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D.W. French  
Ward C. Stienstra

UNIVERSITY OF MINNESOTA  
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# Oak Wilt



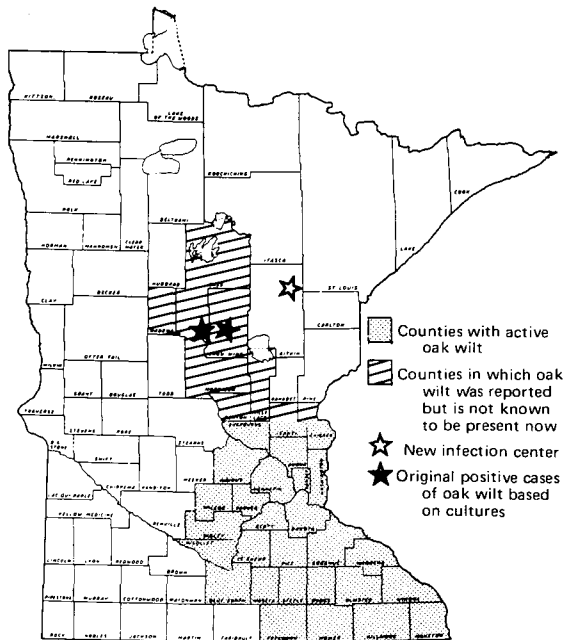


figure 1. Distribution of oak wilt in Minnesota. The isolated infection center near Big Sandy Lake in Aitkin County was undoubtedly the result of carrying infected oak wood into the area.

All species and varieties of oak tested have been found susceptible to oak wilt. Red or Black Oaks are very susceptible and are killed rapidly by the fungus. Bur Oak varies from susceptible to resistant, while White Oak is reasonably resistant to the disease. Oak wilt undoubtedly has been present in the North Central states for many years. Disease survey records as early as 1912 describe mortality in oak stands of Minnesota and Wisconsin similar to that now known to be due to oak wilt. Oak mortality was attributed to several factors such as drought until 1940, when the causal agent was identified as a fungus. Nationally, oak wilt ranges from Minnesota east to Pennsylvania, south to South Carolina and Tennessee, west to northern Arkansas and eastern Oklahoma, north through Kansas and Nebraska to Minnesota. Oak wilt is a serious disease in southeastern Minnesota and is found up to a line from St. Cloud to Taylors Falls and west to a line from St. Cloud to Mankato and south to Iowa (figure 1).

### Symptoms

The leaves of Red Oaks turn a dull green, bronze, or tan beginning at the outer portions of the leaf. The base of the leaf and the portion around the main vein are the last to change (figure 2). Wilting in Red Oaks, the most obvious symptom, generally starts near the top of the tree and then rapidly involves the entire crown. The tree wilts completely within a few weeks after the first symptoms appear. Brown to black discoloration is present in the outer sapwood where the fungus has induced the tree to produce tyloses and gums which account for this discoloration (figure 2).

Red Oaks are not known to recover once infected. Some trees, those infected later in the growing season, occasionally produce some leaves on the lower branches the following spring. These trees wilt and die later that spring.

The leaves of White Oaks and Bur Oaks (figure 3 shows differences between the groups) turn brown from the leaf tip toward the leaf base, and the color changes tend to re-

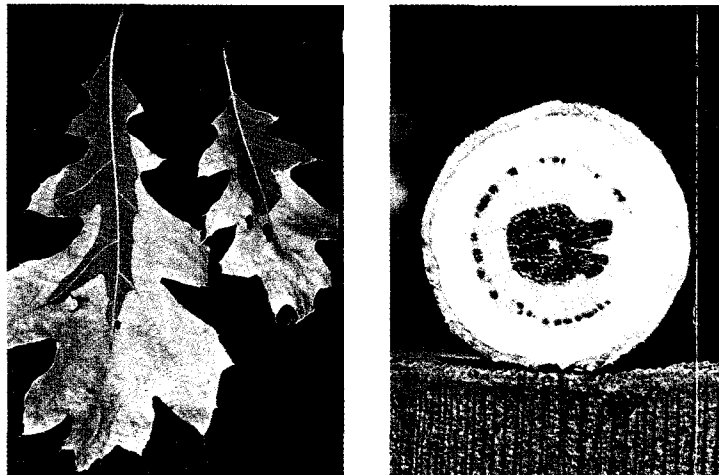


figure 2. Left: Red Oak leaves in process of wilting. Right: Cross-section of Red Oak branch shows discoloration often seen as small dark dots in the white wood just under the bark.

