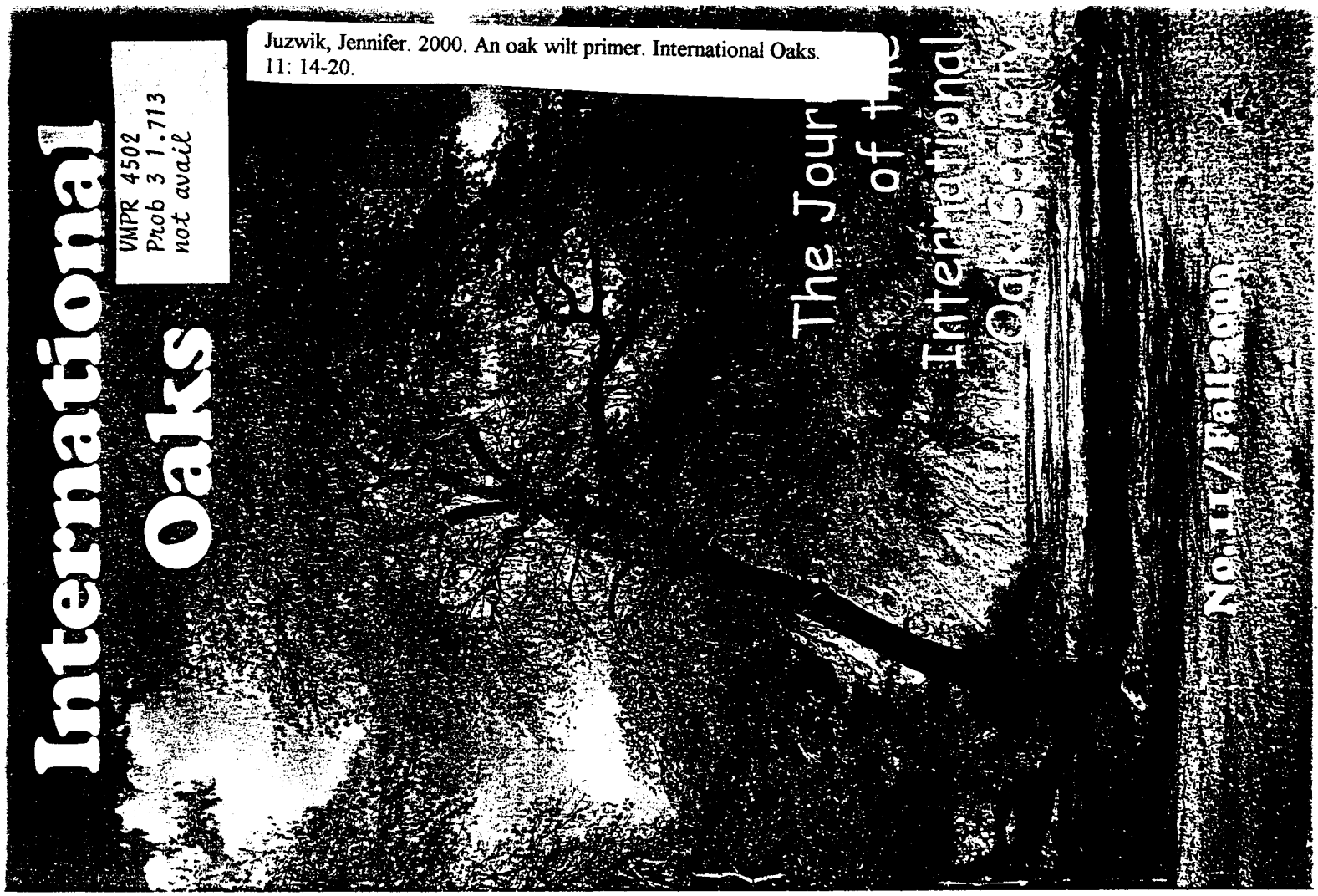

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Authors' Guidelines

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An Oak Wilt Primer

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Oak wilt, caused by the fungus *Ceratocystis fagacearum* (Bretz) Hunt, is an important disease of oaks (*Quercus* spp.) in the eastern United States. The disease occurs in 22 states and is considered the most important forest disease problem in Illinois, Iowa, Minnesota, Texas and Wisconsin. The pathogen causes mortality of thousands of native oaks annually in urban and natural forests in the north-central United States and in Texas.

