# Investigation of the 4x4 and 8x8 Foot Douglas Fir Spacing Plots on the McDonald Forest

by

Walter Kirchner

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Professor of Forestry

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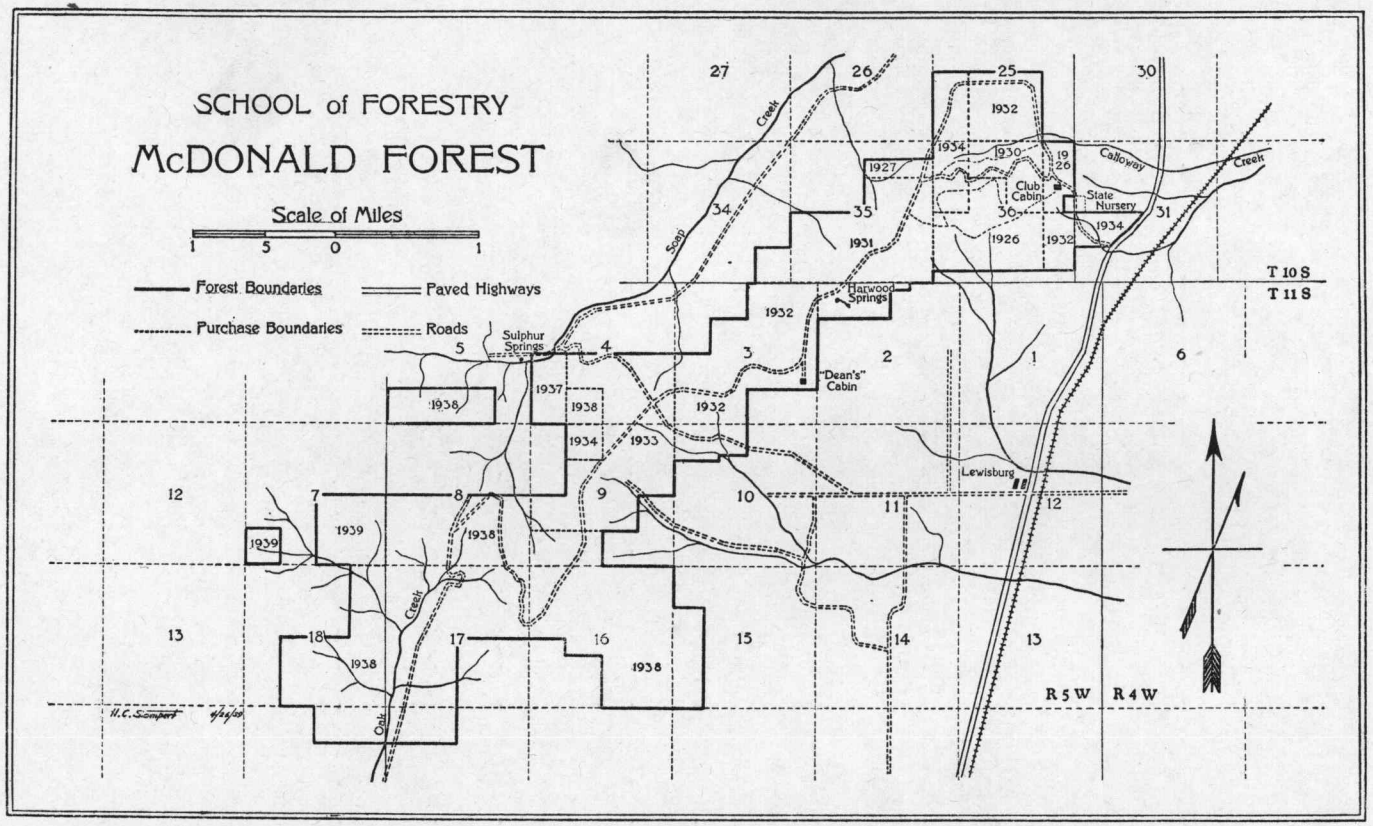

SCHOOL of FORESTRY
McDONALD FOREST
Scale of Miles
1 5 0 1
Forest Boundaries
Purchase Boundaries
Paved Highways
Roads
Sulphur Springs
Harwood Springs
"Dean's" Cabin
Lewisburg
Club Cabin
State Nursery
Calloway Creek
Soap Creek
Oak Creek
T 10 S
T 11 S
R 5 W
R 4 W
H.C. Sampert 4/24/50

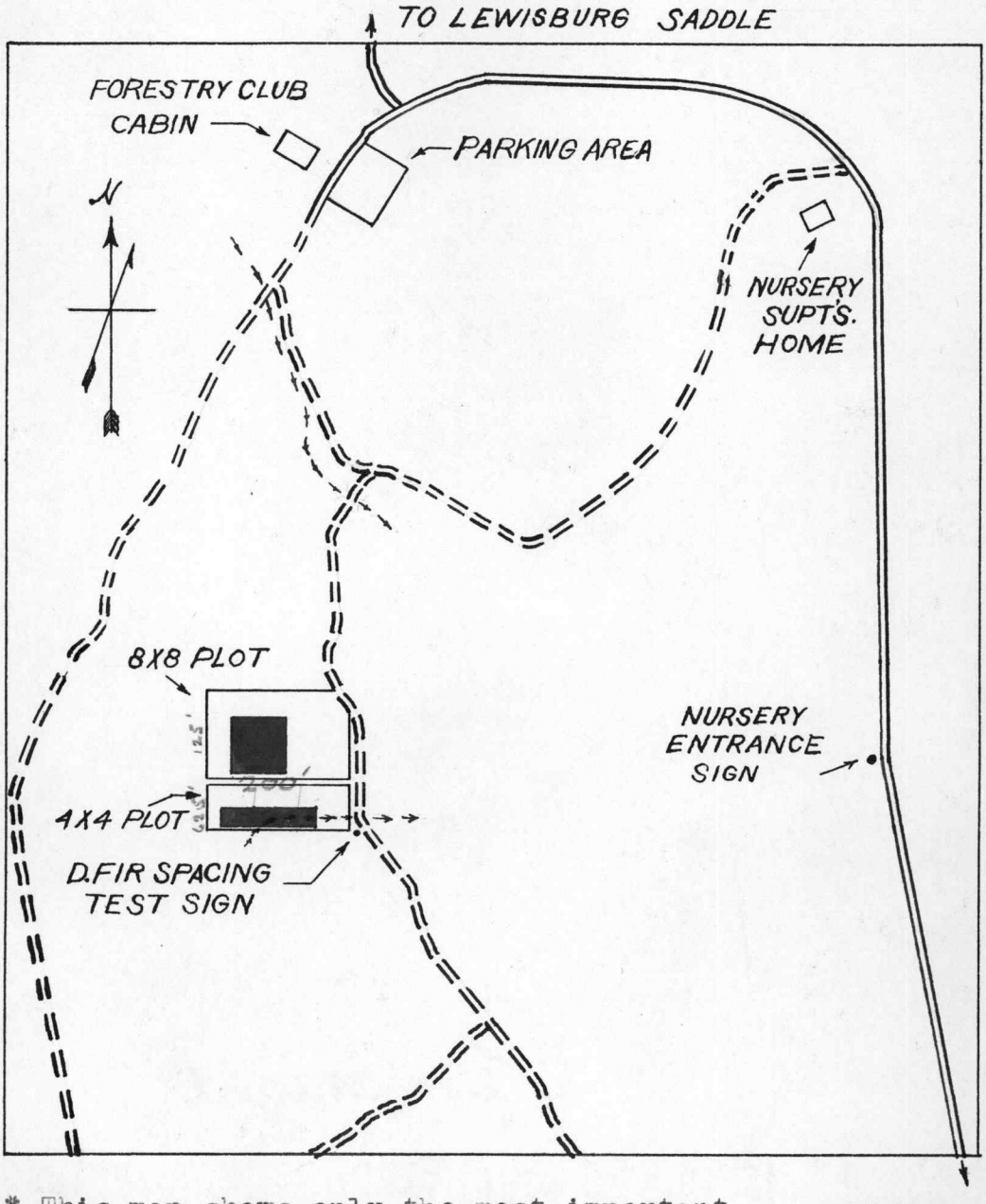
# LOCATION MAP
Showing
Position of 4x4 and 8x8 Spacing Plots*
Scale 1" 250'

