

Forest Pathology



CC BY-3.0. USFS-Region 2-Rocky Mtn. Region Archive, USFS, Bugwood.org



CC BY-3.0. R.L.Anderson, USFS, Bugwood.org



CC BY-3.0. D.Powell, USFS, Bugwood.org



CC By-3.0. USDA For.Serv.Archive, USFS, Bugwood.org

Richard Hamelin

Are diseases the normal state?

- Diseases are integral part of natural ecosystems
- Natural pathosystems: equilibrium between trees and their pathogens



CC-BY-NC-3.0. S.K. Hagle, USFS, Bugwood.org.



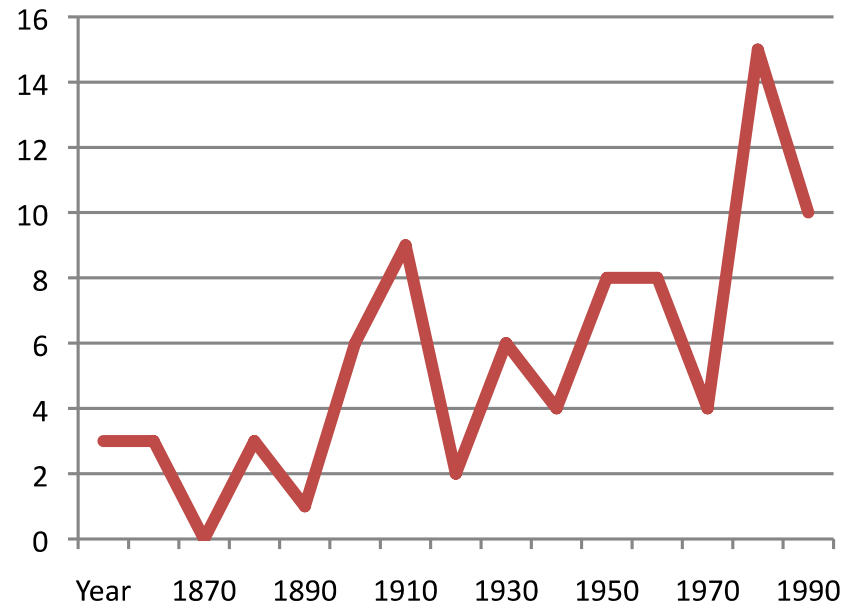
Phellinus weirii-1, Nat. Res. Canada, CFS
<https://tidcf.nrcan.gc.ca/diseases/factsheet/1000027>

What causes epidemics?

