CONTINUING EDUCATION UNIT

SAP ROT

It will let you down

By Christopher J. Luley and Brian Kane

Introduction

When most arborists think of decay in trees, they think of heart rot, decay of the center of the stem. However, sapwood rot, or sap rot as it is commonly named, where the decay progresses from outside the stem toward the center, may be of more importance than heart rot, particularly for arborists that are working in trees. This article explores the biology and identification of sap rot decay and fungi, and why it is important to the working arborist.

Definition

Sapwood rot is the decay of woody stems that typically follows the death of the bark and cambium of living trees, or the decay that quickly follows tree death. Sap rot is so named because the decay initially occurs in the sapwood and progresses from outside the sapwood and toward the center of the stem (Figure 1).

Figure 1. Sapwood decay organisms invade trees after the bark and cambium have died. The decay proceeds from outside the stem toward the center.

Sap rot is somewhat of a misnomer because most sap rot fungi are able to decay the heartwood of a tree once the sapwood has been rotted (Figure 2). However, sap rot decay will be considerably slower when fungi reaches heartwood that has inherent decay resistance. This may occur in trees such as white oak (*Quercus* spp.), black locust (*Robinia pseudoacacia*), and red cedar (*Juniperus virginiana*), among others.

Figure 2. Sap rot decay organisms will also rot heartwood and are important in the breakdown of wood after the tree has died.

Biology

Sap rot fungi have several niches in nature that are important to arborists. First, sap rotters usually become established after larger areas of bark and cambium die on stem or branches. They do not initially attack bark and cambium that are healthy and intact. Common entry points for sap rot fungi on living stems are sunscald damage, lightning strikes, large wounds or when branches are ripped due to ice or wind damage, exposing large areas of sapwood (Figure 3).

Once established in dead tissues, some of these fungi are also capable of killing healthy bark and cambium adjacent to the wounds. In this sense they are acting like a canker organism, but they are also able to quickly decay the wood following the death of the bark and cambium where most canker organisms do not aggressively decay sapwood.

The health of the tree appears to be an important factor in limiting spread of sap rot to adjacent tissues and how much decay follows after they are established. Sap rot fungi can

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LEARNING OBJECTIVES

The arborist will be able to

- discuss biological aspects of sapwood rot fungi
- identify traits that indicate the presence of sapwood rot fungi
- differentiate how sapwood rot and heartwood rot affect stem strength
- discuss the implications of the presence of sapwood rot fungi and how it affects climbing and felling trees

contribute to tree decline when they infect trees that are already declining (Figure 4).

Another niche for sap rot fungi is their development on dead branches that commonly occur in the crown of a tree. Virtually all older trees have some dead wood, and sap rot fungi quickly become established in branches after they die. The decay that follows is often relatively quick. What results is the branch being "naturally" pruned from the tree (Figure 5).

The third niche of sap rots is when the tree dies but remains standing. Here, fungi quickly invades and decays standing, dead trees. On dead or nearly dead trees sap rot fungi can even decay a substantial portion of large stems in a growing season or two, depending on the tree species present. If the sap rot or heart rot was established before the tree died, decay may be extensive in larger branches or the trunk even if the tree died only recently. Some tree species, such as birch (*Betula* spp.), poplars (*Populus* spp.) like cottonwood and aspen, maple (*Acer* spp.), beech (*Fagus* spp.), and most of the conifers, are more prone to rapid invasion by sap rot fungi after they die (Figure 5).

Figure 3. Sap rot fungi often invade stems after the bark and cambium have died from other causes such as sunscald on this sugar maple (*Acer Saccharum*). Some of these fungi can also kill bark and cambium after they are established in dead tissues.

Figure 4. Sap rot fungi can contribute to the further decline of weakened trees. One way to determine sap rot's presence is by the development of small, numerous fruiting structures on the bark of dead tissues.