Datum

Horizontal Control by Pacing
Direction by Hand Compass
Error of Closure 1:40
Mapped March, 1948

Legend

Gravel Road
Fire Trail
Intermittent Creek




* This map shows only the most important landmarks necessary for finding the plots.

## Introduction

Today there is scant written information pertaining to the effect of spacing arrangement on the growth of field planted Douglas-fir. The pioneer in this field of investigation in the Douglas-fir region is the Pacific Northwest Forest Experiment Station. Since 1925 the experiment station has kept a record of the growth of Douglas-fir on fifteen acres of land planted to 4x4, 5x5, 6x6, 8x8, 10x10, and 12x12 foot spacing. Unfortunately this experiment is being conducted on site quality IV land which is not the type of land upon which industrial foresters are interested in planting seedlings. ~~upon~~. It is reasonable to believe that the particular spacing giving the best growth will vary with the site quality. If growth rates of similar spacing arrangements as is found on the above plots but on site quality I, II, or III land could be obtained, much valuable information could be added to the meager supply. On the Oregon State College School of Forestry lands at McDonald Forest permanent spacing arrangement experimental plots were planted in 1927 and fortunately the area is on site quality III land. Today after twenty growing seasons these plots offer an excellent opportunity to observe the growth reaction and to compare it with the site IV growth rates. It is the purpose of this paper to investigate the growth characteristics on the spacing plots at McDonald Forest and to summarize conclusions that seem pertinent at this time. The information contained herein is limited to that obtained from one-seventh acre and one-thirteenth acre plot cruises; hence the scope of this report is necessarily limited.

## History

In the fall of 1927 Professor T. J. Starker with the aid of his silviculture class established 4x4 and 8x8 foot spacing plots in the location as shown on the map page 2 . The spacing test was started to "determine the effect of spacing arrangement, through its effect on competition on the growth of field planted douglas fir."[1] Douglas fir 1-1-2 stock was used on both plots. It had been obtained as 1-1 stock from the Wind River nursery and grown south of the Oregon State College School of Forestry building for two years. On the 4x4 foot spacing site, 800 seedlings were planted using sixteen rows four feet apart with intervals between trees of four feet in each row. On the 8x8 foot plot 400 seedlings were planted using sixteen rows eight feet apart with trees spaced eight feet apart in each row. In the words of Professor Starker, "the plots were located on upper site III land and there was no indication to believe a difference in site quality existed between the two plots." The slope of the land varied between eight and fifteen degrees with an easterly aspect. A sign was placed on the southeast corner of the 4x4 plot with the inscription "D. FIR SPACING TEST" and it is still visible to this day. Extending from the sign and running due west is a woven wire fence. There is no evidence to indicate any mortality of the seedlings for the period up to March,1933 for at that time Harry A.Fowells in his investigations of the

1. Fowells, Harry Ardell, Master Thesis, "A study and summary of the investigational on the McDonald Forest with recommendations," May 15, 1933.

plot made the following comment, "In March, 1933, five growing seasons after the study was started representative rows in each of the two spacings were selected and 100 trees in each spacing measured for total height and leader growth. Status; The following table gives the analysis of the data as found:"

| | 4x4 Total Ht. | Leader | 8x8 Total Ht. | Leader |
|---|---|---|---|---|
| Mean (M) | 6.50 | 1.48 | 6.30 | 1.62 |
| Standard error(S) | 1.88 | 0.34 | 1.78 | .40 |
| Standard error of means (s) | .188 | 0.034 | .178 | .04 |

For the period from the above information to the time this thesis was prepared there is no record of any further investigations. It is unknown at which time the aluminum tags observed on the trees by myself[2] were placed, since there is no record of this in Fowell's report.

As will be shown in this report the weather has played a major role in the history of these plots. From a study of the United States Department of Agriculture Climatological Data, Oregon Section, the weather in the Corvallis area has been unusually harmful to tree growth but once during the period from 1927 to 1948. In January of 1942 the outstanding feature of the month's weather was the ice storm in the northwest counties of the state. A freezing rain which resulted in heavy accumulations of ice on all exposed surfaces caused damage to orchards, shade trees, and forest trees. The lowest temperature in Corvallis during this period was

2. See field notes under "remarks". (Appendix)

17°. As can be observed on the plots, all of the windfalls and broken stems are pointing toward the east. From a comparison of the trees killed from ice damage and wind damage, it appears likely that each occurred at the same stand age. Inadequate wind records however, make it impossible to obtain wind velocities in the Corvallis area.

The lands adjacent to the 4x4 and 8x8 spacing plots contain other Douglas fir and ponderosa pine plantations that are about the same stand age and should not offer any influence on the growth of trees on the cruise plots.

## Procedure

An extensive survey of the 4x4 and 8x8 spacing plots was made to determine the best procedure to follow for an accurate cruise. It was realized that a 100% cruise would be too time consuming for the purposes of this paper because of the extreme difficulty of measuring the heights of the trees. Since there were no noticeable differences in the growth characteristics from one end of either plot to its opposite end a plot covering 25% of the plantation was established a 25% cruise seemed to be the most practical means of obtaining cruise data. Except for the first few planted rows on each plot, the spacing was rather poorly done so in order to avoid confusion, it was decided to map all planted trees on the areas.[3]

To aid in mapping, control strings were strung along the boundaries of the selected cruise plots. The east-west control line on the south side of each control plot was strung so as to include the trees in the second row of the original planted plot. This was done to insure

3. See cruise plot maps pages 10 and 11.

that all cruise trees had grown under the influence of shade from trees of the same spacing. The next step was to decide on what data was necessary ~~to take in order~~ to ascertain the total effect of spacing. In addition to (1) diameter breast height, and (2) total height, it was decided to measure the (3) diameter at one-half height, the (4) height from the ground to the first dead limb ¼ inch or greater in diameter, (5) the height to the first limb with green leaves covering ¼ or more of its length, and finally the (6) height from the ground to a broken stem or spiked top. In addition to (4) and (5), it would be desirable to measure the diameter of each limb, but the time element would not allow it. Finally, it was decided to include any unusual characteristics of growth or health of each tree in a remarks column on the cruise sheet.

