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## Conifer Root Diseases on the Kootenai National Forest, Montana

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**by**

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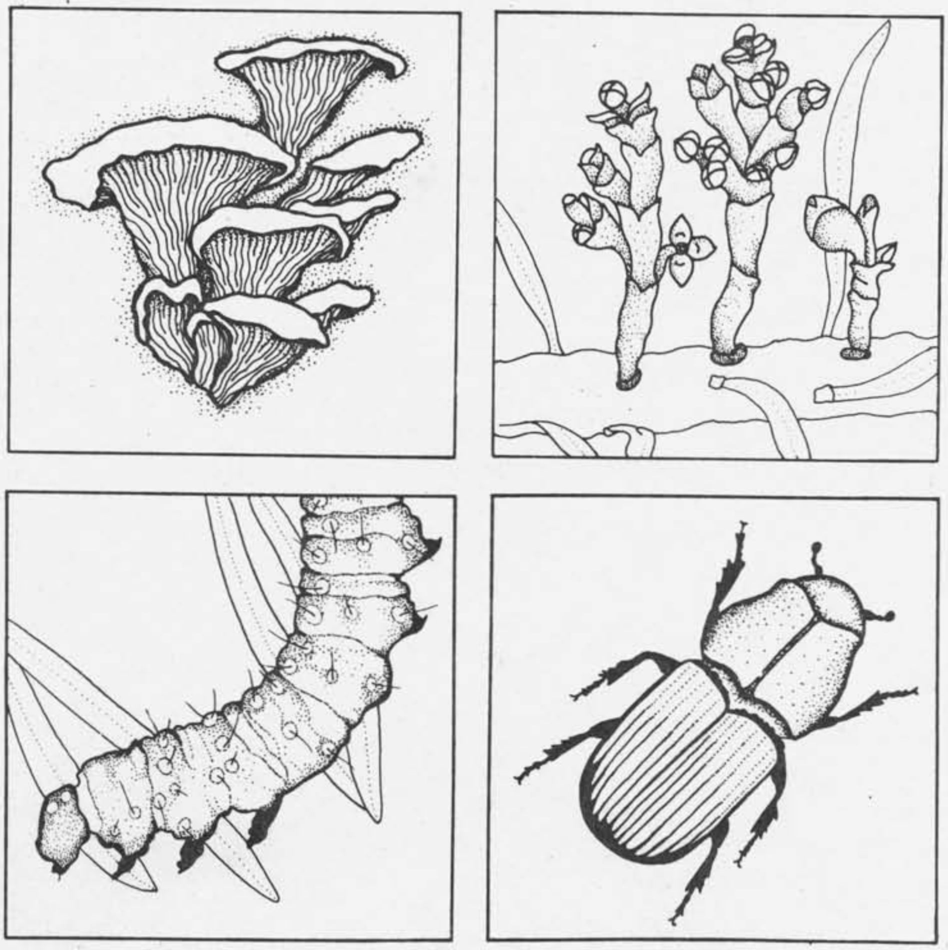

# CONIFER ROOT DISEASES ON THE KOOTENAI NATIONAL FOREST, MONTANA

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and

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Cooperative Forestry and Pest Management

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## ABSTRACT

A survey for incidence and distribution of root diseases was conducted on the Kootenai National Forest using timber inventory subcompartments as primary sample units. Root diseases were located within 23 of 75 sampled subcompartments. At least 1.1 percent of the commercial forest lands within the Forest are infested with root diseases. Large active disease centers occupy more than 1,550 ha (3,830 acres) of forest land. Major pathogens encountered were *Phellinus weirii*, *Armillaria mellea*, and *Phaeolus schweinitzii*. *P. weirii* was found mostly within the Cabinet Ranger District; other pathogens were distributed throughout the Forest. Bark beetles often infested root-diseased trees. Most root disease was found within the *Pseudotsuga menziesii*, *Abies grandis*, and *Tsuga heterophylla* series of habitats. Management procedures for reducing losses in root-diseased stands are discussed.

## INTRODUCTION

Root diseases cause extensive damage to conifer stands within the Northern Region. Although root diseases have been shown to reduce tree growth (Bloomberg and Wallis 1979; Froelich et al. 1977), we believe that premature mortality is the major impact of these diseases in the northern Rocky Mountains. Small trees may be killed directly by root pathogens, whereas larger trees are commonly attacked and killed by bark beetles (Hertert et al. 1975; Lane and Goheen 1979) or are subject to windthrow (Childs 1970; Lane and Goheen 1979). Root diseases may occur as either distinct centers of infection or as mortality in individual trees or small groups scattered throughout infected stands.

