ski Area, Craigieburn Rge., Canterbury, New Zealand, 1200 m a.s.l..

	April 96			Apr. 94	Apr. 88
Average height m	2,7	3,3	4,2	2,7	0,6
- circumference cm	5	9	12		
Number of plants		4		4	4
Average number of stems/plant		1,5			

Less than 20 % of the leaves were brown in April 1996. One of the specimens is dense and nicely fan shaped, while the others are more or less straggly.

Denmark.

Two plants from the 1975 expedition have survived in Forstbotanisk Have, Charlottenlund.

190-75: Mt. Bee Trail, Eyre Mts, Otago New Zealand, 1200 m.a.s.l.

Height 1,3 & 1,4 m. Circumference 3 & 2 cm. 10 % die back.

They were relatively little damaged by the 95/96 winter, but are extremely slow growing (a third plant was stolen in 1995). (Fig.13).



Fig. 13 *N. solandri* var. *cliffortioides* (Hørsholm 190-75) in Forstbotanisk Have. Phot. P.S. July 1996.

Both *N. betuloides* and *N. solandri* var. *cliffortioides* seem to be able to maintain themselves in the Bergen climate and eventually become sizeable ornamental shrubs or small trees when planted in sheltered conditions. In Denmark there is not much hope of getting reliable ornamentals of either *N. betuloides* or *N. solandri* var. *cliffortioides*.

Conclusions.

Nothofagus antarctica seem well adapted to the climate of East-Denmark, *N. pumilio* is promising, and they seem to regenerate without problems from die back caused by cold winters. No substantial die back has been recorded in the Bergen region and with a few exceptions most of the provenances of the two species are performing very well. No significant differences in growth between the two areas can be seen from the figures. But from observations in the field it is obvious that both *N. antarctica* and *N. pumilio* look far more happy in the humid climate of West Norway (about 2000 mm/year), compared to their appearance in the rather dry Danish climate (about 650 mm/year). There seem to be good possibilities to select interesting provenances, growth forms and types for autumn colours from both species, particularly for use in gardens, parks and landscape. In a comparison of growth between *N. pumilio* and *Fagus sylvatica*, Schlätzer (1997) has demonstrated a potential for *N. pumilio* as a producer of wood for pulp. The Scandinavian trials so far do not indicate a similar potential for timber production. However, this might depend on silvicultural practices. Natural self sowings of *Nothofagus* are normally extremely dense, which means that the resulting trees obtain straight single stems with relatively fine branches. An imitation of this in Scandinavian trials might yield more favourable results for *N. pumilio*. The growth rates for some provenances and individuals of *N. antarctica* indicate that this species might also be interesting as a producer of wood for pulp or bio-energy. It must be emphasized that commercially viable results with the two species can only be expected in the westernmost- and southernmost parts of Scandinavia (Denmark, S-Sweden, westernmost and southernmost Norway, the Faeroe Islands and maybe southernmost Iceland). *N. antarctica* flowers regularly and is easy to propagate by seed and by cuttings. Flowers have not been observed in *N. pumilio* in Scandinavia, and regeneration by cuttings has not yet been achieved, as far as known.

N. alpina and *N. obliqua* have been unreliable both in Denmark and in the Bergen area. However, there is an apparent variation in hardiness between provenances, and hardy provenances could be found for both areas. Flowering has been observed in *N. alpina* in Denmark.

Their potential for in vitro propagation is under investigation (Martinez-Pastur & Arena 1995 and 1996), but a practical method for propagation by cuttings does not seem to have been developed. The two species have also shown poor survival and growth in the Faeroe Islands (Ødum, Hansen & Rasmussen 1989, and the author's own observations 1996).

N. betuloides and *N. solandri* var. *cliffortioides* must be considered as rarities in Denmark, the latter being subject to frost damage and of extreme slow growth, and the former being susceptible to both draught and frost-damage. They do better in the Bergen-area, and *N. betuloides* might have a potential as a shelterbelt tree and a producer of greenery for decoration as it has shown in the Faeroe Islands. It could possibly be grown along the outermost parts of the western coast of Norway between 61° and 58° N (from the Sognefjord estuary to Cape Lindesnes). Outside this area the two species will probably be restricted to botanical collections or remain collectors items. Their potential for vegetative propagation is not known.

