Abstracts of Presentations

2nd National Oak Wilt Symposium
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Austin, TX

Welcome to Texas

Speaker: James B. Hull, Texas State Forester

Welcome to Texas - - - Y'all! We are honored to be hosting this prestigious symposium in Austin, and only 6 days after the 80th Texas Legislature adjourned after being in regular session for the past 140 days. This is a process that occurs every two years in Texas, whether we need it or not! Austin is not only the home of the State Capitol, but also the orange and white University of Texas Longhorns. However, the Texas Forest Service is part of The Texas A&M University System, 100 miles northeast of here in College Station. In honor of our school colors, the Aggies have just about perfected a way of genetically causing all of the Texas Bluebonnets in Austin to have a rich maroon color!

Texas is a mighty big and extremely diverse state: Vast Pineywoods of east Texas; rugged mountains of southwest Texas; rich agriculture in the northwest high plains; tropical citrus and other agriculture in far south Texas; and the beautiful rolling hill country in between. Texas has over 350 miles of shoreline along the Gulf of Mexico; 1200 miles of international border with Mexico and 250 miles of international border with Louisiana! It is 885 miles across Texas from north to south, and 835 miles across from East to West.

Texas has six major tree regions, totaling over 29 million acres of forest lands. Now that we have finished our second year of completing a statewide Forest Inventory and Analysis, we are finding that we might actually have up to twice as many acres of forest as previously thought. Commercial forestlands in Texas are undergoing tremendous restructuring in ownerships. Where forest industry historically owned and provided world class forest management on approximately one-third of these forest, recent divestiture of these lands has seen these forests now in the hands of TIMOs and REITs. The other lands belong primarily to individual/family forest owners (64.8%) and public owners (8.0%).

Texas also has a tremendous acreage of range and other open space, yet at the same time we are becoming identified as an urban state. Texas has three of the nation's ten largest cities, and five of the top twenty. Of the 22.5 million Texas residents, 84 percent live in or near cities. One of the biggest challenges to Texas is the population growth into the rural/urban interface. As example, of the 32,000 wildfires that burned in Texas in 2005-2006, 85% of those started within 2 miles of a Texas community.

I was named Texas State Forester in 1996, and since then many folks will tell you that it has been one disaster after another. While some of these disasters have been of my doing, others have been associated with unprecedented wildfires, ice storms, hurricanes,

floods, southern pine beetle outbreaks, wind storms, and the Texas Forest Service had the lead role in the Columbia space shuttle recovery efforts in 2003.

With changing roles and responsibilities, the Texas Forest Service has made the commitments to work smarter and provide the role of leadership in several areas of forestry. Currently, our staff is leading development of the Southern Forestland Assessment for the 13 southern states. This is an effort to identify the forested areas that are in most need of priority attention. We recently completed the Southern Wildfire Risk Assessment that provides GIS tools to identify the highest areas of wildfire risk for planning, fire prevention, mitigation and response activities.

Another Texas-size disaster has been oak wilt devastation across vast areas of the Texas Hill Country in central Texas. Dr. Ron Billings and his Forest Pest Management team have made significant progress over the past 20 years in dealing with this massive problem. To most successfully deal with oak wilt, we have effectively integrated and coordinated it with our Forest Stewardship, Urban, and FIA programs. I am very proud of these accomplishments in this area and no doubt you will hear more about it while you are in Austin.

Thanks again for coming to Texas. While you are here it is our goal to prove to you our claim that Texas is the friendliest state in the United States. Y'all come back now!

An Overview of *Quercus*: Classification and Phylogenetics, with Comments on Differences in Wood Anatomy

Speaker: Dr. Kevin C. Nixon, Cornell University

The oaks (genus *Quercus*) are one of the most important groups of flowering plants, and dominate large regions of the northern hemisphere. They are most prevalent in subtropical, temperate, and montane tropical regions. *Quercus* is phylogenetically divided into at least five major groups, of which three (the red oaks, white oaks, and intermediate oaks) are native to the New World. Overall, there are more than 200 species of oak in the Western Hemisphere, and probably a larger number in Asia, and relatively few in Europe. The center of diversity in the Americas is in the highlands of Mexico, with a secondary center in the southern United States. From the standpoint of susceptibility to disease, the phylogenetic groupings have some predictive capability, and in some cases this may be related to differences in ecology, physiology and wood anatomy. White oaks in general are more diverse in the drier parts of North America, and have heartwood that is typically blocked by tyloses, while red oaks generally have fewer tyloses. Because tyloses block water flow through the heartwood, white oak wood makes good wine barrels while red oak wood does not. Given the greater susceptibility of red oaks to both oak wilt and sudden oak death (SOD), these differences in wood anatomy may be relevant.

