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OAK WILT IN THE NORTH CENTRAL REGION

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ABSTRACT

Oak wilt disease, caused by *Ceratocystis fagacearum*, is the single most important disease of oaks in the North Central region. Many factors, including pathogen distribution, forest stand composition, soil characteristics, and human activities, interact to result in variable levels of disease impact across the region. Opportunities for management are closely tied to activities that interrupt the spread of the oak wilt pathogen. Disruption of functional root grafts is most effectively accomplished by a vibratory plow. Overland spread is prevented by avoiding wounding and destroying potential spore-producing trees. Integration of these and other tools into a comprehensive management plan results in effective management of oak wilt. The USDA Forest Service is actively involved in oak wilt management in the region, through essential research, assistance to state programs, and management on federal lands.

Key words: *Ceratocystis fagacearum*, disease impacts, disease management

Oak wilt is the single most important disease of oaks in the North Central region. Although the origin of the causal agent *Ceratocystis fagacearum* (Bretz) Hunt is still unknown, most pathologists now believe that it is not native to the North Central region (Juzwik et al. 2008, Harrington, this proceedings). In fact, oak wilt has recently emerged as a very serious regional threat to oak health, and has been expanding in distribution and impact. Due to many interacting factors, the impact of the disease varies greatly among different locations. In the following pages we will discuss how these many factors affect the occurrence and management of oak wilt in the region. We will also discuss the distribution of the oak resource and the pathogen, variation in disease incidence severity, how biological factors affect opportunity for effective management, and the role of federal agencies in disease management within the North Central region.

OCCURRENCE AND SEVERITY OF OAK WILT DISEASE

Oak wilt is widely distributed throughout much of the region, yet it has not been reported from every county within the states of the North Central region, and there is considerable area with a significant red oak resource that does not have oak wilt disease (Fig. 1). Within the past 10 years, oak wilt expansion (range extensions or intensification of disease within the known range) has specifically been noted in northern Wisconsin, the Upper and Lower Peninsulas of Michigan, southern Indiana, and urban developments north of the metropolitan area of Minneapolis/St. Paul, MN.

Oak wilt does not cause a consistently high level of impact across the region. Several biological factors that affect the spread and intensification of the disease through root graft connections and vector/host relationships account for this variation. These biological factors are intertwined with additional social factors, such as rural versus urban forests, changes in land use and forest cover, and long distance human movement of the pathogen. These factors are more fully addressed in a separate paper (Juzwik, this proceedings).

New infection centers of oak wilt usually arise when spore-contaminated nitidulids (sap beetles) visit fresh wounds on oaks (Gibbs and French 1980). If a tree becomes successfully infected, the fungus can spread to adjacent trees through grafted roots. Species composition and soil characteristics that affect frequency of root grafts determine the likelihood of this type of spread. In addition, ascospores and conidia from fungal mats can spread locally or longer distance via nitidulids. This type of spread leads to intensification of the disease on a site, or initiation of new sites.

In Missouri, older literature indicates that oak bark beetles may also be important in overland movement of the pathogen, and that competing microorganisms and weather factors may reduce the importance of fungal mats in spread of the disease (Rexrode and Jones 1970). However, three sap beetle species have recently been shown to be important vectors in the state (Hayslett, Juzwik and Moltzan 2008, Hayslett et al, this proceedings)). Studies in Minnesota have shown that, although fungal mats can be formed on oaks during the fall, the spring-produced mats are highly synchronized with nitidulid biology and behavior (Juzwik, Skalbeck and Neuman 2004). Furthermore, due to springwood vessel structure, the oak hosts are highly susceptible to successful infection by *C. fagacearum* during the spring. The synchronization of mat formation with nitidulid biology does not occur in fall (Juzwik et al. 2006).

