Tree Biology, and CODIT

ISA-T Oak Wilt Qualification Training
May 23, 2019
Weatherford, TX

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College Station, TX 77843

TEXAS A&M AGRILIFE EXTENSION

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.

Dr. Alex Shigo

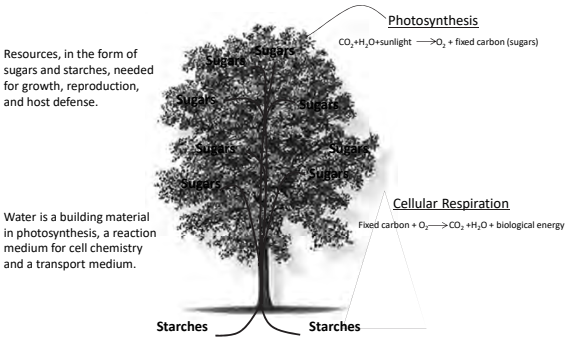
3

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

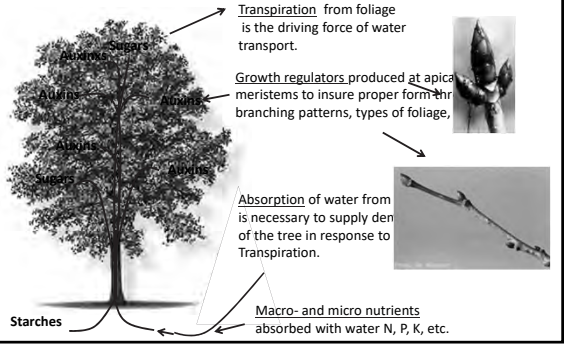
I. Tree Physiology and Resource Allocation



5

II. Tree Physiology and Water Transport

Nutrients and Growth Regulators



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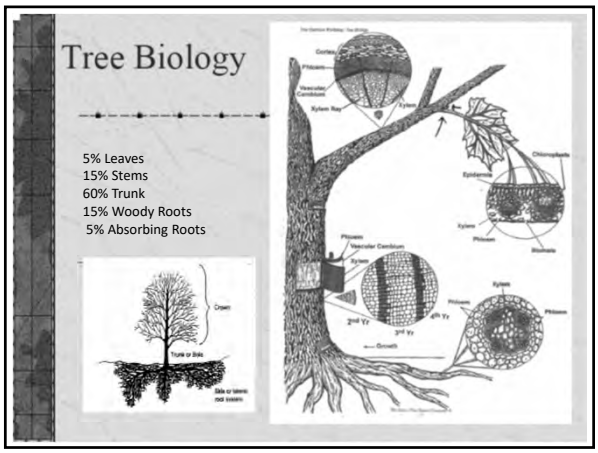
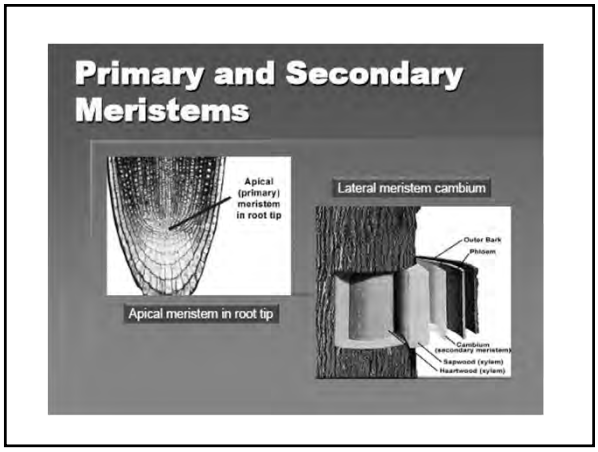
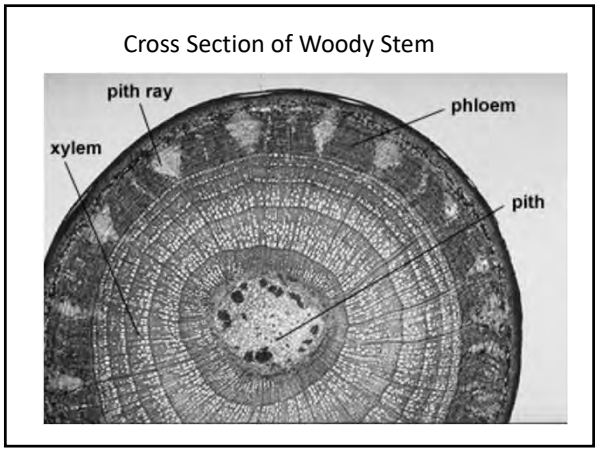

Tree Biology
5% Leaves
15% Stems
60% Trunk
15% Woody Roots
5% Absorbing Roots

7


Primary and Secondary Meristems
Apical (primary) meristem in root tip
Apical meristem in root tip
Lateral meristem cambium
Outer Bark
Phloem
Cambium (secondary meristem)
Sapwood (xylem)
Heartwood (xylem)

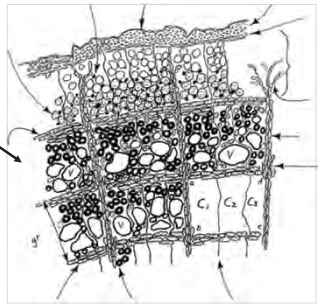
8


Cross Section of Woody Stem
pith ray
phloem
xylem
pith

9

Our secondary growth model:

A typical hardwood tree in cross section (transverse surface).