The Genus *Cerotocystis* and Where the Oak Wilt Fungus Fits

Speaker: Dr. Thomas C. Harrington, Iowa State University

Morphological and phylogenetic data show that *C. fagacearum* is a member of the genus *Ceratocystis*, but there are several unique aspects to the biology of *C. fagacearum*. The genus is comprised of mostly plant pathogens, many of which are wound colonizers, like *C. fagacearum*, but no other species in the genus causes a true vascular wilt disease. A hallmark of the group is the necked perithecium that produces a sticky mass of ascospores at the apex for insect dispersal. Most members of the genus, including *C. fagacearum*, produce fruity volatiles that are thought to be attractive to insect vectors, and some *Ceratocystis* species have been associated with fungal and sap feeding beetles in the family Nitidulidae. Like *C. fagacearum*, many *Ceratocystis* species produce sporulation mats on exposed wood, but only *C. fagacearum* is known to form pressure cushions or pads that push the bark away from the wood in order to crack the bark. Phylogenetic analyses of DNA sequences fail to identify a close relative of *C. fagacearum*. *Ceratocystis adiposa* appears to be the nearest species with a sexual state, and three symbionts of ambrosia beetles (*Ambrosiella* spp.) also show some relationship to *C. fagacearum*. Limited genetic variation within *C. fagacearum* suggests that the fungus was introduced into the eastern USA, but the evolutionary and geographic origins of *C. fagacearum* remain a mystery.

Oak Wilt Biology, Impact, and Host/Pathogen Relationships: A Texas Perspective

Speaker: Dr. David N. Appel, Texas A&M University

Oak wilt and the causal fungus, *Ceratocystis fagacearum,* were first discovered in Texas in 1961. At the time, oak wilt was a well known pathogen in other parts of the United States. Twenty years later, oak wilt became viewed as a major threat to oak resources in the woodlands and urban forests of central Texas. A comprehensive program was launched to quantify the impact and clarify critical aspects of the diagnosis, epidemiology, and control of the disease. The hosts and environmental conditions in central Texas were found to be very different from the same factors in other parts of the range of *C. fagacearum* in the U.S. Host susceptibilities, inoculum sources, diagnostic protocols, and potential impact are all somewhat unique in central Texas when compared to the disease in other forest ecosystems. Pathogen behavior and host response in the semi-evergreen, root-sprouting live oaks (*Quercus fusiformis*) in central Texas woodlands do not conform to the disease as it occurs in deciduous oaks elsewhere. These differences have important consequences and provide great challenges where disease control is concerned. Oak wilt continues to cause enormous losses of trees in central Texas, but great advances have been made in providing landowners and natural resource managers with the tools needed to save trees.

The Spread of *Ceratocystis fagacearum* in Midwestern and Mid-Atlantic States

Speaker: Dr. Jennifer Juzwik, USDA Forest Service, North Central Research Station

The oak wilt fungus is transmitted from diseased to healthy oaks in two general ways – below ground through common or connected root systems and above ground by insect vectors. Various factors affect the frequency of each type of spread and the influence of one type on the other. Although root-graft transmission is the means of below ground spread in the Mid-Atlantic and Midwestern States of the oak wilt disease range, its frequency of occurrence varies within and among the two regions. Root-graft spread frequency, in turn, affects the frequency of recently-wilted trees that may then serve as sources of inoculum for above ground spread. The importance of insect vector groups apparently differs between the two regions. Frequency of insect vector spread is higher over shorter distances than longer ones in Midwestern States. Oak composition and density, terrain, soils, and site productivity are among the factors affecting the frequencies of both types of spread in these regions and help explain observed differences in patterns of spread in oak forest landscapes. Effective oak wilt management efforts in Midwestern States take these factors into account.

