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Decay and Discoloration of Aspen

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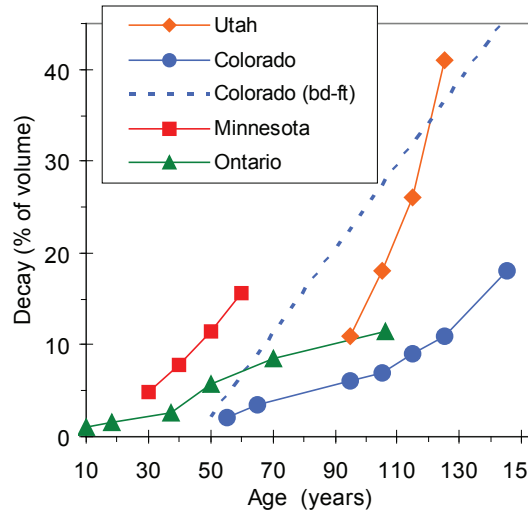
Populus tremuloides (quaking or trembling aspen, hereinafter referred to as aspen) is the most widely distributed tree species in North America and grows on diverse sites. The commercial range includes the Lake States, parts of New England, parts of the Rocky Mountains, and much of Canada. Throughout its range, aspen is highly susceptible to pathogens and insects. Pathogens that cause decay and wood discoloration affect strength and merchantability of the wood, result in hazard trees in developed sites, and contribute to wildlife habitat. The amount of decay and discoloration and the causes vary considerably throughout the tree's range.

Decay

The proportion of volume decayed varies with age, geographic region, and site quality. There is generally a strong trend of increasing decay with age (Figure 1). The increase is particularly pronounced on poor sites, where trees grow slowly and may be more susceptible to infection and development of decay. However, in regions where aspen grows quickly and matures early, such as Minnesota and neighboring states, decay also advances rapidly and early in the tree's life.

Figure 1. Increase of decay with age. Data are based on percent of total cubic volume, but the blue dashed line represents a reanalysis of the Colorado data to give percent cull in terms of board-foot (Scribner) volume. The Colorado data represent intermediate sites; good sites were similar but decay increased faster on poor sites. Data from Basham 1993; Davidson et al. 1959; Hinds and Wengert 1977; Meinecke 1929; and Schmitz and Jackson 1927.



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White trunk rot

Phellinus tremulae causes white trunk rot, the most important stem decay of aspen. Fruit bodies (conks) on living trees are the most reliable external indicator of the disease (Figure 2). Conks typically occur at branch stubs or scars, where the fungus grows out from the internal decay along the branch trace. The conk is triangular in profile, with the upper surface sloping down and the lower surface sloping up. The conk is perennial, hard and woody. The upper surface is pale brown where actively growing but quickly becomes black and cracked. The lower surface is purplish brown and covered with very small pores. Internally, there is a granular core at the point of attachment, the upper flesh is dark reddish brown and fibrous, and the tube layers are indistinctly stratified and become stuffed with white mycelium.

Although white trunk rot occurs throughout the tree's range, the disease varies in incidence and severity. Damage has been related to tree age, diameter, site quality, and genotypic variation. Sampled stands in the Lake States had white trunk rot in 42 percent of the merchantable-sized trees and 86 percent of the infected trees bore conks. *Phellinus tremulae* caused 75 percent of the decay found in merchantable portions of the sample trees. A more recent study of 21- to 50-year-old stands in Minnesota found that 80% of trees had at least some advanced decay, trees with conks (14% of all trees) accounted for 64% of the decay found in the study, and decay associated with conks was underestimated by previously published guides. In Colorado, white trunk rot caused 59 percent of decay loss although it only infected 10 percent of the trees. Among infected trees, 79 percent bore conks. Decay may extend 2-3 m in each direction from conks, and cull increases with number of conks. On good sites, incidence of trees with decay increased linearly with age from near 0% at 40 years to 91% at 160 years. On poor sites, decay tends to be more advanced at a given age.