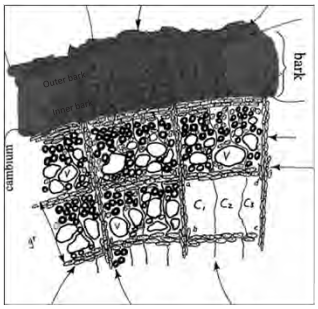


What can you identify?

10

The Bark: = Periderm

The bark is everything outside the vascular cambium.

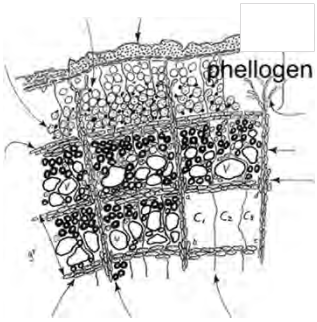


As you can see, there is a lot going on in the bark.

11

The Bark: periderm: phellogen (cork cambium):

The phellogen is the region of cell division that forms the periderm tissues.



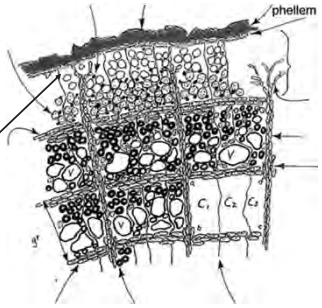
Phellogen development influences bark appearance.

12

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 phellem and in fissures.

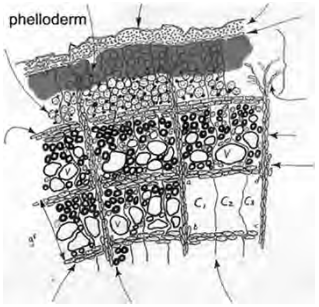


13

The Bark: periderm: phelloderm:

Phelloderm is active parenchyma tissue.

Parenchyma cells can be used for storage, photosynthesis, defense, and even cell division!

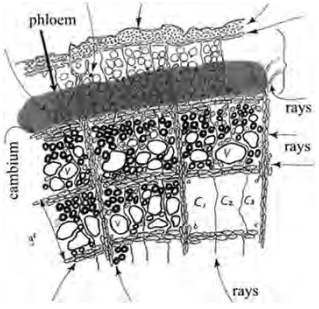


14

The Bark: phloem:

Phloem tissue makes up the *inner bark*.

However, it is *vascular tissue* formed from the vascular cambium.

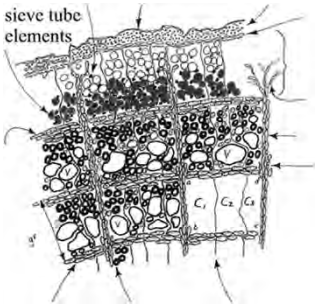


15

The Bark: phloem: sieve tube elements:

Sieve tube elements actively transport photosynthates down the stem.

Conifers have *sieve cells* instead.

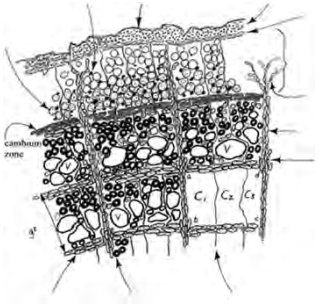


16

The cambium:

The cambium is the primary meristem producing radial growth.

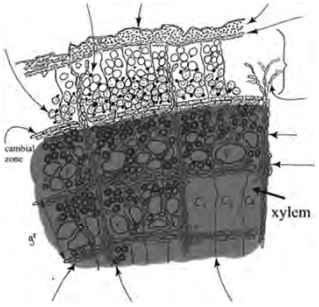
It forms the phloem & xylem.



17

The Xylem (wood):

The xylem includes everything inside the vascular cambium.

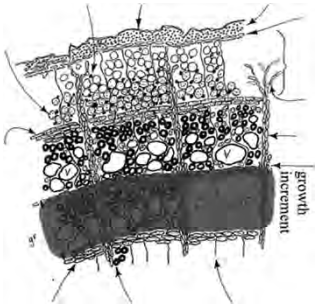


18

The Xylem: a growth increment (ring):

The rings seen in many trees represent one growth increment.

Growth rings provide the texture seen in wood.

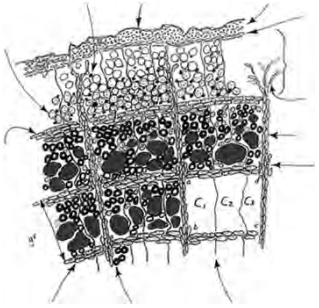


19

The Xylem: vessel elements:

Hardwood species have vessel elements in addition to trachieds.

Notice their location in the growth rings of this tree

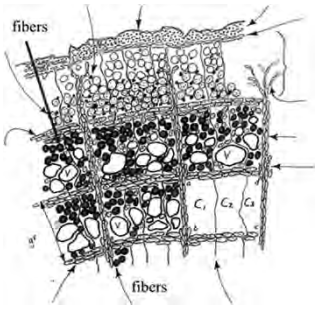


20

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.

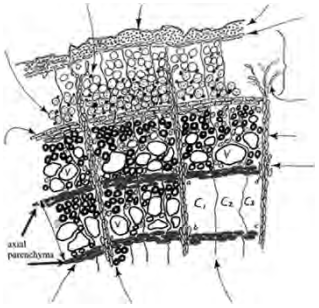


21

The Xylem: axial parenchyma:

Axial parenchyma is living tissue!

