



Oak Wilt in Michigan's Forest Resource

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Introduction

Oaks are popular tree species and often are of concern to forest owners and all Michigan citizens. Acorn production is an important food source for many wildlife species. Annual value of oak stumpage exceeds \$10 million. Oaks are also abundant and important landscape trees in urban and suburban areas.

It's important to avoid wounding oaks from April through July.

Oak wilt (*Ceratocystis fagacearum*), first identified in the USA in the early 1940s, is a serious disease affecting many oak species throughout the eastern United States. The fungus that causes oak wilt is likely an exotic species but to date it has not been identified anywhere outside the U.S. The spread and impacts of oak wilt have recently attracted more attention in Michigan due, in part, to an extensive oak resource across much of the state, which comprised 10 percent of the forest volume in the state. Home construction or utility work in woodland areas, and other human activity, can increase the spread of oak wilt. The disease is present throughout much of the oak range in both the Lower Peninsula and Upper Peninsula. It is especially abundant in some localized areas.

Hosts

There are at least 58 native species of oaks in the USA, most of which occur in the eastern United States. Introduced species of oak are also used in landscapes in Michigan and many other states. Eleven oak species occur in the 2009 USDA Forest Inventory & Analysis surveys. Oak species are distributed throughout Michigan (Table 1). According to Voss (1985), there are 11-12 species of oak in Michigan. Oak species occur throughout Michigan (Figure 1).

Oaks are divided into three taxonomic sections; **red oaks** (Lobatae or Erythrobalanus), **white oaks** (Quercus or Leucobalanus), and **live oaks** (Protobalanus). Live oaks are common in southern states and do not occur in Michigan.



Figure 1. Oak distribution in Michigan.

Courtesy USDA Forest Service

Several red oak and white oak species do occur in Michigan. Red oaks, including black oak, have leaves with pointed tips. Leaves on white oaks have rounded tips (Figure 2).

Red oaks are more vulnerable to oak wilt than white oaks. Trees in the red oak group share root systems through **natural grafts**, which facilitates the underground spread of oak wilt. White oaks are less prone to grafting. White oaks also have tiny plugs in their sapwood vessels called **tyloses**, which act to slow the spread of the wilt disease within the tree. White oaks, therefore, are less vulnerable and more resistant to oak wilt fungus.

Table 1. Oak Species in Michigan Forest Land, FIA 2009 (10.5% of total forestland volume)

Species	Group	Volume (cubic feet)	Percent Volume of Oak Resource	Scientific name	Michigan Range
N. Red Oak	Red	1,669,250,883	47.0	<i>Quercus rubra</i>	Statewide
White Oak	White	722,384,493	20.3	<i>Quercus alba</i>	Mostly Lower Peninsula
Black Oak	Red	647,081,694	18.2	<i>Quercus velutina</i>	Lower Peninsula
N. Pin Oak	Red	290,627,674	8.2	<i>Quercus ellipsoidales</i>	Statewide
Swamp White Oak	White	97,092,984	2.7	<i>Quercus bicolor</i>	S. Lower Peninsula
Bur Oak	White	92,460,425	2.6	<i>Quercus macrocarpa</i>	Statewide
Pin Oak	Red	28,099,007	0.8	<i>Quercus palustris</i>	Few southern counties
Chinquapin Oak	Red	4,249,109	0.1	<i>Quercus muehlenbergii</i>	S. Lower Peninsula
Scarlet Oak	Red	1,365,472	--	<i>Quercus coccinea</i>	Lower Peninsula
Chestnut Oak	Red	89,917	--	<i>Quercus prinus</i>	Uncommon, far south
Dwarf Chestnut	Red	--	--	<i>Quercus prinoides</i>	Few southern counties
Shingle Oak	Red	--	--	<i>Quercus imbricaria</i>	Few southern counties

Source: US Forest Service Forest Inventory & Analysis data, 2009. Range data from Voss (1985).