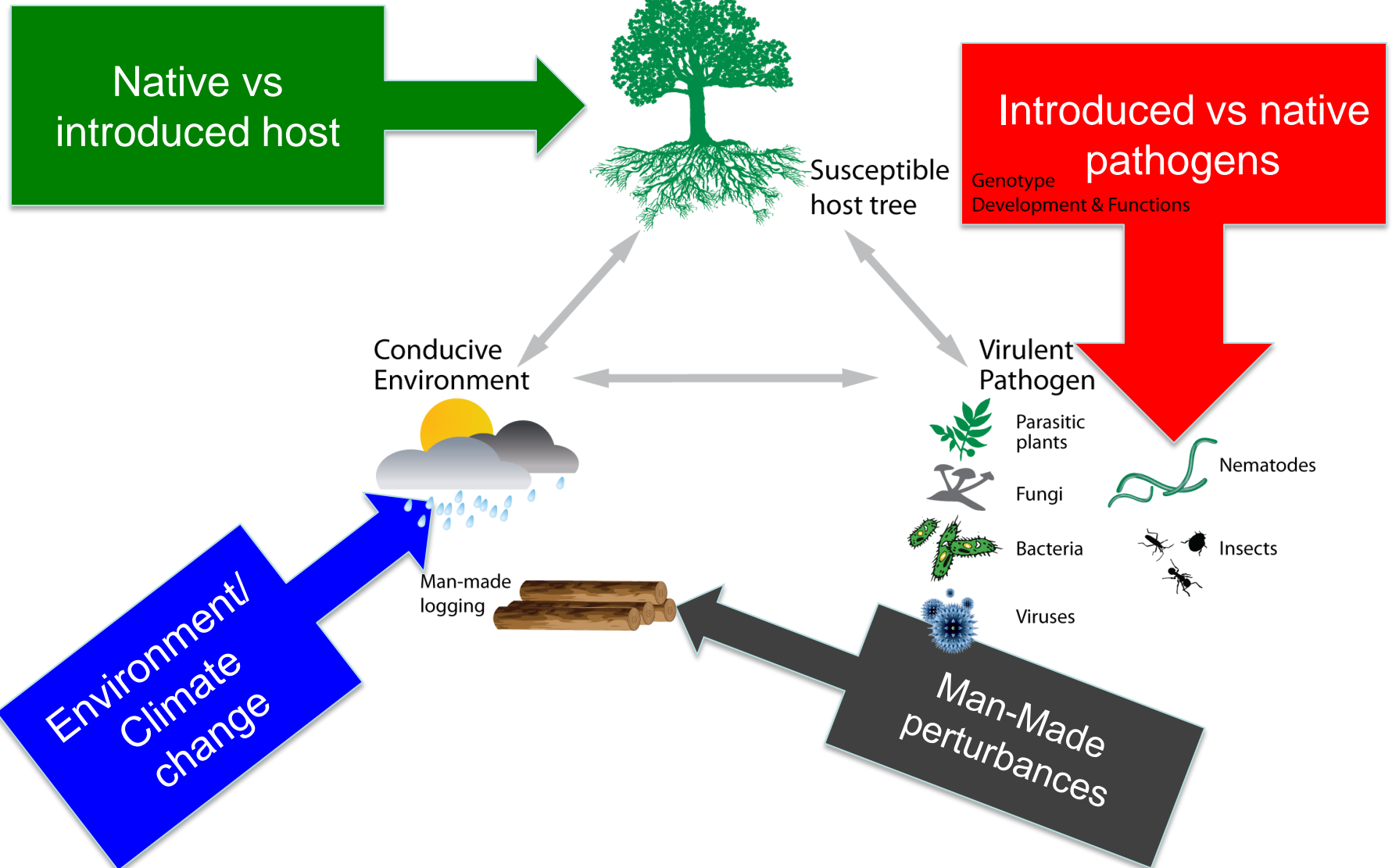
Forest (mis)-management



Invasive Alien pathogens



The disease triangle



Infamous Forest Pathogens

White Pine Blister Rust



Chestnut Blight



Sudden Oak Death



Sudden oak death now threatens more of Britain's trees

After destroying millions of oaks in California, the infection spread to Britain – then suddenly jumped species

Tracy McVeigh
The Observer, Sunday 16 January 2011
[Article history](#)



Fungi rule!

- **1.5 million** species believed to exist! But only **70,000** described species of fungi
- As a comparison there are only about 8000 species of birds in the world



R.Hameli
n



CC-BY-3.0. S.Katovich, USFS,
Bugwood.org



CC-BY-3.0. D.Powell, USFS,
Bugwood.org



CC-BY-NC-3.0. Francis Gwyn Jones, Bugwood.org

Microbes make trees!

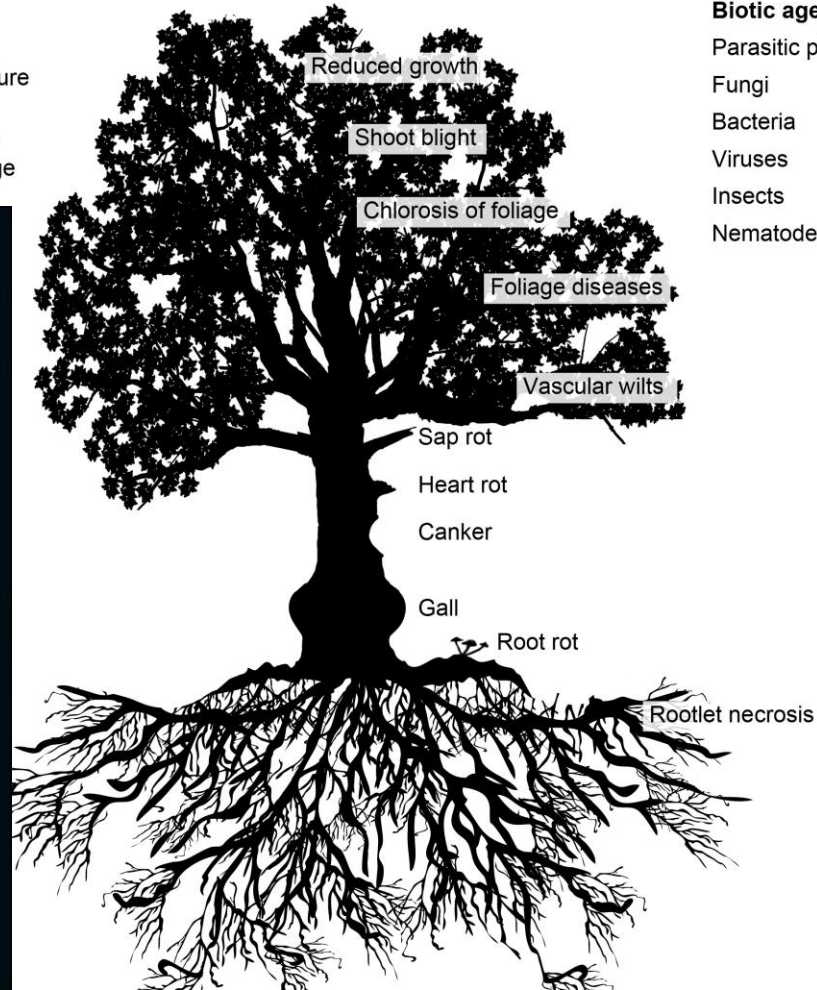
Decline diseases of complex origin

Abiotic agents

- High temperature
- Freezing temperature
- Drought
- Nutrient deficiency
- Mechanical damage