The white or yellowish spongy rot associated with *P. tremulae* begins in the inner wood. The early stage of decay is characterized by a soft cream color, often with distinct dark zone lines separating it from the surrounding healthy wood. In later stages of decay, the wood becomes spongy or punky, yellowish in color, and the decayed wood contains a number of irregular concentric black zone lines (Figure 2). A brown stain is usually found on the perimeter of the decayed wood. The rot can occur throughout the length of the tree and in advanced stages sapwood may be invaded, leading to mortality in slow-growing trees. Occasionally the damage is so prevalent that it masks rot caused by other fungi. *Phellinus tremulae* is an "obligate" stem-decay fungus and, although very destructive to living trees, does not cause damage to stored logs or timber in service. It apparently does not require obvious, substantial wounds or large stubs for entry.

Large black stem galls of unknown cause are common in some areas and are sometimes mistaken for indicators of decay. However, trees with such galls are less likely to have conks than are trees without galls (Crane et al. 1994).

Other stem decays

In the Lake States and central Canada, the next most common defect is probably a brown mottled stain grading into yellow-brown, stringy trunk rot caused by either

Figure 2. Phellinus tremulae *fruit bodies and decay on live aspen stems. Top left: column of decay in stem leaving little sound wood. Top right: perennial conks often form at branch stubs. Bottom: decayed wood in center is surrounded by brown stained wood.*

Peniophora polygonia or *Radulodon americanus* (earlier identified as *Radulum casearium*) (Figure 3). Other frequently encountered trunk decay fungi are *Pholiota aurivella* (= *Pholiota adiposa*), *Conferticium ravum* (= *Gloeocystidiellum karstenii*), and *Inocutis rheades* (= *Polyporus dryophilus*). Important trunk decay fungi found in western North America are *Peniophora polygonia* and *Cryptosphaeria lignyota* (asexual stage *Libertella* sp.), which causes a white mottled rot as well as a canker known as Cryptosphaeria canker. The incidence of trunk infection by *P. polygonia* is greater than that of *Phellinus tremulae*, although the latter causes much more decay. *Radulodon americanus* is seldom found in western North America. *Inocutis rheades* probably occurs throughout the range of aspen but is generally uncommon.

Figure 3. Two fungi that frequently cause stem decay in aspen, but account for less decay volume than Phellinus tremulae*. Top:* Peniophora polygonia *fruiting at the edge of a wound on a live aspen. The callus wood beneath the fruiting was dead and slightly decayed with a white rot. Bottom:* Radulodon americanus *herbarium specimen and associated firm white rot. Ruler is marked in centimeters.*

Root and butt rots

Butt-rot fungi enter the tree through basal wounds, root wounds, and connected roots. *Gymnopilus junonius* (= *Gymnopilus spectabilis* in the sense of A.H. Smith) and *Pholiota aurivella* are common and cause a yellow-brown, stringy butt rot that usually extends upward only a few feet. In western North America, *Flammulina populicola* (recently segregated from *F. velutipes*) and *Ganoderma applanatum* are common. *Flammulina populicola* causes a yellow, stringy butt rot; *G. applanatum* causes a mottled white rot that is probably more common and certainly more important in that it frequently results in volume loss and mechanical failure of the roots or butt of mature trees (Figure 4). In eastern North America, *Armillaria* species are common and important, causing a white to yellow, stringy butt rot that, like *G. applanatum* in the West, results in volume loss and green-tree failure. In western North America, *Armillaria* species are common on dead aspen, but less commonly associated with disease of living trees than in eastern North America. Other common butt-rot fungi are *Pholiota squarrosa*, *Pleurotus populinus* (part of the *Pleurotus ostreatus complex), and Sistotrema* (*Trechispora*) *raduloides*.

