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EVALUATION OF ROOT DISEASE LOSSES ON THE BLUE FAT TIMBER SALE CABINET RANGER DISTRICT KOOTENAI NATIONAL FOREST MONTANA

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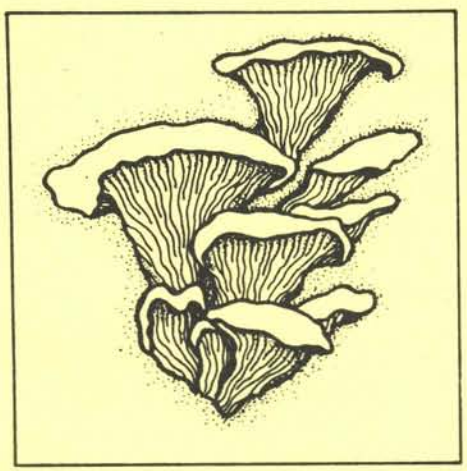

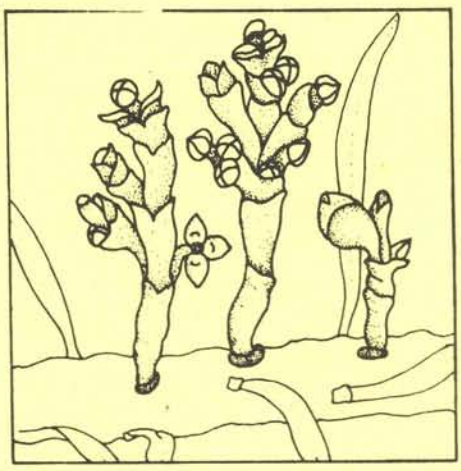

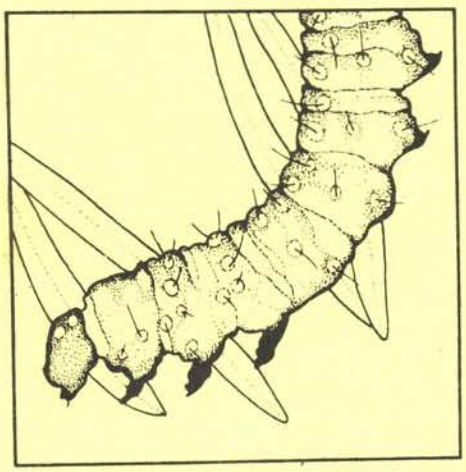

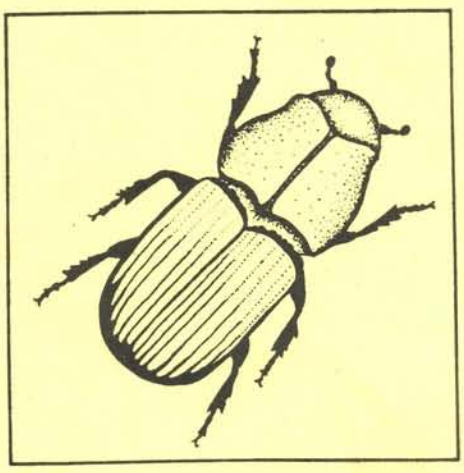

EVALUATION OF ROOT DISEASE LOSSES ON THE BLUE FAT TIMBER SALE, CABINET RANGER DISTRICT, KOOTENAI NATIONAL FOREST, MONTANA

ABSTRACT

A variable plot survey was conducted on approximately 66 acres, representative of the Blue Fat timber sale on the Cabinet Ranger District, Kootenai National Forest, in northwestern Montana. The survey was designed to determine current levels of root disease impact as measured by tree mortality, basal area, and volume losses by different pathogens. The major root pathogen encountered was Phellinus weirii; Armillaria mellea and Phaeolus schweinitzii were also found. Fir engraver and western balsam bark beetle were associated with several grand fir and subalpine fir infected with P. weirii. Evidence of root diseases was found on almost 25 percent of the living and dead trees over 5 inches d.b.h. Only 2.3 percent of the regeneration was root diseased. Most trees with root disease had died 2 to 10 years ago. Average annual rate of root disease mortality for the stand was 2.5 trees/acre for trees over 5 inches d.b.h. and 1.8 trees per acre for regeneration. Many more trees were likely diseased, but lacked sufficient external indicators to warrant detailed examination. Root diseased trees comprised more than 20 percent of the stand basal area and accounted for about 19 percent of the cubic foot volume and 27 percent of the board foot volume of the stand. Site conversion to less susceptible tree species is the best option for returning timber productivity to the area.

INTRODUCTION

Root diseases cause important long-term impacts on forests in the Northern Region. Impacts on forest productivity include accelerated tree mortality (Childs, 1970; Morrison, 1976; Nelson, 1980), growth loss (Bloomberg and Wallis, 1979; Wallis, 1976; Shaw and Toes, 1977), and rendering disease centers unproductive for timber growth (Williams and Leaphart, 1978; James, 1981). Root disease losses are often greater in managed stands with previous cutting history (Childs, 1970; Filip, 1979).

Previous root disease survey efforts in the Northern Region have been directed toward obtaining loss information for entire National Forests (Williams and Leaphart, 1978; James and Stewart, 1981). Although this information is useful for the Forest as a whole, managers need more detailed loss information when preparing stand prescriptions for sites with concentrated root disease.