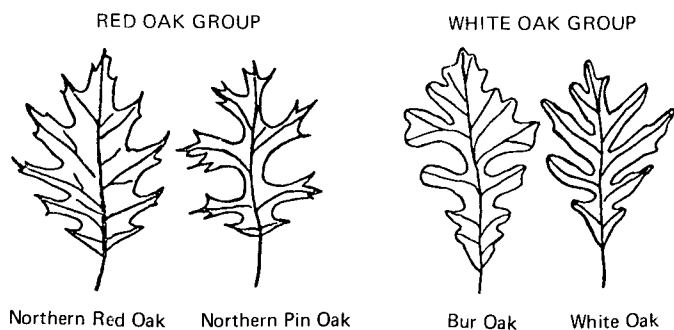


figure 3. Diagrams of the four most common species of oaks in Minnesota

figure 4. Summer symptoms of oak wilt in Red Oak with healthy Red Oaks in background. Because it wilted during July and is a reasonably large tree, this infected tree probably will have spores produced on it the following spring.



figure 6. The wilted Red Oak on the left is a different color from the healthy Red Oaks in the background. On the right is a healthy White Oak, which has leaves that are distinct from both healthy and diseased Red Oaks.

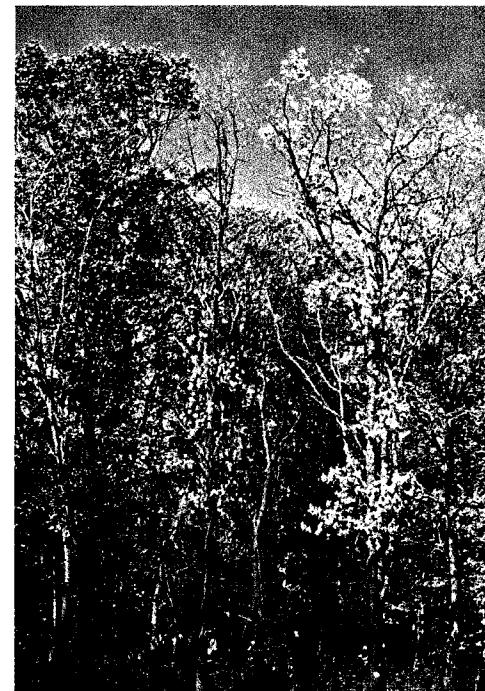


figure 5. Healthy Red Oak on the left and wilted Red Oak on the right. The tree on the right is a potential source of spores the following spring. Two other wilted Red Oaks are in the middle and it's unlikely that spores will be produced on either of these because they wilted earlier in the season than the tree on the right.



figure 7. Red Oaks killed by oak wilt fungus. The substantial development of underbrush and almost total lack of bark suggest that these trees have been dead for a few years. The aboveground parts are no hazard as the fungus can not survive in such trees.

figure 11. Infected Red Oak with white living cambium (stage prior to sporulation).

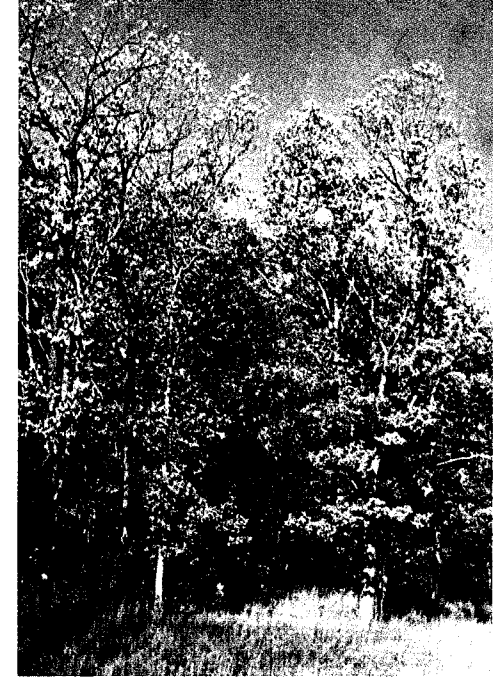


figure 8. A mycelial mat produced by the oak wilt fungus between the bark and wood of a tree that wilted two months before. The dark-colored center of the mat is the pressure pad that cracks open the bark.



