Conifer Root Diseases and Heart Rots

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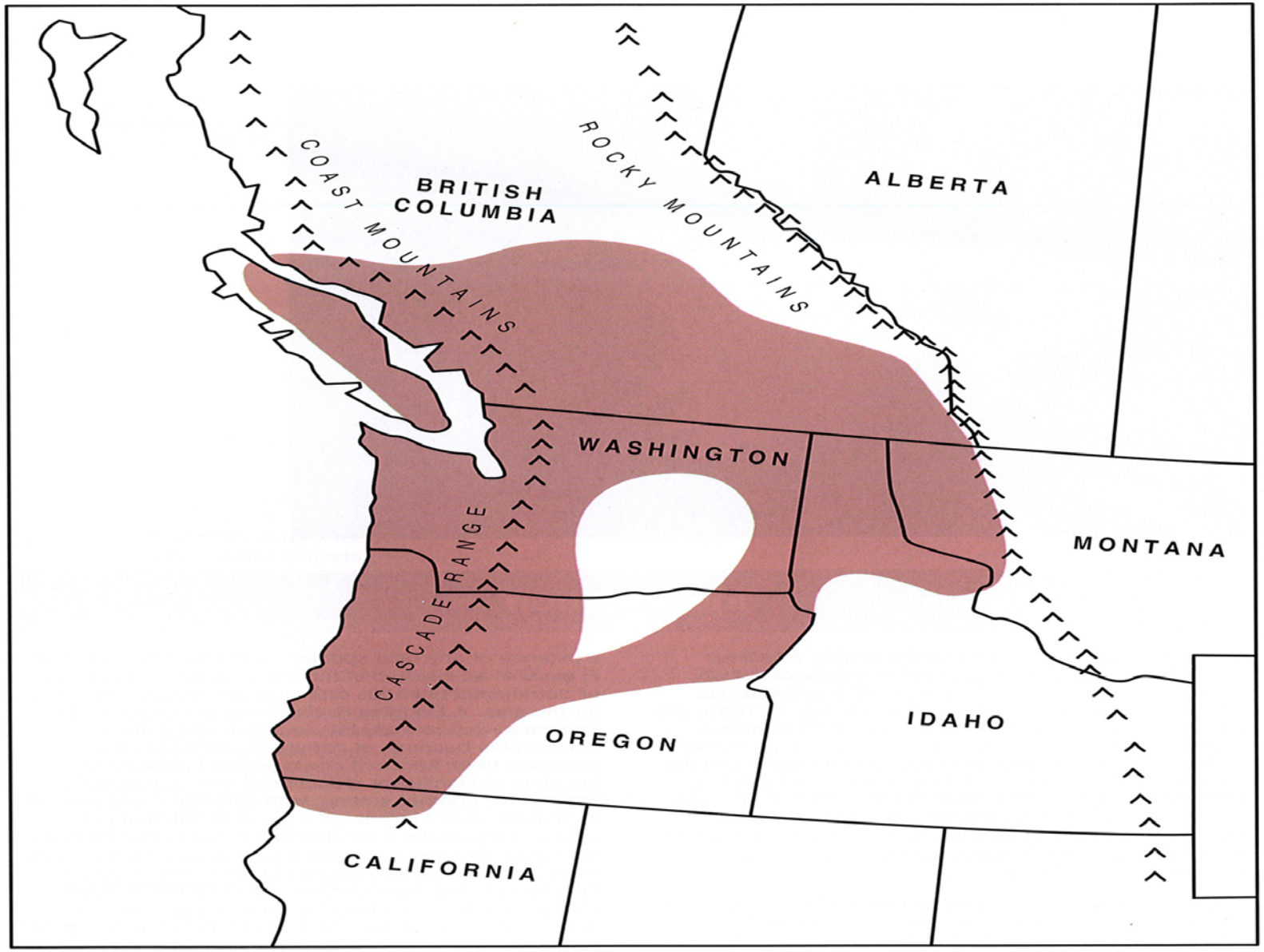
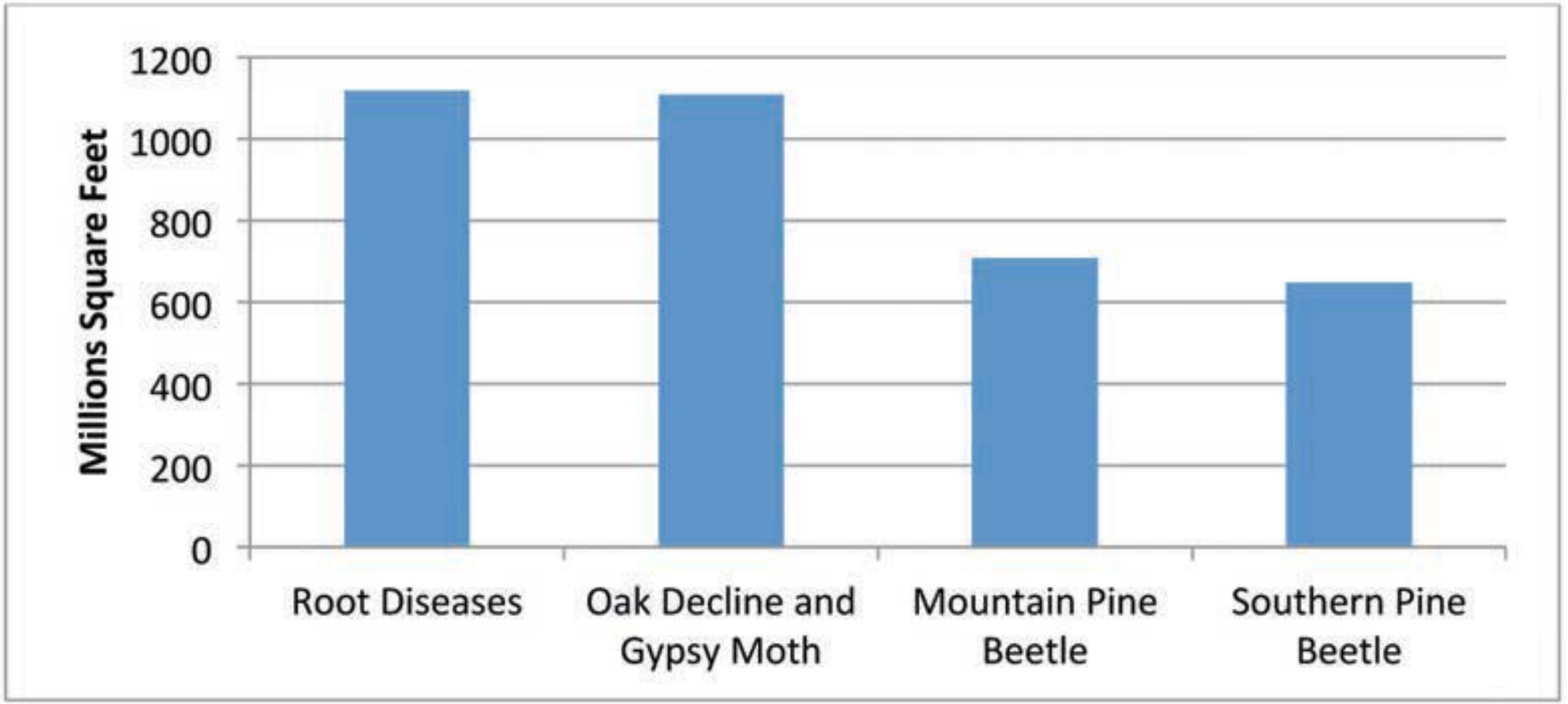
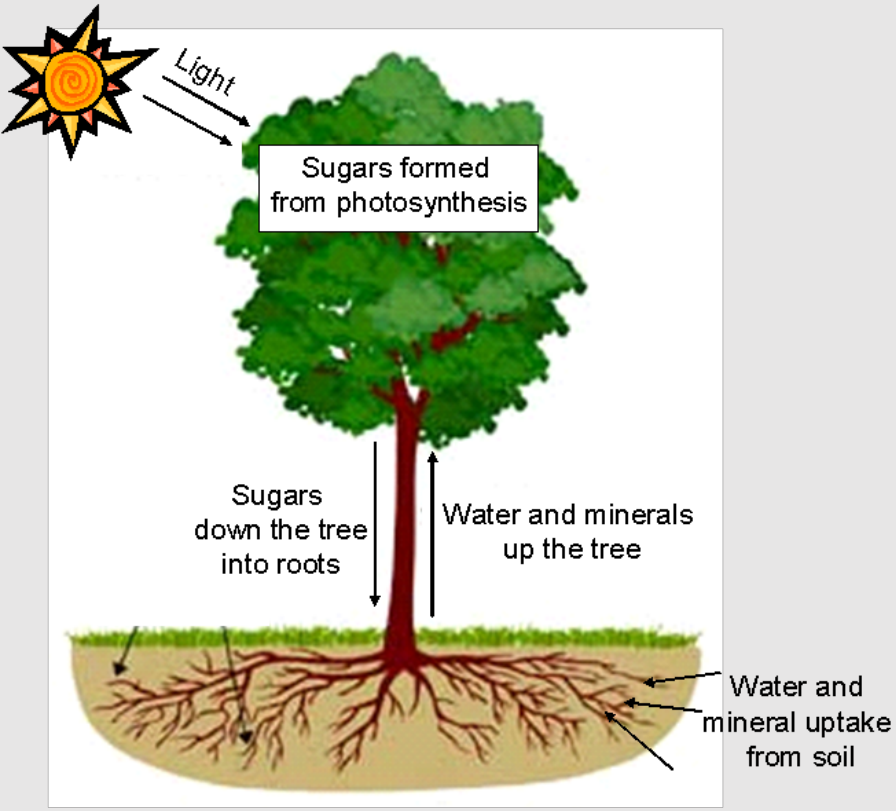
Distribution of Laminated Root Rot in western North America