Wildlife habitat

Aspen with stem decay are strongly selected for excavation of cavity nests by primary cavity-nesting birds. Secondary

Figure 4. Butt rot in aspen. Top left: Flammulina populicola *fruiting in the hollow butt of a live aspen. Top right: root failure associated with decay caused by* Ganoderma applanatum*. Note the conk on the lower stem (yellow arrow); the orientation of the conk indicates that it formed while the tree was standing. Bottom: conks of* G. applanatum *at base of standing trees.*

cavity nesters, which use nests excavated by other species, also take advantage of the habitat provided by the stem-decay fungi (Figure 5). Many mammals also take advantage of decay columns for protection, both before and after the tree falls. In the Rocky Mountains and many other predominantly coniferous forest regions, the great majority of cavity nests are excavated in aspen, even when aspen is a minor forest component, and in some reports all such nests were associated with *Phellinus tremulae*. Such decay in live trees combines the benefit of easy excavation with a barrier of sound wood protecting the nest from predators. Often, live aspen stems are strongly preferred, but in some areas, snags are preferentially used. It is not clear if preference for snags, where it occurs, is associated with either lack of stem decay in live trees or low predation pressure.

Figure 5. Three cavity nest entrances associated with conks of Phellinus tremulae *on a live aspen stem.*

Discoloration and wetwood

Although aspen heartwood is normally not distinct in appearance from sapwood, discoloration, or staining, is common in wood of aspen stems. It may originate as a response to wounds, frost cracks, branch stubs, insect or animal damage, increment-bore holes, etc. In addition, discolored zones often are associated with cankers, decay columns (Figure 6), and other microorganism activity. Discoloration may result from the reaction of living cells of the xylem to various agents, or directly from color imparted by microbial tissues or products.

The color of stained wood includes hues of brown, black, red, yellow, and green. Many stains occur in the heartwood before or during the development of decay. In the initial stages, the strength of affected tissues is not greatly reduced, but later these tissues may be weakened. In an Ontario study, nearly 20 percent of the total merchantable volume of live aspen contained a red mottle or brown stain. Another study associated *Peniophora polygonia, R. americanus, Phellinus tremulae*, and *Chondrostereum purpureum* with a common brown stain and *Peniophora polygonia* and *Bjerkandera adusta* with a mottled stain. In western North America, *P. polygonia* is usually associated with a pink stain and *Cryptosphaeria lignyota* with a greenish-brown stain. However, because of the many fungi and bacteria associated with stain in aspen and the vagaries of stain color and other features, it is difficult to be sure of the causes of particular stains.

Wetwood occurs in many hardwood trees. Wetwood appears wet and discolored and has a high mineral content and variable bacterial populations. It is not necessarily associated with decay; in fact, the anaerobic conditions and organic acids in wetwood inhibit fungal growth. Wetwood can encompass most of the cross section of the bole but generally is more restricted. Although the discoloration in aspen largely disappears when dried, the wood is brash and subject to splitting and cracking, and has reduced strength. Because the color fades, it is difficult to detect and cull out these affected zones early in the manufacturing process.

Figure 6. Advanced white trunk rot in aspen surrounded by discoloration. Note that decay has invaded sapwood and even the cambium is being killed in some areas.

Management

Because of thin bark, relatively minor wounds on aspen permit the entrance of various organisms into the wood beneath. There is no practical way to exclude these organisms by reducing injuries; nor is there any practical

way to reduce prevalence of branch stubs through which some pathogens gain entrance. Partial cutting to thin and remove defective trees is strongly discouraged in aspen because residual stands often deteriorate within five years. Therefore, the goal in managing aspen for fiber production should be to maintain uniform, well-stocked stands and to harvest these stands before decay and discoloration losses become excessive. These losses can be minimized if cutting ages are 50 years or less in the Lake States region and between 80 and 100 years in western North America.

Development of recreation and administrative facilities in aspen stands is discouraged because of aspen's susceptibility to decay, as well as other diseases following injury caused by humans. Developed sites in aspen stands need to be carefully managed to avoid damage and injury due to tree failure. Aspen in such areas should be surveyed and monitored for signs and symptoms of decay. Trees with advanced decay should be removed where there is risk of injury to people or damage to property.

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