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OAK WILT DISEASE: A GUIDE TO RECOGNIZING SYMPTOMS, DIAGNOSING THE PROBLEM AND SAFEGUARDING OAK TREES

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Oak wilt is a deadly plant disease that affects primarily oak trees (*Quercus* spp.) and has recently been recovered from declining chestnut trees (*Castanea* spp.). The disease is caused by a fungal pathogen, *Bretziella fagacearum* (formerly *Ceratocystis fagacearum*). The fungus can infect all types of oaks trees, but red oak trees are more susceptible than white oaks. Oak wilt spreads from infected to healthy trees either: 1) through sap feeding beetle (Coleoptera: Nitidulidae) species that may carry the mycelia and spores of the fungus on their bodies, or 2) via grafts between tree root systems. The fungus grows in the vascular tissues of infected trees, and that triggers the tree's defense mechanisms, which block the vessels of vascular tissue and restrict the growth and movement of the fungal pathogen. That restriction also blocks water and nutrient supplies, leading to premature leaf discoloration, leaf drop, foliar/stem wilt, and eventually tree death. Preventive measures are key to avoiding or reducing infection and the spread of the disease.

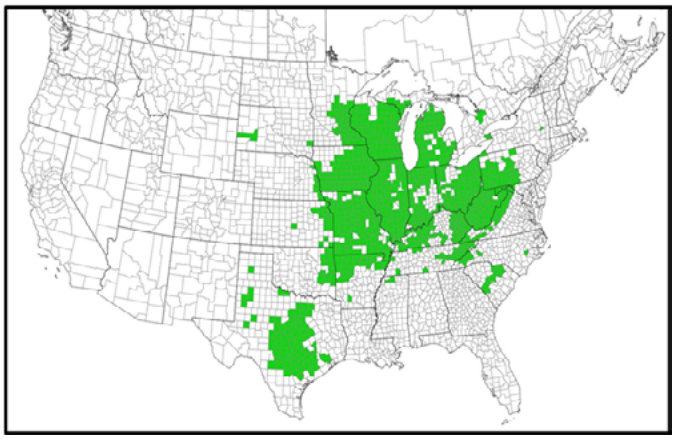


Figure 1. *Distribution of oak wilt in forests across the United States. The map was sourced from eddmaps.org, the Early Detection & Distribution Mapping system (accessed January 2024). The distribution map in Tennessee does not reflect the current prevalence of the disease due to the lack of current survey and isolation of* Bretziella fagacearum *from host plant tissue sample.*

OAK WILT DISTRIBUTION AND RANGE

Oak wilt disease is primarily found in the eastern and midwestern states, with its current range extending to many counties across 24 U.S. states, including 24 counties in Tennessee (Figure 1, EDD Maps, 2024), and southwest to Texas. Threats from oak wilt to woodland and landscape trees in Tennessee are considered low because the *B. fagacearum* fungal pathogen has not been isolated from oak host sample tissues in recent years. However, given past reports and ongoing issues in many nearby states, the Tennessee Department of Agriculture considers oak wilt an emerging threat to the state.

HOST PLANT SUSCEPTIBILITY TO OAK WILT

All types of oak trees are susceptible to oak wilt, but the susceptibility can depend upon classification within the different groups of oak (Table 1). Trees in the red oak group are more susceptible; some species can succumb to disease and die within a few weeks of showing symptoms of infection. Outside of Tennessee, Live oaks (e.g., *Q. fusiformis, Q. virginiana* in Texas) are intermediate in their susceptibility, as mortality can occur after three to six months of infection. However, white oak trees are less susceptible to the fungus and can survive one or more years or recover within one to two years, unless they become repeatedly infected over multiple years. Chestnut trees (*Castanea* spp.) also demonstrated susceptibility in an inoculation experiment (Rexrode and Brown, 1983). Recently, Chahal, *et al.* (2023) reported the first infection of oak wilt fungus on chestnut trees (variety 'Colossal') in Michigan and confirmed the presence of *B. fagacearum* using molecular tools. They also reported the possible root graft transmission of the fungus to 26 adjacent chestnut trees.

Table 1. Oak groups and related species susceptibility as hosts to oak wilt disease.

Oak Group	Oak tree species	Susceptibility to oak wilt	References
Red Oak	Scarlet oak (*Q. coccinea*) Northern pin oak (*Q. ellipsoidalis*) Southern red oak (*Q. falcata*) Turkey oak (*Q. laevis*) Laurel oak (*Q. hemisphaerica*) Blackjack oak (*Q. marilandica*) Willow oak (*Q. phellos*) Northern red oak (*Q. rubra*) Shumard oak (*Q. shumardii*) Black oak (*Q. velutina*) Texas red oak (*Q. buckleyi*) Water oak (*Q. nigra*)	Highly susceptible, mortality observed in few weeks to within a year.	Juzwik *et al*., 2011 Wilson, 2001 O'Brien *et al., 2000*
	Shingle oak (*Q. imbricaria*) Cherry bark oak (*Q. pagoda*) Pin oak (*Q. palustris*) Dwarf chinkapin oak (*Q. prinoides*) Nuttall oak (*Q. texana*)	Susceptibility not well known. These species are also in the red oak group, so are likely to have some susceptibility to oak wilt.	
Live Oak	Coastal/ Southern live oak (*Q. virginiana*) Texas live oak (*Q. fusiformis*)	Intermediate susceptibility, mortality can occur after 3-6 months of infection.	
White Oak	White oak (*Q. alba*) Bur oak (*Q. macrocarpa*) Chinkapin oak (*Q. muehlenbergii*) Monterrey/ Mexican white oak (*Q. polymorpha*). Lacey oak (*Q. laceyi*) White shin oak (*Q. sinuata var. breviloba*) Post oak (*Q. stellata*)*	Less susceptible, natural infection results in dieback of one or few branches, mortality occurring several years after infection, but duration of mortality may depend upon cultivars.	Juzwik *et al*., 2004 O'Brien *et al., 2000*
	Swamp white oak (*Q. bicolor*) Overcup oak (*Q. lyrata*) Chestnut oak (*Q. montana*) Swamp chestnut oak (*Q. michauxii*)	Susceptibility not well known. These species are also in the white oak group, so are likely to less susceptible to oak wilt.	

