

Oak Wilt Qualification Course and Assessment May 19-20, 2022 Glen Rose, Texas

May 19

8:00-8:20	Registration/Coffee
8:20-8:30	Welcome/Introductions/Oak Wilt Qualification Objectives-Gene Gehring
8:30-10:00	Tree Biology & CODIT-Dr. David Appel, Texas A&M University (2)
10:00-10:15	Break
10:15-12:30	Oak Wilt Biology, Control Techniques & Extent in Texas-Appel, Texas A&M University (16)
12:30-1:00	Lunch
1:00-2:15	Oak Wilt in Relation to Other Tree Diseases, Freeze Damage & Drought Mimicry-Appel, Texas A&M University (44)
2:15-2:30	Break
2:30-3:30	Texas A&M Forest Service Practices & Protocols & the Oak Wilt Suppression Project- Dr. Demian Gomez, Texas A&M Forest Service (61)
3:30-4:00	Five Step Diagnosis for Oak Wilt-Karl Flocke, Texas A&M Forest Service (74)
	May 20 - Field
8:00-8:30	Coffee
8:30-9:30	Diagnosis & Treatment Planning-Edmondson, Texas A&M Forest Service
9:30- 10:30	Fungicide Injection Demonstration - Gehring, ISAT, Emmett Muennink, Arborjet
10:30 – 11:30	Tissue Sampling and -Appel, Texas A&M University
12:00-1:00	Lunch
1:00-1:15	Oak Wilt Qualification Protocols/Partnership Website & Contacts-Gene Gehring, ISAT
1:15-3:00	Qualification Exam
3:00	Adjourn

• All presentations can be found at http://isatexas.com/presentations



Tree Biology

Aspects relative to the impact of oak wilt on tree health and function

ISA-T Oak Wilt Qualification Training
May 19 - 20, 2022
Glen Rose, TX

David Appel
Dept. of Plant Pathology and Microbiology
Texas A&M University,
College Station, TX 77843



1

What is a Tree?

Two Perspectives

Old

Plants at least 6 m (20 ft) high at maturity and, more importantly, having secondary branches supported on a single main stem or trunk (see shrub for comparison).





2

What is a tree?

New

Compartmented, generating system that survives, when injured, by forming new barriers and strengthening old barriers that resist the spread of microorganisms, and that protect the structural, transport and storage systems.



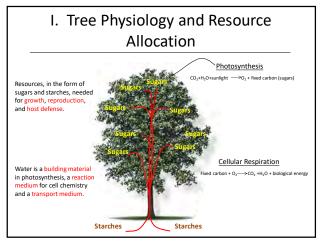
Or. Alex Shigo



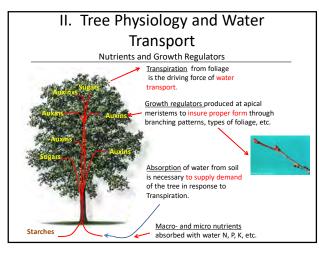
Tree Biology and Response to Injury and Disease

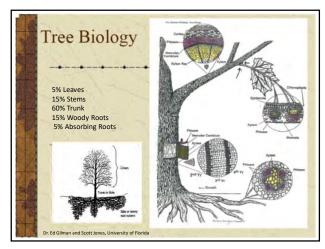
- · Important to understand how a tree functions,
- Understanding certain aspects of tree anatomy help in analyzing tree health,
- Also gives clues to the various treatment options and their limitations.

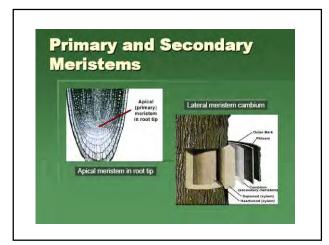
4

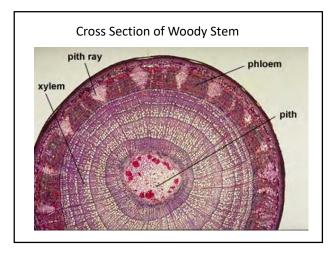


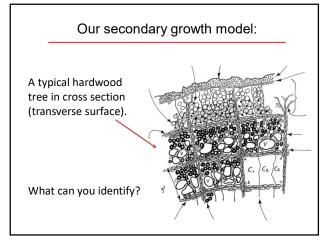
5



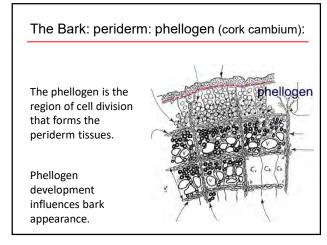








The Bark: = Periderm The bark is everything outside the vascular cambium. As you can see, there is a lot going on in the bark.



The Bark: periderm: phellem (cork): Phellem replaces the epidermis as the tree increases in girth. Photosynthesis can take place in some trees both through the

13

phellem and in fissures.

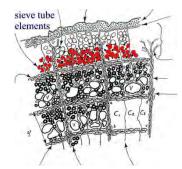
Phelloderm is active parenchyma tissue. Parenchyma cells can be used for storage, photosynthesis, defense, and even cell division!

14

The Bark: phloem: Phloem tissue makes up the inner bark. However, it is vascular tissue formed from the vascular cambium.

The Bark: phloem: sieve tube elements:

Sieve tube elements actively transport photosynthates down the stem.

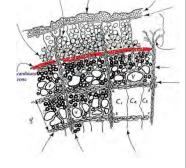


Conifers have *sieve cells* instead.

16

The cambium:

The cambium is the primary meristem producing radial growth.

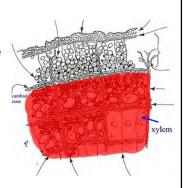


It forms the phloem & xylem.

17

The Xylem (wood):

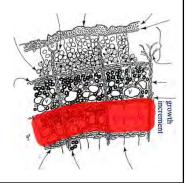
The xylem includes everything inside the vascular cambium.



The Xylem: a growth increment (ring):

The rings seen in many trees represent one growth increment.

Growth rings provide the texture seen in wood.

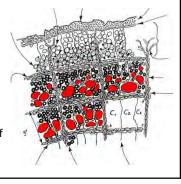


19

The Xylem: vessel elements:

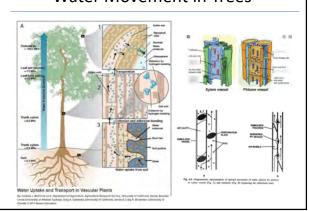
Hardwood species have vessel elements in addition to trachieds.

Notice their location in the growth rings of this tree



20

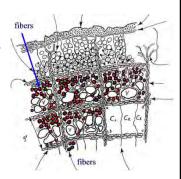
Water Movement in Trees



The Xylem: fibers:

Fibers are cells with heavily lignified walls making them stiff.