Predicting the Potential Distribution of Invasive Forest Pathogens for Assessing Risk

Speaker: Marla Downing, Forest Health Technology Enterprise Team, USDA Forest Service

Knowledge of the potential distributions of invasive pathogens will increase our understanding of the overall risk posed to forest health. Our work explored the use of classification trees as a tool for improving the assessment of risk posed to forest species from the invasive pathogens *Ceratocystis fagacearum (oak wilt)* and *Phytophthora alni*. The classification trees were used to identify the parameters associated with the presence of the invasive pathogens. The variables considered in the analysis included: field sample data; satellite imagery (MODIS, TM, and SPOT); and commonly available, bio-geographical GIS data. Two measures of certainty were utilized, 1) the ten-fold cross validation, and 2) an assessment using additional field-collected data. These measures of certainty indicated that at the landscape scale the classification trees were successful at identifying appropriate parameters for predicting the presence of both *P. alni* and *C. fagacearum*. The parameters identified by the classification trees could then be used to develop potential distribution surfaces and for conducting risk assessments. The products of our work are currently being utilized for prevention, suppression and detection activities aimed at managing the invasive forest pathogens.

Oak Wilt Research at Fort Hood: Controlling Oak Wilt at the Landscape Scale

Speaker: Dr. Thomas A. Greene (with Charlotte M. Reemts), The Nature Conservancy

Fort Hood Military Reservation supports a large population of the endangered golden-cheeked warbler (*Dendroica chrysoparia*, GCWA). Oak-juniper woodland, dominated by

Juniperus ashei and various hardwood species, notably Texas red oak (*Quercus buckleyi*), Plateau live oak (*Q. fusiformis*), and Texas ash (*Fraxinus texensis*), serves as breeding habitat for this species. Oak wilt (causal agent: *Ceratocystis fagacearum*) infects Texas red oak in central Texas and is considered a threat to the GCWA because of its potential to degrade habitat. We have used and evaluated two methods of controlling oak wilt in GCWA habitat on Fort Hood. We have tested the efficacy of basal girdling of symptomatic Texas red oak stems over a 2 year period on Fort Hood for preventing the formation of new infection centers in GCWA habitat by reducing the formation of fungal mats. Although these efforts have been successful at reducing the numbers of fungal mats in our study areas, no overall reduction in infection rates has been noted. We suspect that most new infections in our study resulted from root-to-root transmission of the pathogen, which is not controlled by basal girdling. Approximately 11.2 km of trenches have been installed over the past 4 years to control oak wilt centers in live oak in and near GCWA habitat on Fort Hood. Trenching, though limited to relatively level sites and to infection centers in live oak, has been successful at controlling the spread of oak wilt in live oak in GCWA habitat. We characterized woody species composition and structure after the passage of an oak wilt disease front and tentatively conclude that Texas red oak regeneration is adequate to replace overstory losses due to oak wilt in the absence of overbrowsing.

Oak Wilt Research in Fort Hood, TX and the Impact of Oak Wilt on an Endangered Species

Speaker: Kim Camilli, University of Nevada

Understanding how oak wilt can impact land management activities has recently become an issue at Fort Hood, TX. Fort Hood is home to two endangered bird species, the golden cheeked warbler, *Dendroica chrysoparia*, and the black capped vireo, *Vireo atricapillus*. The golden cheeked warbler (GCW) uses juniper trees for building nests and feeds on Lepidoptera that exist in oak species. Whether the oak wilt pathogen is affecting the GCW habitat, nesting and feeding activities has become a concern. In 2003 and 2004 suppression activities have been conducted on the army base to help stop the spread of oak wilt into the endangered golden cheeked warbler habitat. Fort Hood consists of 88,221 hectares (ha.) and approximately 21,850 ha., or 24.7% of the total installation, is designated GCW habitat. Two surveys were conducted from 2001 to 2004 to determine the approximate amount of oak wilt on the base and how oak wilt will impact GCW habitat. The 2001 survey used IKONOS 1-meter pan sharpened satellite imagery for photo-interpretation of mortality centers within the post perimeter. 821 mortality centers were located, and ground truthing of 10% of those revealed 73% were oak wilt mortality centers. In 2002-2003 extensive field surveys were conducted in four distinct categories (GCW/OW, no GCW/OW, GCW/no OW, and no GCW/no OW). The fifth category (GCW nesting sites) was added for specific GCW nesting habitat requirements. This field data was used in conjunction with a non-parametric statistical technique called decision tree analysis, that incorporates remote sensing sources (2003 Spot 7 and Landsat TM satellite imagery), geographical information system (GIS) data layers (slope, aspect, roads, etc…), and field data to model and describe the factors that are needed for GCW nesting sites within Fort Hood. The decision tree analysis revealed a tree

