# Inter- and Intraspecific Crossing in Douglas-Fir, Pseudotsuga menziesii (Mirb.) Franco.[1][2]

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## Introduction

It is generally recognised that the genus Pseudotsuga contains six species, two of which occur in North America and the remainder in western China, Formosa and Japan. The Asiatic species have been briefly described by Henry and Flood (1920) and as far as is known no more recent information has been published. In North America, the Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco is an extremely important species. Its distribution was originally given by Frothingham (1909) and only minor revisions have been made since that date. The Douglas-fir has an enormous range of nearly 3000 miles from latitude 55° in British Columbia to latitude 19° in Mexico and of almost 1000 miles from the coast eastward. This very wide distribution covers a vast range of elevations, sites and climatic conditions. Some years ago, Duffield (1950) suggested that a Douglas-fir improvement program could proceed along two general lines, namely selective breeding within local races and hybridization between races and species. This paper describes some early studies on the latter rnethods.

## Interspecific Crosses with Douglas-Fir

Duffield (1950) first attempted to cross Douglas-fir with Bigcone Douglas-fir, Pseudotsuga macrocarpa (Vasey) Mayr. from California as pollen parent. He was not successful and concluded that the cross appeared difficult to make. Subsequent studies have shown that this is correct. Ching (1959) made the first successful cross in 1956 although the yield of viable seed was very low compared with that of the controls. In 1962 some crosses were made on seven Douglas-fir growing in southern Vancouver Island, British Columbia. The pollen had been collected that same year from two Bigcone Douglas-fir in northern California. One hundred and thirty cones were collected and 6863 seeds extracted. These were carefully cleanod and found to be empty. Further crosses were made in 1964 on seven other trees growing in the same locality, the pollen being collected earlier that year from another Bigcone Douglas-fir in northern California. Two hundred and thirty-nine cones were collected and 14,199 seeds extracted. These were again carefully cleaned to remove as many empty seeds as possible. The remaining sixty-one seeds were then sown in the nursery. Only eight of these seods germinated from the crosses on two of the trees, the remainder were all found to be empty. As far as is known, no reciprocal cross between these two species has yet been attempted. One probable explanation for the evident incompatibility in this cross is the difference in chromosome number as Christiansen (1963) found that Bigcone Douglas-fir had 2n = 24 and the Douglas-fir 2n = 26 chromosomes.

Pseudotsuga wilsoniana, Hayata from Formosa is the only known Asiatic species to have been crossed with Douglas-fir. R. Silen[4]) (Letter Oct. 4, 1965) made the first cross in 1962 using the former species as pollen parent. Some putative hybrids were raised but sections made of the needles indicated that they were more like those of Douglas-fir than intermediate between both parents. This cross was attempted on one tree at Lake Cowichan in 1963, but although seventeen cones were pollinatod, all the 1,035 seeds were empty. One can only conclude that at this time, the prospects of interspecific crossing with Douglas-fir are not particularly promising. In addition to the difficulty already experienced in making successful crosses, must be added the technical problems of obtaining pollen particularly in the case of the Asiatic species. Attempts to circumvent the latter problem by raising these species from seed has not been particularly successful (Orr-Ewing, 1964).

## Intraspecific Crosses with Douglas-Fir

### Review *and procedures*

Intraspecific crossing with a species with as wide a distribution as Douglas-fir appeared a much more promising approach. Clausen (1951) has pointod out that species which occupied many kinds of environments were able to do so because they had evolved a series of physiologically distinct races which were still able to exchange genes through crossing without disturbing the internal develapmental balance. Johnsson (1956) further considered that intraspecific crossing was one of the most promising lines in tree breeding as one was not restricted by incompatibility barriers which were often the case with interspecies crossing. He also thought it most important to find out to what extent heterosis did occur in such crosses. Few studies with the intraspecific crossing of forest trees have, hawever, been made. In 1916, Johnsson made some wide crosses with Aspen, *Populus tremula* L. from latitudes 55°, 60° and 63° in Sweden. He found that at ten years, the growth of five of the six crosses were superior to that of the parental provenances. Four of these crosses, moreover, were as good or better than the provenance indigenous to the planting site. Nilsson (1958, 1963) has made similar studies in Sweden with the Norway spruce, Picsa *abies* (L.) Karst. In recognising two distinct ecotypes, the Swodish and continental spruces, he crossed selected local spruces with both local and continental pollen parents and finally continental spruces with continental pollen parents. Test plantations finally were established on eight localities at different latitudes. Nilsson (1963) found that at eight years, the provenance hybrids (local spruces crossod with continental pollen parents) had grown more rapidly than both the local crosses between latitudes 50° and 64° and the continental by continental crosses between latitudes 58° and 64°.