Figure 2. Red oak, white oak, northern pin oak, bur oak.

The Pathogen

Oak wilt is a vascular disease caused by the fungus (*Ceratocystis fagacearum*). Oak wilt is related to the well-known fungus that causes Dutch elm disease (*Ceratocystis ulmi*). The fungus clogs sapwood vessels in the oak trees, which inhibits water transport. This results in wilting and eventually kills the tree. In white oaks, however, the tyloses can slow or stop fungal growth and movement within the water-transporting vessels. Because the fungus has little genetic variation and rapidly kills its host, many scientists suspect the organism is not native to the United States.

Pathology

Oak wilt is caused by a fungus that is an obligate pathogen, which means that it requires living tissue to survive. When an oak tree dies, the fungus must move to another tree. It can do so in two ways (Figure 3); 1) underground through root grafts (Figure 4), and/or 2) spores carried overland by insects. Human transport of infected oak, especially firewood, facilitates the overland spread of oak wilt throughout a landscape. The



Figure 4. Red oak root graft.

rate of home construction in oak woodlands has greatly increased since the 1980s, and oak wilt has often followed in this wake.

As trees in the red oak group die, the fungus moves through grafted root systems from tree to tree until all connected oaks are dead. The process can take years for large stands of oak. Cutting infected, dying, or dead oaks will not stop this movement. Cutting live infected trees will cause rapid movement of spores into the root systems, quickening the spread.

Oak wilt often produces a distinctive fruiting body, called a spore mat, on the trunk or branches of infected trees (Figure 5). Spore mats are black and have an elliptical shape. They may be up to six inches long; and if certain environmental conditions occur, they will produce a thumb-pad sized blister called a pressure pad. The pressure pads push against the bark, creating an open crack (Figure 6) which allows access by insects.

The sweet-smelling scent of the spore mat attracts sap-feeding insects, particularly certain nitidulid beetles, commonly called "picnic"



Figure 5. Oak wilt spore mat and pressure pad.



Figure 6. Bark crack from fungal pressure pad.

beetles (Figure 7). As these insects feed on the sap, fungal spores attach to the beetles. When the beetles move to feed on fresh wounds of healthy oak trees, the spores are introduced and a new infection site develops.

These beetles are most abundant in spring and early summer. It is important to avoid wounding oaks, **especially from April through July**, to prevent these beetles from vectoring the oak wilt fungus.

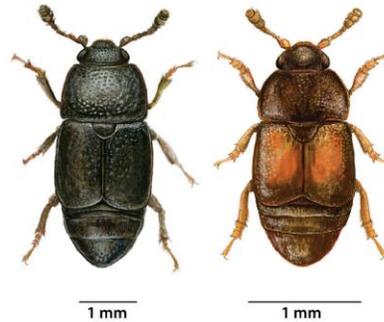


Figure 7. Nitidulid beetles primarily responsible for overland spread of oak wilt. Courtesy USDA Forest Service

