

A Review of Oak Wilt Management Options

Introducing the Oak Wilt Remediation “Kill Ratio”

INTRODUCTION:

Management of Oak Wilt can be tedious, costly, and destructive to properties and ecosystems whether in forests, woodlands, or landscapes (Photo 1). Except for rare circumstances, people who have trees afflicted with Oak Wilt want the preservation of as many trees as possible and complete eradication of Oak Wilt from their property, while desiring that those procedures used to manage Oak Wilt be as cost effective as possible. Oak Wilt remediation procedures vary significantly in their cost and impacts on the site. Important Oak Wilt Management options to **avoid** Oak Wilt have been covered in other publications; in this publication, I will focus on procedures that are used to remediate Oak Wilt assuming the disease has been accurately diagnosed and confirmed.



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Dr. Roberts retired from Michigan State University in 2018 after committing four decades to advancing MSU's Land Grant Mission, originally signed into law by President Abraham Lincoln during the midst of the American Civil War. He has published hundreds of articles and has taught hundreds of lectures and workshops.

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.

In the early 2000s, his research on Ash Decline in Southeast Michigan led to the discovery of the invasive Emerald Ash Borer in North America.

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Oak Wilt Management Options:

Following are brief discussions of the more prominent procedures that are currently in use in Michigan for the management of Oak Wilt. Some of these options have been reviewed in detail in prior publications: ***Oak Wilt Part 2: Prevention and Management Strategies, The Michigan Landscape***, March/April 2016, Pages 44-47; ***Oak Wilt Remediation by The Tier Tree Model, Part 1: Root Graft Disruption, The Michigan Landscape***, March/April 2020, Pages 39-45; ***Oak Wilt Remediation by The Tier Tree Model, Part 2: Tree Injections, The Michigan Landscape***, July/August, 2020, Pages 32-39; ***Oak Wilt Remediation by the Tier Tree Model, Part 3: The Glyphosate Stump Cup Technique, The Michigan Landscape***, September/October 2020, Pages 39-46.

Tier Tree Model RGD: The Tier Tree Model Root Graft Disruption (RGD) was designed by the author in 1984 and has been fine-tuned to encompass nuances of Oak Wilt for the last 37+ years. The procedure is based on the knowledge that the Oak Wilt fungus



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moves *Underground* through roots and root grafts slowly, generally around one tier of trees per year (Photo 2). The Oak Wilt fungus transmits more slowly Underground in situations where diseased trees are left standing prior to remediation efforts than in situations where diseased trees are quickly removed prior to implementation of remediation efforts.

Glyphosate/Stump Cup 'Chaser': While the 'Chaser' is still being tested, the procedure has shown so much potential that many arborists have already adopted the procedure into their management plans. Some arborists have made it their primary, go-to Oak Wilt management tool. ***With this method, only diseased trees are given the Stump Cup and Glyphosate treatment*** (Photo 3). No RGD trenches are needed. Other species of trees/plants are not affected because the glyphosate remains exclusively

P1 Oak Wilt is a challenging disease to manage and often involves "invasive" methods for containment and eradication. The tree in this photo is dying of Oak Wilt and threatens many nearby and distant oak trees in this neighborhood. Root Graft Disruption (RGD), which may be accomplished by backhoes, chain trenchers, mini excavators, vibratory plows, etc., has been the traditional technique for remediation for many decades (Inset). In residential areas, buried utilities can be a major impediment for traditional RGD techniques.

P2 The Tier Tree Model of RGD was developed by the author in the mid-1980s as a viable tool for stopping the advancement of Oak Wilt. In this photo, a *primary* RGD trench is established between the diseased Tier of trees (left, out of sight) and the healthy Tier of trees (left). A *secondary* RGD trench (right) is established between the next Tier of healthy trees to ensure success of containment if the *primary* trench fails.

