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Root Disease SURVEY

on the

Nezperce National Forest IDAHO

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ROOT DISEASE SURVEY ON THE NEZPERCE NATIONAL FOREST, IDAHO

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ABSTRACT

An impact survey to determine extent and distribution of root disease centers was completed for the Nezperce National Forest, Idaho, in 1980. Low-level color infrared photography was used to delineate root disease centers within National Forest inventory subcompartments. Suspected root disease centers were ground checked to determine associated fungi and insects and verify accuracy of photointerpretation. More than 3,800 hectares (about 1.0 percent) of commercial forest land were occupied by large root disease centers. Most root disease occurred in well-stocked, pole to small sawtimber stands and medium-stocked, two-storied stands. The major root pathogen associated with disease centers was Armillaria mellea. Phellinus weirii and Phaeolus schweinitzii were found less frequently. Major bark beetle associates included Dendroctonus ponderosae on lodgepole pine, D. pseudotsugae on Douglas-fir, Dryocoetes confusus on subalpine fir, and Scolytus ventralis on grand fir.

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INTRODUCTION

Root diseases are commonly associated with coniferous stands in north temperate forest ecosystems. These diseases are widespread throughout many portions of the Northern Region, especially west of the Continental Divide (15).

Root diseases impact forest stands by enhancing tree mortality and significantly reducing growth (1, 4). Trees with root disease are often attacked and killed by bark beetles (6, 8, 10), and those with extensive root decay are prone to windthrow (3, 10). Trees infected with root pathogens often

occur in groups of varying sizes (figure 1). Mortality within these disease centers usually occurs over many years; recently killed trees are often on the periphery, whereas older mortality is nearer the center (figure 1). Trees with advanced root disease often show decline symptoms prior to death. These crown symptoms include thin, chlorotic foliage (figure 2) and stress cone crops (figure 3).

Impact surveys to assess extent and distribution of root disease centers were begun in 1972 on the Coeur d'Alene National Forest in northern Idaho (17). Since that time, surveys have been completed on four National Forests in the Region (table 1).

Table 1--Area of root disease centers within commercial forest stands on selected National Forests in the Northern Region.

National Forest	Total commercial area (ha)	Area with root disease centers (ha)	Percent commercial area with root disease centers
Coeur d'Alene	238,441.1	12,160.7	5.1
Kaniksu	315,027.5	2,669.4	0.8
St. Joe	300,261.8	1,367.9	0.5
Lolo	655,613.9	8,011.3	1.2
Totals	1,509,344.3	24,209.3	1.6

These surveys indicate that more than 24,200 hectares or about 1.6 percent of the total commercial acreage of the Forests contain large root disease centers detectable from low level aerial photographs. These estimates do not include scattered individual tree or small group mortality; such root disease mortality may be substantial in some stands (7, 8).

Similar surveys are planned for other National Forests in the Northern Region to provide data for the National Forest Insect and Disease Information System (FIDIS) and to contribute to forest management planning. This report describes one such root disease survey of the Nezperce National Forest in central Idaho.

METHODS

Survey systems with aerial photography have been successful in detecting and measuring extent of root disease (9, 16, 17). The survey system used to sample the Nezperce National Forest was designed by Williams and Leaphart (17); it satisfactorily obtained estimations of forest area occupied by large root disease centers, and served as a basis for the data in table 1.

The survey system used large-scale (1:4000) vertical color infrared photography followed by ground evaluations. The survey was superimposed over an existing timber inventory with sample units called subcompartments.

Figure 1--Root disease center showing typical pattern of mortality. Recently killed and fading trees are on the periphery and older mortality is nearer the center. Regeneration invading disease centers may not reach commercial size if inoculum is present and the trees are susceptible.

Figure 2--Thin, chlorotic crown of tree on the right is indicative of root disease. Compare the crown with the relatively healthy tree on the left.

Figure 3--Stress cone crop of Douglas-fir with root disease. Note the relatively sparse foliage on the infected tree. (Photo by J. Schwandt)

Subcompartments were selected with probability proportional to their National Forest land area (14). Use of subcompartments as primary root disease sample units allowed extrapolation of disease trends to the entire Forest and utilized quantitative site information from timber inventories. Sample subcompartments were divided into stands (the smallest logical management unit). Individual stands were characterized by photointerpretation strata defined by discontinuities in stand height, texture, and stocking (table 2).

Twenty-five subcompartments (figure 4), ranging in size from 38.4 to 275.6 hectares (average 174.3 ha), were photographed and interpreted for root disease centers. Subcompartments were photographed using Kodak Infrared Aerochrome 2443 film at about 1:4000 during July, 1980. Camera focal length was 30.5 cm (12 inches). Flight lines were established to provide 30 percent sidelap and a frame interval of 60 percent endlap.

