

# Skeleton Decay in Eastern Red Cedar

By Kevin T. Smith and Jessie A. Glaeser

**E**astern red cedar (*Juniperus virginiana*) is a common tree species throughout the eastern United States and the Great Plains. Although “cedar” is in the common name, the scientific name shows a botanical kinship to the juniper species of the American southwest. Red cedar can survive and thrive within a broad range of soil conditions, seasonal temperature swings, and soil moisture. The oldest red cedar trees are found on rocky escarpments and the edges of cliffs. These are not necessarily big trees, but can reach 900 years of age or more in areas not easily

reached by lumbermen or wildfire. On more fertile ground, red cedar can grow to be large majestic trees and are most readily found as colonizers of former fields and pastures. Although not traditionally planted as a street or yard tree, red cedar is increasingly part of the community and neighborhood forest as the urban interface extends into former agricultural areas.

Most people know eastern red cedar because of the marvelous smell and the red-to-purple heartwood, historically used in cabinetry both for its beauty and for its ability to repel moths and other insects. Pole-shaped trees were frequently cut and used as fence posts at farms and homesteads because they resisted decay, even with one end buried in the soil. The color, aroma, and decay resistance all come from chemicals produced during the biological transformation of tan- or cream-colored sapwood into the purplish heartwood.

The decay resistance of red cedar does not mean immunity from the decay process, as seen in this specimen from central Missouri (Figure 1). What happened here? We will refer to this pattern of a durable core separated from an outer shell of wood as the “skeleton” pattern. Did a young tree grow within the shell of an old snag that had been hollowed out by decay, only to then die prematurely? Considering how the branches of the central core line up perfectly with the branch stubs of the shell, this is not likely the case. The central core is indeed decay-resistant heartwood. But why are we still seeing an outer shell? Sapwood is quite susceptible to decay fungi, and one would expect the sapwood to be long gone. Perhaps the shell is actually another layer of decay-resistant heartwood? Heartwood is supposed to be in the center, and the sapwood is supposed to be on the outside. What is going on here? Understanding the process that lead to this example can help the arborist explain what the client sees in his community and the countryside, a sure sign of competence and professionalism.

## Breaking Down Skeleton Decay

Recent research on wood quality and infection of red cedar (Shortle et al. 2010) integrates internal processes of tree growth, wood maturation, and fungal infection. Development of the skeleton pattern can be diagrammed



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Figure 1. The skeleton decay pattern in red cedar (*Juniperus virginiana*) displays a solid central core surrounded by a void and enclosed, at least partially, by a decay-resistant shell.

through time for a single idealized cross section along the stem (Figure 2). A young sapling of eastern red cedar contains living sapwood across the cross section of the stem (Figure 2A). Living sapwood cells are part of the symplast, the network of living cell contents that extends throughout the tree. Healthy sapwood conducts water, stores starch, and is capable of active response to injury and infection. Living sapwood resists the spread of infection by maintaining high moisture content when intact and by active compartmentalization when injured and infected. Compartmentalization resists the loss of moisture and the spread of infection through the formation of chemical and anatomical boundaries (Smith 2006; Schwarze 2008). In the living tree, wood decay generally occurs within compartment boundaries. However, wounded or killed sapwood has little natural resistance to wood decay.

As the stem increases in diameter and matures, sapwood is transformed into heartwood through the programmed death of living sapwood cells (Figure 2B). This programmed cell death involves a shift in metabolism to produce the chemicals that contribute to the color, aroma, and decay resistance of heartwood.

Mechanical injury to the stem exposes sapwood to drying and infection by microorganisms, including pioneer and wood decay fungi (Figure 2C). As living cells in the sapwood die from large or small wounds or infection, the wood changes in biological properties. These biological alterations are frequently accompanied by changes in wood color. Injury can have many sources: broken branches or snapped crowns from wind, ice, or snow; fire; insect and woodpecker damage; or the falling of neighboring trees. In the urban forest, wounds are common from vehicles, lawn mowers, and weed trimmers. Small wounds will result in wound-initiated discolored wood (WID) being localized within the tree. When multiple branches are broken at the same time or when the whole top is broken out of a tree, WID can form an entire band around the stem. Alternatively, infections can spread into stem sapwood from infected roots or branch stubs (Figure 2C).