Humans promote initiation of oak wilt centers by creating fresh wounds on oaks during highly susceptible periods. New infection centers in urban areas are well documented to be associated with construction and pruning wounds to oaks in the spring of the year. In forests, harvesting, thinning, road construction, or any other activity that wounds trees during the spring and early summer can lead to new oak wilt infections. This has recently been a problem on National Forest sites in Wisconsin and Michigan, where selective harvest and pruning activities in oak stands were implemented during the spring of the year, resulting in astonishing levels of new oak wilt disease (Joseph O'Brien, unpublished data, USDA Forest Service 2007).

The importance of the various biological factors (frequency of root grafts, stand composition, wounding, etc.) in spread and intensification of oak wilt is also affected by the actual distribution of the oak wilt pathogen. In areas where *C. fagacearum* is not known to occur, humans effect long-distance initiation of oak wilt centers through movement of infected material. Of particular concern is infected firewood or sawlogs that may harbor fungal mats. The presence of oak wilt disease in the Upper Peninsula of Michigan has been attributed to movement of infected firewood to seasonal-use properties (Bob Heyd, personal communication, Michigan DNR 2008).

OAK WILT MANAGEMENT ACROSS THE REGION

The primary tools for managing oak wilt are aimed at disrupting mechanisms of spread of the pathogen. Tools and management practices are available to prevent overland initiation of infection centers via insect transmission of the pathogen, and to prevent below-ground intensification of infection centers via movement of the pathogen through root grafts. In addition, systemic fungicides are being used under certain situations to protect high-value trees. This section expounds on how each of these tools is used in the North Central region.

Prevention of Overland Spread

Avoidance of wounding during the highly susceptible spring period can prevent much overland insect transmission of *C. fagacearum* to healthy oaks. Wounds to oaks during this period require immediate treatment to prevent the cut surface from being infected by spores carried by nitidulid beetles. Even exposed stumps should be treated, as they serve as an open infection court.

In urban and suburban areas, prevention of human-made wounds on oaks is important. In the Midwest, there have been several effective public education campaigns to encourage people, e.g. "Don't prune in April, May and June." Many commercial arborists choose to avoid pruning during this time period. The susceptible period does vary across the region, and between years, so local knowledge is useful. It is also important to protect oaks from wounding at construction sites; this can often be accomplished by putting a fence or barrier around the oaks. This action can be effectively encouraged through education or community ordinances.

In woodlands, it is important to avoid forest disturbance activities during the susceptible period, and again, this can often be accomplished through education, local ordinances, or state guidelines. The Wisconsin DNR recently developed guidelines for harvesting in oak timberlands to minimize the potential for pathogen introduction to oak wilt-free stands or intensification in already affected stands (Wisconsin DNR 2007).

Another means to reduce overland spread is to reduce inoculum from fungal mats and pads. Trees from the red oak subgroup that have died from oak wilt in mid- to late-summer and have suitable sapwood moisture content for production of fungal mats during the following spring are called "potential spore producing trees," or PSPTs. White oaks are not considered to contribute significantly to risk of mat production. To effectively manage oak wilt, all PSPTs should be felled and portions greater than 2" diameter removed, treated, or destroyed prior to vector activity in the spring.

In most situations, removing the tree immediately after it dies is not recommended, because the pathogen may be pulled into the roots of healthy trees by transpiration of the adjacent living trees. The PSPT can be safely removed and treated to eliminate the possibility of spore mat production after vibratory plowing is completed on a site (usually in the fall). The stems can be safely utilized for timber products if they are removed from the site and processed prior to spring. They also can be utilized for firewood if they are debarked or are sealed with a tarp (to prevent nitidulid beetles from reaching the wood if spore mats are produced) from late winter until late summer of the same year. Acceptable methods to destroy wood from PSPTs include chipping, burning, or burying.

Prevention of Spread Through Grafted Roots

There are several tools to prevent transmission of *C. fagacearum* through root grafts. It has been demonstrated that in order to consistently halt the disease, functional grafts must be broken to a depth of 60 in. (1.5 m) (Bruhn and Heyd 1992). A vibratory plow equipped with a specialized blade is one of the most effective tools available for disrupting root connections between trees in the North Central region.