Several heavily root diseased areas were located within and adjacent to the proposed Blue Fat timber sale on the Cabinet Ranger District, Kootenai National Forest, in northwestern Montana. Silvicultural treatment of affected stands seemed desirable to slow the rate of loss and to return timber production. In order to estimate current losses, a detailed root disease evaluation was conducted on a representative stand

within the sale area. Information on this stand can be used to establish treatment priorities and to aid managers in predicting losses under different types of management.

MATERIALS AND METHODS

The sampled stand, comprising approximately 66 acres, was located within sections 15, 16, 21, and 22, T27N, R34W, Principal Meridian (figure 1). The stand was on a southwest aspect with a 13 percent slope and composed of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), grand fir (Abies grandis (Dougl.) Lindl.), western white pine (Pinus monticola Dougl.), western redcedar (Thuja plicata Donn), lodgepole pine (Pinus contorta Dougl.), western larch (Larix occidentalis Nutt.), western hemlock (Tsuga heterophylla (Rafn.) Sarg.), ponderosa pine (Pinus ponderosa Laws.) and subalpine fir (Abies lasiocarpa (Hook.) Nutt.). A variable plot survey (BAF = 10) using the Northern Region's Forest Insect and Disease Damage Survey System (INDIDS) (Bousfield, 1980) was implemented to determine current losses in the stand. This survey system is similar to that commonly used to quantify root disease losses within forest stands in the Pacific Northwest Region (Goheen, 1980; Filip, et al., 1980).

Fifty variable plots were located on an approximate 3- by 3-chain grid throughout the surveyed stand. Diameter at breast height (d.b.h.) of each plot tree was measured. Heights were measured on the first two plot trees over 5 inches d.b.h. encountered in a clockwise direction from the north. Trees less than 5 inches d.b.h. were measured only if they occurred within a 1/300 acre (6.8-ft. diameter fixed) radius plot.

A maximum of three damage codes were recorded for each plot tree. Major damage codes included insect activity, disease occurrence by individual pathogen, or combinations of both. Several surveyed trees had more than one pest associated with damage symptoms.

Trees with foliage or root crown symptoms were examined for root diseases. Two lateral roots on opposite sides of symptomatic trees were excavated about 1 meter to locate signs of disease. Decay, mycelial fans, staining patterns, and sporophores were used in disease diagnosis. Culturing of wood samples for identification of root pathogens was not done.

The INDIDS program summarized stand condition by diameter class for each tree species. Summaries included trees per acre, basal area per acre, and cubic foot and board foot volume per acre for each damage category. Summaries were also obtained for root disease category: root disease infected (live trees with crown or basal symtpoms), current root disease mortality (trees that have died within the past year), and older root disease mortality (trees that have died within 2 to about 10 years ago).

