Phellinus (Poria) weirii Root Rot

The information accessed from this screen is based on the publication: Wallis G.W. 1976. Phellinus (Poria) weirii Root Root Rot. Detection and Management Proposals in Douglas-fir Stands. Environment Canada, Forestry Service. Forestry Technical Report 12 18p.

Preface

The root rot fungus Phellinus (Poria) weirii is causing serious losses in young stands of Douglas-fir in coastal and interior regions of British Columbia. The fungus survives for decades in colonized large roots and stumps in the soil to perpetuate the disease in future rotations (Fig). In the early stages of the infections, P. weirii is difficult to diagnose but wind-throw and deteriorating crowns will eventually indicate the location of root rot centers. The root rot usually continues to spread slowly throughout the life of the stand and, depending upon the incidence and distribution of the initial infections, may cause heavy losses by rotation age.

This report is designed to assist field foresters, in British Columbia, concerned with management of P. weirii infected Douglas-fir stands. A summary of management proposals relative to stand management phases is given at the start of the paper. This is followed by a description of fungus behavior and characteristics needed to identify the disease and its cause. Factors relative to disease behavior which may aid in deciding management strategies to be employed are outlined at the end.

Survey methods and factors to be used when predicting future losses are being developed and will be made available when completed. In the meantime, you are urged to seek advice from the Pacific Forest Research Centre, Canadian Forestry Service, 506 West Burnside Road, Victoria, when attempting to define the consequences of infection in stands and when wishing to undertake training sessions to familiarize personnel with the disease.

Management Proposals

Research findings have indicated a number of proposals that forest managers may use to reduce overall losses from P. weirii root rot; these are summarized below.

Acquaint all concerned management and field personnel with signs and symptoms of the disease. Acquire an accurate knowledge of the intensity and distribution of the root rot.

Regeneration Phase

Replacing over-mature stands

Identify and mark infected stumps when felling.

Remove infected stumps when feasible. Where it is not feasible to remove infected stumps, plant around infected material (inoculum) with a tree species less susceptible than Douglas-fir.

Slash burning will not significantly reduce the level of inoculum in the soil.

Replacing second-growth stands

Land clear when feasible. Where land clearing is not practical, plant infection centers plus a surround with a deciduous species, western red cedar or pine, as dictated by site conditions.

Precommercial Thinning Phase

Where disease centers are less than 10 trees in size and are widely scattered, consider extracting colonized roots and stumps from the soil. Leave species less susceptible than Douglas-fir as crop trees in and around root rot centers when thinning and spacing in stands with few infection centers.

Cutting or chemically killing trees in disease centers plus a surround, at least 4 trees wide, should effectively delay spread of the root rot.

Forego precommercial spacing in stands having an average of 10 or more root rot centers per hectare.

Fertilizers currently recommended for forest use do not appear to reduce disease development.

Commercial Thinning Phase

When a major portion of the increment is being lost to root rot, clear-cut stand (shortened rotation) or undertake salvage thinning operations.

To maximize the number of trees removed at each salvage cut and the period between cuts, familiarize marking and cutting crews with root rot symptoms.

Thin heavily infected stands only when selection of the final crop can be from a tree species less susceptible than Douglas-fir.

Large infected roots and stumps can be torn from the soil by pushing trees over when logging infection centers.

Information relevant to each of the management proposals is discussed in the final section of this paper, "Factors affecting management proposals".

Fungus Behavior

Phellinus (Phel-lin-us) weirii (Murr.) Gilbertson root rot is the most destructive disease known in young-growth Douglas-fir (Pseudotsuga menziesii (Mirb.)) Franco. In British Columbia, annual losses to mortality are estimated to exceed a million cubic meters (37 million cubic feet) (Wallis 1967) and, in the northwest United States, it causes an estimated annual loss of 0.9

million cubic meters (32 million cubic feet) in Douglas-fir west of the Cascades alone (Childs and Shea 1967). The disease occurs generally throughout the range of Douglas-fir in the province.

Phellinus weirii is native to the Douglas-fir region; however, its potential for causing heavy losses in young stands was not recognized until the 1920's. The insidious spread of the fungus on roots below ground, and its ability to survive for decades in old roots and stumps buried in soil, has frustrated researchers in finding an economic method for sanitizing infected sites (Fig).