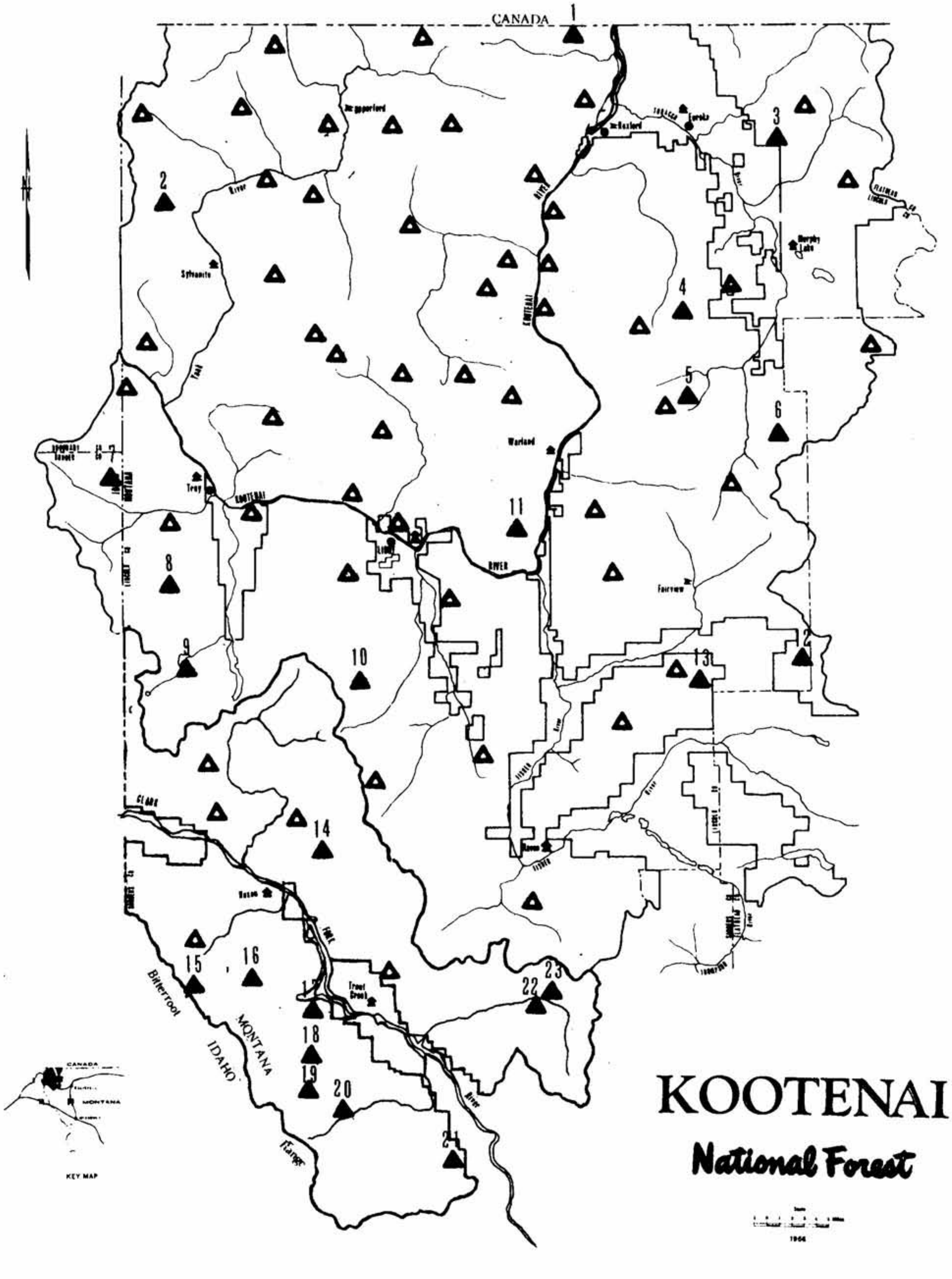
This report summarizes the occurrence and distribution of root diseases from recent surveys within the Kootenai National Forest in northwestern Montana. A section on current recommendations for managing root-diseased stands to reduce future losses is also included.