In order to see *N. cunninghamii*, *N. dombeyi* and *N. menziesii* grown out of doors in Scandinavia one must visit gardens in the Faeroe Islands. The Chilean *N. nitida*, was planted in Torshavn during a joint meeting of the Nordic Arboretum Committee and The Nordic Subarctic Subalpine Ecology Group in 1996. However, the plants did not survive the following winter, so the number of *Nothofagus* species grown out of doors in Scandinavia is still restricted to nine.

Dansk resume

N. antarctica og *N. pumilio* synes at egne sig godt til klimaet i mere beskyttede områder af Danmark og de regenererer relativt hurtigt efter frostskafer i kolde vintre. I Bergensområdet er der ikke fundet store og alvorlige frostskafer på de to arter, og med få undtagelser har de fleste provenienser en tilfredsstillende vækst og udvikling. At dømme efter tabellerne 2 og 3 er der ikke væsentlige forskelle i udvikling for de to arter mellem Bergen og Københavnsområdet. Observationer i felten viser imidlertid klart, at *N. antarctica* og *N. pumilio* befinder sig bedre i det fugtige Bergensklima (2.000 mm/år) end i det relativt tørre danske klima (650 mm/år). Bergensplanterne har tydeligt mere bladfyldte og ser ud til at stortrives, mens de danske planter har et vist tørkepræg.

For begge arter er der tilsyneladende gode muligheder for at selekttere interessante provenienser og typer med hensyn til vækstform, bladform og -størrelse og efterårsfarver med sigte på brug i haver,

parker og i landskabet. Efter en sammenligning mellem væksten af *N. pumilio* og *Fagus sylvatica* i Danmark skriver Schlätzer (1997) at *N. pumilio* på grund af sin hurtige vækst synes at have en fremtid som "producent af tungere ved til cellulose". På baggrund af de hidtige forsøg kan man derimod ikke forvente en fremtid som tømmerproducenter for *N. pumilio* og *N. antarctica* i Norden. Dertil er de alt for grovgrenede og deformerede af tveget vækst. Når *Nothofagus* forynges sig naturligt, vokser den næsten altid op i meget tætte bestande, hvor træerne er enstammede, relativt fingrenede og med god oprensning. Hvis man forsøgte en lignende dyrkningsform ved afprøvning i nordiske forsøg, ville resultaterne utvivlsomt blive bedre. Det er derfor for tidligt at afskrive *N. pumilio* som tømmerproducent, selv om den på dette område vil få svært ved at konkurrere med vores hjemlige bøg. Nye proveniensforsøg bør anlægges både for denne art og for *N. antarctica*. Sidstnævnte har i flere tilfælde vist særdeles hurtig vækst både for enkelte provenienser og især på individniveau og har uden tvivl et potentiale til produktion af masseved eller bioenergi. *N. antarctica* blomstrer regelmæssigt og er let at formere med frø og stiklinger. *N. pumilio* har så vidt vides endnu ikke blomstret i Norden, og det er endnu ikke lykkedes at formere den med stiklinger. For begge arter gælder at kommerciel dyrkning med vedproduktion som mål kun vil kunne svare sig i kystnære områder af Vestskandinavien (Danmark, Sydsverige, Vest- og Sydnorge og Færøerne).

N. alpina og *N. obliqua* er ikke pålidelige i dyrkning i Danmark og tilsyneladende endnu mindre i Vestnorge. Der synes imidlertid at være en betydelig variation i hårdførhed mellem provenienser af de to arter. Det kan derfor ikke udelukkes, at der findes provenienser eller typer, som vil kunne dyrkes under gunstige forhold i Danmark og Vestnorge. Begge arter viser meget dårlig tilpasning til det færøske klima.

N. betuloides og *N. solandri* var. *cliffortioides* må kaldes absolutte rariteter i Danmark. Førstnævnte er meget frostfølsom mens sidstnævnte er både frostfølsom og har ekstremt langsom vækst. I Bergen klarer de sig bedre, og *N. betuloides* har muligvis et lignende potentiale til læ- og værnplantning og pyntegrøntproduktion, som den har vist på Færøerne. Den fortjener at blive prøvet i dyrkning på de yderste dele af vestlandskysten fra Sognefjordens udmundning i nord til Lindesnes i syd. Udover disse områder vil brugen formentlig indskrænke sig til botaniske samlinger og til særligt interesserede amatørers haver.

