Herkomsten
232.12

Douglas fir IUFRO provenances in the Netherlands 1966/67 Series

Douglas IUFRO herkomsten in Nederland

W. Kriek
Bosbouwproefstation, Wageningen

Introduction

Douglas fir, Pseudotsuga menziesii (Mirb. Franco) was first introduced in the Netherlands around the year 1860. This first introduction was quite successful. The result can still be seen in "Park 't Loo" near the town of Apeldoorn in the centre of the Netherlands. Since 1860 Douglas fir was used in plantations with varying success. It was later recognized that the source of the seed had much to do with the results in the plantations, but the provenance of the first introduction and of subsequent imports of seed are unknown.

In 1923 a fairly large-scale provenance study was initiated. In a period of 14 years some 35 seedlots of known origin in British Columbia (Canada) and Washington and Oregon (USA) were imported and 27 experiments containing 1 to 8 provenances were established. The results of these experiments were published by Veen in 1951 and de Vries in 1962.

Some of the provenances grew very well and proved to be well suited to the Netherlands. However by the time this conclusion was reached it was impossible to obtain more seed from these sources as the original stands had disappeared. The experiments were not designed well enough to allow a conclusive comparison of all tested provenances and the sampling of the natural range had not been extensive enough to provide a sound basis for delineation of the most promising seed collection areas for the Netherlands. Thus for import of seeds in the Netherlands the available climatological data of the natural range had to serve as criterion for decisions about whether provenances were suitable.

In 1950 a zone around the Puget Sound in Washington from Blaine in the north-east through Centralia and Elma in the south to Quilcene in the north-west and a zone in the north-west of Oregon around Vernonia and Jewell were designated for seed collection. The altitude in these zones varied from

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Samenvatting

Het douglasherkomstenonderzoek dat in de jaren tussen 1923 en 1937 werd begonnen, heeft een schat van gegevens opgeleverd over de mogelijkheden van aanplant van douglas in Nederland. De bemonstering van het herkomstgebied en de opzet van de proeven waren echter ontoereikend om een samenhangend beeld te krijgen van de genetische kwaliteiten van de soort in de verschillende delen van het herkomstgebied.

De nieuwe bemonstering van het herkomstgebied door de IUFRO (International Union of Forest Research Organizations) bood de gelegenheid om een nieuwe serie herkomstenproeven te entameren, die zou kunnen leiden tot de keuze van de voor Nederland meest geschikte herkomsten en herkomstgebieden.

In eerste instantie werd zaad van 57 van de in de jaren 1966 en 1967 in Brits Columbië (Canada), Washington en Oregon (USA) verzamelde herkomsten ontvangen. Aan drie- tot vijfjarig materiaal van deze herkomsten werden in de jaren 1971 tot 1973 waarnemingen verricht in de kwekerijen "De Dorschkamp" en "Groot Spriel" en in een proefveld in de boswachterij Sleenerzand in Drente. De waarnemingen hadden betrekking op hoogtegroei, uitlopen in het voorjaar, uitval en onvolkomenheden van de jonge planten, zoals dode eindknoppen, dode toppen, dubbele toppen en dubbele stammen. Het voorkomen van veel uitval en onvolkomenheden wijst op schade door droogte en/of vorst en op een minder goed aangepast zijn aan het Nederlandse klimaat. Voor Nederland geschikte herkomsten moeten weinig uitval en onvolkomenheden vertonen, laat uitlopen in verband met late nachtvorsten en een goede hoogtegroei vertonen. De resultaten van de waarnemingen laten reeds duidelijke verschillen in deze eigenschappen tussen de herkomsten zien.

De herkomsten, die op grond van deze waarnemingen voorlopig als de meest geschikte voor Nederland beoordeeld worden blijken voornamelijk uit drie gebieden in Washington te komen. Deze gebieden zijn aangegeven op figuur 4.

Voor gebruik in beplantingen in Nederland wordt

de import van zaad uit deze gebieden aanbevolen. Voor meer gedetailleerd herkomstenonderzoek wordt een bemonstering van dezelfde en aangrenzende gebieden tot een hoogte van 500 m boven zee voorgesteld.

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20 to 40 m in the north to 225 m in the south. These zones were chosen on the assumption that provenances from relatively dry zones would be most suited to the Netherlands. It was realized that some provenances from moister areas were performing well, but some doubts existed about their winter hardiness (Studiegroep Bosbouw 1950). When more experience was gained with source identified material it became evident that provenances from moister zones, for instance in the coastal area and at somewhat higher altitudes in Washington and on Vancouver Island, were to be preferred. However it was unsatisfactory that the choice of provenances for import was based on climatological data without sufficient support from results obtained in provenance research. Therefore the need was felt for more extensive provenance research.

When, under the auspices of the IUFRO (International Union of Forest Research Organizations), plans were made for seed collection of a great number of provenances throughout the natural range for provenance research and gene conservation, the Forest Research Station "De Dorschkamp" decided to start a new series of provenance tests.

Seed of 104 provenances was collected in 1966 and 1967 in British Columbia, Washington and Oregon. Of this first series 57 provenances have been included in our research programme. The present report deals with early results in the nurseries and one experiment.

Other participating countries have already reported on their early results at a meeting of the IUFRO Working Party on Douglas fir Provenances (IUFRO 1973).

Plant material and experiment

The locations of the provenances used is shown on the map of figure 1. More detailed data on the locations and the number of trees per provenance from which seed was collected are presented in table 1.

Seed was sown in three replicates in December 1967 in the nursery De Dorschkamp; the seedlings were transplanted in the spring of 1969 in the same nursery also in three (the same) replicates.

In April 1971 an experiment was established with part of the three-year-old (1+2) material in the forest range Sleenerzand in the Province of Drente in the north-eastern part of the Netherlands. In the (orthogonal) experiment 50 provenances were planted in 6 randomized blocks. On this site larch was planted in 1939. Before planting the Douglas fir, every other row of the larch was felled leaving a distance of 5 m between the remaining rows. In the open space between every two rows of larch, two rows of Douglas fir were planted the spacing being 2 m between the rows and 2 m within the rows. Each plot of Douglas fir consists of two rows of five plants plus two rows of five plants separated by a row of old larch. Thus each provenance is represented by 6 x 20 is 120 trees. A severe drought immediately after planting made watering of the plants during a short period necessary.