The disease occurs in centers which originate, for the most part, when healthy roots contact the fungus in roots and stumps of the previous stand (Wallis and Reynolds 1965). The fungus can survive for at least a century in old Douglas-fir stumps (Childs 1963). The incidence and distribution of these old stumps is a major factor governing losses in the subsequent stands. In managing stands for root rot, it is essential, therefore, to know the location of these inoculum sources. Spores are probably inconsequential in spreading the disease (Nelson 1971). The fungus grows for only a short distance through soil; consequently, spread from tree to tree occurs only where a healthy and diseased root touch or are in close proximity.

Growth losses and mortality normally continue throughout the rotation (Fig); although highly variable, the average annual radial extension of infection centers will be 20 to 40 cm (Nelson and Hartman 1975). Enlarging and merging of centers can create infection centers which extend over several hectares.

Phellinus weirii can kill seedlings 1-2 years of age; however, disease centers will usually not be noticed until the stand reaches 10-20 years of age. Depending on tree size, crown symptoms will appear 5 to 15 years following initial infection, at which time the root system will be in an advanced stage of deterioration. The fungus kills trees by a successive infection of the roots, seldom girdling the root collar, as is characteristic of Armillaria mellea.

Acceptable accuracy in defining root rot centers, using aerial photography, has been obtained on pumice sites in central Oregon (Johnson and Wear 1975). However, additional tests are required before this tool will be applicable to stands along the Pacific Coast.

Replacement of Douglas-fir in disease centers with a less susceptible species, although undoubtedly causing some management inconvenience, is probably the most reasonable solution to P. weirii root rot on the majority of sites in British Columbia, at this time. A general rating of susceptibility of commercial trees to infection by P. weirii relative to that shown by Douglas-fir is as follows:

Resistant: deciduous species

Highly to moderately resistant: western red cedar (Thuja plicata Donn), pine spp.

Susceptible: Douglas-fir, true firs, spruces, western larch (Larix occidentalis Nutt.), western hemlock (Tsuga heterophylla (Raf.) Sarg.) An ability to recognize readily symptoms and signs of this disease is the first requisite in a management plan.

Disease Characteristics to Look For in the Field

Unless mortality has occurred, infection in over-mature stands will not be evident until the trees are cut. A characteristic red-brown stain and laminate (sheet-like) decay will usually be found on the stump top (Fig). The wood discolors within a few days after felling, at which time the stain will no longer be evident. The fungus can survive for many decades in old-growth stumps, providing inoculum for infecting subsequent stands reforesting the site.

When cruising young-growth stands, pay particular attention to trees with deteriorating crowns and wind-thrown trees (Fig) as evidence of root infection. Examine obviously unhealthy and adjacent trees for the following signs and symptoms to ascertain if P. weirii is the cause of the problem.

The first crown symptom is a reduction in leader growth; this is frequently difficult to discern in well-stocked stands of pole-sized and larger trees. In subsequent years, the foliage turns yellow and falls; death ensues shortly thereafter. Reddening of the foliage occurs on occasion, particularly if death is hastened by bark beetle attack. A distress crop of smaller than normal cones may also be produced. These crown symptoms are produced in response to most root disorders and should not be considered specific to P. weirii.

Trees may be wind-thrown before they show readily discernable crown symptoms. This usually occurs in older stands, but has been observed in stands as young as 20 years of age. When trees fall, the infected roots break close to the root collar, producing characteristic "root balls". Typical laminated, pitted decay will usually be found on the ends of broken roots. Callus tissue may also be observed on the ends of roots that were decayed for some period before the tree fell. If the tree has been down for some months, a brown crust-like fungus growth will frequently be present on the decayed wood.

Wind-thrown trees and trees with crown symptoms comprise only a portion of an infection center. Depending on tree age and size of infection center, many trees in the adjacent stand will be infected but will not show crown symptoms. A better appreciation of the total extent of an infection will be gained by examining the root collar of trees on the margins of the opening for mycelium. A brown crust-like mycelial growth often can be found below the duff layer, particularly in the crotches of roots. A grey-white to light mauve fibrous mass of mycelium envelopes the roots of most trees that are in an advanced stage of colonization. Some trees beyond those having mycelium at the root collar will be infected but an extensive exposure of the root system would be required to identify them.