that had an accuracy of 98.2% with significant components of the model comprising road density, selected Landsat TM and Spot 7 satellite imagery bands, elevation, and distance to roads. The results from the decision tree analysis and stand and site characteristics between GCW habitat locations and OW centers revealed that the GCW nesting habitats and OW centers have different stand and species composition. Even though direct losses to GCW habitat from oak wilt may be minimal, further studies are needed to examine other consequences such as edge effects and other site disturbances created by the oak wilt pathogen. Results of this study will help with management conflicts that occur between oak wilt control and endangered species habitat management.

Beetle Trapping in Texas and Missouri to Examine Above Ground Transmission of Oak Wilt Across a Region

Speaker: Maya C. Hayslett, University of Minnesota

Two groups of beetles, sap beetles in the family Nitidulidae and oak bark beetles in the genus *Pseudopityophthorus*, have long been implicated as vectors of oak wilt. Specifics such as which species are responsible and if vector species are the same across the entire range of oak wilt were not examined until recently. This species-specific information is important for enhancing control measures. Experiments were conducted to collect beetles of both major groups in oak wilt centers in Texas and Missouri. This data is compared to work done in other states. Major conclusions from these experiments are that a certain few species are responsible for transmission in each of the major vector groups and that the importance of a vector group or species may vary with location. Results from this research should help to improve control measures and give a better picture of insect transmission of oak wilt across the region.

Wounds as Oak Wilt Infection Courts

Speaker: Dr. Todd Watson, Texas A&M University

Many pathogens are introduced into trees through wounds, which serve as important infection courts for the spread of diseases among trees. Spores of *Ceratocystis fagacearum*, the fungus that causes oak wilt, can be effectively transmitted by insect vectors from fungal mats on diseased trees to fresh wounds on uninfected trees causing the initiation of new disease centers. To reduce long distance dissemination of the fungus among trees by sap feeding insects, wound treatments have long been a potential control measure of interest to researchers and practitioners. Many studies have shown that wound dressings have some benefits when used to prevent infection from the fungal spores of various pathogens. Several other studies have demonstrated that wound dressings can be phytotoxic or non-beneficial to trees. The use of wound dressings for susceptible trees in areas where oak wilt is prevalent has been controversial among arborists. Much of this controversy surrounds the notion that pruning paints are not required when making proper pruning cuts that do not damage branch collars. To address these concerns, a study was developed to determine the efficacy of

applying pruning paint to pruning wounds on susceptible live oaks as a precaution against vector transmission of *C. fagacearum*. Results of this and other studies were discussed to develop a better understanding of pruning wounds and wound dressings and their impacts on vector transmitted spores of *C. fagacearum.*