P3 The Glyphosate/Stump Cup involves making a shallow cup in the trunk of the designated tree by use of a chainsaw applied at a downward angle and circumnavigating the tree's trunk, effectively girdling the tree. Concentrated Glyphosate is poured into the "stump cup". Then, we wait. The tree's vascular system absorbs and translocates the herbicide throughout the tree, hopefully killing the roots of the tree where the Oak Wilt fungus can no longer transfer to nearby, healthy adjacent trees.



S1 This Tier Tree Model sketch demonstrates a mixed species woodland where the red oak trees are depicted as “green” foliage. The diseased oak is clearly visible. Whether the Tier Tree Model Root Graft Disruption (RGD) or the Tier Tree Model Glyphosate/Stump Cup is utilized, this sketch provides an overview of the first Tier of oak trees as depicted by the black circle.

P4 The trees in this photo were only protected from Oak Wilt from diseased trees with Propiconazole fungicide injections. Note stump grindings of diseased oaks in foreground. This is the same site as in Photo 2, which also received Tier Tree Model RGD. This combo of remediation techniques proved very effective for remediating Oak Wilt at this northern Michigan lakefront property.

within the tree species being treated. The procedure is based on many field observations that transmission of the systemic herbicide Glyphosate occurs much more quickly through roots than the Oak Wilt fungus. In fact, in field trials, trees that have presumably been killed by the Oak Wilt fungus and then are treated with the Glyphosate/Stump Cup method exhibit transfer of glyphosate to nearby healthy trees with no transfer of the Oak Wilt fungus, supposedly bypassing the vascular

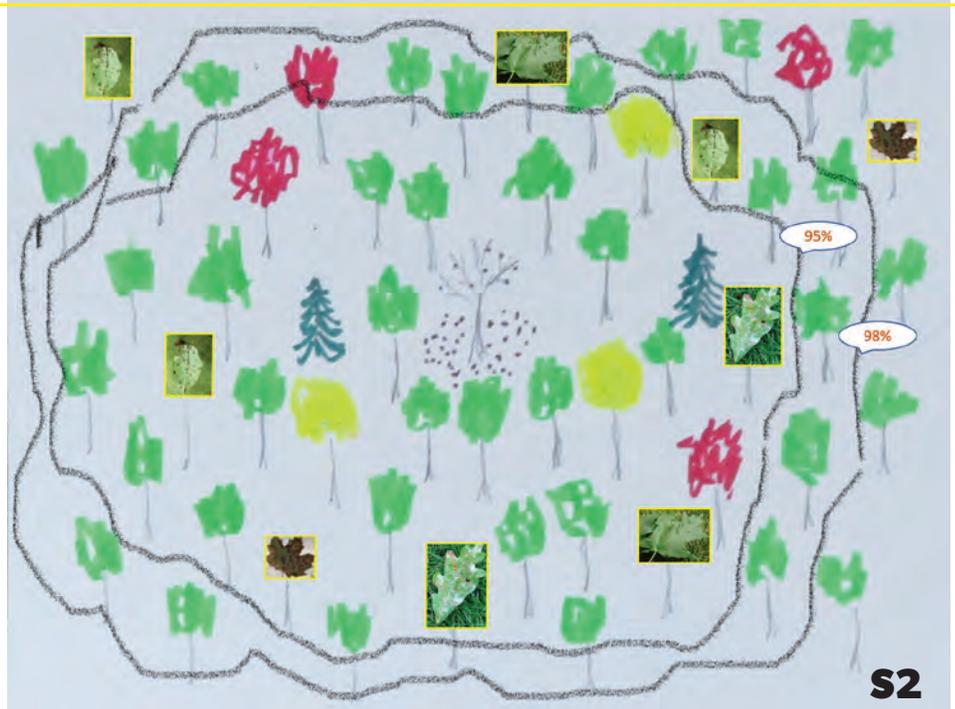
elements plugged by the Oak Wilt fungus. This technique shows so much promise that I predict it will revolutionize Oak Wilt management in Michigan and beyond.

