FURTHER DEVELOPMENT OF DOUGLAS FIR IUFRO PROVENANCES IN THE NETHERLANDS 1966/67 SERIES

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Rijksinstituut voor Onderzoek in de Bos- en
Landschapsbouw "De Dorschkamp"
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ABSTRACT

Results are reported of two trials, Sleenerzand in northeastern Netherlands and Sprielderbos in the centre of the country, with 52 provenances of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) of the 1966/67 IUFRO series.

The results of the flushing observations of 1974 in Sprielderbos are closely correlated with those of 1972 in the nursery and in 1973 in Sleenerzand.

Height increment and survival of provenances from three areas in Washington, selected in 1974 for seed collection for the Netherlands, are in both trials better than those of provenances from outside these areas. The former provenances flush later.

Some provenances from outside these areas such as Chilliwack, Sooke, Franklin River, Alberni and Courtenay, although they flush relatively early, perform fairly well, some of them in particular under the somewhat harsh conditions in Sprielderbos.

INTRODUCTION

Early results from 57 provenances of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) of the 1966/67 IUFRO series in two nurseries and a trial were reported in 1974 (Kriek).

Data on the trees' growth, their flushing, survival and imperfections such as dead terminal bud, dead top, double tops and double trunks clearly indicated that some provenances were more suitable than others for plantation work in the Netherlands. As a result, three regions were identified as being preferable for seed collection for Dutch forestry.

These regions are: east of the Puget Sound; the Olympic Peninsula; and the southwest of the state of Washington (Figure 1). Some provenances from Vancouver Island performed well and were singled out for special mention.

This report deals with the development since 1973 of 52 of the 57 provenances in two trials.

P L A N T M A T E R I A L A N D E X P E R I M E N T S

The necesssary information on the provenances is given in Figure 1 and Table 1*. The seed was sown in three replicates in "De Dorschkamp" nursery in December 1967. The seedlings were transplanted in the same nursery in the spring of 1969. The same replicates were maintained.

In April 1971 some of the three-year-old (1+2) plants were planted in a trial in the Sleenerzand forest range in northeastern Netherlands. The remaining planting stock was transferred to nurseries in the Sprielderbos forest range in the centre of the country. This material was used to set up a trial in Sprielderbos in 1973. At that time the plants were five years old (1+2+2). Detailed information on the trials is summarized in Table 2.

T H E W E A T H E R

Rainfall and temperature were decisive factors for the development of the trees. For the trial in Sprielderbos we may refer to climatic data from De Bilt and for the Sleenerzand trial, to the rainfull data from Emmen and because long-term averages for temperature are not readily available for that station, to temperature data from Eelde (KNMI 1973-1977). The location of the trials and the weather stations is shown in Figure 2.
Latitudes and longitudes are given in Table 3.

Table 3. Latitudes and longitudes of trials and weather stations

station	latitude	longitude
De Bilt	52° 6'	5° 11'
Sprielderbos	52° 14'	5° 41'
Emmen	52° 47'	6° 54'
Sleenerzand	52° 50'	6° 45'
Eelde	53° 8'	6° 34'

All stations are less than 100 m above sea level.

The summers of 1973, 1974 and 1977 had more or less normal temperature and rainfall, but those of 1975 and 1976 were hot and dry to very dry.

Since this report is particularly concerned with the growth of the provenances from 1975-77, detailed information on rainfall in April-October inclusive in 1975, 1976 and 1977 and long-term averages for De Bilt and Emmen are shown in Figures 3 and 4. Cumulative rainfall figures for the periods July + August and June-August inclusive are given in Table 4. The summer of 1976 was very dry over the whole country. The summer of 1975 was also rather dry, especially in central Netherlands; rainfall totals in July and August 1975 were almost as low as in 1976.

* Tables 1,2,5 and 6 and Figures 1-6 are at the end of the report.

Table 4. Cumulative rainfall in the summer months of 1975, 1976 and 1977 at De Bilt and Emmen

	De Bilt				Emmen			
	July/August		June/July/August		July/August		June/July/August	
	mm	%	mm	%	mm	%	mm	%
1975	66	40	152	68	119	64	168	75
1976	60	36	113	51	69	37	100	45
1977	159	96	198	89	164	89	237	106
average*	165	100	223	100	185	100	224	100

* De Bilt: 82 years average; Emmen: 18 years average

The low rainfall in July and August 1975 and June-August 1976 was accompanied by high to very high temperatures (Figures 5 and 6).

Late and early frosts

The data on low temperatures in May, June, September and October at De Bilt and Eelde only indicate the likelihood of frosts. Local circumstances at Sprielderbos probably favoured the occurrence of lower temperatures than recorded at De Bilt, whereas the site in Sleenerzand may be slightly warmer than indicated by the temperature data from Eelde.

Several late frosts were recorded in May 1973. At Eelde the lowest temperature (-1.8°C) was recorded on 15 May. At De Bilt the lowest temperature (-0.5°C) was recorded on 16 May. In May 1974 no late frost was recorded at De Bilt but late frosts of -0.6 to -0.8°C were recorded in 30 May at some other stations in Central Netherlands. In Eelde only one light frost (-0.1°C) occurred. In May 1975 no late frosts occurred, but on the first two days of June rather low minimum temperatures were recorded over the whole country resulting locally in serious late frosts. In 1976 the latest frosts occurred in the first week of May; one at De Bilt and two at Eelde. May 1977 was free of late frosts.