Root diseases among the greatest mortality risks to forests in the U.S., predicted to cause more than 1 billion ft^2 of mortality over 15 years (2013-2027).

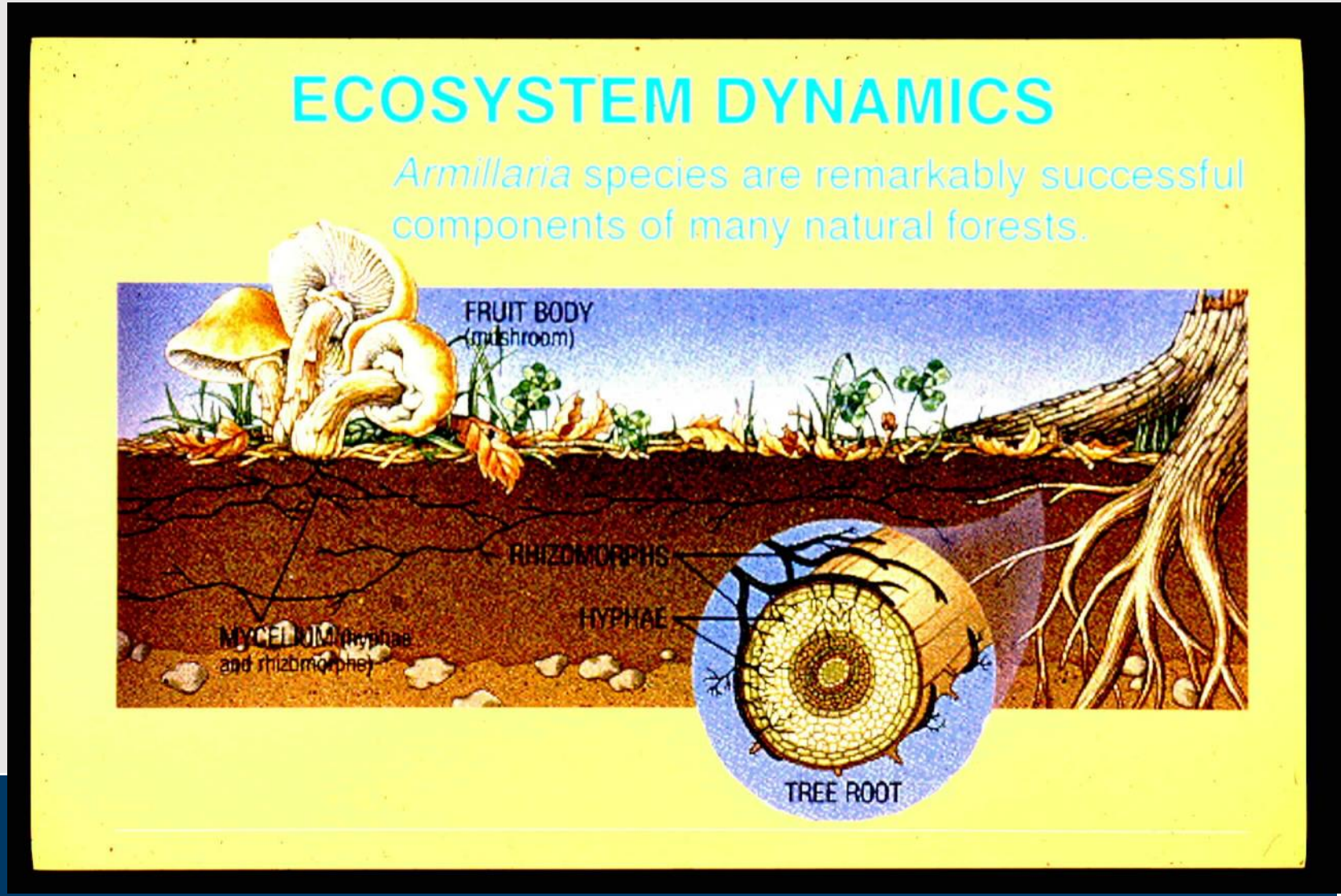


Lockman and Kearns, 2016. Forest root diseases across the United States. RMS-GTR-342.