As far as is known, no previous intraspecific crosses had been made with the Douglas-fir so the series of crosses

[1]) The paper is dedicated to W. Langner, Schmalenbeck on the occasion of his 60th birthday.

[2]) The following kindly supplied the pollen used in this study: W. B. Critchfield, T. E. Greathouse and R. R. Silen, U. S. Forest Service; K. K. Ching, Oregon State University; D. Armit, M. B. Clark, R. Hawkins and K. Illingworth, B. C. Forest Service. A. R. Fraser and I. Karlsson, B. C. Forest Service, both gave considerable assistance, the former in the statistical analysis of the data and the latter in raising the progenies in the nursery. Mr. R. T. Bingham, U. S. Forest Service, kindly reviewed the manuscript.

[3]) B. C. Forest Service Publication T. 61.

[4]) Research Forester, U. S. For. Serv., Corvallis, Oregon.

*Table 1.* — Climatic records for the weather stations nearest to the respective pollen parents.

| Location of pollen parent | Latit. | Longit. | Elev. | Nearest weather station | Elev. | No. of yrs. recorded | Aver. date last spring frost | Aver. date first autumn frost | Frost free period | | Absol. Minim. Temper. recorded |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Longest | Short-est | |
| | ° ' | ° ' | *Feet* | | *Feet* | | | | *Days* | *Days* | °*F.* |
| Priestly | 54.09 | 128.15 | 2200 | Vanderhoof | 2226 | 21 | June 30 | Aug. 9 | 64 | 4[1] | —61 |
| Niemamanous | 52.24 | 126.47 | 200 | Bella Coola | 20 | 52 | May 11 | Oct. 1 | 217 | 95 | —20 |
| Lac Le Jeune | 50.29 | 120.28 | 3800 | Kamloops | 1246 | 47 | April 25 | Oct. 8 | 212 | 137 | —37 |
| Zincton | 50.03 | 117.08 | 3400 | Kaslo | 1930 | 39 | May 4 | Oct. 7 | 223 | 121 | —17 |
| Cowichan | 48.48 | 124.02 | 700 | Cowichan Lake | 545 | 17 | April 26 | Oct. 19 | 199 | 148 | 0 |
| Sol Duc | 48.05 | 124.01 | 2400 | Sappho[2] | 760 | 12 | May 6 | Nov. 4 | 209 | 123 | 3 |
| Pedee 1 & 2 | 44.45 | 123.22 | 460 | Corvallis[3] | 225 | 29 | April 3 | Nov. 4 | 275 | 177 | —14 |
| King's Valley | 44.42 | 123.24 | 550 | Corvallis[3] | 225 | 29 | April 3 | Nov. 4 | 275 | 177 | —14 |
| Lewisburg | 44.39 | 123.18 | 250 | Corvallis[3] | 225 | 29 | April 3 | Nov. 4 | 275 | 177 | —14 |
| Wrens | 44.38 | 123.23 | 550 | Corvallis[3] | 225 | 29 | April 3 | Nov. 4 | 275 | 177 | —14 |
| Weber AE & AF | 38.45 | 120.41 | 1800 | Placerville[4] | 1875 | 30 | April 27 | Oct. 20 | 239 | 82 | 8 |

[1]) This figure is probably unrealistic as results from the arbitrary division of July 15th between spring and autumn frosts.
[2]) Climatic data supplied by E. L. Phillips, State Climatologist, Seattle, Wash.
[3]) Climatic data supplied by K. K. Ching, Assoc. Prof. Oregon State Univ., Corvallis, Ore.
[4]) Climatic data supplied by C. R. Elford, State Climatologist, San Francisco, Cal.

made in 1963 and 1964 were confined to sampling wide geographical regions to the north, east and south of the Research Station at Lake Cowichan in southern Vancouver Island. This sampling was not as complete as desirable as it was considerably restricted by difficulties in obtaining pollen. The variable amounts of pollen that were received further made a balanced crossing program most difficult. *Figure 1* shows the general location of the trees from which pollen was sent, separate collections being made from two trees at Pedee and Weber respectively. The latitudes, longitudes and elevations of the thirteen pollen parents are shown in *Table 1* which also gives some climatic data from the nearest weather stations. Such information, of course, has to be accepted with caution as these records are not necessarily representative of the location of the pollen parent. They do, however, indicate that there was a considerable diversity in climate between the various locations, particularly in regard to the absolute minimum temperatures. The climatic data for the British Columbian weather stations was given by Boughner *et al.* (1956) and Mackie (1965).