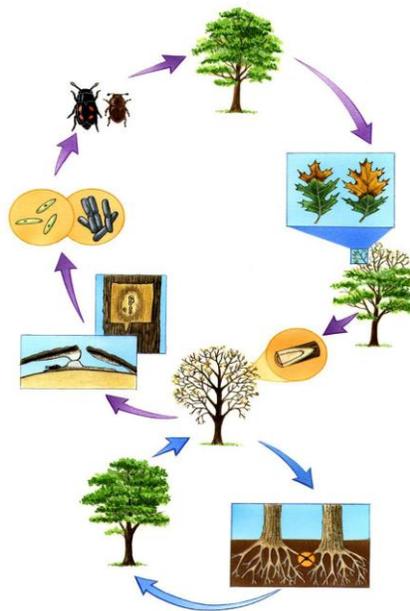


Figure 3. The disease cycle of oak wilt. Courtesy USDA Forest Service

Spore mats and pressure pads most commonly form in the spring and early summer, when conditions tend to be damp. Under dry conditions, the fungus will produce few (or no) pressure pads but wet weather can prolong the production of pressure pads. Pressure pads may be produced through the end of September, although the important insect vectors are usually less abundant by mid to late summer. The spore mats and pressure pads form only on trees that have been killed within the past year. They are most common in the lower 15 feet of the trunk. Oaks killed early in the growing season will sometimes form mats and pads during that same summer. Trees that have been dead for more than a year (with loose bark) do not produce spore mats. Spore mats and pressure pads are common on trees in the red oak group, and sometimes occur on bur oak, which is in the white oak group. Other oaks in the white oak group do not produce pads.

Prevention: It is important to minimize the risk of new oak wilt infections. Once oak wilt

becomes established in an area, oak trees will die and treatment costs can be high. There are two critical practices that can minimize the likelihood of oak wilt establishment. First, avoid wounding oaks from April through July. Beetles that vector oak wilt spores are most active during this period and will be attracted to fresh wounds. Practices such as clearing rights-of-way, tree pruning, and home construction have contributed to the spread of oak wilt across many parts of Michigan. If an oak is wounded, apply tree wound or latex-based paint to seal the wound as soon as possible. This is one of the very few circumstances where painting tree wounds is helpful. Secondly, do not accept oak logs or firewood from unknown sources. Oak wilt spores on the logs or firewood may be active in the spring after the oak trees die.

Symptoms

The most visible evidence of oak wilt is the rapid loss of leaves during the summer, often within two to three weeks (Figure 8). Fallen leaves may be brown, somewhat bronzed, or partially green (Figure 9). They usually appear dried out or wilted. Wilting begins at the top of the tree with leaf color changing to a paler green. Browning often begins at the leaf base with a sharp line between brown and green. This symptom is suggestive of oak wilt but not diagnostic.

Wilting in white oaks occurs one branch at a time and several years may pass before the tree dies.

The sapwood of infected oaks may be streaked or flecked with light brown. This symptom may be difficult to observe, however. Sometimes the sapwood will have a sweet-smelling odor.

Older pockets of oak wilt will include dead oaks in the center and dying oaks scattered around the perimeter (Figure 10). In some years, only one or two oaks will wilt. In other years, the number of dying trees around the perimeter of the pocket may expand significantly. These expanding epicenters are also suggestive of oak wilt, but not diagnostic.



Figure 10. Open areas are former oak wilt epicenters.



Figure 8. Oak wilt leaf loss symptoms.



Figure 9. Wilt pattern in oak leaf.

Cracks in the bark, usually rather narrow and only a few inches long, can sometimes be found in the bark on trees that died during the previous year. Identifying these cracks can be difficult, however, on trees with thick, corky bark. A hatchet or heavy knife can be used to chop out the bark around the crack to expose the spore mat and pressure pad. Finding a spore mat and pressure pad *is* diagnostic for oak wilt. Nothing else will cause these symptoms.

Diagnosis and Tissue Sampling

If fungal spore mats and pressure pads are present, oak wilt infection is certain. If not, a tissue sample should be collected from a suspect tree and submitted to a diagnostic laboratory where it will be cultured to confirm the presence of the oak wilt fungus. Pressure pads are less common in the Lower Peninsula than in the Upper Peninsula. Controlling oak wilt can be quite expensive and invasive, especially if pockets are large. The presence of oak wilt needs to be confirmed before beginning any treatment.

Correct sampling procedures are important to avoid error and expense.

Selecting an appropriate tree is critical. Because oak wilt is an obligate pathogen, living xylem tissue is needed. Trees that are about half-dead are ideal for sampling. Trees with few symptoms of oak wilt may not have as much fungus in the vessels, making the diagnosis more difficult. Trees that are dead, or nearly dead, may also have low levels of the oak wilt fungus, plus an increased level of secondary fungi, which can mask the presence of oak wilt.