Field Procedure on 8x8 Plot

Mapping on this plot was done with the aid of a hand compass and steel tape. Distances between trees within the plot were frequently estimated. The first tree measured is located at the southwest corner of the cruise plot and an aluminum tag with the numerals 1985 is nailed on the east side of the stem approximately breast high. All other trees were measured in numerical order as shown on the cruise map. The diameters were measured with a diameter tape, the heights by means of a topographic abney or 6.6 foot rod--whichever was the most convenient. Since it was not possible because of the dense condition of the trees

to use the abney at a distance of 66feet from the base of each tree, half of this distance was used and the readings divided by two. This was conveniently measured off by laying out five lengths of the 6.6 foot rod. Even at this distance it was often impossible to observe the base of the tree and the leader while standing in one position. This was overcome by placing a white card at a measured distance up the trunk of the tree so that both factors could be observed from the same position. Measuring the heights of the trees under such conditions was the most tedious and time consuming task of all the measurements taken. The heights to the first dead and first green limbs were estimated to the nearest half foot in the former case and nearest foot in the latter. With the aid of the 6.6 foot rod for frequent checks, this was considered accurate enough for all practical purposes. The most practical method of measuring the diameters at one-half the height was to determine half the height of the trees beforehand and to climb them to the necessary height and measure with a diameter tape. The exact position at which to measure was found by dropping a plumb line graduated in feet. The height to the point at which the stem was broken off was estimated. In many cases lateral branches had assumed the leader position of the tree but these trees were included in the same category as those trees broken and dead. As can be noted in the remarks column of the data sheet, the spiked topped trees sometimes had bracket fungus sporophores on their trunks.

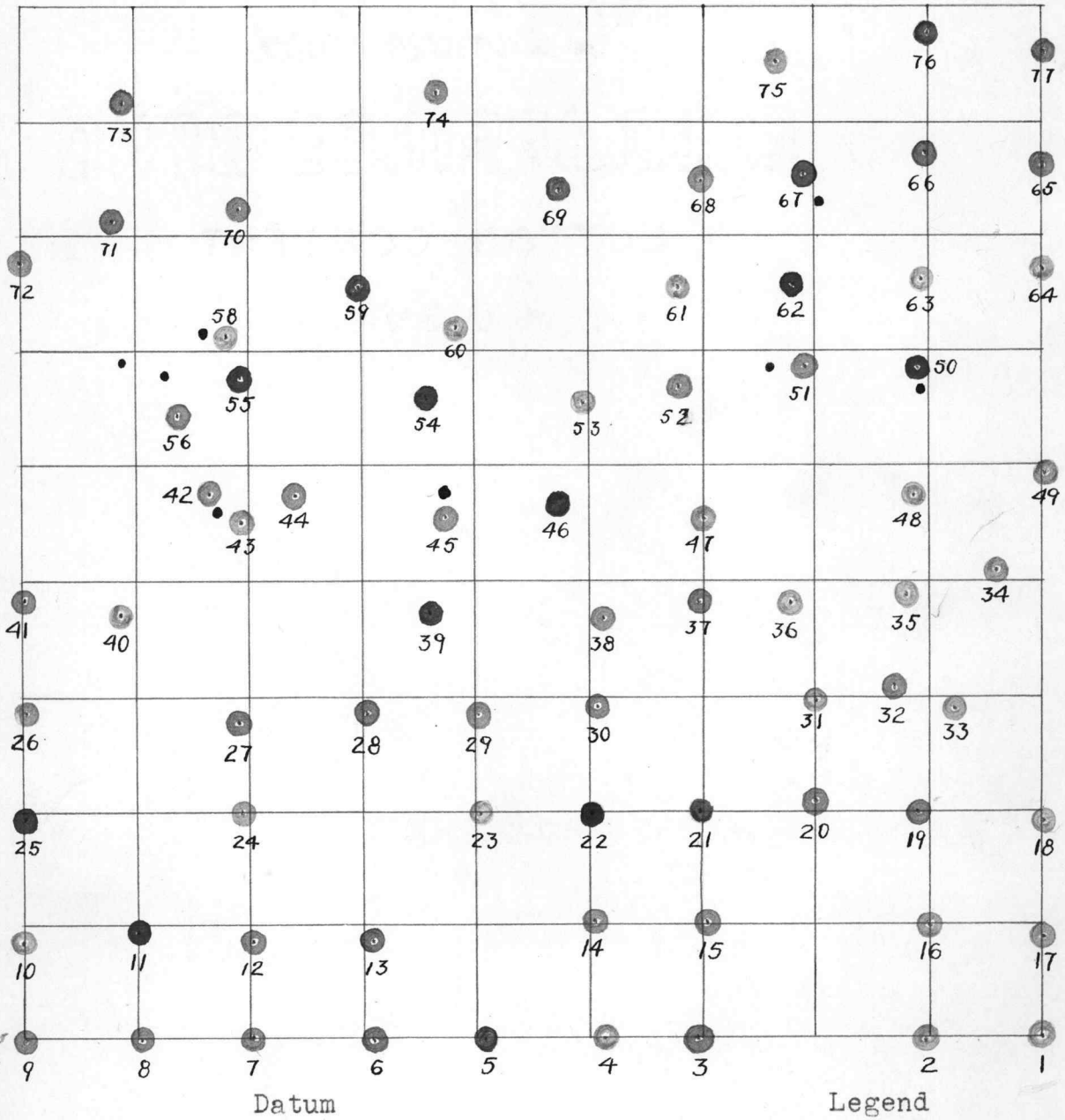
Working by myself, I found the following order of collecting data the most efficient on this plot: (1) map and number the trees, (2) measure the DBH, height to first dead and green limbs, (3) measure total heights or broken heights, (4) measure diameter at ½ height.

Field Procedure on 4x4 Plot

On this plot all of the measurements except those requiring climbing the trees were taken in one operation. In mapping, directions were obtained by means of a hand compass and distances by the use of the 6.6 foot rod previously mentioned. The same instruments were used and the same methods were used to measure the trees on this plot as on the 8x8 spacing. However, because of the more dense nature of this stand, it was often impossible to see the tops of the trees from a distance of one-half chain. Because of this a horizontal distance of three 6.6 foot rod lengths was measured out and the value obtained from the abney arc was divided by 3.33 to get the height of the tree. In future work it is recommended that a per cent abney be used to measure heights for its greater convenience. When the trees were climbed to get the diameter at half the height, it was often possible to reach over to adjacent trees and measure them at the same time. This saved considerable climbing on this plot.

