

Root Diseases

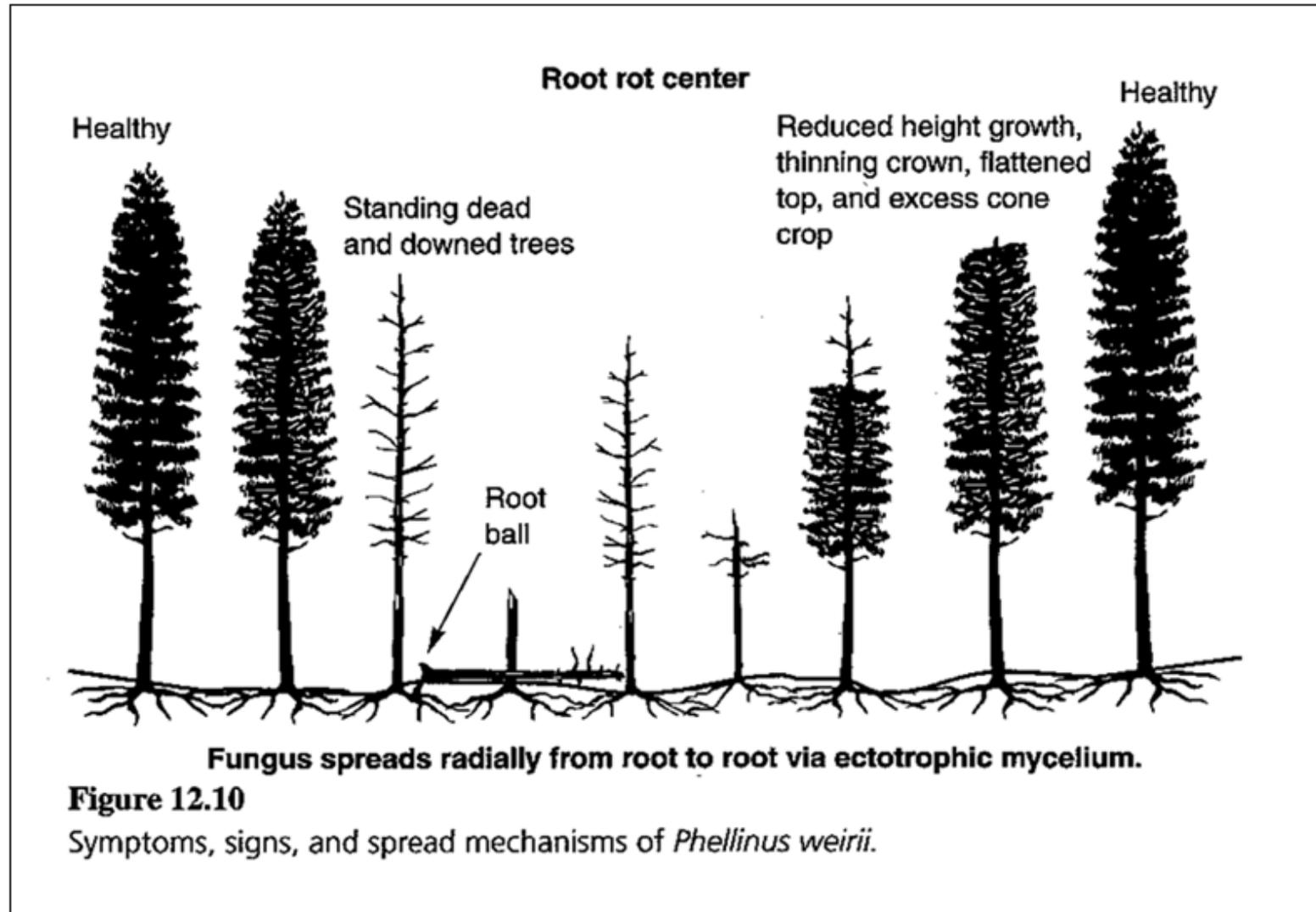


Diagnosis of root diseases can be very challenging

- Symptoms can be similar for different root diseases
- Below ground attacks but above ground symptoms
- Signs are rare and often are produced once a year for short periods



Chronosequence of stand and tree level symptoms of root diseases



Tree level symptoms of Armillaria root disease



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Tree level symptoms of Armillaria root disease

- Dead saplings next to stumps, retaining needles
- Roots of young trees grow into the dead roots infected by Armillaria, come into contact with rhizomorphs and get infected