The remaining plant stock, for which the site was not ready in time, was transferred to nurseries in the forest range Sprielderbos, in the centre of the Netherlands. Part of this material was planted in two replicates in the nursery Groot Spriel.

Climate

In the area of Sleenerzand the climate is characterized by mean daily temperatures per month ranging from 1° in January to 16.5° in July, a frost-free period of 180 days and a mean annual rainfall of 800 mm. The mean daily minimum temperature per month ranges from - 2° C in January to 11.5° C in July and the mean daily maximum ranges from 3.5° C in January to 21.5° C in July.

Observations on flushing have been made on the stock in the nursery Groot Spriel; climatic data of the centre of the country are therefore of some interest. The nursery is situated in an area which is on the whole a little warmer than the site in Sleenerzand. The mean daily temperature per month ranges from 1.5° C in January to 17° C in July, the mean daily minimum from - 1° C in January to 12.5° C in July and the mean daily maximum from 4° C in January to 22° C in July. The number of frost-free days is about 190 and the mean annual rainfall is 800 mm.

Assessments and results (table 2)

Heights

In the nursery De Dorschkamp, the heights of the plants were assessed after the third season, in the autumn of 1970. All plants were measured in 5 cm height classes and means over the three replicates were calculated for all provenances.

In the experiment at Sleenerzand, the heights of all trees were measured at the end of the growing season of 1972, when the trees were 5 years old.

Flushing

Time of flushing at the beginning of the growing season is an important characteristic of provenances as late frosts occur frequently on most sites in the Netherlands causing considerable damage to early flushing plants.

At the beginning of the growing season of 1972 flushing was observed at Sleenerzand on April 26, May 10, May 24 and June 7. Flushing of individual plants was assessed with the aid of photographs of 7 stages of flushing, as established during earlier research. A nought was allocated when the final bud of the leading, or a replacing, shoot was still in rest and not yet swollen and a six when the emerging leading shoot was in the process of stretching, the other marks being allocated to certain stages in between (see photographs of figure 2).

The observations were carried out each time on one row of five trees per plot, but on each date of observation another row was assessed. Thus on each date in principle 30 trees, 5 in each of the 6 replicates, were observed per provenance and at the end of the period all living trees had been assessed once. In table 2 the means for the provenances are presented as calculated from all observations on the four dates.

Observations on flushing have been carried out again in Sleenerzand at the beginning of the growing season of 1973. The dates of observations were the 2nd, 16th and 30th of May and the 13th of June. The procedure followed was the same as the previous year.

In the nursery Groot Spriel flushing was observed in the spring of 1972 in the same way as in Sleenerzand but by a different observer. The observations took place practically on the same dates as in Sleenerzand, on April 28, May 12 and May 26, 1972. A fourth observation was omitted, because on the 26th of May many plants had reached stage 6 already and a fourth observation two weeks later was considered superfluous. In the nursery Groot Spriel all provenances occurred in two replicates. Since 20 plants per replicated were observed each date, 40 plants per provenance per date or a total of 120 plants per provenance were assessed during the period. The means for the 120 plants per provenance are shown in table 2.

Hardiness

Hardiness or adaptability of the provenances may be expressed in terms of percentages living trees without defects. Dead and defective trees as well as trees without defects were counted in the spring of 1972 in Sleenerzand, one year after planting. Those trees with forks, double stems, dead tops or dead endbuds of the leading shoots were considered as defective. The dead tops or dead endbuds may have been caused by drought, early frost or winter frost, forks and double stems were the result of earlier damage of the same kind to the leading shoots. Late frost damage has not occurred so far. The results have been summarized in table 2 as percentages with and without defects and percentages of dead trees.

Discussion

Height growth

For the height growth at age 5 years in the Sleenerzand experiment, an analysis of variance was carried out and the test of Tukey for significance of differences between provenances was applied. The range of non-significance is approximately 31.2 cm at the 99% level of confidence and approximately 28.2 cm at the 95% level of confidence. The height growth data of the plants at age 3 years in the nursery De Dorschkamp have not been analysed statistically. There was hardly any relation between the two sets of data. Indeed provenances that show good height growth in Sleenerzand were among the best growing provenances in the nursery but several other provenances that have grown well in the nursery, such as Sedro Woolley and Sandy, show only average growth in the experiment. The heavy losses and high percentages of defective trees of these provenances may have been caused by the rather severe drought immediately after planting, from which they seem to have suffered more than other provenances.

The provenances with the best height growth in Sleenerzand are: Stella Lake, Courtenay, Sooke, Darrington, Arlington, Granite Falls, Lake Crescent, Louella Guard Station, Forks, Gold Bar, Hoh River, North Bend and Humptulips.

Flushing

Analyses of variance have been carried out for the data (i.e. the means of 5 trees per plot) on flushing from Sleenerzand and Groot Spriel and the test of Tukey for significance of differences between the provenances was applied.

The ranges of non-significance at the different levels of confidence are:

Figure 1. Douglas fir IUFRO provenances 1966/67 series

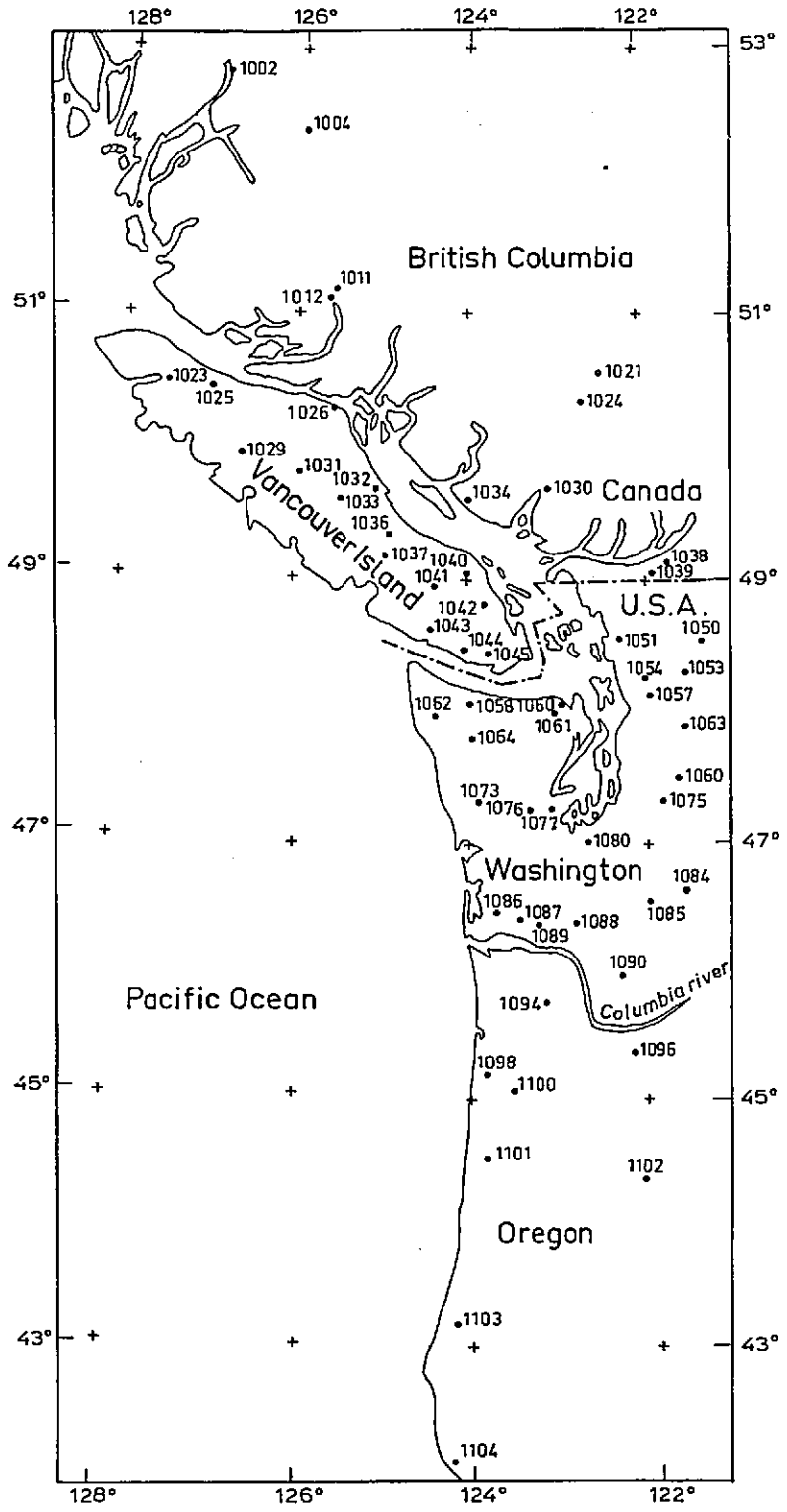


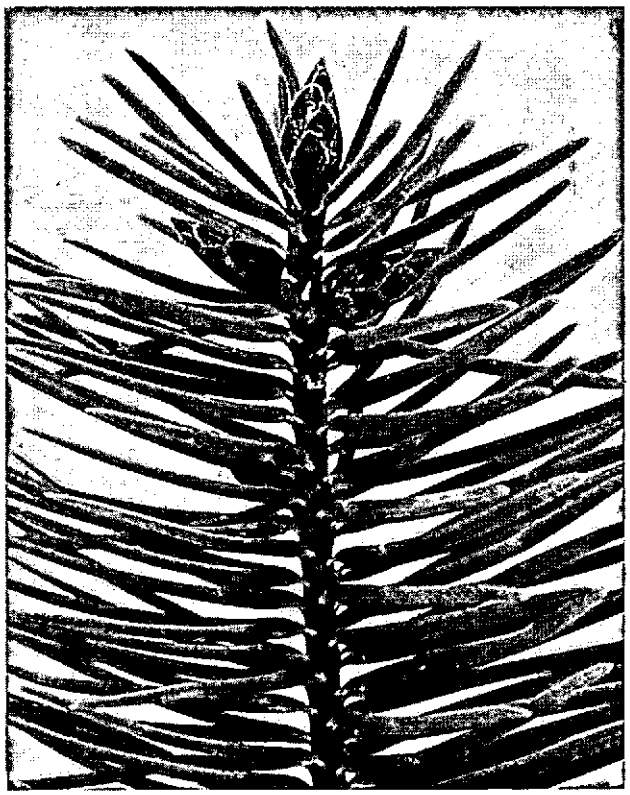
Table 1 Location and number of trees from which seed was collected

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
1011	1655	Klina Klini	51°07'50"	125°35'30"	150	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
1044	1676	Jordan River	48°28'30"	124°14'00"	240	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
1084	1695	Lewis, Packwood	46°34'	121°42'	300	16
1085	1696	" , Randle	46°33'	122°03'	335	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
1103	1708	Coos, Coquille	43°12'	124°10'	30-120	15
1104	1709	Curry, Brookings	42°07'	124°12'	240-365	15

Flushing data	range	confidence level
Sleenerzand 1972	0.69	95 %
	0.76	99 %
Sleenerzand 1973	0.52	95 %
	0.57	99 %
Groot Spriel	0.51	95 %
	0.57	99 %

Late flushing provenances can be as much as 2 weeks slower than early flushing ones as shows an example in 1972. The early flushing provenance Duncan (sel. nr. 1042) reached a mean flushing value of 3.6 on the 10th of May whereas the late flushing provenance Forks (sel. nr. 1062) reached this stage on 24th May.

The data on flushing in Sleenerzand in 1972 are not, in absolute terms, comparable to those in Groot Spriel in the same year. The difference in macro- en microclimate as well as in site conditons (nursery versus field trial) may have caused deviations in the starting point of flushing as well as in the period in which the plants passed through the different stages of flushing. Moreover the observer was not the same for the two sites, which may have resulted in a systematic error, because of a different appreciation of the