Second-growth trees with well-established root rot, when cut, will usually have a red-brown stain and/or decay on the stump surface, occurring as irregular to crescent-shaped patches or throughout the outer heartwood. In living trees, the infection will not usually extend more than 2 to 4 meters (6 to 12 feet) up the bole.

In the advanced stages, the wood breaks down to a pitted, laminate decay fig). Brown, hair-like fungus filaments, best seen with a hand lens, and masses of brown mycelium can usually be found between the sheets of decayed wood, confirming P. weirii as the causal agent.

Phellinus weirii fruiting bodies are resupinate (flat), forming on the underside of downed stems and upturned roots. When young, they are light grey-brown with white sterile margins. Later they turn a uniform chocolate brown. The pore layer is coarse textured. In most years, fruit body development is rare.

Factors Affecting Management Proposals

The first requisite, before attempting management of stands for reducing losses caused by P. weirii root rot at any phase in stand development, is an ability to identify the disease and to obtain an accurate understanding of the extent of infection. All concerned personnel must be knowledgeable on signs and symptoms of the disease. Managers should be aware of current sampling techniques and seek advice as required.

Regeneration Phase

The incidence and pattern of infections in Douglas-fir stands following the over-mature crop will be closely correlated with the incidence and distribution of infected old stumps. In areas where old-growth is still being cut, one should take advantage of the opportunity to pinpoint future hazard spots. Mark infected stumps within 3 days after they are cut, before the wood discolors and the stain is no longer distinguishable. Except where the number of stumps is too high, so as to make the operation economically unacceptable, or terrain and soil type is unsuited, stump extraction machinery or blasting should be employed to remove this inoculum from the soil. Where it is not feasible to remove the infected stumps, the area, extending at least 30 meters (100 feet) beyond the outermost infected stumps, should be planted with a species less susceptible than Douglas-fir. This is particularly critical where the incidence of infected stumps is high and the distribution is scattered.

Many root rot infection centers in young-growth stands growing on land previously carrying over-mature stands. occur on sites burned prior to restocking. Slash burning can not, therefore, be expected to significantly reduce the level of inoculum in old-growth stumps and roots buried in the soil. In addition, a recent hot burn through a pole-sized stand of Douglas-fir showed that P. weirii could survive in roots of second-growth trees covered with just a few centimeters of soil, even though the upper portion of the root was badly charred. In laboratory studies, P. weirii did not survive in buried wood blocks beyond 1 day at a temperature of 39 C (102 F) and beyond 8 days at 32 C (90 F) (Nelson and Fay 1974). Assuming these relationships apply in the field, insulation by soil and root bark is apparently sufficient to protect the fungus against the high temperatures reached during fires.

Replacing Second-growth Stands

Land clearing will satisfactorily sanitize an infected site so that future rotations of Douglas-fir or other susceptible species will be relatively free of P. weirii root rot. Studies in the Kamloops

and Vancouver Forest Districts have shown that land clearing, which includes careful root raking to a depth of at least 60 cm, will remove the majority of inoculum. Broken infected material left on the site is rapidly colonized by secondary organisms so that by the time healthy roots contact it, the pathogen is dead. Piling infected stumps and roots will be necessary to allow satisfactory root raking of the site. Burning the piles is not required provided seedlings are not planted in the vicinity of the piles; burning would, however, destroy the disease and allow planting over the entire area.

Complete-tree utilization should also be effective in substantially reducing the level of inoculum in soil. However, the specific method of stump and root removal will determine whether results similar to those obtained by land clearing are obtained. Where stumps are pulled from the ground, considerable portions of the decayed roots may be left in situ. Even though broken at the top, a longer period will be required for replacement of the pathogen in these roots than if they were broken in small pieces. Where stumps are bulldozed from the soil, results similar to land clearing should be obtained, provided infected old-growth stumps are also removed.

Replanting infection centers with a species less susceptible than Douglas-fir should also be given high priority. This would require delineating root rot centers at the time the stand was cut, unless it was intended to replace Douglas-fir over the entire area of the cut. Again, Douglas-fir should not be planted within 30 meters (100 feet) of an infected stump.