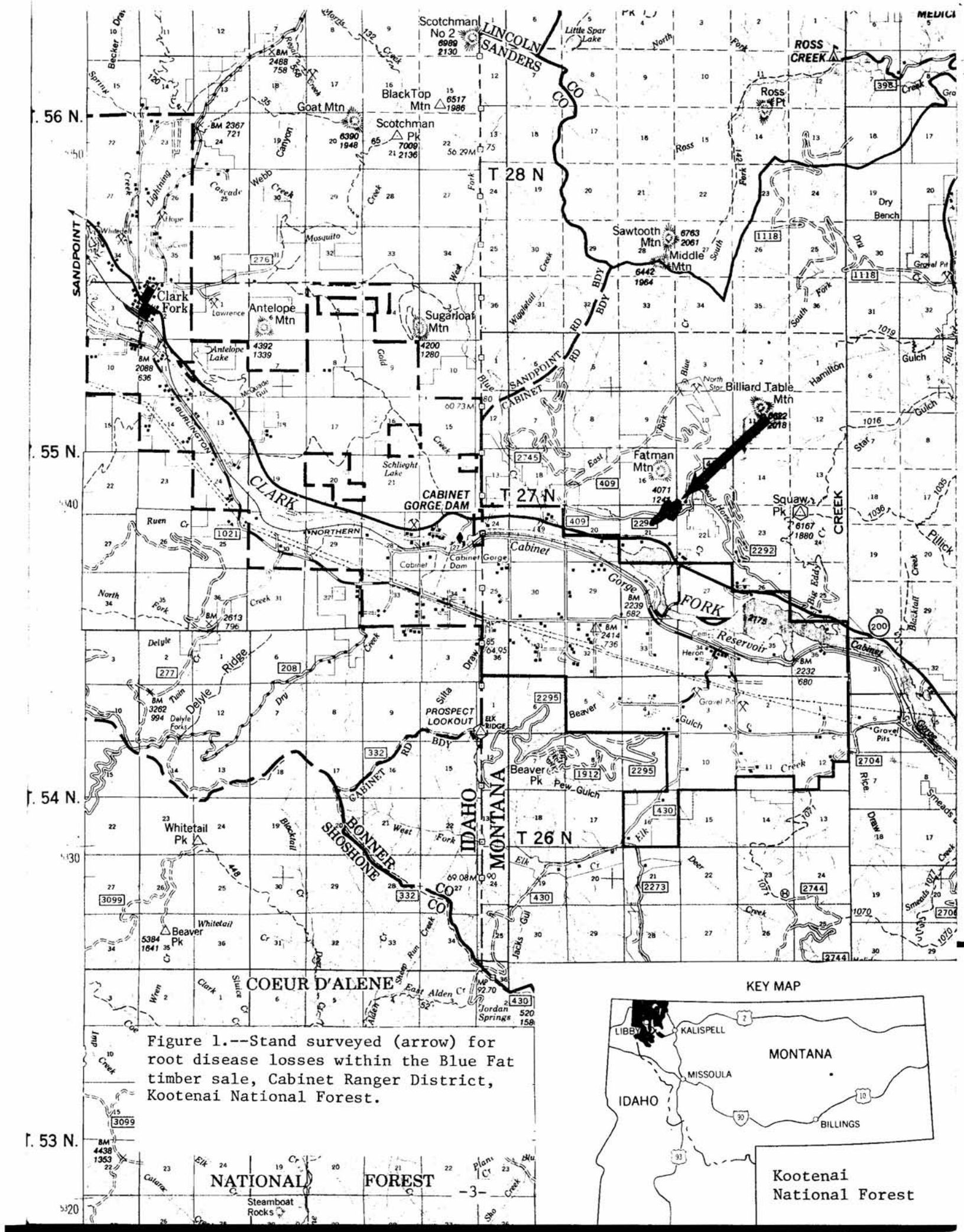

Figure 1.--Stand surveyed (arrow) for root disease losses within the Blue Fat timber sale, Cabinet Ranger District, Kootenai National Forest.

RESULTS AND DISCUSSION

Root diseases were found on 32 (64 percent) of the plots surveyed (table 1). The major pathogen encountered was Phellinus (Poria) weirii (Murr.) Gilb., primarily on Douglas-fir and grand fir, but also recorded on western larch. This pathogen was located on 29 plots distributed throughout the stand (table 1, figure 2). Phellinus weirii causes laminated root rot of several economically important conifers (Childs, 1970; Childs and Nelson, 1971). Losses throughout the Pacific Northwest (Childs and Shea, 1967) and northern Idaho (Williams and Leaphart, 1978) are extensive. Trees with advanced decay often have declining thin, chlorotic crowns. Red-brown stain is common in incipiently decayed wood (Wallis, 1976); advanced decay appears pitted and laminate (Childs, 1970; Wallis, 1976).

The other root pathogens found were Armillaria mellea (Vahl. ex Fr.) Qué. and Phaeolus schweinitzii (Fr.) Pat. on Douglas-fir (table 1). Armillaria root rot was more common in the northwest corner of the stand (figure 3), whereas P. schweinitzii was located within four plots in the middle of the stand (figure 4). Several sampled trees were infected with two or more root pathogens.

Table 1.--Incidence of root pathogens within survey plots on the Blue Fat timber sale, Cabinet Ranger District, Kootenai National Forest.

	Pathogen			
	Armillaria mellea	Phaeolus schweinitzii	Phellinus weirii	Any root pathogen
Number of plots	4	4	29	32
Percentage of plots	8	8	58	64

Bark beetles, primarily Scolytus ventralis LeConte and Dryocoetes confusus Swaine, were associated with several grand fir and subalpine fir infected with P. weirii (table 2). Bark beetles often attack trees weakened by root diseases, hastening tree mortality (James and Goheen, 1981; Lane and Goheen, 1979).

Evidence of root pathogens were located on 24.6 percent of the surveyed trees over 5 inches d.b.h. (table 2), accounting for approximately 27 trees per acre. Less than half the trees in the stand were undamaged by some pest or other damaging agent. Other damaging agents included such things as wind, drought, and animals. Root disease losses to regeneration