## SURVEY METHODS

Forest-wide estimates of the area infested with root diseases were obtained using techniques previously described (James and Stewart 1981; Williams and Leaphart 1978). Timber inventory subcompartments served as primary sample units (Barnard 1978). Use of subcompartments as root disease sample units allowed extrapolation of disease trends to the entire Forest and used quantitative site information from timber inventories (Stage and Alley 1972). Subcompartments were subdivided into stands characterized as photointerpretation strata. These stands were defined by differences in stand height, texture, and stocking (James and Stewart 1981).

Seventy-five subcompartments (figure 1), ranging in size from 40 to 280 ha (100 to 690 acres) (average 174 ha - 430 acres), were photographed in August 1981 with true color transparency film at a scale of about 1:4,000. A Fairchild T-12 camera equipped with a 30.5 cm (12 in) focal length lens was used. Flight lines allowed 30 percent sidelap with a frame interval of 60 percent endlap.

Figure 1.--Location of subcompartments sampled for root diseases on the Kootenai National Forest in western Montana. Subcompartments with root diseases are represented by solid triangles (▲); those where root diseases were not found are shown as open triangles (Δ). Numbers refer to root disease/bark beetle descriptions in table 3.



Subcompartments and stands were delineated on the color transparencies. Stands were then photointerpreted with a Bausch and Lomb stereoscope for suspected root disease centers. Centers were identified as openings in the forest canopy with dead and dying trees on the margins. Snags, windthrown trees, a few scattered live trees, and extensive brush were common within disease centers. Stands near suspected root disease centers were also interpreted for possible scattered root disease mortality, i.e., current mortality at a level of at least 3 trees/ha (1 tree/acre).

Suspected root disease centers and areas of scattered mortality were ground checked to verify photointerpretation by evaluating presence of root pathogens associated with tree mortality. Suspected diseased trees were examined at the root collar, and at least one lateral root was excavated and examined for signs and symptoms of disease. Associated fungi were identified in the field on the basis of signs and decay patterns (Partridge and Miller 1974); when field identification was not possible, wood samples were taken to the laboratory for isolation of fungi. Major bark beetle species were also noted. Several trees were sampled within and adjacent to each disease center to verify whether pathogens were responsible for the damage seen on transparencies.

Color transparencies were reinterpreted following ground checking to adjust for differences between initial interpretation and what was actually found in the field. Approximate margin of root disease centers was outlined directly on transparencies. The percentage of each stand occupied by root disease centers and scattered root disease mortality was determined from transparencies. Then this percentage was multiplied by the actual stand area that had been previously determined, with the resulting value being actual stand area occupied either by root disease centers or scattered root disease mortality.

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:

$$TRDh = \frac{\Sigma\ Dhi/Pi}{\Sigma\ Ahi/Pi}$$

where Dhi = area with root disease in stratum h and in subcompartment i; Ahi = area in stratum h and subcompartment i; and Pi = area of subcompartment i divided by commercial forest area of the Kootenai 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 $TRD_h$ to determine commercial area in root disease.

## RESULTS AND DISCUSSION

We estimate that more than 1,550 ha (3,830 acres) of commercial forest land of the Kootenai National Forest are within large active disease centers that can be discerned from aerial photographs (table 1) and are essentially out of timber production at the present time. This represents only 0.2 percent of the total commercial forest area and is much less than has been found in the other National Forests surveyed in the Northern Region (table 2).

Table 1.--Root disease incidence by photointerpretation strata for the Kootenai National Forest.

| Photo interpretation strata[1] | Forest area (ha)[2] | No. stands sampled | No. stands sampled w/ root disease | % stands w/ root disease | Weighted % of area w/root disease | Estimated forest area with root disease (ha) |
|---|---|---|---|---|---|---|
| 11 | 162,918 | 82 | 11 | 13.4 | 0.4 | 635 |
| 12 | 3,636 | 7 | 0 | 0 | 0 | 0 |
| 13 | 2,160 | 3 | 1 | 33.3 | 1.0 | 22 |
| 14 | 211,593 | 92 | 9 | 9.8 | 0.2 | 508 |
| 15 | 9,832 | 15 | 2 | 13.3 | 0.6 | 63 |
| 16 | 4,659 | 9 | 0 | 0 | 0 | 0 |
| 17 | 130,276 | 109 | 10 | 9.2 | 0.2 | 261 |
| 18 | 19,140 | 28 | 2 | 7.1 | 0.1 | 8 |
| 19 | 5,302 | 2 | 0 | 0 | 0 | 0 |
| 20 | 9,888 | 2 | 0 | 0 | 0 | 0 |
| 21 | 13,706 | 11 | 0 | 0 | 0 | 0 |
| 22 | 9,113 | 6 | 1 | 16.6 | 0.1 | 6 |
| 23 | 40,208 | 31 | 2 | 6.4 | 0.1 | 48 |
| 24 | 16,396 | 24 | 0 | 0 | 0 | 0 |
| 27 | 5,312 | 4 | 0 | 0 | 0 | 0 |
| TOTALS | 644,139<br>1,591,667 acres | 425 | 38 | 8.9 | 0.2 | 1,551<br>3,832 acres |