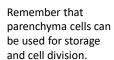
Many fibers in sapwood are alive at maturity and can be used for storage.

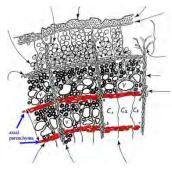


22

The Xylem: axial parenchyma:

Axial parenchyma is living tissue!

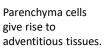


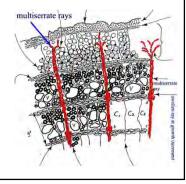


23

The Xylem: rays (multiserrate & uniserrate):

Rays are radial parenchyma cells.

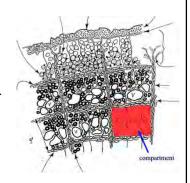




The Xylem: a natural compartment:

Notice that a natural compartment is formed with living tissue at its borders.

How does this support the CODIT model?

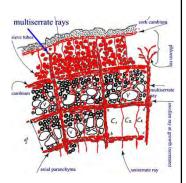


25

The Symplast:

The symplast is the living portion of the tree.

It is all connected via plasmodesmata (tiny passages in the cell walls.)



26

What about heartwood?

Heartwood is xylem that has been chemically altered because of its age.

Not all discolored wood is considered heartwood!

Not all trees form heartwood.

Heartwood is part of the apoplast.

CODIT

Compartmentalization

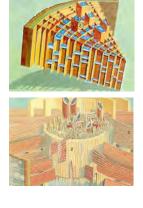
Decay

In

Trees

The 4 Walls

- Tyloses Axial parenchyma and annual growth components Ray cells Wound response of cambium

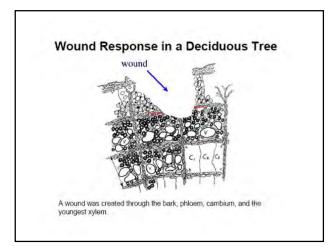


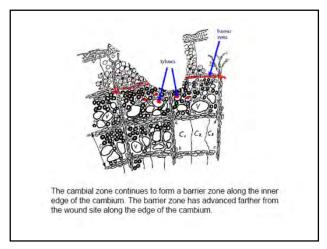
28

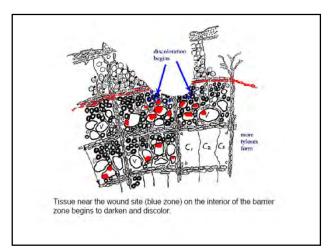
Compartmentalization:

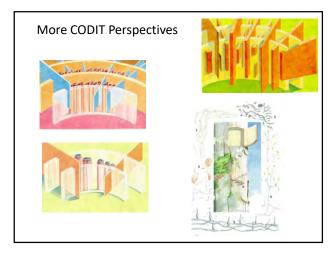
- · Explains why trees rot from the inside out,
- Explains why target pruning is best,
- Explains why wound paints not needed for preventing discoloration and decay,
- Explains why injecting a tree is so difficult,
- Explains how trees Respond to many different diseases.

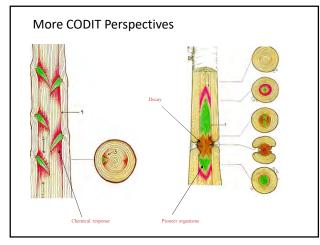
29

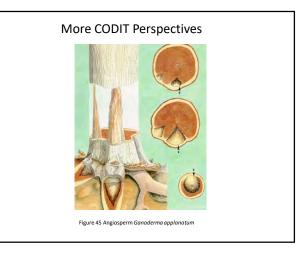












35

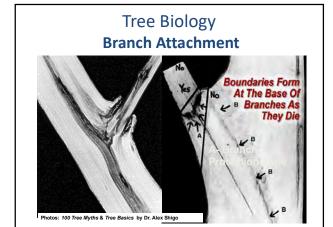
What does it all mean?

- Trees can live longer than other plants.
- They can get bigger than other plants.
- They can respond to damage, disease, insects, and environmental conditions successfully.
- Trees are a long term investment.

Branch Attachment Branch Collar

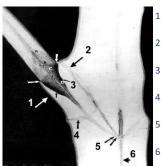


37

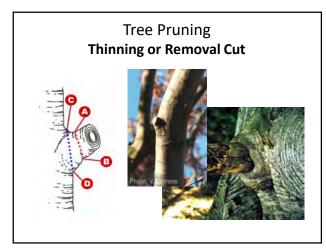


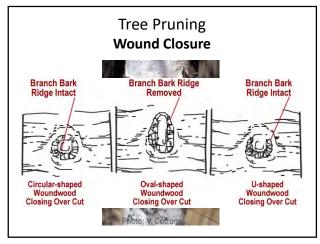
38

Tree Biology Branch Protection Zone



- 1. Branch Collar
- 2. Branch bark ridge
- 3. Branch protection zone
- 4. Dormant bud
 - Pith protection zone
- . Pith





Tree Pruning Wound Dressings

Oak Wilt ID, Control, and Prevention

2021 Qualified Arborist Training May 19 - 20, 2022 Glen Rose, TX

David Appel
Dept. of Plant Pathology and
Microbiology
Texas A&M University
College Station, TX







1

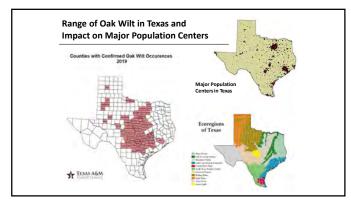
Origins of Oak Wilt

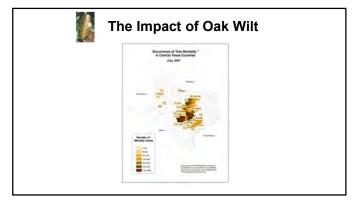
- First described in 1941
 - Wisconsin
- Probably a disease reported as early as the 1890s
 - North Central states
- Also probably a disease of live oak in Austin, TX in the 1930s



2









The Impact of Oak Wilt Rural Areas

Thousands of acres of live oaks have become victims of oak wilt in rural areas of Central Texas.



7

The Impact of Oak Wilt



Rural Residential Areas

Loss of live oaks to oak wilt has greater economic impact around ranch houses.

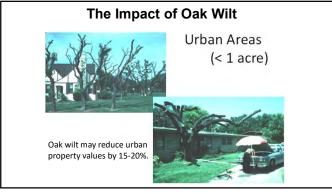
8

The Impact of Oak Wilt



Suburban Areas (1-10 acres)

The many new "ranchettes" (<10 ac) in Central Texas have increased incidence and impact of oak wilt.



The Impact of Oak Wilt

Ecosystem Impact

• Golden cheeked warbler



11

The Impact of Oak Wilt

Ecosystem Impact

• Ash Juniper encroachment



Why Did Oak Wilt Become Epidemic in the Live Oak Savannahs of Central Texas? Species Composition and Stand Structure

- Tree community and structure,
 dominance of live oaks and red
 oaks,
 common theme with oak wilt
 throughout Upper Midwestern and
 Mid-Atlantic States in the U.S.