"Widow maker" is a common term partially attributed to sap rot fungi as these fungi often quickly decay the smaller diameter stems in the top of a tree after it dies. This may cause unexpected failure during felling operations. The decay is what leads to failure of the top of the tree while the butt of the tree may still be relatively sound.

Identification and Interpretation

Sap rot is caused mostly by *Basidiomycete* fungi that produce small (compared to the heart rot fungi), usually numerous fruiting structures on the bark of branches, large stems or trunks (Figure 6). However, identification of individual sap rot species is substantially more difficult than identifying the fungi that cause heart rot on living trees.

Because it usually attacks dead wood, sap rot fungi are part of a much larger group of decay fungi that develop

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Figure 5. Sap rot fungi and decay lead to the premature breakage of stems and branches and can be important to arborists working in trees because they can dramatically reduce the working strength of wood.

on dead tissues. Several sap rot fungi are more common, such as *Schizophyllum commune*, *Trametes versicolor*, *Irpex lacteus* and *Cerrena unicolor*. In most cases, it is not necessary to identify the fungus down to species level. On the other hand, being aware of fungi goes a long way in identifying the type of decay and the potential implications to the stability of the stem and branches.

Arborists should realize that because there are many different sap rot fungi that attack dead tissues, fungi have a wide variety of fruiting body types and appearances. Some sap rot fungi are simply a spore-bearing layer that develops on the bark, while others form a small, leathery, fruiting structure that may have a porous, gilled, toothed or smooth spore-bearing layer.

On living trees, the presence of sap rot structures means the bark and cambium are dead and the branch or stem are at least partially decayed. Because the decay caused by these fungi can progress rapidly into the stem, one must assume that when sap rot fungi is noticeable that a considerable portion of the stem could be decayed. Therefore, stems or branches with these fungi should be considered at an elevated risk for failure. They should not be relied upon to support any weight and should be removed if a target is present.

Sap rot will also develop in trees without the presence of fruiting structures. However, because the decay does not leave the stem hollow, it may be difficult to determine the extent of decay by sounding with mallet or drill testing.

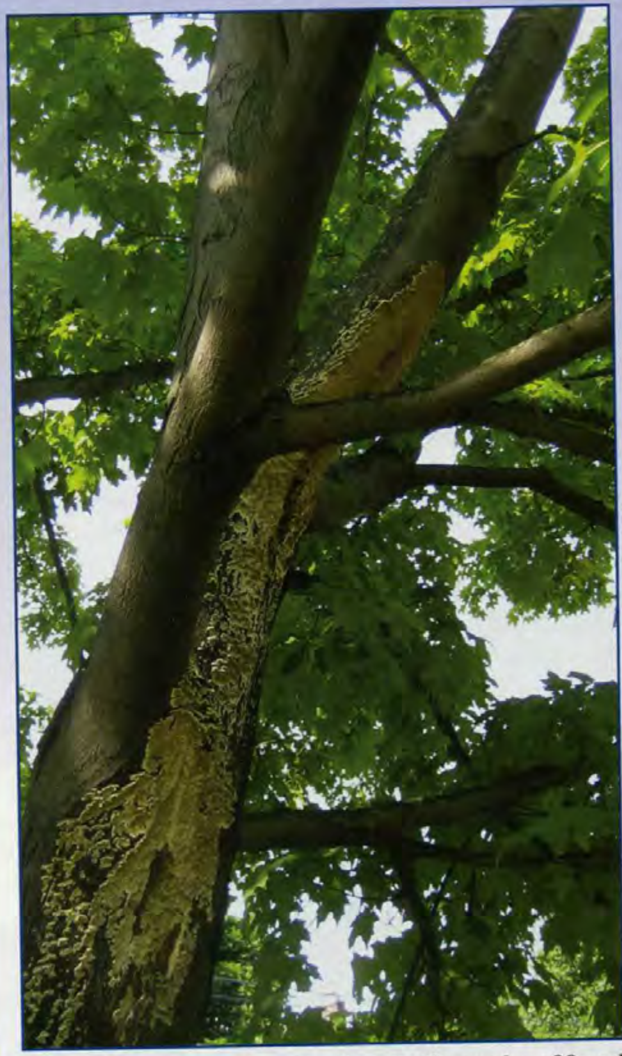

Figure 6. Sap rot caused by *Irpex lacteus*. The number of fungal species that cause sap rot is much greater than those that cause heart rot of living trees. Sap rot fungi have a wide variety of fruiting bodies but most produce a large number of small structures on wood.