Table 2.--Photointerpretation strata for the Nezperce National Forest timber inventory 1/.

Stand height	Photointerpretation strata	Description
More than 12.2 m (40 ft)	11	Well-stocked; coarse-textured 2/
	12	Medium-stocked; coarse-textured 2/
	13	Poorly stocked; coarse-textured 2/
	14	Well-stocked to overstocked; fine textured 3/
	15	Medium-stocked; fine-textured 3/
	16	Poorly stocked; fine-textured 3/
	17	Two-storied 4/; understory well to medium stocked
	18	Two-storied 4/; understory poorly stocked
	21	Cutover 5/; well- to medium-stocked; fine textured 3/
	23	Cutover 5/; two-storied 4/; residual overstory with a well- to medium-stocked understory
	24	Cutover 5/; two-storied 4/; residual overstory with poorly stocked understory
Less than 12.2 m (40 ft)	27	Well-stocked; fine-textured 3/
	28	Medium-stocked; fine-textured 3/
	29	Poorly stocked; fine-textured 3/
	30	Nonstocked 6/; fine-textured 3/
	33	Cutover 5/; nonstocked after cutting

1/ Only photointerpretation strata contributing to commercial forest area are included.

2/ Coarse-textured usually indicates mature or overmature sawtimber.

3/ Fine-textured usually indicates small sawtimber or pole stands. These stands may be mature or immature.

4/ Two-storied indicates at least 4.5 to 6 m height difference between overstory and understory.

5/ Cutover indicates areas with obvious evidence of man's recent cutting activities, such as cutting area boundaries and road systems.

6/ Nonstocked due to natural conditions such as fire, but not due to logging.