 Past Influence of European
 settlement and land use
 practices,
 fire control,
 overgrazing,
 selective removal of non-oak
 species,

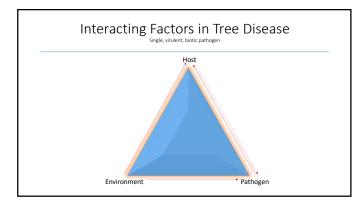
 Current wounding....ranchettes.
- Current wounding....ranchettes, developments, etc.

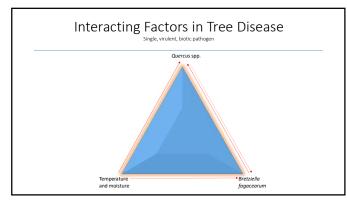


13

What is Plant Disease? The Disease Triangle Host • Pathogen • Environment

14



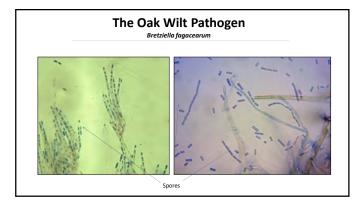


Cause of Oak Wilt

- First described as Chalara quercina
- Endoconidiophora quercina
- Ceratocystis fagacearum
- Bretziella fagacearum



17



Oak Wilt Biology, Interacting Factors

Bretziella fagacearun

- A fungus (Ascomycete)
- Mostly parasitic, but also saprophytic
- A vascular parasite
- Produces two kinds of spores
- Forms mats of tissue under bark on certain trees
- Heat sensitive
- Origin unknown



19

Oak Wilt Biology, Interacting Factors

Genus Quercus

- 70+ oak species in Texas
- Belong to the red oaks and the white oaks
- Red oaks extremely susceptible
 - e.g. Spanish oak, blackjack oak
- White oaks have degrees of resistance
 - e.g. Post oak (high), live oak (low)

20

Oak species affected by oak wilt in Texas

RED OAKS = Susceptible

Q. buckleii

Spanish Oak

Q. marilandica Q. nigra Blackjack Oak Water Oak

WHITE OAKS = Resistant (* Immune)

Q. sinuata var. breviloba

Shin Oak

Q. laceyii

Lacey Oak

Q. polymorpha

Mexican white oak

Q. stellata

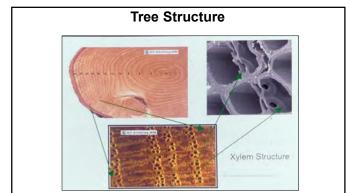
Post Oak

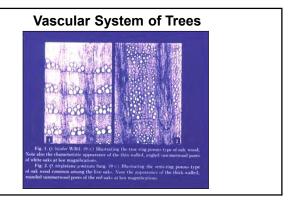
LIVE OAKS= variable

Southern live oak

Q. virginiana Q. fusiformis

Plateau live oak





23

How do oaks die?

- Parmeter, J.R., Kuntz, J.E., and A.J. Riker. 1955. Oak wilt development in bur oaks. Phytopathology 46:423 435.
- Infected bur and white oaks in Wisconsin...:

 - "...rarely die..."

 - symptoms on "...scattered branches only..."

 - less than 1% typically die.
- iess than 1% typically die.
 Infected red oaks...":
 "....rapid and complete wilting...",
 death comes quickly for infected trees,
 members killed in large "pockets".
 nearly 15% typically die.

ONE WILL SECOND	
£ lk Provincia i k fi	Ayes, and A. J. Rikes
And the second s	Break Allery of the country of the part of
The second section of the section of the second section of the section of the second section of the second section of the section	pies entro de les montantes que unite sanse tellenti, sup- tima descriptions homes de l'and pies de la constante de la confession de la tempo, misma, l'an de la companie de la colonne qui descriptions de la companie de la colonne qui description de la colonne del la colonne de la colonne del la colonne de la colonne

What Did They Do? Methods

- Artificially inoculated red oaks and bur oaks in a mixed stand,
 - used several inoculation methods to induce infections with B. fagacearum,
 - also injected with dyes and radioactive tracers,
- · Analyzed disease development and vascular responses,
 - cut cross sections and did histological analyses,
 - observed movement of dyes and tracers.

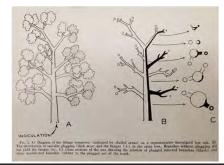
25

Results and Conclusions

- Bur oaks were difficult to inoculate and were rarely killed,
- Complete new annual rings were laid down each year,
- Resistance depended on limiting the pathogen growth in two
 - radial growth,
- growth into new rings formed post-inoculation,
- Tyloses formation and vascular occlusions/staining appear to be resistance responses in bur oak.

26

Tree Resistance to Infection



More Recently (1980)

Cytology and Histology

Colonization of Resistant and Susceptible Oaks by Ceratocystis fagacearum

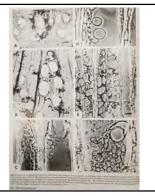
- Red oaks vs. white oaks,
 Artificially inoculated branches of each,
 Did histological investigations of xylem tissues.



28

Results and Conclusions

- Tyloses, gums, bubble-like structures, and darkly stained parenchyma cells associated with the disease,
- Fungus successfully limited in the white oaks,
- Colonization in the red oaks unimpeded,
 Restricted pathogen growth in white oaks due to "...more intense and different host response as well as anatomical variability."



29

Local Spread





Local Spread

- Root grafts
- live oaks and live oaks live oaks and red oaks





31

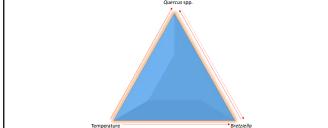
Local Spread

· Root connections – live oaks



32





Oak Wilt Biology, Interacting Factors

Temperature and Moisture

- Spores for insect spread form in cool, moist conditions
- Heat suppresses growth and survival of the pathogen
- During summer, pathogen eliminated from branches and limbs
- Heat suppresses vector activity

34

35





Fungal Mats

- · Contain spores for spread by the beetle
- Produced **only** on red oaks
- Mycelial mats form under bark
- Multiple mats per tree
- Produce a sweet odor like rotting melons



Fungal Mats

- Fungal mat production is accelerated by cool, moist weather
- In Texas trees killed in late summer may produce mats the following spring.



