Conditions for infections of leaves
Need for moisture
Entrance into leaf
Age of leaf

Impact of partial and complete defoliation: conifers versus hardwoods

 Needle casts
most are host specific
always present, most are not killers
generalized life-cycle & symptoms: ascocarp a "hysterothecia", asexual spores absent
or non-infective, single infection cycle/season and only new foliage infected - BUT
symptoms don't show until the following 1-4 years; these symptoms include
premature death and shedding of needles.
Christmas tree production and interactions of microclimate, branches closest to the
ground most susceptible.
Control measures (Christmas trees only) - weed control, no overhead watering,
fungicide
Chronic low levels in natural forest, with occasional weather-related outbreaks

 Elytroderma deformans
 Hosts - for witches brooms and needle cast: ponderosa, Jeffrey, Coulter,
Knobcone pine; for needle cast only: Lodgepole, Jack, pinyon, shortleaf
-only needle cast fungus that moves into branches, witches brooms, can cause
severe growth loss and even death.

 Lophodermium spp.,
 > 20 spp cause diseases on pines an other conifers
 L. crassum & L. piceae on spruce
 L. piniasti complex on pines

 True fir needle casts Lirula abietis-concoloris and Virgella robusta.
very long hysterothecia,
hosts: true firs
Rarely a problem, expect in exceptional weather, or in Christmas tree farms

 Rhabdocline: pseudotsugae & R. weirii
really a set of closely related species and varieties which differ in age of needles
that they show up on
Host: Douglas fir, most important needle cast on Doug fir.
Geographic range: know throughout natural and introduced range of Douglas Fir,
most important in the latter.
Life cycle - ascospore release in spring, requires cool (13º C) wet periods of 3 days
or more for heavy infections; first symptoms typically show late summer or
early fall one year after infection, chlorotic spots becoming purple brown spots
and bands.
Signs: red-brown spots on underside of needles.
Resistance to disease is most common in the trees from the Pacific Northwest.
Usually not a serious problem on native sites, but can kill trees off site.
Management option in Christmas trees include weed control
relationship to the endophyte *R. parksii.*
no disease from *R. parksii* - 6 years or so between infection and sporulation
every needle on mature trees have it
age shift in species; # of clones/tree increases 2 to 3 orders of magnitude from plantations to old growth forest.

**Swiss Needle Cast Phaeocrytopus gaemanni**
**Host:** Douglas fir, most important needle cast on Doug fir.
First discovered in Switzerland (1925) - but native to North America
a problem of Christmas tree plantations and off-site plantings (esp. Europe)

**Needle blights of pine**
**differences from needle casts:** infects all ages of needles, asexual spores important, multiple infection cycles within a single season, symptoms immediate. general life cycle

**Red-band needle blight: Mycosphaerella pini, (Dothistroma pini - name of asexual state)**

Most devastating of the needle blights, 3 varieties based on spore size
Hosts: most hard pines, rarely other conifers
Geographic range: worldwide in natural and introduced range of pines
Signs & Symptoms (develop in 4-12 weeks): red-brown bands followed by death of needle and development of small black asexual fruitbodies,
Lifecycle: a few weeks after death of needle new conidia formed on small black fruitbodies, these are dispersed by rain splash or become airborne and infect all ages of needles, new infection occur as long as conditions are optimal (5-25°C and 100% humidity). In plantations seedlings can be killed in a single year and larger trees usually take several years.
**Resistance age dependent** in some species- after 10 years Monterey pine is usually immune (other interpretations possible), others such as Ponderosa pine are susceptible throughout their age.
**Relationship to off site planting** (Monterey pine, North coast, New Zealand, Africa)

**Brown spot needle blight Mycosphaerella dearnessii (Scirrhia acicola)**
hosts: most pines
rain splash conidia, very little wind dispersal, favored by warm wet weather
symptoms and signs: symptoms show 1 to 6 months after infection, brown bands and dead needle tips with small black fruitbodies (sexual) along length of needle in necrotic areas, sexual fruitbodies produced at end of season, often near apex of needle in long leaf pine; in the north the sexual stage is unknown.
**Long leaf pine interaction with fire**
Snow molds or Felt blights

*Herpotrichia juniperi* & *Neopeckia (Herpotrichia) coulteri*

Hosts: conifers, pines respectively

signs & symptoms: lower branches enveloped in felt, death of branches & seedlings

geographic range: worldwide, high elevation

life cycle (as known): growth under snow, growth stops after snow melt, 2nd winter perithecia (actually pseudothecia) form, asci mature in summer.

Impact: little except for landscape of tree islands in timberline areas

Many common diseases on Hardwoods 2 examples from our campus

**Anthracnose** - common name can be apply to a variety of diseases that cause necrotic spots on broad leafed trees, more common in Eastern US.

*Apiogynomonia veneta* on Sycamore

primary infection by ascospores or overwintering mycelium in buds

secondary infections by conidia during summer, the a latter very weather dependent

**Powder Mildews**

Common on many broadleaved trees and shrubs

primary infection by ascospores or overwintering mycelium in buds

secondary infections by conidia during summer, the at latter can happen at very low humidity, numerous in Mediterranean climates (like California).

*Cystotheca lanestris* - on coastal live oak, resident infection in branches, can actually kill trees, seen most common in city settings (see it on young trees on Lawn in front of Barker hall)

*Microsphaera plantani* - powder mildew, very common on sycamores on campus, probably exacerbated by pruning effects.

