MANAGING OAK WILT

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ABSTRACT

Oak wilt disease (*Bretziella fagacearum,* syn. *Ceratocystis fagacearum*, also described under *Endoconidiophora fagacearum* with its asexual stage *Chalara quercina*) is a fatal systemic vascular fungus transmitted by multiple methods. It is closely analogous to Dutch elm disease (*Ophiostoma ulmi*, syn. *Ceratocystis ulmi*) in *Ulmus*. Oak wilt is fatal to most (probably all) oak taxa that are infected, and it is becoming increasingly prevalent in the eastern and central US. Oak wilt could be considered the most serious of all oak pathogens due to its broad and expanding range, its consistently fatal results, and the number of species susceptible. The PCN oak collection at Starhill Forest Arboretum in Illinois has dealt successfully with this problem on two occasions, with some trees being killed each time before eradication has been completed. Treatment practice includes root separation between trees, fungicide injection, tree removal, stump treatment, and follow-up observation, with critical timing and application protocols being followed.

INTRODUCTION

Long thought to be an endemic disease, symptoms resembling oak wilt were observed initially more than 100 years ago in Wisconsin and Minnesota and the disease was described formally in 1944. It has spread since then to more than 20 US states ranging from Minnesota down through Texas. It is increasingly thought that the disease might have been introduced to North America. It could have originated from Mesoamerica, carried via infected beetles blown by winds or carried by woodpeckers, or more likely via infected wood pieces carried by tourists. This theory is supported by the evidence that the disease is still expanding steadily in North America and that every North American (and also, from our limited experience in cultivation, Eastern Hemisphere) oak species seems susceptible with no apparent evolved resistance, which should be expected over an extended time of association with a native pathogen.

Taxonomically, trees in section Erythrobalanus die very quickly once symptoms become visible, progressing proximally from the top down within a few weeks. Those in section Quercus are more unpredictable and can die more slowly, often starting with scattered branches. Those in section Cerris exhibit variable symptom patterns based upon our very limited observation. However, the end result is always the same: the trees die.

None of this background information directly affects the treatment protocols addressed in this paper. It serves instead to illustrate the serious, complex, and comparatively unknown qualities of the problem.

THE EXPERIENCE AT STARHILL FOREST

Oak wilt presumably was introduced to Starhill Forest from a remote infection center via utility line clearance activities undertaken during the summer on wild trees along the adjacent public road. This probably happened two or three years before the disease became noticeable in the adjacent arboretum. Symptoms initially were observed in 2008 on a hybrid red (Lobatae) oak grown from seed brought originally from Minnesota, and identified in 2009 as the infection spread, and an apparent residual or repeat infection reappeared in 2012-2013.

Opening wounds (*e.g.*, pruning live wood for utility clearance) during the growing season (in our area, from the spring equinox until the autumnal equinox) makes fresh sap available to the small picnic beetles (family Nitidulidae) which feed upon it, and they are able to detect the food scent from a great distance. If they have been feeding at a fresh wound or at the spore pads that emerge through the bark of a tree with advanced infection, they can bring spores long distances to the newly wounded tree to begin a new infection center. Short-distance transmittal also can be accomplished by squirrels which feed upon the spore pads, then move on to adjacent healthy trees where they are known to chew young bark and callus tissue. It also might be possible, but perhaps less likely, that other animals (*e.g.*, woodpeckers) could serve as occasional vectors. Human activities such as transporting infected wood, pruning during the growing season and/or using non-sterilized equipment, and wounding via careless operation of equipment are primary factors in spreading oak wilt.

Once established, the fungus proliferates throughout the vascular system of the affected tree and is spread to adjacent trees via root grafts as well as the spore pads and animal vectors. Oak roots can extend in all directions for a distance far greater than the tree's height, making root transmittal theoretically possible between mature trees up to 100 meters apart. As with *Ulmus* and *Ophiostoma ulmi*, this is the most consistent and effective method for enlargement of untreated infection centers.