Biomechanics

From a mechanical perspective, sap rot can be more dangerous than heart rot in a tree, because of where the decayed wood occurs: the outer rings of the trunk or stem (Figure 7).

From engineering theory, we know that the resistance to bending of a beam with a circular cross-section is related to the square of its diameter. Sap rot dramatically reduces the cross-sectional area of the stem while heart rot does not (Table 1). In essence, sap rot shrinks the tree by decreasing the stem diameter and this quickly reduces the strength of the stem.

A tree's reduction in strength from sap rot is significant because it is related to the square of the stem diameter, is significant. For example, take the difference between trying to bend two branches, one that's half an inch (1.3 cm) in diameter (easy to bend), and one that's 3 inches (7.6 cm) in diameter (very hard to bend).

Table 1. Comparison between strength loss in a 20-inch (51-cm) stem with the same amounts of sap rot and heart rot. The heart rot decay is assumed to be in the center of the stem.

Sap Rot Diameter Loss	Strength Loss	Heart Rot Diameter Loss	Strength Loss	Difference: Sap Rot—Heart Rot
2	34%	2	0.01%	99.9%
4	59%	4	0.16%	99.7%
6	76%	6	0.81%	98.9%
8	87%	8	2.56%	97.1%
10	94%	10	6.25%	93.3%

Figure 7. Sap rot typically reduces the diameter of sound wood by decaying the stem from the outside in. This greatly reduces the strength of the stem when compared to the original diameter.

From a biomechanical perspective, the location of decay is also very important. Decay in the center of the stem, or heart rot, has significantly less effect on the strength of the stem until large areas are decayed. For example, a 20-inch (51-cm) stem with decay in 50% of its cross-sectional area has only lost about 10% of its original strength, assuming that the decay is centered in the middle of the cross-section. But the same 20-inch tree that has lost 3 inches (7.6 cm) of sapwood to decay may be only 50% as strong as the original stem.

Therefore, the outer fibers in a branch or trunk contribute the most to strength, which is why a tree can have half or more of its heartwood decayed while still not being at a high risk of failure. This is also the reason why working arborists should consider the presence of sap rot carefully, because the associated loss of strength may cause the tree to fail prematurely during rigging or felling operations.

Working arborists also need to be aware that sap rot can make climbing dangerous. If a climber uses spikes, he or she might penetrate wood that is not solid. Using a crane or bucket truck to remove trees with severe sap rot would be a much safer alternative. When working on trees with sap rot, pieces of the tree should be lowered in small sizes, and shock loading should be avoided as the tree might not withstand the shock load.

When felling trees with heart or sap rot, one should use a thicker hinge than if no decay were present. Assuming the notch depth should be 20% of the trunk diameter, with sap rot, the outer fibers on either side of the hinge would not provide any strength; so the hinge should always be thicker than normal if sap rot is present. It would be hard to calculate the exact increase in hinge thickness for any of these situations because other factors (tree species, lean, wind, felling direction) also influence hinge thickness. If some part of the hinge is decayed (either from sap or heart rot), the amount of decay should be estimated and the hinge should be made thicker to compensate. If possible, the hinge should be made higher or lower in the tree to avoid areas with sap rot. In the end, it's safer if the tree remains standing as opposed to failing unexpectedly.

Assessment and Working with Sap Rot

There are no "standard" tests to evaluate a branch or stem that has or might have sap rot. Probably, the best practical

Figure 8. Decay fungi such as *Kretzschmaria deusta* attack living trees but can also make the entire tree unstable by decaying sapwood after the tree has died. The contact of wood with soil provides moisture conditions that are conducive to rapid decay of the base of a dead tree.