Remember that parenchyma cells can be used for storage and cell division.

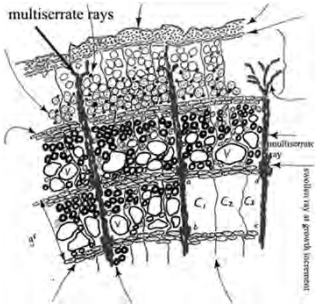


22

The Xylem: rays (multiserrate & uniserrate):

Rays are radial parenchyma cells.

Parenchyma cells give rise to adventitious tissues.

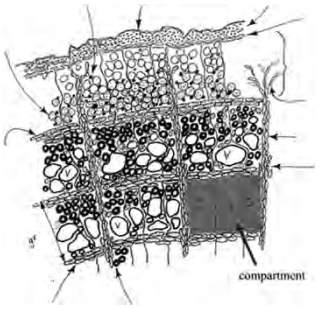


23

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?

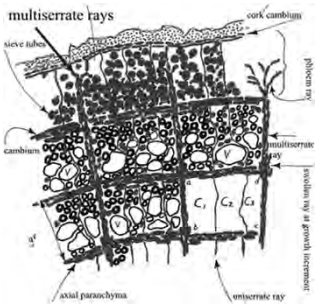


24

The Symplast:

The symplast is the living portion of the tree.

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



25

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.

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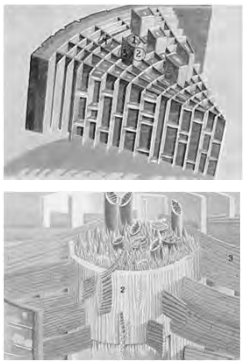
CODIT

Compartmentalization of Decay In Trees

The 4 Walls

1. Tyloses
2. Axial parenchyma and annual growth components
3. Ray cells
4. Wound response of cambium



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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.

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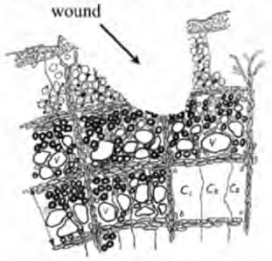
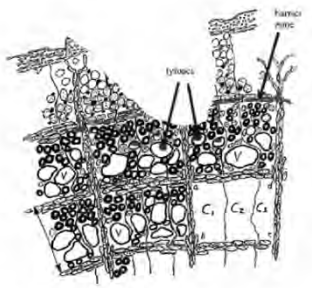
Wound Response in a Deciduous Tree



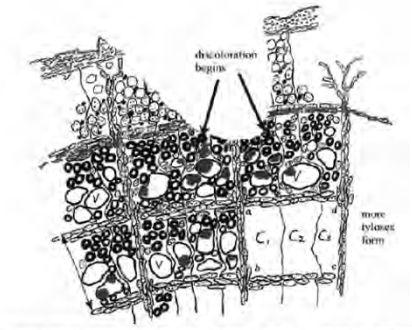
A wound was created through the bark, phloem, cambium, and the youngest xylem.

29



The cambial zone continues to form a barrier zone along the inner edge of the cambium. The barrier zone has advanced farther from the wound site along the edge of the cambium.

30



Tissue near the wound site (blue zone) on the interior of the barrier zone begins to darken and discolor.

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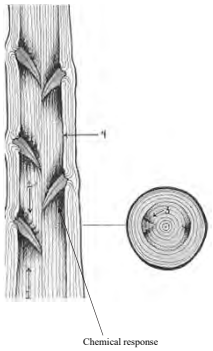
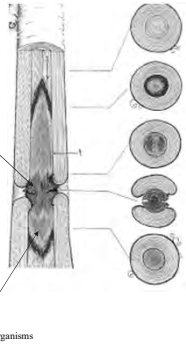
More CODIT Perspectives




32

More CODIT Perspectives





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More CODIT Perspectives

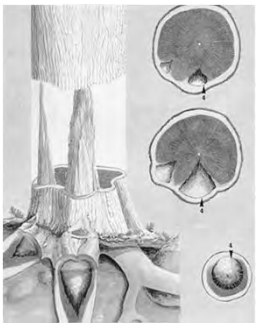

Figure 45 Angiosperm *Ganoderma applanatum*

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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.

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Branch Attachment

Branch Collar

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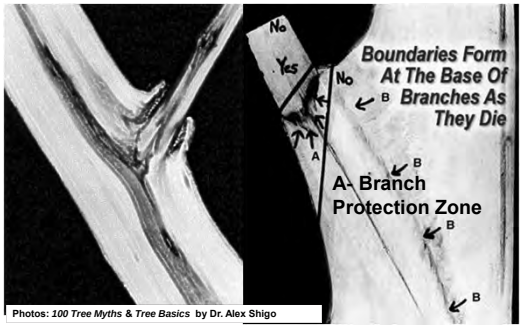
Tree Biology
Branch Attachment



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Tree Biology
Branch Protection Zone

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

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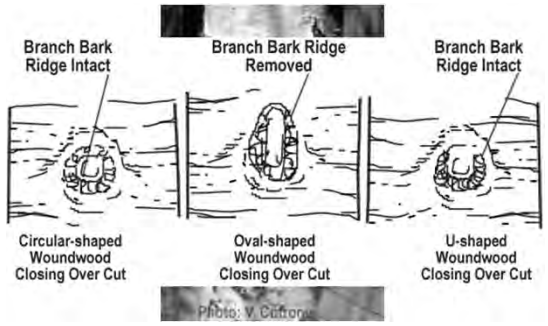
Tree Pruning
Thinning or Removal Cut

