Extension Note

BC Journal of Ecosystems and Management

Southern Interior Forest Region

Laminated root disease Stand Establishment Decision Aid

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Introduction

Laminated (or Phellinus) root disease (*Phellinus sulphurascens* Pilát, syn. = *P. weirii*) is a major, naturally occurring disturbance agent in interior forests and poses a significant threat to its most economically important host, Douglas-fir. The disease spreads below ground at root contacts. In the southern interior of British Columbia, *P. sulphurascens* often occurs together with Armillaria root disease (*Armillaria ostoyae*) and (or) Douglas-fir bark beetle (*Dendroctonus pseudotsugae*). Stand volume in infested areas can be significantly reduced through growth loss and decay, mortality, and windthrow. Post-harvest retention of infected stumps in the soil increases inoculum potential on affected sites, which poses a risk of infection to regenerating trees. Mitigation of disease impacts can best be achieved by recognition of the disease and incidence assessment prior to harvest, and by modification of harvesting and silviculture practices that will minimize exposure of trees to inoculum.

The Stand Establishment Decision Aid (SEDA) format has been used to extend information on various vegetation and forest health concerns in British Columbia. This decision aid summarizes information about laminated root disease occurrence and management in the Southern Interior Forest Region. The first sections provide general information, hazard ratings, and biological and silvicultural considerations for Phellinus root disease. The article then outlines growth and yield implications, other effects and associations of the disease, and various techniques to manage the disease. It also includes a list of references and resources to provide readers with more detailed information. Reference material that is not available online can be ordered through libraries or the Queen's Printer at *http://www.qp.gov.bc.ca*.

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KEYWORDS: *forest health; forest management; laminated root disease;* Phellinus sulphurascens*;* Phellinus weirii*; root disease management.*

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Phellinus root disease centre

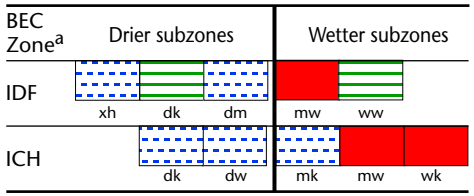
Characteristics of susceptible stands

- Newly established and managed stands of highly susceptible conifers, mainly Douglas-fir and true firs (*Abies* spp.) (see Table 1).
- Preceding stands infested, especially stands located in the Interior Douglas-fir (IDF) biogeoclimatic zone in the Cascades, Kamloops, and Okanagan-Shuswap forest districts, and stands located in the Interior Cedar–Hemlock (ICH) biogeoclimatic zone in the Kamloops, Okanagan-Shuswap, and Arrow-Boundary forest districts.

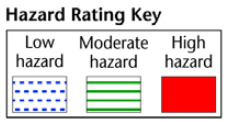
General information

- It has been proposed that the Douglas-fir form of *Phellinus* (formally known as *P. weirii*) should be called *P. sulphurascens* and the species occurring on western redcedar should be called *P. weirii*.
- *P. sulphurascens* is a facultative parasite. During its parasitic phase the fungus will invade and kill host tissue and spread to adjacent trees via root contact. When trees die, the fungus survives as a saprophyte in stumps and roots. Infection by spores is very rare.
- Large infested stumps can serve as a viable inoculum source for many decades.
- The distribution of disease appears random but is distinctly aggregated based on the location of previous suitable hosts. Disease centres may range from a few trees to an area several hectares in size.
- *P. sulphurascens* may be coincidentally associated with other root diseases such as *Armillaria ostoyae*. Refer to the Armillaria root disease Stand Establishment Decision Aid: *http://www.forrex.org/jem/ISS48/vol9_no2_art7.pdf* (Cleary et al. 2008).
- The disease may manifest as small groups of symptomatic and dead trees in young and old, naturally regenerated stands and plantations.
- Distinct openings in the canopy of mature forests caused by tree mortality and windthrow can result in forest cover changes, especially in stands within the ICH zone. Disease presence may be masked in stands by the ingress of short-lived, broadleaved species and a gradual species shift to low-susceptibility species like western redcedar. Also, Douglas-fir bark beetle may preferentially attack trees infected with *P. sulphurascens* or *A. ostoyae*.

Hazard ratings[1]



[a] See Meidinger and Pojar (1991) for an explanation of Biogeoclimatic Ecosystem Classification (BEC) zone, subzone, and variant abbreviations.