[1]See table 3 for descriptions.
[2]Forest area indicates only commercial forest land and excludes reserved, deferred, and nonforest areas.

Table 2.--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. | 12,161. | 5.1 |
| Kaniksu | 315,027. | 2,669. | 0.8 |
| St. Joe | 300,262. | 1,368. | 0.5 |
| Clearwater | 492,156. | 4,863. | 0.4 |
| Nezperce | 378,479. | 3,867. | 1.2 |
| Lolo | 655,614. | 8,011. | 1.0 |
| TOTAL | 2,379,979 | 32,939. | 1.4 |
| | 5,880,928 acres | 81,392 acres | |

We also estimate that another 5,360 ha (13,240 acres) contain scattered root disease-associated mortality of at least three trees per ha. This represents 0.8 percent of the commercial forest area. There is likely much more area with infected trees because estimates of tree infection from above-ground symptoms are probably conservative. Many infected trees do not display symptoms. For example, Wallis and Bloomberg (1981) recently found that only about half of the root-diseased trees they surveyed could be determined from above-ground indicators. Therefore, our estimates of root disease occurrence should be considered conservative and actual areas infected are probably greater.

Most stands with root diseases were within three photointerpretation strata: 11, 14, and 17 (table 1). These stands represent well-stocked, mature to overmature sawtimber, well-stocked small sawtimber, and two-storied stands with a well-stocked understory (table 3). In our survey of the Nezperce National Forest (James and Stewart 1981), most of the root disease was encountered in similar type stands.

Although root diseases were found throughout many portions of the Kootenai National Forest, they were especially prevalent within the Cabinet Ranger District in the southwest corner of the Forest (figure 1). This confirms findings of previous detection surveys and evaluations (James et al. 1982; James and Stewart 1982). In this area, the major root pathogen is *Phellinus weirii* (Murr.) Gilb. Principal hosts of this fungus are Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir (*Abies grandis* (Dougl.) Lindl.). Transect surveys of individual severely infected stands indicated that *P. weirii* was present on almost 25 percent of the trees surveyed (James et al. 1982). Average annual rates of mortality were estimated at 6.2 trees/ha (2.5 trees/acre) for trees more than 13 cm (5 inches) d.b.h. and 4.5 trees/ha (1.8 trees/acre) for regeneration. Disease centers associated with this fungus are surrounded by dead and dying Douglas-fir and grand fir and often contain extensive brush (figure 2). Susceptible conifer regeneration is usually killed before it reaches maturity. The fungus can be detected on individual trees from either characteristic laminate-type decay or ectotrophic mycelium on the outside of infected roots (figure 3).

Table 3.--Photointerpretation strata for the Kootenai National Forest timber inventory.[1]

| Stand height | Photo interpretation strata number | 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 poorly stocked |
| | 18 | Two-storied[4]; understory poorly stocked |
| | 19 | Cutover[5]; coarse textured[2]; well to medium stocked |
| | 20 | Cutover[5]; coarse textured[2]; well to medium stocked |
| | 21 | Cutover[5]; fine textured[3]; well to medium stocked |
| | 22 | Cutover[5]; fine textured[3]; poorly stocked |
| | 23 | Cutover[5]; two-storied[4]; residual overstory with a well or 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]; immature stand less than pole size. |

[1]Only photo interpretation 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.

Figure 2.--Root disease center caused by <u>Phellinus weirii</u>. Note presence of brush and trees in various stages of decline. Broken snags are also characteristic of <u>P. weirii</u> centers.

Figure 3.--White ectotrophic mycelium on a lateral root of Douglas-fir infected with <u>Phellinus weirii</u>.