Biotic agents

- Parasitic plants
- Fungi
- Bacteria
- Viruses
- Insects
- Nematodes



The Economist

The Catholic church's unholy mess
 Paul Ryan: the man with the plan
 Generation Xhausted
 China, victim of the Olympics?
 On the origin of specie

AUGUST 18TH - 24TH 2012

Economist.com

Microbes maketh man



How soon of the cells in your body are bacteria, the benefits of faecal transplants and other things you would rather not know before breakfast

Roles of fungi in the forest

- Saprophytes
 - Decomposition of cellulose and lignin
 - Carbon and nutrient cycling



Gloeophyllum sepiarium, Nat. Res. Canada, CFS
<https://tdcf.nrcan.gc.ca/diseases/factsheet/201>

- Symbionts
 - Mycorrhizal association with plant roots
 - Water, nutrient exchanges, protection



CC-BY-3.0. R.L.Anderson, USFS, Bugwood.org

Role of fungi in the forest



CC-BY-NC 3.0. W.z.M.Ciesla, Forest Health Mgmt. Intl., Bugwood.org

Symbionts: fungus-insect



CC BY-3.0. O'Brien, USFS, Bugwood.org

Pathogen

The exception

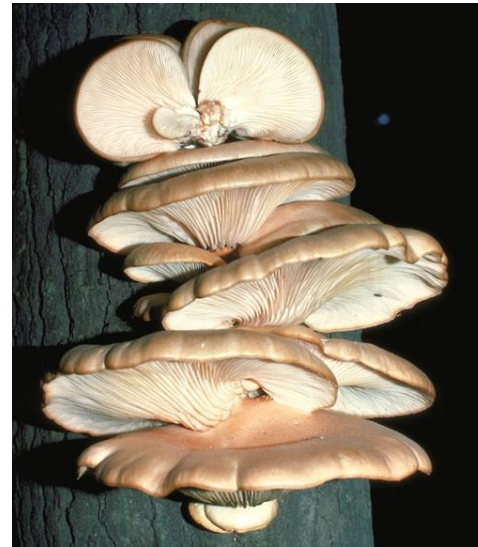


"Squirrel Drying Mushroom" by galaxon. CC BY-NC 2.0
<http://www.flickr.com/photos/51600413@N02/4976092129/>

Food for wildlife

Role of pathogens: good guys

- Diseases can be beneficial
- Stand openings
 - Favors regeneration
 - Increases diversity
 - Increases resilience
- Wild-life habitat
- Nutrient cycling



CC BY 3.0. R.L.Anderson, USFS, Bugwood.org



"Young Barn Owls in Tree Nest" by Hunter-Desportes. CC BY 2.0.
<http://www.flickr.com/photos/hdport/3342795998/sizes/o/in/photostream/>

Role of pathogens: bad guys

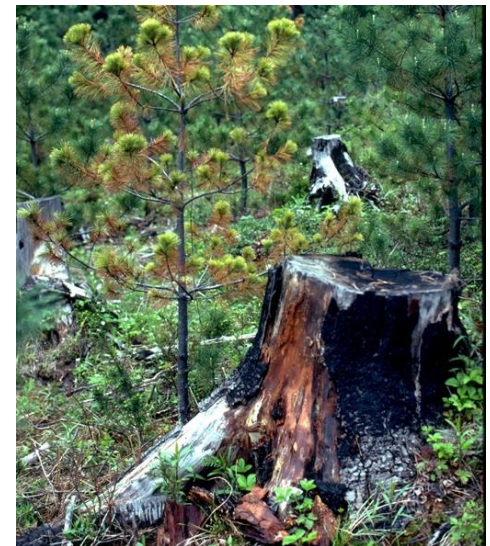
- Conflict between pathogen and user's goals
- Man-made disturbances
 - Fire-suppression
 - Logging: stumps, bark damage: point of pathogen entry
 - Plantations: uniformity is conducive to problems
 - Nurseries: ideal conditions to foster diseases
 - Climate change



John McColgan, Alaska Fire Service
<http://earthobservatory.nasa.gov/IOTD/view.php?id=843>