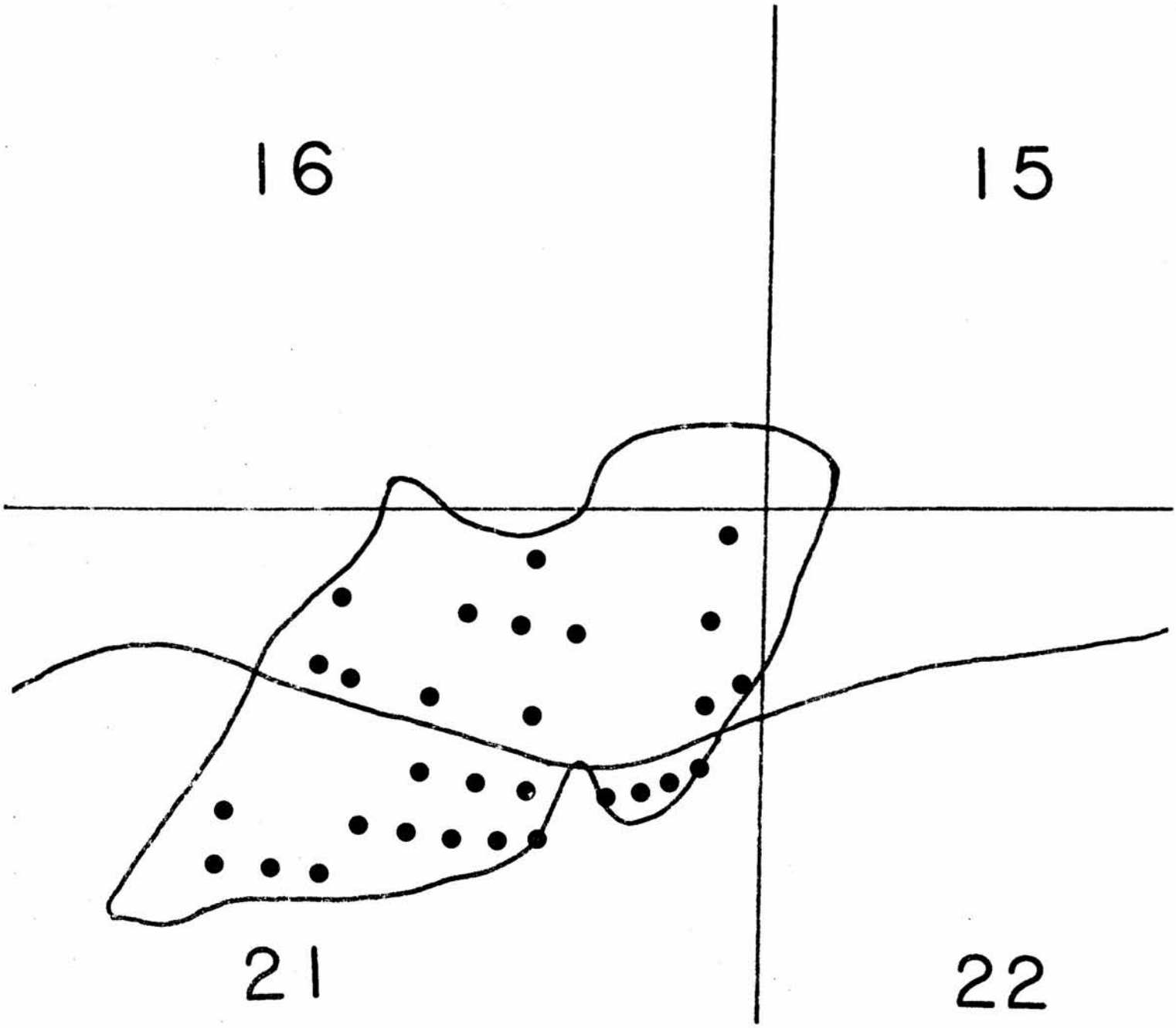

Figure 2.--Location of plots with Phellinus weirii root disease within the Blue Fat timber sale, Cabinet Ranger District, Kootenai National Forest.

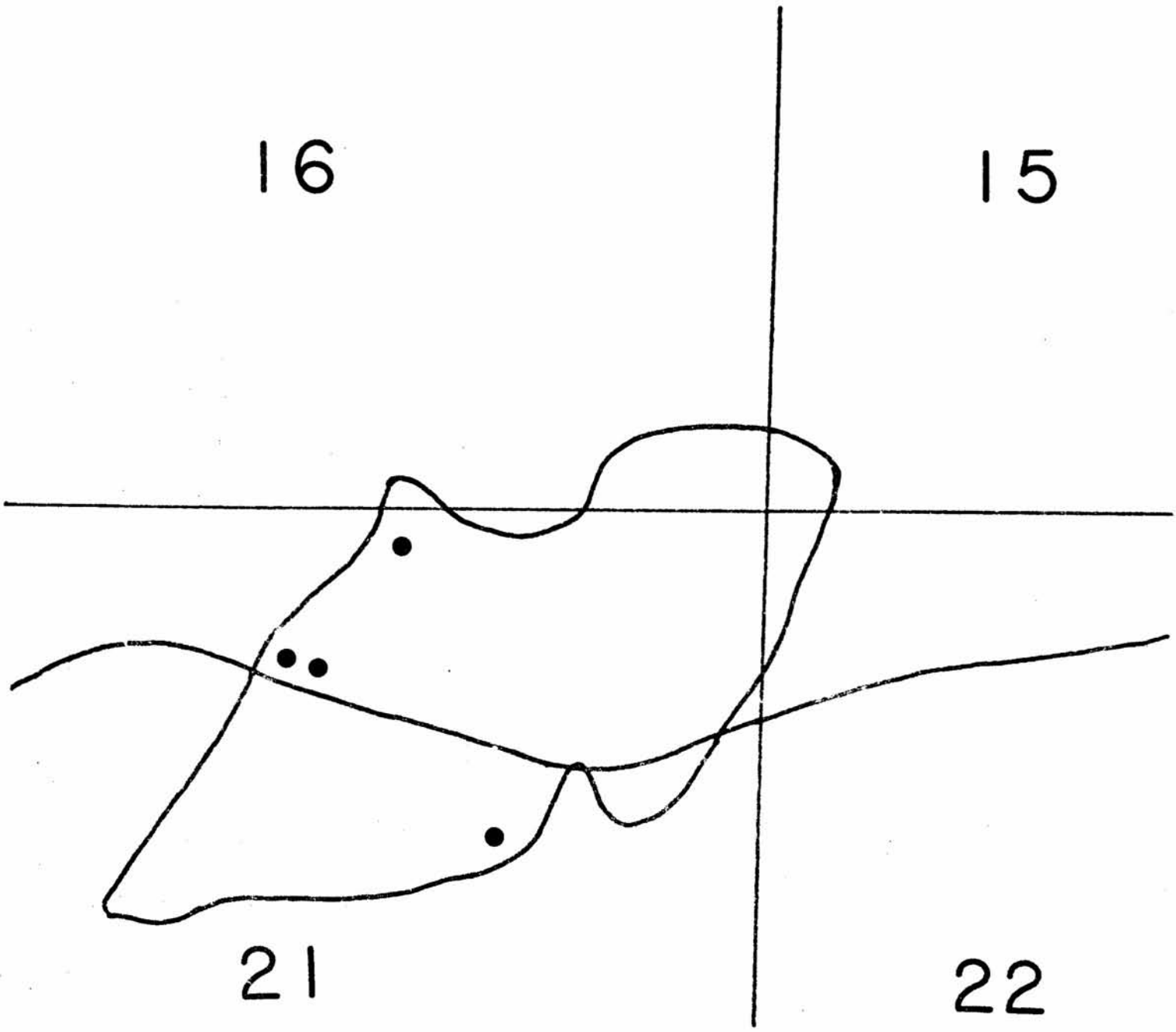

Figure 3.--Location of plots with Armillaria mellea root disease within the Blue Fat timber sale, Cabinet Ranger District, Kootenai National Forest.