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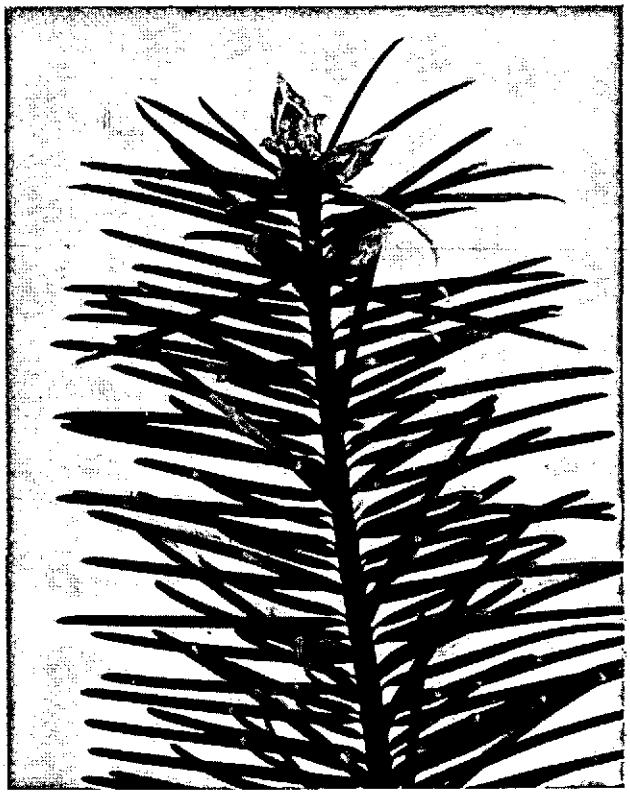

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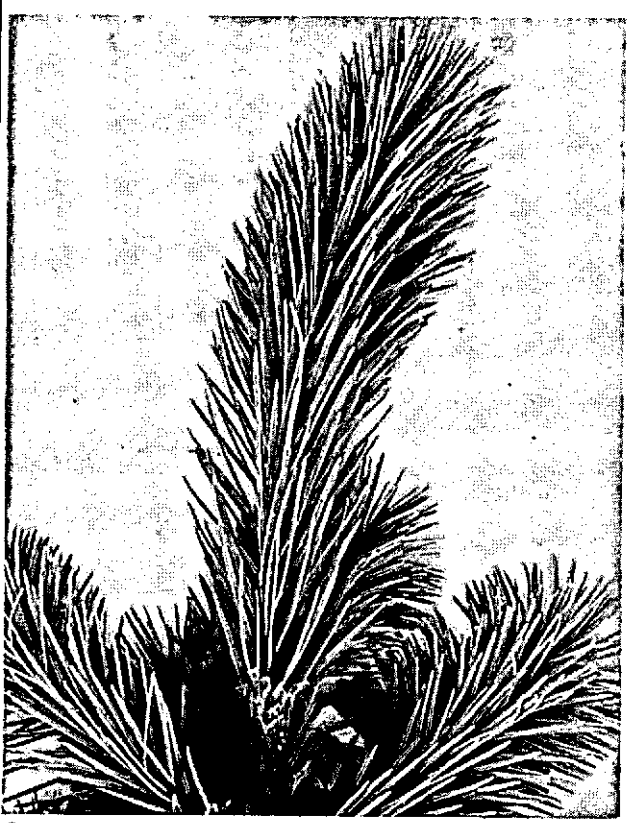

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Fig. 2 Stages of flushing in Douglas fir

0 resting bud
1 bud swollen, the membrane covering the young needles just visible
2 swelling of the bud increased, the membrane extends clearly beyond the bud scales
3 the bud has elongated so much, that more than half of it extends beyond the bud scales, the membrane starts bursting
4 "shaving-brush" stage of the new shoot
5 the new shoot starts elongating
6 continuing elongation of the new shoot, which is slightly curved

Table 2. Results of measurements and observations in the nurseries "De Dorschkamp" and "Groot

sel. no. IUFRO	sel. no. BPS.	provenance	De Dorschkamp height in cm at age 3 years	Sleenerzand height in cm at age 5 years	Sleenerzand % trees without defects at age 4 years	Sleenerzand % defective trees at age 4 years	Sleenerzand % dead trees at age 4 years	Sleenerzand mean value flushing 4 observations 1972	Sleenerzand mean value flushing 4 observations 1973	Groot Spriel mean value flushing 3 observations 1972
1002	1653	B.C. Dean	52	90	63,3	34,2	2,5	4,0	3,9	4,1
1004	1654	" Stuie	48	81	55,0	40,8	4,2	3,7	3,7	3,9
1011	1655	" Klina Klini	51	-	-	-	-	-	-	4,1
1012	1656	" Klina Klini	47	85	50,0	44,2	5,8	3,9	3,8	4,2
1021	1657	" D'Arcy	48	80	46,7	40,8	12,5	4,1	4,0	4,4
1023	1658	" Jeune Landing	48	88	41,7	26,6	31,7	3,9	3,7	4,1
1024	1659	" Owl Creek	40	82	36,7	31,6	31,7	4,0	3,9	4,0
1025	1660	" Nimpkish	39	99	44,2	27,5	28,3	3,2	3,2	3,9
1026	1661	" Stella Lake	47	107	54,2	35,0	10,8	3,8	3,6	3,9
1029	1662	" Thasis	49	99	49,2	21,6	29,2	4,0	3,9	4,1
1030	1663	" Squamish	61	102	37,5	25,8	36,7	3,6	3,5	3,8
1031	1664	" Gold River	54	97	44,2	38,3	17,5	3,6	3,6	4,0
1032	1665	" Courtenay	61	109	56,7	36,6	6,7	3,7	3,4	3,9
1033	1666	" Forbidden Plat.	48	96	41,0	44,0	15,0	3,5	3,7	3,9
1034	1667	" Sechelt	57	98	51,7	27,5	20,8	3,8	3,7	3,9
1036	1668	" Alberni	56	99	47,5	37,5	15,0	3,9	3,7	4,1
1037	1669	" Franklin River	62	96	48,3	30,9	20,8	3,5	3,7	3,6
1038	1670	" Chilliwack	57	100	50,0	32,5	17,5	3,7	3,8	4,0
1039	1671	" Chilliwack	60	101	51,7	35,8	12,5	3,7	3,7	4,0
1040	1672	" Cassidy	55	84	41,7	41,6	16,7	3,0	3,6	4,2
1041	1673	" Caycuse	58	97	54,2	31,6	14,2	3,8	3,6	3,8
1042	1674	" Duncan	59	96	49,2	35,8	15,0	3,8	3,7	3,9
1043	1675	" San Juan	54	91	44,2	28,3	27,5	3,4	3,4	3,9
1044	1676	" Jordan River	58	-	-	-	-	-	-	4,0
1045	1677	" Sooke	61	113	59,2	30,0	10,8	3,7	3,6	4,0
1050	1678	Wash. Marble Mnt.	65	104	54,2	29,1	16,7	3,9	3,8	4,2
1051	1679	" Sedro Woolley	70	101	47,5	27,5	25,0	3,6	3,5	3,6
1053	1680	" Darrington	64	112	63,3	25,0	11,7	3,2	3,2	3,3
1054	1681	" Arlington	53	120	61,7	26,6	11,7	3,5	3,5	3,6

stages from the photographs. For the same reason a systematic deviation may exist between the observations of 1972 and 1973 in Sleenerzand, although they were made by the same person. With these reservations in mind it may be concluded that in 1972 flushing in Groot Spriel did not start much earlier than in Sleenerzand, but passed through the stages more quickly. Compared with 1972 flushing in Sleenerzand in 1973 was delayed by about one week (see table).

