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MONITORING DOT DISEASE MORTALITY: ESTABLISHMENT REPORT

COMPACT

by
S. K. Hagle
Plant Pathologist

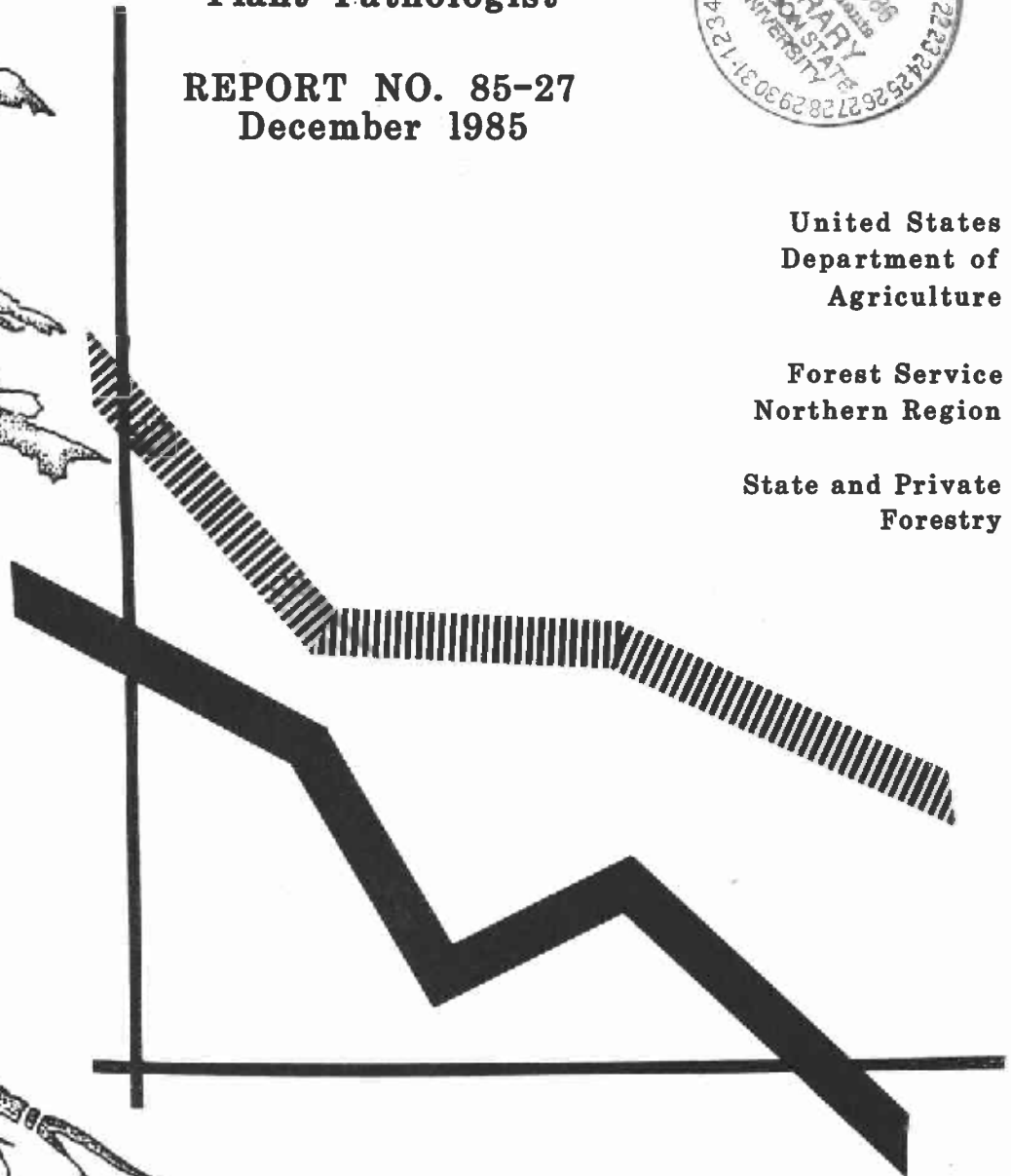
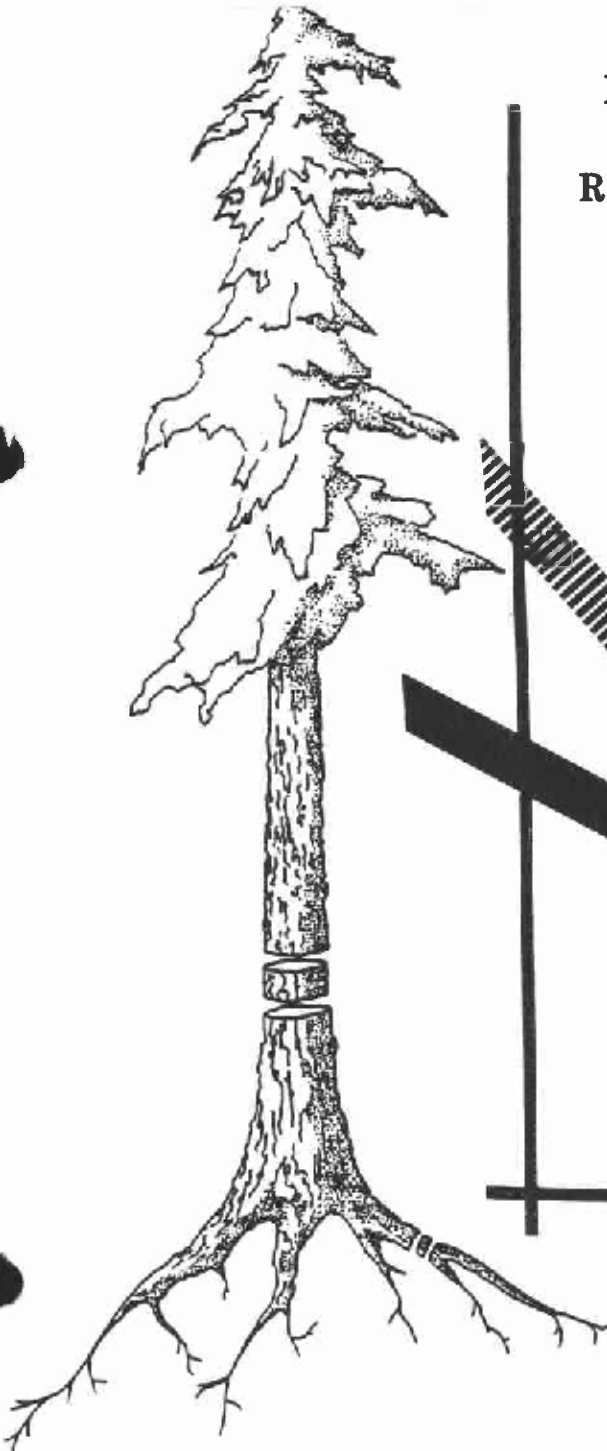
REPORT NO. 85-27
December 1985