figure 12. Infected Red Oak with brown cambium. If fermenting odor is present, spores will form soon.



figure 11. Infected Red Oak with white living cambium (stage prior to sporulation).



figure 13. Red Oak with wood under the bark invaded by insects and beyond the mat-producing stage.



semble normal fall coloration. Infection usually occurs in scattered branches of the crown. These trees may die in one year but more often die slowly over a period of several years. Bur Oaks are intermediate in susceptibility and may be killed as quickly as Red Oaks or as slowly as White Oaks.

Positive identification of oak wilt requires recovery of the fungus from the tree. In areas where oak wilt is not a common problem or when the symptoms do not suggest oak wilt, isolation of the fungus is suggested. Samples ½ inch in diameter, 6-10 inches long, should be cut from branches which are in the process of wilting. The fungus cannot be isolated from dead, dried branches. Samples may be sent to: Dutch Elm Disease Laboratory, 90 West Plato Boulevard, Division of Plant Industry, St. Paul, Minnesota 55107.

### Cause

Oak wilt is caused by the fungus Ceratocystis fagacearum, which develops in the outer sapwood of the trees, mainly in those vessels that conduct water and nutrients from the roots to the leaves. In attempting to protect itself from the fungus, the tree produces tyloses and gums which cut off the tree's water supply and the tree wilts (figure 2).

By the time the symptoms become apparent in the crowns of Red Oaks the fungus is probably present in the conducting vessels throughout the entire tree. The fungus in the branches dies a few weeks after the tree dies; in the trunk and especially in the root system, the fungus remains alive for some time. The fungus can produce spore masses on mats of mycelium under the bark (figure 8). The fungus produces two kinds of spores, conidia and ascospores. Both types of spores are produced in the mycelial or spore mats underneath the bark. The mats range in size from about 1 to 8 inches by ½ to 4 inches, but may be as large as 13 inches long and 7 inches across. Near the center of the mat specialized mycelium (called a pressure pad) forms, which, in conjunction with opposing pads attached to the inside of the bark, develop sufficient pressure to split open the bark. Conidia are produced in abundance. Ascospores are found only if two compatible strains are present.

### Spread

Roots of oaks form natural grafts (figure 9) so once the fungus enters a tree it can spread to nearby trees through root grafts. The fungus continues to spread outward from the origi-



figure 9. A root graft that allows trees to interchange water and with it the spores of oak wilt fungus.

nal infected tree, involving more and more trees. The group of dead and dying trees is called an infection center. Patches of infected trees, where those at the center are dead and decaying and those around the periphery are in various stages of wilting, are a common sight in southeastern Minnesota.

The fungus also can spread by means of spores produced on mycelium mats (figure 8). The fungus masses have a fermenting odor that attracts insects, especially sap-feeding beetles known as Nitidulidae. As the beetles crawl over the mycelial mats, spores of the fungus adhere to them. They then may fly to other oak trees and feed on the sap flow from fresh wounds and in this way infection can result. The beetles can spread the fungus for several hundred feet, but these distances are not known.

## Control

### DETECTION

To effectively deal with oak wilt it is necessary to detect infected trees and recognize those that can serve as sources of infection. During the summer months oak wilt in Red Oaks is rather easily identified (figure 4). The infected trees have brown leaves which in many cases remain on the tree into the winter season. The diseased trees are quite distinctive from healthy trees with green foliage. Trees wilting early in the season generally have leaves that are smaller, lighter brown, and somewhat shriveled in appearance. Trees which wilt late in the growing season will have darker shades of brown and the leaves will be fully developed. Some species of healthy Red Oaks retain almost all of their leaves while others lose most of them in the fall season.

Although the differences between infected and healthy Red Oaks are less apparent during the fall and winter months, it is possible to select out the infected trees and to determine which could have spores produced on them the following spring

(figures 5 and 6). Leaves on healthy Red Oaks are a rich red-brown color whereas the wilted leaves are tan or light brown. Red Oaks dead for more than one year will not have any leaves and generally this is an indication that the trees are not potential sources of spores. To further ascertain whether the tree will produce spores, it is necessary to examine the color, odor, and condition of the cambium (wood immediately under the bark).