Over 33 species and varieties of *Quercus* are known to be susceptible to *C. fagacearum*. In addition, three species of *Castanea*, one species of *Castanopsis*, and one species of *Lithocarpus* are also susceptible. Within the subgenus *Quercus*; members of the section *Erythrobalanus* (= section *Lobatae*) (the red oak group) are very susceptible while members of the section *Quercus* (the white oak group) range from quite susceptible to highly resistant.

Oaks are a dominant component of the expansive oak-hickory forests of the central USA that prevail from the northern boreal forest region to the states bordering the Gulf of Mexico. The oak species group is the most important aggregation of hardwoods in the United States. In the US, oaks are important for providing food for birds and mammals, wood for lumber and veneer, cooperage for the beverage industry, and as landscape trees.

Oak wilt was officially identified and the causal fungus was described in the early 1940s. However, accounts of similar oak problems suggest the occurrence of the disease as early as the mid- to late 1800's in Minnesota and Wisconsin. The disease is

now known to occur within the area delineated from Minnesota east to Pennsylvania, south to South Carolina and Tennessee, west to northern Arkansas and eastern Oklahoma, and north through eastern Kansas and Nebraska to Minnesota. A significant southern extension of the oak wilt range was recognized in the early 1980s when the disease was confirmed in northeastern and central Texas where it has since become increasingly important.

Symptoms

Oak wilt is easily identified in members of the red oak group by the rapid wilting of affected trees. After symptoms first appear, a red oak may wilt completely within four to six weeks. The trees wilt from the top of the crown downward, and individual leaves wilt from leaf tip and margins to the bases, turning bronze to brown. Fallen leaves are often green at the base. In contrast with the red oak group, infected white oaks usually die slowly, a branch at a time, often surviving for many years. Leaf discoloration of affected white oaks resembles autumn colors. Affected live oak leaves in Texas exhibit inter-veinal yellowing and browning during late spring and summer. In species of both the red and white oak group, the outer ring of springwood vessels will be plugged with brown material (tyloses and gums) and streaks of brown may be obvious on the outside of the wood. The vascular discoloration is most easily seen

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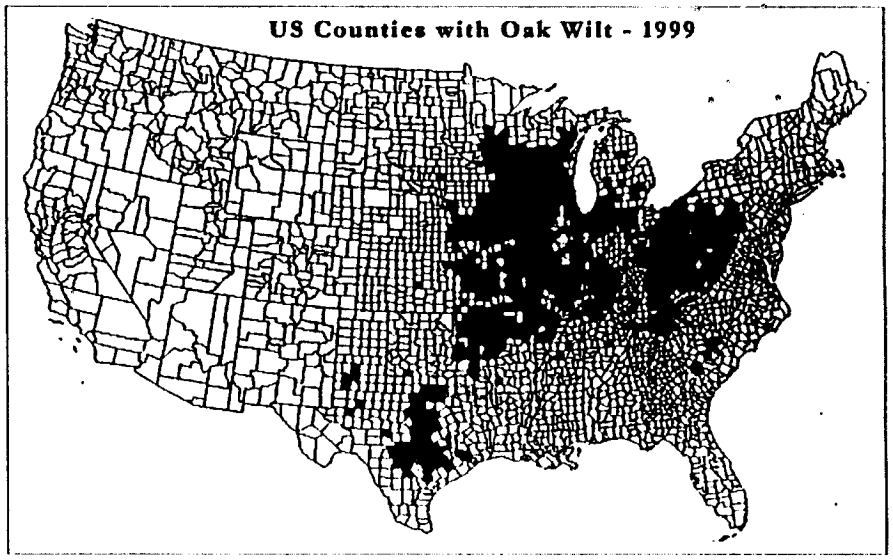

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in cross sections of infected branches of white oaks, and less readily observed in infected red oak branches.