TREE LOCATION MAP
Of
8x8 Spacing Plot
Scale 1" = 12'

77 trees / 5,020 sq. ft.
1 " / 65 " " or 8'x8' sp.
72'x 72'?




2nd row of plants tree

Datum

Horizontal control by estimation
Direction by estimation

Legend

- Healthy trees
- Spike top
- Dead
- Small reproduction or poorly spaced originals

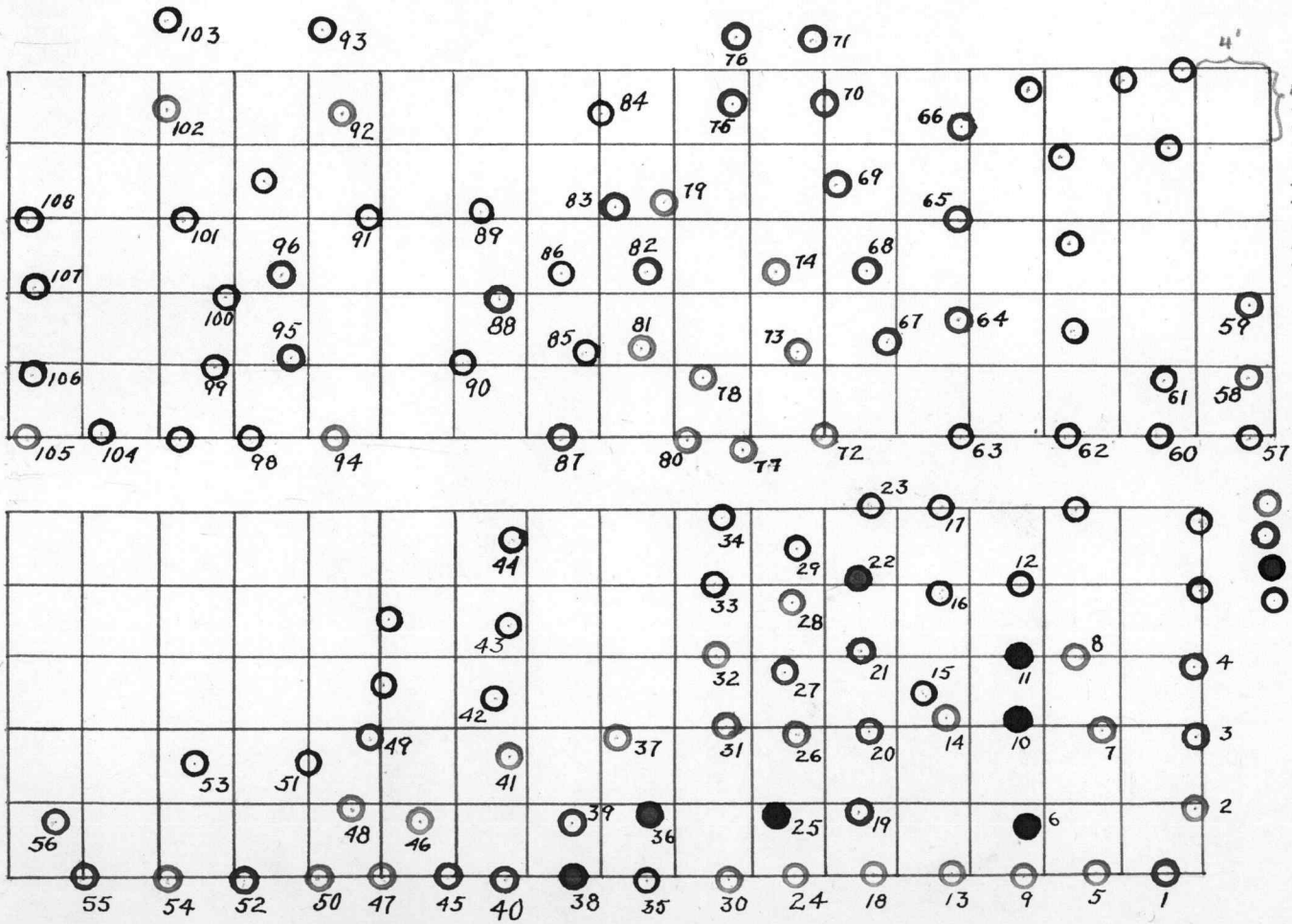
63
8
5
76
8
84

5,184 sq. ft.

108 trees on 2660 sq. ft.
1 tree on 24.6 " "
1 " 5x5 spacing

# TREE LOCATION MAP OF 4x4 SPACING PLOT

Scale 1"= 10'  133'x 20'?




Datum
Horizontal control by 6.6 rod.

Direction by estimation and hand compass.

Legend

| | |
|---|---|
| Healthy trees | 31 |
| Spike top | 32 |
| Dead | 7 |
| Windfalls or leaners | 46 |
| | 116 |


11.

135 x 20

# EFFECT OF SPACING ARRANGEMENT ON FIELD PLANTED DOUGLAS FIR ON McDONALD FOREST

## Summary of Statistics

| Measurement | Remarks | 4x4 Plot | 8x8 Plot |
|---|---|---|---|
| Mean DBH* | For D's, | | |
| $\sigma$ | C's, & I's* | 4.6" | 6.0" |
| | | 1.29 | 1.42 |
| $\sigma_M$ | | .225 | .181 |
| "t" | | 4.86 | 4.86 |
| Mean DBH | For D's | 4.6" | 6.5" |
| $\sigma$ | and C's | 1.29 | .903 |
| $\sigma_M$ | | .225 | .115 |
| Coefficient of variation | | 28% | 13.9% |
| Mean height | For D's, | 33' | 41' |
| $\sigma$ | C's & I's | 5.09 | 5.63 |
| $\sigma_M$ | | .886 | .721 |
| "t" | | 6.13 | 6.13 |
| Mean height | For D's | 33' | 44' |
| $\sigma$ | and C's | 5.09 | 2.70 |
| $\sigma_M$ | | .886 | .359 |
| Coefficient of variation | | 15.4% | 6.1% |
| Basal area | | 4.13 sq. ft. | 12.66 sq.ft. |
| | (per acre) | 55 sq.ft. | 86 sq.ft. |
| Cubic volume | | 70.01 cu.ft. | 255.48 cu.ft. |
| | (per acre) | 934 cu.ft. | 1737 cu.ft. |
| Av. form quotient | | .71 | .65 |
| $\sigma$ | | .086 | .033 |
| $\sigma_M$ | | .024 | .009 |
| Coefficient of variation | | 12% | 5% |
| "t" | | 2.34 | 2.34 |
| Mean ht. to 1st dead limb | | 2' | 1½' |
| Mean ht. to 1st green limb | | 13' | 11½' |
| Area investigated | | 3264 sq.ft. | 6400 sq.ft. |
| Proportion of acre sampled | | 1/13.34 | 1/6.80 |
| Per cent of cruise | | 25.5% | 25% |
| Present site quality | | Site IV | Site III |
| Stock % compared to normal stand | | 60.5% | 80% |