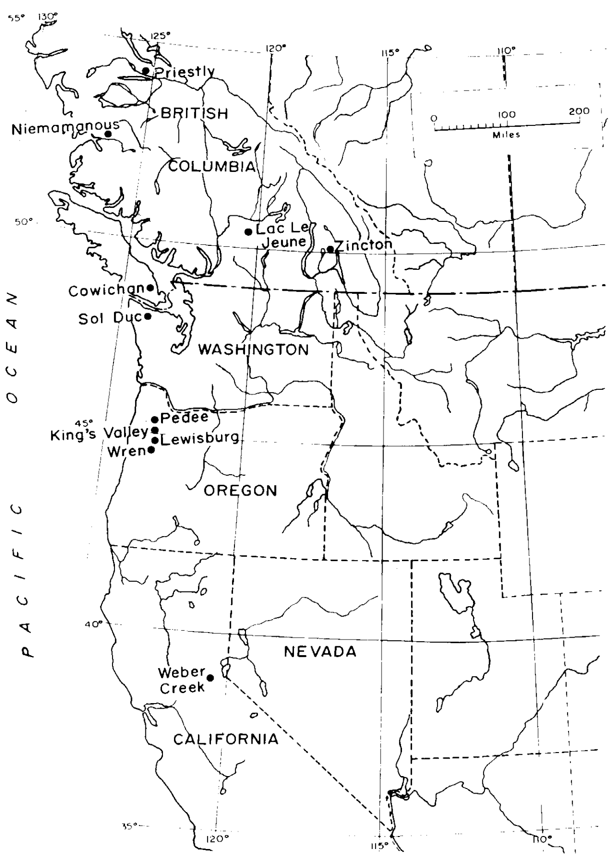


*Figure 1.* — General location of the pollen parents used for the intraspecific crosses in 1963 and 1964.

*The pollinations and early development of the 1963 crosses*

Owing to the very poor cone crop in 1963 there was some difficulty in locating trees on which to make the necessary pollinations. Two trees, numbers 12 and 14, were finally selected in a stand at Lake Cowichan, the remaining four being eleven year old progenies from previous cross, wind and selfing studies on tree 2 (Orr-Ewing, 1954). These six trees were all growing a few miles west and at comparable elevations to the Cowichan pollen parent, a selected plus tree. Other samples came from three trees in northern and interior British Columbia from which the pollen had been collected the year previous owing to late maturation. The remaining samples came from three trees in the vicinity of Corvallis, Oregon. The pollinations were made in April but, unfortunately, only a few of the strobili on tree 14 developed into cones as there was considerable abortion. The cones were collected in September and the seed extracted and counted for each of the crosses as shown in *Table 2*. The seeds were next carefully cleaned in order to remove as many empty ones as possible and were then recounted before being placed in cold storage.

The various lots were stratified in April and the seeds sown in May, a known number being individually spot seeded at one inch spacing in cold frames. These had been previously filled to a depth of twelve inches with U. C. Soil Mix C to which Fertilizer II C had been added (Baker, 1957). The seed lots were sown in rows seven inches apart and not replicated owing to the homogeneous nature of the mix. Weekly germination counts were made, each new germinant being marked on emergence with a toothpick. Germination was satisfactory for all crosses with the exception of those in which the pollen had been stored from the previous year.

The epicotyl length of forty seedlings wherever possible was measured in late October. The details are shown in *Table 2*. The seedlings were selected systematically, every $n^{th}$ one being measured dependant on the total number in each cross. The analysis of growth showed that with one exception all the crosses with Oregon pollen parents had

*Table 2.* — Results of the 1963 pollinations and early development of the crosses, Oct. 1964.