Forest Products Association of Canada,
FPAC.ca



CC BY-NC 3.0: J.W. Byler, USFS, Bugwood.org

Disease symptoms example: Armillaria root disease



Photo R. Hamelin

Stand level symptoms

Disease symptoms example: Armillaria root disease



Disease symptoms example: Armillaria root disease



CC BY 3.0. Borys M. Tkacz, USFS, Bugwood.org



Photo R. Hamelin



Photo R. Hamelin

Tree level symptoms

Signs of the disease



Armillaria ostoyae, Natural Resources Canada, CFS.
<https://tidcf.nrcan.gc.ca/diseases/factsheet/78>



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

Sign: When you see the pathogen

Categories of Forest Pathogens

Foliar pathogens



R. Hamelin

Stem pathogens



CC BY-3.0. O'Brien, USFS, Bugwood.org



CC BY 3.0. S. Katovitch, USFS, Bugwood.org



CC BY-3.0. O'Brien, USFS, Bugwood.org



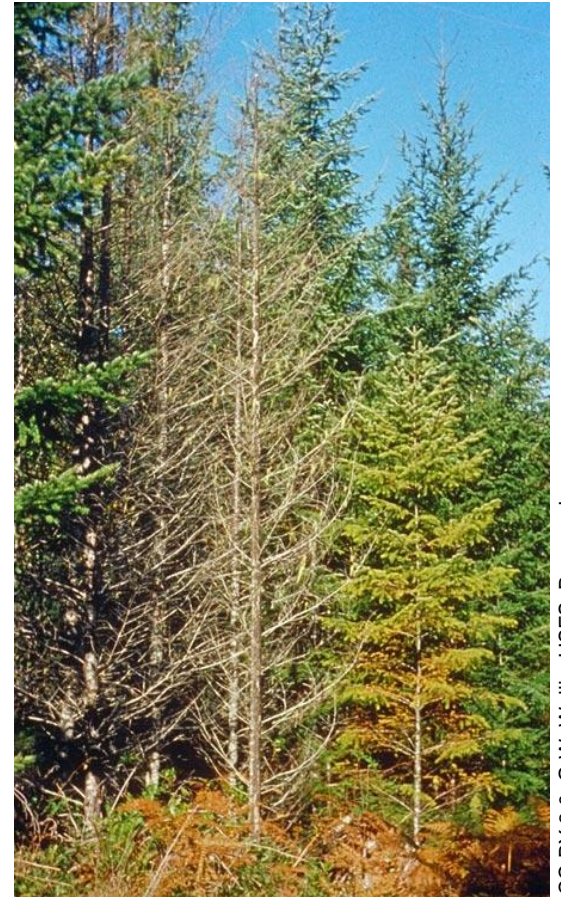
Leucostoma kunzei, Nat. Res. Canada, CFS.
<https://tidci.nrcan.gc.ca/diseases/factsheet/263>

Cankers

Root pathogens



CC BY 3.0. R. Williams, USFS, Bugwood.org



CC BY 3.0. G.W. Wallis, USFS, Bugwood.org

Root rots, wilts



Armillaria ostoyae, Natural Resources Canada, CFS.
<https://tidcf.nrcan.gc.ca/diseases/factsheet/78>

Mistletoes



Rusts



Chrysomyxa arctostaphyli, NRC, CFS.
<https://tidcf.nrcan.gc.ca/diseases/factsheet/1000053>



R. Hamelin



Melampsora occidentalis, Nat.Res.Canada,CFS.
<https://tidcf.nrcan.gc.ca/diseases/factsheet/1000050>



Coleosporium asterum, Nat.Res.Canada, CFS
<https://tidcf.nrcan.gc.ca/diseases/factsheet/55>



CC BY-NC 3.0. Petr Kapitola,
 State Phytosanitary Administration,
 Bugwood.org



CC by 3.0. Joseph O'Brien, USFS,
 Bugwood.org

Decay fungi

Brown rot



“Brown rot” by ressaure. CC BY-NC-SA 2.0
<http://www.flickr.com/photos/ressaure/5458514343/>