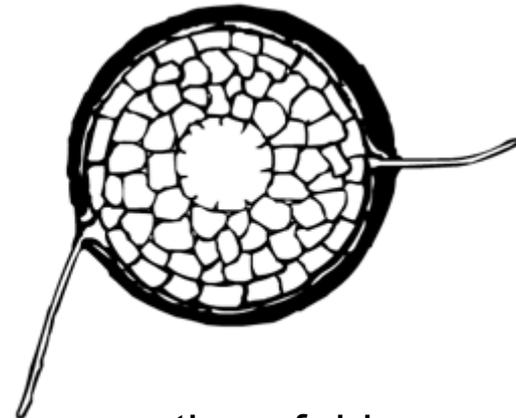


Signs of Armillaria root disease

- Rhizomorphs: specialized highly adapted structures
- Allow the pathogen to explore the environment and survive in the soil for decades
- Contain melanin, a protective compound



"Rhizomorphs (thick fungal threads) of *Armillaria mellea*" Lairich Rig. CC BY-SA 2.0.
<http://www.geograph.org.uk/photo/933530>



Cross section of rhizomorph showing differentiated tissue

Signs of Armillaria root disease

- Armillaria attacks the living cambium of tree roots
- Mycelial fans form under the bark of infected trees
- The mycelium is very strong and can grow under and lift the bark, leaving imprints



UC Statewide IPM Project
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Signs of Armillaria root disease

- Carpophores (fruiting bodies) are honey colored mushrooms
- Belong to the Agaricales (gill fungi!)
- Spores can be spread by air, over long distance, to establish new infection centers