WID no longer functions as sapwood and does not conduct water, store starch, or perform other functions of the symplast. Nor does WID mature into heartwood; it does not contain the chemicals that confer decay resistance and the characteristic color of heartwood. Production of new sapwood continues to move the vascular cambium away from the compartmentalized WID (Figure 2D).

This sapwood, formed to the outside of the compartmentalized WID matures and is transformed into heartwood (Figure 2E).

Along the radius of the stem, from the bark to the pith, the tissues are bark, phloem (frequently and inaccurately termed “inner bark”), vascular cambium, sapwood, heartwood, WID and decayed wood, and more heartwood. These are diagrammed (Figure 2E) and shown in cross section (Figure 3). Normal processes of decay in the living tree and the standing snag first remove the non-durable

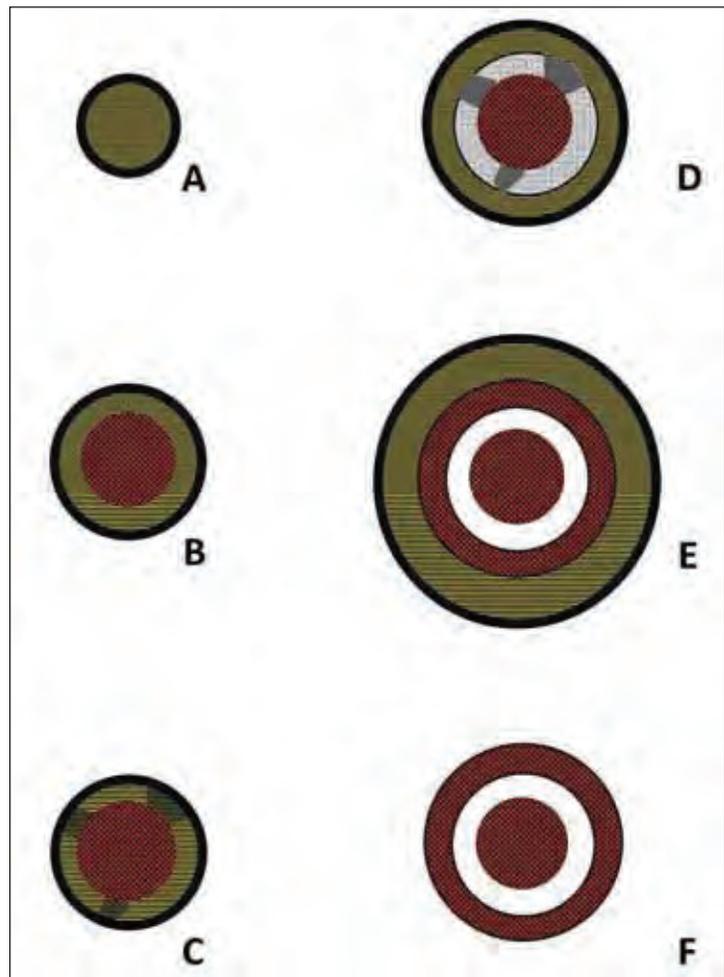
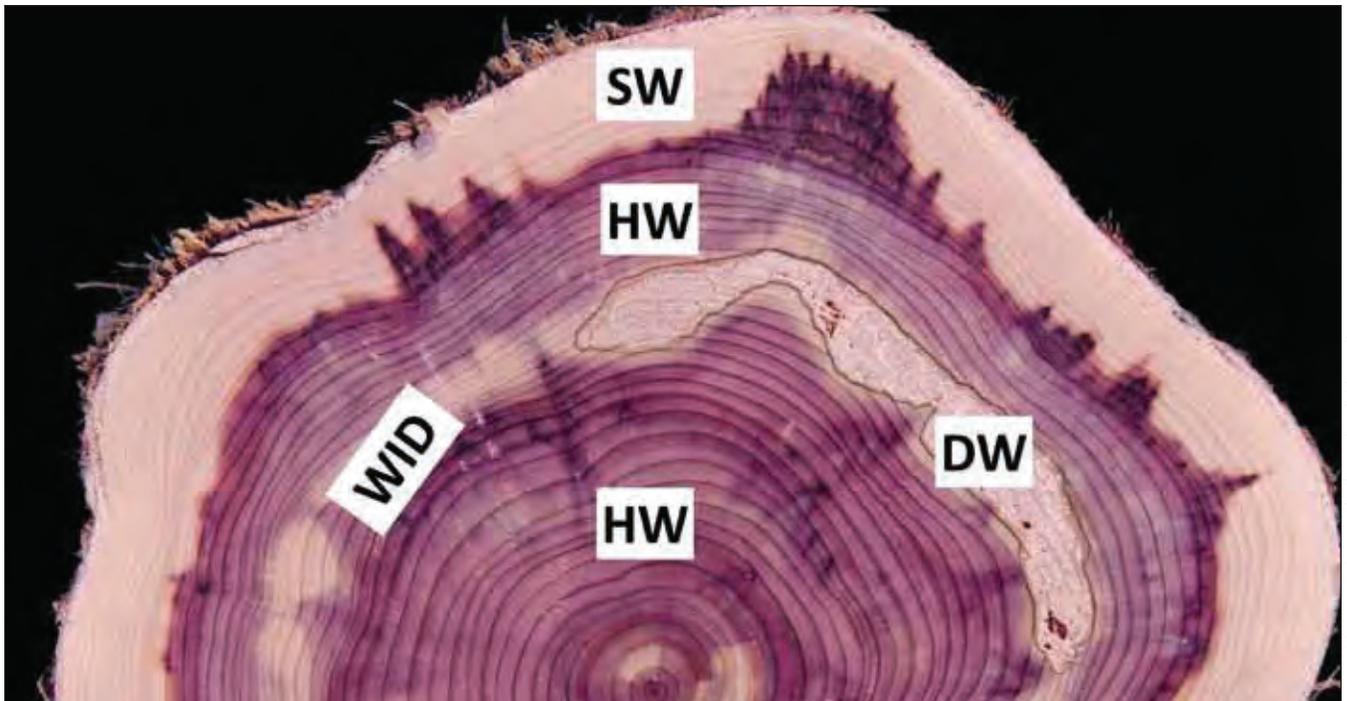