Other species of oaks can be separated on the basis of foliage colors (figure 6). The leaves of White Oaks are distinct from those of both healthy and diseased Red Oaks. Bur Oaks lose all of their leaves rather early in the fall. Occasionally dead leaves will remain on scattered branches of the Bur Oak, which means these branches are dead and possibly afflicted by oak wilt. White and Bur Oaks dead for one year or longer will have no leaves on them, and the bark will be in varying degrees of sloughing off. Trees almost completely devoid of bark have been dead for more than a year and are not a hazard (figure 7) in terms of spore production. The oak wilt fungus, however, can survive for years in root systems adopted by adjacent oaks.

### ROOT BARRIERS

Once oak trees are infected, there is no known way of saving them, at least not with Red Oaks. Control must first be aimed at halting the spread of the fungus through the root grafts. Over 90 percent of the diseased trees probably are invaded through root grafts. Spread through root grafts can be prevented by mechanically trenching around infected trees or by using a chemical, SMDC (Vapam).

A trench 48 or more inches deep between diseased and healthy trees immediately disrupts root grafts between these adjacent trees (figure 10). The trench can be refilled immediately. A vibratory plow is the best way to disrupt common

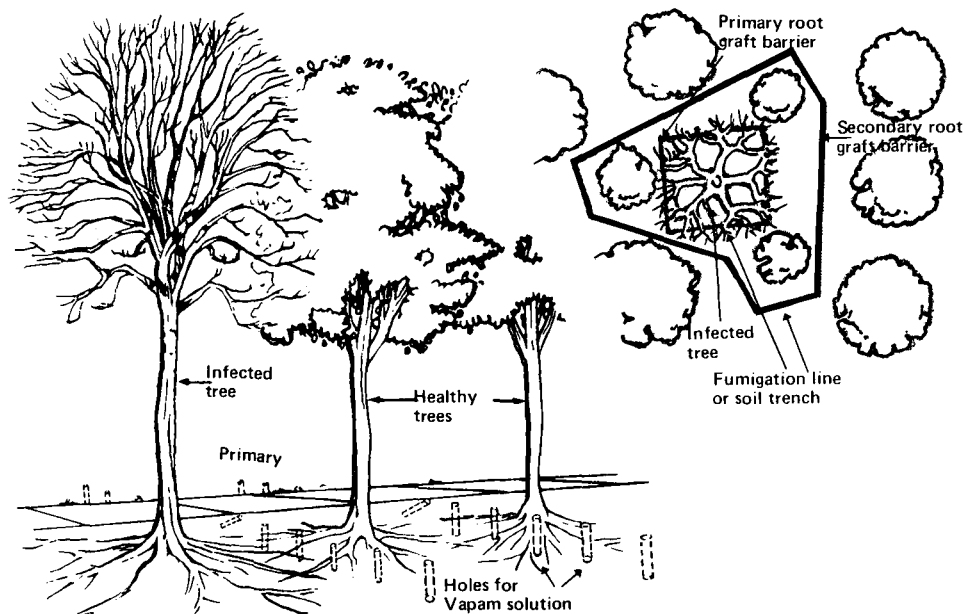


figure 10. Diagram of barriers around infected trees.

roots but it must be used with care where underground utilities are present. If a trencher is used the trench can be refilled and the diseased trees treated as described below. In case the fungus is already in the adjacent healthy trees but has not yet induced symptoms, a second barrier can be placed between this first healthy tree and the next healthy one.

The chemical barrier is established on a line midway between the diseased tree and adjacent healthy tree and should extend as far as necessary to disrupt all potential root grafts. A series of holes, 15 to 18 inches deep, about ¾ to 1 inch in diameter, and 6 inches to 1 foot apart, are established along the barrier line (figure 10). One part of SMDC is mixed with three parts of water and 50 to 200 ml (2 to 8 fluid ounces) of the diluted chemical are placed in each hole. The hole must be closed immediately after adding the SMDC. The SMDC must be applied 2 weeks before the tree is removed. SMDC should not be applied within 10 feet of the healthy tree. Some temporary injury may occur in a healthy tree because of root loss and chemical uptake. Soil temperatures below 50°F and water-logged soils reduce effectiveness of treatment. Since the fungus could already be in the adjacent healthy trees but not have induced symptoms, a second barrier can be placed between this first healthy tree and the next healthy one.