Collect a 3-5 inches long sample from a small branch, about one-half inch in diameter (Figure 11), which has both wilted and green leaves. Alternatively, but less reliably, a chip of sapwood can be collected using a chisel or hatchet. Chips should be about 1.5 x 1.5 inches, and a half-inch deep, with bark retained. It is best to get several branch or chip samples from different locations of a suspect tree. Place samples in separate plastic bags, labeled with location and contact information. Deliver samples to the laboratory as soon as possible. Refrigerate samples if delivery must be delayed. Samples can be mailed if delivery is expected in two or three days. Diagnosis will be most successful if the sample can be cultured within four or five days of sampling. After two weeks, other fungi begin to colonize samples and the oak wilt fungus cannot be identified.



Figure 11. Twig sample for fungal culturing.



Figure 12. Oak wilt fungus in agar dishes. Courtesy: Dana Richter.

Culturing and isolation is the growing of a fungus in a controlled laboratory environment (Figure 12). The oak wilt fungus is identified by characteristic growth form and spore production on agar. Culturing samples may cost \$50-75 apiece. Cultures can be processed at Michigan State University diagnostic labs, at the Michigan Technological University School of Forestry, and by the Michigan Department of Agriculture and Rural Development. The culturing may take ten days and sometimes longer. The oak wilt fungus is identified by growth form and spore production on agar. False negatives (negative culture even though oak wilt is present) can occur due to poor sampling procedure, delayed delivery to a laboratory, or the variability in the distribution of the fungus within a tree.

Similar Oak Pests

Symptoms similar to those of oak wilt can be caused by other damaging agents, making visual diagnosis challenging, especially by those who have little previous experience with oak wilt infections. It is certainly possible that oak wilt may be present at the same time as other agents, which can make diagnosis even more difficult.



Figure 13. Bacterial Leaf Scorch
Courtesy Gerry Adams, MSU

Bacterial Leaf Scorch (Figure 13): Browning leaves, brown leaf margins, and leaf curl may be caused by bacterial infections (*Xylella fastidiosa*). Red oaks are more susceptible than white oaks. It is most common on ornamental trees. Bacterial infections invade the vascular tissue of trees and are often fatal. Mortality usually occurs gradually over several years as branches die. Bacterial leaf scorch is often confused with physiological leaf scorch which occurs when warm summer

temperatures, drought, or other environmental conditions stress trees.

Anthracnose (Figure 14): A group of leaf diseases categorized as Anthracnoses affect many tree species, including oaks. Browning or premature leaf drop may resemble oak wilt symptoms but leaves exhibit different patterns of brown tissue and leaf loss. Affected leaves are usually more common in the lower portions of tree crowns than in the upper canopy. Anthracnoses occur most often when spring weather is cool and wet. Symptoms usually disappear with onset of warmer and drier summer weather. Oaks growing in watered lawns and along golf

course fairways with irrigation may experience higher and more regular Anthracnose infections.

Two-lined Chestnut Borer (TLCB) (Figure 15): The TLCB (*Agrilus bilineatus*) is a phloem-feeding insect attracted to physiologically stressed oaks. Larvae feed on the living tissue under the bark and



Figure 14. Anthracnose on red oak.

disrupt transport of nutrients and water. Leaves may wilt or die but rarely drop during the summer. Infestations of TLCB usually begin in the upper canopy. If populations continue to build, branches will be girdled and die. Leaves on affected branches turn brown, as in oak wilt, but rarely appear to be wilted and the browning is more uniform throughout the leaf. When trees are attacked repeatedly, upper branches may be dead, mid-canopy branches may be dying but lower branches will still be alive with green leaves, unlike trees with oak wilt.

Typically, trees must be attacked by TLCB for several years or have other predisposing factors before mortality occurs. TLCB often occurs in areas with sandy soils, especially in years with severe droughts or repeated defoliation by leaf-feeding insects or where trees are overmature and less vigorous.