Figure 2. An idealized diagram of wood maturation and skeleton decay indicating: (A) the formation of sapwood, (B) the maturation of sapwood into heartwood, (C) the development of wound-initiated discoloration from injured sapwood, (D) the resumption of sapwood production from the vascular cambium, (E) resumption of normal maturation of heartwood from sapwood, and (F) degradation of sapwood after tree death.



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Figure 3. A stem disk of red cedar with a core of decay-resistant heartwood (HW) surrounded by a band of wound-initiated discoloration (WID), some of which has become decayed wood (DW). Another band of HW separates the WID from sapwood (SW).



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Figure 4. This close-up of the skeleton pattern shows the embedded branch bases in the heartwood and the cubical brown rot (arrows), likely formed from the former WID.

sapwood and WID (Figure 2F). The outer band of heartwood fragments from weathering or by animal excavation, aided by wood decay fungi. On the interior of the shell (Figure 4), we can see a series of small, cube-shaped blocks, sharply broken across the grain, indicative of brown rot. Fungi associated with cubical brown rot of eastern red cedar include *Fomitopsis cajanderi* (also known as *Fomes subroseus*) and *Antrodia juniperina* (also known as *Daedalea juniperina*); one of these two fungi probably colonized and degraded the band of WID, leaving only the brown rot residue. Sadly, this tree from Missouri is no longer standing, probably carried away by flooding of the Meramec River. Still, the broken trunk provides us with an excellent example of a complex wood decay process that occurs in many tree species.

#### Literature Cited

- Schwarze, F.W.M.R. 2008. Diagnosis and prognosis of the development of wood decay in urban trees. ENSPEC, Australia. 336 pp.
- Shortle, W.C., K.R. Dudzik, and K.T. Smith. 2010. Development of wood decay in wound-initiated discolored wood of eastern red cedar. *Holzforschung* 64:529–536. <[www.nrs.fs.fed.us/pubs/35488](http://www.nrs.fs.fed.us/pubs/35488)>
- Smith, K.T. 2006. Compartmentalization today. *Arboreal Journal* 29:173–184. <[www.nrs.fs.fed.us/pubs/8529](http://www.nrs.fs.fed.us/pubs/8529)>

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