*Post oak (*Q. stellata*) is least susceptible among white oak (Juzwik *et al*., 2004)

DISEASE IDENTIFICATION

The symptoms of oak wilt can vary among oak species. Symptoms become noticeable in the spring and can continue into the summer. Infected leaves may turn pale green, yellow, or bronzy, and then leaves and softwood stems begin to wilt. As the disease advances, leaves turn brown, curl around the midrib, and eventually fall off. In red oaks, symptoms of oak wilt infection develop rapidly, and marginal necrosis is observed, leading to defoliation, branch die back with "flagging" appearance (Figure 2A), crown dieback (Figure 2B), and adventitious sprouting/suckering at base of the tree (Figure 2C). Progression of these symptoms often culminates in tree death within one or two months of symptom onset (Figure 2D). In rare instances, infected trees may live more than a year.

Figure 2. *Severity of oak wilt symptoms on Quercus species in the red oak group. (A) Crown dieback on Texas red oak (*Q. buckleyi*), (B) branch dieback on water oak (*Q. nigra*), (C) epicormic shoots (suckers) on willow oak (*Q. phellos*), (D) water oak (*Q. nigra*) trees in Aiken, South Carolina, killed by oak wilt (Images: A - Demian Gomez, Texas A&M Forest Service, B, C, D - William Klingeman, University of Tennessee).*

In live oaks, veinal necrosis (Figure 3A), leaf tip burn (Figure 3B), interveinal chlorosis and crown thinning, and defoliation can be observed (Figure 3C).

During early stages of infection, symptoms start at the tips and outer edges of leaves, and then progress toward the midrib and leaf bases (Figure 4A). Symptoms of oak wilt infection in the white oak group include canopy loss (Figure 4B), leaf tip burn, and flagging of the branches. Leaves typically remain attached (Figure 4A), with marginal discoloration. Scouts should become familiar with oak tree responses to other bacterial and fungal plant pathogens that affect the genus and can produce symptoms that are readily confused with oak wilt (see Figure 11A, B).

Figure 3. *Severity of oak wilt symptoms on species in live oaks (*Quercus fusiformis*). (A) Veinal necrosis, (B) leaf tip burn, and (C) crown thinning and defoliation (Images: Demian Gomez, Texas A&M Forest Service).*

Figure 4. *Dieback symptoms caused by oak wilt on different oak (*Quercus*) species. (A) Disease symptoms start at the tip of a leaf and progress toward the midrib and leaf base, branch dieback symptom on chinkapin oak foliage (*Q. muehlenbergii*) and (B) Monterrey or Mexican white oak (*Q. polymorpha*) (Images: Demian Gomez, Texas A&M Forest Service).*