Figure 15. TLCB larvae & galleries.
Courtesy James Solomon, USDA Forest Service, Bugwood.org.

Oak Decline (Figure 16): A decline occurs when several damaging agents are at work at the same time in a particular area. Defoliation by forest tent caterpillar and gypsy moth, combined with droughty conditions, poor soil, or overmature trees can lead to decline. Armillaria, a common soil pathogen, opportunistically attacks stressed trees, including oaks. Oak decline symptoms and causes will vary over geography and time. Oak wilt may be part of the complex of pests affecting the declining oaks, but identifying all the damaging agents involved may be difficult.



Figure 16. Oak decline
Courtesy Joe O'Brien, USDA Forest Service, Bugwood.com.

Treatment and Management of Oak Wilt

Oak wilt has become prevalent across some areas of Michigan and eradication on a site by site basis involves risk and expense. In especially high value areas such as state parks and natural areas, eradication may become a high priority.

An "epicenter" refers to the infected area. This includes dead trees, dying trees, and trees with infected root systems that extend to currently asymptomatic (does not show symptoms) trees.

To effectively stop oak wilt from spreading, both overland and underground routes must be addressed (Figure 17). Removing and properly disposing of symptomatic trees can reduce overland spread; and disrupting root systems can halt underground spread. Suspected oak wilt epicenters should be confirmed by either the presence of spore mats and pressure pads or a positive laboratory culture. Once confirmed, an oak wilt epicenter will need to be delineated. Red oaks within the epicenter must be removed and root grafts between infected and non-infected trees must be severed. When epicenters cross ownership boundaries, treatment will require permission from each property owner.

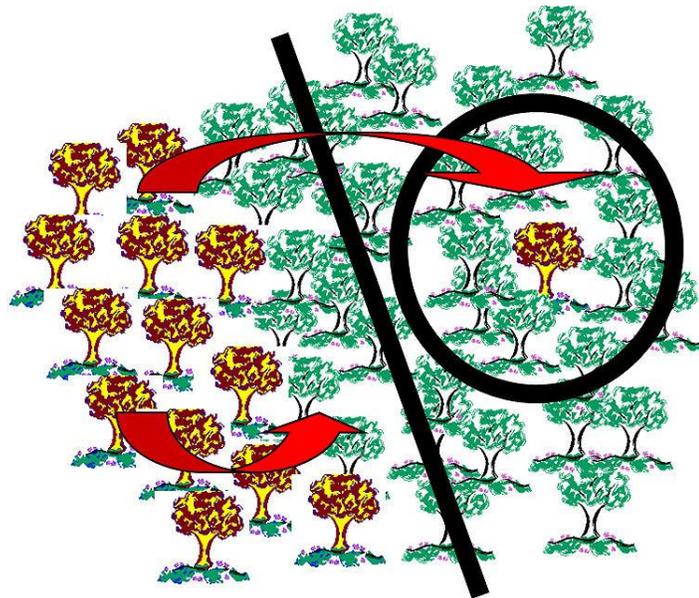


Figure 17. Both overland and underground spread must be prevented.

Marking and Delineating Infected Areas (Figure 18): Symptomatic trees, including trees that died or are in the process of dying should be clearly marked. Once leaves expand in spring, oaks can wilt anytime during the growing season. Epicenters marked early in the season may need to be re-marked in August. Search for symptomatic trees on clear, sunny days. Clouds make it difficult to see the early stages of wilting, which usually begins at the top of trees. Watch for single trees, known as "outliers", that are located beyond a main group of dead/dying oaks but still exhibit wilt symptoms.

Once symptomatic trees have been marked, a perimeter line must be established. The perimeter line will extend beyond symptomatic trees and will encompass the furthest likely extent of the disease underground. The perimeter line should be identified later in the season after all symptomatic oaks have been marked. Perimeter lines are not needed on segments of epicenters that are adjacent to oak-free vegetation.

