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Decay and Discoloration of Sugar Maple

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Decays and discolorations are the greatest protection problem in sugar maple (*Acer saccharum* Marsh.). Although not fatal, these disorders reduce grade and volume, and cause far greater value loss than any other disease, insect, animal, or fire. Many trees are so damaged that harvest is not economical and they must be killed to increase growing space for other trees.

There has been much confusion about discoloration and heartwood in sugar maple, but recent research has shown the deeply colored tissue in the heart zone to be a stain or discoloration and not true heartwood. This discoloration is commonly called "heartwood," mineral streak, mineral stain, darkheart, blackheart, brown stain, or green stain, depending on its color, intensity, or pattern, and local terminology. These discolorations originate from mechanical wounds, dead branches, or butt rots.

Symptoms

In sugar maple, discolorations range from slightly deepened buff to dark brown or olive green and may be found throughout the stem and branches in variable patterns. Within the discolored areas, nearly all cells are dead, moisture contents tend to be higher than in normal wood, and mineral content and pH vary directly with intensity of the discoloration. The deepest discolorations have a pH of 9.0 (normal wood, 6.0), and mineral contents are about 10 times greater than usual. Most of these differences are probably caused by deposits of potassium and calcium carbonates.

Most decays are either soft, yellow brown, and stringy, or soft, white, and spongy, depending on the causal fungus. A brittle, brown cubical rot is rare. Decay is generally in older wood in the center of the stem but is occasionally in younger wood in the outer portions behind large wounds.

Where decays and discolorations enter through branch stubs or stem wounds, their radial limits seldom extend beyond the annual ring in which the wound occurred or the branches died. Wood formed later is generally clear, although later wounding may provide a new, larger radial limit. Vertical extension is extremely variable and depends on the fungus species, age and type of wound, and other factors. Because of this variability and because branches die and wounds occur at different times, the diameter of decay and discoloration, while not exceeding the limits mentioned, may vary up and down the stem (figs. 1 and 2).

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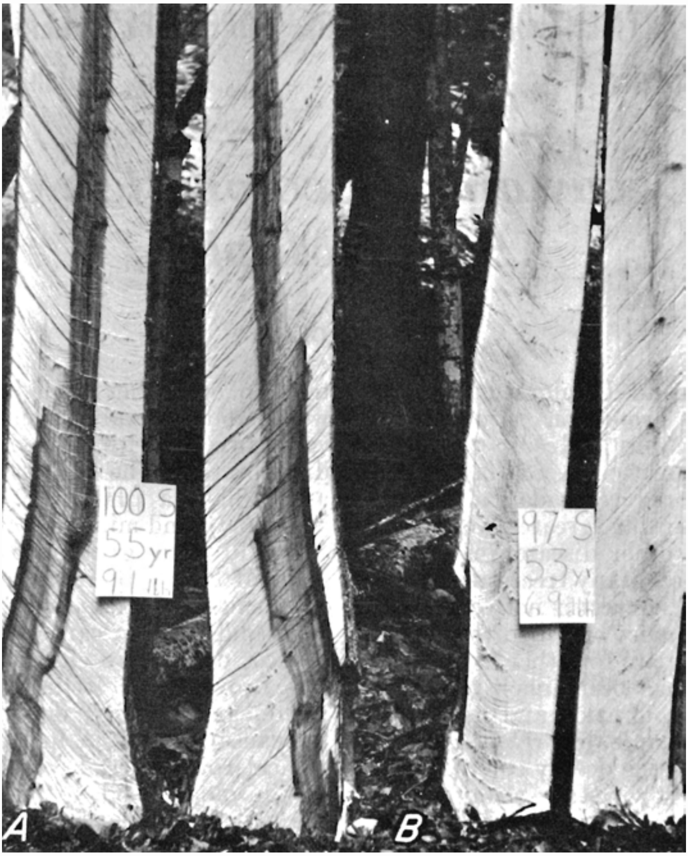

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***Figure 1.*—Sugar maples with 8-year-old basal wounds of the same size. Decay and discoloration did not enter tree *B* apparently because a dark protective barrier formed behind the wound and branches were lost early and healed quickly. Decay and discoloration entered wound of tree *A* and joined with the discoloration that entered from large, dead branches above.**

Butt rots and their associated discolorations show a different pattern, especially in larger trees. The diameter, as well as the height of the decay column, continues to increase, and discoloration develops for many feet above the decay. The discolored core superficially resembles true heartwood and often has a nearly circular outline, which coincides well with the maximum diameter of the decay below (fig. 3).