39

Tree Pruning
Wound Closure



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Tree Pruning
Wound Dressings

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Oak Wilt

ID, Control, and Prevention

2019 Oak Wilt Qualified Arborist Training
May 23, 2019
Weatherford, TX

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

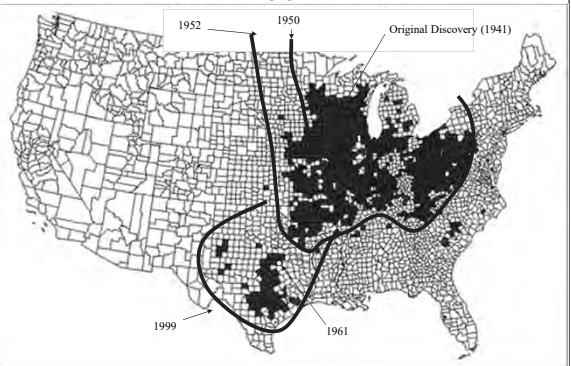
TEXAS A&M AGRILIFE EXTENSION

1

Part I – Background, Biology

2

Background – Origins, Spread, Range of *Bretziella fagacearum*



3

The Impact of Oak Wilt

- "Oak wilt is one of the most destructive tree diseases" (Young, 1949).
- "…. this disease has the potential of becoming one of the worst diseases to attack the forests of the state." (True and Gillespie, 1961).
- " Oak wilt is now one of the most serious forest diseases in the country" (Johns and Phelps, 1992).
- "*Ceratocystis fagacearum*, the cause of oak wilt, is a fungus with the potential to be one of the most destructive of all tree pathogens." (Gibbs and French, 1980).

4

Bretziella, a new genus to accommodate the oak wilt fungus, Ceratocystis fagacearum (Microascales, Ascomycota)

Z. Wilhelm de Beer[1], Seonju Marincowitz[1], Tuan A. Duong[2], Michael J. Wingfield[1]

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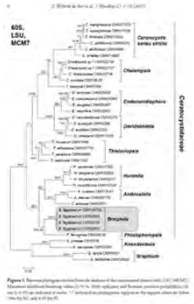
Bretziella, a new genus to accommodate the oak wilt fungus, Ceratocystis fagacearum (Microascales, Ascomycota)

- Multi gene phylogenetic inference,
  - Based on DNA sequences of genes,
- Phylogenetic analysis,
- Construction of a phylogenetic "tree",
  - Based on the smallest numbers of differences in selected genetic sequences,
- Pathogen does not reside in any of previous 4 genera,
  - Causes a true vascular wit,
  - Produces the spore mats under bark.
- Why Bretziella?



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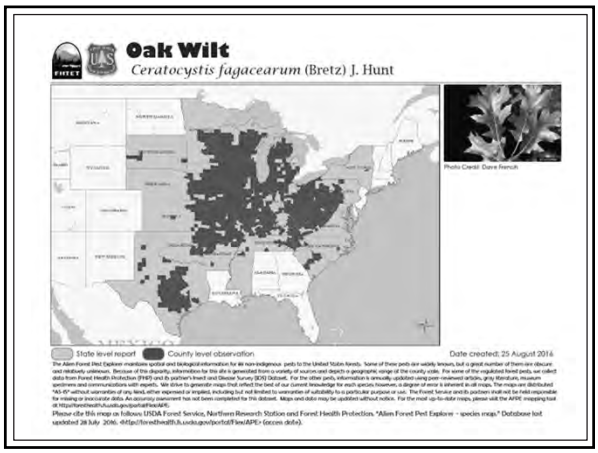
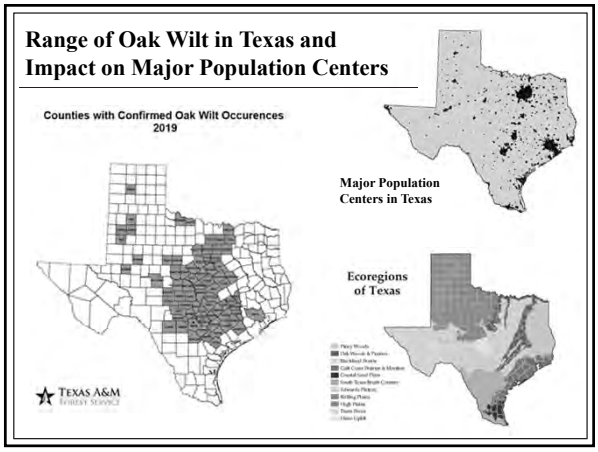
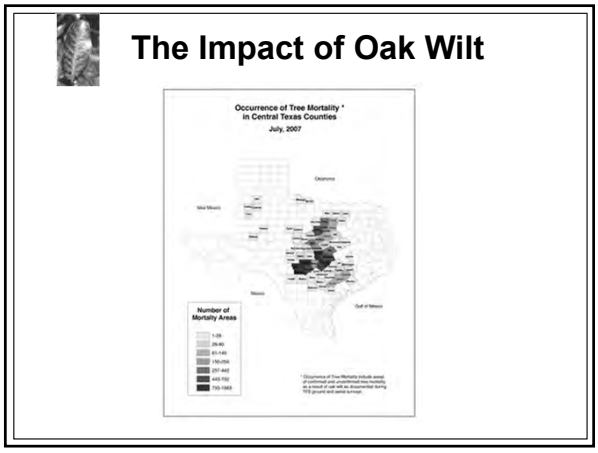

Oak Wilt
Ceratocystis fagacearum (Bretz) J. Hunt
Photo Credit: Dave French
State level report
County level observation
Date created: 25 August 2016

7


Range of Oak Wilt in Texas and Impact on Major Population Centers
Counties with Confirmed Oak Wilt Occurences 2019
Major Population Centers in Texas
Ecoregions of Texas
TEXAS A&M FOREST SERVICE

8


The Impact of Oak Wilt
Occurrence of Tree Mortality * in Central Texas Counties
July, 2007
Number of Mortality Areas

9

The Impact of Oak Wilt

10

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.