Troughout the period 1973 to 1977 no early frosts occurred in September. Sub-zero October temperatures were recorded in 1973 and 1974 at both De Bilt and Eelde, and in 1975 only at Eelde. De Bilt had fewer October days with sub-zero temperatures and these occurred later in the month.
It is unlikely that any provenance suffered damage through early frost, but no detailled observations were made.

A S S E S S M E N T S   A N D   R E S U L T S

The detailed assessments we made allowed us to calculate the percentages of trees that died after beating up, which took place in 1972 in Sleenerzand and in 1974 in Sprielderbos.

In April and May 1974 observations on flushing and late frost damage were carried out in Sprielderbos. The observations on flushing were to supplement the information published in 1974.

Tree height was measured in both experiments after the 1974 and 1977 growing seasons. In 1977 tree heights in 1975, 1976 and 1977 were compared in order to evaluate the influence of the dry summers of 1975 and 1976.

For the presentation of the results (Tables 5 and 6) the provenances have been arranged in six groups:

1. The provenances from the selected area east of the Puget Sound and in some adjoining northern and southern areas.
2. The provenances from the selected area of Olympic Peninsula and some adjoining provenances.
3. The provenances from the selected area in southwest Washington and some adjoining provenances in Washington and Oregon.
4. The provenances from the southern part of Vancouver Island and some adjoining provenances on the British Columbia mainland.
5. All other provenances from Vancouver Island and British Columbia not included in groups 1 and 4.
6. All other provenances from southern Washington and Oregon not included in group 3.

Within the groups the provenances have been ranked according to height in 1977. For each of the provenances in groups 1 to 3 I have indicated whether the provenance is from the appropiate selected area.

Survival

In Sleenerzand survival was very good up to early 1974, two years after beating up. Three-quarters of all provenances had mortality rates of only 0-3.5%. Cassidy (no. 1040) had the highest mortality (13.0%). The drought of 1976 and repeated late frost damage undoubtedly contributed to a rising mortality there-after. The survival of provenances from within the selected areas remained generally good (1-17% mortality up to 1977) with one exception - Skamokawa (no. 1087) - of which 27% of the plants died up to 1977 (Table 5). On the whole, provenances from outside the selected areas did not do as well, with the exception of both provenances from Chilliwack (nos. 1038 and 1039), Sooke (no. 1045), Hebo (no. 1098) and to some extent Courtenay (no. 1032), Franklin River (no. 1037), Stella Lake (no. 1026) and Sandy (no. 1096).

In Sprielderbos survival was reasonable up to late 1974, one growing season after beating up. Three-quarters of the provenances had mortality rates of 2-10%. Of the others, 12-27% of the plants died. Late frost damage and drought subsequently increased mortality considerably. As mentioned in Table 2 a small part of the experiment had to be abandoned because of very low survival, mainly due to repeated frost damage in a frost pocket. Excluding this part of the experiment, mortality was still high, ranging from 9-59% (Table 6). About two-thirds of the provenances had a mortality between 15-30% and one-third of the provenances lost 31-59% of the plants. Humptulips (no. 1073) was the only provenance with less than 15% mortality.

Flushing

Observations on flushing were carried out in the Sprielderbos experiment on 19 April, 3, 17 and 31 May 1974. Seven stages (0-6) were distinguished. The method used was described in detail in the 1974 report.

The mean stages of flushing for the whole trial on the different dates may be compared with the results from the nursery in 1972 (Table 7).

Table 7. Flushing in the nursery and the trial in Sprielderbos in 1972 and 1974 respectively

1972		1974	
date	mean stage	date	mean stage
-	-	19 April	0.6
28 April	1.7	3 May	1.7
12 May	4.3	17 May	3.9
26 May	5.5	31 May	5.3

From this comparison we may conclude that flushing in 1974 in the trial was slightly later and progressed slower than in the nursery in 1972. For each of the provenances a mean value over the four 1974 dates has been calculated. These mean values closely correlate with those of 1972 (r = 0.93). The mean values of 1972 and 1974 in Sprielderbos also closely correlate with those of 1973 in Sleenerzand (r = 0.89 and r = 0.87 respectively). Thus the results of flushing observations on 4- to 6-year-old plants are quite consistent in different years and observations in the nursery also give very reliable results.

Late frost

Observations on damage by late frost were only made once in the Sprielderbos trial on 31 May 1974 at the same time as observations on flushing. The results of the observations will not be given in detail.

It was noted that a late frost at the end of May 1974 had damaged the plants up to a certain level above the ground. Apparently all provenances were in susceptible stages since early and late flushing provenances were equally badly damaged. The seriousness of the damage depended on the height of the tree rather than on the stage of flushing. Badly damaged provenances were Jeune Landing, Stuie, Castle Rock, Owl Creek, Upper Soda, d'Arcy, Matlock, Waldport, Sandy, Sequim and San Juan. Some of these provenances, particularly the first six, now have very high mortality. Matlock is the only one of these badly damaged provenances that comes from a selected area.

Height increment

In 1974 the total heights of all surviving plants were measured in both trials. In 1977 heights up to 1975, 1976 and 1977 were measured on all surviving plants. The two assessments allowed height increments in 1975, 1976 and 1977 to be calculated.
The last assessment took place on fewer plants because mortality had increased as a result of droughts and repeated late frost damage. This should be kept in mind when considering the height increment of 1975 which was calculated from the assessments of 1974 and 1977. Thus the increments of some provenances that lost many of their repeatedly damaged small trees are somewhat exaggerated.