| ♀ Parent | ♂ Parent | No. of cones collected | No. of seeds extracted | Percent of germinants | Length of epicotyl Oct. 1964: No. of seedlings measured | Mean length in cm. | Standard error of mean |
|---|---|---|---|---|---|---|---|
| 12 | Priestly[1]) | 28 | 1348 | 24.1 | 40 | 11.5 | .24 |
| | Lac Le Jeune[1]) | 29 | 1537 | 16.3 | 40 | 8.9 | .25 |
| | Cowichan | 58 | 3223 | 82.3 | 40 | 12.2 | .28 |
| | Kings Valley | 16 | 1008 | 85 3 | 40 | 13.3 | .32 |
| | Wrens | 20 | 1013 | 83.5 | 40 | 13.7 | .39 |
| 14 | Cowichan | 4 | 71 | 60.6 | 40 | 11.0 | .26 |
| | Pedee | 2 | 64 | 64.1 | 40 | 14.3 | .24 |
| | Kings Valley | 6 | 184 | 44.0 | 40 | 14.1 | .32 |
| 2.3.48 | Lac Le Jeune[1]) | 3 | 192 | 15 6 | 29 | 10.6 | .31 |
| | Cowichan | 8 | 599 | 81.3 | 40 | 12.2 | .32 |
| | Pedee | 2 | 147 | 51.7 | 40 | 14.1 | .27 |
| 2W.24 | Priestly[1]) | 2 | 150 | 19.3 | 27 | 12.0 | .32 |
| | Lac Le Jeune[1]) | 6 | 419 | 19.8 | 40 | 10.0 | .19 |
| | Cowichan | 26 | 1780 | 69 6 | 40 | 12.9 | .33 |
| S1.2.13 | Priestly[1]) | 9 | 417 | 20.9 | 40 | 11.2 | .21 |
| | Niemamanous | 2 | 118 | 23.3 | 29 | 11.6 | .38 |
| | Lac Le Jeune[1]) | 3 | 140 | 12.9 | 13 | 7.8 | .63 |
| | Cowichan | 7 | 302 | 46.7 | 40 | 11.6 | .28 |
| | Pedee | 3 | 123 | 66.7 | 40 | 14.0 | .37 |
| | Wrens | 7 | 261 | 34.1 | 40 | 12.3 | .41 |
| S1.2.43 | Cowichan | 1 | 52 | 36.5 | 20 | 11.4 | .53 |
| | Pedee | 3 | 132 | 24.2 | 30 | 13.5 | .36 |
| | Kings Valley | 4 | 177 | 29.4 | 40 | 12.7 | .29 |

[1]) Pollen collected 1962.

*Table 3.* — Second year growth and survival of the 1963 crosses Nov. 1965.

| ♀ Parent | ♂ Parent | No. of seedlings measured | Mean ht. in cm. | Standard error of mean | Mean diam. in cm. | Standard error of mean | Mean of ratio of ht. to diam. | Standard error of mean | Survival percent |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Priestly | 64 | 32.8 | .63 | .66 | .14 | 50.2 | .82 | 93.2 |
| | Lac Le Jeune | 64 | 25.0 | .73 | .58 | .10 | 42.8 | .77 | 97.2 |
| | Cowichan | 64 | 39.7 | .88 | .72 | .13 | 55.4 | 1.11 | 95.3 |
| | Kings Valley | 64 | 46.4 | 1.09 | .79 | .17 | 59.1 | 1.15 | 95.7 |
| | Wrens | 64 | 42.5 | 1.16 | .73 | .18 | 58.1 | 1.38 | 89.6 |
| 14 | Cowichan | 42 | 38.6 | 1.09 | .72 | .14 | 54.0 | 1.35 | 100.0 |
| | Pedee | 33 | 41.7 | 1.40 | .77 | .15 | 53.6 | 1.42 | 80.5 |
| | Kings Valley | 64 | 41.2 | 1.16 | .78 | .17 | 52.3 | 1.23 | 97.5 |
| 2.3.48 | Lac Le Jeune | 29 | 26.0 | .94 | .63 | .30 | 41.5 | 1.00 | 96.7 |
| | Cowichan | 64 | 38.9 | .96 | .74 | .19 | 53.3 | 1.22 | 92.2 |
| | Pedee | 64 | 46.2 | .94 | .82 | .14 | 56.9 | 1.08 | 96.0 |
| 2W.24 | Priestly | 29 | 33.7 | 1.19 | .74 | .23 | 45.4 | 1.00 | 100.0 |
| | Lac Le Jeune | 64 | 27.5 | .59 | .62 | .10 | 44.4 | .72 | 98.8 |
| | Cowichan | 64 | 44.7 | 1.11 | .75 | .10 | 59.9 | 1.46 | 98.9 |
| S1.2.13 | Priestly | 64 | 30.8 | .58 | .71 | .07 | 43.5 | .80 | 88.5 |
| | Niemamanous | 31 | 41.7 | 1.33 | .74 | .23 | 57.2 | 1.70 | 100.0 |
| | Cowichan | 64 | 41.9 | 1.14 | .72 | .19 | 58.8 | 1.49 | 91.5 |
| | Pedee | 64 | 50.3 | 1.06 | .82 | .17 | 61.5 | 1.07 | 95.1 |
| | Wrens | 64 | 42.7 | 1.00 | .78 | .23 | 55.3 | 1.20 | 87.6 |
| S1.2.43 | Pedee | 31 | 42.4 | 1.26 | .75 | .21 | 56.9 | 1.10 | 96.9 |
| | Kings Valley | 47 | 42.4 | 1.17 | .80 | .12 | 52.7 | 1.36 | 92.3 |

