Heartwood and Heart Rot, Part 1: Are they Important to Arborists?

Photo 1: Man has used the increased resistance of heartwood of some tree species for wood in service. Here, black-locust fence posts and white-oak rails have resisted decay in service for more than 20 years. Unless otherwise noted, all photos courtesy of Christopher Luley.

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Tree care professionals frequently assess or estimate the strength of wood within a living tree or dead, standing snag. This is often quite informal, with training and experience that guides decisions to remove or retain a major stem, or where to tie off lines and place a felling hinge. This article will look at the importance of heartwood and how it can impact decisions where wood strength and decay status might affect tree care practices.

Long before modern arboriculture and an understanding of tree biology, humans benefited from the resistance to decay of heartwood found in some tree species. People recognized that the heartwood of certain species (e.g., cedar, black locust, osage orange, white oak) greatly resisted decay when used as fenceposts or in contact with soil. (Photos 1, 1A) Decay-resistant heartwood of western red cedar provides a contemporary example of a product that extends the service life of outdoor furniture and decks.

Heartwood formation can be accompanied by a dramatic change in wood color. This is true for black walnut and black cherry, highly prized by furniture manufacturers. This color change is frequently, but not necessarily, associated

Photo 1A: In this section from a dead white oak, the sapwood is extensively decayed while the heartwood is largely sound. Note that the heartwood in this tree occupies a large volume of the stem.

with increased resistance to decay.

Despite common knowledge about heartwood, the terms heartwood and heart rot have long been confused in both the popular press and scientific literature. Heartwood has been ambiguously defined both on the basis of position (wood in the central core of the stem or branch) and/or visible properties (lack of sap conduction, dark coloration). In this article, we suggest that the hallmark of heartwood formation is a genetically pre-programmed

Photo 2: Heartwood in bitternut hickory. Many tree species form heartwood that may not show resistance to decay or may have only slightly increased resistance to decay.

shift in metabolism. This metabolic shift transforms or converts sapwood into heartwood, as evidenced by the loss of sap conduction and the death of formerly living wood cells.

Heartwood formation

Heartwood formation begins with the oldest (first-formed) ring of sapwood. Trees progressively form heartwood in a transition zone just outside the central core of heartwood. This transition zone has many physiological events taking place. One set of processes results in bubble or embolism formation, followed by the plugging of vessels and tracheids (water-conducting cells in the xylem) along the stem axis. This contributes to heartwood generally having a much lower moisture content than adjacent sapwood.

In some trees (white oak, elm and others), the plugging is accomplished by tylosis formation. Tyloses (balloon-like outgrowths) form in vessels from the cell membranes of adjacent parenchyma. The parenchyma tissues are drawn into the vessel, then encrusted with waterproofing lipids. For species that do not form tyloses, formerly conducting wood cells are still plugged by gum, resins and emboli (air bubbles) during heartwood development.

The chemical constituents that often result in the darker color or increased decay resistance of heartwood come primarily from parenchyma cells as they senesce or die. The production of phenolic (chemical compound that darkens wood and is toxic to many fungi) and other chemical compounds by dying parenchyma cells is often supported by movement of sucrose to these cells from living sapwood. In turn, some essential nutrients in parenchyma cells may be moved back into sapwood for reuse.

Facts about heartwood

This broad and encompassing definition may provide some surprises, including:

- Not all heartwood is significantly more resistant than sapwood to decay (e.g., most red-oak group species, hickory and spruce, among others). (Photo 2)
- Heartwood decay resistance varies among and within individual trees of the same species, depending on heartwood age, tree health and other factors.
- Heartwood may not differ in color from sapwood (as for ash and many pines). (Photo 3) Ripewood is a term primarily used in Europe for heartwood that is similar in appearance to sapwood.
- Some trees (*Acer, Betula, Populus, Fagus*) apparently do not form heartwood as part of their genetic program. In these trees, living sapwood cells may be found all the way to the center of the tree. (Photo 4)

Photo 3: A large-diameter ash trunk cross section shows little apparent difference in heartwood and sapwood coloration. Heartwood of this type is sometimes referred to as ripewood.