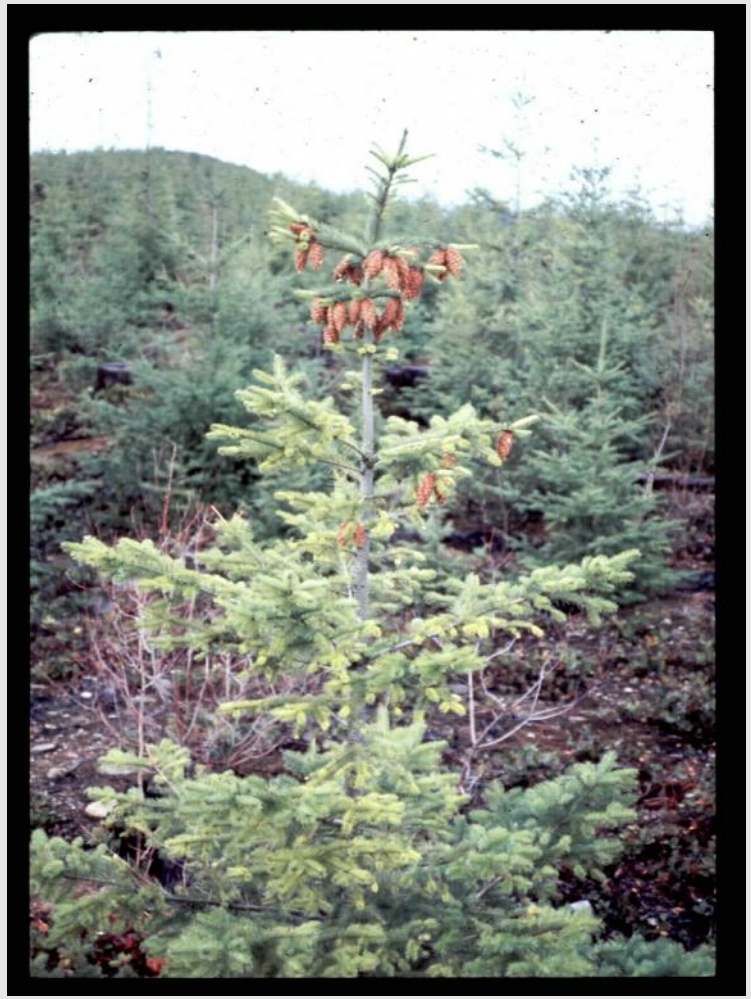
Plants/Trees are Autotrophic

Fungi are Heterotrophic



Tree symptoms:

Basal resinosis



Chlorosis or “yellowing”

Fungi spread along roots

Stand symptoms: Disease “pockets”

- Snags
- Trees w/ no fine branches
- Trees w/ fine branches, no foliage
- Trees w/ thinning foliage
- Seemingly healthy trees

Bark Beetle Mortality

Decayed roots broken close to the root collar leaving only stubs.

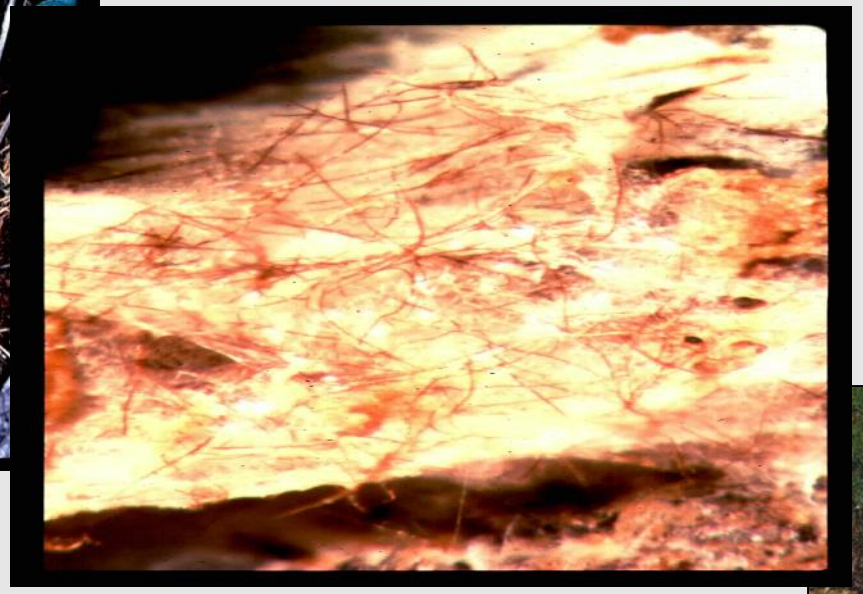
Laminated Root Disease – *Phellinus sulphurascens*

Highly susceptible – Douglas-fir, Grand fir
Resistant – Western redcedar
Immune – Red alder

Laminated Root Disease – signs:

Ectotrophic mycelium

Setal hyphae – “red whiskers”



Sporophore

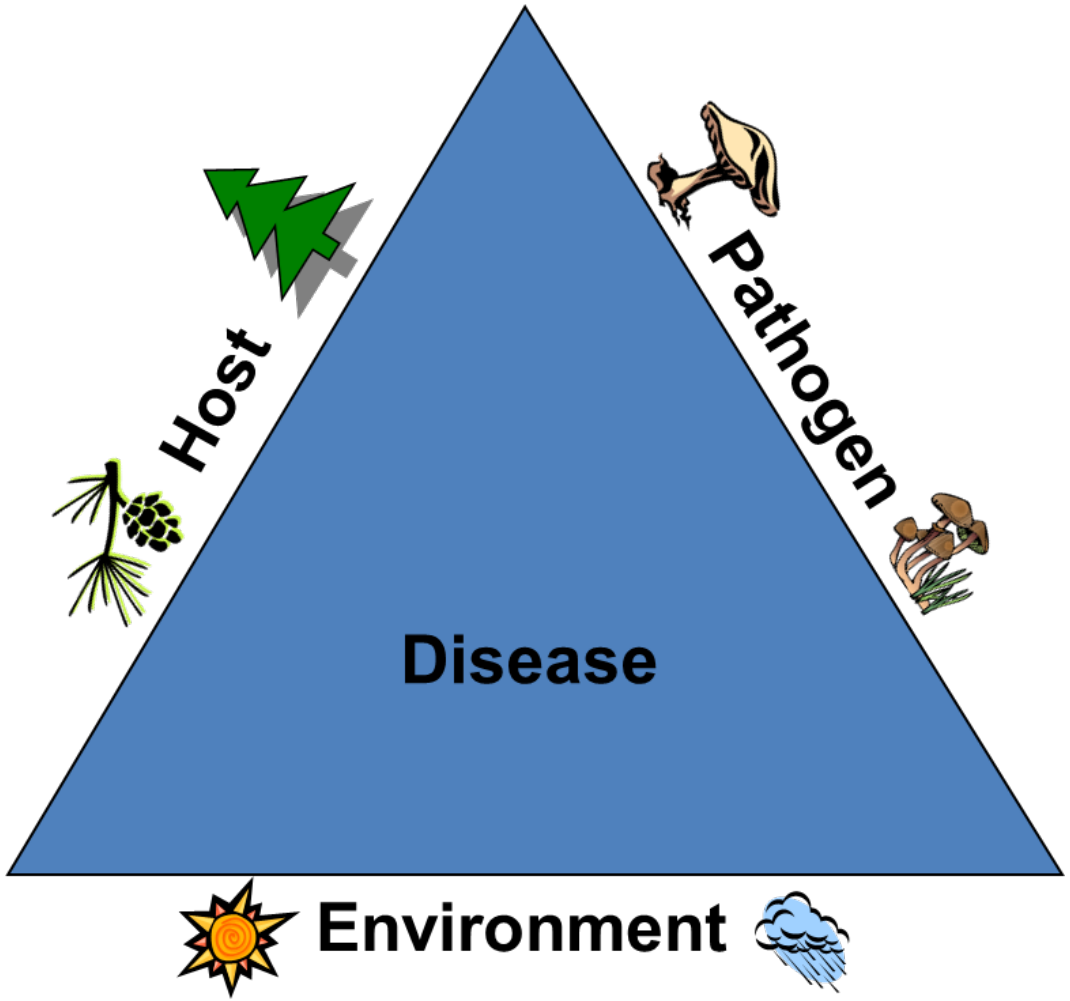
Black Stain Root Disease – *Leptographium wageneri*