37

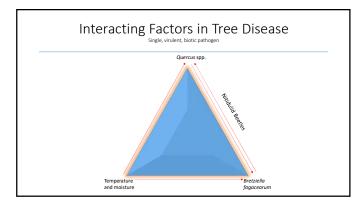
Beetle Spread



Nitidulid Beetle



38



Beetle Spread



- Beetles are only opportunistic
- Sap feeding beetles
- Attracted to sweet smelling odors- ripe fruit, fresh wounds on trees
- Peak beetle populations is in the spring
- High temperatures limit beetle activity
- Visit healthy trees rather than dead trees

40

Beetle Spread

Attracted to sweet smelling odors- ripe fruit, fresh wounds on trees, fungal mats.



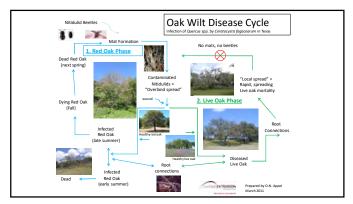
41

Beetle Spread



Part II — Disease Cycle, Control

43



44

Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

Diagnosis – 5 step process

- 1. Pattern of disease in the population of trees
- 2. Pattern in individual trees
- 3. Foliar symptoms
- 4. Presence of fungal mat
- 5. Taking Samples

46

Oak Wilt Diagnosis

1. Pattern of disease in the population of trees

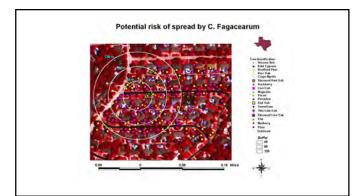
Live Oak Center

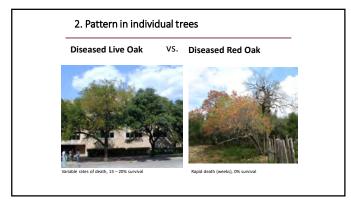
S. Red Oak Center

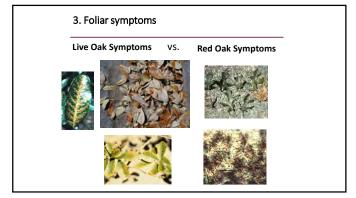


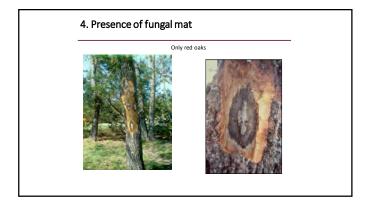


47









5. Taking Samples

- Bole and Branch Samples
- Confirm presence of pathogen





52



53

TPDDL capabilities • General microscopy



Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

56

Pruning – paint wounds

- Avoid Pruning in Spring
- Use wound paints if you do prune





Tree Pruning Wound Dressings



59

Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

Firewood – Cover red oaks logs

- Cover infected red oak logs with clear plastic
- Leave covered for the summer
- C. fagacearum is killed by high temperatures > 36°C





61

Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

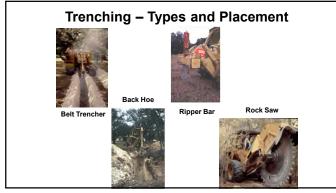
62

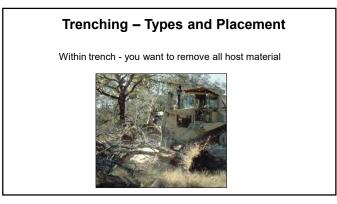
Trenching – Types and Placement

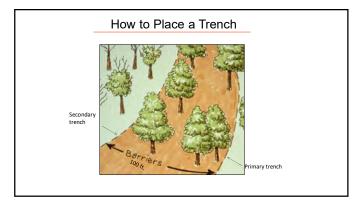
- Trenching (at least 4 feet deep) to halt oak wilt spread through connected root systems
- Roguing (removal of diseased trees within trenched area)











Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

67

Fungicide – Technique and Implementation



- Used on trees under disease pressure- on advancing margin of disease centers
- Therapeutic and Preventative rate based on size of tree
- Treat trees inside trench
- Expose root flares & Inject on root flares igh low concentration

68

Fungicide – Technique and Implementation



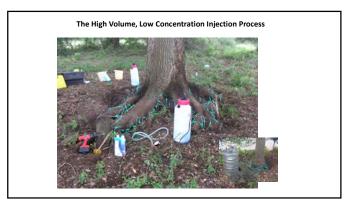
- · Advantages of root flare injections
 - bark is thinner below soil line
 - Increases the number of potential injection sites
 - Incase of future injections, spreads out the wounding
 - Research demonstrated superior distribution of fungicide

Fungicide – Technique and Implementation Fungicide Fungicide Trees being injected

The second second









Criteria for Successful Oak ARBORIET Wilt Treatment

- PRO KIT
- Reliable,
- Verifiable documentation of research results,
- Must increase survival of treated trees over natural population,
- Safe,
- Economical,
- Reasonably easy to apply.



73

Oak Wilt Control Options

- Always starts with diagnosis
- Prevention avoid wounding in spring
- Prevention use wound paints
- Prevention cautious movement of firewood
- Direct control trenching
- Direct control intravascular injection with fungicides
- Plant resistant/immune trees

74

Tree Selection

- 1. Purpose
 - why am I planting this tree?
- 2. Limitations
- can I plant any tree I want? 3. Species
- are all oaks the same? 4. Quality
 - does it really make a difference?



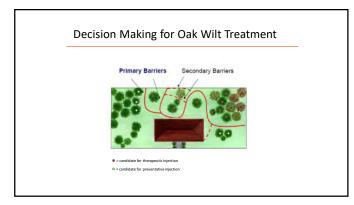














Oak Wilt in Relation to **Other Tree Diseases**

ISA-T Oak Wilt Qualification Training May 19 - 20, 2220 Fredericksburg, TX

David Appel

Dept. of Plant Pathology and Microbiology Texas A&M University, College Station, TX 77843



1

Bretziella fagacearum and the Unique Disease Oak Wilt

- Where did it come from?
- Diagnostics where's the wilt?
 - Veinal necrosis,
 - The casting of green leaves,
 - How does it relate to Dutch elm Disease?
- The inoculum source the fungal mat,
 - Just nitidulids?
 - What about bark beetles?
- A biotroph?