Placement of the perimeter line depends on the distance between symptomatic oaks and healthy oaks and the size of the trees. To

Diagram of an Oak Wilt Treatment Area

- Apparently healthy trees
- Dying & recently dead
- Dead 2+ years
- Non-oak trees
- ▭ Epicenter perimeter

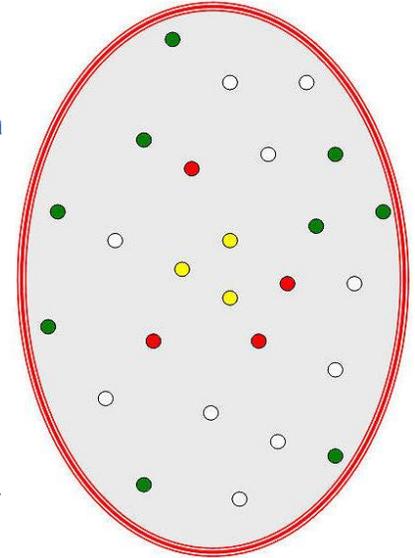


Figure 18. Treatment layout of an oak wilt epicenter.

identify where the perimeter line should be placed, measure the dbh (diameter at breast height, in inches) of the symptomatic oaks on the edge of the epicenter and the dbh of the healthy oaks at some point beyond the epicenter. Larger trees will have larger root systems and require greater distances. Table 2 displays the required minimum distances based on the sum of the dbh measurements. For example, if a symptomatic oak has a diameter of 10 inches and the nearest healthy oak has a diameter of 16 inches; the sum is 26 inches. Table 2 shows that there must be at least 66 feet between the two oaks if the soil is sandy. If the distance is less than 66 feet, then the perimeter line must be placed outside the healthy oak, and the healthy oak will need to be removed. When most oaks are large, the perimeter line will often be 100 feet or more from the nearest symptomatic oak. The perimeter line must be carefully placed with a constant eye to symptomatic trees that may have been previously missed, especially outlier oaks that display wilting.

It is possible that an outlier tree that has recently been infected by overland transmission will not wilt until the next growing season. These oaks will continue to spread oak wilt outside the perimeter. Post-treatment monitoring is recommended for three years.

After an oak wilt epicenter is identified, marked, and delineated, a decision must be made about how to sever root grafts to isolate the

Table 2. Distance–Diameter Table

dbh sum	sand	loam	dbh sum	sand	loam
2	5	4	26	66	53
4	10	8	28	72	57
6	15	12	30	77	61
8	20	16	32	82	65
10	26	20	34	87	69
12	31	24	36	92	73
14	36	29	38	97	77
16	41	33	40	102	81
18	46	37	42	107	85
20	51	41	44	112	89
22	56	45	46	117	94
24	61	49	48	123	98

dbh: tree diameter at a height of 4.5 feet

infected root systems. Most typically this is done using a vibratory plow. For single-tree epicenters, stump-pulling may also be effective. In the past, chemicals have been injected into the soil to kill roots, along with other vegetation. These chemicals are dangerous and can be applied only when vibratory plowing or stump-pulling are not applicable.



Vibratory Plowing (Figure 19): Many miles of oak wilt areas in Michigan have been treated with a vibratory plow pulled behind a large tractor, following the perimeter line delineated around the epicenter. The plow has a blade that slices into the ground, at least five feet deep, facilitated by a powerful vibration action. Plowing must be at least five feet deep to ensure the oak roots are severed. Vibratory plowing should be done during the dormant season.

Figure 19. Vibratory plow trenching.

Vibratory plowing cannot be used in shallow soils underlain by bedrock, areas where large boulders are common, on steep slopes, or where underground infrastructure such as gas lines, septic systems, etc. are present. Water and electric lines can usually be exposed by hand-digging. Always call Miss Dig before beginning a project. A vibratory plow can then be carefully dropped into a hand-dug pit to complete a



Figure 20. Spread of oak wilt through oak stump sprouts.

trench line. This should be done twice, in opposite directions, to minimize the risk of breaking a line.