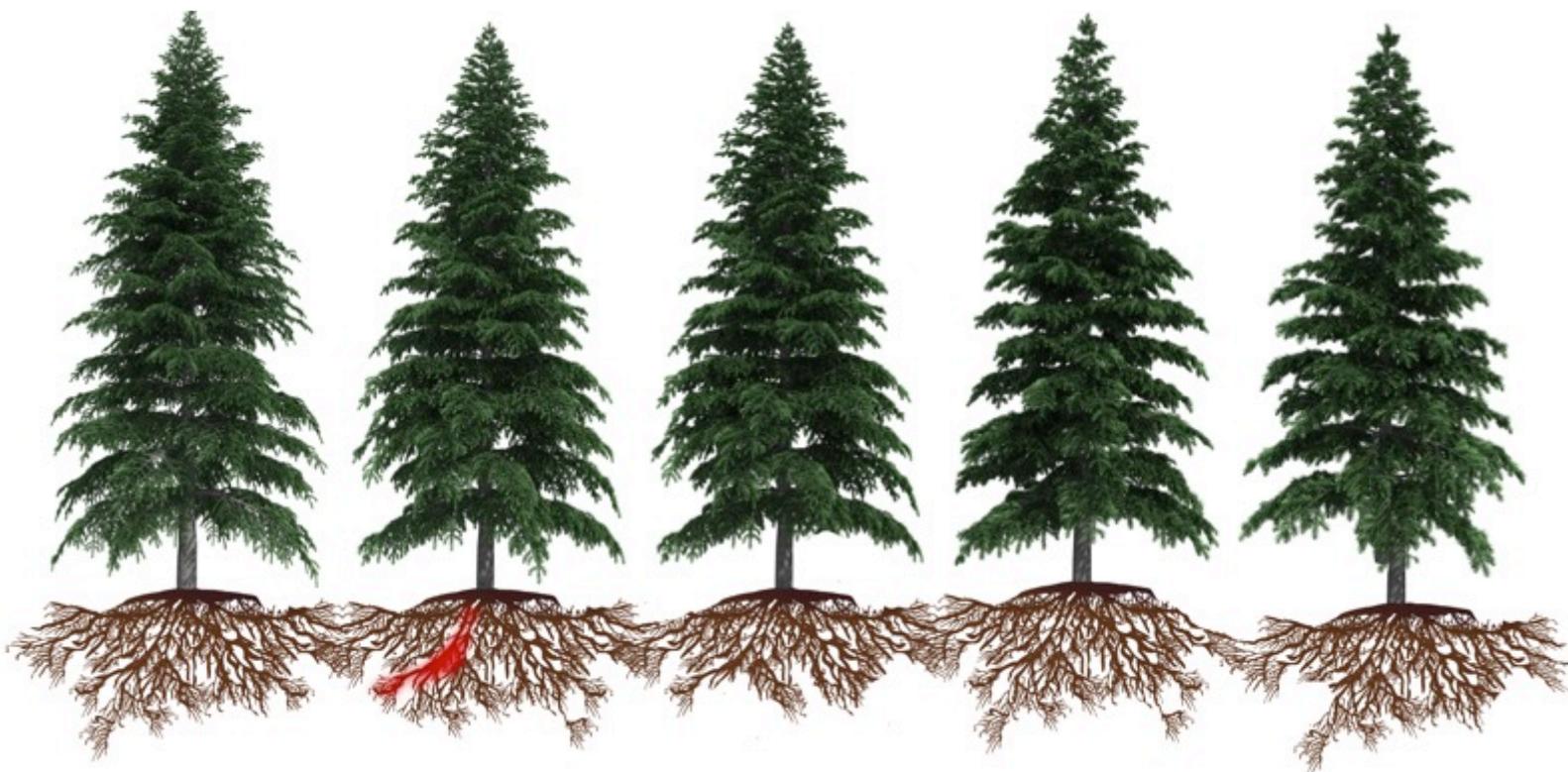


Most root disease problems originate from human actions

- Logging generates ideal conditions for root pathogens to take over and occupy a niche
- Fresh stumps are something that does not occur in nature; some root pathogens have adapted to it



Selective or partial cutting favor Armillaria root disease



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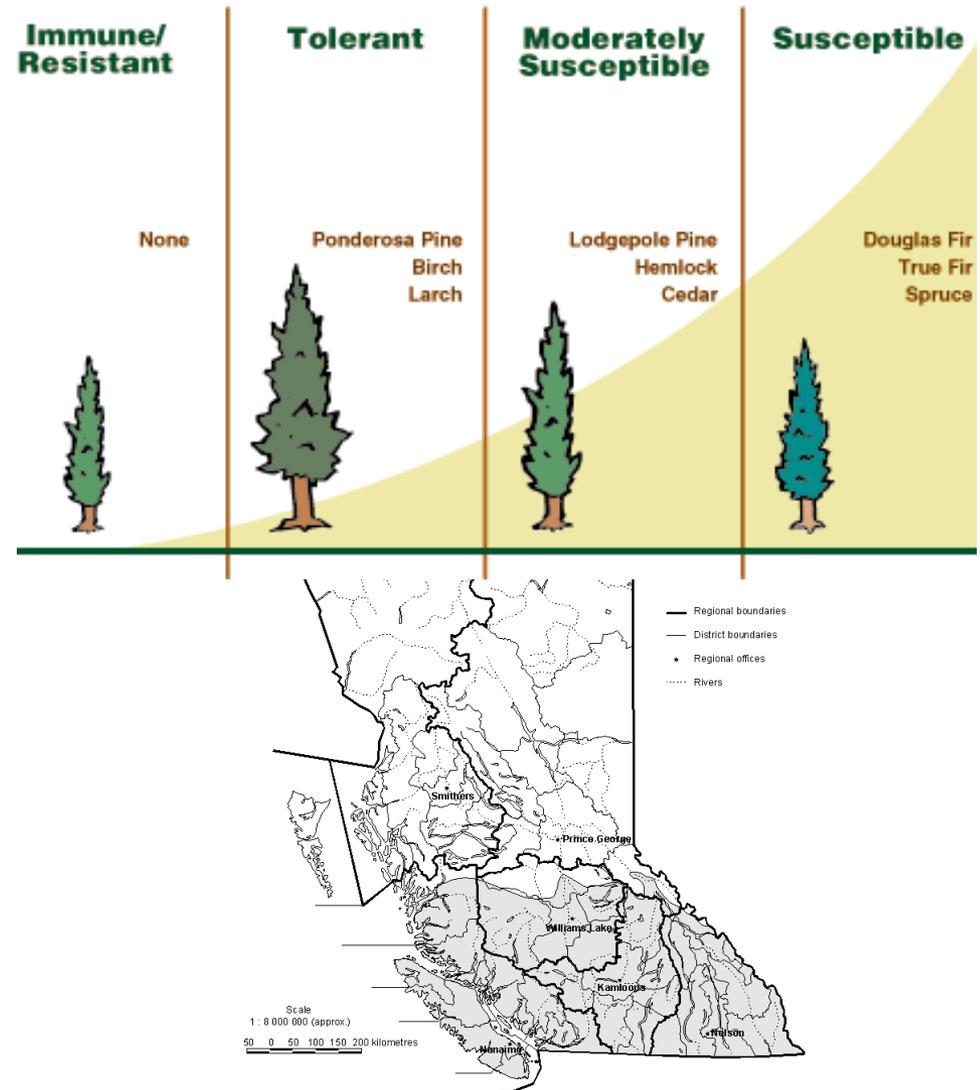


Selective or partial cutting favor Armillaria root disease



Hosts of Armillaria root disease

- No tree is immune or completely resistant to Armillaria root disease
- Firs and spruce are the most susceptible and pine, birch and larch are more resistant, but they can all be attacked under the right conditions