Mean heights in 1974 and 1977 in Sleenerzand and Sprielderbos are shown in Tables 5 and 6 respectively. The graphs in both tables show height increments in 1975, 1976 and 1977, mean height in 1974 being the zero point.

Mean height increments for all provenances in Sleenerzand in 1975, 1976 and 1977 are 0.57 m, 0.32 m and 0.57 m respectively. These figures and the graph of Table 5 clearly show the influence of the very dry summer of 1976. Height increment in that year was almost half that of the preceding year. In 1977 it had revived at least to the 1975 level.

Nearly all provenances from the selected seed production areas had a height increment of at least 0.60 m in 1977. Provenances from outside these areas with equally good height growth in 1977 and with low mortality to date were Chilliwack (nos 1039 and 1038), Sooke (no. 1045) and Hebo (no. 1098). The two provenances from Chilliwack flushed early in Sleenerzand; the other two were intermediate.

The mean height increment of all provenances in Sprielderbos in 1975, 1976 and 1977 was 0.30 m, 0.30 m and 0.49 m respectively. The graph in Table 6 shows that height increments in 1975 and 1976 were almost equal. The increment in 1975 was modest partly, because the plants had not settled sufficiently since the establishment of the trial in 1973, but also because of the dry period during July and August 1975. Height growth improved considerably in 1977, but was still below the level of the Sleenerzand experiment.

The provenances from the selected areas generally showed good height increment in 1977 (at least 0.50 m), as did the two provenances from Chilliwack (nos 1039 and 1038). Some provenances from group 4, such as Franklin River (no. 1037), Alberni (no. 1036) and Courtenay (no. 1032) had reasonably good height growth combined with good survival up to 1977. Most provenances from group 6 had good height increment in 1977 and their survival was not poorer than that of the provenances from the selected areas.

The Sleenerzand and Sprielderbos trials have 42 provenances in common. The height increments in 1977 in both trials appear to be significantly correlated (r = 0.69).

D I S C U S S I O N

The history of the two trials and the circumstances under which the plants are growing differ. The Sleenerzand trial was established two years earlier than the one in Sprielderbos, although the plant material originated from the same sowing. Though the climate in the north is generally somewhat harsher than in central Netherlands, conditions in Sprielderbos were a little less favourable for the establishment of a Douglas fir trial and therefore survival was poorer. Some provenances from Vancouver Island such as Franklin River, Alberni and Courtenay seem to have suffered relatively little from these conditions and are performing rather well. Some provenances from southern Washington and Oregon are growing well in Sprielderbos and have survived reasonably well compared with other provenances.

On the whole we may conclude that notwithstanding the differences in history and conditions, survival, flushing behaviour and height increment in the last year in the two trials compare remarkably well.

In 1974 three areas were selected for Douglas fir seed collection for the Netherlands. These areas were selected on the basis of results with the same plant material in the nursery and the Sleenerzand trial up to age 5 years from seed.

These areas are:

a. East of the Puget Sound approximately from Arlington and Darrington in the nort to North Bend in the south, covering parts of the seed zones 202, 403, 411 and 412 in the altitudinal ranges of 100 to 300 m.

b. In the south of Washington approximately from Cathlamet to the Pacific, covering parts of the seed zones 041 and 030 between altitudes 100 and 300 m.

c. In the northwest of Washington approximately from Matlock and Humptulips in the south at altitudes between 100 and 300 m to Lake Crescent and Louella Guard Station in the north at altitudes between 300 and 500 m.

The results presented in this report from both trials up to age 10 years from seed confirm that provenances from these areas areas are still superior in height growth and excel in survival at least in the Sleenerzand trial.
The choice of areas for seed collection for Dutch forestry appears to be justified by these results.

In 1974 some provenances from Vancouver Island were ranked a good second. This has been borne out, particularly in rather harsh conditions. In any case the provenances Sooke, Franklin River, Alberni and Courtenay performed fairly well in one trial or the other and should not be ruled out altogether. But they flush earlier than the provenances from the selected areas in Washington, and this could be a drawback in certain years.

The two provenances from Chilliwack grow and survive well to fairly well in both experiments. They flush rather early but may also be kept in reserve as good alternatives if no seed from Washington is available.

Some provenances from southern Washington and Oregon (Sandy, Yale, Grand Ronde Ag. and Waldport) stood up well to the rather harsh conditions in Sprielderbos and show relatively good growth and survival there. In Sleenerzand, the survival and/or growth of the first three did not compare so well with the growth and survival of provenances from the selected areas in Washington. In this latter experiment Hebo, another provenance from Oregon, performed very well. However at this stage we would hesitate to speak out in favour of any of these provenances. They flush rather early and they may have been favoured to date by the absence of early frosts.

C O N C L U S I O N S

- The results up to age 10 years from seed in the two trials in Sleenerzand and Sprielderbos with 50 and 44 provenances respectively of the IUFRO 1966/67 series, compare well.
- These results justify the selection of the three areas in Washington for seed collection for Dutch forestry as proposed in 1974.
- The provenances in these three areas are superior in survival and height increment up to age 10 years.
  (In 1974 it was already reported that they flush late and this is confirmed by the latest data).
- Few provenances outside these areas can be considered for second choice: Chilliwack in southern British Columbia and Sooke, Franklin River, Alberni and Courtenay on Vancouver Island.
- Provenances from Oregon sometimes perform well but are considered too southerly for the Netherlands.

R E F E R E N C E S

Kriek, W. 1974. Douglas fir IUFRO provenances in the Netherlands 1966/67 Series. Nederlands Bosbouw Tijdschrift 46(1):1-14; Mededeling Bosbouwproefstation "De Dorschkamp", Wageningen, nr. 136.