Tier Tree Model Glyphosate/Stump Cup: This original Glyphosate/Stump Cup technique was designed by the author around 2008 and gradually underwent field trials over the subsequent decade. With this procedure, a Tier (or two) of healthy trees surrounding an Oak Wilt epicenter is sacrificed by application of the Glyphosate/Stump Cup procedure (Sketch 1). This technique has been highly successful; no breach of the glyphosate-treated sacrificial Tier by the Oak Wilt fungus has ever been observed by the author. With the advent of the ‘Chaser’ variation, however, sacrificial Tiers may not be needed. For full transparency, the ‘Chaser’ was originally incorporated in the Tier Tree Model Glyphosate/Stump Cup technique in 2008.

Tier Tree Model Glyphosate/Stump Cup ‘Half Moon’: This variation on the Glyphosate/Stump Cup technique was designed to minimize collateral damage to healthy, non-target oak trees that are destined for preservation. Implementation of the procedure involves creating a half stump cup (‘Half Moon’) in the direction of the advancing Oak Wilt front. Presumably, the Glyphosate will be concentrated towards the infected Oak Wilt trees and not in the direction of healthy trees meant for preservation. The ‘Half Moon’ has not been tested in field trials to any appreciable extent. However, the technique was used in field experiments to show that the Glyphosate/Stump Cup technique is superior to the Garlon 4/ Double Girdle technique in destroying targeted, sacrificial trees to stop Oak Wilt root graft transmission (discussed below with the Bruhn Model). This ‘Half Moon’ field experiment was summarized along with other Glyphosate/Stump Cup variations in the publication: *Promising Variations of the Glyphosate/Stump Cup Technique for Remediation of Oak Wilt: ‘Chaser’ and ‘Half Moon’*, *The Michigan Landscape*, September/October 2021, Pages 51-57.

Tier Tree Model Tree Injections: Tree injections with the fungicide Propiconazole have proven to be effective to protect healthy oaks within root graft range from root graft transmission from nearby diseased oaks. There have also been failures. The technique involves injecting healthy trees in Tiers from the Oak Wilt infection center (Photo 4). Injection of one Tier will not contain the expanding Oak Wilt epicenter. For optimal results, inject multiple Tiers of trees with 20 ml per inch dbh (diameter at breast height=4.5 feet above grade) every two years for a minimum of six years. Failures of tree injections to protect healthy trees may be caused by various factors. Improper number of injection sites, improper technique, and lower rates of the fungicides likely contribute to Oak Wilt management failures. Another important reason for Tree Injection failure not often considered by “Oak Wilt Experts” is that non-injected healthy trees within root graft range of healthy, injected trees may dilute the fungicide in trees that are injected due to root graft transmission of the fungicide.

Bruhn Model RGD: This Root Graft Disruption (RGD) model for Oak Wilt Control was created by Dr. Johann Bruhn in the mid-1990s. The technique specifies two RGD lines at 95% and 98% confidence limits (Sketch 2), according to Michigan State University E-2764, authored by Blankenheim, Adams, and Bruhn. After installation of the two RGD lines, all (red) oaks within the RGD



S2 This artist rendering exhibits a mixed woodland/forest where the Bruhn Model Root Graft Disruption (RGD) is expected to be implemented as depicted by the two trench lines encircling many trees and representing the 95% and 98% confidence limits for Oak Wilt containment. According to the Bruhn Model, both RGD lines must be installed. All red oaks within the two trench lines are removed and stumps treated with an herbicide. In lieu of RGD, the Garlon 4/Double Girdle technique is applied to all red oaks within the two RGD circles. Both the RGD and Garlon 4/Double Girdle techniques are costly and needlessly destructive, not only to the woodland but to the environment and ecosystem. Other species of trees would also be severely affected or lost. Can you identify the yellow poplar, cherry trees, white oaks, conifers, volunteer crabapples, and maples?