For at se *N. cunninghamii*, *N. dombeyi* og *N. menziesii* dyrket på friland i

Norden må man til Færøerne. Der findes de bl.a. i Arboretet ved Skogrøkt Landsins planteskole i Hoydalar nær Torshavn. Den chilenske *N. nitida* blev i august 1996 plantet i Torshavns byskov, Gundadalur, i forbindelse med et fællesmøde mellem Nordisk Arboretudvalg og forskergruppen "Nordic Subarctic & Subalpine Ecology Group". De fire planter døde i den følgende relativt kolde vinter og der er således stadig "kun" 9 arter af *Nothofagus* i dyrkning på friland i Norden.

Tak til Gammel Kjøgegård Skovdistrikt og til ejeren af plantagen på Fusa, Bjarte Krüger, til Bergen Skog- og Treplantingsselskab og til Arboretet på Milde, for adgang til deres materiale af *Nothofagus*. Også tak til B.H. Ingvarsen for tegning af *Nothofagus* blade. Og til sidst en tak til det færøske Skogrøkt Landsins, som arrangerede et vellykket møde i august 1996, hvor hovedindholdet i denne artikel blev præsenteret.

Bibliography:

Cockayne, L. & E. Phillips Turner, 1967: The Trees of New Zealand. 6th ed. Wellington

Cros, E.T. du, H. Duval, E. Teissier du Cros, 1990: Comportement de *Nothofagus* à la suite du froid de début 1985. Revue For. Française 42: 3, 322-328.

Deans, J.D., H.L. Billington, & F.J. Harvey, 1992: Winter frost hardiness of two Chilean provenances of *Nothofagus procera* in Scotland. Forestry-Oxford. 65: 2, 205 - 212.

Donoso, C., 1987: Variación natural en especies de *Nothofagus* en Chile. Bosque 8: 85-97.

Donoso, C., 1996: Ecology of *Nothofagus* Forests in Central Chile. In: Veblen, Hill and Read: The Ecology and Biogeography of *Nothofagus* Forests. 1996. 271-292.

Heyman, P., 1988: Anbauerfahrungen mit verschiedenen *Nothofagus*-Provenienzen in Nordrhein-Westfalen. Mitt. Dtsch. Dendrol. Ges. 78, 23-33.

Hill, R.S. & J. Read, 1991: A revised infrageneric classification of *Nothofagus* (Fagaceae). Botanical Journal of the Linnean Society. 1, 37-72.

- Hill, R.S., 1991: Tertiary *Nothofagus* (Fagaceae) macrofossils from Tasmania and Antarctica and their bearing on evolution of the genus. Bot. Journ. of the Linn. Soc. 1, 73 - 112.
- Hill, R.S., 1992: *Nothofagus*: evolution from a southern perspective. Trends in Ecology and Evolution. 1992, 7: 6,190-194.
- Hill, R.S. & G.J. Jordan, 1993: The evolutionary history of *Nothofagus* (Nothofagaceae). Australian Systematic Botany. 6: 2, 111-126.
- Hill, R. S., 1997. Personal communication.
- Hill, R.S. and M.E. Dettmann, 1996: Origin and Diversification of the Genus *Nothofagus*. In: Veblen, Hill and Read 1996: The Ecology and Biogeography of *Nothofagus* Forests. pp 11-24.
- Hiorth, G., 1956: Allverdens trær i norsk jord (Trees from all over the world in Norwegian soil). Flekkefjord, Norway.
- Hjellestad, I., 1985: Lokalklimatiske undersøkelser på Det norske arboret, Milde 1978-1979 (Investigation of the local climate in The Norwegian Arboretum, Milde 1978-1979). Botanisk Inst. rapp. nr. 37, Universitetet i Bergen.
- Humphries, C.J., 1981: Biogeographical methods and the southern beeches. In V.A. Funk and D.A. Brooks (eds.). *Advances in Cladistics*. British Museum and Cambridge University Press. Cambridge, pp. 283-97.
- Lange, J., 1994: Kulturplanternes indførselshistorie i Danmark - indtil midten af 1900 tallet (History of introduction of cultivated plants in Denmark - to the middle of the 20th Century). Jordbrugsforlaget, Frederiksberg
- Madsen, H.B., E.S. Nielsen, & S. Ødum, 1980: The Danish Scientific Expedition to Patagonia and Tierra del Fuego 1978 - 1979. Geografisk Tidsskrift 1980, 28 pp.
- Martin, P.G. & J.M. Dowd, 1993: Using sequences of rbcL to study phylogeny and biogeography of *Nothofagus* species. Australian Systematic Botany. 6, 5, 441-447.