The development of infection in the spontaneous roadside trees at Starhill Forest initially went unnoticed until some of them began to die in 2009. By that time, the fungus had spread via root grafts to adjacent trees that comprised part of the oak collection. We had lost the initial arboretum tree in 2008, without knowing the cause. The following spring, we first observed the putative successful fungus transmittal via root grafts from that first tree across three taxonomic sections – Cerris, Erythrobalanus, and Quercus – in 2009 (a finding contemporaneously noted on the IOS web site). The significance of this observation is that it makes control of this disease problematic even in genetically diverse oak groves or intersectional groupings, such as in arboreta and in native forests with oak populations even representing more than one section (*e.g.*, via convergent evolution). These forest guilds might include, for example: *Q. marilandica* and *Q. stellata* on dry uplands; *Q. rubra* and *Q. alba* in mesic forests; or *Q. bicolor* and *Q. palustris* in wetlands. Thus we could not rely upon any natural taxonomic boundaries between oak groups to limit the underground spread via root connections.

TREATMENT PROCEDURES

After confirmation via lab culture to confirm the presence of the oak wilt fungus and rule out causes of similar symptoms such as *Xylella fastidiosa* bacterial scorch, we undertook quick informal consultations with phytopathologists, university extension staff, practicing arborists familiar with the disease, and the primary company in North America (Rainbow Tree Care Scientific) involved with treatment materials and applications. Then we proceeded immediately with treatment. The first phase was to isolate symptomatic oaks from nearby healthy oaks. Realizing that symptomatic trees might have been infected for a considerable amount of time prior to presentation of symptoms, we made the assumption that apparently healthy trees immediately adjacent to symptomatic ones might already be infected.

To separate the root systems, trench lines were set up extending below lateral root depth (~80 cm in this soil) midway between the symptomatic trees and adjacent trees. Then secondary trench lines also were set up between these trees and the next layer of healthy trees. The symptomatic trees were isolated as a group within the inner trench, and the remaining trees were divided into small groups via cross trenching between the inner trench and the outer trench. Thus we could be able to save an individual oak or small group of oaks not yet infected between the inner and outer trenches. This might not be very important in a large forest plot, but it becomes critical in an arboretum where every tree might be unique and irreplaceable.

Concurrently with the trenching, trunk injection was started, initially with generous volunteer technical assistance from Rainbow staff. The process we used, known as macro-infusion, involves pressure injection of Alamo fungicide (a.i. propiconazole) at a sustained pressure of 20 PSI into carefully drilled shallow holes in the root flare at or near soil level. Placing the holes as indicated allows the optimum dispersal of the treatment across the entire vascular system, whereas holes placed higher on the trunk would not. Using a very sharp drill bit is also critical in order to maintain cleanly cut, open vessels.

Special plastic “T” pipes are inserted using a small mallet, with lateral holes that allow introduction of the fluid into the outermost (active) one to two annual rings of wood. Those Ts are interconnected via tubing, with one temporary opening, and run to a pressure tank filled with the recommended dosage for the tree based upon tree size (diameter). The line then is bled of air under low pressure, the valve is temporarily closed, the bleeding loop is connected, and full pressurization begins. When operating pressure is reached, the valves are opened. Each tree can require from 15 minutes to a full day for uptake, depending upon tree vigor, size, and transpiration conditions, so this procedure can take several weeks if many trees are involved (we treated more than 30 trees each time). All trees scheduled for treatment are double flagged and the treated tree has one flag removed upon completion so there will be no missed trees. Every tree within the trenched area that is not being removed is treated, as are the trees outside but adjacent to the outer trenched area. If one of these trees has an incipient infection, the goal is to intercept that infection before it can move further into the tree or infect adjacent trees and before it can advance enough to compromise the vascular circulation that carries the fungicide.

There is little reasonable chance of curing a symptomatic tree because the vascular system that would carry the fungicide has shut down already, causing the wilt symptoms. However, a valuable section Quercus tree that exhibits isolated wilt on one individual branch (flagging), caused directly by an above-ground vector infection rather than a systemic root infection, might be saved with immediate drastic pruning coupled with injection. The traditional protocol for doing this with *Ulmus* and *Ophiostoma ulmi* is to prune the flagging tree at least 3 meters proximal to the innermost visible sign of cambial necrosis, using a sterile saw. We have not tested this technique here, but a similar protocol might be tried with early-symptom flagging oaks that develop strong tyloses in their vascular systems (*i.e*., section Quercus).