United States
Department of
Agriculture

Forest Service
Northern Region

State and Private
Forestry



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ABSTRACT

Two thousand and thirty-nine trees on 213 plots are being monitored yearly for root disease infection and mortality. Three compartments on the Fernan Ranger District of the Idaho Panhandle National Forests are the site of the project. Relationships between factors such as species, aspect, slope, elevation, habitat type, stand appearance on aerial photography, plot root disease severity ratings, and measured volume losses due to root disease mortality are being evaluated. Effective means of judging past and future losses in root disease-affected stands are sought.

INTRODUCTION

We are presently unable to adequately relate root disease severity to loss in productivity of affected sites. Root disease damage in stands ranges from creation of large, open centers which are easily detected to scattered mortality, especially in mixed-species stands, which is easily overlooked. Trees of all ages and sizes are killed by root disease throughout the growing season. Dying trees may be clustered or scattered and tend to die and deteriorate at highly variable rates. By contrast, trees killed in an outbreak of bark beetles, for example, are uniform in size, are attacked during "flight" periods when beetles emerge *en masse*, and tend to be clustered within stands. Thus, the problems of monitoring and interpreting data regarding bark beetle population trends and damages are relatively straightforward compared to root disease impact evaluation.

Numerous surveys have been completed to quantify root disease impact in the Northern Region (Williams and Leaphart 1978; Stewart et al. 1982; James and Stewart 1983). These surveys successfully measured acreages in root disease centers on a sample of Forests, and some were moderately successful in measuring acreages with scattered and small-group patterns of root disease mortality (Stewart et al 1982; James and Stewart 1983). Volume loss estimates from these surveys are much more tenuous (Stewart et al. 1982). Two confounding factors are the highly variable deterioration rates of dying and dead trees and a lack of information regarding annual fluctuations in mortality rates. Two projects in this Region have been monitoring deterioration rates and annual mortality rates for 5 (Dubreuil et al. 1981) and 3 (Schwandt 1984) years. Results of these projects indicate that previous assumptions regarding deterioration rates which were used in the root disease impact surveys were inaccurate. Annual or even 5-year mortality estimates from these point-in-time measurements are inadequate. These tree deterioration rate studies were limited in scope, however, not addressing variations in site and disease severity.

A direct measurement of annual mortality rates and characterizations of the deterioration process are needed for a variety of sites and stand conditions. This information will be used to improve regional impact estimates, Forest- and District-level planning, and stand management.

The first portion of the project involves establishment of semi-permanent plots to be monitored annually for 5 years.

Evidence suggests mortality rates increase following partial cutting (Filip 1977). Commercially thinned stands in the Pleasant Creek drainage of the Fernan RD currently have very high rates of mortality (Smith and Sheldon 1984). Effect of commercial thinning on mortality rates has not been measured. To supplement the plots monitored for annual mortality in the absence of partial harvest, additional semi-permanent plots were established in an adjacent compartment which is scheduled for commercial thinning within 4 years. These plots will be monitored annually for at least 5 years following thinning.

The project will meet three objectives: (1) to measure annual rates of mortality over a 5-year period in stands with varying degrees of root disease severity; (2) to develop criteria that may be used to identify high loss stands in two compartments and comparable stands elsewhere in the Region; (3) to measure effect, if any, of commercial thinning on mortality rates in stands with various levels of root disease severity.

METHODS

Three compartments in two drainages on the Fernan RD, Idaho Panhandle NF's, were selected for installation of the semi-permanent plots. Forty 3-subplot clusters were established in two compartments of the Marie Creek drainage and twenty 3-subplot clusters in a compartment of the Alder Creek drainage.

Marie Creek Compartments

The Marie Creek drainage provides an opportunity to measure rates of mortality over a range of root disease conditions. Stands vary from those with large mortality centers to scattered single-tree mortality and essentially healthy stands. The major root pathogens of the Region, Armillaria ostoyae (Romagn.) Herink and Phellinus weirii (Murr.) Gilb. are present in abundance in the Marie Creek compartments. Phaeolus schweinitzii (Fr.) Pat. is also present in about 20 percent of the stands. Marie Creek compartments 269 and 271 together consist of 241 merchantable-sized stands. Species composition varies from 50 to 100 percent Douglas-fir and grand fir with ponderosa pine and western larch as the major seral species. About two-thirds of the stands have had significant impacts from root disease. The compartments consist of 6,059 acres; average stand size is 25 acres, but this is highly variable. Each of the 241 stands was sampled in a stand exam project in 1983. Basal area, species composition, average diameters, habitat types, and occurrence of root disease were available for each of these stands. These data were used to better assure adequate sampling for this root disease monitoring project by prestratification of stands for sample selection.

Alder Creek compartment

Alder Creek Compartment is 900 acres adjoining Marie Creek on the south. Habitat types, age, and species composition are similar in Alder Creek and

Marie Creek compartments. Compared to Marie Creek, soils in Alder Creek are rockier and slopes on the average are somewhat steeper. Root disease severity and patterns are comparable between the two areas.

Alder Creek compartment 370 contains 91 stands which, like Marie Creek stands, vary considerably in size. The unit has been sold as a commercial thinning. The purchaser was granted a 5-year extension in 1983 so harvest is expected within 3 years. This presents an unusual opportunity to begin accumulating data within a relatively short time on response of mortality rates to thinning.

Plot Establishment

Each cluster plot consists of three 1/20-acre circular subplots located 1.5 chains between subplot centers. The subplots of each cluster are in line with an east-west cardinal orientation except where stand boundaries or nonstocked areas necessitated relocation of one or more subplots. Location of the center subplot of each cluster was selected using a random number to select intersects on a grid placed over a compartment map. Selected points were pricked on 1:24,000 aerial photographs which served for ground location of plots. Compartment and stand boundary delineations were stereoscopically transferred to cronaflex maps from the photographs.