Vibratory plows are not common and availability may be limited, and a backhoe can be used in some cases. Care must be taken to ensure the trench excavated by the backhoe is at least five feet deep. The soil will need to be replaced into the trench. A backhoe requires more time and often is more expensive than a vibratory plow, but it may be a good option for small epicenters or in locations where boulders are an issue.

In areas with multiple epicenters, perimeter lines may need to be merged to make treatment more efficient, more effective, and less costly. The disease will continue to move through the root grafts of stump sprout clumps to the perimeter (Figure 20). Extending perimeter lines too far beyond the distances given in Table 2 may provide enough time for grafts to re-establish across the perimeter, thus allowing the underground spread across the perimeter. When the distances given in

Table 2 are exceeded, follow-up foliar herbicide application on stump sprouts may be advisable.

Stump Pulling (Figure 21): Stump pulling is an alternative to vibratory plowing for new epicenters. Symptomatic and healthy buffer trees should be felled within the perimeter line. Stumps of these trees can then be pulled using an excavator or pushed out with a bulldozer. Large stumps are more difficult to pull and require a larger machine. Monitoring for follow-up treatment is recommended. Trees should be felled and stumps pulled during the dormant season.

This technique has more visual impact than using a vibratory plow and will usually be appropriate only for first-year, usually single tree, epicenters. It may also be feasible in locations where vibratory plowing is not an option. Be cautious about underground infrastructure.

Trials in Minnesota and Michigan have shown that pulling stumps can be successfully used to treat oak wilt epicenters.



Figure 21. Stump-pulling and chipping.

Courtesy Roger Mech.

Chemical Root Disruption: Biocidal chemicals can be effectively used to kill root systems but they are difficult to work with and dangerous to apply. Chemicals may be an option where vibratory plowing or stump pulling are not possible. Only licensed pesticide applicators trained in this technique should apply these products. Chemicals are placed into holes that are systematically drilled into the ground. Soils must have a uniform texture to facilitate chemical dispersal and these products cannot be used where water tables are close to the surface. These chemicals kill all tree roots and living organisms within the treatment zone.

Individual Tree Injection: Fungicides can be used to prevent oak wilt symptom development of high value trees in residential and community areas. Products containing **propiconazole** are injected into oaks by licensed applicators and protection lasts two years. These fungicides cannot, however, "cure" trees that are already infected. The high cost of these products usually limits their use to valuable landscape trees or trees in special use areas, such as golf courses or parks.

Oak Removal and Use: Red oak trees within the perimeter line must be felled and removed during the fall or winter to minimize potential overland spread by sap beetles in the following years. Symptomatic red oaks should be clearly marked and will require special care. Wood from

infected red oaks must either be destroyed or should be treated to ensure it is too dry for spore mats and pressure pads to form.

Options for disposing of infected trees:

1. Saw into boards. Tops and limbs can be left on-site.
 2. Burn or bury.
 3. Chip for boiler fuel.
 4. Tarp tightly to the ground (beetle-proof) through July.
 5. Debark and dry thoroughly.
 6. Cut, split, and stack loosely to allow maximum air movement.
- Firewood must be thoroughly dry *before* the next spring to prevent formation of spore mats and pressure pads.

Asymptomatic red oaks within the perimeter line of the epicenter should be removed but do not require special treatment. Trees within the white oak group, as well as all non-oak species, can be retained.

Depending upon the objectives of the forest owner, the sale of the timber within an oak wilt epicenter can be combined with a larger timber sale. The timber from a small epicenter may have insufficient volume or value to attract a logging contractor. Incorporating a larger area or multiple properties may increase interest in and lead to a viable commercial timber sale.

Uncooperative Owners

Multiple property owners are likely to be involved if the oak wilt epicenter is large. For a variety of reasons, some owners will choose not to treat their infected oak stands. This creates two challenges to effective oak wilt control. First, persistent sources of fungal inoculum will continue to infect new stands via overland transmission. Second, epicenters shared with adjacent uncooperative forest owners may not be treatable, depending upon the geographic distribution of the epicenter. Treatment success is reduced in areas of high inoculum.



