Root Diseases

Effects of root disease
- change in composition because of specificity - succession? (primary hosts and seconday hosts)
- predisposition - especially to bark beetles
- Growth loss greatest, (height first)
- Loss of accumulated volume - also premature death & decay
- Delays in restocking - decades in gaps
- hazards - in populated areas

General symptoms of root disease
- tree mortality spread out over many years and usually present in only some species; in new centers young suppressed trees are often the first to go lions tailing due to slow growth (in contrast to needle loss caused by pollution)
- reduced production of needles, Chlorosis (yellow needles)
- premature pruning of lower branches
- Bark beetle attack esp. *Dendroctonus* spp. in pine and Doug-fir, Scolytus in fir.
- Resinosus (*Pinus, Picea, Pseudotsuga, Larix* only)
- discoloration in wood, lesions on roots

*Heterobasidion (Fomes) annosum* - root rots of conifers
- point entry into stands, spreads along roots to adjacent trees, fruits deep in stumps (California).
- Species complex of 3 biological species, conidia are produced but their role is unknown.

**P type** - (*H. annosum sensu stricto*) Pine, Juniper, Incense Cedar and some hardwoods.
- In pine enters through stumps (not wounds); kills cambium. range: NA & Eur. (Asia?). North American and European types are interfertile, but are quite different in neutral markers.

**S type** - (now *H. parviporum*) Spruce, Fir, Hemlock, Giant Sequoia, (Douglas fir?); can enter through wounds, decays heart wood and inner sap wood, butt rots and root decay, range: same minus eastern NA.

**F type** (now *H. abietinum*) - *Abies alba*, Northern and central Italy, Mates with S-type of Finland but not in Alps (example of ABC mating pattern, =sympatric intersterility, allopatric compatibility). pathology similar to S-type.

Signs and symptoms: general symptoms of root disease, Conks (position varies with climate) and button conks, *Oedocephalum* anamorph, distinctive rot pattern -white stringy (laminated in fir), species of trees that are killed

Complex population structure of centers, limits to size (200 m²). In Yosemite valley 158 centers have been identified - there average rate of expansion is .67m/yr. (if interested see Can J. For. Res. 25:244-252)
Effect of management practices, stump treatments and relationship to species and size of stumps & biological control (*Phlebiopsis gigantea*)

**Armillaria**
Complex of "biological species"

<table>
<thead>
<tr>
<th>mating group</th>
<th>Species</th>
<th>Pathogenicity / Virulence</th>
<th>distr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NABS I</td>
<td><em>A. ostoyae</em></td>
<td><strong>major pathogen</strong> on conifers, also attacks hardwoods, large clones</td>
<td>NA, Eur.</td>
</tr>
<tr>
<td>NABS VI</td>
<td><em>A. mellea</em></td>
<td><strong>major pathogen</strong> on hardwoods particularly ornamentals, also attacks conifers</td>
<td>NA, Eur</td>
</tr>
<tr>
<td><strong>NABS VI</strong></td>
<td><em>A. gallica</em></td>
<td>weak pathogen, but may act as a secondary invader of stressed trees, common in suppressed over mature hardwoods, very large clones</td>
<td>NA, Eur</td>
</tr>
<tr>
<td></td>
<td><em>(bulbosa)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>A. borealis</em></td>
<td>moderate pathogen, common butt rot of conifers in northern Europe</td>
<td>Eur</td>
</tr>
<tr>
<td></td>
<td><em>A. cepistipes</em></td>
<td>similar to <em>A. gallica</em> in morphology and behavior, associated with butt rot of conifers in Finland</td>
<td>NA, Eur</td>
</tr>
<tr>
<td>NABS II</td>
<td><em>A. gemina</em></td>
<td>apparently weak pathogen</td>
<td>NA</td>
</tr>
<tr>
<td>NABS III</td>
<td><em>A. calvenscens</em></td>
<td>Observed as a hardwood pathogen in the NE</td>
<td>NA</td>
</tr>
<tr>
<td>NABS V</td>
<td><em>A. sinapina</em></td>
<td>Weak pathogen acts like <em>A. gallica</em>, NA haploids may be more virulent</td>
<td>NA</td>
</tr>
<tr>
<td><strong>NABS IX</strong></td>
<td><em>nabsnona</em></td>
<td>Weak pathogen acts like <em>A. gallica</em>, NA haploids may be more virulent</td>
<td>NA</td>
</tr>
<tr>
<td>NABS X</td>
<td>unnamed</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>NABS XI</td>
<td>unnamed</td>
<td></td>
<td>NA</td>
</tr>
</tbody>
</table>