Stand exam data collection procedures as detailed in the R-1 stand exam handbook (USDA Forest Service 1984) were employed with certain modifications (Appendix 1). All trees with 5 inches or greater d.b.h. on plots were tagged with an identification number. Dead trees were marked at the base with tree-marking paint.

Plots were assigned root disease severity ratings of 0 to 9 (Appendix B).

The plots will be re-examined yearly between June 1 and July 1 for a minimum of 5 years. Tree condition will be recorded in each re-examination with root disease damage codes assigned as appropriate. Trees which have died between examinations will be marked with paint. Plots will be assigned a root disease rating yearly as well.

Aerial Photography

A set of high quality 1:12,000 true color aerial photographs of Marie and Alder Creek compartments was taken in July 1984. Stand delineations were drawn on the photographs and each stand was rated according to root disease severity on a scale of 0 to 9 (Appendix C). These data will be compared with average plot ratings for sampled stands, current stocking, and mortality rates of trees on plots.

Plots and stands will be poststratified in various ways to test for relationships among factors such as stocking density (basal area), habitat type, mortality rates, and root disease severity ratings. Measurements or, as in the case of root disease severity, values which are on a continuum rather than classes will be used to regress compared factors within strata. This provides a sensitive test for relationships while concurrently developing a set of criteria to relate mortality rate measurements from Marie Creek and Alder Creek to comparable stands elsewhere.

RESULTS AND DISCUSSION

The sample contains excellent representation of grand fir and hemlock series habitat types which constitute the majority of the Marie and Alder Creek compartments (Table 1). Douglas-fir series types are also sufficiently represented considering only two habitat types of this series occurred in the sample. Subalpine fir series is marginally represented, appearing only within the Marie Creek compartments sample. Several plots fell within western redcedar-Aserum habitat type which is very wet in this case due to a beaver pond. This type represented 2 percent of the sample plots in the Marie Creek compartments (Table 2).

Table 1.—Sum of plots and trees by habitat type.

Habitat type series	Marie Creek		Alder Creek		Total	
	# plots	# trees	# plots	# trees	# plots	# trees
Ponderosa pine	2	0	0	0	2	0
Douglas-fir	19	89	15	177	34	266
Grand fir	48	542	39	285	87	827
Western hemlock	63	694	14	150	77	844
Subalpine fir	3	74	0	0	3	74
Cedar	10	28	0	0	10	28
TOTAL	145	1,427	68	612	213	2,039

Table 2.—Proportion of plots and trees occurring on each habitat type series and sum of types.

Habitat type series*	Marie Creek			Alder Creek			Total		
	% plots	% trees	# types/series	% plots	% trees	# types/series	% plots	% trees	# types/series
PIPO	1	0	1	0	0	0	1	0	1
PSME	13	6	2	22	29	2	16	13	2
ABGR	33	38	6	57	47	5	41	41	6
TSHE	43	49	6	21	25	3	36	42	6
ABLA	2	5	1	0	0	0	1	0.3	1
THPL	7	2	1	0	0	0	5	1	1
			17			10			17

*PIPO = Pinus ponderosa; PSME = Pseudotsuga menziesii; ABGR = Abies grandis; TSHE = Tsuga heterophylla; ABLA = abies lasiocarpa; THPL = Thuja plicata.

Two hundred and thirteen plots were established in all compartments, 145 in Marie Creek and 68 in Alder Creek. Two thousand and thirty-nine trees were tagged, 1,427 in Marie Creek, and 612 in Alder Creek. Plots averaged 9.5 trees overall although this figure varied considerably among plots. Averages ranged from 2.8 trees per plot on western redcedar-Aserum to 24.7 in subalpine fir series.

Species tagged include Douglas-fir, grand fir, subalpine fir, western white pine, western larch, western hemlock, western redcedar, lodgepole pine, Engelmann spruce, and ponderosa pine.

Root disease severity ratings ranged from 0 to 9 and averaged 3.6 for all plots. Eighty-six percent of all plots were rated as having been affected by root disease (ratings 1 to 9) while only 14 percent showed no evidence of root disease (Table 3). Fifty percent of the plots were rated 1, 2, or 3. A rating of 1 indicates that root disease-damaged trees were detected within 50 feet of the plot boundary. A rating of 3 indicates that slight changes in volume, stocking, or species composition were evident as a result of root disease damage. These plots will be of particular interest in the Alder Creek compartment following thinning as they represent the greatest potential changes in root disease mortality rates.