Armillaria root disease severity depends on BEC Zones

Tree species	BEC Zones						
	Species ^c	PP	IDF	MS	ICH	SBS	ESSF
Douglas fir	Fd	M	H	H	H	H	-
	Bl	-	-	H	H	H	H
	Bg	-	H	-	H	-	-
	Hw	-	-	-	H	-	H
	S	-	M-H	M-H	M-H	M-H	M-H
	Py	M	M	-	M	-	-
	Pw	-	-	-	M	-	-
Lodgepole pine	Pl	-	M	M	M	M	M
Western red cedar	Lw ^d	-	L	L	L	-	-
	Cw ^b	-	L	-	L	-	L
	Ep ^e	-	L	L	L	L	-
	At ^e	-	L	L	L	L	L
	Ac	-	L	L	L	-	L

H=highly susceptible
M=Mildly susceptible
L=Low susceptibility

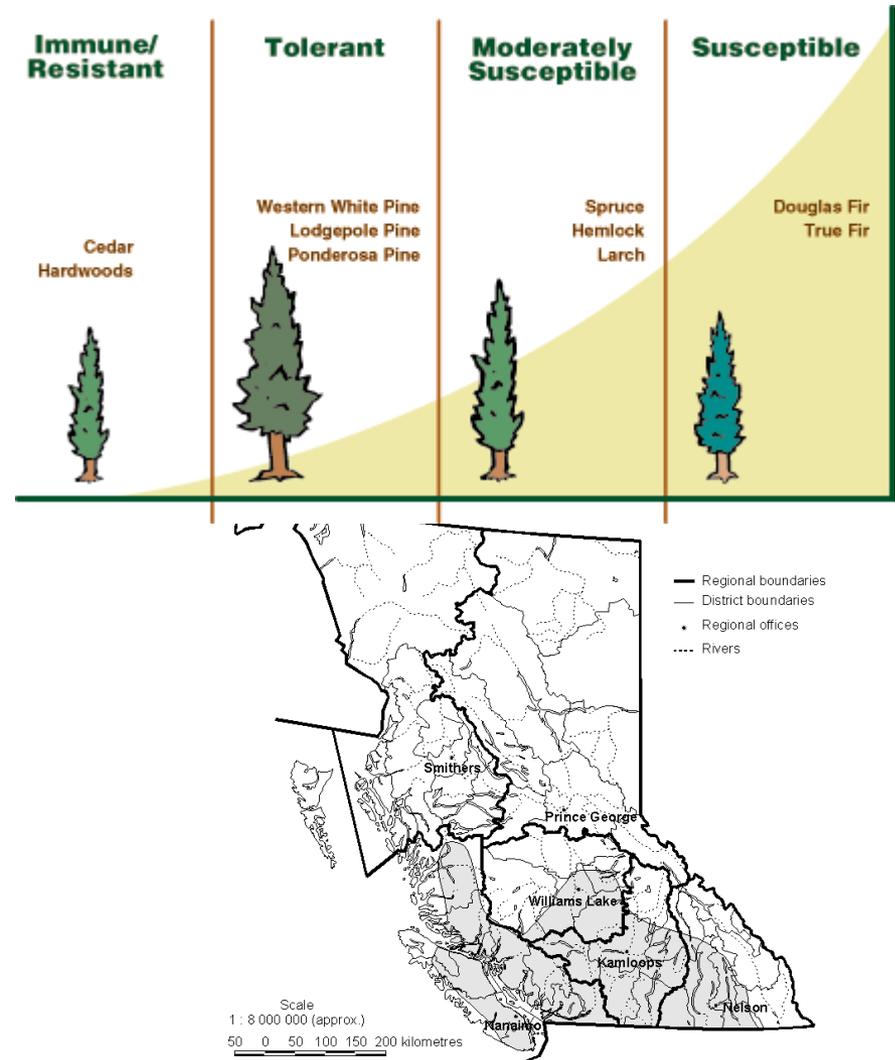
Armillaria root disease reduces growth cumulatively

- Within 10 years growth rings are reduced, up to 40% growth losses in 35 years
- Pitching episodes can be seen, where the tree has effectively slowed the fungus spread



Laminated root rot

- Causal agent:
Phellinus sulphurascens
- Host: Douglas fir, hemlock, spruce
- Geographic range: follows the distribution of Douglas-fir
- Different species on cedar: *Phellinus weirii*



Laminated root rot stand level symptoms

- Infection centers creating gaps, with chronosequence pattern
- Species composition shift: deciduous trees, western red cedar replacing Douglas fir and western hemlock