- Martinez-Pastur, C.J. & M.E. Arena, 1995: In vitro propagation of juvenile *Nothofagus obliqua*. Australian Journal of Botany. 43, 6. 601-607.
- Martinez-Pastur, C.J. & M.E. Arena, 1996: In vitro propagation of *Nothofagus nervosa* (Phil.) Dim. et Mil. Phytion. 58.
- Nordisk Illustreret Havebrugsleksikon, 1946 (Nordic Illustrated Dictionary of Gardening). København.
- Premoli, A., 1997: Personal communication.
- Schlätzer, G., 1976: Nogle sydamerikanske *Nothofagus* (Some South American *Nothofagus* Species). Dansk Skovforenings Tidsskrift. 61. 35 - 70.
- Schlätzer, G., 1997: Sydens bøger i dansk brug. Jord og Viden, 142. 10. 10-12.
- Schlätzer, G., 1997: Lidt snak om Sydbøger fra Sydamerika til Danmark. Syvdalen. Årg. 4, nr. 3., 18-20.
- Scriven, L.J. & R.S. Hill, 1996: Relationships among Tasmanian Tertiary *Nothofagus* (Nothofagaceae) populations. Botanical Journal of the Linnean Society, 121, 345-364.
- Søndergaard, P., T. Benedikz & H. Vedel, 1977: The Nordic Arboretum Expedition to New Zealand, Tasmania and South-East-Australia 1974-75. The Norwegian Arboretum, N-5067 Store Milde. 82 pp.
- Søndergaard, P., 1989: Experiences with cultivation of plants from the southern hemisphere in West Norway compared with observations from the Faeroe Islands. In "Træplanting í Føroyum í eina øld" - A century of tree-planting in the Faeroe Islands.- Ann. Soc. Scient. Faeroensis. Suppl. XIV, 165-180.
- Tuley, G., 1980: *Nothofagus* in Britain. Forestry Commission Forest Record 122. Her Majesty's Stationary Office, 26 pp.

- Veblen, T.T., C. Donoso, T. Kitzberger and A.J. Rebertus, 1996: Ecology of Southern Chilean and Argentinian *Nothofagus* Forests: In Veblen, Hill and Read 1996: The Ecology and Biogeography of *Nothofagus* Forests. pp 293-353 .
- Veblen, Thomas T., R.S. Hill and J. Read, editors, 1996: The Ecology and Biogeography of *Nothofagus* Forests. Yale University Press, New Haven and London. 403 pp.
- Ødum, S., J.P. Hjerting & B. Søegaard, 1977: The Nordic Arboretum Expedition to southernmost Argentina and adjacent Chile 1975. Hørsholm Arboretum, DK 2970 Hørsholm. 37 pp.
- Ødum, S., 1986: Vinterskader blandt træer og buske på Arboretet i Hørsholm. Ugeskrift for Jordbrug 131 (8) 226-227.
- Ødum, S., 1989: A 10 year trial with South American trees and shrubs with special regard to the *Nothofagus* spp. In: "A century of tree-planting in the Faeroe Islands". Annal. Soc. Scient. Faeroensis. Suppl. XIV. 125-156.
- Ødum, S., 1991: Choice of Species and Origins for Arboriculture in Greenland and the Faeroe Islands. Dansk Dendrol. Årsskr. 9, 1 - 78.
- Ødum, S., 1997: Personal communication.