*bold species are known from California*

**Symptoms & sign**
- many species of host effected, both hardwoods and softwoods
- mushy or spongy white rot
- Mycelial fans under bark of dead trees
- Bioluminescent mycelium (fox fire)
- Black rhizomorphs
- honey mushrooms in the fall, dry remnants in the spring

**Disease / Saprobic cycles**
- role of predisposition, interactions with other root pathogens
  *Armillaria* - oaks & fir, pines.
Black Stain root disease (*Leptographium wageneri*) - a vacular root disease

**Biology**
- asexual state of ascomycete, sexual state appears not to be important in nature, effects on population genetics
- grows in tracheids of outer sapwood, moves through bordered pit and induces tyloses - **not a rot**
- **temperature sensitive** likes relatively cool settings (15-21°C) - this limits the extent of bole colonization (2 m in pine, as much a 10 in Doug Fir)
- long distance dispersal vectored by root feeding bark beetles *Hylastes macer*, *H. nigrinis*, also root weevils *Pissodes faciatus* and *Steremnius carinatus*.
- short range via root contact or near root contact, mostly through small 2ndary rootlets
- can kill all ages of trees but usually less than 80-100 year range, often shows up in the 35-50 year age class
- predisposition to beetles & Armillaria
- **does not persist in dead trees or soil very long.**
- most common in cool moist sites with deep soils; other soil characteristics: high moisture and organic content, rate of growth correlated with moisture, temp, and soil organisms
- disturbance, particularly disturbance that results in soil compaction is correlated to disease incidence. Ridge tops in Oregon versus Valleys in California. Precommercial thinning attracts beetles and weevils into stumps.

**Three Varieties** with specific host ranges
- *pseudotsugae* Doug-fir, smaller more frequent centers with more rapid beetle entry, often several cm in sapwood
- *ponderosa* - P pine, Jeffrey, (Lodgepole), larger centers, usually in outer most sapwood, in Sierras found at restricted elevational zone: 1290m to 1775M
- *wageneri* - pinyon pine, large centers, usually in outer most sapwood

**Signs & Symptoms**
as in other root diseases, black streaks, or arcs in cross section in outer sapwood near base of tree. Sapwood also resin soaked and often with a distinctive odor (citrus like)

**Digression to Blue Stains**, Black stains and wilts ecological association with bark beetles

Genera involved:
- Sexual stages - *Ceratocystis* and *Ophiostoma*
- asexual stage - *Leptographium* and others

**Part of wood colonized** - parenchyma - esp rays

no ability to digest cellulose enzymes available to breakdown resins

Effect on tree - occlusion of sapwood, but generally not enough to directly kill tree.
### Ceratocystis vs. Ophiostoma

<table>
<thead>
<tr>
<th>Feature</th>
<th>Ceratocystis</th>
<th>Ophiostoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perithecia</td>
<td>Black</td>
<td>Black or white</td>
</tr>
<tr>
<td>Anamorphs (asexual states)</td>
<td><strong>Chalara</strong></td>
<td><strong>Phialographium, Leptographium, Trichosporium, &amp; other non-phialidic anamorphs</strong></td>
</tr>
<tr>
<td>Cell Walls</td>
<td><strong>Cellulose - . Rhamnose -</strong></td>
<td><strong>Cellulose +. Rhamnose +</strong></td>
</tr>
<tr>
<td>Sensitivity to Cyclo-hexamide</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

### Beetle interactions

All bluestains are vectored with beetles, but the association is tight in that some fungi are vectored almost exclusively by certain beetles but loose in that the spores are carried superficially.

Examples of tight associations:
- *Scolytus ventralis & Trichosporium symbioticum*
- *Dendroctonus ponderosae & Ophiostoma clavigerum*

Examples of antagonism
- *Dendroctonus frontalis & Ophiostoma minus*

Some are beneficial to specific beetles, and antagonistic to others

Most are pathogens to some degree, but the degree varies and does not seem to correlate with beetle virulence.