-Hosts: Douglas-fir and ponderosa pine
-Insect-vectored, wilt disease
-Vectors include root feeding bark beetles and weevils (*Hylastes* sp., *Pissodes* sp., *Steremnius* sp.)

Fungal hyphae passing through pits of Douglas-fir tracheids.


E. Hansen

The disease triangle is integral for understanding tree diseases.



Stain occurs in circles or arcs and is usually found in the outer rings of the xylem and does not extend to the center of the tree.

Typical wedge shape of blue stain fungus associated with bark beetles.

Armillaria Root Disease

Genus: *Armillaria*

Diverse ecological roles

- Virulent pathogen
- Beneficial saprophyte
- Mycorrhizal associate

Worldwide distribution and wide host range

Potential for long-term and wide-spread occupancy of a site

Over 40 species worldwide

Armillaria spp. in North America

Species & Synonyms	Relative Pathogenicity	Primary Hosts
A. solidipes = A. ostoyae	High	Conifers
A. mellea	High	Hardwoods
A. gemina	Moderate?	Hardwoods
A. calvescens	Low	Mixed
A. sinapina	Low	Mixed
A. gallica = A. bulbosa	Low	Mixed
A. alitmontana (NABS X)	Low	Mixed
A. cepistipes	Low	Mixed
A. nabsnona	Low	Hardwoods
A. socialis = A. tabescens	Variable	Hardwoods

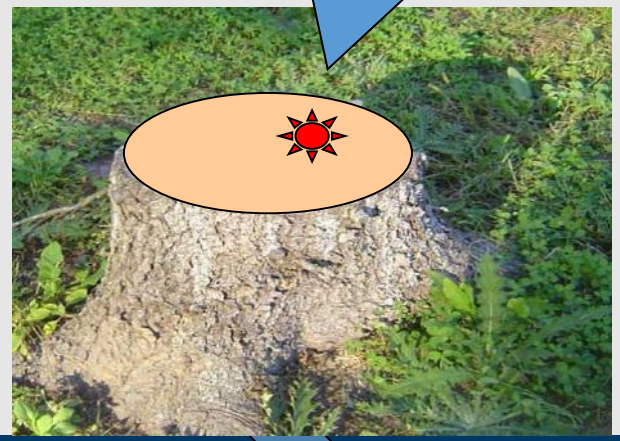
Susceptibility to *Armillaria ostoyae*

Hosts: Common Name	Hosts: Scientific Name	Susceptibility
Douglas-fir Eastside	*Pseudotsuga menziesii*	severe
Ponderosa pine	*Pinus ponderosa*	severe - low*
Grand & White fir	*Abies grandis, A. concolor*	severe
Douglas-fir Westside	*Pseudotsuga menziesii*	moderate**
Engelmann & Sitka spruce	*Picea engelmannii, P. sitchensis*	moderate
Lodgepole pine	*Pinus contorta* var. *latifolia*	moderate
Pacific silver & Subalpine fir	*Abies amabilis, A. lasiocarpa*	moderate
Western & Mountain hemlock	*Tsuga heterophylla, T. mertensiana*	moderate
Western red cedar	*Thuja plicata*	moderate
Western white pine	*Pinus monticola*	moderate
Western larch	*Larix occidentalis*	moderate-low

Armillaria Root Disease

Signs – white, cream-colored mycelial ‘fans’
- honey-colored mushrooms

Annosus Root and Butt Rot



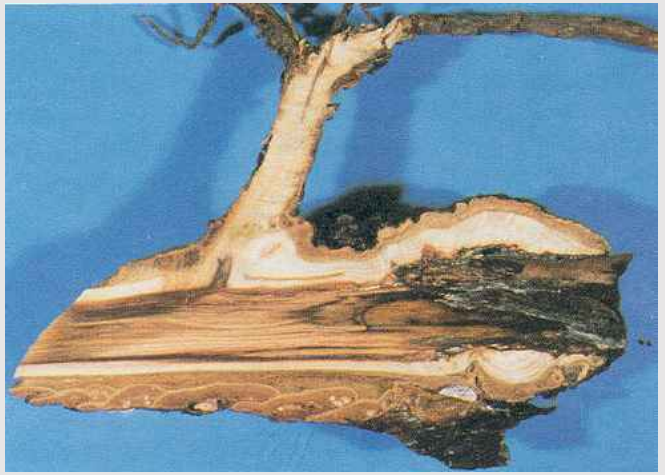
Heterobasidion irregular and *Heterobasidion occidentale*

Highly susceptible – western hemlock, true fir (*H.o.*), ponderosa pine (*H.i.*)
Seldom damaged – western larch, western redcedar

White pockets of decay interspersed with black flecks.

Schweinitzii Root Disease – *Phaeolus schweinitzii*

- “Velvet top fungus” or “cow-pie fungus”
- Hosts include Douglas-fir and Sitka spruce



Root Disease Management: Do's…..

Learn to recognize the disease.

Survey – where is it?

Keep records on its location.

Favor less susceptible species.

Remove roots & stumps where cost effective.

Reduce yields if no mitigation.

Monitor treatments for success.

When you look is a strong predictor of what you will find.

Time = 0

Time = 6 yrs.

Time = 13 yrs.

Time = 30 yrs.