Disease Development and Spread

The causal fungus reaches healthy oaks through roots grafted between diseased and healthy trees or via insect vectors that carry spores of the fungus on their bodies. Once introduced, the mycelium of the fungus grows into the water-conducting cells of the xylem. Secondary invasion of the ray cells may follow.

The fungus physically plugs the cells of the xylem, as do tyloses formed by the tree in response to fungal invasion. This plugging prevents the upward translocation of water and minerals to the foliage, resulting in wilting of the leaves. In the spring or fall immediately following tree death, the fungus aggregates on the inner phloem and outer xylem of the trees forming mirror-image structures known as oak wilt mats. Mats may form on in this manner on main stems and branches that over 6cm in diameter. Spores of the fungus are produced on the mats. Specialized, compact tissue called pressure pads also form within each mat. Pressure exerted by the growing, opposing pads often forces open the bark, causing a vertical crack through which insects may enter.

Above ground spread of oak wilt is accomplished by insect vectors which have acquired viable spores of the oak wilt fungus. The fungus spores are then transmitted to healthy oaks. Insect transmission is significant in the establishment of new infection centers in adjacent as well as distant forest stands, and is the only way the fungus can cross highways, rivers, and open fields. In the Upper Midwest in the US, sap beetles of the insect family Nitidulidae are considered the primary vectors of *C. fagacearum*. In other parts of the oak wilt range, oak bark beetles (*Pseudopityopthorus* spp.) and ambrosia beetles have been implicated as important vectors of the causal fungus, although the relative importance of each insect vector group is not known in these areas. Two species of sap beetles (*Carpophilus sayi* and *Colopterus truncatus*) have recently been identified as the principal insects involved in successful transmission of *C. fagacearum* to healthy trees in Minnesota. Sap beetles are commonly attracted to the sporulating mats produced between April and early July on red oaks that wilted the previous summer. This is also the same period of time during which red oaks pro-

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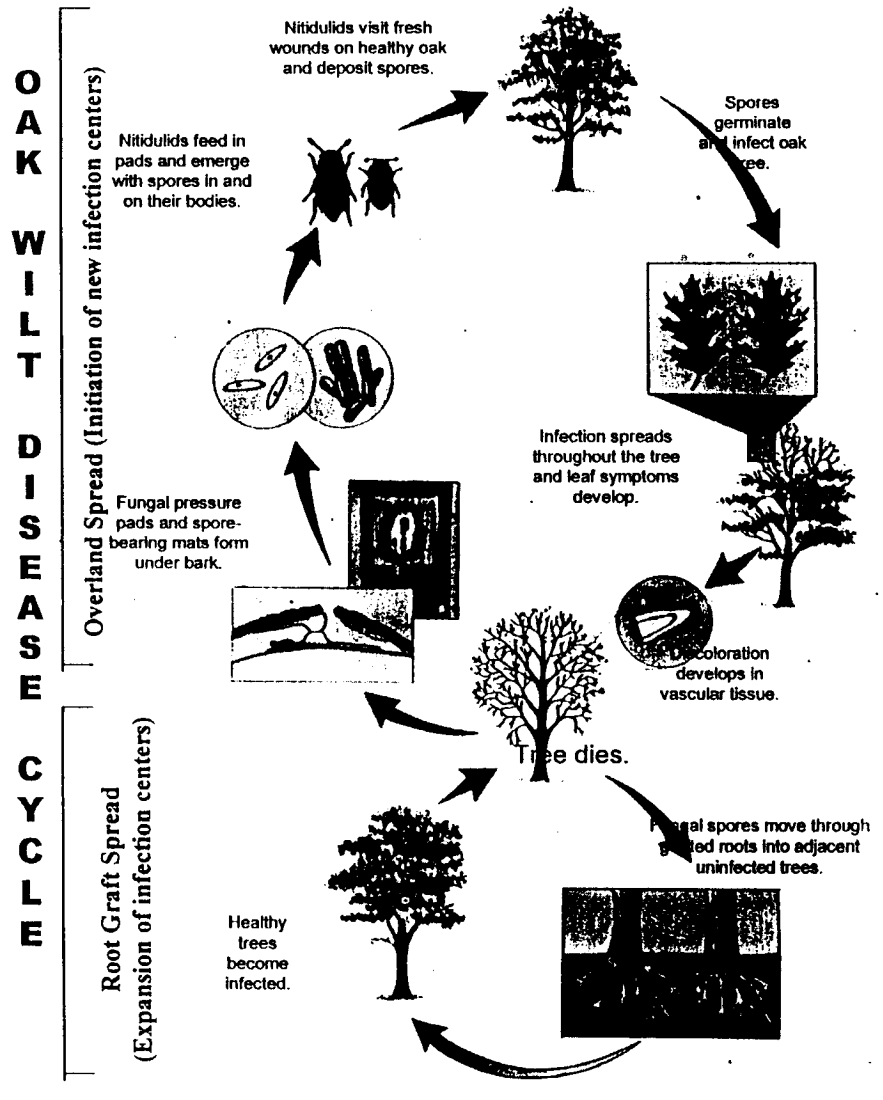