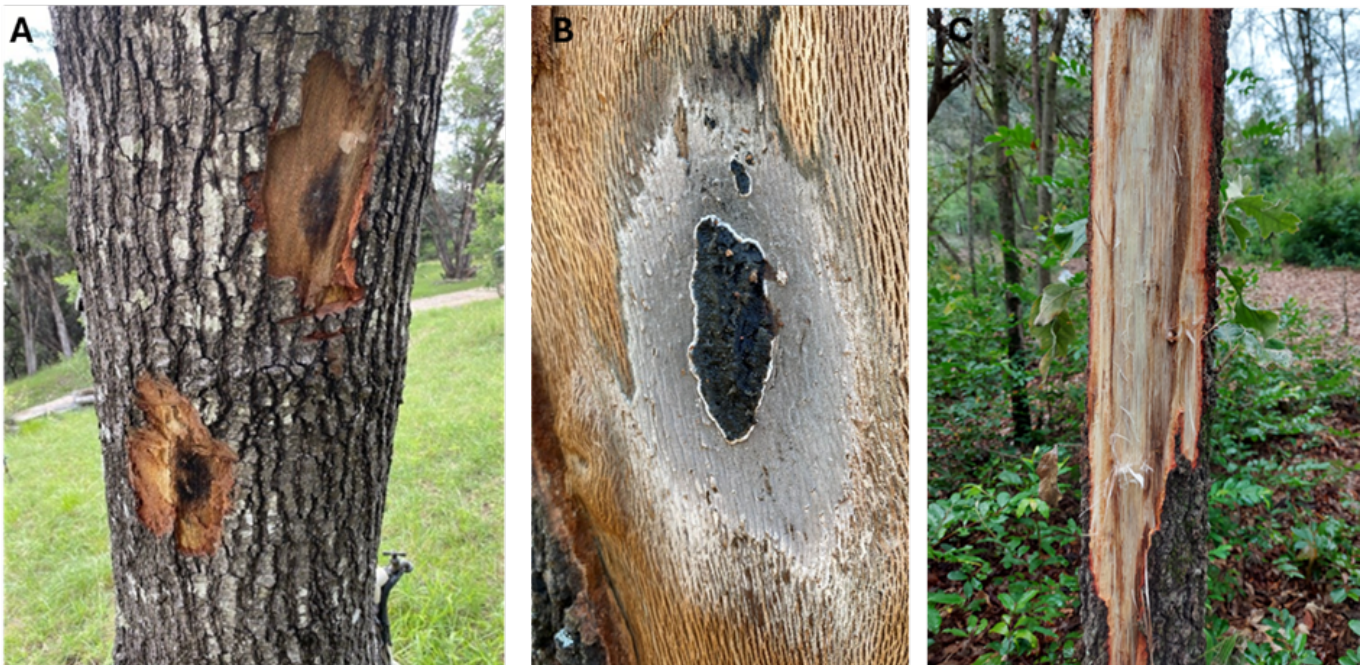


Figure 5. *Symptoms of oak wilt on red oak group. (A, B) Mycelial (fungal) mats of oak wilt on shumard oak (*Quercus shumardii*), (C) vascular streaking or discoloration on water oak (*Q. nigra*) (Images: A &B, Demian Gomez, Texas A&M Forest Service, C, William Klingeman, University of Tennessee).*

A specific sign of the disease on dead and dying red oaks is the presence of black and gray fungal mats under the tree bark, which are special spore producing structures (Figure 5A, 5B) that produce a characteristic odor like fermenting fruit (Wilson, 2005). Fungal mats have not been observed in live or white oak (Wilson, 2005). These fungal mats typically form in spring and fall on trees that were killed by oak wilt disease in the previous year (Wilson, 2005). The timing and production of fungal mat structures depends on geographical location, environmental conditions, and the timing of tree death (Appel, 2001). Mild temperature and high soil moisture favor fungal mat formation (Wilson, 2005).

A symptom of oak wilt that may occur on white oaks is black-to-brown sapwood discoloration that is evident in a cross-sectional view. The discoloration in red oaks can only be seen in the longitudinally sectioned branch after removing the bark (Figure 5C) (Pokorny, 1999). Crown symptoms in red oaks are most noticeable, with evidence of shoot "flagging" appearance, whereby entire branches or crown sections turn red brown. A disease called bot canker caused by the fungus Diplodia corticola also causes similar flagging symptoms (see Figure 11A). If red oaks become infected through root grafts, dieback occurs on the side closest to another infected tree (Juzwik *et al.*, 2011).

Oak wilt symptoms can be confused with other diseases including oak branch canker and dieback caused by *Diplodia corticola* and *D. quercivora* (see Figure 11A) bacterial leaf scorch caused by *Xylella fastidiosa* (see Figure 11B). If oak wilt is suspected, samples can be sent to a diagnostic lab for confirmation. Pokorny (1999) provided recommendations for collecting plant samples from the trunk or from the infected branches of suspect trees. Briefly, select branches with leaves that are demonstrating characteristic symptoms of oak wilt. Some oak species, like red oak (*Q. rubra)* and water oak (*Q. nigra*), sapwood may exhibit vascular discoloration (streaking) beneath bark of main trunk(s) and branches on oak wilt-infected trees. Other oak species, like southern red oak (*Q. falcata*) may not show any sapwood discoloration. For these reasons, sapwood discoloration may be a less reliable scouting characteristic than searching for compromised leaf tissue for sampling branches with those tissues for use in obtaining a diagnostic confirmation of *B. fagacearum*. Send three cut branch sections, each at least 6 inches long and 1 to 2 inches thick, from recently wilted branches that include symptomatic leaves. If sampling from a trunk (bole) or branch, it will be helpful to remove a section of bark and sample tissues from discolored sapwood, if present (Figure 5C); remember discoloration might not be present in some species. Collect a few strips of sapwood 2 to 3 inches wide and 6 to 7 inches long. Place the sample in a sealed plastic bag and do not add paper towels or additional moisture to the bag. After collecting samples, contact your local county Extension office for help in sending the sample for confirmatory analysis. Keep the sample cold (refrigerate or put in a cooler with ice) prior to shipping.

OAK WILT DISEASE CYCLE

Understanding the life cycle of oak wilt disease is crucial for managing the spread of the fungal pathogen. Oak wilt spreads through natural, below-ground root grafting and by interactions with insect vectors (Figure 6). Below-ground spread is a common cause in localized spread of the disease, in which the fungus is transmitted from infected trees to nearby healthy trees through natural grafts that form among tree root systems.