Overall means of flushing values in Sleenerzand and Groot Spriel in 1972 and 1973

	Observation dates in 1972				
	26/4	10/5	24/5	7/6	all dates
Sleenerzand	1.2	3.0	4.6	5.4	3.6
	Observation dates in 1972				
	28/4	12/5	26/5		all dates
Groot Spriel	1.7	4.3	5.5		3.8
	Observation dates in 1973				
	2/5	16/5	30/5	13/6	all dates
Sleenerzand	1.1	2.8	4.7	5.4	3.5

Spriel" and in the field experiment Sleenerzand

sel. no. IUFRO	sel. no. BPS.	provenance	De Dorschkamp height in cm at age 3 years	Sleenerzand height in cm at age 5 years	Sleenerzand % trees without defects at age 4 years	Sleenerzand % defective trees at age 4 years	Sleenerzand % dead trees at age 4 years	Sleenerzand mean value flushing 4 observations 1972	Sleenerzand mean value flushing 4 observations 1973	Groot Spriel mean value flushing 3 observations 1972
1057	1682	Wash. Granite Falls	59	116	66,6	21,7	11,7	3,1	3,1	3,3
1058	1683	" Lake Crescent	57	107	65,8	22,5	11,7	3,3	3,1	3,5
1060	1684	" Sequim	54	94	42,5	38,3	19,2	3,6	3,6	3,9
1061	1685	" Louella Gua. Sta.	58	119	81,7	15,0	3,3	3,3	3,5	3,7
1062	1686	" Forks	61	122	74,2	22,5	3,3	2,8	2,8	2,9
1063	1687	" Gold Bar	53	110	65,8	28,4	5,8	4,0	3,9	4,1
1064	1688	" Hoh River	65	111	67,5	21,7	10,8	3,2	3,3	3,5
1069	1689	" North Bend	68	118	65,0	28,3	6,7	3,8	3,6	4,1
1073	1690	" Humptulips	64	107	53,3	24,2	22,5	2,6	2,6	2,8
1075	1691	" Enumclaw	68	95	22,5	20,8	56,7	3,0	3,3	3,7
1076	1692	" Matlock	50	101	56,7	33,3	10,0	3,0	3,1	3,1
1077	1693	" Shelton	45	99	61,7	26,6	11,7	3,5	3,3	3,9
1080	1694	" Yelm	50	102	67,5	20,8	11,7	3,9	3,8	4,2
1084	1695	" Packwood	45	-	-	-	-	-	-	4,1
1085	1696	" Randle	52	96	58,3	25,0	16,7	3,7	3,6	3,8
1086	1697	" Naselle	58	91	40,8	25,9	33,3	3,0	3,1	3,2
1087	1698	" Skamokawa	47	99	42,5	25,8	31,7	2,8	2,9	3,1
1088	1699	" Castle Rock	63	95	39,2	25,0	35,8	3,7	3,5	3,7
1089	1700	" Cathlamet	58	103	64,2	19,2	16,7	3,1	3,1	3,4
1091	1701	" Yale	67	95	49,2	20,8	30,0	3,6	3,2	3,9
1094	1702	Ore. Vernonia	66	96	54,2	25,0	20,8	3,7	3,5	3,9
1096	1703	" Sandy	72	100	41,7	26,6	31,7	3,5	3,6	4,0
1098	1704	" Hebo	63	97	49,0	29,0	22,0	3,4	3,4	4,0
1100	1705	" Grande Ronde Ag.	61	103	54,2	26,6	19,2	3,8	3,7	4,2
1101	1706	" Waldport	58	-	-	-	-	-	-	4,0
1102	1707	" Upper Soda	52	-	-	-	-	-	-	3,8
1103	1708	" Coquille	53	-	-	-	-	-	-	4,0
1104	1709	" Brookings	48	-	-	-	-	-	-	4,6
		Overall means	56	100				3,6	3,5	3,8

The order of flushing of the provenances in Sleenerzand in 1972 and 1973 is very similar. The order of flushing in Groot Spriel is largely in agreement with that in Sleenerzand. Since late flushing is a desirable characteristic, the behaviour of a number of late flushing provenances will be dealt with in some detail.

Ten provenances are consistently late flushing in Sleenerzand and Groot Spriel:

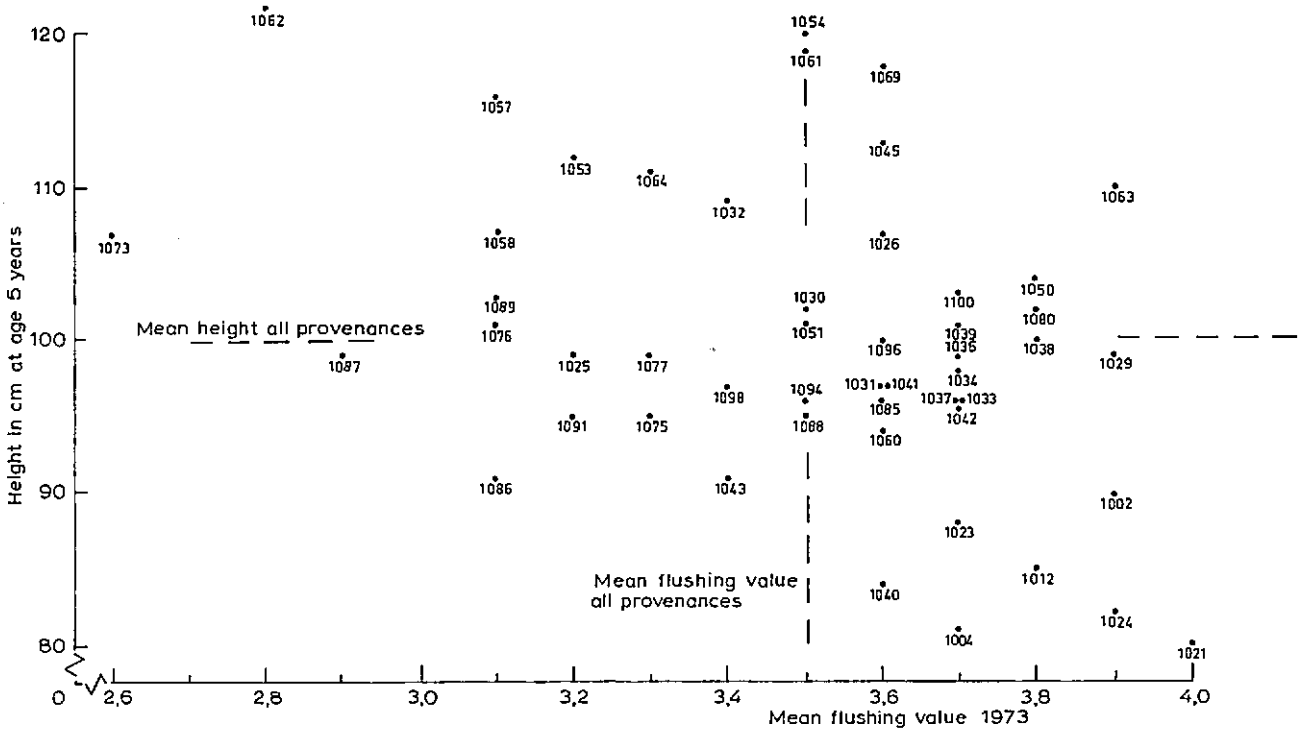
Sel. no IUFRO	Provenance	mean flushing value Sleenerzand 1972	Sleenerzand 1973	Groot Spriel 1972
1073	Humptulips	2.6	2.6	2.8
1062	Forks	2.8	2.8	2.9
1087	Skamokawa	2.8	2.9	3.1
1076	Matlock	3.0	3.1	3.1
1086	Naselle	3.0	3.1	3.2
1057	Granite Falls	3.1	3.1	3.3
1089	Cathlamet	3.1	3.1	3.4
1053	Darrington	3.2	3.2	3.3
1064	Hoh River	3.2	3.3	3.5
1058	Lake Crescent	3.3	3.1	3.5

Table 3 Weather Reporting Station (W.R.S.) and IUFRO Provenances in Washington State (USA)
Climatological data

sel. nr. IUFRO	seed zone	provenance and/or Weather Reporting Station	map ref. W.R.S. Pr.	x	elevation in m W.R.S.	elevation in m provenance	average summer temp. in oC	absolute minimum temp. in oC	summer precip. in mm	annual precip. in mm	number of frost days	remarks on performance of provenance
		de Bilt, Netherlands			50		9	-	400	760	184	
1050	402	Marblemount	△	o	104	120			491	1957		early flushing
	402	Concrete	△		73		16	-18	409	1656	146	
1051	202	Sedro Woolley	△	o	16	60	13	-18	365	1170	172	high perc.dead and defective trees
1054	202	Arlington	△	•	30- 61	90			361	1126		excellent height growth
1057	202	Granite Falls	▲	•	105-180	90	14	-17	509	1509	176	excellent
1053	403	Darrington	▲	•	165	150	14	-24	475	2045	201	excellent
	411	Start up	▲		168		15	-15	483	1245	146	
1063	411	Gold Bar		o		120						good height growth, early flushing
	411	Index	▲		160				596	2296		
	411	Skykomish	▲		280		14	-23	490	2032		
	412	Snoqualmie Falls	▲		132		14	-19	414	1532		
1069	412	North Bend	▲	•	61	150	13	-16	330	1321		excellent height growth
	412	Palmer	▲		269		14	-18	726	2401		
1075	412	Enumclaw		o		240						high perc. dead and defective trees
	412	Buckley	△				14		401	1252	170	
	412	Mud Mnt. Dam	△		392		13	-14	457	1194		
	411	Snohomish	△		15				354	1105		
	411	Monroe	△		36		15	-19	346	1188		
	212	Seattle, Univ. of W.	△		34		16	-14	224	888		
	212	Seattle, Tacoma Atp.	△		116		15	-12	241	989		
	421	Rainier Carbon River	△		515		12	-22	533	1757		
	422	Mineral	△		450				476	2224		
	422	Alder Dam	△		390		14	-22	311	1164		
1080	232	Yelm	△	o	106	60			220	1002		early flushing
	240	Centralia	△		55		15	-27			190	
1088	430	Castle Rock		o		150						high perc. dead and defective trees
	430	Kid Valley	△		207		13	-11	406	1270	190	
	041	Longview	△		4		15	-29	284	695		
1089	041	Cathlamet	▲	•	143	150-240			432	2057		fair height growth, late flushing
1087	041	Skamokawa		•		180-240						fair height growth, late flushing
	041	Naselle	▲		8				584	2819		
1086	041/ 030	Naselle		o		30- 60						poor height growth, high perc.dead and defective trees, late flushing
	030	South Bend	△		15		14	-16	483	2108	163	
	030	Hoquiam	△		3		14	-14	475	2147	99	
	240	Oakville	△				15		292	1386		
	240	Elma	△		75		14	-15	356	1499	181	
1077	231	Shelton	△	o	7	90	16	-13	305	1633	168	fair height growth, late flushing
1076	030	Matlock		•		120						fair height growth, late flushing
	030	So. Olympic Tree Farm	▲		174				594	3027		
1073	030	Humptulips		•		140						good height growth, late flushing
	012	Quinault	▲		63		14	-12	762	3200	157	
	222	Cushman Dam	▲		237		15	-19	463	2546	156	
1064	012	Hoh River		•	240							excellent
1062	012	Forks	▲	•	113	90	13	-20	660	2921	184	excellent
1058	012	Lake Crescent		•		300						excellent
1061	221	Louella Guard. Sta.	▲	•	330	460	13	-18	381	1321	215	excellent height growth
	221	Port Crescent	△		23			-14	216	1016	162	
	221	Elwha	△		103		14	-18	245	1421	163	
1060	221	Sequim	△	o	54	30- 90	13	-19	129	427	181	high perc. dead and defective trees
	221	Quilcene	△		37		14	-18	291	1295	198	
	222	Quilcene Dam	△		308				340	1709		

x • provenance with good performance
o provenance with poor growth and survival and/or early flushing
▲ Weather Reporting Station in area with good provenances
△ Weather Reporting Station outside area with good provenances