CC BY 3.0. Minnesota Dept. Nat. Res. Archive,
Bugwood.org

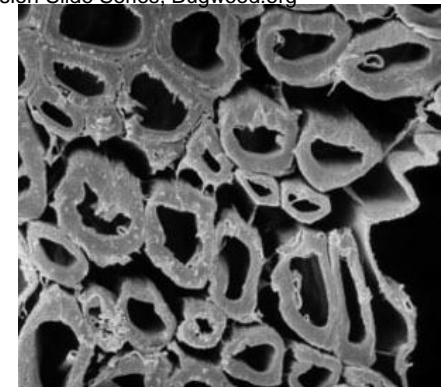
White rot



CC BY 3.0. Clemson U.-USDA Coop. Extension Slide Series, Bugwood.org

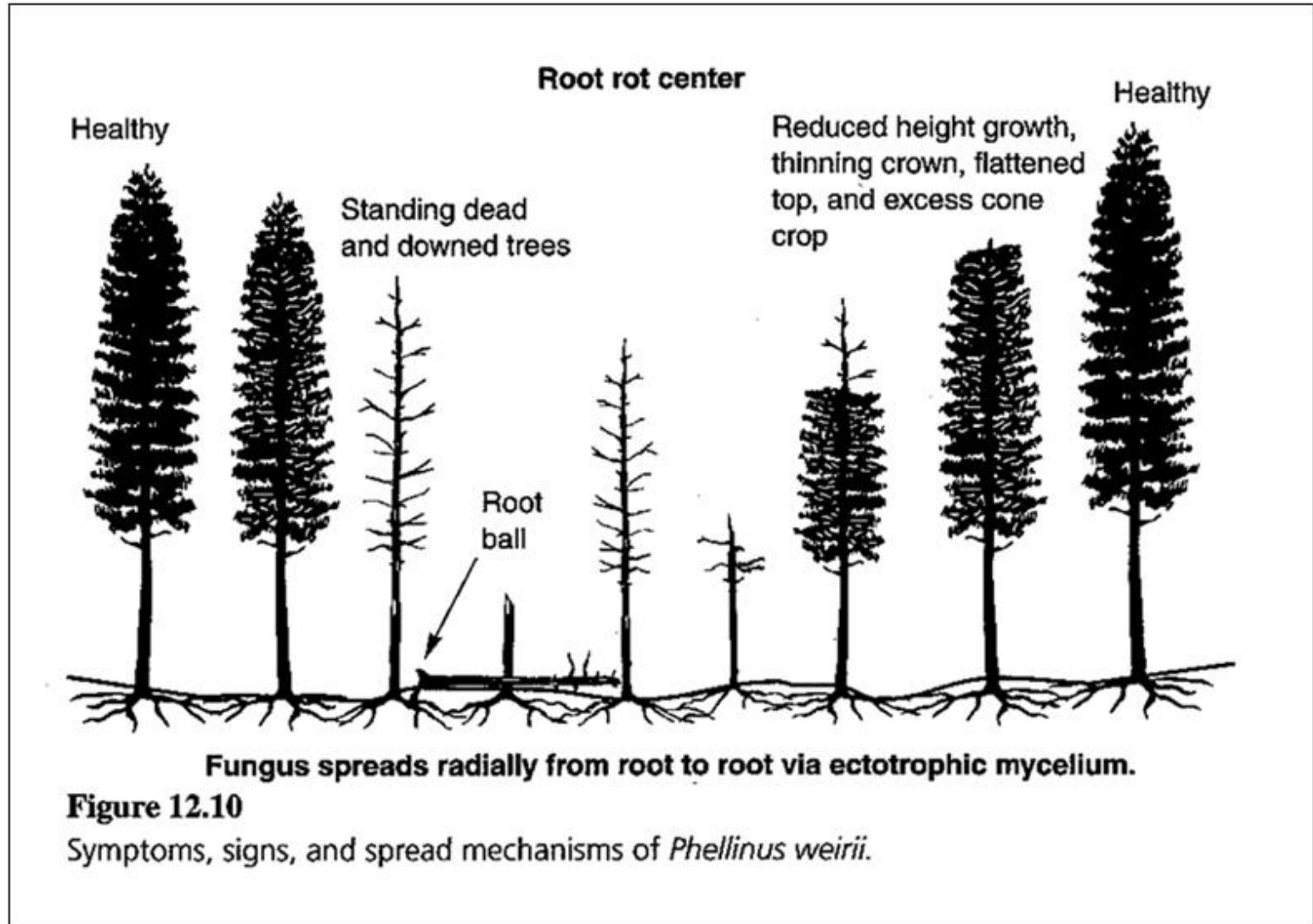


CC BY-NC 3.0. USDA Forest Service Archive,
USFS, Bugwood.org



Source: Dr. Robert Blanchette, U of
Minnesota
<http://forestpathology.cfans.umn.edu/microbes.htm>

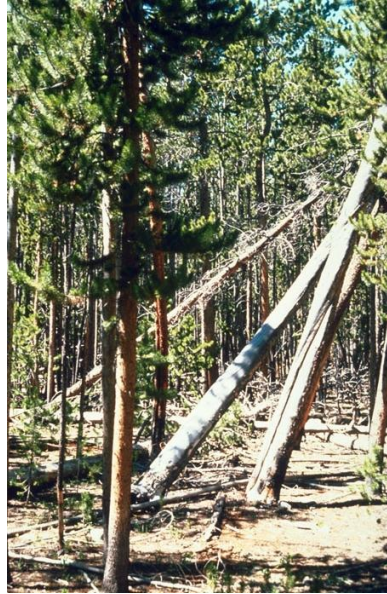
Root diseases



Source: Fig.12.10, p.312 Forest Health and Protection by Edmonds, R. L., J. K. Agee and R. I. Gara. 2011. Waveland Press, Long Grove, IL. 2nd ed. Used with permission from Waveland Press Dec.13, 2011.