Studies have shown that deciduous species have a high degree of resistance to infection by P. weirii. Alder (Alnus rubra Bong.) has received the most attention for planting in infection centers in coastal stands because: 1) it is resistant to infection by P. weirii, 2) the survival period of P. weirii in roots in soil beneath alder may be reduced (Nelson 1968), and 3) alder adds significantly to the fertility of the site on which it is growing (Tarrant 1961; Tarrant and Miller 1963). Phenolic acids inhibitory to P. weirii have been isolated from the roots of red alder (Li et al. 1972) and from soil beneath these trees (Li et al. 1970). Inoculation trials, undertaken by the author in mixed alder-Douglas-fir and pure Douglas-fir stands, showed a reduced survival of the pathogen in the inoculum accompanied by about one-third the level of infection in the mixed versus the pure stand. Observations on natural infection centers in mixed alder-Douglas-fir stands, however, suggest caution in interpreting the above results too broadly. *Phellinus weirii* infections of Douglas-fir roots intermingled with alder roots in 40-year-old mixed stands did not appear to be inhibited. *Phellinus weirii* was still viable in roots as small as 4 cm in diameter of old-growth stumps in these stands. If the alder is to be replaced with Douglas-fir, and the previously infected material was sawtimber and old-growth stumps, two rotations (60-80 years) of alder will probably be required.

Bigleaf maple (Acer macrophyllum Pursh) was also shown to be resistant to infection by P. weirii in inoculation trials undertaken by the author.

When restocking disease centers with conifer species, western red cedar should receive high priority on suitable sites. Cedar shows a high resistance to infection; when infection is successful, decay is usually confined to the butt, and killing and wind-throw are rare. Growth of mycelium on the surface of cedar roots is very limited.

Although occasionally harboring infection, pine species have usually resisted attack by P. weirii when restocking root rot centers. Inoculations of lodgepole pine (Pinus contorta Dougl.), western white pine (Pinus monticola (Dougl.) and ponderosa pine (Pinus ponderosa Laws.), using woodblock inoculum, were unsuccessful, even though 50% of the roots of Douglas-fir and western larch inoculated at the same period were killed or contained decay (author, unpublished). Also, examination of the root system of 11 sawtimber white pine trees growing adjacent to infected Douglas-fir and western larch showed this species to be a good candidate for planting on infected sites.

Western hemlock, when growing in pure stands, has not suffered significant losses from P. weirii root rot. However, when growing in mixture with infected Douglas-fir, disease incidence can be high. Hemlock has a higher resistance to root killing by P. weirii than does Douglas-fir, butt rot being more common. The rate of spread of the pathogen on the root bark surface of hemlock is similar to that on Douglas-fir.

Studies by Childs (1970) and the author have shown that mountain hemlock Tsuga mertensiana (Bong.) Carr.) and the true firs can suffer losses similar to those sustained by Douglas-fir. Extensive disease centers have been recorded in pure stands of western larch and when this species is growing in association with infected Douglas-fir. Natural infections of Engelmann spruce (Picea engelmannii (Parry) have been observed on only a few occasions, but this species proved highly susceptible in inoculation trials. Sitka spruce (Picea sitchensis (Bong.) Carr.) is infected when associated with highly susceptible species (Childs 1970).

Precommercial Thinning Phase

In most instances, P. weirii symptoms will not be obvious by the time stands are ready for precommercial spacing. However, if small centers of dead and dying trees are common, about 10 or more per hectare (4 or more per acre), and the cause is P. weirii, do not space. Realizing that the fungus can survive for many years in small roots and that only a portion of the infected trees can be recognized from above-ground symptoms, spacing will act as a delaying action at best; many of the trees designated at this stage for the final crop will be lost to root rot. Delay thinning these stands until they are ready for commercial thinning, at which time disease symptoms will be more advanced and a more accurate appraisal of disease intensity will be possible.

In stands having only a few widely scattered infection centers, extracting infected stumps and roots will retard spread of the disease. This operation should be done as soon as the symptoms become evident, when the roots are still small. A surround, at least two trees wide beyond trees showing symptoms, must be included. To sanitize the area, it would be necessary, of course, to remove the infected stumps of the previous crop from which the disease was initiated. Cutting or chemically killing trees in these centers, plus a surround at least 4 trees wide, will effectively delay spread of the disease until roots of surrounding trees extend sufficiently to contact the fungus.

