CONTINUING EDUCATION UNIT

The Big Five and Urban Decay Ecology

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Learning Objectives

- Learn about the common wood decay fungi likely to affect urban trees.
- Review the difference between facultative pathogens and obligate saprophytes.
- Understand the different methods of identification of wood decay fungi.

CEUs: A, U, M, T, L, Bs, Bp

Figure 1. Some wood decay fungi have the unique capacity to breach barrier zones and reaction zones and cause progressive amounts of decay in urban trees. These fungi, such as *Ganoderma applanatum*, shown here breaching reaction zones in a red oak (*Quercus rubra*), are termed facultative pathogens.

Reaction Zone—Primarily chemical barriers to decay fungi formed by living, thin-walled parenchyma cells in the sapwood in response to fungal invasion.

Barrier Zone—Also known as Wall 4, the barrier zone is formed by the cambium at the time of wounding; it contains chemical and physical barriers to decay and is the strongest barrier in living trees.

There are thousands of fungi that decay wood and produce fruiting bodies on wood (Gilbertson 1980). Fortunately, the number of fungi that decay the wood of living trees is substantially less, partially because of the natural protective barriers that living trees have against wood decay fungi. Although there have been no systematic studies of decay fungi frequency in urban trees in North America, observations indicate that the fruiting of some species is more common. Importantly, there are only a limited number of fungi that commonly fruit and are important to the vitality and stability of urban trees.

One premise of this article is that urban environments and tree species composition affect the species diversity of urban decay fungi. The common and important decay fungi of urban trees in North America have similar characteristics that lend themselves to decaying and fruiting on urban trees. For arborists, this is an important point, as urban conditions potentially reduce the number of important fungi that they are likely to encounter.

All the most destructive wood decay fungi that affect living urban trees are facultative pathogens, meaning that they have the capacity to attack living sapwood and in some cases kill bark and cambium after becoming established in a tree (Shortle and Dudzik 2012). They uniquely have the ability to breach the barrier zones or reaction zones found in living sapwood (Figure 1). The breaching of barriers to decay seems to happen most commonly in physiologically weakened or mechanically damaged trees.

Therefore, management practices such as watering during drought periods or other practices that help maintain tree health are also thought to help slow decay progression.

I have arbitrarily designated five important and common facultative pathogens on urban trees that, based on my observations and limited research (Luley et al. 2009), arborists should be familiar with. The Big Five (Luley 2022) of deciduous trees in order of importance are presented in Table 1.

Table 1. The Big Five common and important decay fungi of urban trees.

Name	Common name	Common hosts	Type of decay	Type of fruiting	Perennial or annual	Fruiting location
Kretzschmaria deusta (Figures 2 and 3)	Burnt crust fungus	Maple, beech, hickory, hackberry, oak	Soft rot	Black stromatic tissue	Annual	Buttress roots and butt
Pseudoinonotus dryadeus (Figures 4, 5, and 6)	Warted polypore	Oak, sometimes maples	White rot	Bracket	Annual	Roots or very base of tree
Ganoderma sessile (Figures 7 and 8)	Reishi	Maple, oak, hickory, beech	White rot	Bracket	Annual	Roots or butt
Armillaria mellea (Figure 9)	Honey mushroom	Maple, oak, most urban species	White rot	Mushroom	Annual	Roots or very base of tree
Ganoderma applanatum (Figures 1 and 10)	Artist's conk	Maple, oak, beech	White rot	Conk	Perennial	Butt or trunk

Figure 2a. (right) The light-gray asexual state of *Kretzschmaria deusta* on a European beech (*Fagus sylvatica*). This fungus is one of the most overlooked and destructive wood decay fungi of urban trees in the Northeastern US.

Figure 2b. (above) Decay in the base of same beech seven years later.

Figure 3. Black stroma formed by *Kretzschmaria deusta*. The fruiting bodies of the sexual state are formed in this stroma and release airborne ascospores capable of infecting nearby susceptible trees.

Figure 4. Freshly formed conk of *Pseudoinonotus dryadeus* on an oak root showing amber guttation drops. The guttation drops dry, leaving pockmarks in the surface. The fungus decays woody roots and in the later stages of decay may progress into the base of the tree.

Figure 5. Large applanate, or flattened, conks of *Pseudoinonotus dryadeus* on a red oak (*Quercus rubra*). This annual fungus initially fades in color as it ages and then becomes dark brown to black when old.

Figure 6. An oak street tree that failed due to *Pseudoinonotus dryadeus*. The tree was ringed with conks prior to failure. Photograph courtesy of Russ Carlson.

Figure 7. Annual conks of *Ganoderma sessile* on a pignut hickory (*Carya glabra*). The conks on the right are covered in brown basidiospores. The darker conks in the middle are from the previous year's fruiting.

Figure 8. Conks of *Gandonerma sessile* on the roots and butt of a Norway maple (*Acer platanoides*). The fungus can kill and decay woody roots, and many trees with *G. sessile* infections are in declining biological health.