11

The Impact of Oak Wilt

Rural Residential Areas

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

12

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.

13

The Impact of Oak Wilt

Urban Areas (< 1 acre)

Oak wilt may reduce urban property values by 15-20%.

14

The Impact of Oak Wilt

Ecosystem Impact

- Golden cheeked warbler

15

The Impact of Oak Wilt

Ecosystem Impact

- Ash Juniper encroachment

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Why Did Oak Wilt Become Epidemic in the Live Oak Savannahs of Central Texas?

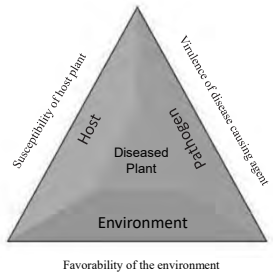
Species Composition and Stand Structure

- 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, developments, etc.

17

What is Plant Disease? The Disease Triangle

- Host
- Pathogen
- Environment



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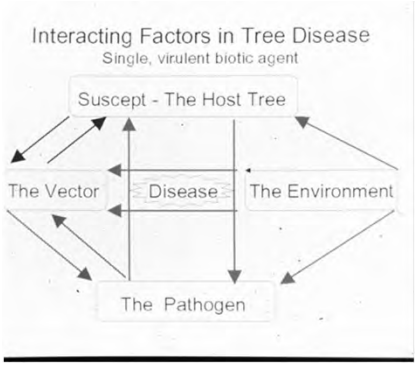
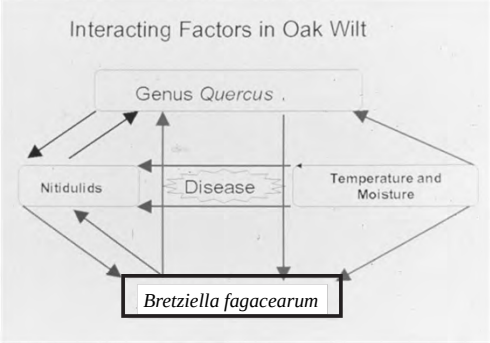

Interacting Factors in Tree Disease
Single, virulent biotic agent
Suscept - The Host Tree
The Vector
Disease
The Environment
The Pathogen

19


Interacting Factors in Oak Wilt
Genus Quercus
Nitidulids
Disease
Temperature and Moisture
Bretziella fagacearum

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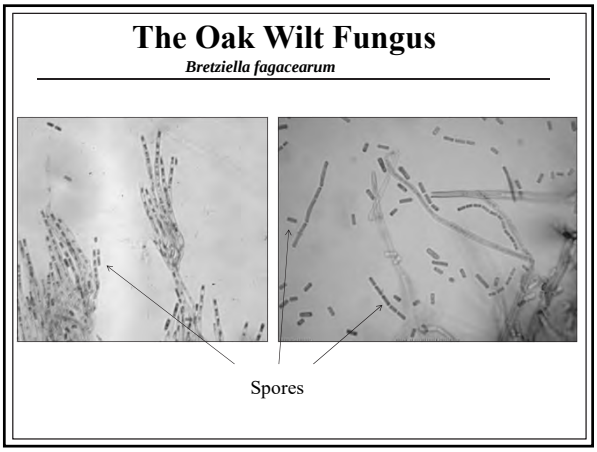

The Oak Wilt Fungus
Bretziella fagacearum
Spores

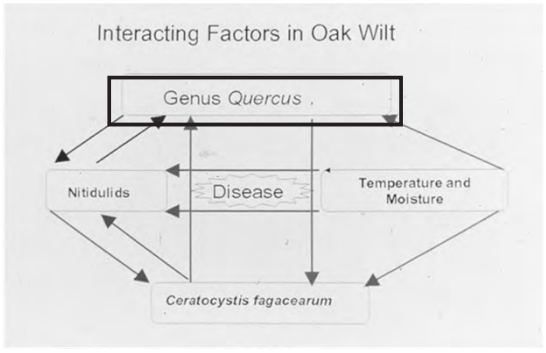
21

Oak Wilt Biology, Interacting Factors

Bretziella fagacearum

- 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

22



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Oak Wilt Biology, Interacting Factors

Genus *Quercus*

- 50+ 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)

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Oak species affected by oak wilt in Texas