2

Examples of Existing Tree Diseases in Texas

- Herbicides
 Drought, other abiotics
 Declines (numerous species)
 Black spot (elm)
 Oak leaf curl
 Actinopelte on oak
 Leaf rust on oak
 Unkown virus on hackberry
 Brown spot needle blight
 Needle rusts
 Lophodermium needle cast
 Anthracnose (ash)

- Anthracnose (ash)
- Anthracnose (psamore) Foliar

 Hypoxylon cankers (hardwoods)

 Hypoxylon cankers (hardwoods)

 Hypoxylon cankers (hardwoods)

 Hypoxylon cankers (hardwoods)

 Folian condition canker

 Botrydiplodia canker

 Phomopsis (and others) tripblight

 Pitch canker

 Cedar x Hawthorne rust

 Fusiform rust

 Crown gall

- Branch, Trunk

Bacterial wetwood Dutch elm disease Oak wilt Native elm wilt

Fusarium Wilt (mimosa)
Pinewood nematode
Bacterial leaf scorch
Fire blight
Lethal yellows on palms
Ganoderma root rot

Heterobasidion root rot

Sudden oak death (nurseries)	
Cotton root rot	
Root knot nematode on Pecans	
Heart rots (numerous species)	Root Rots
Sooty mold	
Ball moss	

Vascular

Non - pathogens

Examples of pathogens Biotic Pathogens Fungi Bacteria Viruses **Abiotic Pathogens** Nutrient deficiencies Poor water relations Climatic extremes Nematodes Air pollution Phytoplasmas Toxic chemicals Parasitic flowering plants Herbicides **The Declines** Combination of abiotic and biotic pathogens Possibly the most common of tree disease, syndromes May occur on any species of trees Symptoms usually similar for different species and locations

Example of an Abiotic Pathogen

Iron Chlorosis

- · Caused by lack of iron,
- Particularly in high pH soils (>
- More of a problem on non-native plants (but not exclusively), Also often prevalent on disturbed sites,
- Difficult to correct, but supplemental iron can be used

 - Soil applications,Direct injection of tree.



5

Examples of an Abiotic Pathogens

Herbicide Damage - Treaty Oak

Velpar®

Hexazinone - broad spectrum weed and brush control





6

Examples of Abiotic Pathogen

Severe Drought = Severe Stress = Disease

- Trees respond to drought,
- compensate for the stress,
- If unsuccessful, symptoms develop,
- If sufficiently severe, tree will die.









7

Examples of Biotic Pathogens

Common Foliar Problems on Trees in Texas







Powdery Mildew on oak

Rust on post oak

K



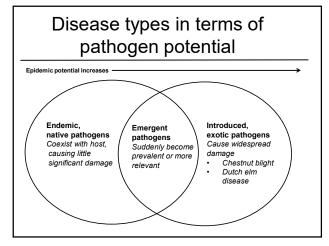
Fireblight on Bradford Pear

Virus on hackberry

8

Some Attributes of Foliar Diseases and Their Control

- Broadleaved, deciduous hardwoods rarely harmed by foliar diseases,
- Potential damage usually doesn't justify extraordinary control measures,
- · Chemical sprays generally not recommended,
- Sanitation (rake leaves, pick up twigs, remedial pruning) usually sufficient,
- Good tree health practices.



Vascular Diseases

How does oak wilt compare to other similar diseases?

- Some of the most damaging of all tree diseases,
- · Usually rapid, often fatal,
- Many are considered to be introduced, exotic pathogens,
- Usually vectored by insects.

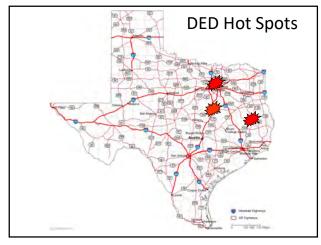
11

Dutch Elm Disease

The Pathogen



- Ophiostoma novoulmi,
- · Vascular parasite,
- Invaded North America in mid 1920s,
- Spread throughout native elm population,



13

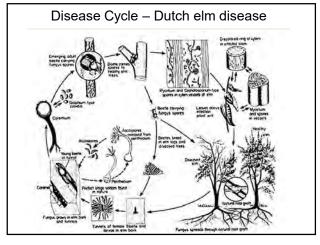
Dutch elm disease

Disease Biology

- Elm bark beetles are vectors,
- Also spreads through root grafts,
- Inoculum forms in beetle galleries,
- Every tree source of inoculum.



14



15

Dutch elm disease

Management – compare to oak wilt





- Detection,
- · Isolation,
- · Removal,
- · Disposal,
- · Injection,
- · Host resistance.

16

Another Way to View Pathogens Pathogen "lifestyles" – a continuum of extremes

- Saprophyte vs. parasite,
 - Based on nutrient exchange = "trophic" relations,
- · Biotroph vs. necrotroph,
 - Obligate biotroph,
 - absolute requirement for a living host =strictly parasitic,
 - Nectroph,
 - lives off of dead tissue = saprophyte,
 - Hemibiotroph,
 - start off with latent period (asymptomatic phase),
 - the switches to a "killing spree",
- · Trees respond (resist) these pathogens accordingly,

17

Examples of pathogens Abiotic Pathogens

Nutrient deficiencies Poor water relations Climatic extremes Air pollution Toxic chemicals Herbicides

Biotic Pathogens

Fungi Bacteria Viruses Nematodes Phytoplasmas Parasitic flowering plants

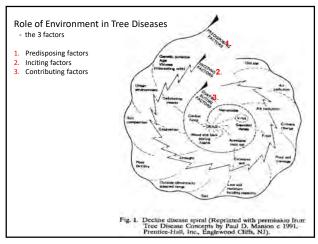
The Declines

Combination of abiotic and biotic pathogens Possibly the most common of tree disease, syndromes May occur on any species of trees Symptoms usually similar for different species and locations

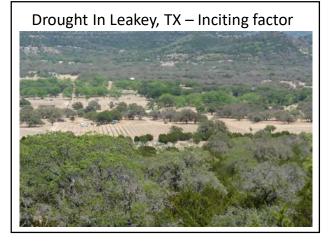
Types of Pathogens The Declines

- Combination of abiotic and biotic pathogens,
- Possibly the most common of tree disease, syndromes
- May occur on any species of trees,
- Symptoms usually similar for different species and locations.

19



20



Freeze – another inciting factor



22

Summary of Drought Effects

Predisposing factor, Inciting factor

- Mild drought = mild stress = little strain,
- no detrimental effects,
- Moderate drought = moderate stress = predisposing strain,
 - wilting, mild scorching,
 - infection by pests and diseases that normally do no harm,
- Severe drought = severe stress = disease,
 - drought becomes a pathogen,
- dieback, death......
- Same for freeze damage.





23

Long-Term Consequences of Drought

Drought as a Predisposing Factor, if Tree Survives

- Weakened, starch depleted trees,
- · Unable to respond to pests and pathogens,
 - Normally do them no harm,
 - "secondary", "weak" pathogens,
 - Usually consist of cankers, root rots, wood boring insects,
- Syndrome called "Diseases of Complex Etiology" or Declines.

24

Tree Diseases Expected to Increase Due to Drought in Texas

Contributing Factors and Their Control

- 1. Twig and branch cankers,
 - Hypoxylon canker on oaks,
 - native elm wilt on cedar elm,
- 2. Root rots,
 - Ganoderma root ,
- 3. Bacterial Leaf Scorch,





25



Endothia gyrosa on

Cankers



Nectria canker on

Nectria canker on dogwood

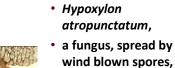
Hypoxylon atropunctatum on oak

26

Hypoxylon Canker

Pathogen, Hosts







 been found on oaks, elms, sycamores, pecans.