Armillaria root disease

- Widespread worldwide
- Small to very large infection centers
- New York Times article "humongous fungus": 15 ha, 1500 years old, 10000 kg!
- Conflicts with human use of forest



CC BY 3.0. Fred Baker, Utah State U., Bugwood.org



CC BY 3.0. Borys M. Tkacz, USFS, Bugwood.org



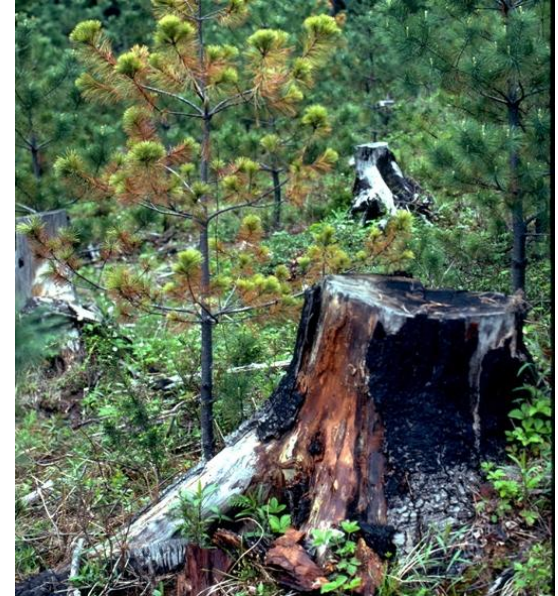
CC BY 3.0. R. Williams, USFS, Bugwood.org

Survival and spread

- Root to root contacts
- Rhizomorphs
 - specialized highly adapted structures that can survive in the soil for decades



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



CC BY-NC 3.0. J.W. Byler, USFS, Bugwood.org



Armillaria ostoyae, Natural Resources Canada, CFS.
<https://itdof.nrcan.gc.ca/diseases/factsheet/78>

Host defense

- Host reacts to infection by producing resin, trying to 'pitch out' the fungus
- This defense can be quite successful and trees can live for centuries with Armillaria infection
- But when trees are cut, the stump remains but not connected to a living tree!
- Fungus free to invade stump and occupy a unique niche