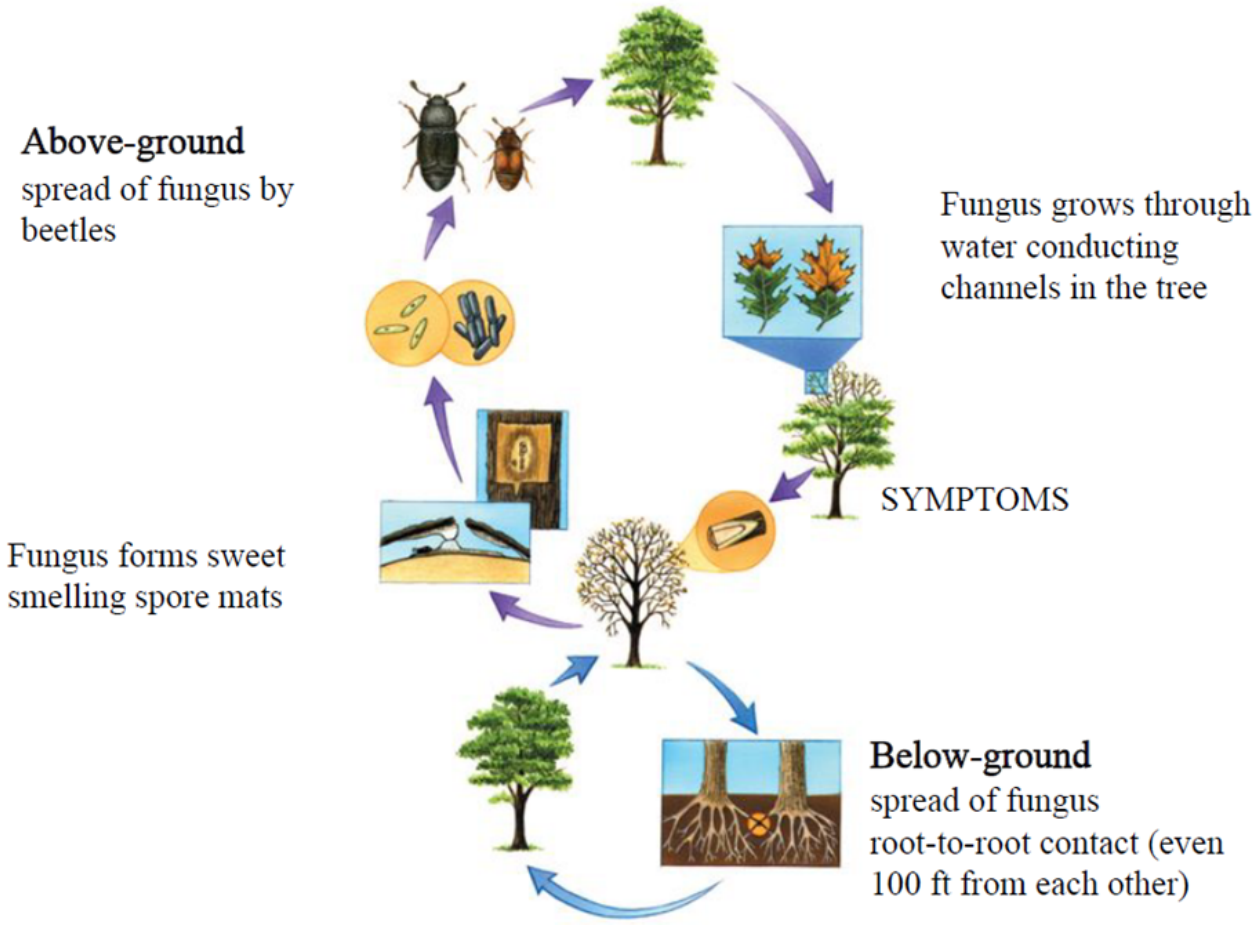


Figure 6. *Disease cycle of the oak wilt pathogen. (Adapted from O'Brien* et al.*, 2000).*

Above-ground spread can occur through movement of fungal propagules on the bodies of insect vectors. The most commonly observed beetle species are sap feeding beetles in the family Nitidulidae. These flying insects can transmit the oak wilt fungus to fresh wounds that occur mechanically or from environmental causes (e.g., freeze injury) that occur on healthy oak trees. Several nitidulid beetle species that have been associated with oak wilt are listed in Table 2. Several sap beetle species known to spread oak wilt, including *Colopterus truncatus, Carpophilus sayi, Glischrochilus fasciatus*, and *G. quadrisignatus*, are widely distributed in Tennessee (Figure 7). This means that some oak trees in Tennessee are at risk of oak wilt infection if the pathogen is re-introduced to locations in the state through transport by humans.

Table 2. Sap beetle species (*Coleoptera: Nitidulidae*) and a bark beetle species (*Coleoptera: Curculionidae: Scolytinae*) trapped or collected in oak woodland and forest habitats. Species are listed (within taxonomic subfamily) that have been identified with oak wilt fungus (*Bretziella fagacearum*) or that have been associated with wounded oak trees or fungal mats.