Table 3.—Distribution of root disease plot ratings.

	Root Disease Rating										Total
	0	1	2	3	4	5	6	7	8	9	
<u>Alder</u>											
# plots	7	11	15	6	5	3	4	4	8	4	67
Proportion	.10	.16	.22	.09	.07	.04	.06	.06	.12	.06	.98
<u>Marie</u>											
# plots	29	13	30	26	7	7	10	7	10	7	146
Proportion	.20	.09	.21	.18	.05	.05	.07	.05	.07	.05	1.02
<u>All</u>											
# plots	36	24	45	32	12	10	14	11	18	11	213
Proportion	.17	.11	.21	.15	.06	.05	.07	.05	.08	.05	1.00

Two of the three stands without root disease were in western redcedar-Aserum habitat type influenced by a beaver pond. This excessively wet environment probably accounted for low stocking density observed on these sites.

At the other end of the scale, those stands averaging 7 to 9 root disease ratings were distributed among grand fir, western hemlock, and Douglas-fir series habitat types.

Analysis of variance and Duncan's multiple range test demonstrated that root disease severity was significantly lower ($P = 0.05$) in Douglas-fir series compared to grand fir and western hemlock series (Table 4). The average root disease severity code for Douglas-fir series was 1.7 compared to 4.1 and 3.8 for grand fir and western hemlock types respectively. Root disease severity also appeared to be significantly related to aspect of sloped plots (Table 5). Root disease severity ratings for northeast, southeast, and east aspects were not significantly different from each other but were significantly higher than all other aspects. Steepness and elevation did not appear to influence root disease severity.

Table 4.—Root disease ratings by habitat type series.

Series ^{1/}	Sum of ratings	# plots	Avg. rating	Relationship ^{2/}	Range
<u>All plots</u>					
PSME	57	34	1.7	A	0-8
ABGR	354	86	4.1	B	0-9
TSHE	<u>291</u>	<u>77</u>	<u>3.8</u>	B	0-9
Total	702	197	3.6		
<u>Marie Creek only</u>					
PSME	36	19	1.9	A	0-8
ABGR	196	47	4.2	B	0-9
TSHE	<u>224</u>	<u>63</u>	<u>3.6</u>	B	0-9
Total	456	129	3.5		
<u>Alder Creek only</u>					
PSME	21	15	1.4	A	0-7
ABGR	158	39	4.1	B	0-9
TSHE	<u>67</u>	<u>14</u>	<u>4.8</u>	B	2-8
Total	246	68	3.6		

1/ PSME = Pseudotsuga menziesii; ABGR = Abies grandis;
TSHE = Tsuga heterophylla

2/ Same letter indicates averages which are not significantly different (P = 0.05) using Duncan's Multiple Range Comparison test.

Table 5.—Root disease ratings by aspect of plots.

Aspect	Sum ratings	# plots	Avg. rating	Relationship ^{1/}	Range
NE	78	16	4.9	A	1-9
SE	139	29	4.8	A	0-9
E	47	10	4.7	A	1-9
NW	47	14	3.4	B	1-7
N	39	13	3.0	B	0-8
SW	20	7	2.9	B C	0-7
S	38	14	2.7	C	0-8
W	<u>46</u>	<u>24</u>	<u>1.9</u>	D	0-8
	454	127	3.6		

1/ Same letter indicates averages which are not significantly different (P = 0.05) using Duncan's Multiple Range Comparison Test.

Live tree stocking densities varied greatly among stands in Marie Creek compartments from a low of 23 trees per acre, 29 ft² basal area, to a high of 346 trees per acre and 235 ft² basal area per acre (Table 6). Densities were notably lower in stands with average plot ratings of 0, 7, and 9 (none of the stands in Marie Creek averaged plot rating 8).

Table 6.--Stocking densities for stands by average root disease ratings in Marie Creek compartments. TA = trees per acre; BA = basal area.