The placement of vibratory plow lines is critical to treatment success. Two methods are used in the North Central region. The "rule of thumb" method developed by D. W. French places a "primary" line outside the closest apparently healthy trees, so that there is a buffer zone of healthy trees between the oak wilt center and the plow line (French and Juzwik 1999). A secondary line can optionally be placed between the dead or dying trees and some or all of the buffer zone trees to try to 'save' some of these trees. A mathematical model developed by Bruhn, Pickens and Stanfield (1991) defines line placement with an equation that predicts the probability of the pathogen moving to an adjacent healthy tree within one year based on diameter of the healthy tree, diameter of the diseased tree, distance between the two trees, and soil type (Bruhn and Heyd 1992, Carlson and Martin 1996). With either method, oaks within the vibratory plow line are generally removed, either in a single preemptive action or over time as they succumb to oak wilt. Use of the mathematical equation method usually results in the removal of more trees than the "rule of thumb" method. Both methods are used within the North Central region, depending on the situation, location and preferences of the person defining line placement.

If a plow is not available, a trenching machine may be used to sever common roots, but the depth (usually 48") is inadequate to achieve consistent control. A backhoe can be used to dig an effective trench; however this is quite disruptive to a site.

Recently, on National Forest land, a previously untested method was used to control oak wilt center expansion in an area where uneven topography and rocky conditions precluded effective treatment with a vibratory plow. The method involves cutting and removing infected and adjacent trees and then using an excavator to rip out and overturn the stumps and root masses, a procedure coined "root rupture." In doing this, many of the root grafts are broken and diseased tissues are isolated from neighboring healthy oaks. Internal Forest Service documentation indicates that this method was greater than 90% effective in halting the spread of oak wilt (John Lampereur, personal communication, Chequamegon-Nicolet National Forest 2007).

The use of buffer zones alone, or simply cutting out oak wilt pockets, generally fails to halt the spread of oak wilt disease in the North Central region. Use of herbicides to kill a buffer zone of trees, with the hope that the root systems of killed trees will die and deteriorate quickly, has repeatedly been proposed as an alternative means of interfering with the graft connections of oak. Although some herbicide combinations have been identified that consistently kill oaks without sprouting, the root systems of the treated trees do not die quickly, making this method ineffective or impractical (Bruhn et al., 2003, Ed Hayes and Linda Haugen, MN DNR and USFS, respectively, personal observation, 2004).

Fungicide Injection

Systemic chemical treatment of high value oaks with propiconazole (PPZL) is a common practice in urban forests of the region. Preventive treatment of white and bur oaks within root grafting distance of infected oaks of the same species is effective in preventing wilt symptom development in treated trees (Eggers et al. 2005). Therapeutic treatment of *C. fagacearum*-infected white and bur oaks with $\leq$ 30% crown wilt symptoms has also been shown to prevent further wilting in such trees. Due to the observed success, commercial arborists generally only treat these species once they are infected.

Preventive treatment of red oak species within root grafting distance of pathogen-infected red oaks is common practice. In an evaluation of operational treatment by commercial arborists in the Minneapolis/St. Paul, MN, area, 39% of preventively treated red oaks died from oak wilt over 5 years, but the deaths largely occurred 3 to 5 years after the single treatment (Eggers et al. 2005). Thus, many arborists commonly re-treat red oaks with PPZL two seasons after initial treatment.

In an experimental field trial involving paired treated and non-treated plots, differences in PPZL efficacy occurred by soil type/topography and by one versus two time treatments when compared to the control trees (Juzwik unpublished data). Results of a recent experimental study in red oaks suggests that PPZL likely suppresses disease development rather than eradicating *C. fagacearum* from roots or preventing root graft transmission (Blaedow and Juzwik 2008). Treatment of currently wilting red oaks is not advised as success in arresting wilt symptom development only occurred in trees exhibiting $\leq$ 25% crown wilt at the time of injection (Ward, Juzwik and Bernick 2005).