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Relative susceptibility[1] of Pacific Northwest conifers to damage by root diseases

Hosts	Root disease				
	Laminated root rot	Armillaria root disease	Annosus root disease	Black stain root disease	Port-Orford-cedar root disease
Douglas-fir (coastal)	1	2	3	1	4
Douglas-fir (interior)	1	1	3	3	4
Fir (grand, white)	1	1	1	4	4
Fir (Pacific silver)	2	2	1	4	4
Fir (noble, red, subalpine)	2	2	2	4	4
Hemlock (mountain)	1	2	1	3	4
Hemlock (western)	2	2	2	3	4
Incense-cedar, juniper, redwood	4	3	3	4	4
Larch (western)	2	3	3	4	4
Pine (ponderosa, Jeffrey, lodgepole)	3	2	2	3	4
Pine (knobcone, sugar, white)	3	2	3	3	4
Port-Orford-cedar	4	3	3	4	1
Redcedar (western)	4	2	3	4	4
Spruce (Engelmann)	2	2	3	4	4
Spruce (Sitka)	3	2	3	4	4

[1] 1 = severely damaged, 2 = moderately damaged, 3 = seldom damaged, and 4 = not damaged. Ratings based on field observations in the Pacific Northwest.

Shaw, Oester and Filip, 2009

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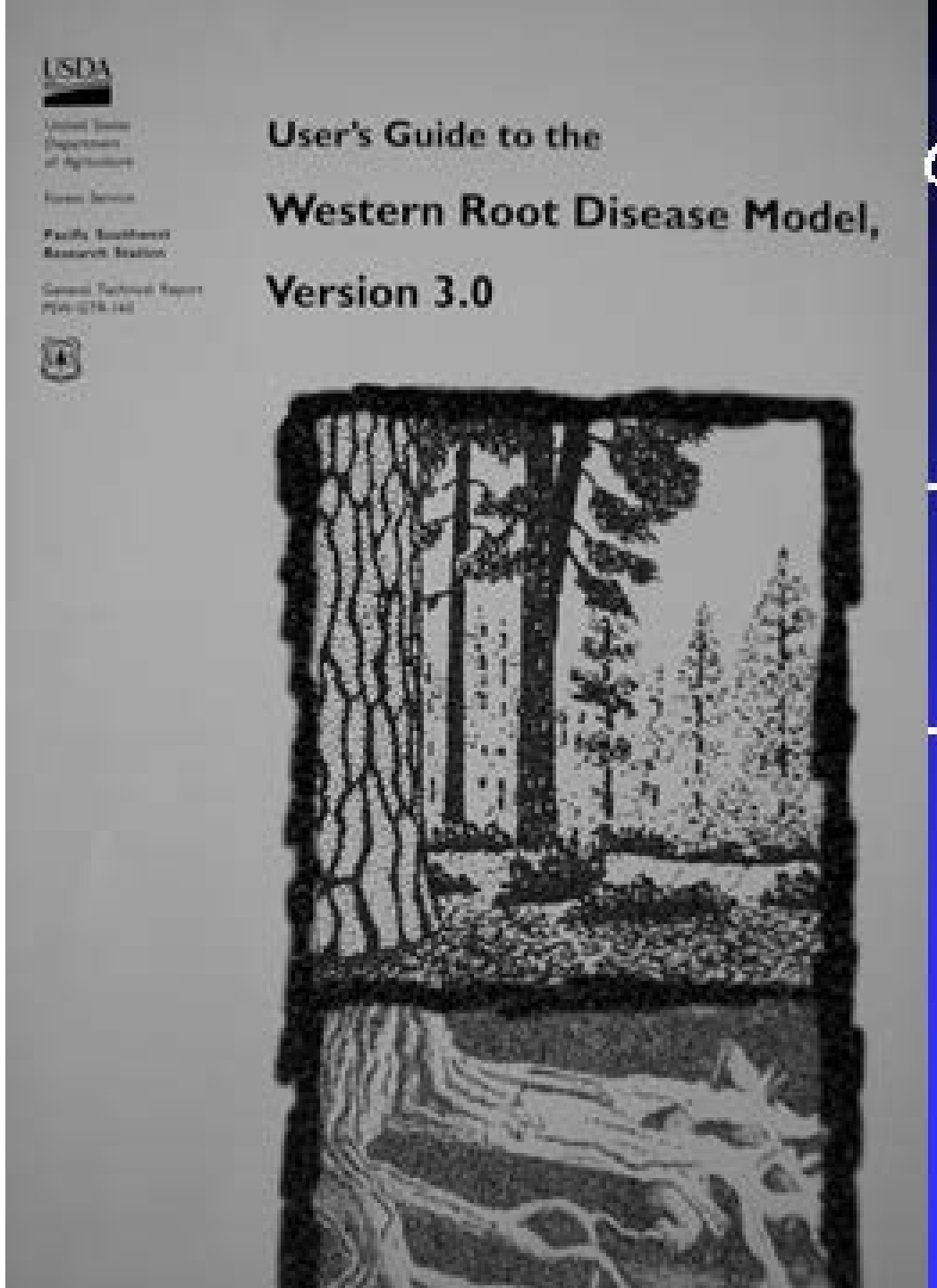


Compares:

- future stand conditions and productivity.
- effects of inoculum on management objectives
- effects of silvicultural prescriptions.

Root Disease Management: …… and Don'ts

Classify entire stand as infested if not so.

Assume all mortality caused by root disease.

Thin within infection centers.