made significantly[5]) better growth than their half-sibs from crosses with the local Cowichan pollen parent. None of the crosses with northern and interior pollen parents were particularly promising. The epicotyl length of the crosses with the Lac Le Jeune pollen parent without exception, were significantly less than those made on the same parent tree. During the winter months the cold frames were covered with glass to protect the seedlings against the heavy wet snow. In mid-December, the outside temperature fell to 6° F., but there was no damage to any of the crosses.

[5]) In this paper "significant" is used in a statistical sense and means that a difference by 't' test was shown to exist at the 5 percent level of probability or lower.

*Second year growth and survival of the 1963 crosses*

The dormant crosses were lifted in mid-February, counted and divided for the four replications used in the transplant beds. They were then stored at 34° F. in sealed bags until April 6th, the earliest date at which transplanting could begin. Two crosses each with less than twenty seedlings were not retained owing to the small numbers. The remainder were transplanted in April, a spacing of four and eight inches being left between each seedling and row respectively. Their locations in each of the four replications were assigned at random.

In November, the total heights and diameters at ground level of the various crosses were measured, sixteen seedlings per cross being selected systematically wherever possible in each of the four replications. The results are shown

Table 4. — Dormancy records for the crosses in the transplant beds, 1965.

| ♀ Parent | ♂ Parent | No. seedlings | Date dormancy first observed | Date 50 percent seedlings dormant | Date 90 percent seedlings dormant |
|---|---|---|---|---|---|
| 12 | Priestly | 303 | July 30 | Aug. 6 | Aug. 20 |
| | Lac Le Jeune | 243 | July 30 | Aug. 6 | Aug. 13 |
| | Cowichan | 825 | Aug. 6 | Aug. 20 | Oct. 29 |
| | Kings Valley | 823 | Aug. 13 | Oct. 22 | Oct. 29 |
| | Wrens | 758 | Aug. 13 | Aug. 27 | Oct. 29 |
| 14 | Cowichan | 43 | Aug. 13 | Aug. 27 | Oct. 29 |
| | Pedee | 33 | Aug. 13 | Oct. 8 | Nov. 5 |
| | Kings Valley | 79 | Aug. 13 | Sept. 17 | Oct. 22 |
| 2.3.48 | Lac Le Jeune | 29 | Aug. 6 | Aug. 13 | Aug. 27 |
| | Cowichan | 449 | Aug. 6 | Aug. 20 | Oct. 29 |
| | Pedee | 72 | Aug. 20 | Oct. 15 | Oct. 29 |
| 2W.24 | Priestly | 29 | Aug. 6 | Aug. 13 | Aug. 20 |
| | Lac Le Jeune | 82 | Aug. 6 | Aug. 13 | Aug. 20 |
| | Cowichan | 847 | Aug. 13 | Oct. 15 | Oct. 29 |
| S1.2.13 | Priestly | 77 | July 30 | Aug. 13 | Aug. 13 |
| | Niemamanous | 31 | Aug. 27 | Oct. 1 | Oct. 15 |
| | Cowichan | 129 | Aug. 13 | Oct. 15 | Oct. 22 |
| | Pedee | 78 | Aug. 20 | Oct. 22 | Oct. 29 |
| | Wrens | 78 | Aug. 20 | Sept. 24 | Oct. 29 |
| S1.2.43 | Pedee | 31 | Aug. 27 | Oct. 22 | Nov. 12 |
| | Kings Valley | 43 | Aug. 13 | Oct. 22 | Nov. 5 |

in *Table 3* and an analysis of the growth indicated a similar trend to that of the previous year. The crosses with the Oregon pollen parents were again the most vigorous, their heights and diameters being significantly better than those with the Cowichan pollen parent, the only exception being the crosses from parent tree 14. There was no change in the ranking of the crosses with the northern and interior pollen parents, those with the Lac Le Jeune pollen parent again being significantly smaller than their half-sibs from the same parent tree. The percentage of survival for the various crosses from time of germination to completion of the second growing season is shown in *Table 3*, and was satisfactory for all crosses.