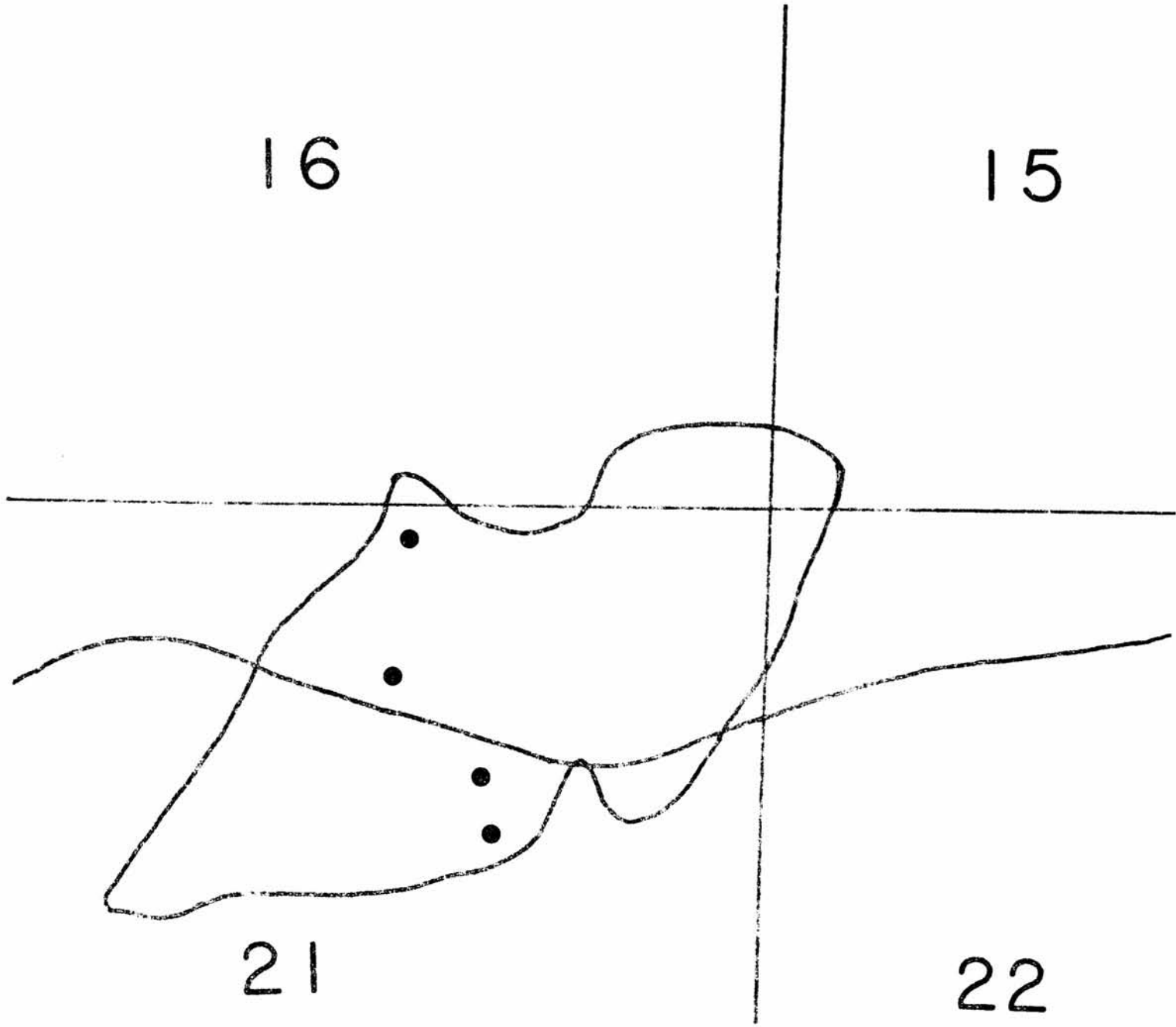

Figure 4.--Location of plots with Phaeolus schweinitzii root disease within the Blue Fat timber sale, Cabinet Ranger District, Kootenai National Forest.

(less than 5 inches d.b.h.) were low, accounting for only 2.3 percent of the sampled trees or about 24 trees per acre (table 3). Most root diseased trees over 5 inches d.b.h. died from 2 to about 10 years ago. Current root disease mortality accounted for only 4.5 percent of the loss and live trees with crown or basal symptoms comprised 7.1 percent of the root diseased trees (table 4). Root disease loss summaries for regeneration (table 5) also indicate that most loss (75 percent) was older mortality. Average annual rate of root disease mortality for the stand was 4.3 trees of all sizes per acre per year.

Many more trees were likely diseased, but lacked sufficient external indicators to warrant root excavation. Research has shown that only about half of the area and number of trees with root disease can be determined by examining trees with above-ground symptoms (Wallis and Bloomberg, 1981).

Root diseased trees over 5 inches d.b.h. comprised more than 20 percent of the stand basal area (table 6). Basal area losses in regeneration were also substantial (table 7). Tables 8 and 9 summarize basal area losses by root disease category (current live infected, current mortality, and older mortality) for trees over 5 inches d.b.h. and regeneration, respectively. Most loss occurred as older mortality; estimated annual basal area loss from root disease was 1.2 square feet per acre per year.