[1] Hazard is defined as the likelihood of disease presence in an ecosystem. Hazard ratings apply only to Douglas-fir-leading stands and are based on survey results from Canadian Forest Service data records, forest health landscape-level surveys in the Okanagan Timber Supply Area, and FSP–FIA project #103130 conducted by the authors. Only those biogeoclimatic zones in which the disease is prevalent are considered here. Laminated root disease can be present in the Montane Spruce (MS) and Engelmann Spruce–Subalpine Fir (ESSF) zones, but there is insufficient information on disease occurrence and intensity to apply a hazard rating to those ecosystems.

Host Susceptibility Table

TABLE 1. Levels of host susceptibility[a] to laminated root disease by biogeoclimatic[b] zone

Species[c]	IDF	MS	ICH	ESSF
Fd	H	H	H	–
Bl	–	M	M	M
Bg	H	–	H	–
Hw	–	–	M	M
S	M	M	M	M
Py	T	–	T	–
Pw	–	–	T	–
Pl	T	T	T	T
Lw	M	M	M	–
Cw	L	–	L	L
Ep	I	I	I	–
At	I	I	I	I
Ac	I	I	I	I

[a] Levels of susceptibility: **High susceptibility (H)** = trees are readily infected and killed; **Moderate susceptibility (M)** = trees are readily infected but usually not killed and may have extensive decay in the lower portion of the tree; **Low susceptibility (L)** = trees are rarely infected and almost never killed; **Tolerant (T)** = trees are infrequently infected unless growing in association with susceptible hosts, but if they become infected they are rarely killed; **Immune (I)** = trees are never infected.

[b] Only those biogeoclimatic zones where the disease is known to occur in the Southern Interior Forest Region are considered. Ratings are only provided for species common in and suitable for the respective zones.

[c] For explanation of tree species abbreviations, go to *http://www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-species.html* and click on "Download BC Tree Code List."

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Diagnosis

- Above-ground symptoms of disease on individual trees are variable and include reduced terminal growth, thinning of crowns, chlorosis of foliage, and a stress-induced cone crop. Crown symptoms may also depend on the amount of advanced decay in affected roots and (or) stems. Other root pathogens induce similar crown symptoms; therefore, closer examination of the root collar area and individual roots for signs of *P. sulphurascens* (see below) is recommended. Unlike with Armillaria, basal resinosus on conifers infected with *P. sulphurascens* is rare.
- Windthrow in mature forests occurs when extensively decayed major roots fail and the tree loses structural support. Advanced heartrot may also structurally weaken infected trees, causing stem breakage. Windthrown trees fall in random directions, gradually creating root disease centres with a criss-cross pattern of fallen trees. Downed trees may have a distinct compact "root wad" or "root ball" with few or no roots. Callus may be evident on infected roots and adventitious rooting may be observed from or near this callus tissue.

Symptoms of Phellinus root disease on broken roots

- A sheath of grey-white, tawny-brown, or mauve-coloured ectotrophic mycelium can often be found on the surface of infected roots, especially those occurring in mineral soil, and on bark surfaces near the root collar.
- Incipient decay appears as a red-brown stain in the wood, along the sapwood/heartwood boundary of fresh-cut stump tops, or in cross-sections of roots.
- Advanced decay is a white rot that appears as small oval pits that eventually leads to separation (delamination) along annual rings. Red-brown, hair-like (setal) hyphae may form in pits between layers of wood. Setal hyphae are usually visible with a hand lens; clumps of setal hyphae are visible to the naked eye.
- Fruiting bodies of *P. sulphurascens* appear to rarely form and thus are rarely seen, especially in drier interior ecosystems. If formed, they generally occur on the underside of boles of fallen trees or on undersides of uprooted stumps.

Harvesting and silviculture considerations

- The longevity of inoculum in stumps left in the ground after harvest increases the potential risk of infection in regenerating trees.
- Indiscriminate regeneration with highly susceptible conifers may result in considerable mortality and volume loss over a rotation.
- Stand treatments should be prescribed after a visual assessment for the presence of root disease. A systematic survey should be conducted to determine intensity and distribution (aggregation) of root disease(s). Surveyors should have knowledge of stand- and tree-level symptoms for both Phellinus and Armillaria root diseases, given the large overlap in their distribution.
- Treatment strategies to mitigate future losses in stand productivity include inoculum reduction (stump removal, also known as stumping) or regeneration with tolerant, resistant, or immune hosts. When no treatment strategy is suitable or available, a significant yield reduction should be expected.
- For productive sites, if disease distribution is suitably aggregated, stratify out treatment unit(s). Treatment units should include clearly defined infection centres, plus a buffer of disease-free trees. Adjacent areas may be left untreated.
- Use of alternative silvicultural systems (e.g., selection harvesting, commercial thinning), which can lead to increased inoculum and faster disease spread, should be given careful consideration even though the relationships between partial cut systems and root disease dynamics and possible impacts on productivity are not well quantified.
- Root disease assessments should be conducted prior to small-scale salvage operations for Douglas-fir beetle as root diseases are often found in association with this bark beetle.
- Free-growing surveys are not practical for projecting root disease levels in the long term, especially since tree mortality in newly established stands does not typically peak until after the free-growing survey window (i.e., 12–15 years).