Figure 3. Height growth and flushing in Sleenerzand



Consistently late flushing in Sleenerzand but in a middle position in Groot Spriel are Enumclaw and Nimpkish. Some provenances are late flushng in Sleenerzand in one year and in a middle position in another year while also taking a middle position in Groot Spriel. Others are consistently in a middle position in Sleenerzand but relatively late flushing in Groot Spriel. The flushing data of the provenances of these three groups are summarized in the following table:

Sel. no IUFRO	provenance	mean flushing value Sleenerzand		Groot Spriel
		1972	1973	1972
1075	Enumclaw	3.0	3.3	3.7
1025	Nimpkish	3.2	3.2	3.9
1061	Louella Gua. Sta.	3.3	3.5	3.7
1091	Yale	3.6	3.2	3.9
1077	Shelton	3.5	3.3	3.9
1032	Courtenay	3.7	3.4	3.9
1054	Arlington	3.5	3.5	3.6
1051	Sedro Woolley	3.6	3.5	3.6
1037	Franklin River	3.5	3.7	3.6

Hardiness

The adaptability or hardiness of the provenances as expressed in terms of percentages living trees without defects shows considerable differences between the provenances. The best performers in this respect in the experiment in Sleenerzand appear to be Louella Guard Station, Forks, Hoh River, Yelm, Granite Falls, Lake Crescent, Gold Bar, North Bend and Cathlamet.

Choice of the best overall provenances

Provenances that combine the three characteristics, good height growth, late flushing and good adaptability, are to be preferred for use in forestry practice in the Netherlands. In order to get an idea which provenances combine at least two of these characteristics, height growth in Sleenerzand at age 5 years was plotted against flushing in 1973 in Sleenerzand in the graph of figure 3. The best performers in terms of height growth and flushing appear to be:

Sel. no IUFRO	provenance	Sel. no IUFRO	provenance
1073	Humptulips Wash.	1064	Hoh River Wash.
1062	Forks Wash.	1032	Courtenay Vanc. Is.
1076	Matlock Wash.	1054	Arlington Wash.
1089	Cathlamet Wash.	1061	Louella Guard Sta. Wash.
1058	Lake Crescent Wash.	1069	North Bend Wash.
1057	Granite Falls Wash.	1045	Sooke Vanc. Is.
1053	Darrington		

The last five are included for the time being although they flush not exactly late, but their height growth is good to excellent. The majority of these provenances have good survival and few defective trees. Humptulips, Matlock, Courtenay and Sooke are somewhat less outstanding in this respect.

Skamokawa (sel. nr. 1087), Nimpkish (sel. nr. 1025) and Shelton (sel. nr. 1077) are borderline cases of early flushing and just below average height growth. Skamokawa and Nimpkish have somewhat poorer survival and more defective trees than the above listed best performers. Special attention is drawn to Gold Bar (sel. nr. 1063), which shows good height growth, good survival and few defective trees, but consistent early flushing.

Seed collection zones for the Netherlands

Washington

The best performing provenances, so far, come from Washington State, USA, which therefore will be the most important area for seed collection for further provenance research and forestry practice. However, differences do occur within the area sampled by IUFRO, both in climate and in performance of the provenances.

Three areas with good provenances may be distinguished, which are shaded on the map of fig. 4:

a In the northeast we find an area with the good provenances Arlington, Darrington, Granite Falls and North Bend. Gold Bar is here an exception because of its early flushing.

b In the south Cathlamet is the only good provenance, but Skamokawa is not too bad. From this area came the very best provenance so far imported in the Netherlands. It was tested in two trials of the earlier provenance investigation and is known under the name Pacific Coast. (Only one small stand of this provenance still exists in the Netherlands).

c The third area is found in the northwest, around Mount Olympus with the good provenances Matlock, Humptulips, Hoh River, Forks, Crescent Lake and Louella Guard Station.

In order to see whether these areas have anything in common climatologically, the IUFRO provenances and a number of Weather Reporting Stations around the Puget Sound and along the coast of Washington have been listed in geographical order from northeast through south to northwest in table 3 (see also figure 4). Altitude and climatical data are given after the names (Manning Seed Company 1954, Phillips undated, 1966, 1968, 1972). The list is headed by the main Dutch Weather Reporting Station (KNMI, De Bilt).

If the climatological data of the areas with the best provenances are compared and the differences in altitude between seed sources and the nearest Weather Reporting Stations taken into account, it appears that for a good seed source summer precipitation is more than 400 mm.

The best provenances in all these areas come from 100 to 300 meter a.s.l. only Crescent Lake and Louella Guard Station, on the north slopes of the mountains on the Olympic Peninsula, come from between 300 and 500 meter a.s.l. The lower limits coincide more or less with the lower limit of 400 mm summer rainfall.