RED OAKS = Susceptible

Q. buckleii	Spanish Oak
Q. marilandica	Blackjack Oak
Q. nigra	Water Oak

WHITE OAKS = Resistant

Q. sinuata var. breviloba	Shin Oak
Q. laceyii	Lacey Oak
Q. polymorpha	Mexican white oak
Q. stellata	Post Oak

LIVE OAKS= variable

Q. virginiana	Southern live oak
Q. fusiformis	Plateau live oak

25

Differences Among Live Oaks, Red Oaks, White Oaks

Live Oaks

- root sprouting
- spread by root grafts
- semi ring porous

White Oaks

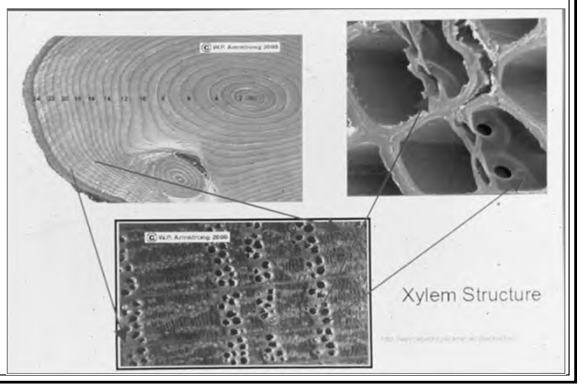
- not root sprouting
- very small pores

Red Oaks

- not root sprouting
- produce fungal mats
- large summerwood pores

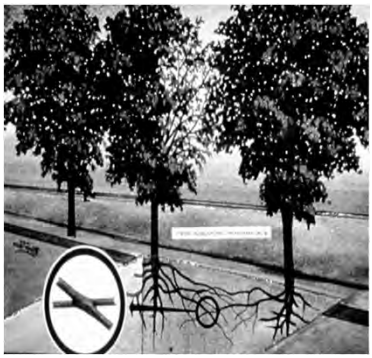
26

Tree Structure



27

Local Spread



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Local Spread

29

Local Spread

- Root grafts

  - live oaks and live oaks
  - live oaks and red oaks

30

Local Spread

- Root connections – live oaks

31

Vascular System of Trees

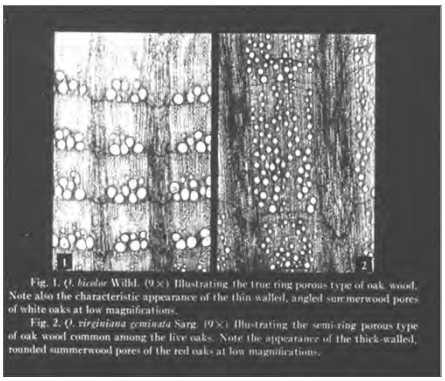
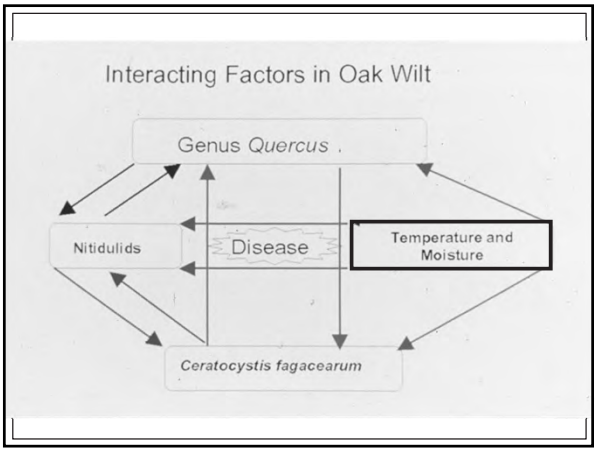


Fig. 1. *Q. bicolor* Willd. (9×). Illustrating the true ring porous type of oak wood. Note also the characteristic appearance of the thin-walled, angled summerwood pores of white oaks at low magnifications.

Fig. 2. *Q. virginiana geminata* Sarg. (9×). Illustrating the semi-ring porous type of oak wood common among the live oaks. Note the appearance of the thick-walled, rounded summerwood pores of the red oaks at low magnifications.