**Rusts**

basidiomycetes, but very different from all others

All are obligate biotrophic parasites

Huge number of species >5000 described

Most are temperate rusts are heteroecious (they cycle between two unrelated hosts)

requirement to infect through leaves or stems limits the success of infections to areas or times with high humidity (similar to other foliar pathogens!).

This means that infections are not uniform in time or space, especially in dry regions (like Western North America)

Microclimate effects - lower branches, grassy areas, fog belts, waterfalls,

Timing effects - "Wave years"
Complex life cycle - 5 spore stages and two hosts. (simplified in text fig 10.11), more detail in 13.13, p328 ), and attached alternative figure - essentially the White Pine blister rust (Cronartium ribicola) cycle

*Cronartium ribicola* - White pine blister rust

**Hosts** - 5-needled pines ("white or soft" pines - Aecial host
   Both Ribes spp. and *Pedicularis* - telial and Uredinial hosts
   introduced from Asia - generally lethal to pine hosts in North America (more on this latter)

Western (and Eastern and fusiform) Gall rust
   life cycle - a simplification derived from Eastern Gall rust, which cycle between pine and oak.

   Aeciospores produced in galls on pine, re-infect pine. No other host or spore stage is involved.

   Spores infect directly through bark of young shoots. Timing and weather are critical for high infection rates.

   Interactions with growth rate of hosts and sites

   Infection remain localized in the gall area

   Infected branches can live several to many years. Ultimately they are killed by secondary pathogens that invade the wounded stressed tissue (especially canker fungi like *Nectria*).

   Trees can live for many years with multiple gall infections

   Trees that are infected in the main shoot are more likely to die

   Tree death is typically cause by a combination of secondary pathogens and bark beetles.

   most common pine rust in western NA. Common hosts in our area: **Lodgepole**, Ponderosa, Jeffrey, **Monterey, Knobcone, and Bishop pines**.

   Very common in coastal pines, incidence in the Sierra's varies with microclimate.
Some rusts that we may see or hear about elsewhere (those in bold you should know; those with a * are important diseases on forest trees)

<table>
<thead>
<tr>
<th>Rust</th>
<th>Spermagonial/Aecial hosts</th>
<th>Uredinial/Telial hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Western Gall rust:</strong> <em>Peridermium harknessii</em> <em>(Endocronartium in text)</em></td>
<td>hard pines on stems: <em>Pinus</em> spp</td>
<td>None</td>
</tr>
<tr>
<td><strong>Eastern Gall rust &amp; fusiform rust:</strong> <em>Cronartium quercuum</em> complex</td>
<td>Hard pines on stems:</td>
<td>Oaks: <em>Quercus</em> species</td>
</tr>
<tr>
<td>Coleosporium sp.</td>
<td>Pine needles</td>
<td>Various members of Asteraceae (e.g. <em>Solidago</em>, <em>Madia</em>)</td>
</tr>
<tr>
<td><strong>Melampsora</strong> spp.</td>
<td>various members of Pinaceae on needles:</td>
<td>Popular and Willow – very important on hybrid poplars!</td>
</tr>
<tr>
<td><strong>Gymnosporangium libocedri</strong></td>
<td>Juneberry: <em>Amelanchier</em> spp.&amp; other rosaceous shrubs</td>
<td>Incense cedar: <em>Calocedrus decurrens</em></td>
</tr>
<tr>
<td>Broom rust of true fir:* Melampsorella caryophyllacearum</td>
<td>True fir: <em>Abies</em> spp.; <em>Abies concolor</em> in our region</td>
<td>chickweeds: <em>Stellaria</em> spp. and <em>Cerastium</em> spp.</td>
</tr>
<tr>
<td>Spruce Broom rust:* Chrysomyxa Arctostaphyli</td>
<td>Spruce: <em>Picea</em> spp.</td>
<td><em>Arctostaphylos uvi-ursi</em></td>
</tr>
<tr>
<td>Uredinopsis</td>
<td>Abies needles</td>
<td>Ferns (Bracken fern in our area)</td>
</tr>
</tbody>
</table>

References
For Foliar Diseases other than rusts. See pp 309-313 and 318-323 in your text

Rust coverage in the text book  p 323-331. Life cycle coverage is good, but almost nothing is mentioned about Western Gall rust!
Typical *Cronartium* rust cycle from an ecological prospective. 1) Infection of the pine occurs in late summer or early fall from haploid *basidiospores* produced on the angiosperm leaves. These spores are thin-walled and fairly susceptible to desiccation. As a result they have a relatively short dispersal distance, especially in dry climates. 2) Successful spores infect pine needles and grow into the branches where they make a perennial infection that last for as many years as the pine branch lives. Fertilization via insect dispersed haploid spermatia yield dikaryotic *aeciospores* in different genetic combinations. 3) Aeciospores are released each spring in huge numbers from cankers on the pine. The thick wall enables long distance dispersal. Leaves of a particular angiosperm host are the target. 4) Thick-walled dikaryotic *urediniospores* are produced throughout the summer on the angiosperm leaves and infect the same host species. They too can be dispersed long distances. In areas where leaves are retained throughout the year (e.g. coastal California) the rust can maintain itself with this host alone. 5) Basidiospores are produced after karyogamy and meiosis.