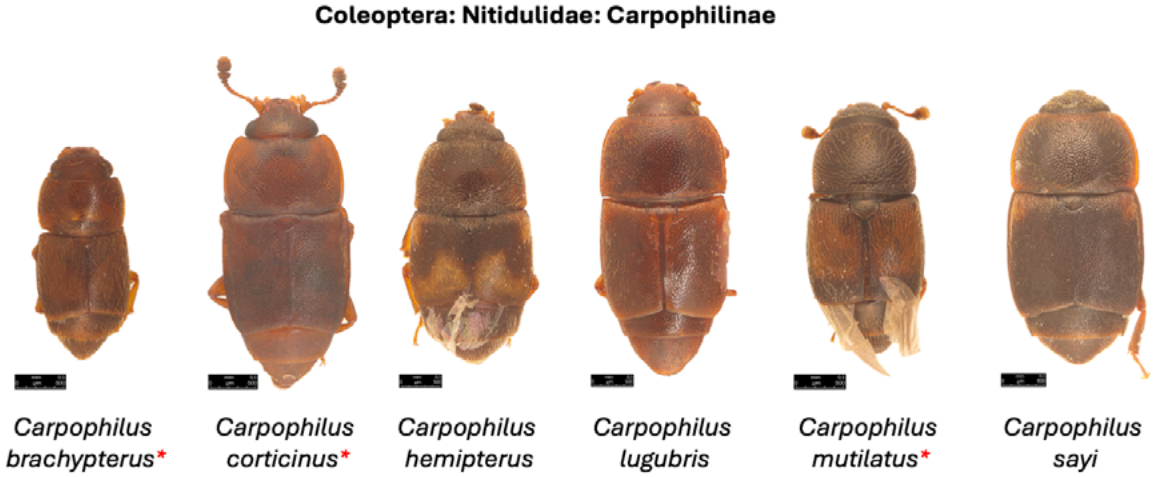
Coleoptera: Nitidulidae species	Cryptarchinae
Cillaeinae	*Cryptarcha ampla* [4,8 **]
Colopterus maculatus [(see 2)]	***Crypt. concinna*** [(see 2)]
Col. niger [4]	***Glischrochilus fasciatus*** [3,5 **]
Col. semitectus [4,8]	***Glisc. quadrisignatus*** [3,8]
Col. truncatus [1,3,4,8,9]	*Glisc. sanguinolentus* [3 **]
Carpophilinae	Epuraeinae
Carpophilus hemiptera [8]	*Epuraea corticina* [3,8 **]
Carp. lugubris [(see 2, 8),9]	*Lobiopa undulata* [(see 2) **]
Carp. sayi [1,3,4,5,8,9]	Coleoptera.: Curculionidae: Scolytinae species
	Pseudopityophthorus minutissimus [(see 2),4,6]

References: [1]Ambourn *et al*., 2005; [2]Appel *et al*., 1990; [3]Cease and Juzwik 2001; [4]Hayslett *et al*., 2008; [5]Hayslett *et al*., 2009; [6]Juzwik *et al*., 2011; [7]Juzwik *et al*., 1983; [8]Juzwik *et al*., 2004; [9]McLaughlin *et al*., 2022

Species in **Bold** indicate that a *B. fagacearum* fungal culture was recovered from surface (or wash) of the beetle body. Fungus contaminated specimens of *Colopterus niger*, *Col. semitectus*, and *Col. truncatus* were most frequently recovered in April and May (e.g., Juzwik *et al*., 2004; Hayslett *et al*., 2008).

** Captured from fresh wounds on oak trees (in Missouri and Minnesota); oak wilt fungus (*B. fagacearum*) was not isolated from these beetles (see Cease and Juzwik, 2001; Juzwik *et al*., 2004; Hayslett *et al*., 2008).

Nitidulid beetles and other fungus beetle species are attracted to volatile chemicals emitted from fungal mats on infected trees. As adult beetles crawl over the fungal mats, fungal spores stick to their bodies. Sap beetles are also attracted to the smell of plant sap weeping from freshly wounded trees and then transmit fungal spores between trees after landing on mechanically or environmentally induced wounds. Therefore, prune at the time when beetles are not active to minimize disease spread. The extent of oak wilt spread depends on proximity between infected and healthy trees and the presence of fresh wounds.



Coleoptera: Nitidulidae: Cillaeinae

Colopterus maculatus | *Colopterus niger* | *Colopterus semitectus* | *Colopterus truncatus* | *Colopterus unicolor**

Coleoptera: Nitidulidae: Cryptarchinae

Glischrochilus fasciatus | *Glischrochilus obtusus* | *Glischrochilus quadrimaculatus* | *Glischrochilus sanguinolentus*