32



33

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

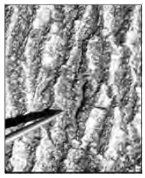
34

Fungal Mats

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

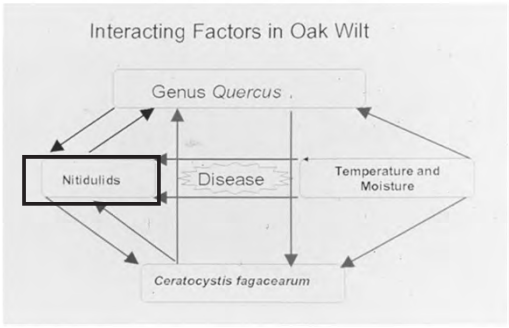


36

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



38

Beetle Spread

Nitidulid Beetle

39

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

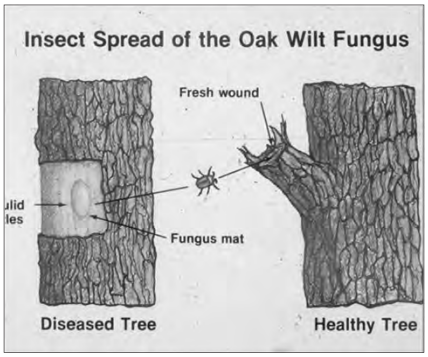
40

Beetle Spread

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

41

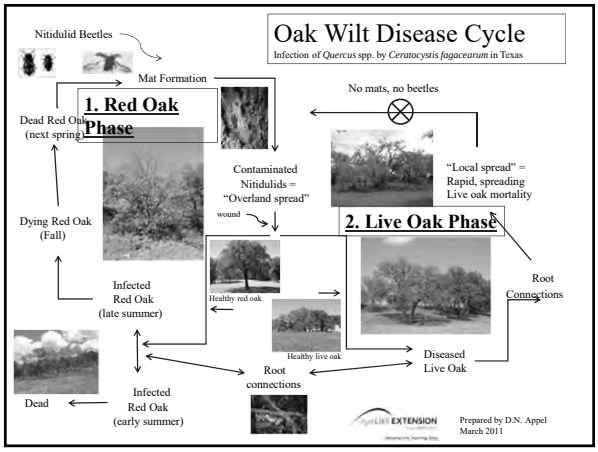
Beetle Spread



42

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

45

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

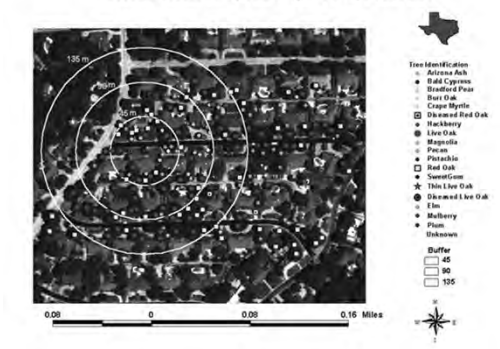
Oak Wilt Diagnosis

1. Pattern of disease in the population of trees

Live Oak Center vs. **Red Oak Center**

47

Potential risk of spread by C. Fagacearum



48

2. Pattern in individual trees

Diseased Live Oak vs. **Diseased Red Oak**

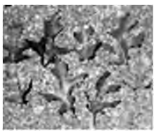
Variable rates of death, 15 – 20% survival

Rapid death (weeks), 0% survival

49

3. Foliar symptoms

Live Oak Symptoms vs. **Red Oak Symptoms**



50

4. Presence of fungal mat

Only red oaks

51

5. Taking Samples

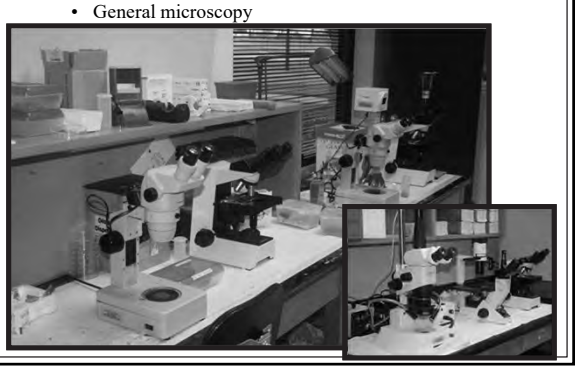
- **Bole and Branch Samples**
- **Confirm presence of pathogen**

52

53

TPDDL capabilities

- General microscopy



54

Packaging for Oak wilt

55

Oak Wilt Control Options

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- Plant resistant/immune trees

56

Pruning – paint wounds

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

57

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Tree Pruning
Wound Dressings

59

Oak Wilt Control Options

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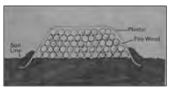
60

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 > 36ºC



61

Oak Wilt Control Options

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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)

63

Trenching – Types and Placement

Belt Trencher

Back Hoe

Ripper Bar

Rock Saw

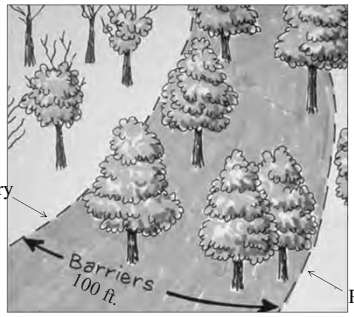
64

Trenching – Types and Placement

Within trench you want to remove all host material

65

How to Place a Trench



66

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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

69

Fungicide – Technique and Implementation

Fungicide


Injection equipment


Trees being injected


Double helix bit


Green T

70

The High Volume, Low Concentration Injection Process

71

Alternative Products and Techniques


Propiconazole 14.3
Fungicide

72

Criteria for Successful Oak Wilt Treatment

- 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
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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?

75


Texas Tree Planting Guide
TEXAS A&M FOREST SERVICE
Express Tree Selector
Custom Tree Selector
Tree Planting Tools

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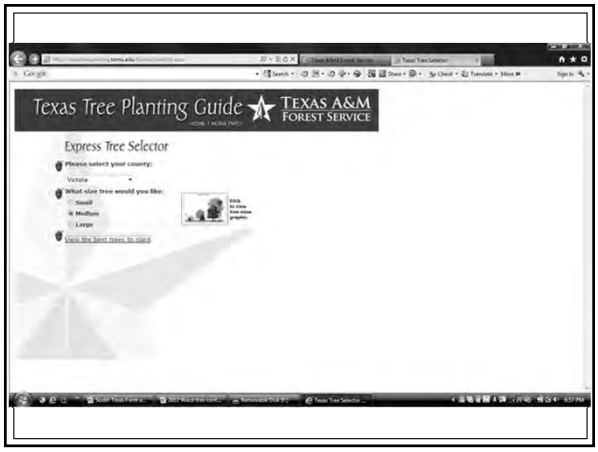
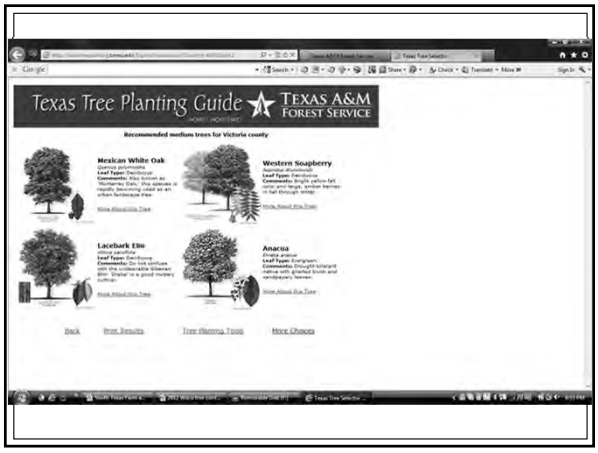

