Oak Wilt Remediation by The Tier Tree Model

Part 2: Tree Injections

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Dr. Roberts has researched many issues in Michigan's plant industry, including Oak Wilt, Dutch Elm Disease, Diplodia Tip Blight of Pines, along with a variety of cultural problems such as plant nutrition and herbicide toxicity. During his career, he has discovered a variety of new diseases and pests such as Phomopsis Canker of Spruce and the first bacterial wilt disease of turfgrasses in North America.

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INTRODUCTION

Oak Wilt (OW) is one of the most serious diseases of trees in Michigan (Photos 1A, 1B & 1B Inset). Red Oak Family members such as Northern Red Oak, Black Oak, Scarlet Oak, and Pin Oak are highly susceptible and often die within a couple of months of becoming infected. Members of the White Oak Family such as White Oak, Swamp White Oak, English Oak, Chestnut Oak, and Bur Oak tend to be more tolerant of the disease. Bur Oak is often considered one of the more susceptible species of the White Oak Family group.


P1B

P1A & 1B INSET Most people love their trees. These two photos show Oak Wilt dissemination "Overland" (1A) and "Underground" (1B). In Photo 1A, all trees in the photo were pruned at the high-risk period of Overland spread of Oak Wilt. As an anomaly, the two trees in the center of the photo escaped infection even though they were pruned. In aerial Photo 1B, an Oak Wilt epicenter developed from Overland spread but is now expanding Underground (center left of photo). Due to failure with inadequate RGD depth, the disease is moving onto the 100' cliff that drops down to a northern Michigan bay (Inset).

F1 In 1984, The Tier Tree Model was developed by the author by adapting the RGD technique for Dutch Elm Disease management. Over the ensuing decades, The Tier Tree Model has evolved into three major Oak Wilt remediation techniques: **Root Graft Disruption, Tree Injections,** and the **Glyphosate/Stump Cup Treatment**. Tree injections are discussed in this article.

F2 A comparison of two major Root Graft Disruption Models shows that the Forest Management Model (Bruhn) was designed *strictly* for forest situations with trees of relatively low value, compared to The Tier Tree Model that was designed for locations with trees of higher value - such as those in urban/residential areas, parks, resorts, nature preserves, etc.

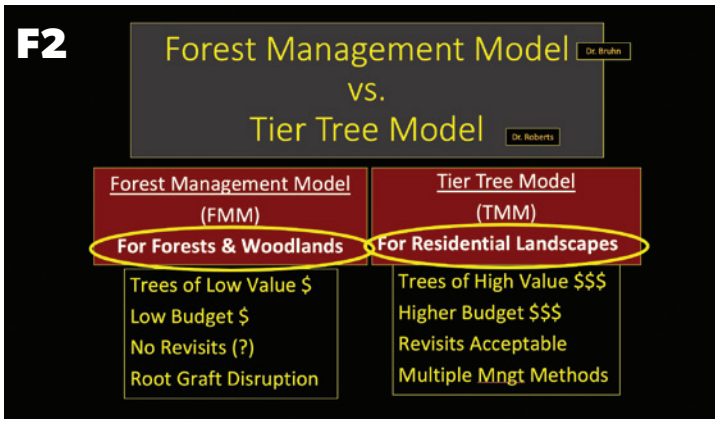
As discussed in previous articles in *The Michigan Landscape*™, the Oak Wilt fungus may be spread by two major modes: **1) "Overland"**, by sap beetles to fresh wounds on Oak trees, often created by pruning Oak trees at inappropriate times or by storm damage, and **2) "Underground"**, through root graft connections between infected trees and nearby healthy Oak trees. Root graft transmission usually occurs between trees that are most genetically related, i.e. of the same species.

General information about Oak Wilt was previously published in a three-part series in *The Michigan Landscape*™: **"Oak Wilt Part 1: Symptoms, Biology and Diagnosis"**, January/February 2016, Pages 43-46; **"Oak Wilt Part 2: Prevention & Management Strategies"**, March/April 2016, Pages 44-47; and **"Oak Wilt Part 3: Tales of Horror"**, March/April 2017, Pages 46-51. Criteria for avoiding Oak Wilt are very important and were published in Part 2. These publications are available as PDFs from the author or the editor at the Michigan Nursery and Landscape Association.

Once the Oak Wilt fungus infects trees on a particular property, it can be extremely difficult and costly to manage. Extensive confusion exists among arborists/landscapers and the public about how to properly control Oak Wilt. Most of the confusion appears to originate from the people giving a wide range of disparate advice. The sources of confusing recommendations include University scientists, government agencies and various plant societies.