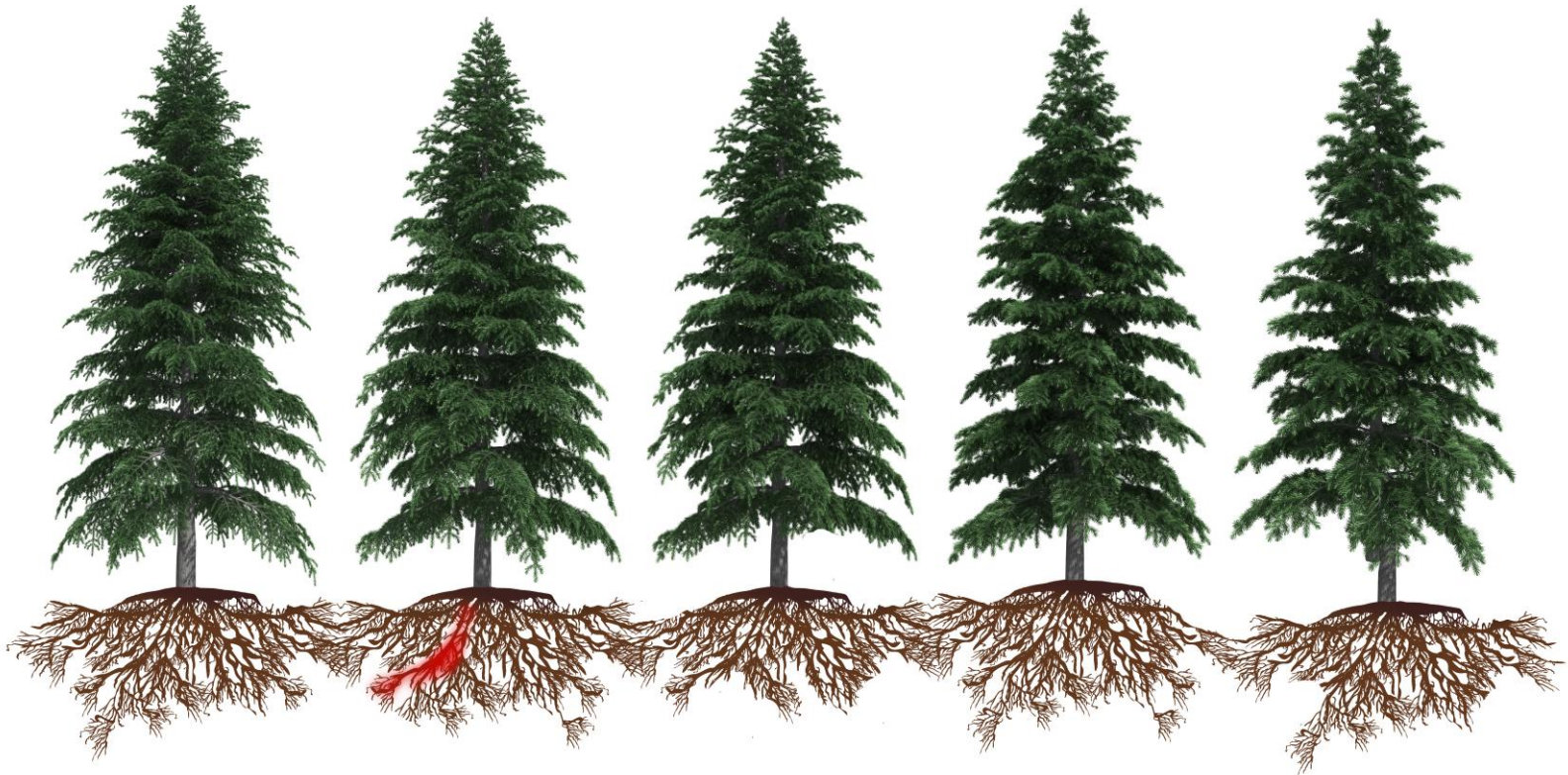


CC BY 3.0. USFS Archive, USFS, Bugwood.org



CC BY 3.0. USFS, FS Archive, USFS, Bugwood.org

Partial Cutting and Root Disease



Partial Cutting and Root Disease



Partial Cutting and Root Disease



Partial Cutting and Root Disease



Root disease management

- Inoculum removal
 - Stump removal, or ‘stumping’
 - Stumps are pulled out of soil and roots exposed
 - Not necessary to burn or remove since the fungus will stay in the stump and roots, but root contacts are broken

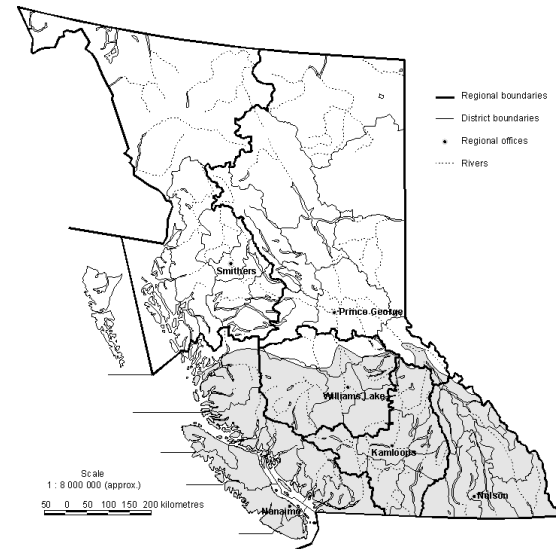
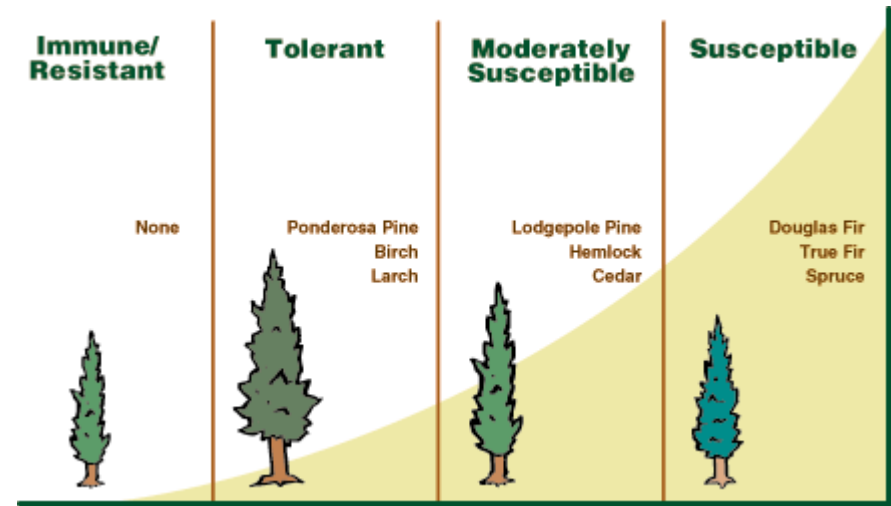


Armillaria ostoyae, Nat.Res.Canada, CFS.
<https://tidcf.nrcan.gc.ca/diseases/factsheet/78>

- But...can cause erosion, compaction, and provide seedbed for alder
- Expensive operation, but can be an investment; if disease is removed stand can return to its full productivity and result in large future gains

Alternate species selection

- Regenerate with less susceptible conifer species
- Hardwood cropping also an option