Laminated root rot stand level symptoms

- Root balls, caused by tree roots being decayed and providing no more support
- Fallen trees crisscrossed; by contrast, wind-throws would be fallen in same direction, usually at the edge of stands



Laminated root rot tree level symptoms

- Delamination, caused by selective delignification
- Incipient decay showing reddish to brown discoloration



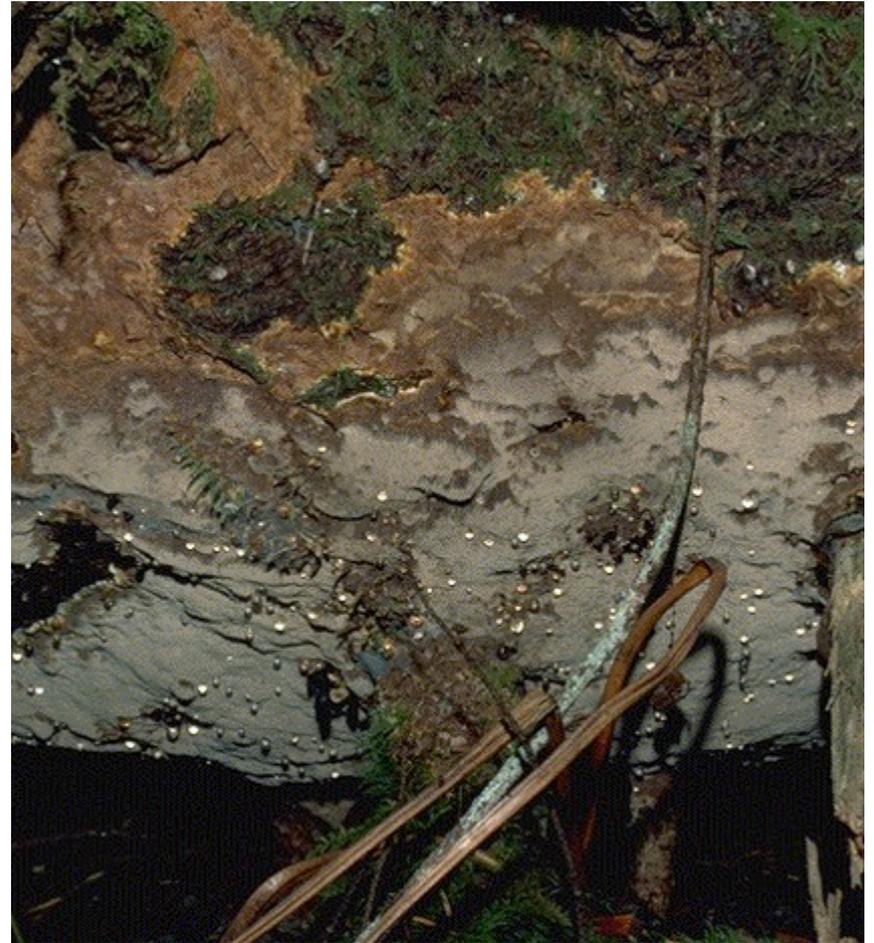
Signs of laminated root disease

- Setal hyphae, hair-like structures found between sheets of delaminated wood
- Ectotrophic mycelium and brown crust-like mycelium
- Help the fungus with spread and long-term survival in tree stumps



Signs of laminated root disease

- Fruiting bodies are resupinate: the pores are laid directly on the bark, without stems
- They are very inconspicuous and are rarely seen, they don't provide a reliable diagnostic feature



Tricks to differentiate root diseases

Symptoms/signs	Armillaria root rot	Laminated root rot
Reduced height	✓	✓
Foliage chlorosis	✓	✓
Chronosequence	✓	✓
Stress cone crop	✓	✓
Rapid tree death, saplings	✓	✗
Resinosis	✓	✗
Rotten roots (root balls)	✗	✓
Crisscrossed windthrows	✗	✓
Species composition shift	✗	✓

Management of root diseases

Strategy	Tactic	Comments
Inoculum reduction	Stumping	Slope less than 35%, highly productive sites, no other options
	Push-over harvesting	Similar to stumping
Alternate species	Regenerate less susceptible species	For Laminated, cedar, pine or deciduous; For Armillaria, cedar, pine or birch
	Hardwood cropping	Economic acceptability; hardwood pest problems
Inoculum avoidance	Variable planting density	Cost of planting
	Stump avoidance	
Chemical/biological	Fumigation	Cost, environmental effect
	Hypholoma, competitor	Experimental, promising, field studies needed

Stumping out root diseases

- Stump removal, although expensive, is the most effective method of control and eradication of root disease
- Stumping can remove 83– 94% of the belowground biomass