Invented by the author about 36 years ago and refined over the last several decades, The Tier Tree Model using Root Graft Disruption (RGD) was the premier method for containing and eradicating Oak Wilt from sites, especially residential properties. For more than 20 years, a new technique using The Tier Tree Model and tree injections with the fungicide propiconazole has been developed for situations where RGD is not possible or as an augmentation of the RGD efforts. A third Tier Tree Model technique called the Glyphosate/Stump Cup technique, also developed by the author, will be covered in Part 3 of The Tier Tree Model Series. Hence, The Tier Tree Model has evolved over the years into three major techniques for Oak Wilt remediation; tree injections are the subject of this article (Figure 1).

It is important to consider that The Tier Tree Model was originally designed for residential landscapes where the later developed Forest Management Model for RGD was considered too wasteful and destructive (Figure 2, also see *The Michigan Landscape*™, **"Oak Wilt Remediation by The Tier Tree Model: Part 1: Root Graft Disruption"**, March/April 2020, Pages 39-45). However, The Tier Tree Model's primary objectives are two-fold: to contain and eradicate Oak Wilt from sites and save as many trees as possible. Hence, The Tier Tree Model can be utilized just about anywhere, including urban/residential areas, woodlands, forests, natural areas, nature preserves, parks, or wherever it is desired to save Oak trees from destruction by the lethal Oak Wilt disease.



P2

P3


P4

Types of Tree Injection Systems

There are quite a few Tree Injection Systems available on the market for our use (Photos 2, 3 & 4). Each of the tree injection units has its unique advantages and disadvantages. Therefore, it is sometimes prudent for an arborist/landscape company to have several types of injection equipment. Tree injections may be employed for disease/pest management, for ameliorating nutritional deficiencies, for delivering growth regulators, among tree health corrective measures. Possibly, tree injection systems can be arbitrarily distinguished as two major types: Micro and Macro-Injection, also known as Micro and Macro-"Infusion". A tree injection system may be considered Micro or Macro largely on the volume of solution delivered. In other words, those that inject larger amounts of product (often diluted with water) are termed "Macro" and those that inject smaller volumes (sometimes more concentrated) are regarded as "Micro". With more tree injection systems being developed all of the time, the differences among Macro systems and Micro systems is becoming somewhat blurred. In the author's experience more volume or diluent is better for even distribution of the product throughout the tree and to help preclude the potential for phytotoxicity (see page 36). Depending on the injection system and the manufacturer's design, some injection systems administer products in the lower trunk, and some administer products in the root flares. As a rule, at least in my opinion, tree injections should not be performed as a routine arboriculture practice to remediate rather minor problems with trees. Instead, in my opinion, tree injections are especially justified in life and death situations such as with the lethal Dutch Elm Disease, Oak Wilt or Emerald Ash Borer maladies.

Tree Injection Protocol for Oak Wilt Management

Tree injections are generally applied in Oak Wilt sites for two reasons: 1) to increase insurance of successful remediation by augmentation of other remediation efforts such as Root Graft Disruption (RGD), and 2) as a primary remediation tool when no other reasonable options are available. Referencing #2, there are some situations where RGD is not feasible; such Oak Wilt sites include situations where application of RGD in tight quarters might result in excessive damage to nearby trees' roots (see Critical Root Zone, page 35) or, for example, where RGD is not appropriate due to the presence of abundant underground utilities. Trees can be injected at almost any time they will absorb or take up the product. As one supplier stated, "Propiconazole is more effective in the tree rather than sitting on the shelf." There is a lot of wisdom in that statement. Many arborists find that trees readily take up propiconazole in the (early) morning, just after sunrise, and that the trees often "shut down" by late morning to early afternoon.

There are several chemistries that are registered for Oak Wilt management. Copper-based fungicides and propiconazole are two of the most common active ingredients. Propiconazole is the fungicide labeled for most Tree Injection Systems for the management of Oak Wilt. Although the rates on their labels may vary, though typically from 10 ml to 20 ml per trunk diameter inch at 4.5 feet (dbh=diameter at breast height), the author has documented Oak Wilt control failures in the management of Oak Wilt with any rate less than 20 ml, regardless of injection system.