drawing courtesy of United States Department of Agriculture Forest Service, Northeastern Area, State and Private Forestry

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duce large springwood vessels and thus are particularly susceptible to infection. Several species of the same sap beetles are also attracted to fresh (generally less than 48 hours old) wounds on healthy oaks during spring (e.g. from early April to early July in Minnesota). Visitation of such wounds by *C. fagacearum*-contaminated beetles results in oak wilt infection.

Once a tree in an otherwise oak wilt-free stand becomes infected via insect transmission, the fungus moves to adjacent trees through grafted roots. This is the means by which the highest proportion of oaks becomes infected. Grafting between trees within a *Quercus* species may be common, but frequency is influenced by distance between trees, presence of other species, soil type, and topography. In Texas, live oaks in a stand are generally all inter-connected via a common root system due to the sucker-reproduction habit of the species. Occasionally root grafts may occur between different species of oaks. Outward spread of the fungus via root grafts from the initially infected tree often leads to irregular circular patches of dead and dying trees called infection centers.

Disease Management

Stopping spread of *C. fagacearum* through common root systems or grafted roots in existing infection centers is an important part of an oak wilt control program. Disruption of root grafts can be accomplished mechanically using a vibratory plow with a 1.5 m (5-foot) blade, or with a trenching machine that reaches depths of 1.2 m (4 feet) or greater. If buried utilities are present, manually dug trenches or a chemical soil sterilant (Vapam) can be used to disrupt roots, but neither is nearly as effective as the mechanical methods. Root graft barrier lines must be positioned between oak wilt infected and non-infected trees. Often, two lines are recommended: a primary line outside a ring of apparently healthy trees that may actually have early infections, and a secondary barrier outside of every obviously infected tree. The fungus can be in a tree for 2 – 3 weeks without leaf symptoms appearing. Barrier placement requires experience and requirements vary by region. In the Upper Peninsula of Michigan, a model based on tree size and two soil types has been developed to place lines such that they have 95 percent and 99 percent probability of preventing root graft transmission (summarized in Cummings-Carlson and Martin, 1994). The oldest model for the region (as in French and Juzwik, 1999) has been shown to be 85 percent to 93 percent effective when experienced arborists place

lines. In Texas, root graft barriers are established 30 m beyond the last infected tree, and the remaining living oaks between the infection center and the barrier are rogued. Herbicide treatment of living oaks surrounding infected trees is a method currently being investigated as an alternative to mechanical disruption methods where topography, location, etc., may prevent their use. In high value white (subgenus *Quercus*) and live oaks, systemic injection with propiconazole by a qualified arborist may prevent infection of trees adjacent to oak wilt infected ones.

Preliminary data also suggests that high value red oaks (subgenus *Lobatae*) may also be similarly protected. Propiconazole treatment of white oaks exhibiting early crown symptoms of oak wilt (i.e. theraputic treatment) can also prevent further disease development within infected trees for at least two years in species of this subgenus.