27

Hypoxylon Canker

Disease Biology



- Non-aggressive facultative parasite,
- · Present on healthy trees,
- Some level of predisposition of host required,
- Poor water relations the most commonly implicated source of stress.



28

Commonly Held Opinions and Observations of Hypoxylon Canker

- · "Colonizes stressed trees",
- "Weak parasite",
- · "Causes no harm to healthy trees"
- "...lives harmlessly in very outer bark and aids the tree in quickly shedding limbs and branches..."
- "It is extremely rare to observe Hypoxylon canker on the trunk and the tree recover"
- "Disease does not spread from tree to tree"
- "It would be inaccurate to say a tree died from Hypoxylon canker"

29

Conclusions - Bassett and Fenn, 1984

Research on Hypoxylon Canker

- Most important conclusion the "natural" occurrence of Hypoxylon in 57% of branches and 11% of trunks of apparently healthy oaks,
 - Note: not ALL trees were colonized,
- Latent colonization explains the rapid increases following drought,
- · Previously found species differences were not observed,
 - greater incidence of stromata development in red/black oaks vs.
 white/post oaks probably due to differences in drought resistance,
 - note: this was borne out in Brazos Valley, where incidence in water oaks exceeded post oaks in 2011.

30

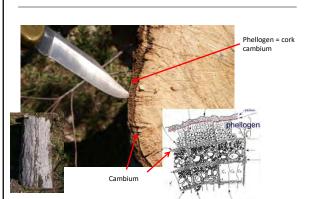
Observations on Hypoxylon Canker of Oaks in Texas - Pathogen, Hosts



- *H. atropunctatum* on red oak species,
- Not always lethal,
- Trees appear to be to compartmentalize expanding cankers,
 - Success probably depends on stress management,
- May have implications for control.

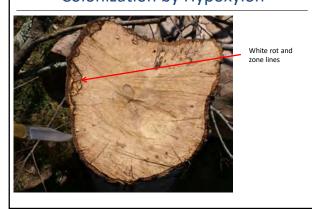
31

Colonization by Hypoxylon

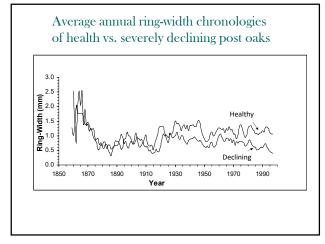


32

Colonization by Hypoxylon



33



Bacterial Leaf Scorch

Pathogen, Hosts



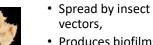
- Xylella fastidiosa,
- Xylem limited, fastidious bacterium,
- Many different strains,
- Oaks, elms, sycamores, mulberry, catalpa, maple, birch, sweetgum, many fruits

35

Bacterial Leaf Scorch

Disease Biology







- Produces biofilms,Sharpshooters,
- Limited by low temperatures,
- Stress probably involved to some degree,
- Confused with OW.

36

Bacterial Leaf Scorch Management Best Practices to maintain tree health, Proper diagnosis critical, Vector management, Antibiotic injections (?), Treatments to improve stress response, Cambistat®

37



Ganoderma Root Rot

Pathogen, Hosts

- Ganoderma spp.
- · Occurs statewide,
- A basidiomycete, produces "conks",
- Wide host range on hardwoods, some conifers.

38

Disease Biology P S II O A tt

Ganoderma Root Rot

- Produces windblown spores,
- Infects through wounds on roots at base of tree,
- Also spreads tree to tree by overlapping roots,
- Stress undoubtedly involved in disease development.

39

Ganoderma Root Rot

Management



- Best Practices to maintain healthy trees,
- Grind stumps?
- Proper tree selection,
- Avoid basal wounds,
- · Vertical mulching!

40

Managing Declines Note how they compare to Oak Wilt Management!

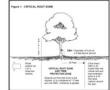
- Improve tree health, avoid further stress,
- Plant the proper tree for the site,
- · Manage fertilization and watering practices,
 - Note vertical mulching,
- · Manipulate tree health directly,
 - Cambistat[®],
- · Remedial pruning,
- · Proper pruning,
- Reduce stress.

41

Vertical Mulching for Enhancing Tree Health

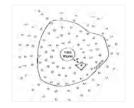
Objectives

- · Improve soil properties,
- Stimulate growth of root system,
- Increase tolerance to soil pathogens,
- Enhance growth of crown and tolerance to canker pathogens, heart rots, and other contributing factors.
- Pan, J.F. 1958. Effects of Vertical Mulching and Subsoiling on Soil Physical Properties. Agron J 51:412-414.
 - decreased bulk density values,
 - increased soil aggregation.



Implementing Vertical Mulching

- 1. Identify root zone,
- 2. Drill holes,
- 2" wide, 18 24 " deep 3. Fill holes with treatment,
- - Ground organic matter, mulch, bark, etc.





43

Confusing Drought With Other Problems – Oak Wilt

- Anecdotal evidence this may have occurred during the 1950s drought,
- Oak wilt can be a very difficult disease to diagnose
- · Symptoms may resemble drought,
 - Dieback, slow decline in some live oaks
 - Failure to find specific foliar symptoms is common,
 - Red oaks pose further complications
 - Foliar symptoms of oak wilt and drought can be similar.
- The services of the Texas Plant Disease Diagnostic Laboratory may be needed.

44

Comparison of Oak Wilt and Drought Symptoms in Live Oak Foliage









45

Comparison of Oak Wilt and Drought Symptoms in Live Oak Trees





Oak Wilt

Drought

46

Foliar Oak Wilt Symptoms in Red Oak







47

48

https://discussions.texasbowhunter.com/forums/showthread.php?t=5 96358

Community Forum of TexasBowhunter.om





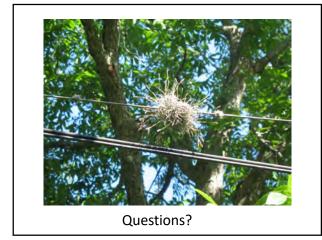




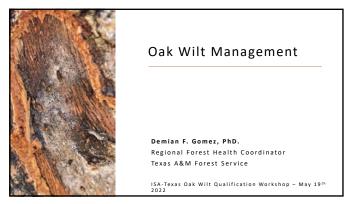
Probably Overwatering Mimics Oak Wilt Symptoms

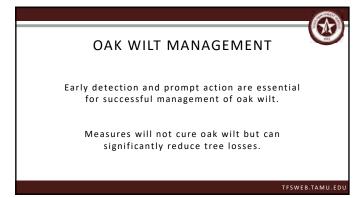


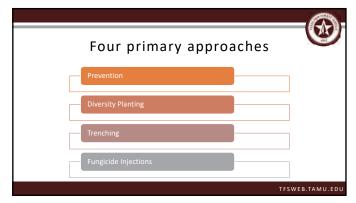
49



50







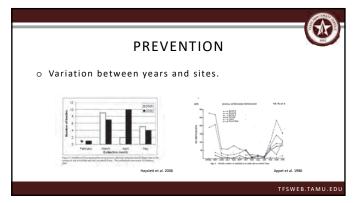


PREVENTION

To prevent new oak wilt infections from occurring through pruning management, diseased red oak control (cost-shareable) and firewood management

TFSWEB.TAMU.ED





PREVENTION

- o Reduce opportunity for fungal mats to form.
- o Destroy infected Red oaks.
- Do not salvage infected Red oaks for firewood!