It is currently thought that propiconazole will provide protection against root graft transmission for two years; this has been borne out in my observations in numerous field trials. It is also believed that the Oak Wilt fungus can survive in Oak Wilt-infected tree roots for at least 4-5 years. Hence, the current recommendations include treating symptomless Red Oaks within root graft range of infected Red Oaks for at least 6-8 years. In other words, every other year (every two years) for at least 3-4 treatments. The goal of tree injections is to protect apparently healthy Red Oaks within root graft range of diseased Red Oaks for a sufficient period of time until the fungus dies

P2,3 &4 Tree Injection Systems are typically employed for a variety of tree issues. Although there are currently a variety of injection systems on the market, three of the more common ones include: Rainbow Tree's Macro-Infusion (Photo 2), ArborJet's Tree I.V. (Photo 3), and Arborsystems' Wedgle (Photo 4, Portal System shown). Most companies market their own propiconazole formulations for Oak Wilt and other disease management efforts: Rainbow Tree's 'Alamo', ArborJet's 'Propizol', and Arborsystems' 'Shephard'.

with the death of roots of nearby infected trees before the protected tree is invaded and killed by the OW fungus.

Tree injections may be regarded by some individuals as somewhat expensive; it is not unusual for an injection treatment to average between $200-400 per tree for one treatment, depending, of course, on the size of the tree. So, if the tree requires treatment three or four times over 6-8 years to "out-survive" the deadly fungus, the expenditures to save a single tree could accumulate to $800 to more than a $1,000 per tree over that period of time. However, those investments in treatments are relatively minor compared to those of a grand, mature landscape Oak tree, whose value may range from $10,000 to $20,000 or more. Also consider that the removal of a large tree and replacement with a young tree is rather costly. Furthermore, it is inconceivable for anyone to believe that they can replace a large Oak and grow a young Oak tree to a significant size and maturity within a human generation or two.

Tree Injections by Tier: Caution Please!!!

Research performed in Texas more than two decades ago revealed that tree injections with propiconazole may not prevent the Oak Wilt fungus from "passing through" injected trees, thus permitting the Oak Wilt fungus to attack unprotected trees in the 2nd or 3rd tier. Hence, it would be advisable to treat more than one tier of trees or utilize tree injections in combination with the RGD technique to prevent transfer of the fungus to unprotected trees. I have often used tree injections in conjunction with RGD with great success.

Critical Root Zone (CRZ)

Whether we should use Tree injections or RGD (or both) to remediate Oak Wilt is a challenging proposition. Considering the CRZ can help us make the appropriate decision. The CRZ is the root area of a tree that should not be invaded if we desire to maintain good tree health and viability. Invading the CRZ by disturbances of roots by such techniques as trenching or vibratory plowing could result in severe damage to the tree and may lead to tree decline and/or death (Photo 5). CRZ is generally defined specifically as follows: for every inch trunk **D**iameter at **B**reast **H**eight (dbh=4.5 feet above grade), there should be one foot of undisturbed roots measured in radius from the trunk of the tree (Photo 5). A common Oak Wilt situation where tree injections might prove beneficial is where RGD cannot easily be utilized…where trees are in too close quarters and RGD might harm the very trees we would like to preserve. Photo 6A demonstrates the concern for CRZ at the onset of Oak Wilt after overland transmission to pruning wounds and five years later (Photo 6B). Consideration of the CRZ, the allotted budget and the value of the trees to the

P5 The Critical Root Zone (CRZ) is defined as follows; for every inch of trunk diameter at chest/breast height (dch or dbh= 4.5 feet above grade) there should be at least one-foot undisturbed root zone measured as radius from the trunk of the tree. In transplanting this large 32-inch dbh oak, there should be at least 32 feet of undisturbed root zone measured radially (radius) from the tree's trunk. Clearly the root zone of this transplanted tree was inadequate, which is why the tree died the spring and summer after transplanting.

P6A At this residence near Grand Rapids, Michigan, "Overland" dissemination of Oak Wilt occurred to this landscape after the trees were trimmed in the high-risk period of spring. For some reason, the two trees in the center of the photo escaped infection, but all other trimmed trees in both directions became infected by the Oak Wilt fungus. Because of the close proximity of the two symptomless trees to the infected trees, RGD (trenching) could not be used without invading the CRZ of the two symptomless trees, possibly causing severe harm to them. Trunk injections alone were administered to protect the two symptomless trees from root graft transmission (see Photo 6B).

P6B The two trees in the landscape's center in Photo 6A were saved by tree injections only; no RGD was performed between infected trees and the two apparently healthy trees. This photo was taken five years after Oak Wilt was introduced into the landscape by overland transmission through pruning wounds. Note the "For Sale" sign in the front yard, possibly creating an ethical dilemma for me (as I monitor the treatments) and the arborist who is treating the site. At least one, possibly two tree injection cycles would still be needed to preserve the healthy trees. Did the sellers disclose that Oak Wilt was an issue on the property to the buyers?