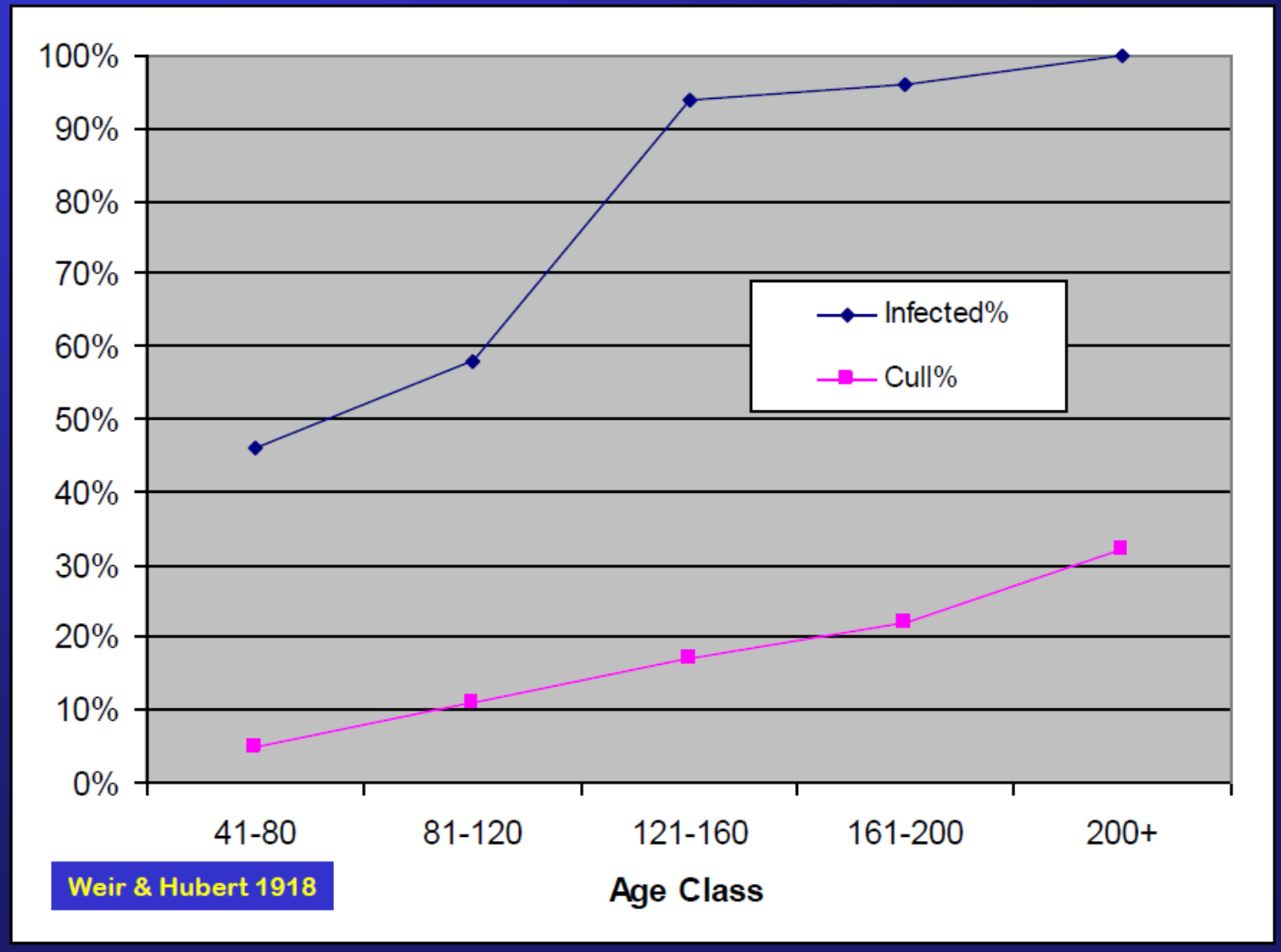
Plant infested sites with susceptible species.

Attempt to control the disease by broadcast burning, thinning or fertilization?

Heart Rots

1. Decay is confined to true heartwood.
2. Consistently produce conks on live trees.
3. Never invade slash or dead material.
4. Mechanical injuries do not appear to be principle infection courts.

Indian Paint Fungus - Western hemlock



Indian Paint Fungus – *Echinodontium tinctorum*

Frequent hosts:
- True firs, hemlocks

Occasional hosts:
- Douglas-fir, spruce

Red Ring Rot Fungus – *Porodaedalea* (*Phellinus) pini*

Frequent hosts:
- Douglas-fir, western hemlock,
- western larch

Occasional hosts:
- Pines, western redcedar

Less susceptible:
- True firs

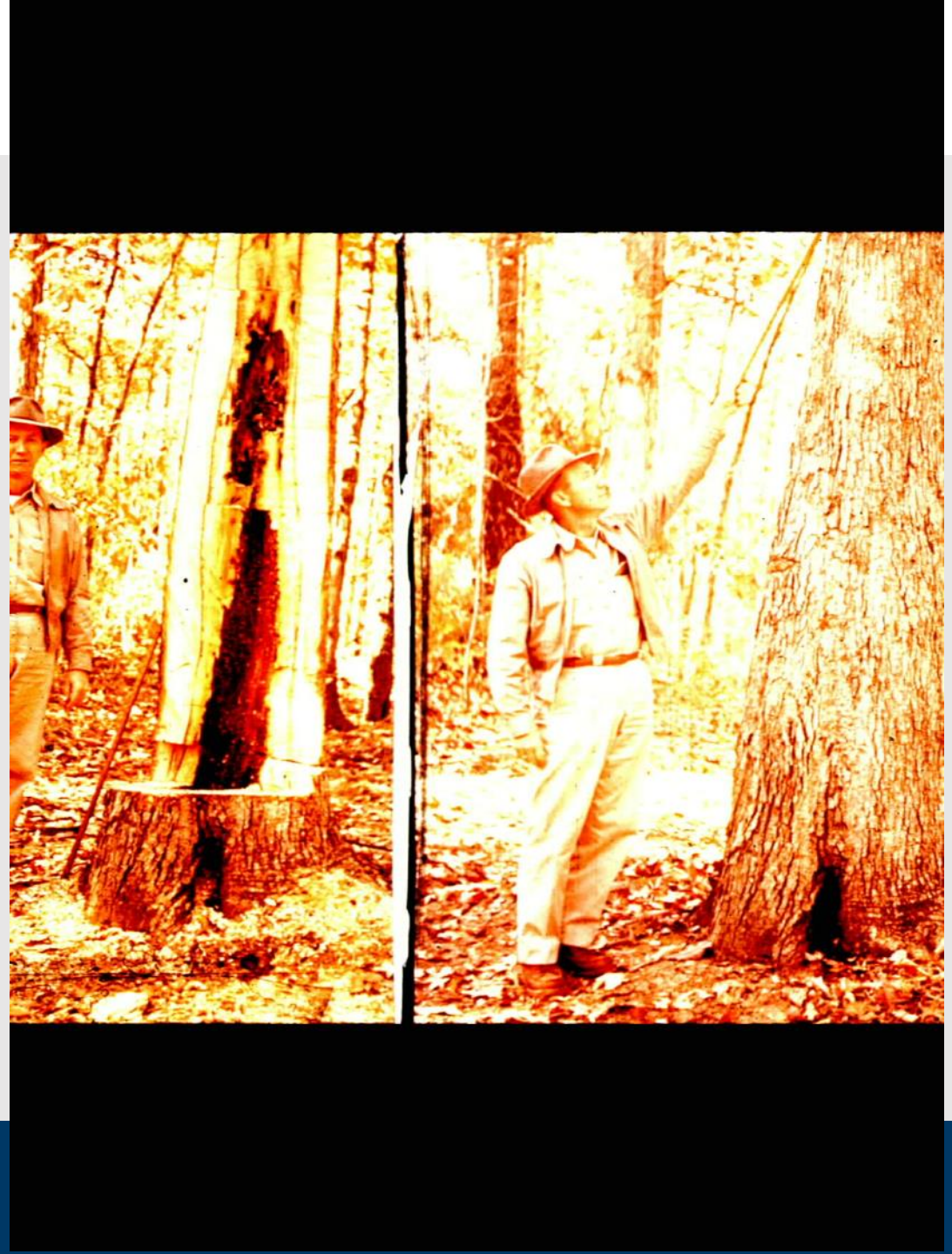
Brown Trunk Rot – *Fomitopsis officinalis*

Frequent hosts:
- Douglas-fir, western larch

Occasional hosts:
- Western hemlock, true firs

Decay Management

- Shorten rotations to limit decay development (pathological rotation)
- Prevent injuries to residual trees
    - Minimize stand entries
    - Plan roads, skid trails carefully
    - Keep vehicles away from trees
    - If pruning, do so early
- Dedicate wounded trees to wildlife