Other major root pathogens we encountered on the Forest were Armillaria mellea Vahl. ex Fr. and Phaeolus schweinitzii (Fr.) Pat. Armillaria was common on Douglas-fir, grand fir, subalpine fir (Abies lasiocarpa (Hook) Nutt.) and occasionally lodgepole pine (Pinus contorta Dougl.). This fungus is also associated with regeneration mortality where it kills young trees adjacent to infected stumps (James and Stewart 1982). We found that ponderosa pine (Pinus ponderosa Laws) plantations are especially vulnerable to damage. Phaeolus schweinitzii was located within only two subcompartments, often associated with A. mellea. However, we believe that this fungus is much more prevalent because of the difficuly in diagnosing it without extensive root excavations and its common occurrence on nonsymptomatic trees. Apparently, trees initially infected with P. schweinitzii may later be attacked and killed by A. mellea (Dubreuil 1981).

Although black stain root disease caused by Verticicladiella spp. was not located in this survey, the disease has previously been found on the Kootenai National Forest. Black stain was first reported on the Forest within plantations of eastern white pine (Pinus strobus L.) near the Sylvanite Ranger Station (Leaphart 1960). The disease was subsequently found on lodgepole pine near these plantations (Williams 1971) and adjacent to the Yaak River Campground. Black stain is also a common disease on lodgepole pine within the southern interior forests of British Columbia (Hunt and Morrison 1980).

Several species of bark beetles were found on root-diseased trees (table 4). These included Douglas-fir beetle (Dendroctonus pseudotsugae Hopk.) on Douglas-fir, fir engraver (Scolytus ventralis LeConte) on grand fir, and mountain pine beetle (Dendroctonus ponderosae Hopk.) on lodgepole pine. We suspect that these beetles were attracted to trees weakened with root infection. Attacked trees were usually killed rapidly and beetle populations may increase on root-diseased trees (Furniss et al. 1979).

Root diseases were found in stands within 11 different habitat types (table 4). Most root-diseased stands were in the Pseudotsuga menziesii, Abies grandis, and Tsuga heterophylla series. Major habitat types with root diseases included Tsuga heterophylla-Clintonia uniflora, Abies grandis-Clintonia uniflora, Abies grandis-Xerophyllum tenex, and Pseudotsuga menziesii-Physocarpus malvaceus. Previous surveys in northern Idaho (James and Stewart 1981; Stewart et al. 1982) indicated that Pseudotsuga menziesii and Abies grandis series habitats were most commonly associated with root diseases.

## ROOT DISEASE MANAGEMENT

If root-diseased stands remain untreated or are managed improperly, losses can be expected to increase and productivity may be reduced throughout current and subsequent rotations. Since direct control of root diseases may be difficult and expensive, the usual goal of managing diseased stands is to design silvicultural prescriptions to reduce stand susceptibility or inoculum on the site.

Table 4.--Association of root diseases with habitat types of stands within the Kootenai National Forest.

| Series | Habitat type | No. stands with root disease |
|---|---|---|
| *Pseudotsuga menziesii* | PSMA/PHMA[1] | 3 |
| | PSMA/LIBO[2] | 2 |
| | PSME/VAGL[3] | 2 |
| | PSME/SYAL[4] | 2 |
| | PSME/CARU[5] | 2 |
| *Abies grandis* | ABGR/CLUN[6] | 4 |
| | ABGR/XETE[7] | 3 |
| *Abies lasiocarpa* | ABLA/CLUN[6] | 2 |
| | ABLA/XETE[7] | 2 |
| *Tsuga heterophylla* | TSHE/CLUN[6] | 8 |
| *Tsuga mertensiana* | TSME/MEFE[8] | 1 |

[1] *Physocarpus malvaceus*

[2] *Linnaea borealis*

[3] *Vaccinium glomerata*

[4] *Symphoracarpos albus*

[5] *Calamagrostis rubescens*

[6] *Clintonia uniflora*

[7] *Xerophyllum tenex*

[8] *Menziesia ferruginea*

Probably the most common silvicultural alternative in root-diseased stands is changing stand composition to favor those commercial species which are less susceptible to the pathogens present. Fortunately, not all conifer species are equally susceptible to root pathogens (table 5). Usually there are one or more species available which can be favored on heavily root-diseased sites. For example, on sites where *P. weirii* is common, such as the Cabinet Ranger District, western larch, lodgepole or ponderosa pine often survive well.