Aboveground transmission of the oak wilt fungus is less readily controlled than belowground spread. Current efforts in established control programs include the removal of recently killed red oaks prior to formation of oak wilt mats in the spring. In Minnesota and Wisconsin, for example, such trees should be removed and properly disposed of or treated prior to April. In forest stands where a large number of trees may be involved or where location prohibits tree removal, mat formation can be limited or prevented by girdling the infected oaks as they begin to wilt. Successful use of this method requires early disease detection and treatment of infected trees in early stages of wilting. Girdling trees into the outer xylem weakens the standing tree making it more susceptible to toppling by wind. Liability issues prevent the use of this method in residential settings. Infected white oak (*Q. alba*) do not need to be removed because the fungus rarely sporulates on this species.

Oaks should not be wounded or pruned during the critical spring months (e.g. April through June in Minnesota) or warm winter and spring months (e.g. November through April in Texas) when the sap beetles are active and oak wilt mats are present. If trees are accidentally wounded or pruning is unavoidable during these high susceptibility periods, the wounds should be immediately painted with water-based paint or shellac to prevent direct contact of the beetles to exposed wood. Tree climbing irons should never be used on living oak trees.

Oak wilt mats may form on logs cut from wilting or recently wilted trees and should not be moved in any form (including firewood) to areas where oak wilt is not present. Oak wilt mats may form on these logs. Long distance movement of firewood obtained from such logs has accounted for the establishment of oak wilt centers in areas of Michigan, Minnesota, and Texas that previously had been unaffected by the disease. European countries require chemical fumigation (e.g. with methyl bromide) of oak logs before im-

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portation from counties in the USA with known oak wilt infection centers.

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Editor's Note: As this issue of *International Oaks* was going to press, Professor Juzwik contacted us with some news about the Sudden Oak Death (SOD) disease that has been killing oaks in California. Suspected by some to be a variant of Oak Wilt, new research results have found instead that the problem apparently is caused by an as-yet unidentified species of the *Phytophthora* genus of fungi.

The epidemic affecting tanoaks, coast live oaks, and California black oaks was first noticed in Mill Valley, California in 1995. Thousands of trees in the area from Santa Barbara to Humboldt counties have become infected. Trees ooze a dark, viscous fluid when the fungus penetrates the bark and begins to kill the tree's phloem.

David Rizzo, a plant pathologist at the University of California at Davis, identified the pathogen as a new *Phytophthora* species which does not match any of the 60 known *Phytophthora* species anywhere else in the world. It can be spread in soil (on shoes, tires, etc.) or in infected wood.

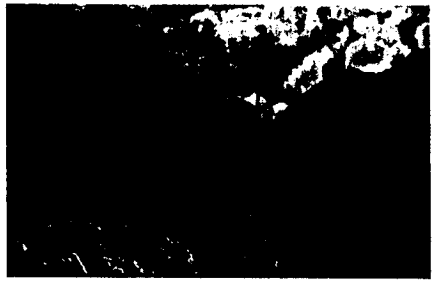
For more information on SOD, refer to the following web site:
http://camfer.cnr.berkeley.edu/oaks/
and review the other information available through the links page of the International Oak Society web site:
http://www.saintmarys.edu/~rjensen/wwwsites.html

Oaks of the Chihuahuan Desert Region

by Michael Martin Melendrez
Los Lunas, New Mexico

Presented below are 23 species of white oak, six of black oak, and two intermediate, or golden oaks, found in the southwestern United States (primarily New Mexico, Arizona, and western Texas). These numbers may be disputed by some oaks students. Differences of opinion exist as to the true boundaries of the Chihuahuan Desert, the potential hybrid status of some of the oaks, and their delineation. Also, new oaks not previously known to occur in the area are continually discovered. Counting the additional oaks found in the adjacent Mexican State of Chihuahua, there are more than 60 species. The Chihuahuan Desert Region is truly *The Land of Oaks*.

The production nursery industry of our area has started, on a small scale, the introduction of oaks with a limited species selection. Unfortunately, the southern live oak (*Quercus virginiana*) usually is the first one to be grown and sold, and it is commonly promoted as the best oak for the desert cities of the Southwest. The species of oak native to this arid part of the country are much



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Author Michael Melendrez standing below Q. arizonica in Catwalk Canyon, Gila National Forest, New Mexico.

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