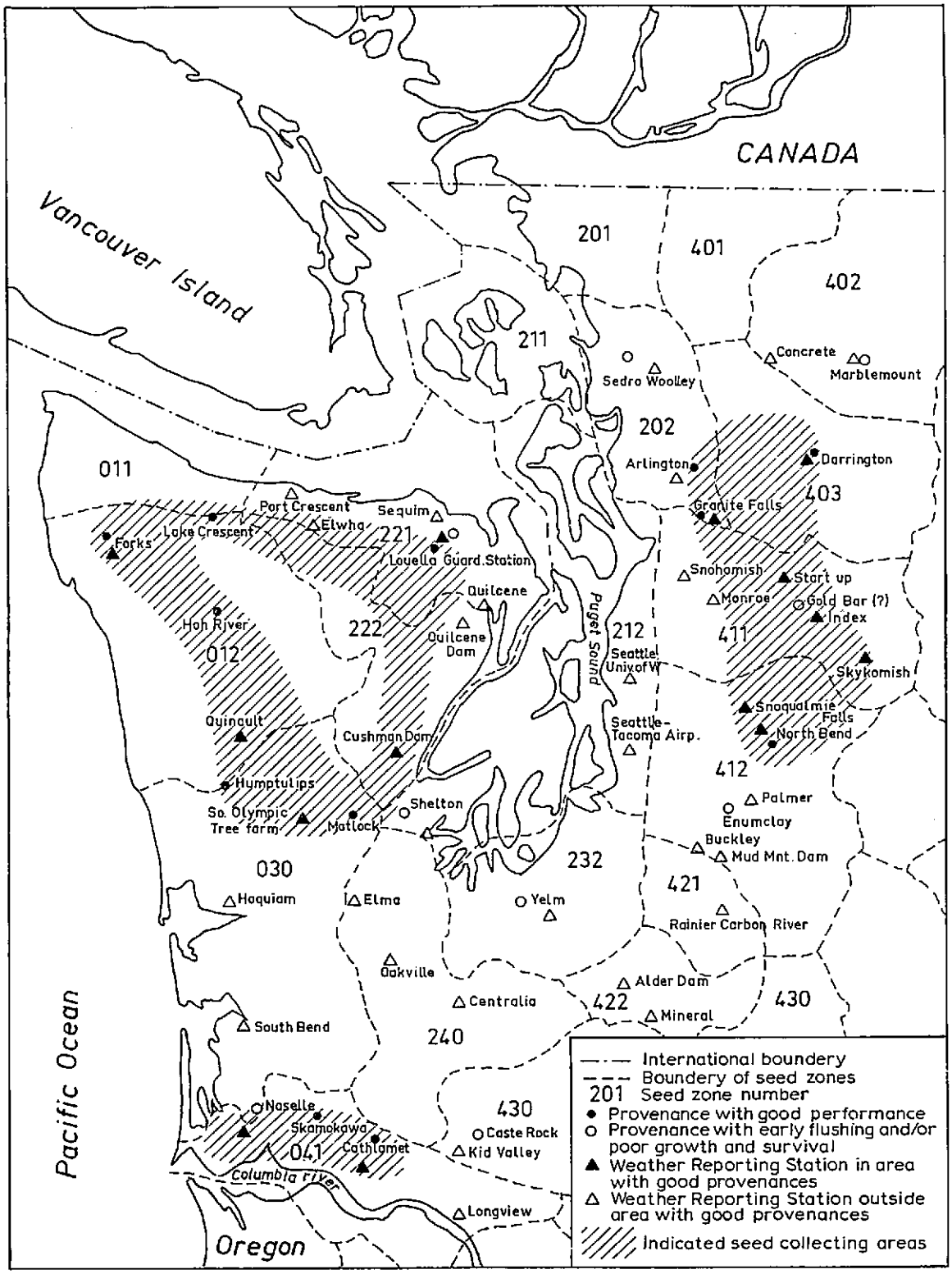
Provenances from areas with a summer rainfall of less than 400 mm are poorer, such as Sedro Woolley and Yelm in the area immediately around the Puget Sound, and Sequim on the north coast of the Olympic Peninsula.

The shaded areas of the map in Figure 3 cover parts of the seed zones 202, 403, 411 and 412; 041 and 030; and 030, 012, 221 and 222. Some other climatological characteristics of these areas are an average summer temperature of 13 to 15° C and at least 150 frost days. The absolute minimum temperature in these areas ranges between - 15° and - 24° C. These characteristics are very similar to those in the Netherlands. Our country may be in general somewhat drier, but it is also cooler.

In the foregoing an attempt was made to find a basis for the choice of seed collection areas. This choice must be provisional since it is based on early results. Moreover it is known that the ecological conditions and genetical characteristics of the species may vary considerably over short distances. Therefore not all provenances from the selected areas will be suitable, on the other hand it is unlikely that all provenances from the surrounding areas need to be absolutely unsuitable.

For instance, climatological data from the areas just north and south of the shaded area east of the Puget Sound suggest that good provenances could possibly be found there, although the results obtained with the provenance Enumclaw, to the south, are not very hopeful. Collections from Elma and Oakville tested in the older provenances trials proved to be good. Presumably the collections were made at higher altitudes than indicated

Figure 4. Weather Reporting Stations and IUFRO provenances in Washington State (USA)



for the Weather Reporting Station Elma, in the hills south of Elma and Oakville.

It is therefore suggested that, if seed will be collected for further provenance research, not only the selected areas, but also some adjacent areas and in particular the hills between the Olympic Peninsula and Cathlamet should be sampled. Care should be taken not to sample seed sources situated lower than 100 meter (300 meter on the north coast of the Olympic Peninsula) or higher than 500 meter. Since less desirable early flushing provenances occur in the areas to be sampled, rather extensive descriptions of the site of the seed source (position on a slope, aspect of the slope etc.) could be useful in explaining the flushing pattern of provenances.

Imports of seed for plantation work should preferably be from the shaded areas of the map in Figure 3 and within these areas from altitudes between 100 and 300 meter (on the north coast of the Olympic Peninsula between 300 and 500 meter). No guarantee can be given that all imports from these areas will be perfect as pointed out above. It is possible that some less well adapted populations will come from the indicated areas even if collections are made from native material. Collections from artificially founded stands in the area give no guarantee for quality whatsoever.

Vancouver Island

The few relatively good provenances of Vancouver Islands are not from one area. So no definite seed collection zone for either continued provenance research or forestry practice can be indicated. The provenances Courtenay and Sooke may prove to be of some value for the Netherlands and may be considered as second choice alternatives for the above mentioned seed collection areas in Washington.

Conclusions

1 The early results of the IUFRO provenances 1966/67 Series show significant differences between the provenances in height growth at age 5 years and in flushing in the nursery Groot Spriel and the Sleenerzand experiment. The differences in percentages dead, defective and surviving trees without defects are important.

2 The best provenances for the Netherlands, showing good height growth, late flushing and good adaptability, i.e. few deaths and defective trees as a consequence of drought and frost damage, come from Washington State, USA.

3 Three areas could be indicated provisionally for collection of seed for forestry practice in the Netherlands. These areas are situated:

a East of the Puget Sound approximately from Arlington and Darrington in the north 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.

4 For further provenance work the same areas and some adjacent areas, in particular the hills between the Olympic Peninsula and Cathlamet could be sampled up to 500 meter a.s.l.

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