Coleoptera: Nitidulidae: Cryptarchinae

Cryptarcha ampla | *Cryptarcha concinna* | *Cryptarcha strigatula*

Coleoptera: Nitidulidae: Prometopinae

Phenolia grossa

Coleoptera: Nitidulidae: Nitidulinae

Lobiopa undulata

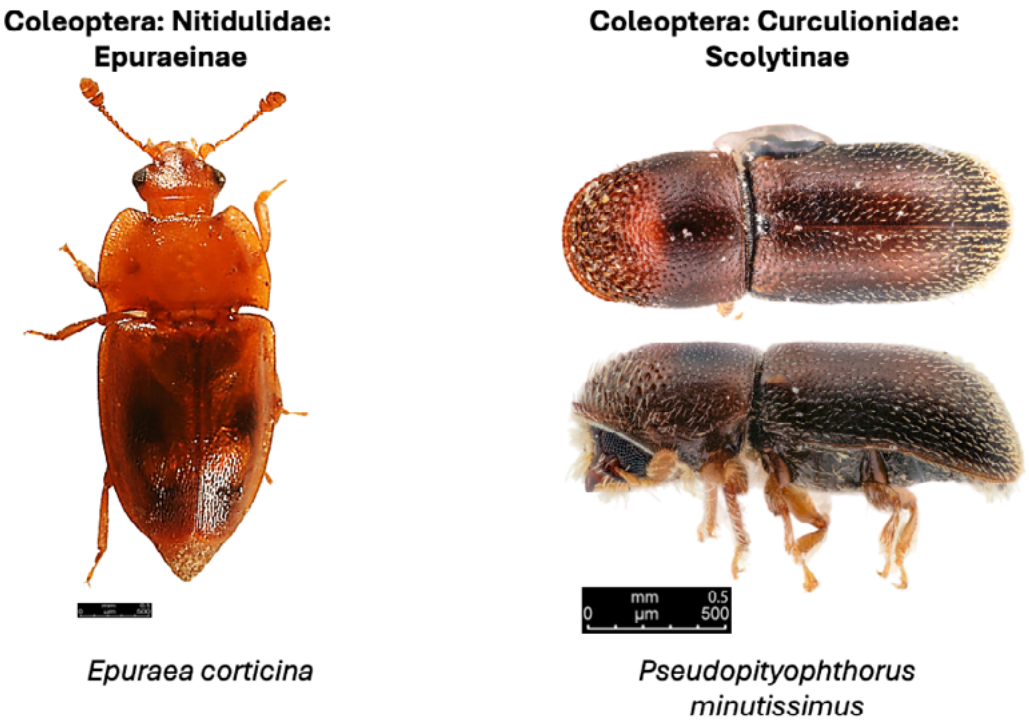


Figure 7. *Sap beetles and a scolytine bark beetle species found in landscapes, oak woodland and forest habitats that have been identified in association with* Bretziella fagacearum *(Images courtesy of Alex Gonzalez Murillo, Ph.D. student, The University of Tennessee, Tom Murray (for* Epuraea corticina*), and Chris Wirth, Purdue University Entomological Research Collection Manager (for* Pseudopityophthorus minutissimus*).*

HUMAN-MEDIATED PATHOGEN TRANSPORT

Potential pathways for introducing oak wilt disease into new areas is often through human activities. This can involve the cutting and off-location dumping of infected branches, wood, and foliar debris, or transportation of infested, untreated firewood from dead red oak trees killed by oak wilt. Although there is no data to confirm the transmission of oak wilt pathogen from infected plant parts of white or live oak firewood, any oak wilt infected firewood may contain insect vectors and fungal hyphae, mycelia, spores and fungal mats. When infected debris or firewood is introduced into a new habitat, the aroma of fungal structures and mats may attract native sap beetles from local populations. As the beetles visit infected firewood and healthy oak trees in the new environment they can begin above-ground spread of the disease to nearby trees in previously unaffected areas. Currently, there are no strict quarantine regulations in place to control the transport of oak firewood from oak wilt endemic areas across different states. Consequently, the disease may unintentionally be spread through human transport (Wilson, 2001). To address this, public awareness initiatives have been implemented such as “Buy It Where You Burn It” to help reduce the spread of oak wilt and other plant diseases and insect pests.

INTEGRATED PEST MANAGEMENT STRATEGIES

Preventive measures are the most effective strategies to manage oak wilt. Planting disease free trees and certified disease resistant or tolerant cultivars are highly recommended. Additionally, diversifying the landscape by planting oak trees with other tree species that are not susceptible to the oak wilt pathogen can help to decrease the disease spread. The integrated approaches that target breaking the disease cycle of the pathogen are discussed below:

Scouting and Monitoring of Disease Symptoms and Detection Through Screening Candidate Vector Species:

Early detection of the disease is crucial for successful management. Carefully observe symptoms such as browning or bronze-colored leaves and necrosis on veins of oak leaves. If leaf discoloration or necrosis is present, there may be many contributing causes including look-alike bacterial leaf scorch, so it is crucial to get a quick and accurate diagnosis. Send samples of any suspected cases quickly for laboratory confirmation. Molecular methods of isolating the oak wilt fungus from infected sapwood and detecting it through molecular tools are effective means of confirming the oak wilt disease (Yang and Juzwik, 2017; Bourgault *et al.,* 2022).

Sap beetles can be monitored by using Lindgren funnel traps (Figure 8) or wind-orienting sap beetle traps, which are constructed from PVC pipe and fittings (Figure 9) (Lindgren *et al.*, 1983; DiGirolomo *et al.,* 2020). Effectiveness of both types of traps is enhanced through use of sap beetle pheromone lures and paired with fermentation malt extract baits (e.g., DiGirolomo *et al.*, 2020; McLaughlin *et al.,* 2022). Traps can be strategically placed to target the sap beetles in locations where oak wilt fungus is suspected. Trapping candidate insect vectors between April and August has provided valuable information about the time of year when sap beetles are active and has enabled detection of the fungus carried by these beetles using molecular methods. For proactive urban foresters, land managers, arborists, researchers, and Extension agents who need to act early in efficiently managing and limiting the spread of oak wilt disease, sap beetle monitoring can inform when these insects are active. Pruning activities should be avoided when beetles are active and mats are likely to form. In Texas for example, pruning is not recommended between February and June due to high beetle activity and higher chances of fungal mat formation (Camilli *et al.*, 2007).