A Hypovirulent Strain of the Oak Wilt Fungus

Speaker: Dr. Dennis Fulbright, Michigan State University

Hypovirulent strains of the chestnut blight fungus, *Cryphonectria parasitica*, isolated from blight-recovering chestnut trees in Italy and Michigan are reduced in virulence, show altered culture morphology, and harbor cytoplasmically transmissible hypoviruses. Hypovirulent strains without hypoviruses have also been isolated and carry mitochondrial DNA mutations that lead to debilitated respiration as measured by an increase in alternative oxidase. Our laboratory duplicated mitochondrial-based hypovirulence in *Ceratocystis fagacearum,* the cause of oak wilt. Conidia from a wild-type strain, Fenn, were exposed to ethidium bromide and ultra-violet light and then screened for slow growth, an indicator of possible mitochondrial dysfunction. One mutant, PM447, showed altered morphology, high levels of alternative oxidase, and reduced virulence. PM447 was able to protect 28-day-old seedlings from disease when inoculated two-weeks prior to inoculation by the virulent, wild-type Fenn strain. In an effort to apply this technology to a wider application, we expanded the parameters of the original study to include challenges beyond two weeks, varying the strain of virulent wild-type used in the challenge inoculation, varying the number of spores of PM447, and using the mutant to protect young and mature trees in field plots.

The Potential for Using Trench Inserts for Oak Wilt Management

Speaker: Dr. Dan Wilson, USDA Forest Service, Southern Hardwoods Laboratory

Trench inserts are physical barriers used to control root transmission of *Ceratocystis fagacearum* which provide a significant new strategy and technology for oak wilt suppression in the United States. This cultural control method has been shown experimentally to significantly extend the effective life and utility of trenches in Texas. The utilization of trench inserts also has increased the effectiveness of trenches as physical barriers to root transmission. Water-permeable trench inserts are more effective barriers than trenches alone because they prevent new root graft formation in trench-backfill soil indefinitely. Trench inserts may provide greater insurance against future trench breakouts in backup trenches when original trenches fail. Water-impermeable trench inserts are not as effective because, in some cases, they tend to direct root growth around (usually above) the insert when inserts are buried too deeply. Trench inserts may be installed at a fraction of the costs of primary trenches and may not significantly increase total trenching costs. The use of trench inserts could potentially save millions of dollars through protection of uninfected trees, avoidance of tree removal costs, and reductions in property value depreciations for Texas landowners. This technology is equally applicable in other areas of the United States

affected by this disease. Some potential problems associated with the installation of trench inserts are discussed.

Regional Impact Report: Oak Wilt in the Appalachians

Speaker: Dr. William L. MacDonald, West Virginia University

A few decades after blight nearly eradicated the American chestnut, oak wilt was discovered, heightening concern that the oak resource in North American might be threatened similarly. Fortunately, in most Appalachian areas, the disease has spread slowly and erratically among a susceptible population of red oak species. This has occurred in spite of the existence of components of the disease that are common to areas of the United States where oak wilt is devastating; namely, a highly virulent casual pathogen, *Ceratocyctis fagacearum*, the existence of insects that have been identified as vectors, and the presence of root graft unions among susceptible oak species. A variety of hypotheses have been forwarded as to why the spread of oak wilt has been slow in the Appalachians. Certainly, the diversity of hardwood species has limited tree-to-tree spread that is typical of areas in the upper Midwest and south-central United States where *C. fagacearum* spreads freely through interconnected oak root systems. Likewise, many Appalachian sites possess rocky soils which have been speculated to restrict the development of functional root grafts, thereby further limiting tree-to-tree spread. Although known insect vectors are present in the Appalachians, their effectiveness is highly dependent of a variety of temporal conditions including the availability of inoculum as well as fresh wounds to serve as inoculation sites. All evidence suggests that the vectors are highly inefficient and proof of their relative importance in establishing new infections is circumstantial. In spite of the limited spread of oak wilt in the Appalachians, the disease can have very consequential influences in localized areas where it may smolder for decades, killing hundreds of oaks over time. The future of this disease could change rapidly if a more efficient vector were to emerge in the oak-rich region.

Regional Impact Report: Oak Wilt in the North Central Region

Authors: Linda Haugen, Joseph O'Brien, Jill Pokorny, and Manfred Mielke, U.S. Forest Service, Forest Health Protection, St. Paul, MN, and Jennifer Juzwik, U.S. Forest Service, Northern Research Station, St. Paul, MN.

Oak wilt disease 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 Forest Service is actively involved in

oak wilt management in the region, through essential research, assistance to state programs, and management on federal lands.