* DBH---diameter breast high

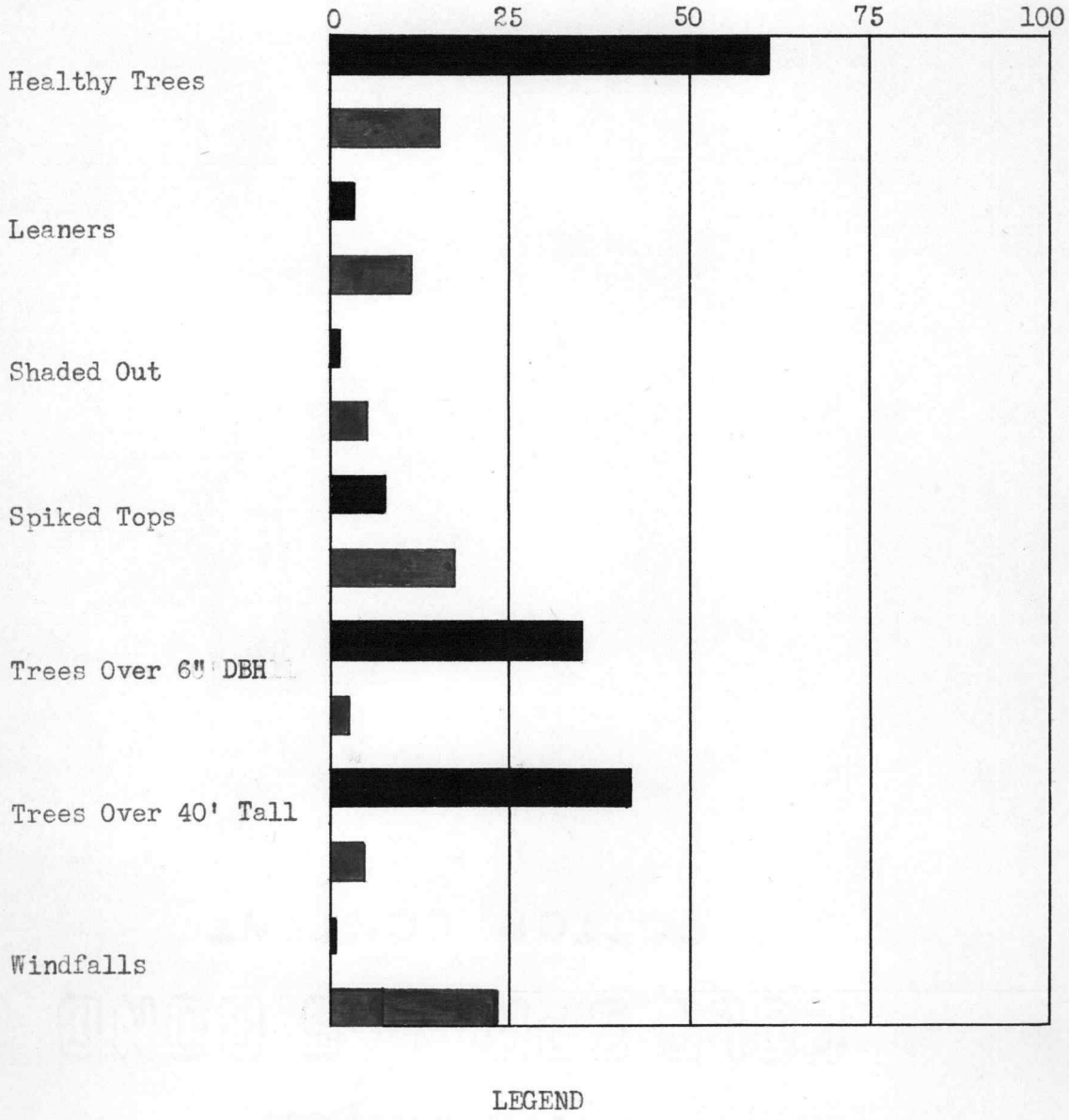
$\sigma$ ---standard deviation

$\sigma_M$ ---standard error of the mean

"t"---probability of difference between two measurements; 2.0 to 2.5 offer 20 to 1 odds there is a difference. Above 2.5 the odds are greater.

*D means dominant, C co-dominant and I intermediate

GRAPHIC COMPARISON OF THE 4x4 AND 8x8 PLOTS



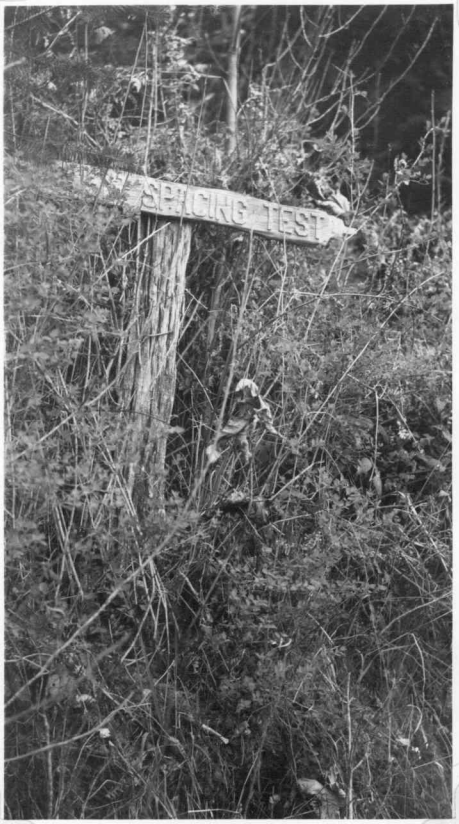

Healthy trees--dominant, codominant and intermediate trees free of defect.

Leaners--trees leaning more than 15° and less than 85° from vertical position.

Shaded out--dead or suppressed trees as a result of intense shade.