Maandelijks Overzicht der Weersgesteldheid. 1973-1977 v. Koninklijk Nederlands Meteorologisch Instituut,De Bilt. 70(1973), 71(1974), 72 (1975), 73(1976), 74(1977).

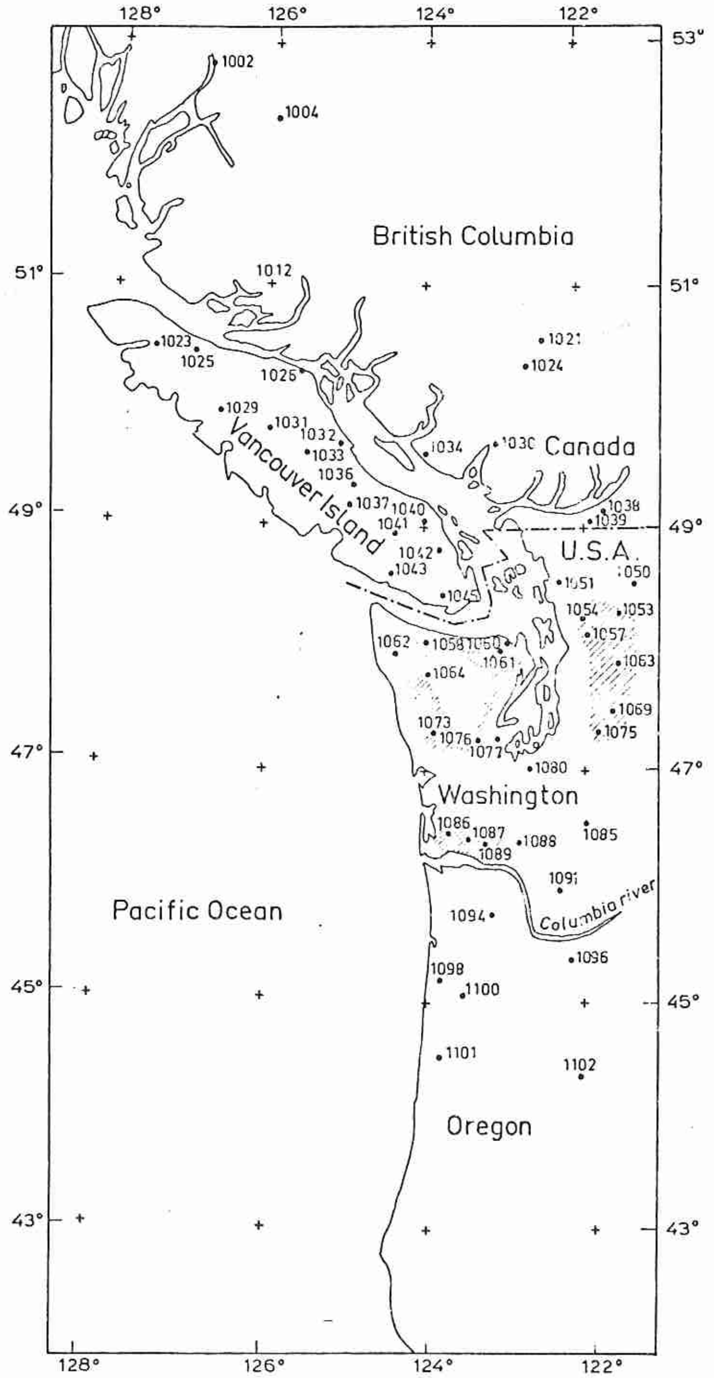

Figure 1. Douglas fir IUFRO provenances 1966/67 series.
Areas selected in 1974 for seed collection for the Netherlands.