Regional Impact Report: Oak Wilt in Texas

Speaker: James B. Rooni, Texas Forest Service

Since its official laboratory confirmation in the state of Texas in the early 1960s, the fungus which is responsible for the disease known as oak wilt (*Ceratocystis fagacearum*) has been confirmed in over 60 counties in central and west Texas. Since that time, explosive population growth throughout central Texas has resulted in the fragmentation of traditionally large agricultural property holdings into smaller 10-50 acre "ranchettes." This fragmentation has been partly responsible for a transition in land use that moves away from traditional agriculture and toward a more multi-use management style. This new management regime also recognizes the added value that trees and tree canopy can provide. Not only does the introduction and preservation of trees satisfy these new multi-land use objectives which include aesthetics, soil conservation, erosion control, and wildlife habitat, but trees directly contribute to an increase in overall value of the property. This new-found fondness of trees and their value to a growing population of tree-loving Texans also creates certain opportunities. From the inception of the Texas Oak Wilt Suppression Project in 1988, it has been acknowledged that in order to make effective forward progress in the treatment and suppression of oak wilt, the number of new disease outbreaks must be kept under control. The key herein lies in the ability of state forestry officials and their public and private partners to effectively increase the level of oak wilt awareness among these environmentally-conscious landowners. Currently, this is being addressed by creating one-stop sources of technical oak wilt information and assistance, and making them more easily accessible to the public by way of web-based services and GIS technology. By increasing the current levels of oak wilt awareness and empowering the public with accurate and timely information on management of the disease, citizens and communities alike can be empowered to partner with state officials in better managing this statewide epidemic by first effectively addressing oak wilt at the local level.

Infection, Infusion, and Systemic Movement in Trees

Speaker: Dr. Terry A. Tatter, University of Massachusetts

Tree injection or infusion is not new. The first reports of the introduction of materials into trees date to the 12th century. Leonardo DaVinci conducted tree injection experiments on fruit trees in the15th century. Materials in liquids can be injected into the woody tissues of trees, known as xylem, because the pressure within the xylem is below that of atmospheric pressure on the outside of the tree. Under this condition of negative pressure, liquids introduced into healthy xylem through a fresh injection wound will be taken into the xylem and distributed within the tree in the sap stream. The principles of injection and systemic movement are the same regardless of volume applied. Solid materials applied to injection

wounds are dissolved by tree sap and distributed in the same manner as liquids. The explanation for upward sap movement is known as the "evaporation-cohesion-tension theory" and is widely accepted by tree scientists. However, experimental field data from those who studied sap movement in plants and those who studied vascular diseases of trees have reported evidence of downward movement for over 250 years. Many of these researchers used dyes or fungal spore suspensions to track the downward movement of sap in trees. Injection of the antibiotic oxytetracycline has been used to relieve symptoms of bacterial leaf scorch and of peach X-disease. Both these diseases are caused by systemic bacteria which live primarily in the root system. Microinjection has also been used clinically for many years to correct micronutrient deficiencies during the fall. Injection studies by Tattar and Tattar (1999) have found that sap mobile dyes move primarily downward following injection in the fall when soil temperatures are above 5°C (40°F). Similar dye uptake studies, performed during the summer growing season, revealed that both downward and upward movement occur within a tree at most times during the growing season. These findings may help to explain how trunk injection can be effective in the treatment of pathogens that are primarily transmitted through the root system, such as the pathogen that causes oak wilt, as well as provide control of the systemic bacteria. Tattar and Tattar (1999) also found dye movement across the entire cross section of root xylem following lower trunk injection . Multi-year xylem sap distribution in roots would appear to explain vascular disease control beyond one growing season achieved using injectable fungicides, such as reported with propiconazole injections. It appears that portions of trunk-injected materials are transported downward into the roots and are then transported upward in the sap stream in the following season or seasons. This theory could also account for the efficacy of fall-injected materials in the following spring. The current focus of tree injection research has been to develop systemic formulations of antibiotics, insecticides, fungicides, mineral nutrients and plant growth regulators. Research has also focused on improved injection techniques to increase uptake speed and maximize distribution of injected products, and, at the same time, to minimize the effects of injection wounding of the tree. Literature Cited: Tattar, T. A. and S. J. Tattar, 1999. Evidence for the downward movement of materials injected into trees**.** J. Arboriculture 25: 325-332.