Reforestation

In stands where a high proportion of overstory trees were red oaks, the impact of oak wilt or oak wilt treatment will be dramatic. Landowners may wish to actively reforest the affected areas. The choice of tree species to replace the oaks will depend on the soils and customary tree planting considerations. In some cases, there may be advance natural regeneration of various species, including oaks, which can be encouraged. Seedling oak (not stump sprouts), either natural or planted, may be a good option as the oak wilt fungus will no longer be present on the site. Even when nearby oak stands are infected and serve as sources of overland spread, it will be many years before young oaks reach a size attractive to beetle vectors and root systems begin to graft. Reforestation options should be discussed with a consulting forester and become part of a modified management plan for the forest.

Post-treatment oak stand in Menominee County.

Summary Tips

- Avoid pruning and other activities that are likely to wound oaks from April through July.
- Be certain that oak wilt is the cause of dying oaks before considering any treatment.
- Infected areas should be marked and delineated by experienced individuals.
- Symptomatic trees require special disposal care.
- Treatment choice will depend on a number of factors, such as cost, availability of equipment, environmental conditions, and human infrastructure.
- Removal of affected red oaks should be done in the dormant season following marking, delineation, and trenching.
- Monitor the site for at least three years, re-treatment may be necessary.
- Consider reforestation options.

Contacts

Many consulting foresters are aware of oak wilt and can help you diagnose unhealthy oak stands. MSU Extension provides a self-service directory of consulting foresters at: [\[http://forestry.msu.edu/extension/extdocs/consulfor/consult.htm\]](http://forestry.msu.edu/extension/extdocs/consulfor/consult.htm).

Conservation Districts and MSU Extension offices can serve as portals for information and forestry services.

Michigan DNR offices can provide contacts for DNR forest health specialists. Sometimes, grants are available for oak wilt control.

References

- How To Identify, Prevent, and Control Oak Wilt, NA-FR-01-11. 2011. J.G. O'Brien, M.E. Mielke, D. Starkey, and J. Juzwik. USDA Forest Service, Northeastern Area State & Private Forestry.
- Challenges and Successes in Managing Oak Wilt in the United States. 2011. J. Juzwik, D.N. Appel, W.L. MacDonald, and S. Burks. Plant Disease, Vol. 95 No. 8.
- Voss, E.G. 1985. "Michigan Flora-Part II". Cranbrook Institute of Science.



DIAGNOSIS

Not Oak Wilt?
Good News!
Seek Other Info

Begin at the "DIAGNOSIS" box (assuming that you've had a trained person examine your tree or stand). From there a series of choices need to be made that will lead to another set of choices. Depending on your situation, there are several possible outcomes.

Yes, Oak Wilt For Certain

Single Tree Epicenter

Check "Infrastructure" (see below)

Pull Stump

Larger Infection

One Property Owner

Multiple Property Owners?

Agreement Among Owners?

Mark Symptomatic Trees

Mark Perimeter Using Buffer Table

Infrastructure?
Septic?
Water?
Gas? Power?
TnE Species?
Cultural Sites?
Steep Slopes?
Boulders?
Shallow Soil?
Miss Dig?

Trench Perimeter
Vibratory plow?
Backhoe?

Remove Oaks
Special Care of Symptomatic Trees

MONITOR
At Least 3 Years

Lack of Agreement Among Owners?

Viable Treatment Area Among Cooperative Owners

Cannot Trench?

Pull Stumps

Treatment Not Viable

Annual Monitoring

No Chemicals

No Heavy Machine Access? Too Expensive?

Chemicals

Do Nothing

Annually Remove and Properly Dispose of Symptomatic Oaks

Figure 22. Decision tree of oak wilt treatment alternatives.