Records should be maintained of where barriers are placed in the event that further efforts are required in subsequent years. Utility lines which require trenches, if recently placed, should constitute adequate barriers and should be considered in placing barriers around diseased trees.

Since the diseased tree and its root system die, regrowth of roots across the trench is not a problem. Root grafts can occur under sidewalks and driveways, therefore it is advisable to angle the fumigation hole underneath the asphalt or concrete to disrupt root grafts under these surfaces. All potential root grafts must be disrupted if spread is to be stopped.

### SPORULATION CONTROL

The second control technique is aimed at preventing spore formation on diseased trees. This is a reasonable approach because the fungus sporulates for a relatively brief period of time after the tree dies and spores are produced on a small portion of the infected trees. To effectively control oak wilt, every effort must be made to eliminate any chance of overland dissemination of the oak wilt fungus. But it is not reasonable to attempt eradication of every dead oak tree. How do you accurately select out the hazardous trees and deal with them appropriately? As far as we know now, the oak wilt fungus seldom produces spores on the Bur Oaks (*Quercus macrocarpa*), and rarely if ever on White Oak (*Q. alba*). On Red Oaks, Northern Red Oak (*Q. rubra*), Northern Pin Oak (*Q. ellipsoidalis*), Black Oak (*Q. velutina*) and Scarlet Oak (*Q. coccinea*), the fungus will produce spores only for a brief period of time following death of the tree. The cambium layer between the wood and bark changes from white to brown and is then colonized by the fungus (figures 11,12,13). This process starts at the top of the tree and moves downward, usually more rapidly on the south side of the tree. The rate of

death of the cambium and the sporulation of the fungus depends on tree diameter, being rapid in small trees and slow in large trees. As the wood tissue approaches the stage when spores are formed by the fungus, the wood has a distinctive fermenting odor. The approximate dates for sporulation in relation to when trees wilt are as follows:

Tree Wilts	Spores Formed
June	September of the same year
July-August	October of the same year, May in the following year
September	June or later in the following year

All species of oak appear to be most susceptible to infection by insect-disseminated spores in May and the first half of June. Therefore, the trees of greatest concern are Red Oaks, which wilt in July and August and could have spores on them the following May or June (figures 8 and 12). Spores once formed on a tree are present for a relatively short period of time and will not be produced again on that tree. The fungus cannot be isolated from the aboveground parts of a tree after it has died and the moisture content is 20 percent or less. If for any reason the moisture content of the wood just under the bark is too low, the fungus cannot produce mycelial mats on which spores form (figure 13). Therefore, any treatment that hastens the drying of wood tissue will tend to reduce sporulation. Deep mechanical girdling of the tree trunk speeds drying of the wood. If done during early stages of the disease, spores will not be produced.

Pruning and trimming of oaks in the spring (May and June) should be avoided as they are most susceptible at that time. If oaks are damaged in the spring by storm or construction, the wounds should be covered immediately with a tree wound dressing. In our experience infection has not occurred through wounds protected by tree paint. Based on a large number of trees wounded throughout the growing season, infection from insect-carried spores occurred only in trees wounded in May and June.

### Prospect

Oak wilt can be controlled without destroying every diseased tree. In fact, the oak wilt fungus will produce spores for insect transmission on only a portion of the infected trees. If these hazardous trees are selected and treated to be certain that no spores will form on them, these plus all other infected oak trees can then be used for firewood or other purposes. Bur and White Oaks can be used any time, while Red Oaks may be used when they are beyond the stage of producing or harboring spores (figure 13). If a Red Oak is not past the sporulation stage, it can be used if the bark is removed or if chipped. If these trees are not chipped or do not have the bark removed, they can be wrapped in plastic prior to May 1 and kept covered until July 1 at which time they can be unwrapped and used for firewood. Plastic must completely enclose those portions of the tree 6 inches or larger in diameter and be thick enough (4 mil) to provide reasonable protection.

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