Inoculum avoidance

- Variable stand density
- 50 cm stump avoidance, still experimental



Biocontrol and chemical



© Jaroslav Maly

www.naturfoto.cz

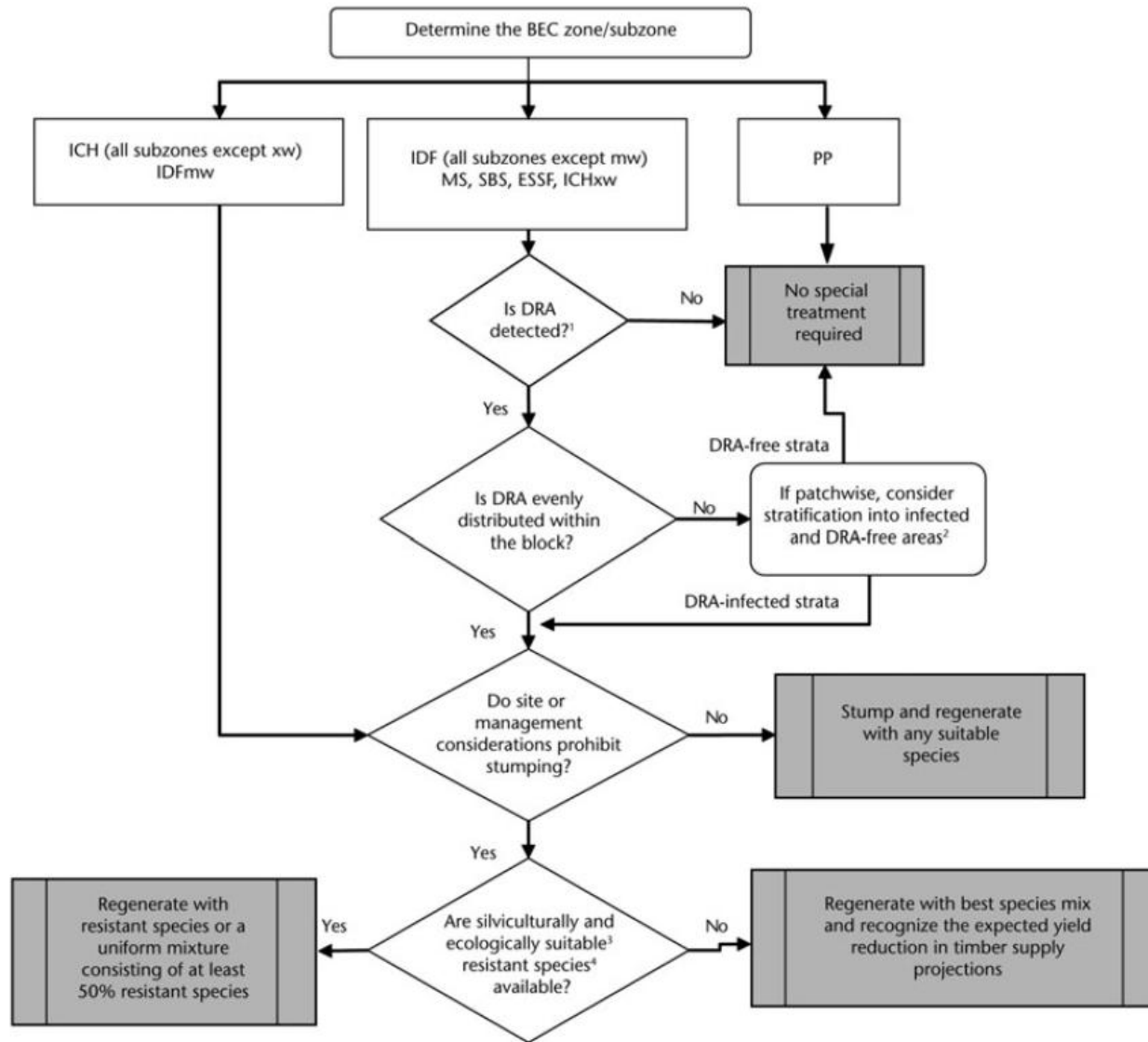
USING *HYPHOLOMA FASCICULARE* INOCULATION
AS A MEANS TO CONTROL ARMILLARIA
ROOT DISEASE ON CALCAREOUS SOILS:
TRIAL ESTABLISHMENT AND MONITORING¹

**Inoculation of stumps with *Hypholoma fasciculare*
as a possible means to control armillaria root
disease**

Bill Chapman and G. Xiao

Armillaria Root Disease – Southern Interior Forest Region

FIGURE 1. Decision key for different treatment strategies for Armillaria-infested sites by BEC zone/subzone for the Southern Interior Region.



Prevention is the key!

Diagnosis

- Learn how to recognize pathogens, conduct proper diagnosis

Epidemiology

- Understand pathogen biology, survival, dissemination

Disease management

- Know the toolbox of management options