Management Conclusions

Just as the severity of the oak wilt pathogen varies across the region, the usefulness of these tools also varies. In areas with high incidence of root graft spread and deep sandy soils, use of the vibratory plow is highly successful, especially in parts of the region where vibratory plows and the necessary 60” blades are readily available. In other parts of the region, plows are harder to find, and 60” long blades are often not available.

Effective oak wilt control requires integration of tools to address all of the constraints and opportunities. The USDA Forest Service has produced three “How to” guides that provide valuable information to manage oak wilt (O’Brien et al. 1999, Pokorny 1999, Cervenka et al. 2001). The Forest Service has recently prepared other information products to assist with overall management of oak wilt disease.

In 2004, Forest Health Protection and Northern Research Station collaborated to produce a CD product to help communities implement an effective oak control program (Juzwik et al. 2004). This CD, entitled “Oak wilt: People and Trees, A Community Approach to Management”, included powerpoint presentations, pdf files of relevant publications, and additional materials. The CD can be obtained from the Northern Research Station publications website, or from the Forest Service authors (Jennifer Juzwik and Linda Haugen).

In 2007, the Forest Service Forest Health Protection staff prepared “Northeastern Area Participation Guidelines for Oak Wilt Cooperative Prevention and Suppression Projects”. This document provides guidance to help States and federal agencies implement effective oak wilt suppression projects. Suitable for a 3-ring binder, it includes appendices with detailed information on oak wilt biology, technical details of control measures, factors to consider when prioritizing treatment areas, and description of necessary documentation for federal projects. The guidelines are available from the US Forest Service Northeastern Area, State and Private Forestry, Forest Health Protection, St. Paul, MN.

THE ROLE OF FEDERAL AGENCIES IN OAK WILT CONTROL

The USDA Forest Service (FS) plays a vital role in the management and control of oak wilt disease in the North Central region. Its role is multifaceted and involves programs administered through State and Private Forestry and Research and Development.

State and Private Forestry programs, as authorized by Federal law, provide financial and technical assistance to protect state, private, and federal lands from the impacts of forest insects and diseases that pose a serious threat to the health and sustainability of urban and rural forest resources. Oak wilt is recognized as the single most important disease of oaks in the North

Central region, and the need to implement effective oak wilt management strategies has been identified as a high priority in several states.

To facilitate the effective management of oak wilt, State forestry agencies can use core-level funding provided by the FS annually, and they can apply for Cooperative Prevention and Suppression Grants. State agencies normally request Cooperative Prevention and Suppression funding because the anticipated costs of an eradication or suppression project exceed available state, local, or private funds. Federal land managers can also apply for Cooperative Prevention and Suppression Grants. To date, Oak Wilt Cooperative Prevention and Suppression Grants have been provided to State forestry agencies in MN, MI and WI; the Chequamegon-Nicolet and Huron-Manistee National Forests; and other federal agencies including the Department of Defense, Department of Interior, and Bureau of Indian Affairs.

State and Private Forestry staff also provides technical assistance to State and Federal partners. Technical assistance usually comes in the form of helping partners complete project documentation needed to meet NEPA requirements, including completion of biological evaluations, site specific environmental assessments, and consultations with the US Fish and Wildlife Serve (US F&WS) and the State Historic Preservation Office (SHPO).

Research and Development staff has dedicated significant efforts to conduct studies that have led to new or improved oak wilt management tools. A protocol was developed for monitoring flight activity of the predominant sap beetle vectors, particularly in early spring in Minnesota and Wisconsin (Kyhl et al. 2002). Sap beetle dispersal studies and frequencies of *C. fagacearum* contaminated beetle occurrence have been used to refine high, low and no risk time periods for tree pruning and harvesting activities (Ambourn, Juzwik and Moon 2005, Juzwik et al. 2006, Hayslett, Juzwik and Moltzan 2008). Experimental and observational studies on efficacy of PPZL for oak wilt control have resulted in improved guidelines (Eggers et al. 2005).