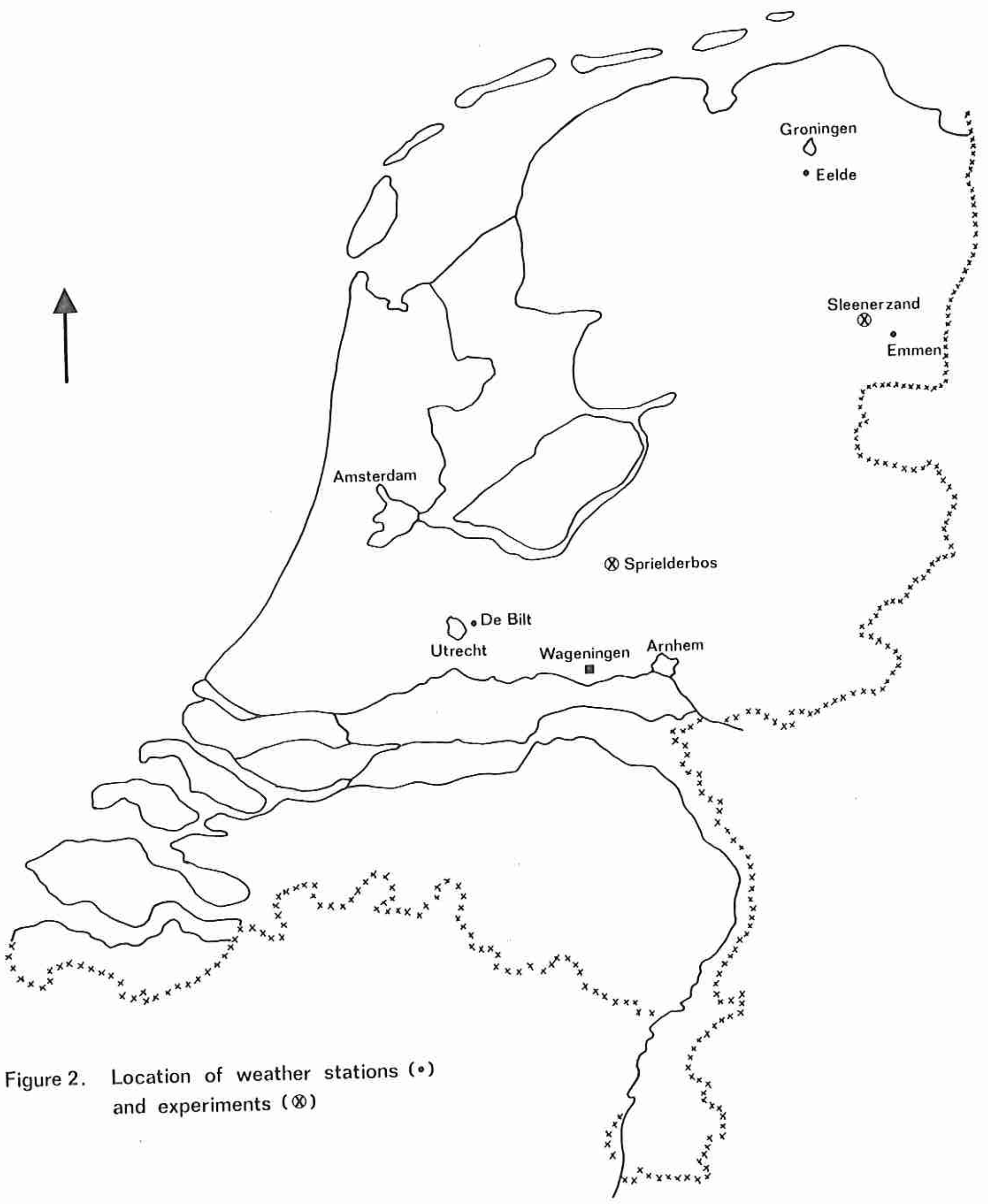

Figure 2. Location of weather stations (•) and experiments (⊗)