Table 5. — Results of the 1964 pollinations with subsequent germination and survival, Nov. 1965.

| ♀ Parent | ♂ Parent | No. of cones collected | No. of seeds extracted | Percent of germinants | Survival percent |
|---|---|---|---|---|---|
| 12 | Zincton[1]) | 26 | 1670 | 23 8 | 99.5 |
| | Pedee 2 | 34 | 2546 | 84.0 | 95.8 |
| | Weber AE | 45 | 3192 | 81.4 | 97.9 |
| | Weber AF | 40 | 2723 | 67.6 | 99.3 |
| | Wind | 135 | 9801 | 21.9 | 97.3 |
| 13 | Zincton[1]) | 9 | 682 | 33.9 | 99 6 |
| | Lewisburg | 3 | 202 | 43.1 | 97.0 |
| | Weber AE | 15 | 866 | 19.6 | 98.8 |
| | Weber AF | 24 | 1468 | 73.3 | 99.1 |
| | Wind | 27 | 1693 | 55.7 | 99.6 |
| 16 | Zincton[1]) | 18 | 815 | 9.4 | 98.7 |
| | Pedee 2 | 29 | 1521 | 78.3 | 100.0 |
| | Lewisburg | 14 | 651 | 82.2 | 100.0 |
| | Weber AE | 56 | 2906 | 73.1 | 100.0 |
| | Weber AF | 56 | 3170 | 80.1 | 99.6 |
| | Wind | 201 | 10432 | 29.2 | 100.0 |
| 18 | Sol Duc | 36 | 1982 | 72.9 | 99 4 |
| | Lewisburg | 33 | 1851 | 26.3 | 100.0 |
| | Wrens | 38 | 2703 | 59.6 | 99.0 |
| | Weber AE | 46 | 2554 | 83.5 | 97.9 |
| | Weber AF | 41 | 2065 | 73.4 | 100.0 |
| | Wind | 69 | 3661 | 58.1 | 97.6 |
| 383 | Sol Duc | 42 | 2176 | 30.7 | 99.4 |
| | Lewisburg | 26 | 1419 | 40.4 | 99.3 |
| | Wrens | 23 | 1212 | 13.4 | 90.2 |
| | Weber AE | 34 | 1793 | 69.5 | 99.0 |
| | Weber AF | 17 | 853 | 51.7 | 100.0 |
| | Wind | 32 | 1686 | 15.9 | 98.1 |

[1]) Pollen collected 1963.

Observations made the previous year had shown that crosses with pollen parents from northern and interior British Columbia became dormant several weeks earlier than their half-sibs. In 1965, therefore, the various stages of dormancy in the crosses were recorded at weekly intervals from July to November. At each examination, every seedling in all four replications was carefully checked for signs of dormancy, the total number of dormant seedlings being expressed in percent for that cross. ROMBERGER (1963) has defined dormancy as a temporary suspension of visible growth and development and this definition seemed the most appropriate for the study.

It was found that there was considerable variation in dormancy between the replications of some crosses. The summarised results in *Table 4*, however, clearly indicated that some of the seedlings from crosses with the Lac Le Jeune and Priestly pollen parents became dormant at the end of July. Ninety percent of these seedlings, moreover, were dormant by the second week in August, a full two months before their half-sibs reached this stage. The crosses with the Oregon pollen parents were generally the last to go into dormancy.

*The pollinations and early development of the 1964 crosses*

In 1964, the potential cone crop was better than that of the previous year so that more pollinations were possible on the five trees selected at Lake Cowichan. In addition, there were enough cones to provide wind-pollinated seed for controls. Pollen again had been obtained the previous year from Zincton in British Columbia, the other lots coming from individual trees in Washington, Oregon and California. The pollinations were completed in April and the cones collected in the autumn. The seed was extracted, counted and cleaned to remove as many empty seeds as possible. After stratification, the various lots were each sown in two replications, one going into the four cold frames used the previous year which had been topped up with an inch of fresh mix. The other replication was sown in four new cold frames filled with fresh mix. The results of the pollinations with the subsequent germination and survival are shown in *Table 5*. Germination was generally high and the percentage of survival most satisfactory for all crosses.