Decay columns in living trees are surrounded by discolorations and their associated nondecay fungi and bacteria (fig. 4). These nondecay organisms may inhibit radial extension of the decay fungi. While decay always advances through discoloration, discoloration does not indicate that decay will follow; many times it does not.

Fruiting bodies of decay fungi indicate decay and discoloration, but many are short lived, inconspicuous, or not present until the tree

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Figure 2.—**Discoloration entered from two branch stubs. The upper branch died first, and discoloration entering the lower branch has joined earlier discoloration. Note how diameter of discolored column increases and decreases up and down the bole. Cross section is from the base and is clear.**

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Figure 3.—**Column of discoloration extending more than 30 feet above *Armillaria mellea* butt rot in a large sugar maple. Discoloration has joined with other discolorations entering from branch stubs, which died earlier, and now forms a nearly circular column.**

dies and thus often are not detected. For this reason, other external indicators are generally more useful in revealing internal defect in sugar maples. These indicators may be abnormal swellings or depressions on the bole, mechanical wounds, unhealed branch stubs, cracks, seams or holes, cankers, sunscald, bird pecks, and insect holes.

Causes

While not all the processes causing discoloration of sugar maple are known, enough information is available to outline the probable course of events: Living xylem cells exposed by wounding, by branches dying or breaking off, root rot fungi entering the butt, etc., initiate physiological processes that form polyphenols in those cells which die slowly. Later, fungi and bacteria invade and aggravate these conditions, presumably by producing toxic substances that act at a distance. Their effect is sometimes exerted for many feet vertically but never for more than a few millimeters laterally.

Several nondecay fungi and bac-

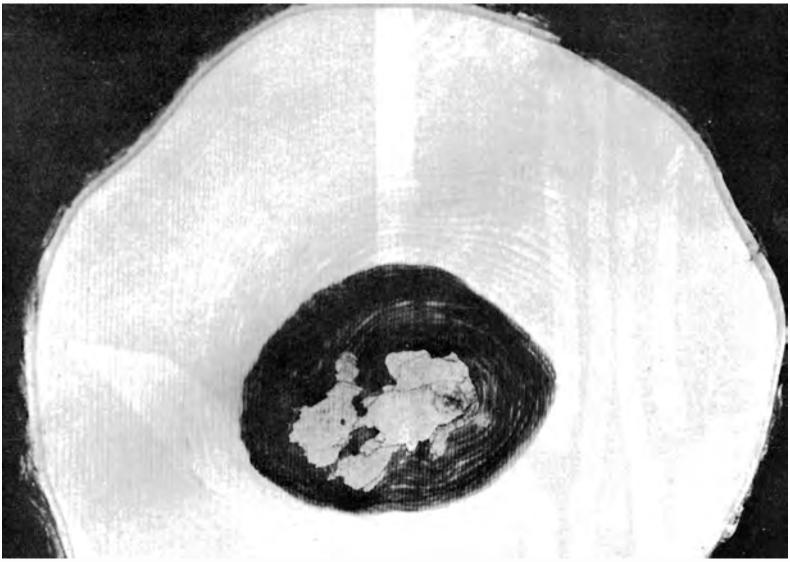

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***Figure 4.*—Decay and discoloration in cross section. Isolations generally contain decay fungus in the soft, punky center, bacteria and nondecay fungi in dark discoloration surrounding the rot, and no organisms in the clear wood.**

teria are commonly isolated from discoloration. The more common fungi are *Phialophora melinii* (Nannfeldt) Conant, *Tricocladium canadense* S. J. Hughes, and *Hypoxylon* sp.; the most common bacteria are *Pseudomonas* sp.