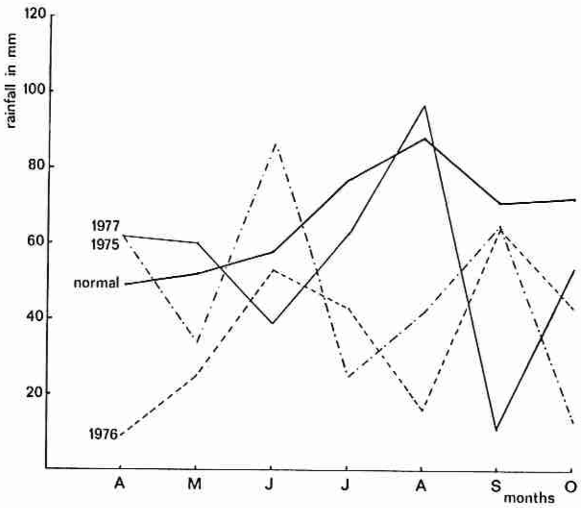

Figure 3. Rainfall in De Bilt

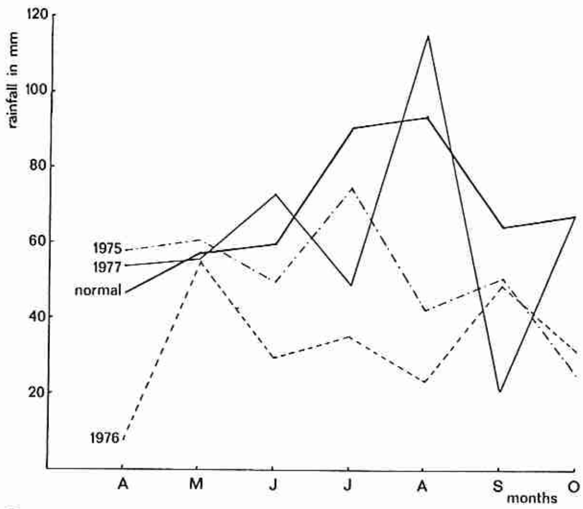

Figure 4. Rainfall in Emmen

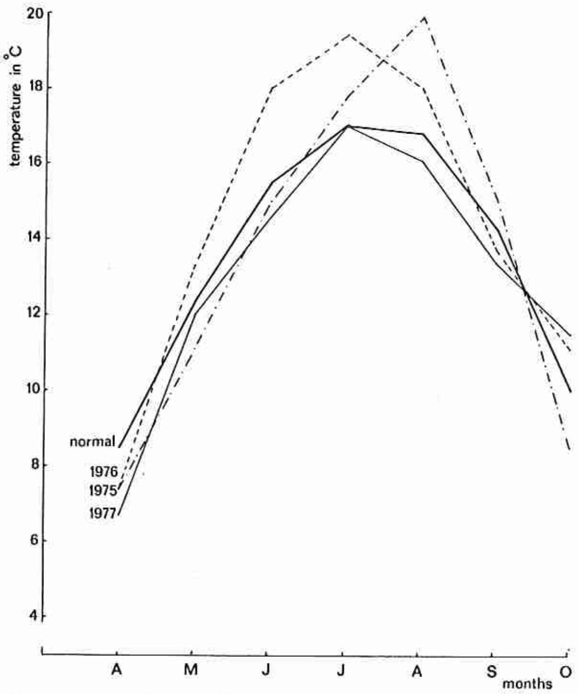

Figure 5. Temperatures in De Bilt

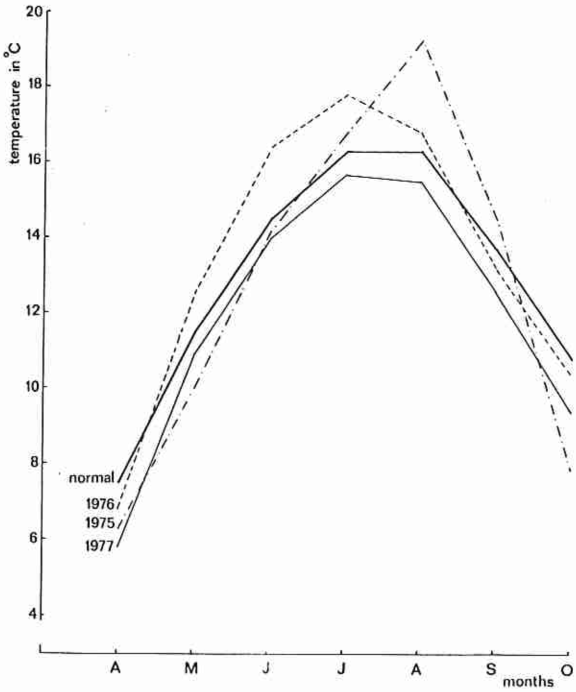

Figure 6. Temperatures in Eelde

Table 1. Location and number of trees from which seed was collected

sel. no. IUFRO	sel. no. BPS	provenance	latitude N.	longitude W.	altitude in m	no. of trees
Canada-B.C.						
1002	1653	Dean	50°48'00"	126°57'30"	20	15
1004	1654	Stuie	52°22'00"	126°00'00"	230	16
1012	1656	Klina Klini	51°07'00"	125°35'45"	5	15
1021	1657	D'Arcy	50°33'24"	122°30'00"	270	15
1023	1658	Jeune Landing	50°27'00"	127°27'00"	170	15
1024	1659	Owl Creek	50°20'00"	122°43'30"	210	15
1025	1660	Nimpkish	50°19'00"	126°53'00"	90	15
1026	1661	Stella Lake	50°17'00"	125°28'00"	150	15
1029	1662	Thasis	49°47'30"	126°38'20"	15	11
1030	1663	Squamish	49°46'40"	123°09'00"	15	15
1031	1664	Gold river	49°45'00"	126°04'00"	90	15
1032	1665	Courtenay	49°41'45"	125°03'50"	70	15
1033	1666	Forbidden Plat.	49°39'45"	125°09'20"	610	15
1034	1667	Sechelt	49°30'40"	123°52'55"	180	15
1036	1668	Alberni	49°19'30"	124°51'00"	140	15
1037	1669	Franklin River	49°06'00"	124°46'00"	150	15
1038	1670	Chilliwack	49°06'00"	121°42'00"	910	15
1039	1671	Chilliwack	49°04'24"	121°48'00"	170	15
1040	1672	Cassidy	49°03'30"	123°57'00"	200	15
1041	1673	Caycuse	48°55'25"	124°26'00"	210	15
1042	1674	Duncan	48°45'00"	123°45'00"	60	15
1043	1675	San Juan	48°34'50"	124°04'48"	210	15
1045	1677	Sooke	48°24'00"	123°44'00"	45	15
Washington						
1050	1678	Skagit, Marble Mnt.	48°35'	121°24'	120	15
1051	1679	" , Sedro Woolley	48°32'	122°19'	60	16
1053	1680	Snohomish, Darrington	48°16'	121°38'	150	15
1054	1681	" , Arlington	48°13'	122°04'	90	15
1057	1682	" , Granite Falls	48°05'	122°02'	90	19
1058	1683	Clallam, Lake Crescent	48°04'	124°00'	300	15
1060	1684	" , Sequim	48°02'	123°02'	30- 90	16
1061	1685	" , Louella Gua. Sta.	48°00'	123°05'	460	15
1062	1686	" , Forks	47°59'	124°24'	90	15
1063	1687	Snohomish, Gold Bar	47°51'	121°39'	120	15
1064	1688	Jefferson, Hoh River	47°48'	123°58'	240	15
1069	1689	King, North Bend	47°28'	121°45'	150	16
1073	1690	Grays Harbor, Humptulips	47°19'	123°54'	140	17
1075	1691	King, Enumclaw	47°16'	121°56'	240	15
1076	1692	Mason, Matlock	47°15'	123°25'	120	16
1077	1693	" , Shelton	47°15'	123°12'	90	15
1080	1694	Thurston, Yelm	47°01'	122°44'	60	15
1085	1696	Lewis, Randle	46°33'	122°03'	336	16
1086	1697	Pacific, Naselle	46°22'	123°44'	30- 60	15
1087	1698	Wahkiakum, Skamokawa	46°21'	123°30'	180-240	16
1088	1699	Cowlitz, Castle Rock	46°19'	122°52'	150	15
1089	1700	Wahkiakum, Cathlamet	46°18'	123°16'	150-240	15
1091	1701	Cowlitz, Yale	46°00'	122°22'	120	16
USA Oregon						
1094	1702	Washington, Vernonia	45°46'	123°13'	210	15
1096	1703	Clackamas, Sandy	45°23'	122°18'	270	15
1098	1704	Tillamook, Hebo	45°13'	123°51'	120-180	15
1100	1705	Yamhill, Grande Ronde Ag.	45°06'	123°36'	150-210	15
1101	1706	Lincoln, Waldport	44°24'	123°52'	30- 90	15
1102	1707	Linn, Upper Soda	44°23'	122°12'	915-1070	15

Table 2. Data on the provenance trials in Sleenerzand and Sprielderbos

	Sleenerzand	Sprielderbos
date of planting	: April 1971	March 1973
previous crop	: Japanese larch of 1939	Scots pine of 1920
site preparation	: Every other row of the larch was felled leaving 5 m between the remaining rows, which were oriented east-west.	Some of the Scots pine was felled in 1972 leaving strips of the old stand oriented east-west. These remnants of the old stand were thrown by the storms of 1972 and 1973, before and just after planting.