Relative susceptibility[1] of Pacific Northwest conifers to stem-decay fungi

Major hosts	Decay type and fungus						
	Rust-red stringy rot Indian paint fungus	Red ring rot White speck	Brown trunk rot Quinine fungus	Schweinitzii root and butt rot Velvet-top fungus	Brown crumbly rot Red-belt fungus	Gray-brown sap rot Pouch fungus	Pitted sap rot Purple conk
Cedar	4	3	3	3	3	3	1
Douglas-fir	4	1	2	1	1	1	1
Fir (grand, white, Pacific silver)	1	1	3	1	1	1	1
Fir (other true)	2	2	2	2	1	2	1
Hemlock (mountain)	1	1	3	2	1	2	1
Hemlock (western)	2	2	3	2	1	2	1
Larch	4	2	2	1	1	2	1
Pine	4	1	2	1	1	1	1
Redwood/juniper	4	4	4	4	4	4	4
Spruce	3	2	3	2	1	2	1

[1] 1 = often decayed, 2 = occasionally decayed, 3 = seldom decayed, and 4 = not decayed

Shaw, Oester and Filip (2009)

Heart rot decay is a major cause of stem failure!

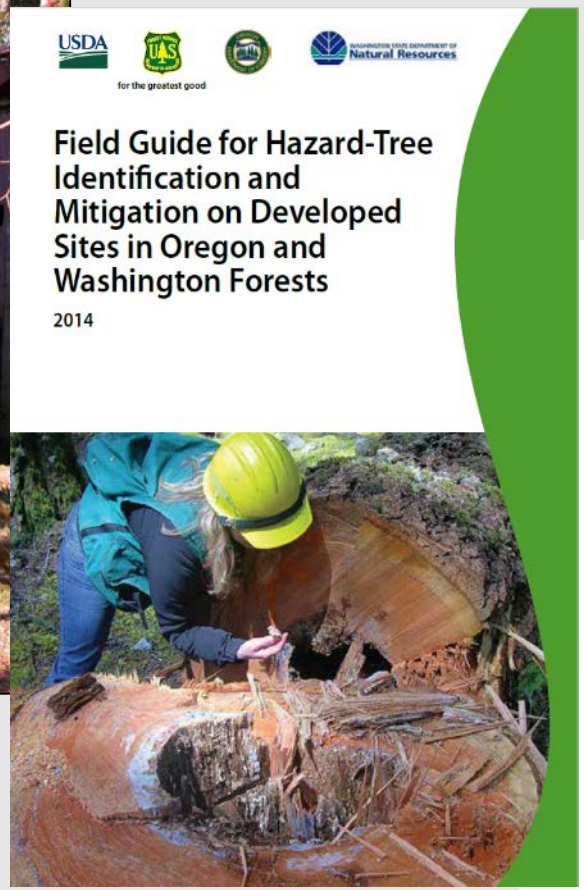


Table 3A - Minimum sound-rind thickness[1] at various diameters inside the bark of conifers measured at the defect for trees *without open wounds*. Trees with sound-rind thickness below minimum values have high-failure potential (score=4).

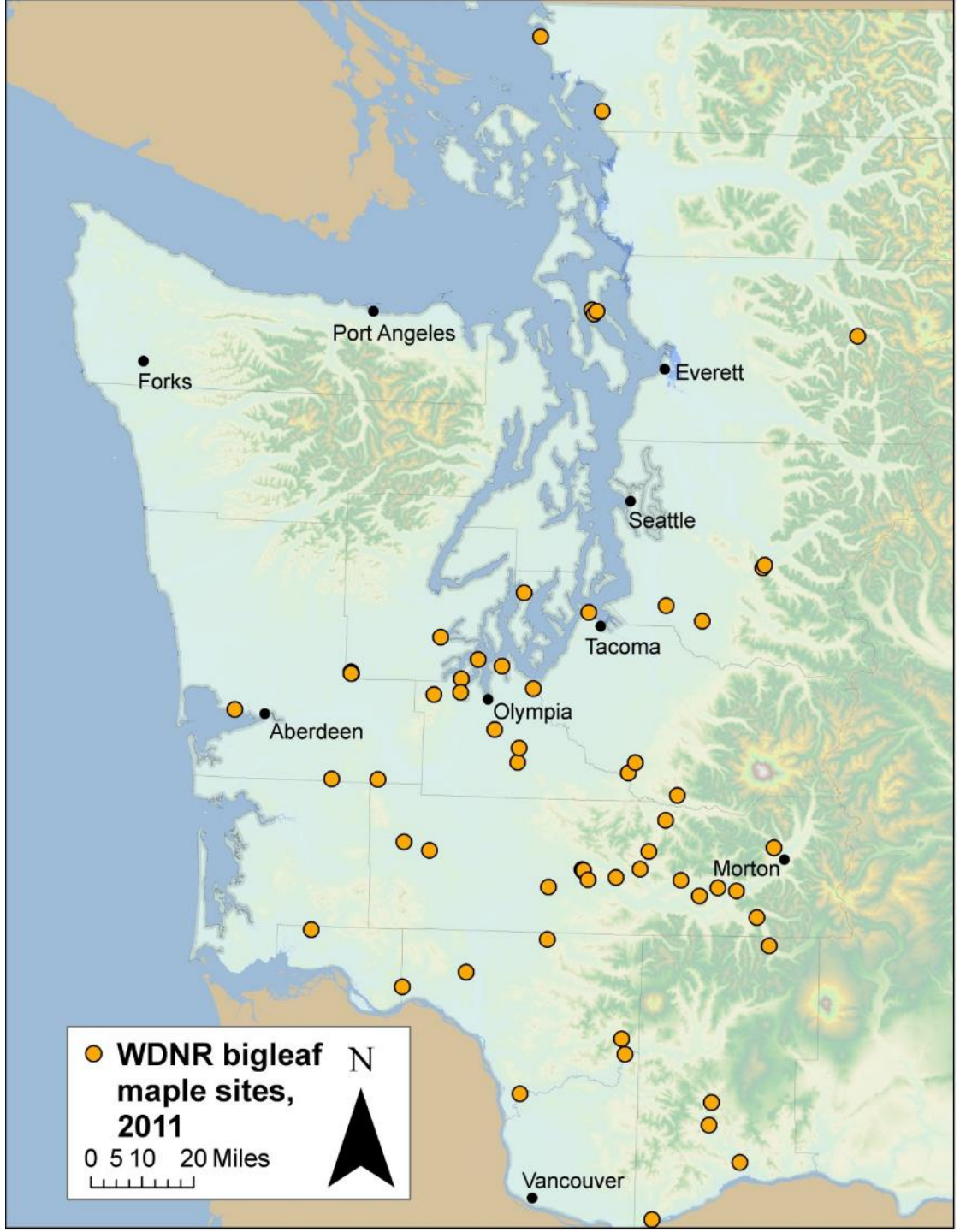
Tree diam. (in.)	Rind thickness[2] (in.)	Tree diam. (in.)	Rind thickness[2] (in.)
4	0.5	44	6.5
6	1.0	46	7.0
8	1.0	48	7.0
10	1.5	50	7.5
12	2.0	52	8.0
14	2.0	54	8.0
16	2.5	56	8.5
18	2.5	58	8.5
20	3.0	60	9.0
22	3.5	62	9.5
24	3.5	64	9.5
26	4.0	66	10.0
28	4.0	68	10.0
30	4.5	70	10.5
32	5.0	72	11.0
34	5.0	74	11.0
36	5.5	76	11.5
38	5.5	78	12.0
40	6.0	80	12.0
42	6.5	82	12.5

[1] Modified from Wagener (1963) by expanding the range of diameters covered
[2] Minimum sound-rind thickness is 0.15 x diameter and rounded to the nearest 0.5 in.