Once the trees have been trenched to separate all root connections, the trenches can be backfilled. The symptomatic trees then are removed and immediately burned or buried. In this case, “immediately” does not allow any time for a stray beetle to find the newly cut infected wood and spread the disease further. The wood literally is cut and thrown onto the fire without even hitting the ground. If this step had been taken prior to trenching, a back-flush condition with root-flow reversal could infect adjacent root-grafted trees, so follow the proper sequence in treatment. Once a tree has been cut to stump height, the cut surface of the stump is sealed tightly and solarized under heavy black plastic to sterilize it and isolate it from beetle feeding. Before the chain saw is used elsewhere, the bar and chain are sterilized by running at idle speed through isopropyl alcohol. The alcohol can be left in the scabbard overnight with the saw hung bar down so the bar and chain are immersed. The sprocket should have been heated sufficiently by engine heat to prevent any further risk, but we also use the running chain to spread alcohol onto this area of the saw. Bleach (5% sodium hypochlorite as a 10% solution in water) may also be used, but it is corrosive and can damage the saw as well as any unprotected eyes of the operator.

Close observation of the infection center and surrounding trees is required for at least 24 months after treatment. Retreatment is recommended for early summer of the following year or the second year if there is any doubt that the disease was completely eradicated. Since the injection process is an invasive one that wounds the wood, and the fungicide is very expensive, unnecessary retreatment is discouraged.

CONCLUSION

The oak collection of Starhill Forest numbers approximately 750 trees comprising 290 taxa – it is the most comprehensive PCN-certified living oak collection in North America. Of these, we lost one each of the following to the two outbreaks of oak wilt:

Q. ellipsoidalis × *Q. rubra* (2008 – first tree, first infection – Section Lobatae)

Q. ×*subfalcata* (2009 - Lobatae)

Q. variabilis (2009 - Cerris)

Q. mongolica (2009 – Quercus)

Q. hartwissiana (2012 – first tree, second infection – Section Quercus)

Q. buckleyi (2013 – Lobatae)

Q. macranthera (2013 – Quercus)

Q. liaotungensis (2013 – Quercus)

Q. serrata (2013 – Quercus)

Q. ×*rosacea* (2013 – Quercus)

Each of these trees was replicated elsewhere in the collection, fortunately. Still, the treatment process was expensive, exhausting, and disheartening. Had we not acted promptly, using every tool and technique available to us, the infections certainly would have continued and we would have lost at least 100 adjacent trees while fostering a massive infection center that easily could have spread to every other oak in the arboretum and the surrounding forest.

This experience should reinforce in the minds of all oak managers the need for planting patterns that incorporate “firebreaks” of non-oak species. It also shows that vigilance in observation is crucial, especially in late spring and early summer when symptoms typically appear, and it demonstrates the need of avoiding pruning or wounding during the active-stage vector period if oak wilt is present within the potential flight distance of the vector. Any unavoidable growing-season cuts must be covered fully and immediately with a non-phytotoxic dressing, such as grafting wax, shellac, or exterior latex paint, to exclude vectors. One vector carrying one spore to one exposed fresh wound is all it takes to create disaster.

ILLUSTRATIONS:

Figure 1. Symptomatic leaves on three taxonomic sections -- *Quercus rubra* in Elkhart Illinois (section Lobatae, upper right); *Q. variabilis* at STarhill Forest (section Cerris, lower right); *Q. mongolica* at Starhill Forest (section Quercus, left)

Figure 2. Three weeks of disease progression in *Quercus ellipsoidalis* x *Q. rubra* (left) and *Q. mongolica* (right) at Starhill Forest

Figure 3. Trenching to isolate root systems

Figure 4. Interrupting root grafts prior to tree removal

Figure 5. Macro-infusion of *Quercus velutina* with propiconazole