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evaluation method is to first inspect any stems that are critical to a job for presence of fruiting structures. Picking at decayed areas can reveal soft decayed wood that would be easily removed with a pick, knife or other pointed tool. Arborists cutting through stems can also visually see and feel the difference between sound wood and sap rotted wood.

Arborists should be particularly aware of the fact that sap rot may progress quicker at the base of a tree after it dies because of its contact with moisture from the soil. The potential presence of decay fungi already in place before the death of the tree may also contribute to the quick spreading of sap rot. Most root and butt rot fungi will continue to decay the roots and base of a tree once it has died, essentially acting as sap rot organisms (Figure 9). One should thoroughly inspect the base of a tree before any work begins because the base is a critical fulcrum point during climbing and removals.

In living trees, branches with sap rot should be removed as a standard practice if there is a potential target. Trees with sap rot decay or fruiting structures on the main trunk or scaffolds are usually in poor or declining health and should be evaluated closely for both health and structural issues.

On dead or nearly dead trees, the presence of sap rot means the potential for a structurally-compromised tree exists. The tree may not withstand shock loading or other mechanical forces that occur during climbing, removal, or lowering wood. Therefore, trees with sap rot represent a potential hazard to working arborists and adequate inspection of the extent of decay is likely warranted. On stems that are critical to climbing or load bearing, arborists must assume a branch or stem with sap rot is defective and must inspect the stem or adjust removal practices accordingly.

Thorough inspection can help determine the presence and amount of sap rot decay, but this is often impossible in a time-sensitive work environment or when working on large trees. Failure to recognize the importance and implication of sap rot decay has resulted in arborist fatalities when stems or main trunks break down unexpectedly during removals.

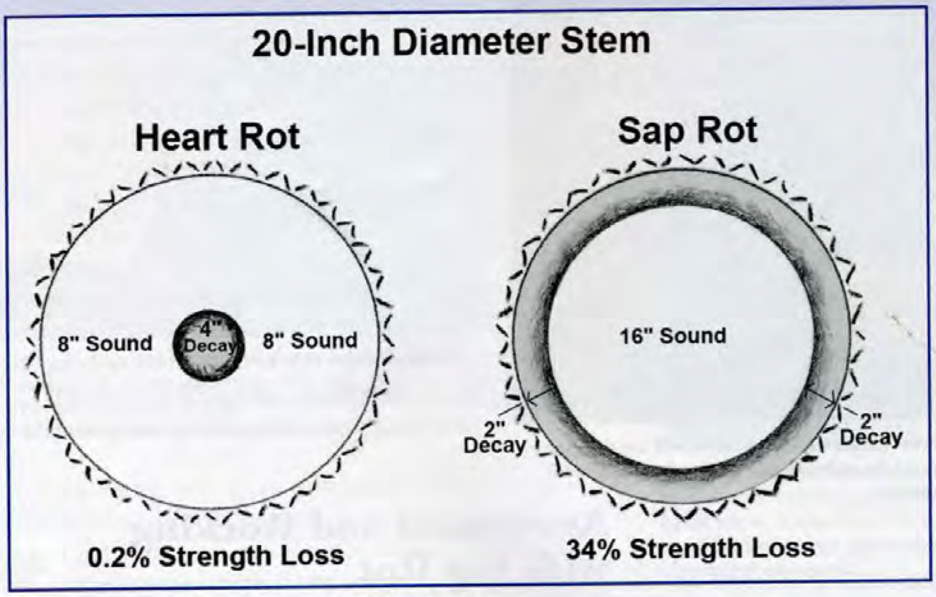

Figure 9. A comparison of strength loss in trees.

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CEU TEST QUESTIONS

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CEUs for this article apply to Certified Arborist, Utility Specialist, Municipal Specialist, Tree/Worker Climber, and the BCMA science category.