*Table 6.* — Early development of the 1964 crosses, Nov. 1965.

| ♀ Parent | ♂ Parent | Mean ht. in cm. | Standard error of mean | Mean diam. in cm. | Standard error of mean | Mean of ratio of ht. to diam. | Standard error of mean |
|---|---|---|---|---|---|---|---|
| 12 | Zincton | 17.3 | .61 | .25 | .06 | 68.9 | .14 |
| | Pedee 2 | 20.8 | .47 | .26 | .06 | 81.1 | .13 |
| | Weber AE | 19.9 | .44 | .25 | .05 | 82.2 | .17 |
| | Weber AF | 19.9 | .43 | .25 | .06 | 80.0 | .12 |
| | Wind | 18.2 | .53 | .24 | .06 | 76.8 | .15 |
| 13 | Zincton | 20.1 | .47 | .28 | .04 | 70.8 | .12 |
| | Lewisburg | 18.1 | .35 | .24 | .05 | 75.8 | .13 |
| | Weber AE | 22.5 | .41 | .32 | .06 | 70.0 | .11 |
| | Weber AF | 21.9 | .42 | .29 | .05 | 76.3 | .11 |
| | Wind | 21.1 | .49 | .27 | .07 | 81.5 | .22 |
| 16 | Zincton | 15.2 | .38 | .25 | .04 | 61.6 | .14 |
| | Pedee 2 | 18.3 | .39 | .26 | .06 | 72.3 | .13 |
| | Lewisburg | 17.7 | .41 | .25 | .06 | 70.2 | .11 |
| | Weber AE | 17.4 | .29 | .25 | .05 | 71.1 | .10 |
| | Weber AF | 18.4 | .34 | .26 | .05 | 72.2 | .11 |
| | Wind | 13.6 | .62 | .20 | .07 | 67.9 | .14 |
| 18 | Sol Duc | 17.5 | .45 | .24 | .06 | 74.6 | .12 |
| | Lewisburg | 18.3 | .34 | .26 | .05 | 70.1 | .10 |
| | Wrens | 19.3 | .46 | .26 | .05 | 74.6 | .15 |
| | Weber AE | 20.0 | .37 | .27 | .03 | 75.4 | .14 |
| | Weber AF | 18.1 | .38 | .28 | .04 | 75.9 | .10 |
| | Wind | 17.3 | .51 | .23 | .06 | 74.5 | .12 |
| 383 | Sol Duc | 18.9 | .36 | .25 | .05 | 74.6 | .11 |
| | Lewisburg | 19.0 | .38 | .26 | .05 | 73.4 | .12 |
| | Wrens | 21.3 | .37 | .28 | .06 | 75.7 | .10 |
| | Weber AE | 20.3 | .31 | .26 | .03 | 79.9 | .13 |
| | Weber AF | 17.4 | .51 | .23 | .05 | 75.7 | .12 |
| | Wind | 17.8 | .52 | .25 | .06 | 72.3 | .14 |

*Table 7.* — Dormancy records for the crosses in the cold frames, Nov. 1965.

| ♀ Parent | ♂ Parent | No. seedlings | Date dormancy first observed | Date 50 percent of seedlings dormant | Date 90 percent of seedlings dormant |
|---|---|---|---|---|---|
| 12 | Zincton | 396 | Sept. 17 | Oct. 8 | Oct. 15 |
| | Pedee 2 | 925 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Weber AE | 929 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Weber AF | 970 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Wind | 799 | Oct. 8 | Oct. 22 | Oct. 29 |
| 13 | Zincton | 230 | Sept. 17 | Oct. 15 | Oct. 15 |
| | Lewisburg | 85 | Oct. 8 | Oct. 22 | Oct. 29 |
| | Weber AE | 168 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Weber AF | 967 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Wind | 940 | Oct. 8 | Oct. 29 | Oct. 29 |
| 16 | Zincton | 76 | Sept. 17 | Oct. 8 | Oct. 15 |
| | Pedee 2 | 930 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Lewisburg | 535 | Oct. 8 | Oct. 22 | Oct. 29 |
| | Weber AE | 857 | Oct. 8 | Oct. 29 | Oct. 29 |
| | Weber AF | 927 | Oct. 8 | Oct. 29 | Oct. 29 |
| | Wind | 885 | Oct. 1 | Oct. 22 | Oct. 29 |
| 18 | Sol Duc | 944 | Oct. 8 | Oct. 15 | Oct. 22 |
| | Lewisburg | 488 | Oct. 8 | Oct. 15 | Oct. 29 |
| | Wrens | 840 | Oct. 8 | Oct. 8 | Oct. 22 |
| | Weber AE | 906 | Oct. 8 | Oct. 22 | Oct. 29 |
| | Weber AF | 909 | Oct. 8 | Oct. 22 | Oct. 29 |
| | Wind | 853 | Oct. 8 | Oct. 15 | Oct. 29 |
| 383 | Sol Duc | 622 | Oct. 8 | Oct. 29 | Oct. 29 |
| | Lewisburg | 569 | Oct. 8 | Oct. 22 | Oct. 29 |
| | Wrens | 147 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Weber AE | 894 | Oct. 15 | Oct. 29 | Nov. 5 |
| | Weber AF | 441 | Oct. 8 | Oct. 29 | Nov. 5 |
| | Wind | 263 | Oct. 8 | Oct. 29 | Oct. 29 |