7

PREVENTION

- Transport and use only dry, wellseasoned red oak firewood.
- Purchase wood locally that has been thoroughly dried for at least one full year.
- o Cover wood with clear plastic and bury the edges to prevent insects from leaving the pile.



8

TREE PLANTING

To reduce the effects of oak wilt by creating species diversity in the landscape

TFSWEB.TAMU.EDU









TFS Tree Planting Resources

- o Texas Tree Planting Guide. https://texastreeplanting.tamu.edu
- o Central Texas Restoration and Recovery Program.

https://tfsweb.tamu.edu/CentralTexasRestorationandRecoveryProgram/

o West Texas Nursery.

http://tfsweb.tamu.edu/WestTexasNursery/

TFSWEB.TAMU.ED

13



TRENCHING

To halt the localized spreading of the oak wilt fungus through interconnected root systems by **mechanically severing** these **connections**, thus providing a physical barrier to the fungus (cost-shareable)

TFSWEB.TAMU.EDU

14

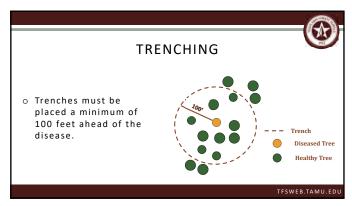


TRENCHING

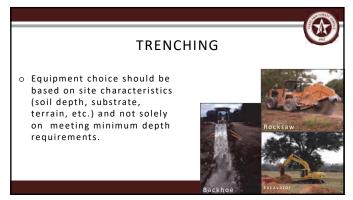
- Determine the disease perimeter using visual symptoms (pattern of mortality, leaf symptoms, etc.).
- Make any necessary adjustments for utilities, fences, roads, etc.



TFSWEB.TAMU.ED









- o Backfill the trench using the same soil.
- Pushing all oaks within the barrier may improve trench effectiveness.







- The disease should progress to the barrier within 2 - 4 years.
- Repeat procedures if a break-over occurs.



TFSWEB.TAMU.EDU

20

TRENCHING

- o Trench fail:
 - $\circ \ \ \text{Misplaced the trench}.$
 - o Local conditions.



TESWER TAMILED



INJECTION

To prevent or halt the invasion of the oak wilt fungus throughout the water conducting vessels of oaks by introducing a specific fungicide into these tissues, thus keeping these tissues open and functional.

TFSWEB.TAMU.ED

22

INJECTION

- Protect high-value oaks in advance of an expanding oak wilt center.
- o The best candidates for treatments are healthy or non-symptomatic live oaks within 75' to 100' from symptomatic trees.



23

INJECTION

- Success depends upon the health of the tree, application rate, and possibly the injection technique.
- Injection does not stop root transmission of the fungus!



INJECTION

 Macro-injections of Alamo® have been scientifically proven effective and continue to be the industry and TFS standard.



TFSWEB.TAMU.ED

25



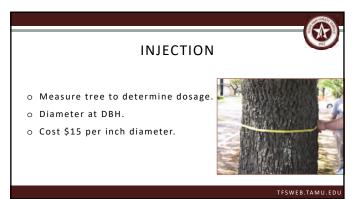
26

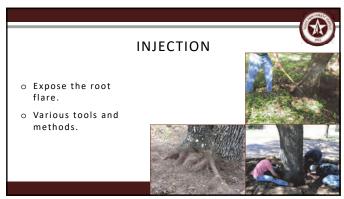
INJECTION

- o Reliable.
- Verifiable documentation of research results.
- Must increase survival of treated trees over natural population.
- o Safe.
- o Economical.
- o Reasonably easy to apply.
- o Legal to use!



TESWER TAMILED







INJECTION

- Drill holes every 4" to 6" along the flare roots all the way around the tree.
- o Aim for center of root



31

INJECTION

- o Attach the harness
- o Install Ts, avoid valleys.
- o Don't install in areas of discoloration.



32

INJECTION

- o Mix fungicide solution.
- 10-20 ml of fungicide per 1" trunk diameter in 1 liter of water per 1" trunk diameter.
- o Pressurize the system to 10-15 psi.



INJECTION

- $\circ\,$ Bleed all air out of the harness and close the system.
- o Check for and rectify leaks.
- o Monitor for leaks, drops in air pressure, blown tees, and adjust as necessary.



34

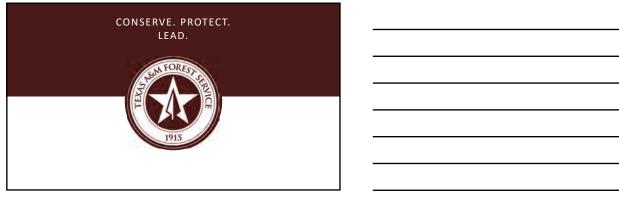


- o Takes 2-3 hours to take product.
- o During spring and more humid, and breeze.
- o Heat and fungicide can be phytotoxic.
- o Wait 2-3 years to retreat.



35







The Oak Wilt Suppression Project

Demian F. Gomez, PhD.
Regional Forest Health Coordinator
Texas A&M Forest Service

ISA-Texas Oak Wilt Qualification Workshop – May 19th 2022

1

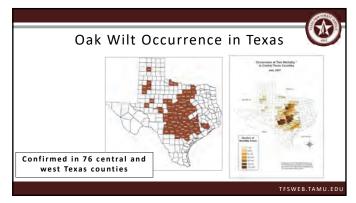


Oak Wilt Suppression Project

"The overall goal of the Texas A&M Forest Service's Cooperative Oak Wilt Suppression Project is to minimize the spread of oak wilt (Bretziella fagacearum) in central Texas"

TFSWEB.TAMU.EDU

2





Oak Wilt Suppression Project

- Since 1988.
- Initiated by the Texas A&M Forest Service and the USDA Forest Service Forest Health Protection (USFS/FHP).
- Professional staff to assist private landowners across central Texas.