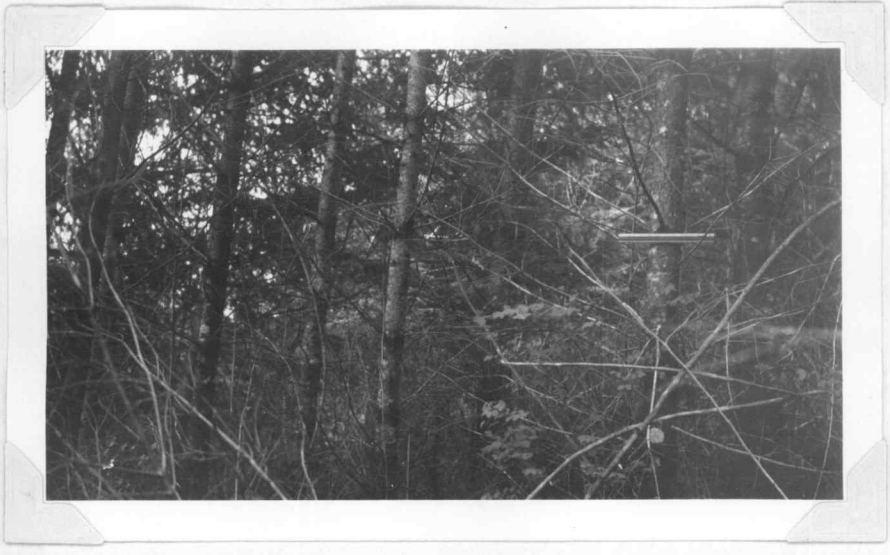
Windfalls--trees 85° or greater from vertical position.

Spiked tops--trees that have broken tops or stems from ice or wind damage.




Identification sign located on the southeast corner of the 4x4 plot as seen from the road.

These trees are located on the south boundary of the 4x4 plot. Despite the added light available to them, the natural prunning and form quotient factor is splendid. Unless some of these trees are thinned, all of them will probably be lost in a severe wind storm.



This is an ideal situation in a 4x4 spacing arrangement. The stems are straight with little taper and good natural prunning.

Broken stems from wind and ice damage.

4x4 spacing--the windfalls exemplify the effect of strong winds on this spacing arrangement.

This picture illustrates the breaking of the stems at weakened points by a severe wind. A light thinning would have eliminated the chances of such heavy losses. Note the absence of such losses on the 8x8 plot.

Wind falls on the 4x4 plot.

RESULTS OF SPACING EXPERIMENT AT WIND RIVER EXPERIMENTAL FOREST AFTER 26 GROWING SEASONS[4]

| | 4x4 Plot | 8x8 Plot |
|---|---|---|
| *Present site quality (on basis of av. ht. of D's and C's.) | V | V |
| Av. DBH | 2.7" | 3.8" |
| Av. ht. all trees | 24.5' | 25.4' |
| Av. ht. C's and D's | 29.9' | 29.7' |
| Ht. to bottom of live crown | 7.1' | 1.1' |
| Av. limb diameter | .36" | .54" |

*Fifteen acres in all were planted to 4x4, 5x5, 6x6, 8x8, 10x10, and 12x12. All trees were planted on site quality IV land.

4. Munger, Thornton T., 1946. "The spacing in Plantations," Forest Research Notes, No.34, Pacific Northwest Forest Experiment Station.

## Conclusions

1. Because of the high mortality on the 4x4 plot, growth characteristics exhibited on it cannot be considered normal, especially if compared to growth rates on the 4x4 plot established at the Wind River Experimental Forest.

2. In view of the difference in effect the wind and ice storm had on the 4x4 and 8x8 plots, it appears inadvisable for this reason to plant trees to a 4x4 foot spacing arrangement that are subject to these dangers and are not going to be thinned under the management plans.

3. The 4x4 plot is no longer useful for measuring the effect of spacing arrangement on growth because of the high mortality on it.

4. As was true on the Wind River experimental plots, the 4x4 and 8x8 plots on McDonald Forest exhibited height characteristics that showed a decrease in site quality.

5. 8x8 spacing is superior to 4x4 spacing on site III areas that are suceptible to wind throw or ice damage, but it is quite possible that 7x7 or 6x6 spacing would be better.

# APPENDIX

## 8x8 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| Tag 1985 | 1.C* | 6.3 | 39½ | 1 | 11 | 4.3 | -- |
| Tag 1986 | 2.D | 6.8 | 51 | 1½ | 11 | -- | -- |
| Tag 1987 | 3.D | 7.2 | 46 | 1½ | 5 | -- | -- |
| | 4.C | 6.4 | 43 | 1½ | 13 | -- | -- |
| Tag 1989,Dead | 5. | 4.0 | -- | 2 | -- | -- | -- |
| Tag 1990 | 6.C | 4.9 | 42 | ½ | 11 | -- | -- |
| Tag 1991 | 7.C | 4.5 | 38½ | 1½ | 19 | 3.2 | -- |
| Tag 1992 | 8.D | 6.4 | 47 | 1½ | 17 | -- | -- |
| | 9.C | 6.5 | 45 | 2 | 15 | -- | -- |
| | 10.D | 5.2 | 39 | 1½ | 8 | -- | -- |
| Spike Top | 11. | 6.0 | 40½ | 1½ | 8 | -- | 22 |
| | 12.D | 6.3 | 46 | 2 | 21 | 4.1 | -- |
| | 13.C | 8.1 | 43½ | 1 | 26 | -- | -- |
| | 14.C | 5.8 | 42 | 2 | 16 | 3.8 | -- |
| | 15.C | 6.6 | 43½ | 2 | 11 | -- | -- |

*C means co-dominant; D, dominant; and I, intermediate.

## 8x8 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 16.C | 5.0 | 44 | 2 | 17 | -- | -- |
| | 17.C | 5.6 | 44½ | 2 | 15 | 3.3 | -- |
| | 18.C | 6.7 | 45 | 2 | 13 | -- | -- |
| | 19.D | 7.7 | 38½ | 2 | 12 | 5.3 | -- |
| | 20.C | 5.5 | 40½ | 2 | 11 | -- | -- |
| Spike Top | 21. | 4.5 | 37 | 1 | 8 | -- | 16 |
| Spike Top | 22. | 4.3 | 30 | 2 | 11 | -- | 12 |
| | 23.C | 7.4 | 43 | 2 | 16 | -- | -- |
| | 24.C | 7.3 | 45½ | 1½ | 15 | -- | -- |
| Dead | 25. | 2.9 | 15 | - | -- | -- | -- |
| Leaner | 26. | 4.6 | 24 | 2½ | 13 | -- | -- |
| | 27.C | 4.8 | 39½ | 2 | 10 | -- | -- |
| | 28.I | 7.1 | 37½ | 1½ | 13 | -- | -- |
| | 29.C | 5.7 | 42½ | 2 | 18 | 3.9 | -- |
| | 30.C | 7.2 | 45 | 2 | 18 | -- | -- |