Figure 9a. (above) Large clusters of *Armillaria mellea* at the base of an oak. The fungus commonly attacks stressed trees and can kill and decay woody roots and also cause decay in the base of trees.

Figure 9b. (right) *A. mellea* has a ring around the stem and produces a white spore print.

Figure 10. A large specimen of the perennial fungus *Ganoderma applanatum*. The fungus is usually associated with extensive internal decay by the time conks develop on the surface of the tree.

These fungi all have the capacity to decay healthy sapwood and in some cases kill bark and cambium. On conifers where fruiting of decay fungi is relatively uncommon, *Phaeleus schweinitzii* is by far the most common facultative pathogen in urban environments (Figure 11).

It is important to consider that this list is applicable primarily in the Northeastern United States, where maples (*Acer* spp.) dominate (Cowett and Bassuk 2013). Oaks (*Quercus* spp.) and other urban species are also an important portion of the species composition, especially as one moves south from the Northeast. Arborists may see other fungal species more commonly depending on where they work, as local environment and common tree species likely impact fungal diversity. For example, the root and butt rot fungus *Laetiporus cincinnatus* (white pored sulfur shelf) is relatively rare in the Northeast but has been observed to be more common in the upper Midwest.

Figure 11. *Phaeolus schweinitzii* at the base of a white pine (*Pinus strobus*). The fungus usually fruits from roots near the immediate base of a tree. It causes a brown rot of roots and butts on a wide range of conifers.

Figure 12. The fungi that cannot decay healthy sapwood but can only decay heartwood or wood killed or damaged by other means are termed obligate saprophytes. *Volvariella bombycina* shown fruiting here is an obligate saprophyte.

Obligate Saprophytes

The fungi that cannot decay healthy sapwood but only can rot heartwood (if present, as some trees do not form heartwood)(Sinclair and Lyons 2005) or that can decay wood that has been damaged or is no longer living are known as obligate saprophytes (Shortle and Dudzik 2012) (Figure 12). The difference in importance is obvious: although obligate saprophytes cause decay that damages trees, facultative pathogens have the greatest potential to cause serious amounts of decay by progressively attacking healthy sapwood.

Obligate saprophytes are important to tree stability, particularly when larger areas of wood are damaged in living trees. These fungi can, in combination with facultative pathogens or other structural defects, contribute to tree failures, as larger areas of damaged sapwood are decayed. Further, the location of decay can be as important as the amount of decay or aggressiveness of the decay pathogen. For example, when the tops of branches become decayed because the bark and cambium have been damaged or killed, rapid strength loss occurs, and branch failure can follow (Luley and Kane 2009). Another example is when decay is associated with codominant stems.

Frequency and Importance of Fruiting

Fruiting of decay fungi is relatively rare on urban trees. Observations indicate that a little over 3% of street trees had wood decay fruiting structures. Even if a fungus is fruiting on a tree, it is also very important to consider that multiple species of wood decay fungi may be decaying wood in a tree. Decay evaluations need to take this into consideration, as it may affect management decisions.

The presence of any decay fungus on a living tree definitively indicates the presence of decay. The need for identification and further evaluation of any fungus is dependent on the context of the situation, just the same as when decay is found in any urban tree, whether fruiting is present or not.

However, the identification of wood decay fungal species provides valuable information that may assist management decisions. Identification can provide the following information:

- Type of decay present in the tree (brown, white, or soft rot)
- Likely location of decay, especially for root decay that may not progress significantly into the trunk
- Potential severity and progression of decay
- Potential need for and type of advanced decay testing
- Potential for other adjacent trees to be affected
- Potential impact on tree biological health
- Need for and type of follow up laboratory identification, such as speciation and RNA/DNA testing
- Edibility, medicinal uses, production of dyes, tinder, amadou (felt like material), and other uses

Field Identification

Field identification is likely tentative and may require laboratory confirmation. Some common wood decay fungi can reliably be identified in the field with experience and attention to detail. Certain decay fungi will require laboratory testing for final species confirmation because of their small size (for example *Kretzschmaria deusta*) or when one or more species appear too similar to reliably separate them by appearance. Arborists should be aware of these limitations and approach field identification judiciously, depending on the use of the information. For example, forensic investigations, or high-risk locations, require precise identification.

Laboratory Identification and DNA/RNA Testing

Microscopic identification, provided through commercial or state university extension plant disease diagnostics laboratory services, can confirm species and help arborists gain confidence in field identifications. DNA/RNA testing is also now a reality for the identification of many wood decay fungi. This testing is relatively inexpensive and can also be used for wood samples in the absence of fruiting. However, cross-contamination of samples is a very important issue, and specific attention to sampling procedures is needed to avoid contamination. DNA/RNA testing currently requires that tests be conducted for specific fungi, so some knowledge of what species might be present is necessary when submitting samples. Some commercial laboratories are now offering testing for some wood decay fungal species, and they have directions for collecting samples to limit the possibility of cross-contamination.