Effective Longevity of Propiconazole in *Quercus rubra*

Kelly L. Peacock, Michigan State University

In 1987, more than four decades after *Ceratocystis fagacearum* was identified as the causal agent of oak wilt, the first promising fungicide treatment for this disease was reported: injection of propiconazole into affected oaks. Today, propiconazole treatments are considered an essential tool for managing oak wilt, particularly when high value trees are at risk and in situations where trenching to break root grafts is not a viable option. Research indicates that propiconazole can protect a treated tree for up to two years against root graft transmission of the pathogen. We investigated the duration of propiconazole activity in an oak stand in Michigan without root graft transmission as a determining factor (since trees were directly inoculated). Our results demonstrate that propiconazole inhibits wilt development even at 34 months post-injection; however, several factors apparently influence

its effective longevity, including the amount actually injected, the degree of disease pressure, and the relative distribution of the pathogen and fungicide within a tree.

Studies on the Potential for Developing an Oak Wilt Resistant Live Oak

Speaker: Myron C. (Mike) Gray, Texas A&M University

Oak wilt, caused by *Ceratocystis fagacearum,* was confirmed in Texas in 1961 and has since been found in 60 Texas counties. Much of the epidemiology of oak wilt in Texas has been elucidated. Protocols have been developed to hinder local and long distance spread of the pathogen, to treat infected high-value live oak trees, and to protect high-value trees situated next to diseased trees. What is lacking in the arsenal to defeat this epidemic in Texas is resistant live oak (*Quercus fusiformis*) stock. One unique aspect of the Texas epidemic is the apparent, partial resistance in live oak to the disease. This suggests that either genetic or environmental components are responsible for variable survivability to the pathogen. Previous research at Texas A&M found evidence for heritable, genetically-determined resistance and for phenotypic markers (allozymes) associated with disease tolerance. In order to expand on these findings, we used clone and seedling crops to test for genetically-determined resistance to the pathogen. In one study, resistance of clone groups and seedling groups was tested for a potential correlation with prior levels of disease tolerance exhibited by the parental post-epidemic trees. We also conducted population experiments to test prior findings of a correlation between survival and two allozyme alleles (genetic markers). Some half-sib groups and some clonal groups do perform better than other groups when grown in greenhouses and inoculated with the pathogen. This makes a strong case for the presence of genetic resistance. However, no significant correlation between prior parental tolerance under natural disease conditions and seedling tolerance was found. We attribute this finding to a strong environmental component in determining the survival of live oak trees in natural settings. In the study comparing allozyme allele frequencies between pre- and post-epidemic populations, we found no evidence of markers linked to resistance. Further research will be required for the identification of superior live oak selections with reliable oak wilt resistance.

Oak Wilt Management: A Neighborhood Perspective

Speaker: Nathanial Chapin, Travis Heights Neighborhood Association, Austin, TX

This presentation described how a group of private citizens in the central Austin neighborhood of Travis Heights organized, managed and paid for a large oak wilt containment project that cost nearly $200,000 and involved over a mile of trenching in city streets. The project was accomplished with little public funding or governmental oversight.

Texas Cooperative Oak Wilt Suppression Project: Lessons Learned in the First 20 Years