## 8x8 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at. ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 31.I | 3.5 | 33½ | 2 | 7 | -- | -- |
| | 32.C | 7.1 | 40 | 1½ | 17 | -- | -- |
| | 33.I | 3.5 | 35 | 2 | 6 | -- | -- |
| | 34.I | 3.1 | 29 | 1½ | 5 | -- | -- |
| | 35.D | 8.2 | 48 | 1½ | 9 | 5.2 | -- |
| | 36.C | 6.9 | 40½ | 2 | 14 | 4.4 | -- |
| | 37.C | 4.3 | 40 | 2½ | 12 | 2.9 | -- |
| | 38.C | 5.2 | 43½ | 1½ | 18 | -- | -- |
| Dead | 39. | .7 | 9.9 | ½ | -- | -- | -- |
| | 40.C | 8.1 | 45½ | 1½ | 14 | 5.5 | -- |
| | 41.I | 4.7 | 35½ | 2 | 8 | -- | -- |
| | 42.C | 5.6 | 45½ | 2 | 17 | -- | -- |
| | 43.D | 6.9 | 49 | 2 | 10 | -- | -- |
| | 44.I | 4.1 | 38 | 2 | 6 | -- | -- |
| | 45.C | 7.4 | 42½ | 1½ | 11 | -- | -- |

8x8 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| Spike Top | 46. | 6.1 | 44 | 2 | 22 | -- | 22 |
| | 47.C | 5.6 | 44 | 2½ | 17 | -- | -- |
| | 48.C | 6.2 | 43½ | ½ | 8 | -- | -- |
| Suppressed | 49. | 1.8 | 17 | 1½ | 4 | -- | -- |
| Diseased | 50. | 4.5 | 31½ | 2 | 11 | -- | 12 |
| | 51.C | 6.6 | 42½ | 2 | 11 | -- | -- |
| | 52.D | 7.4 | 48 | 1½ | 17 | 4.4 | -- |
| | 53.D | 8.1 | 49 | 2½ | 8 | -- | -- |
| Dead Leaner | 54. | 2.3 | 15 | 2 | -- | -- | -- |
| Spike Top | 55. | 5.4 | 41 | 2 | 12 | -- | 21 |
| | 56.D | 8.6 | 52½ | 2½ | 6 | -- | -- |
| | 57. | | | | | | |
| | 58.C | 6.6 | 44½ | - | 12 | -- | -- |
| Spike Top | 59. | 6.0 | 35 | 2 | 8 | -- | 15 |
| | 60.I | 3.8 | 29 | 2 | 7 | -- | -- |
| | 61.C | 7.1 | 43 | 1 | 8 | 4.2 | -- |

8x8 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| Windfall | 62. | 3.8 | 20 | 3 | -- | -- | -- |
| | 63.C | 6.4 | 41 | 2 | 12 | 4.2 | — |
| | 64.C | 6.1 | 40½ | 1½ | 5 | -- | — |
| | 65.C | 5.5 | 40 | 2 | 10 | -- | — |
| | 66.I | 3.2 | 33 | 3 | 9 | -- | — |
| | 67.I | 3.0 | 28½ | 2½ | 6 | -- | — |
| | 68.I | 6.6 | 38 | 1 | 8 | -- | — |
| | 69.C | 6.7 | 40 | 2 | 6 | -- | -- |
| | 70.C | 6.9 | 45½ | 1 | 4 | -- | — |
| | 71.I | 4.4 | 31 | 2 | 8 | -- | -- |
| | 72.C | 7.4 | 44½ | 2 | 8 | -- | -- |
| | 73.I | 5.1 | 35½ | ½ | 4 | -- | -- |
| | 74.C | 7.2 | 43½ | 1½ | 3 | -- | — |
| | 75.I | 3.6 | 24½ | 1 | 4 | -- | -- |
| Spike Top | 76. | 6.7 | 35 | 2 | 10 | -- | 24 |
| | 77.I | 4.5 | 38 | 2 | 14 | -- | -- |

# APPENDIX

## 4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 1. | 4.2 | -- | 2 | 13 | -- | 13 |
| | 2.C * | 3.4 | 33 | 4½ | 13 | -- | -- |
| | 3. | 3.8 | -- | 2 | 11 | -- | 11 |
| | 4. | 3.9 | -- | 2½ | 11½ | -- | 12 |
| | 5.D | 6.2 | 41 | 2 | 16 | 3.8 | -- |
| Dead | 6. | 3.6 | -- | -- | -- | -- | -- |
| Tag 1961 | 7.C | 4.2 | 31 | 2 | 15 | 3.7 | -- |
| | 8.D | 7.2 | 42 | 1½ | 12 | 4.7 | -- |
| | 9.C | 4.2 | 33 | 1½ | 12 | 3.1 | -- |
| Tag 1962 | 10. | 1.5 | Dead | -- | -- | -- | -- |
| Dead | 11. | 1.9 | -- | 2½ | -- | -- | -- |
| Windfall | 12. | 2.0 | -- | -- | -- | -- | -- |
| | 13.C | 3.9 | 38 | 1½ | 12 | 2.8 | -- |
| Tag 1963 | 14.C | 5.0 | 29 | 1½ | 16 | -- | -- |
| Leaner | 15. | 3.6 | 25 | 2 | -- | -- | -- |

*C means co-dominant; D, dominant; and I, intermediate.

## 4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| Leaner | 16. | 4.3 | -- | 1 | -- | -- | -- |
| Windfall | 17. | 3.2 | -- | -- | -- | -- | 1 |
| | 18.C | 5.0 | 38 | 2 | 14 | 3.6 | -- |
| Diseased | 19. | 3.5 | Dead | -- | -- | -- | 7 |
| Tag 1964 | 20. | 3.1 | -- | -- | -- | -- | 7 |
| | 21. | 2.7 | -- | -- | -- | -- | 2 |
| Dead | 22. | .7 | -- | -- | -- | -- | -- |
| Leaner | 23. | 3.6 | -- | -- | -- | -- | -- |
| Suppressed | 24. | 1.6 | 16 | 2½ | 11 | -- | -- |
| Dead | 25. | .8 | -- | -- | -- | -- | -- |
| Tag 1965 | 26.D | 6.3 | 40 | 2 | 13 | 3.9 | -- |
| | 27. | 3.3 | -- | 2 | -- | -- | 3 |
| Leaner | 28.C | 5.5 | 35 | 2 | 14 | -- | -- |
| Leaner | 29. | 4.2 | 20 | 2½ | 14 | -- | -- |
| | 30.I | 4.0 | 27 | 1½ | 10 | -- | -- |
| Tag 1966 | 31.C | 3.6 | 32 | 1½ | 18 | -- | -- |