P7 At this landscape near Grand Rapids, Michigan, the small Red Oak at the right (arrow) became infected by overland spread to a pruning wound created by the homeowner for better mowing clearance. The smaller tree (left) turned brown due to phytotoxicity from propiconazole trunk injections. Interestingly, the large tree (center of photo) was also injected but exhibited no phytotoxic symptoms. Fortunately, the arborist and I had warned the property owner of possible phytotoxicity prior to injections. (Photo Credit: Bill Drews, Woodland Tree Service)

P8 At this landscape in Traverse City, one tree exhibited abundant leaf fall on the lawn after a recent injection of propiconazole to prevent root graft transmission of Oak Wilt. Thankfully, the tree recovered very nicely.

property owner will provide guidance for what procedures should be utilized. Implementing The Tier Tree Model will probably result in the salvation of as many trees as possible, especially when compared to the sacrificial/ destructive Forest Management Model.

Propiconazole Phytotoxicity

Propiconazole is the primary fungicide in current use with tree injection systems for management of Oak Wilt. Some companies have registered copper-based fungicides and other chemicals. In technical terms, propiconazole is a "Fungistat" and not a "fungicide", per se. Like many "fungicides", propiconazole primarily *inhibits* spore germination and fungal growth, which is the reason propiconazole is often considered "fungistatic". Where it might possibly exhibit "fungicidal" capabilities is when the fungus dies because of its inability to grow and reproduce. Regarding Oak Wilt and tree injection trees, it is not unusual for propiconazole to be phytotoxic to trees and other plants that are exposed to the chemical. Phytotoxicity is defined as "plant toxicity", which may occur when a plant is exposed to something that causes the plant harm, often unintentional harm. For reasons that are not well understood, some trees react to propiconazole exposure by leaf shedding and/or exhibiting scorched or brown foliage (Photos 7 & 8). Many/most (Oak) trees do not exhibit phytotoxicity to propiconazole. At some Oak Wilt sites, 10-20% of the injected trees might show phytotoxicity symptoms. When phytotoxic responses occur, I have had to sometimes insert myself between a homeowner and the arborist to diffuse a potential altercation… because the property owner automatically concludes that the arborist has killed the treated tree, probably by infecting it with Oak Wilt. The symptoms of propiconazole phytotoxicity can mimic symptoms of Oak Wilt. In every case of propiconazole phytotoxicity I have encountered, trees have recovered either the same year or the following year, depending on when the phytotoxicity occurs (early or late in the season). When performing tree injections for Oak Wilt control, I strongly recommend that clients be warned about the potential for phytotoxicity of the fungicide as a preemptive measure, which could forestall "shock and awe" reaction from tree owners and build credibility if such phytotoxicity occurs. When educating a client about the potential for phytotoxicity, I often relay the analogy of hair loss in cancer patients undergoing chemotherapy.

Tree Injection Controversy and Failures

I have witnessed tree injections for the management of Oak Wilt succeed as well as fail. On the basis of tree injection failures, some individuals and entities express a dismal view of tree injections. Why do tree injections fail? I think there are a variety of possible reasons. First, it is possible that some applicators are not administering the fungicide correctly. Second, I strongly suspect that insufficient product is being administered; some applicators are using the 10ml rate rather than the 20ml rate. Some applicators are administering the lower rates because they are worried about "sticker shock" of the higher propiconazole rates to property owners; it is better to do it right than fail. Third, at the time of injection, some trees may already be infected by the Oak Wilt fungus without showing conspicuous symptoms. In general, infected Red Oaks most likely cannot be saved. Some research with much higher rates of propiconazole administered to infected Red Oaks has shown positive

results (Photo 9).

As a rule, preventative (prophylactic) tree injection treatments with propiconazole are not recommended, unless the risk from root graft transmission is imminent. Some individuals might also determine that preventative treatments could be warranted if *unmanaged* Oak Wilt epicenters are very close to but, perhaps, just out of root graft range of highly valued trees.

Tree injections may also be controversial to some individuals because of the injury the equipment causes to trees. For most injection systems on the market, drilling into the trunk or root flare is required. This type of injury is generally not lethal to trees unless some disease agent invades the wounds created by the drilling equipment. Injection sites may exhibit seepage of liquids from the injury for quite some time (Photo 10). The seepage may be sap or may be an indicator of a Slime Flux/Bacterial Wetwood infection. Neither issue should be harmful to the tree in the long term. However, we want to be very cautious about over-injecting trees (Photo 11).