N.B. In the Netherlands Douglas fir is normally planted in strips of cleared forest (often Scots pine stands) oriented east-west in between strips in which several rows of trees of the old stand are left untouched. These remnants of the old stand protect the young Douglas fir against insolation during the winter, which often causes the physiological condition of the plants to deteriorate.
The cleared strips are usually $1\frac{1}{2}$ times as wide as the height of the old stand.
The system in Sleenerzand was different because larch is deciduous and gives less protection against insolation. In Sprielderbos the original plans were upset by the storms.

	No further preparations	Sods 50 x 50 cm were cut before the planting holes were dug.
soil type	: "Haar" podzol soil (rather dry)	"Holt" podzol soil
spacing	: In the cleared strips 2 x 2 m	2.00 x 2.50 m
plants	: Three years old (1+2)	Five years old (1+2+2)
layout	: 6 blocks; 50 provenances in 6 replicates	8 blocks; 40 provenances in 8 replicates, 4 provenances in 4 replicates
plot size	: 4 rows of five plants; 10 x 10 m	4 x 4 plants; 8 x 10 m
remarks	: The remaining Japanese larch trees were felled in 1974 and 1975	Serious late frosts killed most of the trees in 21 adjoining plots in blocks I and III. These plots had to be abandoned

Table 5. Sleenerzand, measurements and observations in 1974 and 1977, at age 7 and 10, respectively.
For the graph height 1974 is zero point.

sel. IUFRO	no. BPS	provenance	position*	flushing**	height 1974 in cm	increments in cm 1975	1976	1977	height 1977 in cm	1977 deaths since 1972 %
1. East of Puget Sound and adjoining areas										
1054	1681	Snohomish,Arlington	●	±	210	69	35	70	384	10
1053	1680	Snohomish,Darrington	●	+	201	61	40	73	375	7
1069	1689	King,North Bend	●	±	210	64	34	58	366	15
1063	1687	Snohomish,Gold Bar	●	-	200	61	36	60	357	7
1057	1682	Snohomish,Granite Falls	●	+	195	59	32	68	354	7
1039	1671	B.C.Chilliwack	o	-	175	55	33	70	333	7
1050	1678	Skagit,Marble Mnt.	o	-	178	62	35	57	332	27
1075	1691	King,Enumclaw	o	+	178	63	31	58	330	33
1038	1670	B.C.Chilliwack	o	-	179	48	38	62	327	12
1051	1679	Skagit,Sedro Wooley	o	±	179	58	28	61	326	22
2. Olympic Peninsula and adjoining provenances										
1062	1686	Clallam,Forks	●	+	207	57	36	80	380	1
1061	1685	Clallam,Louella Gua.Sta.	●	±	213	61	38	66	378	3
1073	1690	Grays'Harbour,Humptulips	●	+	187	62	38	74	362	12
1064	1688	Jefferson,Hoh River	●	+	203	64	31	59	357	17
1076	1692	Mason,Matlock	●	+	185	56	36	75	352	6
1080	1694	Thurston,Yelm	o	-	180	65	35	58	338	18
1058	1683	Clallam,Lake Crescent	●	+	189	48	31	62	330	10
1077	1693	Mason,Shelton	o	+	173	63	33	52	321	32
1060	1684	Clallam,Sequim	o	±	160	51	25	41	277	36
3. South-west Washington and adjoining north Oregon										
1089	1700	Wahkiakum,Cathlamet	●	+	174	53	32	68	327	14
1086	1697	Pacific,Naselle	●	+	171	48	35	68	322	10
1087	1698	Wahkiakum,Skamokawa	●	+	173	51	31	61	317	27
1094	1702	Washington,Vernonia	o	±	166	63	28	50	307	32
1088	1699	Cowlitz,Castle Rock	o	±	166	65	28	47	306	37
4. Southern Vancouver Island and adjoining Mainland of British Columbia										
1042	1674	B.C.Duncan		-	171	72	34	59	336	20
1045	1677	B.C.Sooke		±	188	51	33	61	333	12
1032	1665	B.C.Courtenay		±	189	48	32	50	322	16
1033	1666	B.C.Forbidden Plateau		-	168	68	32	52	320	40
1037	1669	B.C.Franklin River		-	173	58	34	53	318	17
1034	1667	B.C.Sechelt		-	173	46	39	59	317	22
1030	1663	B.C.Squamish		±	181	56	29	50	316	30
1036	1668	B.C.Alberni		-	172	52	29	51	304	22
1041	1673	B.C.Cayacuse		±	173	49	29	51	304	27
1043	1675	B.C. San Juan		±	163	57	28	49	297	18
1040	1672	B.C. Cassidy		±	142	64	25	42	273	57
5. Northern Vancouver Island and British Columbia Mainland										
1025	1660	B.C.Nimpkisk		+	188	55	29	50	322	21
1026	1661	B.C.Stella Lake		-	174	56	34	51	314	17
1002	1653	B.C.Dean		-	165	59	30	54	308	20
1029	1662	B.C.Thasis		-	173	40	33	56	302	21
1023	1658	B.C.Jeune Landing		-	159	67	28	46	300	42
1031	1664	B.C.Gold River		±	162	65	24	42	293	33
1012	1656	B.C.Klina Klini		-	155	59	31	41	286	37
1004	1654	B.C.Stuie		-	142	56	27	47	272	33
1024	1659	B.C.Owl Creek		-	148	49	30	42	269	37
1021	1657	B.C. D'Arcy		-	137	50	28	44	259	38
6. Southern Washington and Oregon										
1085	1696	Lewis,Randle		±	175	63	30	57	325	22
1098	1704	Tillamook,Hebo		±	165	55	35	69	324	12
1100	1705	Yamhill,Grande Ronde Ag.		-	173	53	33	53	312	24
1091	1701	Cowlitz,Yale		+	163	59	26	53	301	27
1096	1703	Clackamas,Sandy		±	169	45	30	55	299	17