P5 Implementation of either the Bruhn RGD or Bruhn Garlon 4/Double Girdle method kills so many trees that after the location is fully remediated, the site often appears as a clear-cut lumber operation.

lines are removed and stumps are treated with herbicide. Obviously, this management procedure, preferred and recommended by the DNR and the Oak Wilt Qualification program, is very destructive and needlessly sacrifices many healthy oaks, reminding me of clear-cut lumbering operations (Photo 5). While the technique may have some practical application in forests where trees are of low value and can be harvested for lumber, its use in residential areas or woodlands or any sites where preservation of oaks is desired is, in view of the author, irresponsible.

Bruhn Model Garlon 4/Double Girdle: This model was adapted by the Michigan DNR from American Indians in Minnesota. The procedure involves making double girdle cuts approximately 3-4 inches apart encircling the girth of target trees (Photo 6) and applying Triclopyr (Garlon 4) to the double girdles. The Garlon 4/Double Girdle is applied to all trees within the RGD trench lines but in lieu of RGD trench lines (Sketch 2). In some field trials with the ‘Half Moon’ technique (discussed earlier with Glyphosate/Stump Cup) in comparison with



P6



P7A



P7B

P6 The Bruhn Model adaptation of the Garlon 4/ Double Girdle variation in lieu of RGD involves making a double girdle cut and applying triclopyr (Garlon 4) to the circumnavigating cuts. The author's research with the 'Half Moon' Stump Cup or Girdle showed that Garlon 4 likely has no impact on the health of the treated trees.

P7 A&B On public property managed by the state government, application of the Garlon 4/Double Girdle technique resulted in survival of some trees. Apparently, even if the double girdle was not effective in killing the above ground portion of the tree, application of Garlon 4 had no impact upon the health of treated trees. Note the narrow healing callus (7A, arrow) that is supporting the large canopy of the surviving tree (7B).

Glyphosate, Garlon 4 had no verifiable impact upon the health of the treated trees. Where the technique was used on state lands, trees treated by the double girdle and Garlon 4 were sometimes observed to recover (Photos 7A & 7B). If the Bruhn Garlon 4/Double Girdle technique is effective for remediation of Oak Wilt, it's likely due to the sacrifice of so many Tiers of healthy trees (Sketch 2) and not the result of any impact of Garlon 4 upon the health of oak trees as it is used in this technique; it may be difficult for the fungus to negotiate through the vast root networks and root connections to escape all of those sacrificial trees

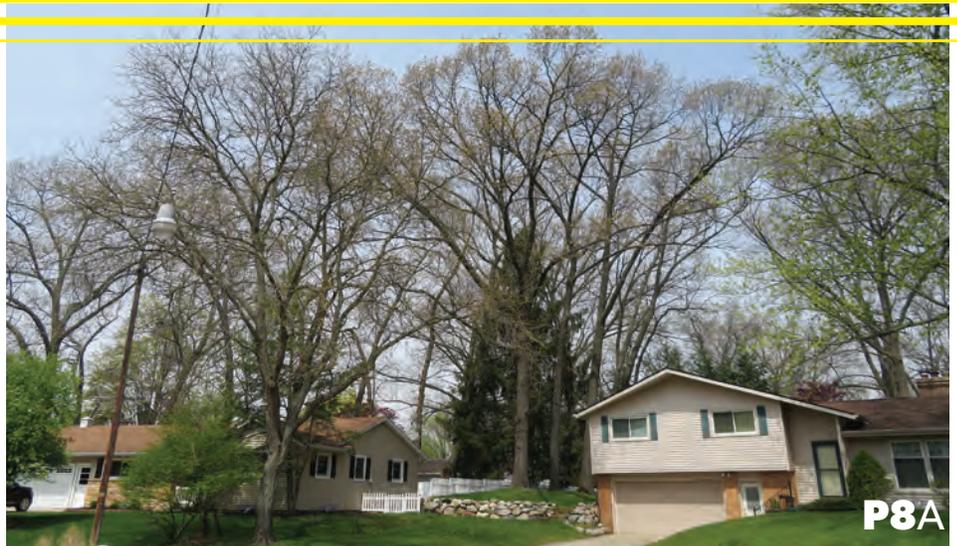
Combinations of Oak Wilt Management Techniques:

All Oak Wilt sites are unique. Sometimes more than one Oak Wilt management technique may be advisable. At the same northern Michigan Oak Wilt site (Photos 2 & 4), the Tier Tree RGD Model was combined with Tier Tree Model Tree Injections for 100% success without the sacrifice or destruction of a y other trees. No further development of Oak Wilt has occurred on this site in the last eight years. There are many potential combinations that might be useful. Suppose, for example, that the Glyphosate Stump Cup 'Chaser' is planned for application to a large, infected oak in someone's front yard, but there is another large, valuable, uninfected, healthy oak nearby. If practical, a RGD trench line could be placed between the two trees to minimize transfer of Glyphosate from the diseased oak to the healthy oak. In this case, the Glyphosate would also transmit through root grafts missed by the trenching operation but not likely harm the healthy oak.

Practical & Impractical Applications of Oak Wilt Remediation Options:

Connie has lived in her home in an "urban forest" for many decades (Photo 8A, right). She is part of a community where an oak forest resides through many properties. In 2020, a large oak near Connie's home contracted Oak Wilt after her tree became infected via Overland spread to a broken branch

wound (Photo 8B). Leaves began falling from her afflicted oak during the summer. A neighbor who had experience with Oak Wilt told Connie that her tree affliction was likely Oak Wilt. The disease was affirmed by two lab tests obtained by two separate arborists. Connie contacted several arborists whom she hoped would help her contain and eradicate Oak Wilt, which not only threatened many oaks on her property but adjoining properties as well. A satellite image of Connie's property and her neighbors is shown in Photo 9. The infected tree is located by the yellow arrow.



P8A

Arborist #1: Bruhn RGD Model: The first arborist Connie contacted proposed the Bruhn RGD Model. The two Bruhn RGD trenches are depicted in Photo 9 as two large, white circles, representing the 95% and 98% confidence limits for controlling Oak Wilt. The implementation of the Bruhn Model at Connie's property would have required the destruction of at least 32 healthy oak trees over four adjoining properties. Any other species of trees would likely be destroyed from collateral damage with the removal of those 32+ sacrificial oak trees along with many shrubs, wildflowers, and other plant life in this diverse ecosystem. Damage to birds and other wildlife habitat would have also been significant. Perhaps even endangered species would be destroyed with implementation of this Model.



P8B

P8 A&B Connie has lived in her home in this residential community for decades (Photo 8A). The urban forest is composed primarily of red oaks. Unfortunately, one of her large oaks became infected by Oak Wilt in the spring of 2020 likely due to Overland spread of the Oak Wilt fungus by sap beetles to a broken branch (Photo 8B and Inset). The afflicted tree, which can readily be identified as the tree with no leaf emergence, is in the center of Photo 8B. Both Photos were taken in April 2021, almost a year after the tree became infected in 2020.

P9 In this aerial view of Connie's and her neighbors' properties, application of either Bruhn Model (RGD or Garlon 4/Double Girdle) according to an arborist's recommendation would have resulted in the destruction of all trees within the large, white circles, approximately 32 oaks in all plus collateral damage to other tree species, wildflowers, wildlife habitat, etc. The smaller orange circle represents where the application of the Tier Tree Model Glyphosate/Stump Cup method would be applied if Connie authorized that work; approximately 6-8 large oaks would need to be destroyed with this method. The smaller incomplete yellow circle represents where a single Tier Tree RGD trench would be installed between her diseased oak and her healthy oak, resulting in no sacrifice of any nearby trees. Connie's choice of the Glyphosate/Stump Cup 'Chaser' technique (Photo 10) to her lone diseased oak required no RGD trenching and no sacrifice of any healthy trees. The site will be monitored for several years to ensure success; adjustments can be made if necessary.