TFSWEB.TAMU.EDI

4



Private and Public Partners

 Texas A&M Forest Service, the USDA Forest Service Forest Health Protection (USFS/FHP), Texas AgriLife Extension, Texas A&M AgriLife Research, Texas Plant Disease Diagnostic Lab, Master Gardeners and Master Naturalists, and the Texas Chapter, International Society of Arboriculture.

TFSWEB.TAMU.EDU

5



Goals of the Suppression Project

- 1) Provide \boldsymbol{public} $\boldsymbol{awareness}$ and $\boldsymbol{education}$ about oak wilt
- 2) Identify and map **mortality centers** with ground verification of oak wilt
- 3) Provide treatment recommendations and cost-shares (when applicable) to landowners
- 4) Conduct **post suppression evaluations** on cost-shared treatments to determine efficacy
- 5) Establish and maintain detailed and accurate records

TFSWEB.TAMU.EDU

Regional Areas • Seven foresters/woodland ecologists. • Six central Texas regions. • Provide technical on-site services to landowners.

TESWER TAMILED

7

Cost-Shares



Cost-shares may be available to private landowners:

- Containment trenching around oak wilt centers
- Pushing or rouging all oaks within the boundaries of costshared trenches
- Removal of diseased red oaks in urban areas

TFSWEB.TAMU.EDU

8

Cost-Shares



Trenching: 40% of actual costs not to exceed \$1000.00 per individual per year with a maximum of \$3,000.00 per project per year.

Red oak removal: 40% of actual costs not to exceed \$500 per cooperator per year.

TFSWEB.TAMU.ED

Criteria to Qualify for Cost- Shares

- 1) Complete containment of the disease center (natural land features and existing underground infrastructure can be used in select cases)
- 2) Relative isolation of the disease center
- 3) High potential of fungal mat formation (red oaks)
- 4) Compliance with Cultural Resources Preservation Act



10

NOT Eligible for Cost-Shares



- 1) Removal of dead trees
- 2) Trenching around healthy stands of trees
- 3) Secondary trenches
- 4) Engineering charges, consulting fees or permit fees
- 5) Loss or reduction in revenues from the land
- 6) Stump grinding
- 7) Fungicide treatments
- 8) Replanting or landscaping

TFSWEB.TAMU.EDU

11

Cost Share Application Process



- Cost-Share Application
- Treatment Plan
- Cultural Resources Survey Form
- TARL Records Check
- Treatment Maps
- General Location Map
- Underground Utility Waiver
- Cultural Resources Acknowledgement Form
- W-9 Tax Identification Form





Project Accomplishments

1988 - 2020

2877 Centers Trenched – 841 Total Contracts 3,552,048 Feet (673 miles) Trenches Installed 3,736 Red Oak Trees Removed 70% Trenching Success

TFSWEB.TAMU.ED

13



Oak Wilt Suppression Project

- Sufficient and sustained program funding has been critical.
 - \$2,815,416 Distributed Cost-Shares
 - •\$7,899,305.00 Total Costs
- Economic analysis benefit:cost ratio of 6:1

TFSWEB.TAMU.EDU

14



Project Obstacles

- Rapid increase in human population with new residents unfamiliar with oak wilt.
- Small staff with involvement in other projects.
- No state-mandated funding.
- Cost of trenching has increased since 1990.



TFSWEB.TAMU.ED



Public Education and Awareness

- Public education is essential.
- Public awareness www.texasoakwilt.org

TECWED TAMIL ED

16



17



Oak Wilt Resources

Texas Oak Wilt Information Partnership website:

http://texasoakwilt.org

Texas A&M Forest Service website: http://tfsweb.tamu.edu

How To Identify and Manage Oak Wilt in Texas brochures

TECWER TAMILED







Five Step Diagnosis for Oak Wilt

Texas Oak Wilt Qualification 2022



1



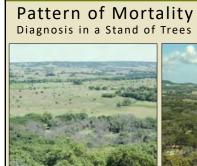
Diagnosis – 5 Step

Process
1. Diagnosis in a stand of trees (pattern of mortality)

- 2. Diagnosis in individual trees
- 3. Foliar symptoms
- 4. Presence of fungal mats
- 5. Taking samples



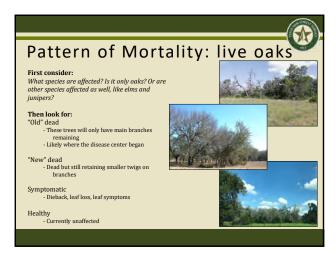
2

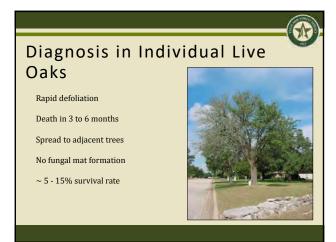


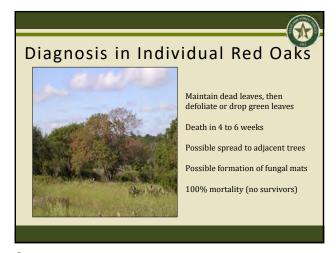


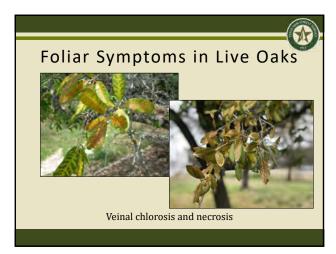
Live Oak Center

Red Oak Center





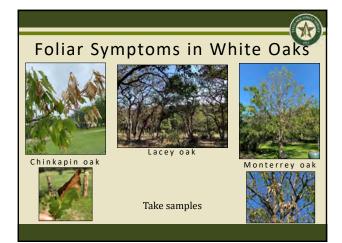


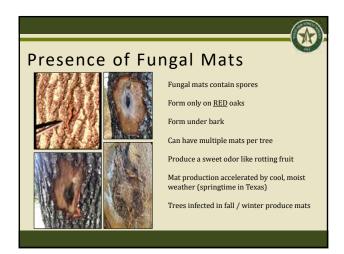






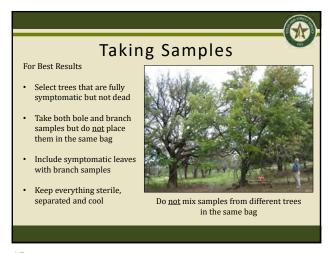










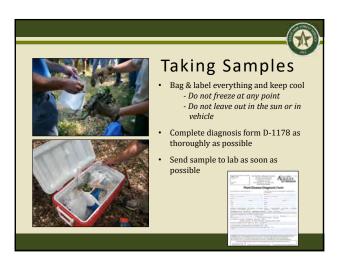














Taking Samples

For more information:

Texas Plant Disease Diagnostic Laboratory

plantclinic.tamu.edu

979-845-8032 plantclinic@ag.tamu.edu

19



Questions?

Karl Flocke karl.flocke@tfs.tamu.edu

Erin Davis edavis@tfs.tamu.edu