		D I S E A S E R A T I N G									
		0	1	2	3	4	5	6	7	9	All
n ^{1/}		3	4	9	5	6	4	3	4	1	39
Σx	TA	256	660	2,072	1,152	934	580	380	293	32	6,359
	BA	300	637	1,543	890	781	387	301	269	47	5,155
\bar{x}	TA	85	165	227	230	156	145	127	98		162
	BA	100	159	171	178	130	97	100	90		132
Range	TA	23- 180	127- 220	70- 287	113- 346	35- 233	120- 200	100- 167	87- 106		23- 346
	BA	29- 208	125- 199	89- 217	106- 235	73- 164	71 132	86- 128	43- 84		29- 235

^{1/} Number of stands

Greater stocking densities were recorded in stands with average root disease ratings of 2 and 3. These stands were probably on the more productive sites and had not experienced notable losses to root disease.

Rough trends are indicated in the relationships between tree root disease damage codes and plot damage ratings. The lowest numbers of trees (and basal area) were recorded as having been damaged by root disease on plots rated 0, 1, and 9 (Table 7). In the case of plots rated 9, numbers of root disease-affected trees per acre (16) were proportionately very high compared to total number of live trees/acre (32). Analysis of these relationships is included in a separate project which will incorporate data from many more stands than are in this project. The number of stands occurring in each root disease rating category is too small to test for statistical significance within the scope of this project.

Stands have been rated according to root disease severity on aerial photographs and analysis of these data has been initiated. Ratings for all stands in Marie Creek compartments ranged from 0 to 9 and averaged 3.5 (Table 8).

Table 7.--Trees per acre (TA) and basal area (BA) damaged by root disease (tree codes 2 to 4) compared to root disease plot ratings in Marie Creek stands.

		DISEASE RATING									
		0	1	2	3	4	5	6	7	9	All
n ^{1/}		3	4	9	5	6	4	3	4	1	39
Σx	TA	0	20	433	188	339	226	141	429	16	1,792
	BA	0	10	217	242	288	200	88	329	21	1,395
x̄	TA		5	48	38	57	67	47	107		47
	BA		3	24	48	48	50	29	82		36
Range	TA		0- 20	7- 100	7- 74	20- 127	0- 180	20- 87	14- 327		0- 327
	BA		0- 5	3- 55	34- 86	15- 105	0 133	22- 44	5- 241		0- 241

^{1/}Number of stands.

Table 8.--Root disease severity rating from aerial photographs of Marie Creek subcompartments.

Subcompartment	Sampled stands			All stands		
	Σx	n	x̄	Σx	n	x̄
369-2	12	5	2.40	122	37	3.30
369-3	23	8	2.88	198	36	3.03
369-4	24	6	4.00	184	49	3.76
369-5	11	3	3.67	143	40	3.58
371-1	10	4	2.50	132	31	4.26
371.2	12	5	2.40	108	32	3.38
371.3	14	4	3.50	109	28	3.89
371.4	8	1		38	12	3.17
371.5	6	4	1.50	40	18	2.22
Total	120	40	3.00	1,074	283	3.80
Range x	1.50 - 4.00			2.22 - 4.26		

Average root disease ratings for subcompartments in Marie Creek ranged from 2.22 for 18 stands of subcompartment 371-5 to 4.26 for 31 stands of 371-1. Average ratings of sampled stands of most subcompartments were lower in general than the overall average ratings from those subcompartments. This means the

losses measured in the sampled stands may be conservative when expanded to represent losses in the compartments. However, the differences are not great and will probably not prove significant.

SUMMARY

The trees tagged in this project are judged to be a representative sample of Marie and Alder Creeks compartments with respect to species composition, aspect, elevation, slope, root disease severity, and the three major habitat type series in which root disease is most often a problem. The full range of root disease severities were observable on the 1:12,000 aerial photography.

In addition to trends currently observable from the plot establishment data, the plots will be monitored yearly for at least 5 years to obtain direct data regarding mortality rates.

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APPENDIX A

Location and measurement of Marie Creek plots are similar to establishment criteria for Region 1 permanent plots (Timber Management Plan Handbook 2409.21-1), with some modifications and simplifications.

Cluster Plots

Each "cluster plot" consists of three 1/20-acre circular subplots with a spacing of 1.5 chains between subplot centers. Cluster orientation is on an east-west cardinal direction, except where subplot layout has to be modified by stand boundaries or nonstocked areas.

Point location on compartment map indicates location of center subplot of cluster. Where stand boundaries do not permit location of any outlying subplot on an east-west orientation, the subplot may be relocated north or south of the center subplot (north is the first relocation to be used). Cluster subplots must also be relocated if they fall within 2 chains of a road.

