Armillaria Root Disease

Most important root disease in the Rocky Mountain Region

Pathogen—Armillaria root disease is caused by many species of *Armillaria*, a genus of mushroom-forming fungi. *Armillaria solidipes* (= *A. ostoyae*) is the most common species in the Rocky Mountain Region, but there are indications that additional species are present in Wyoming.

Hosts—Armillaria root disease has a very wide host range and has been found on almost all common tree species and in all major forest types in the Rocky Mountain Region. It is also very widespread, probably occurring in all forests of the Region. It seems to be most abundant in spruce-fir and mixed conifer forests.

Signs and Symptoms—Signs are physical evidence of the pathogen and are diagnostic (unique to the disease) when reliably identified:

- Mushrooms. Mushrooms are the most conspicuous sign of the pathogen (fig. 1). However, they are only abundant in certain years and only last for a few weeks, usually in late summer to fall. The other signs are almost always present with the disease.
- Rhizomorphs. These brown to black, root-like fungal organs are several millimeters in diameter, branched, and composed of fungal hyphae aggregated within a protective sheath. They grow in soil or along roots and infect when they encounter susceptible hosts.
- Mycelial fans. These whitish, fan-like layers of fungal tissue grow between bark and wood as the fungus invades roots and lower stems (figs. 2-3).

Symptoms may not appear until very late in disease development and are not diagnostic when they do appear. Symptoms may include:

- Resinosis. Resin exudation near the soil line (above or below) is a good symptom (figs. 3-4). It occurs mostly in the resinous conifers but not in all cases. It is evidence of the host attempting to defend itself.
- Wood decay. Openings or uprooting of the tree may reveal decay in the wood of roots or lower stem. Otherwise, decay is hidden and difficult to detect. The decay is a white rot and often contains zone lines (fig. 5).
- Crown symptoms. These include slower terminal growth, thin or yellow foliage, branch dieback, and stress crop of cones (particularly in Douglas-fir).

Figure 1. Mushrooms of *Armillaria ostoyae* can be abundant for short periods in late summer to fall during wet years. Mushrooms are usually in clusters around the base of a tree. Caps are honey-brown with small scales; gills are white and attached to the stem, which is white to scurfy brown at the base with a poorly-formed ring. *Photo: William Jacobi, Colorado State University.*

Disease Cycle—The pathogen survives many years in dead roots, perpetuating the disease on a site. It has two main ways of spreading. One is local spread: the fungus grows across root contacts and grafts between infected and healthy roots or, in some cases, via rhizomorphs that grow through soil. This can result in gradually expanding disease centers (fig. 6). However, many of the Region's subalpine forests are completely colonized, so infection is spatially random rather than occurring in discrete centers. The fungus also spreads is by producing mushrooms with wind-dispersed spores. Spores are rarely successful, and it is thought that this mode of spread is uncommon, especially in the arid West. Small, stressed, or highly susceptible trees may succumb quickly. Older, vigorous, or somewhat resistant trees may survive for many years with the disease progressing slowly or remaining isolated in initially infected roots.

Impact—Armillaria root disease causes mortality, growth reduction, cull, and predisposition to other lethal agents. Root diseases lead to stand heterogeneity, creating openings and patches of coarse woody debris, uneven age classes, and altered composition. Mortality is often through mechanical failure of live trees, which can be dangerous in developed sites (figs. 7-8). Impacts are not quantified in the Rocky Mountain Region (though annual volume losses in subalpine fir alone in Colorado were estimated at 10,500 m^3 [370,800 ft^3]), but because the disease is widespread in most forest types, impacts are undoubtedly substantial. In lodgepole pine, mortality is common up to about age 20, when the mortality rate greatly decreases (fig. 9). In most other species, impacts seem to be more severe in mature trees. Subalpine fir is often killed quickly, but Engelmann spruce often survives until

Figure 2. Mycelial fans under the bark are the characteristic sign of Armillaria root disease. *Photo: USDA Forest Service training slide set*

Figure 3. Symptoms and signs of Armillaria root disease: mycelial fan barely visible in the bark on the left (near fingers); resinosis apparent in upper right; decay in a root near the soil line. *Photo: Jim Worrall, USDA Forest Service.*

Figure 4. Resinosis is a symptom often caused by Armillaria root disease near the soil line. *Photo: Jim Worrall, USDA Forest Service.*

Figure 5. Armillaria decay with zone lines. *Photo: Jim Worrall, USDA Forest Service.*

Figure 6. Armillaria root disease center with standing mortality. *Photo: Jim Worrall, USDA Forest Service.*

mechanical failure. In the Front Range and Black Hills, 62% and 75% of ponderosa pine attacked by mountain pine beetle were also infected by Armillaria root disease. Similar interactions probably occur in spruce-fir forests.

Management—Management of Armillaria root disease is difficult. The following approaches used in other areas are impractical in this Region's forests but can offer general guidance:

- Manage for resistant species. Almost all tree species in the Rocky Mountain Region are susceptible, and few are suitable for a given site. However, lodgepole pine becomes resistant at about 20 years and aspen is usually little affected, so some heavily impacted stands can be converted by favoring resistant species in thinning or during regeneration.

- Tailor management in disease centers. In subalpine forests in this Region, the disease is typically random rather than aggregated in discrete disease centers. However, where centers are recognized, management can be tailored to them.
- Stump extraction. In the Pacific Northwest, long-term experiments have demonstrated that removing stumps during regeneration can significantly reduce root disease in the future stand. This is sometimes used operationally there, but has not been attempted in the Rocky Mountain Region.
- Biological. Research suggests that competitive fungi might be manipulated to reduce the food available to the pathogen and perhaps even replace it. However, these approaches are not operational at this time.

Figure 7. Vehicle crushed by a tree infected with Armillaria root disease that failed while green. *Photo: Jim Worrall, USDA Forest Service.*

Figure 8. Aftermath of an Armillaria root disease center in a campground. *Photo: Pete Angwin, USDA Forest Service.*

Figure 9. Armillaria in young lodgepole pine. *Photo: Pete Angwin, USDA Forest Service.*

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