Photography and Observations

Arborists should be aware that multiple photographs are often needed for reliable identification from images alone. Close-up photographs of the top, stem if present, context (interior), and sporulation layer are essential for many species. Spore prints are useful to identify fleshy, gilled species.

Urban Ecology

Environmental conditions and management of urban trees are different from forested settings and appear to impact species diversity in urban areas. For example, in urban landscapes, downed trees are seldom allowed to remain and are typically removed, chipped, converted to firewood, or used for wood in service. Trees that are extensively decayed or dead are also typically removed quickly. Further, stumps and larger diameter roots are also commonly taken out shortly after tree removal. These management actions remove common sources of decaying trees and wood where fruiting bodies of decay fungi are often produced for extended periods in forested environments. They also point to the importance of sanitation by removing sources of sporulation of decay fungi.

Studies in forested environments that isolated decay fungi from living trees showed that some fungal species seldom or never fruit on living trees. For example, the common and well-known chaga on birch (*Inonotus obliquus*) was found only on downed trees between 7 and 12 years after felling (Zabel 1976)(Figure 13). Further, Hepting (1971) noted that for forested oaks, one could not judge the incidence of different decay fungi by the frequency of their conks. The same may be true for urban trees, but this remains to be determined.

The Big Five fungi have several characteristics that may contribute to their seemingly more common development on urban trees. These fungi are root and butt rot pathogens, and except for *P. dryadeus*, have wide host ranges. They all readily produce conks or mushrooms

Figure 13. Removal and disposal of dead and decaying trees in urban environments may limit the frequency of decay infections caused by some fungi. For example, the chaga (Inonotus obliquus) forms sterile conks on living trees and was found to only produce fertile conks after 7 to 12 years on downed logs.

from the larger roots and basal areas of living trees, often for many years before the trees are removed. This provides a ready source of spores for spread to other trees, even if infected trees are eventually removed. In addition, they also will fruit for long periods of time on stumps. *G. sessile* and *P. dryadeus* will also fruit on roots even after stumps and large roots have been ground out (Figure 14).

An exception is *A. mellea*, which is more common in urban environments where there is some connection to previously forested environments. It is included in the Big Five because of its ability to attack and contribute to the decline of trees weakened by stress in urban environments and decay roots and butts of a wide range of tree species. In contrast, the similar-appearing *Desarmillaria caespitosa* (previous name *Armillaria tabescens*) is common in urban settings, often fruits from roots in turf, and does not seem to require some forest connection (Figure 15).

Figure 14. Ganoderma sessile fruiting from the roots of a previously removed tree. The persistence and ability of some decay fungi to fruit from stumps and buried roots may contribute to their elevated frequency, especially in trees of poor health in urban environments.

Figure 15. Urban management practices and environments seem to favor fruiting of some decay fungi. Desarmillaria caespitosa (previous name Armillaria tabescens) shown here is often found fruiting in turf, while the similar-appearing Armillaria mellea is usually associated with more forested environments.

The importance of microclimate differences between forested and urban environments is potentially important to the development of fruiting, although this has not been extensively studied. Some fungi that are common on forest trees are seldom seen on urban trees. For example, *Oxyporus populinus* is very common on maple in forested environments (Figure 16) but is rarely seen on urban maples, despite the fact that they often make up more than 40% of urban tree populations in some northeastern states (Cowett and Bassuk 2013).

Urban environments are well known to be warmer, drier, and dominated by heat-radiating hardscapes. Fruiting of wood decay and other fungi is observably influenced by periods of cool, damp weather or environments, as evidenced by the mycological abundance of the Pacific Northwest. Thus hotter, drier conditions in urban areas may favor root and butt decay fungi that are more closely tied to the soil that moderates moisture and temperature in their favor. In addition, wounding at the base of trees and on exposed roots is very common on urban trees. This provides common infection sites for the root and butt decay fungi that infect wounds.

Conclusion

The presence of wood decay is a common condition in urban trees, as more than 50% of urban trees have been found to have decay when just the lower trunk is considered (Luley et al. 2009; Koeser et al. 2016). While the fruiting of decay fungi is relatively rare, a number of fungi seem to fruit more readily on urban trees. The most important decay fungi are facultative pathogens that have the capacity to progressively decay living sapwood, potentially resulting in tree failures. Because identification of wood decay fungi can be challenging, being familiar with these common and important fungi is a good starting point for arborists.

Urban environments and management practices appear to favor fruiting of the Big Five and limit fruiting of some decay fungi that are better adapted to forested environments. Management practices that limit wounding at the base of trees and roots and eliminate dead and seriously decaying trees along with stumps and large roots will help reduce the spread of decay fungi.

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Figure 16. Some wood decay fungi are more common in forested environments and are seldom seen fruiting on urban trees, such as Oxyporus populinus fruiting on sugar maple (Acer saccharum) here.

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