Table 5.--Relative susceptibility of Northern Region conifer species to root pathogens.

| Pathogen | Most susceptible | Moderately susceptible | Least susceptible |
|---|---|---|---|
| Phellinus weirii[1] | Douglas-fir<br>Grand fir | Subalpine fir<br>Western hemlock<br>Engelmann spruce | Lodgepole pine<br>Western white pine<br>Ponderosa pine<br>Western larch<br>Western redcedar |
| Armillaria mellea[2] | Douglas-fir<br>Grand fir<br>Subalpine fir | Ponderosa pine<br>Lodgepole pine<br>Western white pine<br>Western hemlock | Western larch<br>Engelmann spruce<br>Western redcedar |
| Phaeolus schweinitzii[3] | Douglas-fir<br>Ponderosa pine<br>Lodgepole pine | Grand fir<br>Subalpine fir<br>Western white pine | Western larch<br>Western hemlock<br>Western redcedar<br>Engelmann spruce |
| Verticicladiella spp.[3] | Douglas-fir<br>Ponderosa pine<br>Lodgepole pine | Western white pine | Grand fir<br>Subalpine fir<br>Western hemlock<br>Western redcedar<br>Western larch<br>Engelmann spruce |

[1]Based on observations by Hadfield and Johnson (1976). Minor changes were made to agree with observations in the Northern Region.

[2]Based on observations from southern interior forests of British Columbia by Morrison, (1981). Armillaria root disease. A guide to disease diagnosis, development, and management in British Columbia. Can. For. Serv., Pac. For. Res. Cen. Victoria, B.C., BX-X-203. 15 pp.

[3]Based on observations in the Northern Region.

Conversion to less susceptible species usually involves clearcuts or seed tree cuts. Past experience with partial cutting, including most shelterwood systems, has often resulted in increased mortality rates of residual trees in root-diseased stands. This is probably the result of root pathogens colonizing stumps created by partial cutting and forming sufficient inoculum to cause mortality of nearby trees. Partial cuts may also tend to favor regeneration with susceptible species such as Douglas-fir and grand fir. When pathogen complexes are present and few species alternatives are available, managers should favor those conifers which seem to be doing best.

Stands with root disease centers may be managed for susceptible species using the following guidelines. All susceptible trees within 30 m (100 ft) of disease centers should be cut. Since inoculum remains in stumps of infected trees a long time, stump removal will be necessary if susceptible species are planned for regeneration. On fairly level ground, bulldozers equipped with special brush blades can be used to lift stumps. Once infected stumps are out of the ground and allowed to dry, they are no longer hazardous to new tree crops. Chemical treatment of infected stumps to reduce infection hazard has not yet proven effective or economical. Other approaches to control of root diseases, such as broadcast burning during site preparation and breeding for disease resistance, have not been tested.

Most silvicultural guidelines developed for root diseases involve reducing on-site inoculum or decreasing stand susceptibility. Prescriptions dealing with root diseases should be site specific and should consider possible interactions of all hosts and pathogens present. The following guidelines[2] have been developed for managing stands infested with A. mellea and serve as an example of a general approach to root disease management:

1. If there are 10 or more root disease centers per hectare, precommerical thinning is not recommended because it will likely result in serious understocking. With this much root disease, we would expect accelerated losses, particularly of susceptible species.

2. If fewer disease centers exist, normal thinning can be done, except around the disease centers. Around these centers, trees should not be thinned or the least susceptible species should be left.

3. If a stand is heavily infected, commercial thinning should be excluded. Consideration should be given to harvesting the stand if net volume increment (growth minus mortality) is unacceptable.

4. If a stand is lightly infected, it may be commercially thinned. However, disease centers should receive special treatments, depending on the frequency of harvest or salvage operations in the stand. When stands can be entered at 5- to 10-year intervals, all dead trees and those with crown symptoms should be salvaged. If the interval between stand entries is greater than 10 years, all dead and symptomatic trees and those within 10 meters of symptomatic trees should be removed.

5. In stands heavily infected with root diseases, partial cutting is not recommended.

6. When harvesting infected stands, root pathogen inoculum can be eliminated from disease centers by removing all stumps and large roots from the ground with a bulldozer fitted with a brush blade. The site may then be regenerated to any desired species. An economic analysis of the benefits and costs of such operations should be completed prior to initiating these procedures.

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[2]Guidelines derived from Morrison (1981). They were developed for the southern interior forests of British Columbia.

7. If inoculum cannot be removed due to economic or terrain limitations, the least susceptible species should be favored. Clearcutting followed by planting is often required.

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