In November, the total heights and stem diameters at ground level were measured for each cross, twenty seedlings being selected systematically in each replication. The summarised results in *Table 6* showed that in every instance the best of the two crosses with the northern California pollen parents were significantly taller than the half-sib controls from wind pollination. The same conclusions can be applied to the crosses with the Oregon pollen parents with the exception of those with tree 13. Neither the crosses with the Sol Duc not or Zincton pollen parents were as promising at this stage. There were some interesting differences in the general combining ability of the five parent trees, tree 16, for example, produced some of the poorest progenies in every combination.

Individual seedlings from crosses in both replications were carefully checked for any visible signs of dormancy from July to November. The summarised results in *Table 7* again indicated the early onset of dormancy for crosses with pollen parents from interior British Columbia. Ninety percent of the crosses with the Zincton pollen parents were dormant two to three weeks earlier than their half-sibs.

### Discussion

These early results are encouraging enough that intraspecific crossing with Douglas-fir should be continued. Further crosses will be made with pollen parents south of British Columbia although one limiting factor to their value will undoubtedly be the length of the growing period in relation to the first autumn frosts. Crosses with northern and interior pollen parents in British Columbia do not appear as promising for conditions on the coast as the progenies go into dormancy so early in the summer. The seedlings, however, are very sturdy and could be of value in the interior of the province but the necessary trials are beyond the scope of this study. Early conclusions as to the potential value of any of these crosses, however, can not be made at present, as they have been growing under optimum conditions in one nursery where it is hardly possible to predict their performance under the variable conditions on different planting sites. NILSSON (1963) for example, found that one quarter of his thirty-six progenies of Norway spruce had radically changed their ranking in height between the first and eighth year. It will be of considerable interest, therefore, to follow the future development of these crosses when they have been planted at different test sites distributed over Vancouver Island and the lower mainland of British Columbia.


### Summary

In 1963 and 1964, a series of inter- and intraspecific crosses were made on ten Douglas-firs *Pseudotsuga menziesii* which were growing at latitude 48° 48' on Vancouver Island, British Columbia. The interspecific crosses were made with both Bigcone Douglas-fir, *Pseudotsuga macrocarpa* from California and *Pseudotsuga wilsoniana* from Formosa as pollen parents. These pollinations, however, were largely unsuccessful as only a few viable seeds were obtained in the cross with *P. macrocarpa*. The intraspecific crosses were made with pollen parents ranging from latitude 54° 09' in northern British Columbia to latitude 38° 45' in northern California. In general, there was no reduction in the number of viable seeds produced in comparison with the controls whilst germination was satisfactory. The growth measurements of both the one and two year old crosses with the Oregon and Californian pollen parents were in general significantly better than those with local pollen parents. The crosses with pollen parents from northern and interior British Columbia went into dormancy early in the summer months with a significant reduction in growth.



### Résumé

Titre de l'article: *Croisements inter et intraspécifique de douglas, Pseudotsuga menziesii (Mirb.) Franco.*

En 1963 et 1964, on a fait une série de croisements inter- et intraspécifiques sur 10 douglas situés dans l'île de Vancouver, Colombie britannique à la latitude 48° 48'. Pour les croisements interspécifiques on a employé comme parents mâles *Pseudotsuga macrocarpa* de Californie et *Pseudotsuga wilsoniana* de Formose, mais ces pollinisations ont pratiquement échoué et on n'a obtenu que quelques graines viables dans le croisement avec *Pseudotsuga macrocarpa*. Pour les croisements intraspécifiques on a employé comme parents mâles des arbres situés depuis la latitude 54° 09' dans le nord de la Colombie britannique jusqu'à la latitude 38° 45' dans le nord de la Californie. On n'a aucune réduction du nombre de graines viables par rapport aux témoins et la germination est bonne. Les croisements obtenus avec des parents mâles d'Oregon et de Californie ont, à un et deux ans, une hauteur significativement plus grande que ceux obtenus avec des parents mâles locaux. Les croisements réalisés avec des parents mâles venant de la région nord et de l'intérieur de la Colombie britannique entrent en dormance plus tôt en été et ont une croissance significativement plus faible.


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