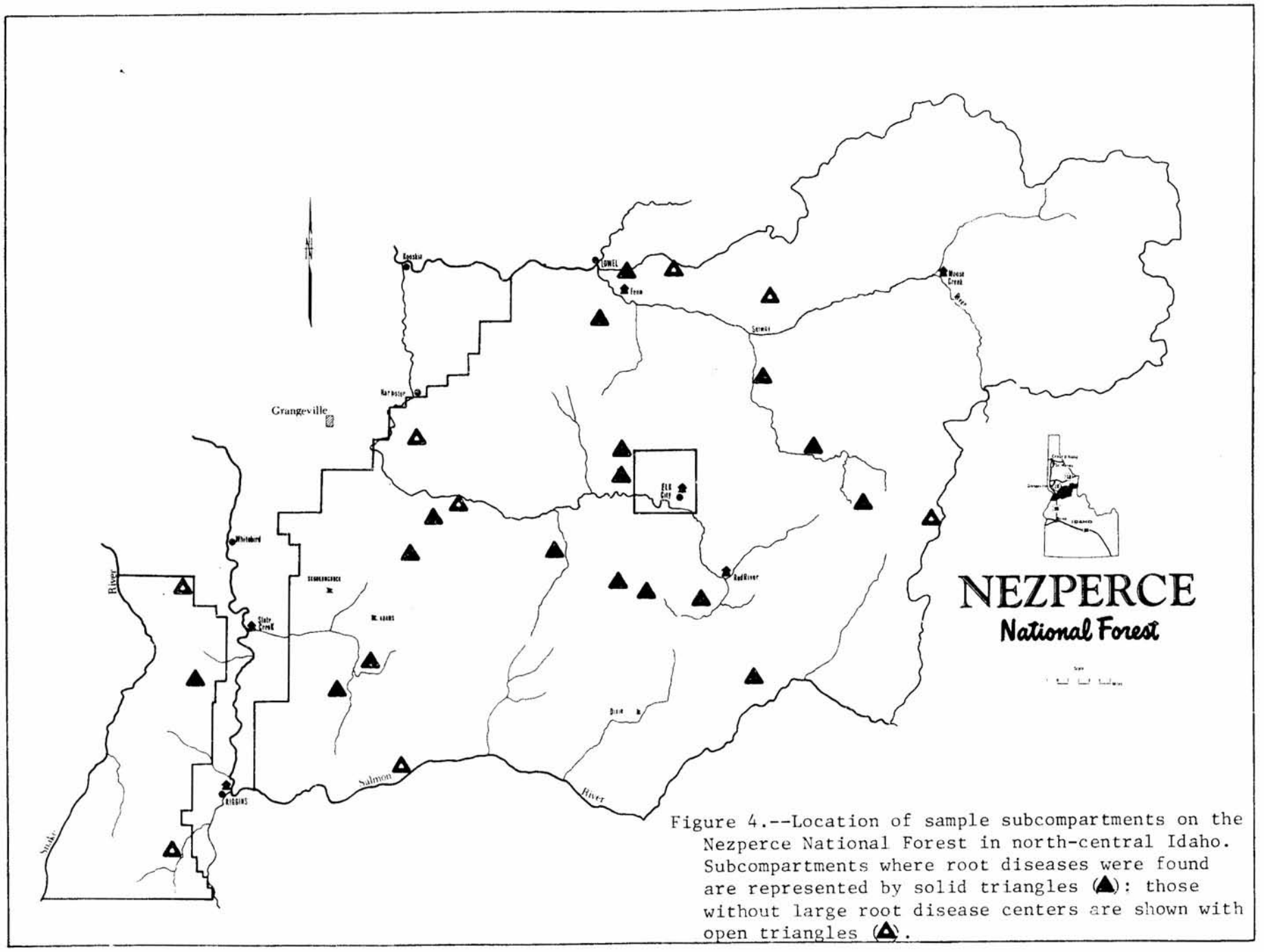

Figure 4.--Location of sample subcompartments on the Nezperce National Forest in north-central Idaho. Subcompartments where root diseases were found are represented by solid triangles (▲): those without large root disease centers are shown with open triangles (△).

Subcompartments and stands were delineated on photographs, which were then interpreted with a Bausch and Lomb stereoscope. Suspected root disease centers were marked on photographs. Centers were identified as openings in the forest canopy with dead and dying conifers on the margins; snags, windthrown trees, a few scattered live trees, and extensive brush were often within disease centers.

Each suspected root disease center was ground checked to verify photointerpretation by evaluating presence of root pathogens associated with tree mortality. Suspected diseased trees were examined at the root collar for signs and symptoms of disease. Associated fungi were identified in the field on the basis of signs and decay patterns (13). Samples were not collected for laboratory analysis. Major associated bark beetles were also noted. A sufficient number of trees were sampled within and adjacent to each disease center to verify whether pathogens were responsible for the damage seen on photographs.

Aerial photographs were reinterpreted following ground checking to adjust for differences between initial interpretation and what was actually found in the field. Approximate area occupied by root disease centers was outlined directly on photographs. However, these areas could not be directly measured from photographs because exact scales could not be maintained over mountainous terrain. Therefore, the percentage of each stand occupied by root disease centers was first determined from photographs with a numonics electronic graphics calculator. Then the percentage was multiplied by the actual stand area as determined by Forest personnel, with the resulting value being actual stand area occupied by root disease centers.

Root disease area within each stand was extrapolated to the entire Forest on the basis of photointerpretation strata. Weighted mean percentage of root disease for each stratum was calculated with the formula:

$$TRD_h = \frac{i\ D_{hi}/P_i}{A_{hi}/P_i}$$

where D_{hi} = area with root disease in stratum h and in subcompartment i; A_{hi} = area in stratum h and subcompartment i; and P_i = area of subcompartment i divided by commercial forest area of the Nezperce National Forest. This is the probability factor by which each subcompartment was originally selected for sampling. Total commercial forest area in any photointerpretation stratum was multiplied by the appropriate TRDh to determine commercial area in root disease centers.

RESULTS AND DISCUSSION

Root diseases were estimated to occupy more than 3,800 ha (about 1.0 percent) of commercial forest land in the Nezperce National Forest (table 3). These diseases were found in 11 of 17 (64.6 percent) photointerpretation strata. Most disease was found in strata 14 and 17, which also

were the strata most intensively sampled (table 3). Stratum 14 represented pole to small sawtimber, well-stocked to overstocked stands more than 12.2 m in height; stratum 17 contained two-storied stands more than 12.2 m in height where the understory is well to medium stocked (table 2). Areas with larger, older trees generally had more root disease.

Root diseases were found in almost 36 percent of the stands (table 3) and 68 percent of the subcompartments sampled (figure 4, table 4). This indicates that root diseases are relatively abundant and widely distributed throughout the Nezperce National Forest.

Table 3.--Root disease incidence by photointerpretation strata for the Nezperce National Forest.

Photointer-pretation strata1/	Forest area (ha)2/	Number stands sampled	Number stands sampled with root disease	Percent stands with root disease	Weighted percentage area with root disease	Estimated forest area with root disease (ha)
11	50,133.1	18	6	33.3	.7	350.9
12	14,624.4	11	4	36.4	.3	43.9
13	4,461.3	5	0	0	0	0
14	100,427.8	62	28	45.2	1.1	1,104.7
15	11,894.4	9	3	33.3	.2	23.8
16	2,267.9	1	0	0	0	0
17	126,069.2	70	32	45.7	1.6	2,017.1
18	10,184.4	15	3	20.0	1.4	142.6
21	2,631.3	1	0	0	0	0
23	13,217.7	6	1	16.7	.4	52.9
24	1,262.6	2	1	50.0	.1	1.3
27	21,622.8	4	1	25.0	.1	21.6
28	3,611.1	5	1	20.0	3.0	108.3
29	3,305.9	1	0	0	0	0
30	10,314.8	12	0	0	0	0
33	2,449.2	1	0	0	0	0
Total	378,477.9	223	80	35.9	--	3,867.1

1/ See table 2 for descriptions.