Root diseased trees accounted for 18.7 percent of the cubic foot volume and 27.0 percent of the board foot volume of the stand (tables 10 and 11). Volume losses by disease category (tables 12 and 13) indicated that 265.1 cu. ft/acre or 951.3 board feet/acre were in root diseased trees; most loss occurred as older mortality. Average annual volume loss from root disease was 22.7 cu. ft/acre/year or 77.3 bd. ft/acre/year.

These data indicate that root diseases are significantly impacting the stand by causing high levels of annual mortality of the larger diameter trees. The survey also indicates that root diseases are causing unacceptable losses if the stand is managed for timber production. Although openings created by tree mortality are being regenerated, most trees being established are disease susceptible. They establish themselves quickly and grow quite well for a few years until their root systems come in contact with disease inoculum in the soil. Then the trees often decline rapidly and die. This cycle will likely continue indefinitely with few or no trees reaching commercial size unless steps are taken to reduce disease inoculum (Hadfield and Johnson, 1976). Because this inoculum can remain viable in the soil for decades (Hansen, 1976; Wallis and Reynolds, 1965), it must either be physically removed or rendered ineffective by allowing it to die out. The cost of physically removing inoculum in stumps and large roots is usually prohibitive. Utilizing nonsusceptible or disease tolerant species to regenerate disease sites usually results in loss of inoculum viability over several decades (Hadfield and Johnson, 1976).

Not all conifer species are equally susceptible to P. weirii or A. mellea (table 14). Since many species can probably be grown successfully in the Blue Fat area, site conversion to less susceptible trees is probably the best alternative if timber production is desired. Western larch and pine are probably the best replacements for the more susceptible Douglas-fir and true fir. With over 78 percent of the current basal area of the stand made up of these most susceptible species (table 15), successful site conversion will likely require drastic measures. Clearcutting the existing stand, site preparation by broadcast burning or dozer piling, followed by planting larch and pine will probably be required to return the stand to productivity. Without many susceptible trees on the site, we would expect decline in inoculum viability so that within several decades Douglas-fir and true fir can again be grown successfully on the site.

Other possible management options for the area include:

1. Dead and dying trees can be salvaged. Although rates of disease spread and tree mortality will not be reduced by salvage operations, recovery of potentially lost wood will be possible. There is indirect evidence, mostly observational, that salvage cutting may aggravate root disease problems. When mixed conifer stands are partially cut, more shade tolerant tree species are favored (Smith, 1962). Several of these species, particularly the true firs, are the most susceptible to root diseases (table 14). Therefore, partial cutting might be expected to enhance existing root disease problems, especially if susceptible trees such as Douglas-fir and true fir are left as potential seed sources. Stumps provided by partial cutting may also act as food bases for root pathogens, thus aggravating the disease situation. Verification of the hypothesis with field data is lacking; tests are being conducted to evaluate partial cutting effects on root disease activity.

2. Experimentation in stopping marginal spread of root disease centers and reclaiming these sites for future production has been tried in several areas with varied results (Byler and James, 1981; Wallis and Reynolds, 1965). Procedures include removal of all trees and stumps for a 1- to 2-chain radius around well defined root disease centers. Stumps and major roots are then removed from centers if sites are to be regenerated with susceptible species. Such procedures are costly (Shaw and Roth, 1978) and may fail because of the difficulty in determining relationships between above-ground disease symptoms and presence of root infection (Byler and James, 1981; Wallis and Bloomberg, 1981; Shaw and Roth, 1978).

3. If nothing is done, mortality will continue as disease centers enlarge. Centers will become occupied with brush and a few trees; timber productivity will be lost as centers regenerate with susceptible trees and mortality continues. However, resulting brush fields may be beneficial for big game habitat.

Table 2.--Losses from root diseases and other pests on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - trees per acre over 5 inches d.b.h. by pest category.

Tree species	Pest Category: Undamaged	Armillaria mellea	Phellinus weirii	P. weirii bark beetle complex	Phaeolus schweinitzii	Other insects and diseases	Other damaging agents	Other mortality	Stand total 1/
Grand fir	4.5	0	0.7	1.9	0	2.6	0	2.3	9.4
Subalpine fir	0	0	0	0.3	0	0.3	0	0	0.3
Western larch	4.5	0	2.2	0	0	2.6	0	1.3	8.5
Western white pine	1.1	0	0	0	0	0.7	0	0.8	2.5
Ponderosa pine	0.7	0	0	0	0	0.1	0	0.2	1.0
Douglas-fir	30.6	2.9	19.6	0	0.9	22.4	0.6	5.5	58.6
Western red cedar	4.3	0	0	0	0	0	0	0	4.3
Western hemlock	1.0	0	0	0	0	0	0	1.2	2.2
All species	46.7	2.9	22.5	2.2	0.9	28.7	0.6	11.3	86.8
Percent	40.3	2.5	19.4	1.9	0.8	24.8	0.5	9.8	-

1/ Values in "stand total" column do not necessarily represent the total of values for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 3.-- Damage characteristics of conifer regeneration (less than 5 inches d.b.h.) on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - trees per acre by pest categories.