Regeneration/Establishment

Site preparation

- The impact of laminated root disease in new plantations can be reduced by mechanically removing inoculum (infected stumps and roots) from the soil during or after harvest of the previous stand. Stumping operations are limited by various site constraints, such as adverse slope or the presence of soils unsuitable for machine traffic. Only stumps of highly susceptible species (e.g., Douglas-fir) need to be removed.

Planting

- When inoculum removal is not an option, regeneration of stands with less susceptible host species is preferred (see Table 1). Choice of species may be limited by their ecological suitability.
- Highly or moderately susceptible species growing near infected stumps may become infected and killed within a few years.
- Where possible, natural regeneration of low-susceptibility, tolerant, or immune hosts (e.g., western redcedar or hardwoods) should be encouraged to increase density and species diversity.

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Regeneration/Establishment (continued)

Plantation maintenance

- For plantations that have sustained high mortality early in stand establishment, consider increasing stocking levels by fill-planting disease centres with less susceptible species.
- When pre-commercial thinning infected stands, retain low-susceptibility, tolerant, or immune tree species that can serve as a barrier to disease spread between root systems of susceptible host species.
- For commercial thinning operations in stands where root disease distribution is clearly aggregated, target harvest operations in areas where infected centres, including an adjacent buffer, are clearly delineated in order to reduce disease spread.
- Avoid thinning in areas where the disease is widely dispersed as it is likely that asymptomatic but infected trees will be retained and subsequently killed.

Potential productivity implications

- In southern interior forests, the distribution of laminated root disease is usually aggregated and observed as distinct centres typically within larger infected areas. Disease centres in young to mid-rotation stands are characterized by single or small clumps of dead and symptomatic trees. Older stands may have reduced vigour, and infected areas are characterized by windthrown trees.
- The scattered killing of Douglas-fir overstorey by *P. sulphurascens* can create structural diversity. The disease can also drive the rate of ecological succession of stands, particularly in the ICH zone. Over time, stand openings become occupied with species that have lower susceptibility to the fungus.
- Inoculum (stumps and roots) left intact and in the ground after harvest will directly impact site productivity and harvestable yield through tree mortality and volume losses in trees that sustain non-lethal infections. Stumping will reduce this long-term impact.
- Results from an operational stumping trial in the Okanagan-Shuswap timber supply area show that after 40 years, stumping reduced Douglas-fir mortality caused by Phellinus root disease by nearly 100%, compared to unstumped plots (D. Morrison, pers. comm., May 14, 2011). Stumping is recommended only for sites with a slope of < 35% and soils with low to moderate hazard rating for mass wasting, erosion, compaction, and soil displacement. To minimize site disturbance, stumping should be done by operators experienced at removing stumps and push-falling trees.
- For timber supply purposes, an operational adjustment factor (OAF2) for the TASS/TIPSY growth and yield model for Phellinus root disease applicable to Douglas-fir timber types in the IDF and ICH zones for southern interior districts is being developed (contact authors for more information).

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Test Your Knowledge . . .

Southern Interior Forest Region: Laminated root disease Stand Establishment Decision Aid

How well can you recall some of the main messages in the preceding Extension Note? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. What are the diagnostic signs of laminated root disease on affected roots?
   A) Grey-white, tawny, or purplish ectotrophic mycelium
   B) Reddish-brown stained wood and delaminations along annual rings
   C) Brown setal hyphae in pitted, decayed wood
   D) All of the above

2. Which of the following conifers is *not* considered to be susceptible to laminated root disease?
   A) Douglas-fir
   B) Western redcedar
   C) True firs
   D) Spruce

3. Which of the following is *not* considered a practical treatment option for laminated root disease?
   A) Stumping
   B) Planting with low-susceptibility, resistant, or immune species
   C) Trenching around disease centres
   D) The "do nothing" approach and anticipate a yield reduction at rotation

ANSWERS

1. D 2. B 3. C