## 4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 32.C | 4.2 | 30 | 1½ | 19 | -- | -- |
| Crooked | 33. | 5.6 | Widower | 2 | 15 | -- | -- |
| | 34. | 4.3 | -- | -- | -- | -- | 1 |
| Windfall (Broken Up) | 35. | -- | -- | -- | -- | -- | -- |
| Dead | 36. | 1.7 | -- | -- | -- | -- | -- |
| Tag 1967 | 37.C | 3.9 | 28 | 2 | 10 | -- | -- |
| Suppressed | 38. | .5 | 6.6 | 2½ | 4½ | -- | -- |
| Dead | 39. | 3.0 | -- | -- | -- | -- | -- |
| Dead | 40. | -- | -- | -- | -- | -- | 3 |
| Tag 1968 | 41.D | 5.7 | 35 | 2½ | 11 | -- | -- |
| Leaner | 42.I | 4.0 | -- | 2 | 2½ | -- | -- |
| Windfall | 43. | 3.8 | -- | -- | -- | -- | -- |
| Windfall | 44. | 3.7 | -- | -- | -- | -- | -- |
| Diseased (At Break) | 45.I | 4.0 | 27 | 2½ | 15 | -- | 7 |
| | 46.C | 3.6 | 28 | 2 | 12 | 2.3 | -- |
| | 47.C | 2.8 | 28 | 3 | 16 | 2.1 | -- |

4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 48.D | 5.0 | 36 | 2 | 15 | 2.4 | -- |
| Leaner | 49.I | 4.4 | -- | 4 | -- | -- | Broken Tip |
| | 50.C | 3.6 | 33 | 2½ | 12 | 2.8 | -- |
| Tag 1970 | 51.I | 4.2 | Leaner | 4½ | -- | -- | -- |
| Dead | 52. | 1.9 | -- | 1½ | -- | -- | 6 |
| Tag 1971 | 53.I | 3.0 | -- | -- | -- | -- | -- |
| Poor Form | 54.C | 6.5 | 39 | 2½ | 7 | -- | -- |
| Diseased | 55. | 3.3 | -- | -- | -- | -- | 8 |
| | 56. | 2.0 | -- | -- | -- | -- | 6 |
| Poor Form | 57.I | 3.8 | -- | 2½ | 11 | -- | -- |
| | 58. | 3.3 | -- | -- | -- | -- | 6 |
| Tag 1972 | 59. | 2.8 | -- | -- | -- | -- | 6 |
| Suppressed | 60. | .4 | 6.6 | 1½ | 3 | -- | -- |
| | 61.C | 5.3 | 37 | 2½ | 10 | -- | -- |
| Suppressed | 62. | .3 | 6.6 | 1½ | 3 | -- | -- |
| Windfall | 63. | 3.7 | -- | -- | -- | -- | -- |

4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| Tag 1974 | 64. | 2.5 | -- | -- | -- | -- | 8 |
| | 65. | 5.1 | -- | 2 | 7 | -- | 15 |
| | 66. | 5.8 | -- | 2 | 9 | -- | 19 |
| Diseased | 67. | 2.4 | Dead | -- | -- | -- | 6 |
| Tag 1975 | 68. | 3.3 | -- | -- | -- | -- | 9 |
| | 69. | 4.9 | -- | -- | -- | -- | 18 |
| Diseased | 70. | 2.8 | -- | -- | -- | -- | 7 |
| Diseased | 71. | 2.0 | -- | -- | -- | -- | 8 |
| | 72.C | 3.7 | 32 | 2 | 15 | -- | -- |
| | 73.C | 4.1 | 34 | 2 | 16 | -- | -- |
| | 74.C | 3.7 | 30½ | 1½ | 16 | -- | -- |
| | 75. | 6.2 | -- | 1½ | 12 | -- | 14 |
| | 76. | 3.5 | -- | 1½ | 12 | -- | 12 |
| | 77.I | 2.3 | 23 | 2½ | 14 | -- | -- |
| | 78.I | 3.0 | 23 | 2½ | 14 | -- | -- |
| Poor Form | 79.D | 5.9 | 40 | 2 | 20 | -- | -- |

## 4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 80.C | 4.6 | 31 | 1 | 17 | -- | -- |
| | 81. | 3.0 | 27 | 2 | 11 | -- | -- |
| Dying | 82. | 2.8 | -- | 1½ | 15 | -- | 15 |
| | 83. | 3.4 | -- | 2 | -- | -- | 16 |
| Dead | 84. | 3.5 | -- | 1½ | -- | -- | -- |
| Widower | 85. | 2.6 | -- | 1½ | -- | -- | -- |
| Widower | 86. | 4.3 | -- | 1½ | -- | -- | -- |
| Dead | 87. | -- | -- | -- | -- | -- | 4 |
| | 88. | 2.1 | -- | 2 | 7 | -- | 12 |
| Diseased | 89. | 5.1 | -- | 1½ | 7 | -- | -- |
| Diseased | 90. | 3.1 | 20 | 2 | 12 | -- | -- |
| | 91. | 2.6 | -- | 1½ | 14 | -- | -- |
| | 92.C | 7.4 | 33 | 2 | 9 | -- | -- |
| Diseased | 93. | 4.0 | -- | -- | -- | -- | -- |
| | 94.C | 4.4 | 29 | 3 | 10 | -- | -- |
| | 95. | -- | -- | -- | -- | -- | 4 |

4x4 DATA SHEET

| Remarks | Tree No. | DBH | Height | Ht. to 1st. Dead Limb | Ht. to 1st. Green Limb | Dia. at ½ Height | Ht. to Broken Stem |
|---|---|---|---|---|---|---|---|
| | 96. | -- | -- | -- | -- | -- | 4 |
| Widower | 97. | 3.2 | 18 est. | 1 | 14 | -- | -- |
| Poor Form | 98. | 3.3 | 26 est. | 2 | 11 | -- | -- |
| Leaner | 99. | 3.9 | 20 est. | 2½ | -- | -- | -- |
| Leaner | 100. | 2.1 | -- | 1½ | -- | -- | -- |
| | 101. | 5.4 | -- | 2 | -- | -- | 2 |
| | 102.D | 6.3 | 41 | 2½ | 12 | -- | -- |
| | 103. | 3.3 | -- | -- | -- | -- | -- |
| Dead | 104. | 1.5 | 14 est. | 2½ | -- | -- | -- |
| | 105.C | 5.0 | 36 | 2½ | 11 | -- | -- |
| Diseased | 106. | 1.7 | -- | 2½ | 8 | -- | 12 |
| | 107. | 4.6 | -- | 1½ | -- | -- | ½ |
| | 108. | 2.2 | -- | 1½ | -- | -- | -- |

# BIBLIOGRAPHY

1. Bruce, Donald and Schumacher, F. X., 1942. Forest Mensuration, 2nd Ed., McGraw-Hill Book Co., New York.

2. Howells, Harry A., 1933. "A study and summary of the investigational on the McDonald Forest with recommendations," Master Thesis, Oregon State College.

3. McArdle, Richard E. and Meyer, Walter H., 1930. "The yield of Douglas fir in the Pacific Northwest," Technical Bulletin, No. 201, U. S. Department of Agriculture. 64 pp.

4. Munger, Thornton T., 1946. "The spacing in Plantations," Forest Research Notes, No.34, Pacific Northwest Forest Experiment Station.

5. Toumey, James. W. and Korstian, Clarence F., 1947. Seeding and Planting in the Practice of Forestry, 3rd Ed., John Wiley & Sons, Inc., New York.