Tree species	Trees per acre				
	Undamaged	*Phellinus weirii* root disease	Other insects and diseases	Other mortality	Stand total 1/
Grand fir	276.0	6.0	6.0	18.0	300.0
Lodgepole pine	6.0	0	0	0	6.0
Western white pine	30.0	0	0	6.0	36.0
Douglas-fir	486.0	18.0	18.0	66.0	570.0
Western redcedar	24.0	0	0	0	24.0
All species	822.0	24.0	48.0	138.0	1074.0
Percent	79.6	2.3	4.6	13.5	-

1/ Values in "stand total" column do not necessarily represent the total of values for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 4.--Root disease loss categories on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - trees per acre over 5 inches d.b.h.

Tree species	Trees per acre: Root disease infected [1]	Current root disease mortality [2]	Older root disease mortality [3]	Total root disease
Grand fir	0	0	2.6	2.6
Subalpine fir	0	0	0.3	0.3
Western larch	0	0	2.2	2.2
Douglas-fir	1.9	1.2	18.4	21.5
All species	1.9	1.2	23.5	26.6
Percent	7.1	4.5	88.4	-

1/ Represents live trees with crown or basal root disease symptoms.

2/ Represents trees that have died within the past year.

3/ Represents trees that have died from 2 to about 10 years ago. Average annual rate of root disease mortality is 2.5 trees per acre per year.

Table 5.--Root disease loss categories of regeneration (less than 5 inches d.b.h.) on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - trees per acre.

Tree species	Trees per acre: Root disease infected [1]	Current root disease mortality [2]	Older root disease mortality [3]	Total root disease
Grand fir	0	0	6.0	6.0
Douglas-fir	6.0	0	12.0	18.0
All species	6.0	0	18.0	24.0
Percent	25.0	0	75.0	-

1/ Represents live trees with crown or basal root disease symptoms.

2/ Represents trees that have died within the past year.

3/ Represents trees that have died from 2 to about 10 years ago. Average annual rate of root disease mortality is 1.8 trees per acre per year.

Table 6.--Losses from root diseases and other pests on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - basal area per acre of trees over 5 inches d.b.h. by pest categories.

Tree species	Undamaged	*Armillaria mellea*	*Phellinus weirii*	*P. weirii* bark beetle complex	*Phaeolus schweinitzii*	Other insects and diseases	Other damaging agents	Other mortality	Stand total 1/
Grand fir	3.2	0	0.4	0.6	0	1.0	0	1.2	5.4
Subalpine fir	0	0	0	0.2	0	0.2	0	0	0.2
Western larch	3.4	0	0.4	0	0	0.8	0	0.2	4.4
Western white pine	0.8	0	0	0	0	0.4	0	0.2	1.4
Ponderosa pine	1.4	0	0	0	0	0.2	0	0.2	1.8
Douglas-fir	20.2	1.6	9.2	0	0.8	10.8	0.2	2.8	33.8
Western redcedar	3.6	0	0	0	0	0	0	0	3.6
Western hemlock	0.4	0	0	0	0	0	0	0.4	0.8
All species	33.0	1.6	10.0	0.8	0.8	13.4	0.2	5.0	51.4
Percent	50.9	2.5	15.5	1.2	1.2	20.7	0.3	7.7	-

1/ Values in "stand total" column do not necessarily represent the total of values for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 7.--Damage characteristics of conifer regeneration (less than 5 inches d.b.h.) on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - basal area per acre by pest categories.

Tree species	Basal area per acre: Undamaged	*Phellinus weirii* root disease	Other insects and diseases	Other mortality	Stand total [1/]
Grand fir	0	0.7	0.7	0	0.7
Douglas-fir	2.1	0.4	0.4	1.0	3.6
All species	2.1	1.1	1.1	1.0	4.3
Percent	39.6	20.7	20.7	19.0	-

1/ Values in "stand total" column do not necessarily represent the total of values for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 8.--Root disease loss categories on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - basal area per acre over 5 inches d.b.h.

Tree species	Basal area per acre: Root disease infected [1]	Current root disease mortality [2]	Older root disease mortality [3]	Total root disease
Grand fir	0	0	1.0	1.0
Subalpine fir	0	0	0.2	0.2
Western larch	0	0	0.4	0.4
Douglas-fir	1.4	0.2	8.8	10.4
All species	1.4	0.2	10.4	12.0
Percent	11.7	1.7	86.6	-

1/ Represents live trees with crown or basal root disease symptoms.

2/ Represents trees that have died within the past year.

3/ Represents trees that have died from 2 to about 10 years ago. Average annual rate of root disease mortality is 1.1 sq. ft. per acre per year.

Table 9.--Root disease loss categories of regeneration (less than 5 inches d.b.h.) on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - basal area per acre.

Tree species	Basal area per acre			
	Root disease infected 1/	Current root disease mortality 2/	Older root disease mortality 3/	Total root disease
Grand fir	0	0	0.7	0.7
Douglas-fir	0.4	0	0	0.4
All species	0.4	0	0.7	1.1
Percent	36.4	0	63.6	-

1/ Represents live trees with crown or basal root disease symptoms.

2/ Represents trees that have died within the past year.

3/ Represents trees that have died from 2 to about 10 years ago. Average annual rate of regeneration from root disease is 0.1 sq. ft. per acre per year.