Therapeutic Propiconazole Treatments

To protect members of the Red Oak Family from root graft transmission of the Oak Wilt fungus, propiconazole is administered *preventatively* (prophylactically, before trees become infected). Many experienced arborists and Oak Wilt experts consider preventative treatments as the only procedure for Red Oaks. White Oaks already infected by the Oak Wilt fungus can receive *therapeutic* benefit from propiconazole injections; such treatments can actually "cure" White Oak Family members of Oak Wilt. For more than a decade, I have been experimenting with high or repeated doses of propiconazole on infected Red Oaks to ascertain if Red Oak Family members can be *cured* after infection by the Oak Wilt fungus. Some of my experiments have prolonged the lives of infected Red Oaks for many years. Some arborists and scientists have recently engaged in similar research to save infected Red Oak Family members (Photo 9). The results are encouraging, so stay tuned.

Ethical Considerations

Because Oak Wilt remediation efforts can be long term commitments, especially with tree injections, ethical problems may occasionally arise. In some instances, property owners may request more frequent than normal treatment rates (Photo 11). This is not advisable. In another ethical dilemma, property owners may decide to move and sell their home before the recommended treatment schedules are completed. Ideally, the seller will inform the buyer of the need for further treatment as a condition of the disclosure process. If disclosure does not occur, is it up to the arborist or scientist to inform the new homeowners (Photo 6B)?

P9 Oak Wilt had been advancing at this site in Southwest Michigan for several years before the property owner sought assistance. This large Red Oak began shedding leaves in 2018 from likely root graft infection of Oak Wilt from nearby infected trees. Oak Wilt was confirmed on this tree by laboratory testing. The property owner desired to save this valuable, visible tree regardless of cost and regardless of the probability of not saving an infected Red Oak. The arborist, who had been experimenting with higher rates at several locations, injected the tree in the fall with 40 ml/per dbh of propiconazole, double the usual dose. The tree fully leafed-out in the spring of 2019 and remained symptomless throughout the year, showing some potential promise for therapeutic doses of propiconazole in Red Oaks.

P10 It is not unusual for trees that are drilled for the injection technique to weep through the injection sites after the procedure is completed. Seepage can occur for weeks, months or even years.

P11 At the property owner's authorization, this tree was injected every year for six years. Note the physical damage on the lower trunk due to annual injections. Injections are typically recommended every other year. This annual injection injury may result in gradual decline and dieback of the tree.

DISCUSSION

Tree injection can be a valuable procedure in the toolbox for the containment and eradication of Oak Wilt. Tree injection can be used by itself or in combination with other procedures such

P12A At this property near Onekama, Michigan, an Oak Wilt epicenter developed and advanced for a couple of years after a couple of trees were trimmed near a sidewalk leading down to the lake (see Photo 12B). Many of the trees on the property benefited from two Tier Tree Model RGD trenches: the first between diseased trees and the next tier of healthy trees, the second between the next tiers of healthy trees…for added insurance and because the site was a couple of years old before an arborist was contacted for assistance.

P12B The trees in this photo were isolated with the diseased trees by the first RGD trench. In other words, no RGD occurred between the diseased trees (foreground, now removed) and the initially healthy, unaffected trees in the background. Tree injections only were used to save them from root graft infections from the diseased trees. Photo was taken several years after Oak Wilt remediation was initiated at this site.

as RGD. I find that every Oak Wilt site is different and that remediation of Oak Wilt at the site needs tailored options. For example, there are occasional circumstances where RGD alone may not isolate all trees to be protected from root graft transmission of Oak Wilt; those circumstances are where tree injections might prove useful (Photos 6A, 6B & Photos 12A, 12B).

While none of the Oak Wilt treatment options can guarantee control of Oak Wilt, if utilized correctly by experienced personnel, there is a very good chance of success. That is why it is vitally important to solicit the most highly qualified "Experts" when considering Oak Wilt remediation. Having invented and fine-tuned The Tier Tree Model for nearly three and a half decades, I have found that most of the sites on which I've provided guidance have been 100% successful in remediating Oak Wilt, provided the proper protocols are followed. If Oak Wilt remediation according to The Tier Tree Model fails, the failure can usually be attributed to insufficient propiconazole usage or insufficient RGD depth, etc.