Bigleaf Maple

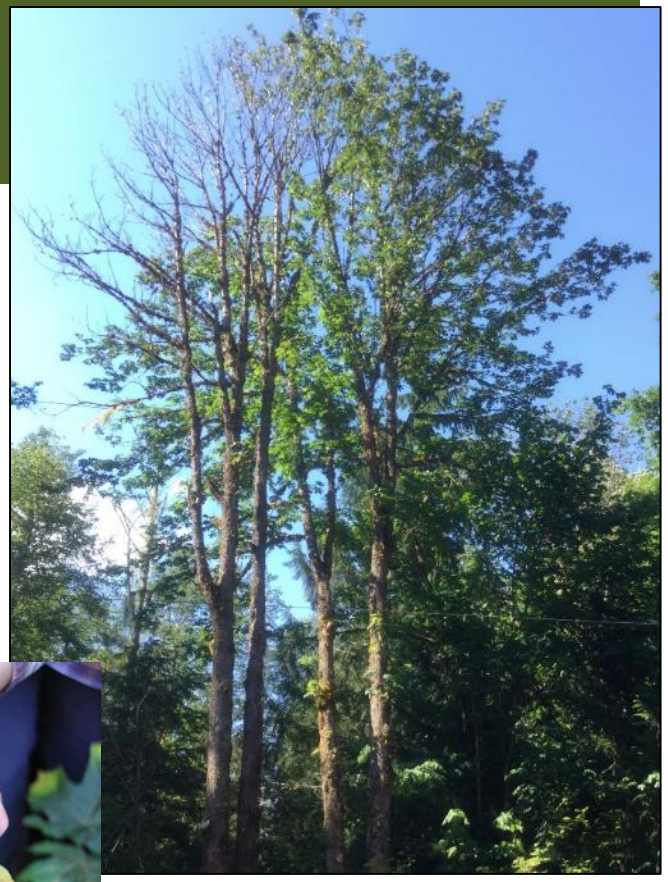
Verticillium wilt of maple

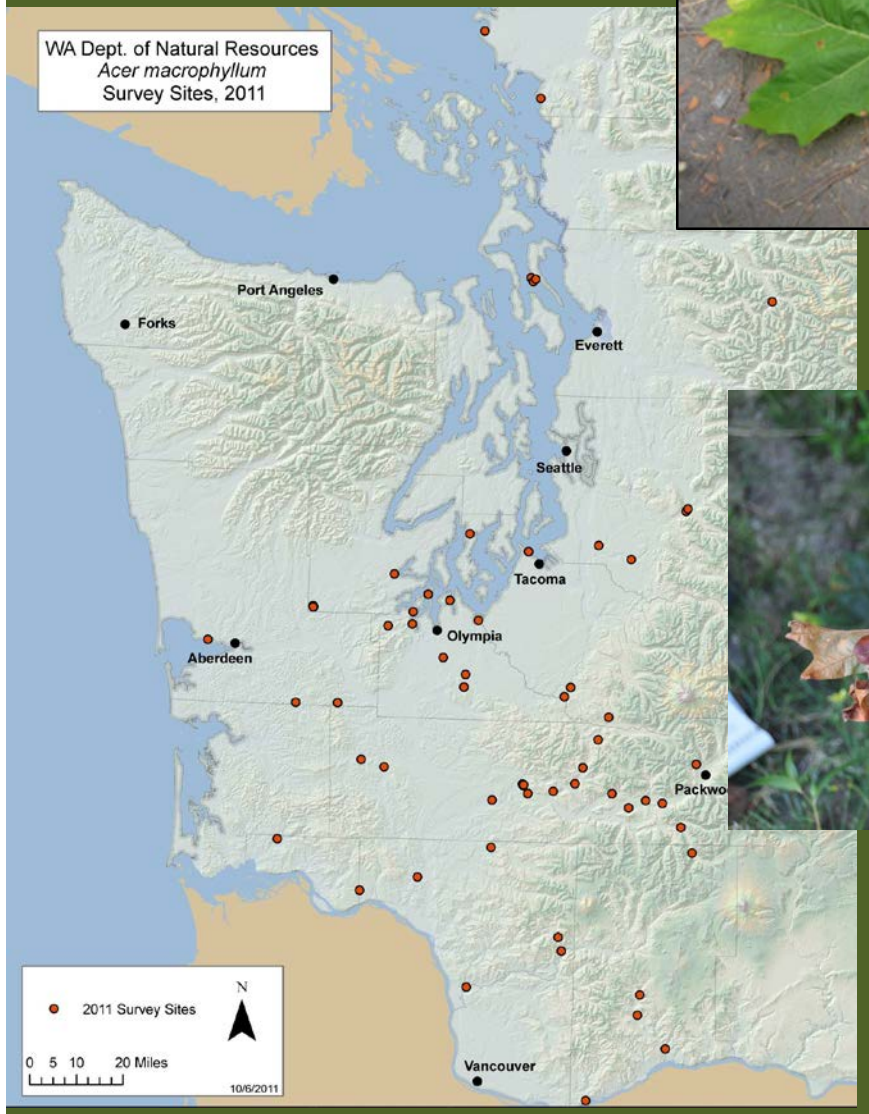
Internal streaking in the sapwood is typical of wilt infection.



Agent	Occurrence (%)
Armillaria spp.	11
Ganoderma sp.	3
Verticillium spp.	0

Bigleaf Maple Decline





Unlikely Causes of Bigleaf Maple Decline:

- *Phythium* ssp. present but not pathogenic.
- *Phytophthoras* present but not common.
- *Armillaria* contributes to some decline but not all.
- *Verticillium* wilt rare.
- *Nectria* and *Neonectria* occasionally present.
- *Ganoderma* present but not widespread.

Future study:

1. Survey spatial extent of BLMD
   - -Environmental
   - -Anthropogenic
   - -Weather/climate
2. Dendrochronological techniques to analyze impact of biotic and abiotic drivers.
3. Determine spatial/temporal patterns associated with BLMD in western WA.