2/ Forest area indicates only commercial forest land which excludes reserved, deferred, and nonforest areas.

Table 4.--Pathogens and bark beetles associated with root diseases on the Nezperce National Forest.

Sample subcompartment	Pathogen[1/] -host[2/] complexes	Bark beetles[3/] -host[2/] complexes
103-6	AM-SAF	----------
112-1	No root disease found	----------
124-1	No root disease found	----------
313-1	AM-DF,GF,LP,SAF	----------
317-3	AM-DF,GF; PW-GF	----------
322-2	No root disease found	----------
407-2	No root disease found	----------
416-1	No root disease found	----------
418-1	AM-DF	----------
419-5	AM-DF,GF,LP	DP-LP
503-2	AM-DF,LP	DP-LP
511-3	AM-DF,GF,LP	DPS-DF
519-2	AM-SAF	----------
525-7	No root disease found	----------
703-2	AM-DF; PW-GF	DPS-DF
705-2	No root disease found	----------
708-1	AM-DF,SAF	DPS-DF; DC-SAF
714-3	PW-DF,PS-GF	----------
727-2	AM-DF,GS,SAF	----------
729-3	No root disease found	----------
809-6	AM-DF,GF,SAF; PS-GF	DC-SAF; SV-GF
821-1	AM-DF,GF,LP	DP-LP
822-5	AM-DF,GF,LP	DP-LP
825-2	AM-DF,GF,LP,SAF	----------
831-3	AM-DF,GF,LP	----------

1/ Pathogens: AM = Armillaria mellea; PW = Phellinus weirii; PS = Phaeolus schweinitzii.

2/ Hosts: DF = Douglas-fir; GF = grand fir; LP = lodgepole pine; SAF = subalpine fir.

3/ Bark beetles: DP = Dendroctonus ponderosae; DPS = Dendroctonus pseudotsugae; DC = Dryocoetes confusus; SV = Scolytus ventralis.

Estimates of root disease incidence obtained from this survey may be greatly understated. Scattered individual tree and small group mortality associated with root disease were not included in these estimates. Observations on the Nezperce National Forest and elsewhere indicate that such mortality may be substantial. Future estimates of root disease impact will address annual losses expressed as number of trees and timber volumes. This information will provide more reliable and accurate estimates of actual root disease losses.

The most common pathogen associated with root diseases was Armillaria mellea (Vahl. ex Fr.) (table 4). This fungus was most often found on Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco); however, it also infected grand fir (Abies grandis (Dougl.) Lindl.), lodgepole pine (Pinus contorta Dougl.), and subalpine fir (Abies lasiocarpa (Hook) Nutt.). Other root pathogens found included Phellinus weirii (Murr.) Gilb. on Douglas-fir and grand fir and Phaeolus schweinitzii (Fr.) Pat. on grand fir (table 4). Probably other root fungi were also associated with decline of sampled trees. However, more extensive diagnostic techniques are needed to determine presence and roles of other organisms. Previous comprehensive examinations of trees in southern Idaho (12) indicate that several different root fungi often interact to cause tree decline. These fungi apparently colonize roots in defined successional patterns; fungi which are primary invaders may subsequently be replaced by other fungi. Organisms located at the root collar may not necessarily be the primary pathogens. For example, evaluations in western Montana (2, 7) have indicated that Douglas-fir initially may be colonized by Ceratocystis wageneri Goheen & Cobb, cause of black stain root disease (5), and subsequently infected and killed by A. mellea. However, the only fungus detectable at the root collar was A. mellea.

Black stain was often found on small roots distal from the root collar and could not be detected without substantial root system excavation. Although the role of black stain is unclear in Douglas-fir pathogenesis, it appears that rates of tree decline and disease center spread may be influenced by interaction of the different pathogens (2, 7). Similar disease complexes may exist on the Nezperce National Forest. However, more comprehensive evaluations, including extensive root excavations, will be necessary to evaluate roles of different organisms.

Bark beetles were associated with many root diseased trees (table 4). Major beetle species included mountain pine beetle (Dendroctonus ponderosae Hopkins) on lodgepole pine; Douglas-fir beetle (Dendroctonus pseudotsugae Hopkins) on Douglas-fir; western balsam bark beetle (Dryocoetes confusus Swaine) on subalpine fir; and fir engraver (Scolytus ventralis LeConte) on grand fir. Most root diseased Douglas-fir, grand fir, and subalpine fir probably were infested with bark beetles. However, associations between root disease and mountain pine beetle may be less definite in lodgepole pine.

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