Effectiveness of fertilizers currently recommended for forest use in reducing survival and

spread of the pathogen in the forest is still under investigation. Nelson (1970), in greenhouse trials, showed a striking reduction in survival of P. weirii in small wood blocks buried in soil into which he had mixed NH4 and NO3 forms of N, compared to untreated soil. Application of these fertilizers at 168,336 and 674 kg N/ha (150, 300 and 600 lb N/acre) to field plots, however, failed to produce conclusive results. Nelson (1973), following a broadcast application of urea at a rate of 674 kg N/ha to soil in a Douglas-fir stand, concluded that survival of P. weirii was affected in wood blocks buried to a depth of 23 cm. He attributed the reduced survival to a stimulation of soil microorganisms antagonistic to P. weirii to invade the Phellinus-colonized blocks. Two years following application of urea and NO 3 fertilizers to P. weirii infection centers in a 25-year-old Douglas-fir plantation at a rate of 448 to 2242 kg N/ha (400 to 2000 lb N/acre), vigor of the surviving infected trees was improved but tree mortality caused by the pathogen continued and fungus growth on the roots was vigorous (Wallis and Reynolds 197A). Further tests to determine the effects of a wide range of chemicals on growth of P. weirii are in progress.

Commercial Thinning Phase

Where root rot is well established in pole-sized and larger timber, probably less than half of the infected trees can be recognized from above-ground symptoms. Height and diameter growth of infected trees will probably start to decrease 8-10 years prior to death and will have almost ceased by the onset of advanced crown symptoms. Butt rot is usually confined to the lower 2-4 meters of the bole of live trees.

Where root rot is significantly reducing the growing stock, consideration should be given to clear-cutting the stands, or at least to undertaking periodic salvage cuts to remove dead and dying trees. Thinning in these stands will seldom prove to be a wise management decision unless sufficient numbers of trees of a species less susceptible than Douglas-fir are left to form the final crop. Thinning in heavily infected stands will be followed by frequent wind-throws and death of a major portion of the crop trees. For example, a 50-year-old Douglas-fir stand in which root rot centers were frequent was thinned to 60% of its original volume and growth plots were established in what appeared to the manager to be disease-free areas. Twenty years following treatment, when the study was terminated, 23% of the crop trees on the plots had been killed and an additional large number were showing reduced growth because of advanced root rot. A clear-cut in 2 hectares (5 acres) of this stand at the termination of the thinning study showed that 70% of the remaining trees had advanced infection, as seen by decay and stain on the stumps.

The necessity of having marking and cutting crews familiar with disease symptoms and signs when undertaking management operations in an infected stand was emphasized following a thinning in a 35-year-old Douglas-fir stand where crews unfamiliar with the disease were used. After thinning, 24 root rot centers were chosen at random in which 435 infected stumps and wind-thrown trees were recorded. One year following treatment, 40 additional trees were dead or showed crown symptoms and should have been salvaged; by 8 years, this had increased to 156 trees.

A cursory inspection of the root collar of trees surrounding obvious infection centers will significantly improve accuracy in estimating disease occurrence on most sites. Failing this, a rule of thumb suggested by Childs and Nelson (1971) may be employed: "In stands of poles and sawtimber, trees within 15 feet (4.6 meters) of a tree killed by laminated root rot are usually infected. The further a living tree is from a killed one, the less likely it is to be infected; at distances of 50 feet (15.3 meters), infection from the same source is uncommon."

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Figures

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Figure 237-0098. Decayed root, Phellinus weirii.

Figure 237-0097. Western hemlock killed by Phellinus root rot.

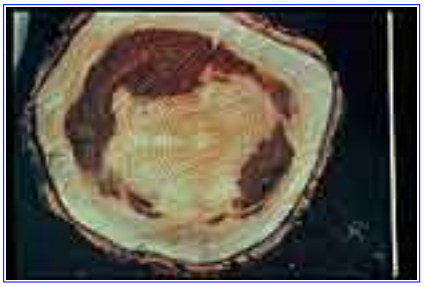

Figure 237-0099. Cross section of Douglas-fir with Phellinus root rot.

Figure 237-0100. Blowdown and root balls with Phellinus root rot.