Table 10.--Losses from root diseases and other pests on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - cubic foot volume per acre. 1/

Tree species	Undamaged	Armillaria mellea	Phellinus weirii	P. weirii bark beetle complex	Phaeolus schweinitzii	Other insects and diseases	Other damaging agents	Other mortality	Stand total 2/
Grand fir	94.2	0	10.6	11.3	0	21.9	0	28.8	144.8
Subalpine fir	0	0	0	5.3	0	0	0	0	5.3
Western larch	84.0	0	2.7	0	0	12.1	0	0.8	97.0
Lodgepole pine	0	0	0	0	0	0	0	0	0
Western white pine	23.4	0	0	0	0	8.0	0	2.9	34.3
Ponderosa pine	50.4	0	0	0	0	7.0	0	5.8	63.2
Douglas-fir	526.0	37.7	202.8	0	22.1	242.2	3.4	65.2	833.5
Western redcedar	90.5	0	0	0	0	0	0	0	90.5
Western hemlock	6.8	0	0	0	0	0	0	4.7	11.5
All species	875.3	37.7	216.1	16.6	22.1	291.2	3.4	108.2	1280.1
Percent	55.7	2.4	13.8	1.1	1.4	18.5	0.2	6.9	-

1/ Volume estimates are for trees over 5 inches d.b.h.

2/ Values in "stand total" column do not necessarily represent the total of values for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 11.--Losses from root disease and other pests on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - board foot volume per acre. 1/

Tree species	Undamaged	Armillaria mellea	Phellinus weirii	P. weirii bark beetle complex	Phaeolus schweinitzii	Other insects and diseases	Other damaging agents	Other mortality	Stand 2/ total
Grand fir	409.9	0	42.3	31.5	0	73.8	0	88.7	572.4
Subalpine fir	0	0	0	22.8	0	0	0	0	22.8
Western larch	367.8	0	0	0	0	43.7	0	0	411.5
Lodgepole pine	0	0	0	0	0	0	0	0	0
Western white pine	105.2	0	0	0	0	27.5	0	0	132.7
Ponderosa pine	265.2	0	0	0	0	36.8	0	26.4	328.4
Douglas-fir	2236.2	155.2	705.8	0	100.3	860.1	0	233.6	3329.9
Western redcedar	385.4	0	0	0	0	0	0	0	385.4
Western hemlock	21.6	0	0	0	0	0	0	0	21.6
All species	3791.3	155.2	748.1	54.3	100.3	1041.9	0	348.7	5204.7
Percent	60.7	2.5	12.0	0.9	1.6	16.7	0	5.6	-

1/ Volume estimates are for trees over 5 inches d.b.h.

2/ Values in "stand total" column do not necessarily represent the total of vlaues for all damage categories because more than one pest may have been found on particular surveyed trees.

Table 12.--Root disease loss categories on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - cubic foot volume per acre. 1/

Tree species	Cubic foot volume per acre			
	Root disease infected 2/	Current root disease mortality 3/	Older root disease mortality 4/	Total root disease
Grand fir	0	0	21.9	21.9
Subalpine fir	0	0	5.3	5.3
Western larch	0	0	2.6	2.6
Douglas-fir	38.2	1.4	195.7	235.3
All species	38.2	1.4	225.5	265.1
Percent	14.4	0.5	85.1	-

1/ Volume estimates are for trees over 5 inches d.b.h.

2/ Represents live trees with crown or basal root disease symptoms.

3/ Represents trees that have died within the past year.

4/ Represents trees that have died from 2 to about 10 years ago. Average annual volume loss from root disease is 22.7 cu. ft. per acre per year.

Table 13.--Root disease loss categories on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest - board foot volume per acre. 1/

Tree species	Board foot volume per acre			
	Root disease infected 2/	Current root disease mortality 3/	Older root disease mortality 4/	Total root disease
Grand fir	0	0	73.9	73.9
Subalpine fir	0	0	22.8	22.8
Douglas-fir	178.1	0	676.5	854.6
All species	178.1	0	773.2	951.3
Percent	18.7	0	81.3	-

1/ Volume estimates are for trees over 5 inches d.b.h.

2/ Represents live trees with crown or basal root disease symptoms.

3/ Represents trees that have died within the past year.

4/ Represents trees that have died from 2 to about 10 years ago. Average annual volume loss from root disease is 77.3 bd. ft. per acre per year.

Table 14.--*Relative susceptibility of selected conifer species to Phellinus weirii and Armillaria mellea*. 1/

Pathogen	Tree species 2/		
	Most susceptible	Less susceptible	Tolerant or resistent
Phellinus weirii	DF, GF	SAF, WH	WL, WWP, PP, LPP, WRC
Armillaria mellea	DF, GF, SAF, LPP	WWP, WH, WRC	WL, PP 3/

1/ Most of the susceptibility ratings are based on field observations rather than experimental data. References for ratings include Filip and Schmitt, 1979, Hadfield and Johnson, 1976, Morrison, 1981, and Shaw and Roth, 1978.

2/ DF = Douglas-fir GF = Grand fir SAF = Subalpine fir

WH = Western hemlock WL = Western larch WWP = Western white pine

PP = Ponderosa pine LPP = Lodgepole pine WRC = Western red cedar

3/ Ponderosa pine may be susceptible when young but often develops resistance with age (Morrison, 1981).

Table 15.--Basal area of sampled stand on the Blue Fat Sale, Cabinet Ranger District, Kootenai National Forest.

	Tree species									
	Grand fir	Subalpine fir	Western larch	Lodgepole pine	Western white pine	Ponderosa pine	Douglas-fir	Western redcedar	Western hemlock	All species
Basal area (sq. ft.)	6.1	0.2	4.4	0	1.4	1.8	37.4	3.6	0.8	55.7
Percent	11.0	0.4	7.9	0	2.5	3.2	67.1	6.5	1.4	100.0

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