* ● provenance inside selected area
o provenance outside selected area

** flushing results 1973
+ late
± intermediate
- early

Table 6. Sprielderbos, measurements and observations in 1974 and 1977, at age 7 and 10 respectively.
For the graph height 1974 is zero point.

sel. IUFRO	no. BPS	provenance	position*	flushing**	height 1974 in cm	increments in cm 1975	1976	1977	height 1977 in cm	1977 deaths since 1974 %
						0 40	80	120 160		
1. East of Puget Sound and adjoining areas										
1057	1682	Snohomish,Granite Falls	●	+	180	40	34	64	318	23
1051	1679	Skagit,Sedro Woolley	o	+	172	42	32	62	309	24
1039	1671	B.C.Chilliwack	o	-	170	37	35	56	298	22
1053	1680	Snohomish,Darrington	●	+	155	26	32	58	285	26
1054	1681	Snohomish,Arlington	●	+	171	24	32	53	280	31
1038	1670	B.C.Chilliwack	o	-	168	31	29	51	279	19
1069	1689	King,North Bend	●	±	160	37	30	52	279	39
1063	1687	Snohomish,Gold Bar	●	-	154	34	25	46	259	27
2. Olympic Peninsula and adjoining provenances										
1073	1690	Grays Harbour Humptulips	●	+	169	31	38	71	309	9
1064	1688	Jefferson,Hoh River	●	±	157	38	28	53	276	38
1076	1692	Mason,Matlock	●	+	154	33	31	57	275	27
1060	1684	Clallam,Sequim	o	±	155	37	29	49	270	18
1058	1683	Clallam,Lake Crescent	●	+	156	27	29	52	264	35
1061	1685	Clallam,Louella Gua.Sta.	●	±	147	32	25	53	257	50
1077	1693	Mason,Shelton	o	±	149	27	31	49	256	28
1062	1686	Clallam,Forks	●	+	143	21	29	60	253	36
3. South-west Washington and adjoining north Oregon										
1089	1700	Wahkiakum,Cathlamet	●	+	157	33	31	55	276	23
1088	1699	Cowlitz,Castle Rock	o	±	151	34	27	50	262	45
1087	1698	Wahkiakum,Skamokawa	●	+	153	26	32	47	258	46
4. Southern Vancouver Island and adjoining mainland of British Columbia						0 40	80	120 160		
1030	1663	B.C.Squamish		-	163	37	33	49	282	23
1037	1669	B.C.Franklin River		+	158	30	31	54	273	15
1042	1674	B.C.Duncan		±	162	30	30	50	272	22
1045	1677	B.C.Sooke		±	166	22	36	43	267	26
1036	1668	B.C.Alberni		-	160	26	30	51	267	15
1034	1667	B.C.Sechelt		-	160	25	29	47	261	26
1032	1665	B.C.Courtenay		±	154	26	30	49	259	15
1041	1673	B.C.Cayacuse		±	156	24	28	47	255	24
1040	1672	B.C.Cassidy		-	155	23	30	40	248	29
1043	1675	B.C.San Juan		±	145	16	29	44	234	30
1033	1666	B.C.Forbidden Plateau		-	142	22	24	39	227	23
5. Northern Vancouver Island and British Columbia Mainland										
1031	1664	B.C.Gold River		-	148	33	32	49	262	25
1026	1661	B.C.Stella Lake		-	148	37	28	40	253	24
1002	1653	B.C.Dean		-	151	30	30	38	249	24
1023	1658	B.C.Jeune Landing		-	144	31	27	35	237	52
1012	1656	B.C.Klina Klini		-	137	15	23	41	226	41
1021	1657	B.C.D'Arcy		-	118	21	28	39	206	41
1024	1659	B.C.Owl Creek		-	113	24	27	42	206	32
1004	1654	B.C.Stuie		±	124	12	23	33	192	43
6. Southern Washington and Oregon										
1096	1703	Clackamas,Sandy		-	151	47	33	59	290	29
1090	1701	Cowlitz,Yale		±	155	40	35	57	287	25
1085	1696	Lewis,Randle		±	156	38	30	54	278	38
1100	1705	Yamhill,Grande Ronde Ag.		-	159	32	28	51	270	20
1101	1706	Lincoln,Waldport		-	145	26	26	50	247	17
1102	1707	Linn,Upper Soda		±	113	17	26	34	190	59

* ● provenance inside selected area
o provenance outside selected area

** flushing results 1974
+ late
± intermediate
- early