Subplots should be relocated if they are nonstocked. Nonstocking includes natural openings (scree slopes, meadows, etc.) or open areas caused by root disease centers. In order to be "stocked," the subplot should have at least one Douglas-fir or true fir >5.0 inches d.b.h. When a cluster center subplot falls in a nonstocked area, this subplot should be relocated 1 chain north or south (north is first choice). Outlying subplots will then be located east-west 1.5 chains from the new center subplot. When an outlying subplot is nonstocked, the subplot should be relocated 1.5 chains east of the original subplot (if original subplot is east of center subplot), or 1.5 chains west of the original subplot if original subplot is west of center subplot). If stand boundaries do not permit relocation of outlying subplots in an east or west direction, replacement plots may be located 1.5 chains north or south of center subplot. Condition of nonstocked and replacement subplots should be documented, and subplots which are nonstocked because of root disease should be assigned a root disease plot rating of 10. Cluster subplot orientation should be diagramed and documented for each stand with location or original and replacement subplots specified.

Plot Measurements

Tree measurements will be taken as directed by the Region 1 Timber Management Plan Handbook. Trees will be coded as current mortality only if foliage has turned completely red. All trees >5.0 inches d.b.h. and sound stumps >4.5 feet tall are to be tagged at the root crown and measured on each subplot. Any cut stumps must also be tagged and measured (take diameter at stump height). Specify that the tree was cut. Windthrown trees (current or older mortality) will not be tagged or measured.

Age and 10-year growth will be recorded for the first tree of each species in each diameter class as outlined in the permanent plot guidelines, except that the smallest diameter class measured is the 5-inch to 8.9-inch class.

When coding root disease damage and severity for individual trees, use a severity code of 2 if the tree has both crown symptoms and pathogen or diagnostic symptoms.

Azimuth and distance (to nearest one-tenth foot, corrected for slope) should be recorded from subplot center to four tagged trees on subplot. Subplot centers can thus be relocated if lost or destroyed. Subplot boundaries should also be flagged.

Referencing Plots

Starting point, distance, and azimuth to cluster centers should be recorded. Starting point trees or other landmark objects should be painted and tagged with a reference marker and their characteristics documented.

Coding of Field Record Forms

Use a code of 20 for survey type on the field record form. Use column 23 on card 2 of the field record form to record the plot disease rating.

APPENDIX B

A scale of 0 to 9 is used to rate root disease severity on each plot. Descriptions presented reflect levels of severity to be used as a guideline to increase consistency of ratings.

"Normal" stocking is that which is expected for the site at the age of the stand in the absence of root disease. Apparently nondiseased portions of uncut stands represent the "normal" condition unless another serious pest has been present.

"Overstory" trees are of the age and canopy position of the apparently nondiseased portions of the stand. For example, trees which have seeded in root disease-caused openings are not considered overstory even if they are the tallest trees on the plot.

<u>Rating</u>	<u>Condition</u>
9	Plot entirely within a root disease center; no nonroot disease-tolerant trees (Douglas-fir or true firs) on plot.
8	Plot partly within a root disease center but at least one overstory tree of a nonroot disease-tolerant species is within the plot boundary.
5	Stocking is at least 75 percent of normal; there is evidence of root disease-caused mortality on the plot. Includes old snags on downed trees as well as live trees with <u>obvious</u> root disease symptoms such as advanced chlorosis or resinosus.
2	Stocking appears normal but there is evidence of root disease within 50 feet of the plot.
0	No apparent root disease within 50 feet of the plot.

APPENDIX C

Photo Interpretation Classification for Rating Root Disease Severity.

A scale of 0 to 9 is used to rate root disease severity on aerial photos. Descriptions presented reflect levels of severity to be used as guidelines to increase consistency of ratings.

<u>Rating</u>	<u>Condition</u>
9	Stand is completely occupied by root disease center.
8	Almost all of stand area occupied by root disease centers.
5	Stand canopy reduced by half due to root disease pockets and centers.
3	Root disease pockets sufficient to serve as distinguishing characteristic for stand delineation or 30 percent canopy reduction.
1	Root disease present in small, scattered pockets of mortality barely distinguishable on photos.
0	No root disease present.