Photo 4: Sugar maple with discolored wood in the center of the trunk that is not heartwood. Some species such as sugar maple do not form heartwood, as they may have living cells all the way to the center of the tree. Discolored wood in sugar maple is often due to mineral stain. Some sources refer to this as sugar-maple heartwood.

Photo 6: Discolored wood due to injury and decay in silver maple. This may be mistakenly interpreted as heartwood due to its location in the center of the stem. Photo courtesy of Thomas Draves.

Photo 5: Heartwood in the branch and trunk of a black walnut. Heartwood also can be found in larger-diameter roots. Some fungi can enter the heartwood in the stems of trees through infection of heartwood in branches.

However, those species may develop mineral streak or wound-initiated discoloration as part of the tree response to injury and infection. (Photos 4 & 6) Maple species provide good examples of trees that do not form heartwood, but which frequently contain discolored wood associated with wounding, such as from construction or storm injury. Be aware that many sources confuse wound-initiated discoloration ("false heartwood") with heartwood.

- Heartwood can be found in roots (near the base of the tree), the main trunk (as a cone passing into and up the trunk) and larger-diameter branches. (Photo 5)

The darkened or discolored core in the stem or large branch challenges the arborist. Is the coloration due to decay-resistant heartwood or induced biological responses to injury or infection? Further, there is no way to know from the appearance of the heartwood of any particular species if it is more resistant to decay. One must consult outside resources that may contain erroneous information.

Heartwood strength and decay

In the absence of fungal decay, heartwood strength is not significantly different from sapwood. So why should arborists care about heartwood formation?

1. Many fungi that can decay damaged sapwood are unable to decay heartwood.

2. Although some tree species do produce durable heartwood that resists decay, the mere presence of darker wood does not indicate residual strength or heartwood presence.

3. Given sufficient time and conditions, even durable heartwood can decay and cause structural weakness.

4. Placement of a felling hinge requires sound wood. The arborist needs to recognize that even durable heartwood can still rot (albeit slowly). So discolored wood and even heartwood at a felling-hinge site does not necessarily indicate greater wood strength.

5. Some heartwood-decay fungi can progress into healthy sapwood. (Photo 7) The number of fungi that can decay both heartwood and healthy sapwood is relatively small compared to the number of fungi that can only decay damaged sapwood. Furthermore, the number of fungi that can break down

Photo 7: Some decay fungi, such as **Ganoderma applanatum,** *can decay healthy sapwood, as shown here. Note that the heartwood on this red oak is decayed.*

Photo 9: Heartwood decay can compromise tree stability when decayed heartwood occupies large volumes of the stem, as in this bur oak.

normally decay-resistant heartwood in living trees is also much more limited.

More roles of fungi

As with other aspects of forest pathology, specialized fungi can overcome otherwise effective host defenses. For example, relatively few decay fungi are found that can decay the heartwood of black locust. (Photo 8) Knowing which tree species produce decay-resistant heartwood (and that consequently support fewer decay fungi) can aid fungal identification by reducing the number of species known to attack that species.

Fungal decay of heartwood can be important to tree stability, especially when the decay is associated with other defects, such as codominant stems. For trees that maintain only a narrow band of sapwood, heart-rot decay may leave only a narrow outer shell of stem wood, resulting in an increased risk of structural failure. (Photo 9) Heartwood is also an important component in the defense of some trees to decay, functioning in some cases as part of the second wall, or Wall 2, in the Compartmentalization of Decay in Trees (CODIT, now referred to as compartmentalization of damage) model.

Photo 8: Heartwood of black locust is very resistant to decay and can be used for fence posts and other uses. The number of fungi that decay the heartwood of living locust is limited, and this aids identification of potential pathogens. **Fulvifomes robiniae** *(also known as* **Phellinus robiniae***), shown here, is the most common decay fungus on this species.*

Conclusion

The term "heart rot" has been variously applied with little explicit distinction between "decay at the center of the tree" from "decay of heartwood." Knowing how the term is defined by particular authors helps evaluate how to apply existing guides to fungal identification and tree treatment. The specific terms and definitions are less important than the underlying concepts that guide tree assessment and care.

Part 2 of this article, planned for the July issue of *TCI*, will look at the importance of the fungi that can decay heartwood and healthy sapwood, as well as how decay in heartwood impacts stem strength and resistance to breakage.

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