1. Sapwood rot progresses
   a. from the outside sapwood towards the center of the stem
   b. from the heartwood towards the bark
   c. from the bark to the inner bark where it remains
   d. only from the bark to the cambium
2. Sapwood rot fungi do not decay heartwood.
   a. True
   b. False
3. Which of the following is an important sap-rot-fungi niche for arborists?
   a. Decaying wood on living trees after large areas of bark and cambium have died.
   b. Decaying dead branches in living trees.
   c. Decaying dead trees and down branches.
   d. all of the above

4. "Widow maker" is so named because
   a. many people have died eating sap rot fungi
   b. certain sap rot fungi produce deadly toxins that are released when a branch with them is cut
   c. rapid invasion of the top of a tree by sap rot can cause its unexpected failure during felling operations
   d. black widow spiders prefer trees with sap rot
5. Small numerous fruiting structures are typical of
   a. heart rot
   b. initial decay by heart rot fungi
   c. sap rot
   d. initial formation of sap rot fruiting structures
6. Sap rot fungi form fruiting structures with
   a. pores
   b. teeth
   c. a smooth spore-bearing layer
   d. all of the above
7. The presence of sap rot fruiting structures indicates
   a. the presence of sap rot decay.
   b. that the bark and cambium are dead.
   c. a stem that may be structurally compromised.
   d. all of the above
8. Sap rot can occur without the presence of fruiting structures on a stem.
   a. true
   b. false
9. Identification of sap rot fungi down to the species level is critical.
   a. true
   b. false
10. When sap rot develops in trees, it may be difficult to detect the presence and extent of decay by sounding with a hammer because
    a. the decay does not leave the stem hollow
    b. this is not a tool commonly used in decay detection
    c. this is a subjective assessment
    d. the stem diameter and strength are reduced
11. Sap rot significantly affects the tree's mechanical structure because
    a. it is a white rot
    b. of its location in the outer rings of the stem
    c. it is a brown rot
    d. all of the above
12. The impact on strength reduction caused by sap rot is related to
    a. the square of the stem diameter
    b. the cube of the stem diameter
    c. amount of decay in the parenchyma
    d. the square of the surface area of bark affected
13. A 20-inch (51 cm) tree diameter with 4 inches (10 cm) of sap rot and 4 inches of heart rot has
    a. 10 percent and 50 percent strength loss, respectively
    b. 59 percent and 0.16 percent strength loss, respectively
    c. 30 percent and no strength loss, respectively
    d. equal amounts of strength loss
14. A tree with sap rot may be more dangerous to the working arborist because
    a. spikes may not hold in sap-rotted wood
    b. hinges may not hold in sap-rotted wood
    c. trees may fail unexpectedly due to sap rot
    d. all of the above
15. Which of the following alternatives should be adopted when working on trees with extensive sap rot?
    a. Using a crane or bucket truck.
    b. Taking smaller pieces to avoid shock loading the tree.
    c. Making large hinges as needed or moving the location of cuts to sound wood.
    d. all of the above
16. The standard test to confirm the presence of sap rot is with
    a. drill testing
    b. pick testing
    c. cut testing
    d. there is no single standard test
17. Sap rot may progress quickly at the base of a tree because
    a. the wood at the base of a tree is generally weaker
    b. of the absence of heartwood at the base of a tree
    c. the base of the tree is in contact with soil moisture
    d. carpenter ants carry sap rot spores
18. The presence of decay that is already established in a tree before it dies
    a. can increase the impact of sap rot decay after the tree dies
    b. is not a problem if it is in the heartwood
    c. has little impact after the tree is dead
    d. all of the above
19. Sap rot at the base of a tree is significant because
    a. it is a fulcrum point during climbing and removals
    b. conks are usually present at the base
    c. sap rot fungi quickly decay roots
    d. none of the above
20. Stems with sap rot that are critical to climbing or loading during pruning or removal should be
    a. okay if they do not also have heart rot
    b. evaluated for the extent of decay
    c. okay if carpenter ants are not present
    d. all of the above