Figure 8. *A Lindgren funnel trap on a 1.5 meter (4 foot) tall pole. (Image courtesy of Axel Gonzalez, PhD student, The University of Tennessee).*

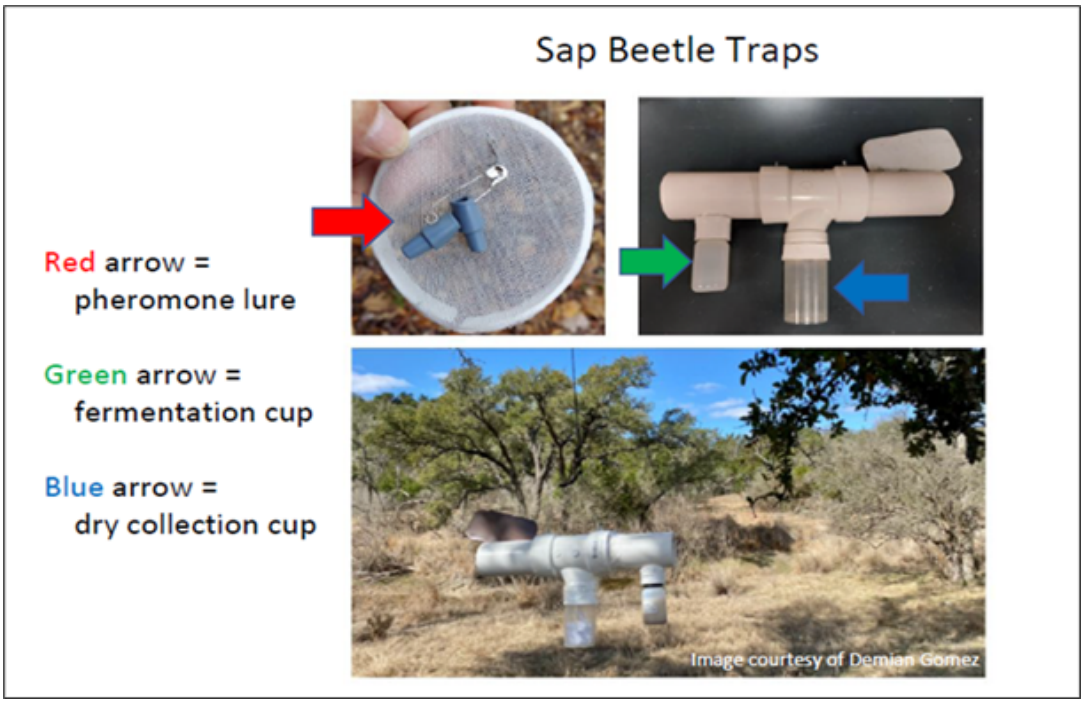


Figure 9. *A wind-oriented sap beetle trap constructed from PVC pipe and fittings modified with addition of lids and a smaller (front) fermentation vial and larger (sample collection cup) jar. The vial and jar lids were hot glued to fitting threads. A sheet metal blade was cut, bent, and screwed into the PVC pipe. Commercially available sap beetle pheromones come impregnated into the gray rubber septa, which are suspended from a safety pin (red arrow) that is then pinned behind screen into the windward-facing PVC aperture (above the green arrow). (Images: William Klingeman, University of Tennessee, Plant Sciences and Demian Gomez, Texas A&M Forest Service).*

CULTURAL METHODS

Sanitation efforts that are made to eliminate potential inoculum sources is an effective cultural method for managing this fungal disease. After confirming the presence of the fungus through a confirmatory test, it is crucial to properly dispose of affected oak trees and tree parts to prevent the fungus from spreading. Sanitation is particularly critical in infected red oak trees because fungal mats are attractive to sap beetles and can increase the vectoring potential of spread to other susceptible oak species, increasing the risk of disease transmission. Proper disposal and effective methods include burning, burying, or chipping the logs and tree parts.

Managing Above-ground Spread

Sap beetles are attracted to fungal-derived, sweet-smelling volatile chemicals released by fungal mats and the scent of fresh host plant sap. Wilted red oaks produce fungal mats in spring; therefore, removing and properly disposing of infected logs that could potentially produce fungal spores interrupts the disease cycle. To prevent new infections, it's best to prune oak trees responsibly during the dormant period from December to February and avoid pruning during the months when sap beetles are active (April to November). Sanitizing pruning tools is a recommended practice to prevent the potential spread of disease between trees. Pruning tools can be sanitized by dipping tools for 30 seconds in a 10 percent bleach solution.

In regions where oak wilt disease pressure is high and pruning to oak trees is unavoidable, or where other types of trunk damage occur, then research-based recommendations are to immediately apply wound paints or wound dressings (French and Juzwik, 1999; Wilson, 2001; 2005; Camilli *et al.*, 2007). Wound paints and dressings can be effective by either reducing the attractiveness of fresh wounds to sap beetles or preventing the entry of spores into the vascular system (Koch *et al.*, 2010). Wound paint and wound dressings in Minnesota have reduced or prevented infection and death of wounded oaks (Juzwik *et al.*, 1985). In Texas, painting wounds from pruning seemed to reduce infection levels by 40%, but this reduction was not statistically significant (Camilli *et al.*, 2007). However, certified arborists caution that applying wound coatings and dressings, along with their constituent solvents, may hinder tree recovery or lead to discoloration.

While it is always advisable to avoid pruning during the growing season, if pruning is unavoidable, coating with latex paint or wound dressing the cut can reduce the oak wilt infection and help safeguard valuable trees. Moving firewood and infected tree portions between locations can rapidly spread oak wilt into a new habitat. It is crucial not to transport either firewood or infected tree parts from an oak wilt epidemic area. To prevent beetles from reaching potential fungal mats in suspected oak wilt firewood, cover the stack with transparent plastic on all sides. The tarp generates heat that can help to kill the fungus. Transport and field dumping of cut trunk and branch debris from infected or suspect-infected oak trees should be avoided.