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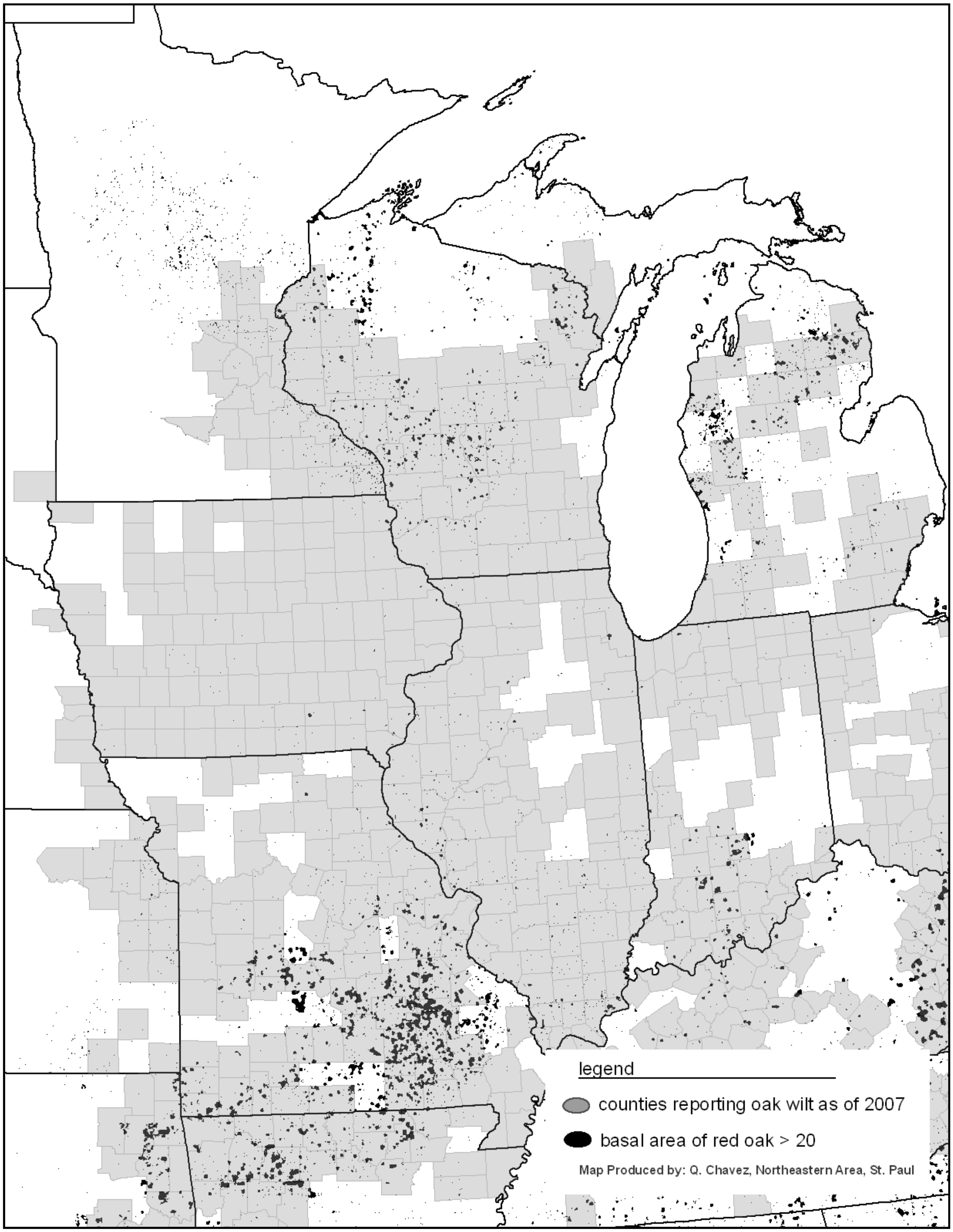

Figure 1. Distribution of oak wilt by county in 2007 and areas with basal area of red oak > 20 ft^2 according to Forest Inventory and Analysis (FIA) in the North Central region.