Discoloration is caused by deposits of dark material concentrated mainly in dead parenchyma cells, and its intensity varies with the amount and color of this material. Cells that die quickly are not discolored, suggesting that the process is a reaction by living cells in the tree to invasion. Extreme discoloration can also be produced by injecting various toxic materials, such as copper sulfate, into the stem.

All decays are caused by fungi. While more than 40 species have been isolated from decayed sugar maple, 8 are responsible for more than 80 percent of the volume lost. *Armillaria mellea* (Vahl ex Fr.) Kummer and *Polyporus glomeratus* Peck each cause about 25 percent of the decay. The following fungi each cause 10 percent or less: *Hypoxylon deustum* (Hoffm. ex. Fr.) Grev. (syn. *Ustulina vulgaris* Tul.), *Fomes connatus* (Weinm.) Gill, *Steccherinum septentrionale* (Fr.) Banker (syn. *Hydnum septentrionale* Fr.), *Pholiota adiposa* (Fr.) Kummer, *P. spectabilis* (Fr.) Kummer, and *F. igniarius* (L. ex Fr.) Kickx. *Corticium vellereum*

Ellis and Cragin is frequently isolated from decayed sugar maple but is probably incapable of decaying sound wood.

Decay fungi grow through discolored wood, producing enzymes in advance of their threadlike hyphae. These enzymes are capable of digesting cell walls of the wood. As the fungus advances, cell walls continue to disintegrate until only a soft punky mass remains.

Life History

Nearly all micro-organisms causing decay and discoloration in living sugar maple require a break or opening in live bark to enter a tree. An exception is the butt rot fungus, *Armillaria mellea*, which may directly penetrate some living roots.

The fungi reproduce by forming many spores which are spread by wind, water, insects, or animals. So many are produced that, although only a small fraction land under conditions favorable for germination and invasion, enough are established to continue the cycle. Most decay fungi produce their spores in characteristic fruiting bodies visible to the unaided eye; these are termed conks, mushrooms, or perithecia, depending on the species. The nondecay fungi associated with discoloration usually produce their spores in minute fruiting bodies visible only under a microscope.

The bacteria are spread in much the same way. However, most do not form spores, and the entire bacterial cell (generally smaller than a fungus spore) is disseminated. Bacterial cells are visible only at high magnification.

Newly wounded tissue or recently killed branch stubs are normally invaded by successions of organisms, beginning with bacteria and nondecay fungi and culminating with decay fungi growing through the discolorations and completely disintegrating the wood. At various times in the successions, the fungi produce their spores or bacterial cells become available for dissemination, and new successions begin at new infection courts.

Control

Control of decay and discoloration in sugar maple lies in *recognizing* and *eliminating* high-risk trees from a stand as early as is consistent with silvicultural considerations, such as spacing and stocking.

Guides for determining volume reductions associated with various external indicators have been published by Zillgitt and Gevorkiantz for the Lake States and by Silverborg for the Northeast. (See References.) These guides, based on data obtained from several hundred trees, are reasonably accurate when applied to stands or several trees but may be in considerable error when applied to an individual tree.

In general, good silviculture will reduce the number of high-risk trees and keep losses to an acceptable minimum. Practices that shorten rotations and promote rapid growth, early pruning, and good form will contribute greatly to control. Thinnings, improvement cuttings, and elimination of sprout clumps are essential; and pruning of certain crop trees may also be desirable. While pruning creates wounds through which decay and discoloration may enter, such damage is insignificant if pruning is confined to live branches less than 2 inches in diameter on saplings or pole-size trees.

Nearly all decays and discolorations enter through wounds, which therefore must be minimized. Close supervision of logging is particularly important. Depending upon its size and location, one wound can easily mean the difference between a grade 1 butt log worth $140 M bd.

ft. and a grade 3 log worth $35 M bd. ft. or ultimately a worthless cull occupying valuable growing space. Damage from insects, animals, and fire must also be controlled. Sugar maple is a highly valuable species and well worth any slight investment in care and protection.

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