### Phellinus (*Poria*) weirii  
Laminated rot root

The most serious root decay organism in Douglas fir

Geographic range - Pacific NW, & Asia

Two forms:
- Douglas fir form (primary hosts: Douglas-fir, White fir, Grand fir, Hemlock)  
  annual basidiocarps, mortality in most susceptible species, butt rot in others (e.g. Pine).
- Red Cedar form - (primary host Western red Cedar), perennial basidiocarps, mostly causes butt rots

#### Signs and Symptoms
- Mycelium with brown hairs (Setae, actually common to all *Phellinus*):
- Gray-brown resupinate basidiocarp with white margin on wind-thrown root balls
- Reddish-brown stain in stump, prior to noticeable decay
- Laminate rot with pitting
- Huge circular or semicircular centers

#### Disease cycle
- Long term survival in dead roots and stumps (> 50 yrs)
- Contact of healthy roots with decay, roots may be as small as 2 cm in diam
mycelium grows superficially along root and penetrates at several points in some trees the cambium is attacked and the tree is girdled and killed in most trees the root and butt root result in wind throw often snapping at butt centers spread at about 2ft/yr, often undergo succession changes

Interaction with fire cycle & succession
Work of Dickman (1992) -

Phaeolus schwinitzii (velvet-top, or cow patty fungus, brown cubical butt rot)
most serious butt rot of old growth Douglas fir. also found in true fir, and white pines; most confers can occasionally be hosts

Range: North America and Eurasia

Signs and Symptoms - distinctive decay, terpintine odor, resinosus, durable (though annual) fruitbodies at base of trees.

Disease cycle - infection by spore on wounds, possibly via soil, Chlamydospores produced in culture, but function in nature not known. Large centers usually are not formed (except in Montana). Can colonize roots occupied by Armillaria.

Inonotus circinatus, I. tomentosus, I. triqueter (false velvet top)
Hosts - spruce and other conifers
2nd most common root and butt rot of fir and spruce in eastern Canada and the Lake States. I. circinatus also important in Florida
I triqueter occurs on the coast of California (e.g. Pt. Reyes, but is not recognized as a problem because it doesn't affect commerical forestry
Infects through wounds at butt or root collar -feeding wounds of rot weevils (Hylobius sp.) can serve as infection courts.

Symptoms & Sign - causes resin soaked wood with reddish coloration -ultimately a white pocket rot, ugly brown basidiocarps on soil at base of tree

Oomycete root diseases
Phytophthora cinnamomi
Biology
- three spores produced: Zoospores, Chlamydospores, Oospore
- infection via zoospores at feeder roots, colonization of cambium follows, rapid growth, seedlings killed quickly, larger plants decline
- thought to be an introduction from New Guinea or Southeast Asia, mating types
- generally a problem only in warm soils that are at least seasonally wet, does not persist in climates in which soils freeze

Diseases
- nurseries and ornamentals

- Little leaf disease, Piedmont soils - Short leaf and Loblolly pine, interaction with agriculture, soils, species composition change, management
Symptoms - as in other root diseases, + shortened needles, distress crops of cones
- Oak decline in Spain, Eastern US??
- Behavior in Australia Jarrah Forest in Western Australia

*Phytophthora lateralis* (Phytophthora root rot of Port Orford cedar)

- Host: Port Orford Cedar *Chamaecyparis lawsoniana* (*Rhododendron* in east)
  introduced pathogen, first noticed in nursery stocks 1923, spread throughout main
  range of host by human activities
- areas along road and waterways most susceptible
- infects via feeder roots, leaves, wounds, colonized cambium and girdles tree
- seedlings are killed in a few weeks, mature trees are killed in 2-4 years
- temperature optimum 15-20°C, infections and growth are primarily limited to
  spring and Fall
- goes dormant during the summer: Oospores and Chlamydospores

Sign & Symptoms - selective killing of Port Orford cedar, cinnamon brown color of
inner bark near butt.

Management - eliminate entry into stands, plant other species where disease is
known to be a problem

Reading:

Root disease
Chapter 12 in your book pp 275-307

Readings for next week

*Slaughter and Rizzo 1999* Past forest management promoted root disease in

Carrol, and D. T. Wicklow, eds.*) The fungal community, its organization and role in the
ecosystem.* pp. 499-520 New York, Marcel Dekker. Skip part about *Armillaria
luteobulbalina.*