Speaker: Dr. Ronald F. Billings, Texas Forest Service

Live oaks (*Quercus virginiana* and *Q. fusiformis*), prized in central Texas for their stately beauty and welcomed shade, are being threatened by a destructive disease – oak wilt, caused by *Ceratocystis fagacearum*. In 1988, the Texas Forest Service (TFS), the USDA Forest Service, Forest Health Protection (USFS/FHP) and others initiated the Texas Cooperative Oak Wilt Suppression Project. For twenty years, this project has been managing the oak wilt problem through unique partnerships and local cooperation. Goals of the Suppression Project have focused on increasing public awareness about oak wilt, identifying and mapping active oak wilt infection centers, and partnering with landowners to contain oak wilt spread. More than 2 million dollars of federal cost shares have been delivered to participating landowners since 1988 as an incentive to treat expanding oak wilt centers. To date, the Suppression Project has installed more than 3.4 million feet (648 miles) of trenches to control 2,466 oak wilt centers. Of these, 2,156 centers (87%) were cost shared with $2.1 million of federal funds. An economic analysis has documented that the $9.2 million of federal, state, city, and private funds invested in the Suppression Project have yielded an average benefit:cost ratio of 6:1 and saved Texas communities an estimated $55 million in tree removal, replanting, and fungicide costs. Achievements in public awareness also have been substantial. An Internet web page devoted to oak wilt management in Texas (www.texasoakwilt.org) has been developed, representing a partnership among various stakeholders. In an on-going effort, specialists with TFS and Texas Cooperative Extension have trained various groups of Master Gardeners/Master Naturalists and International Society of Arboriculture-certified arborists on the basics of oak wilt identification and management. These accomplishments and lessons learned in the last 20 years concerning operational management of oak wilt in Texas were summarized.

USDA Forest Service Perspective on Oak Wilt Suppression

Speaker: Dale A. Starkey, USDA Forest Service, Forest Health Protection

For many years, insect and disease suppression has been a part of the efforts of the USDA Forest Service and its state and federal cooperators in fulfilling our mission to the nation. Various enabling laws have provided authority to cooperatively fund suppression projects over the years. Disease suppression efforts in the U.S. began with the discovery of the introduction of several non-native and virulent tree pathogens which cause such diseases as chestnut blight and white pine blister rust. Both federal and state governments have supported suppression efforts against such diseases. Native diseases have also received attention such as oak wilt and dwarf mistletoes. Cooperative oak wilt suppression programs began in the early 1950s in Pennsylvania, West Virginia, and other eastern states; but by the 1970s they were deemed largely ineffective and unnecessary. More recently, outbreaks of oak wilt in Central Texas and Minnesota have precipitated suppression projects that have had better success and continue at the present time. Generally, funding of cooperative pest

suppression projects is provided where a pest presents a significant threat to a major forest resource and the likelihood of success is reasonably high. Availability of funds, competition with other significant pest threats, and politics can often influence funding availability and decisions. Oak wilt suppression projects, like all projects, are considered within this context. While suppression projects remain a fundamental component of the overall USDA Forest Service mission (and that of state agencies, too), prevention activities and early detection/rapid response efforts are being increasingly employed in an effort to minimize the introduction, spread, and effects of insect and disease pests at an early date, before major epidemics can occur.

Other Threats to Oaks: Sudden Oak Death

Dr. Matteo Garbelloto, University of California, Berkeley

Exotic *Phytophthora* species represent a significant threat to native North American oaks. The diseases they cause may range from extremely virulent aggressive pathologies to secondary diseases in need of further weakening factors in order for plant mortality to occur. The severity of the disease may depend both on the pathogen and host species. Exotic Phytopthoras can further be divided in two groups; one of recently discovered introduction and one of species long known in the agricultural world, but only recently-discovered in wild environments in some North American regions. Population genetics information can be deployed to determine linkages between agriculture and wildlands, and at times surprising results about the role played by specific strains may be obtained, indicating that particular emphasis may be needed to prevent introductions of pathogen genotypes linked to some specific source.

***Xylella fastidiosa* and Bacterial Leaf Scorch of Oaks: Subliminal, Subtle, and Suspect**

Speaker: Dr. Edward L. Barnard, Florida Division of Forestry

The fastidious xylem-inhabiting bacterium *Xylella fastidiosa* is a widely-distributed vascular pathogen occurring in a variety of plants and trees. Vectored by several insects (primarily leafhoppers), *X. fastidiosa* causes various symptoms including marginal leaf scorch, decreased fruit production, declining vigor, delayed bud break, stunting, dieback, and sometimes death in susceptible hosts. Surveys have documented a wide distribution of *X. fastidiosa* in oaks, and it is considered by some to be a debilitating pathogen in certain species, especially red oaks. What does all this portend for oak populations? What is the role of *X. fastidiosa* in oak decline? How does *X. fastidiosa* interact with other oak pathogens? This paper briefly reviews the state of our understanding, offers some hopefully relevant commentary, and poses some questions worthy of research attention.