P9



destructive option. Connie contacted yet another arborist.

Arborist #3A: Tier Tree RGD: A third arborist summoned me to examine and advise on the situation. I visited the site with Arborist #3 in early April 2021, almost a full year after Connie's single tree became infected by Overland Spread. Even with this time frame and knowing that Oak Wilt doesn't translocate quickly to nearby trees within the first year after infection, I immediately determined that a simple Tier Tree Model RGD trench line between the infected tree and the next Tier of healthy trees would likely contain and eradicate Oak Wilt from the site (Photo 9, small incomplete yellow circle). The implementation of this technique would not have required the sacrifice of a y healthy trees on Connie's or her neighbors' properties. Connie was elated that no other trees would likely be lost because of her Oak Wilt dilemma. And her neighbors would also be happy that they would not lose any trees nor need to expend large sums of their life's savings.



Arborist #3B: Glyphosate/Stump Cup 'Chaser': Connie was on a roll. By being cautious and thorough in her inquisitiveness about Oak Wilt remediation, she had reduced the number of trees that needed to be destroyed on her and her neighbors' properties from more than **32 trees to zero**. She was considering the Tier Tree RGD Model but understood that even operating a trenching machine through her property to sever roots at least 5 feet deep could do some damage to her trees and other plants. So, she asked if there were any other options. With some hesitancy, because my new 'Chaser' technique was technically still in research field trials, I described the technique using the Glyphosate/Stump Cup procedure. I related that with this technique, only her infected oak would be treated and subsequently removed; there would be no RGD trenching, no tree injections with fungicide, and (hopefully) no sacrifice of a y healthy trees. I also related that the technique had been utilized at quite a few locations around Michigan and that it exhibited significant potential after three years of trials. Connie quickly warmed to the

P10 Connie watches as Matt Bainbridge (American Arbor) applies Glyphosate to the Stump Cup he had just created to Connie's lone infected Oak Tree. Connie, who is deeply religious, tells me every time I visit that she often prays and thanks God for delivering Matt and me to her in her hour of need. It is very humbling for me to experience so much heart-felt appreciation from Connie and others I've been able to help throughout my almost 50-year career in Science.

P11 This photo, taken on February 1, 2022, shows Connie's Oak Wilt-infected tree (left, arrow), and her neighbor's tree (right, arrow) that was affected with Glyphosate from root graft transmission from Connie's infected tree after treatment with the Glyphosate/Stump Cup 'Chaser'. The neighbor's tree might survive despite the glyphosate toxicity but because it has a severe, acute lean towards the neighbor's house (Inset), the tree will be removed along with Connie's tree within a few days of this photo. Incidentally, implementation of either Bruhn Model techniques would have resulted in the destruction of most of the trees in the background of this photo plus others not visible, approximately 32 large oaks in all.

Arborist #2: Tier Tree Model

Glyphosate/Stump Cup: Connie was disappointed with the recommendations of Arborist #1 not just because of the astronomical expenditures, but because of the destruction to her property and neighbors' properties. So, she contacted another arborist who examined the situation, realizing what Arborist #1 recommended, and concluded that Dr. Roberts' Tier Tree Model Glyphosate/Stump Cup technique would be far better (Photo 9, small orange circle). This technique would require the sacrifice of 6-8 healthy oak trees, far less than the 32 trees potentially sacrificed by the Bruhn Model. Connie was relieved with this information but still wondered if there was even a less

Table 1: The Oak Wilt Kill Ratio and Rating According to Specific Oak Wilt Management Techniques