Controlling Below-ground Transmission and Spread

The below-ground spread of oak wilt occurs through natural root grafts that form between infected and healthy trees. One method to stop this is grafting to disrupt root connections between susceptible tree species by trenching or plowing around the infected trees (Figure 10). Trenching and plowing should be done by tree care professionals and under careful supervision of disease management experts. This action should ideally occur before removing the infected trees. A general dimension for an effective trench is 48 inches deep and 8 inches wide. A water-permeable physical barrier of trench-insert material (e.g., Typar spun-bonded fabric) can be installed to improve efficiency of the trench (Wilson, 2009; Wilson and Lester, 2002).

Figure 10. *Trenching for root-graft disruption. (A) PTO driven trenching tool, (B) pruning the roots with a clean blade, (C) measuring the depth of the trench, (D) trench ready for barrier fabric. (Images courtesy of Jennifer Franklin, University of Tennessee Institute of Agriculture, School of Natural Resources).*

CHEMICAL MANAGEMENT APPROACHES

Chemical treatment is not practical for general applications at the landscape level because of high application cost; however, chemical treatments may help protect high value and specimen trees and may be the only option for oak wilt management in some settings. In locations where there may be high risk from oak wilt fungus, preventive fungicides (e.g., propiconazole) can be applied through systemic trunk injection to high-value trees. Treatments should be applied every two to three years depending on the tree size. Preventive fungicides don't work effectively when red oak trees are already infected and/or with more than 30 percent of canopy-loss in living oaks. However, fungicides can delay symptoms or tree death when applied in the early stages of infection (Appel and Kurdyla, 1992). Fungicides cannot cure red oak trees that are already infected.

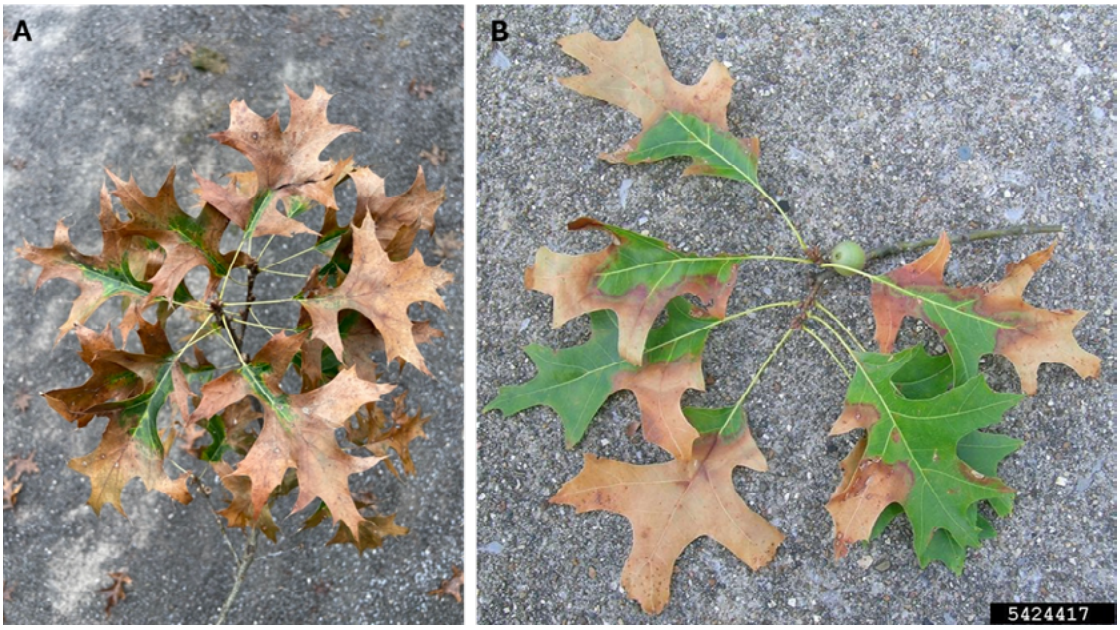


Figure 11. *Oak wilt look-alike symptoms caused by other plant pathogenic agents. Leaf symptoms caused by (A) Bot canker (*Diplodia corticola*), and (B) Bacterial leaf scorch (*Xylella fastidiosa*) (Images courtesy of Chris Smallwood, USDA-ARS SEA Jackson, TN for A. and John Hartman, University of Kentucky, bugwood.org for B.).*

SUMMARY

Oak wilt disease is a significant threat to health and survival of susceptible oak tree species where the causal fungal pathogen, *B. fagacearum*, has been introduced. Several other diseases caused by bacterial and fungal pathogens, as well as abiotic stressors, can produce symptoms in affected oak trees that can be confused with oak wilt. Fungus in oak wilt infected trees can be spread to neighboring host trees through root grafts that occur underground. Insects, particularly sap beetle species, also associate with infected trees and the fungal mats that are produced for a short time in spring beneath the bark. These insects also have the capability to vector the fungus to new susceptible host tree species. Information in this guide is provided to help urban landscape and forest managers recognize characteristic signs and symptoms of oak wilt and assist scouts and diagnosticians to obtain good quality samples that are needed for correct identification of the causal fungal pathogen. This knowledge and accurate identification of *B. fagacearum* will be critical in guiding subsequent management actions, including appropriate disposal of infected tree portions, that are necessary to mitigate disease spread and to protect oak tree species at new infection locations.

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