Kill Ratio		
# Trees Killed by Remediation vs. # Trees Killed by Oak Wilt		
Technique	Kill Ratio*	Rating
Glyphosate/Stump Cup 'Chaser'	0:1	Excellent
Tier Tree Model Glyphosate/Stump Cup 'Half Moon'	Untested	???
Tier Tree Model Root Graft Disruption	0:1	Excellent
Tree Injections w Propiconazole	~0:1 ?	Good/Excellent**
Tier Tree Model Glyphosate/Stump Cup	6-8:1	Good
Bruhn Model Root Graft Disruption	>20-30:1	Unacceptable
Bruhn Model Garlon 4//Double Girdle	>20-30:1	Unacceptable

*Typical but Variable according to situation

** Tree Injections exhibit variable efficacy

idea and wanted to become a participant in my 'Chaser' research (Photos 9 and 10). Her site was unique among my field trials because I could be treating her tree almost a year after it became infected; I typically like to treat infected oaks with the 'Chaser' method within a few months or the same year the trees became infected, whether by Overland or Underground transmission of the deadly fungus. Connie's tree was treated with the Glyphosate/Stump Cup 'Chaser' method on April 27, 2021. By early June, a neighbor's tree, only about 12-15 feet distance from Connie's diseased oak, exhibited Glyphosate toxicity symptoms throughout its entire crown (Photo 10 Inset). Even so, the tree remained alive throughout 2021 and showed no symptoms of Oak Wilt, meaning the Glyphosate translocated through the root grafts very quickly while the Oak Wilt fungus had not transferred the short distance in almost two years (two warm seasons) (Photo 11).

The Oak Wilt "Kill Ratio":

The "Kill Ratio" was created by the author for arborists to help their clients as property owners understand the diverse impacts that the various Oak Wilt remediation techniques present to landscapes, woodlands, and forests (Table 1). The Oak Wilt Remediation "Kill Ratio" is defined as follows.

Kill Ratio (KR) = #Trees Killed by Remediation vs. #Trees Killed by Oak Wilt

also summarized by the following equation
KR=Remediation Tree Deaths vs. Oak Wilt Tree Deaths

potentially expressed as
KR=12:1

Interpreting the above Kill Ratio of 12:1, twelve trees would be sacrificed through application of an Oak Wilt remediation method (i.e. Root Graft Disruption and tree removals) for each tree killed by the Oak Wilt fungus. Please note that the KR's with a particular remediation technique are not intended to be exact but are variable depending on the circumstances, such as density and population of oak trees. KR's that are presented herein may be typical for the sake of discussion and, perhaps, guidance when contemplating the remediation options for sites impacted by Oak Wilt. Please refer to Table 1 for typical Kill Ratios for the Oak Wilt Remediation Options in use in Michigan currently.

Conclusions:

There are a variety of Oak Wilt remediation options available to Michigan arborists and their clients.

In my opinion, the destructive methods with very high Kill Ratios should not be utilized in the vast majority of Oak Wilt situations; to do so is irresponsible. Confusion exists about Oak Wilt control as evidenced by the variable arborists' advice for Connie's Oak Wilt situation (and many others I have documented), which could affect many properties in her community. I think the confusion that does occur is because the Bruhn Models (RGD and Garlon 4/Double Girdle) are both promoted by the Michigan Department of Natural Resources and an Oak Wilt Qualifications Program, over which the DNR has significant influence. I want to clarify that Michigan arborists are very skilled and knowledgeable but that what they are being told and taught is very confusing. This article will hopefully correct some of the misperceptions about what procedures are beneficial for arborist and their clients' needs. The Oak Wilt Remediation Kill Ratio conveys in stark, sober terms the impacts of the various options. The cost differential among the various options is staggering, ranging from a few \$100s to many \$10,000s or even \$100,000s or more, if property value loss, tree removal costs, and other impacts on the environment are considered.

Please feel free to contact me if guidance on Oak Wilt is desired.