Texas Tree Planting Guide
TEXAS A&M FOREST SERVICE
Express Tree Selector
Please select your county:
What size tree would you like:
Small
Medium
Large

77


Texas Tree Planting Guide
TEXAS A&M FOREST SERVICE
Recommended medium trees for Victoria county
Mexican White Oak
Western Soapberry
Lacebark Elm
Anacua
Back
Print Results
Tree Planting Tools
More Choices

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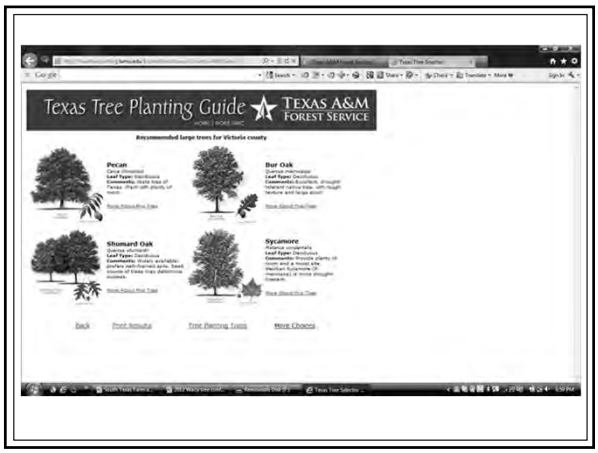

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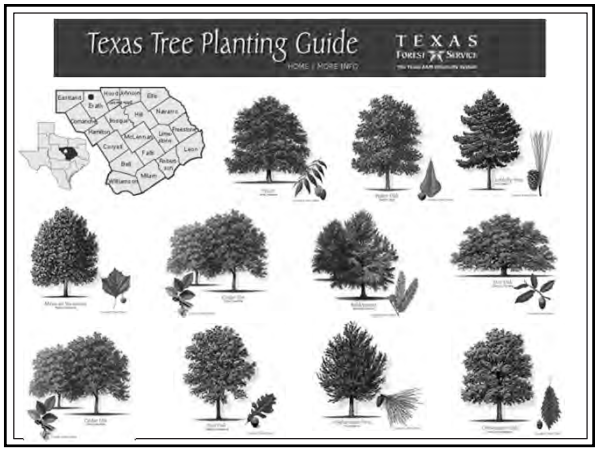
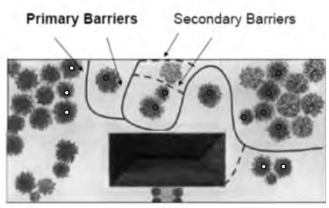


80

Decision Making for Oak Wilt Treatment



● = candidate for therapeutic injection

○ = candidate for preventative injection

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Oak Wilt in Relation to Other Tree Diseases

ISA-T Oak Wilt Qualification Training
May 23, 2019
Weatherford, TX

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

TEXAS A&M AGRILIFE EXTENSION

1

Examples of Existing Tree Diseases in Texas

- Herbicides
- Drought, other abiotics
- Declines (numerous species) — Abiotic
- 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 (sycamore) — Foliar
- Hypoxylon cankers (hardwoods)
- Mistletoe (true and dwarf)
- Giant dodder (native,exotic)
- Endothia canker
- Botrydiplodia canker
- Phomopsis (and others) tipblight
- Pitch canker
- Cedar x Hawthorne rust
- Fusiform rust
- Crown gall
- Smooth patch — 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 — Vascular
- Ganoderma root rot
- Heterobasidion root rot
- Phytophthora root /crown rot
- Sudden oak death (nurseries)
- Cotton root rot
- Root knot nematode on Pecans
- Heart rots (numerous species) — Root Rots
- Sooty mold
- Ball moss
- Lichens — Non - pathogens

2

What's Wrong With My Tree?

- **Tree problems are difficult to diagnose**
- **Actual diagnosis isn't important**
- **Prognosis may be more important**
- **Are levels of diagnosis**

Fusiform rust of slash pine

3

Why Are Tree Problems Difficult to Diagnose?

- **A large portion of the tree is mostly inaccessible to analysis**
- **Spatial relationship between the cause and effect may be obscure**
- **Trees support the growth of dozens of microbes**
- **Tree respond slowly to injuries**
- **One cause - one disease relationship is relatively rare**

4

Why is Prognosis Important?

- Refers to prospects for recovery
- Has the opportunity to save time and money
- May even prevent doing more harm than good
- Emphasizes looking for other problems, e.g. hazardous trees

5

Levels of Confidence in Diagnosing Tree Diseases

- **Degrees of flexibility are acceptable Sometimes a 100% reliably positive diagnosis is achieved**
- **Accuracy depends on whether information complete**

6

Levels of Confidence in Diagnosing Tree Diseases

- **Often can only achieve 90 - 100% reliability**
- **Indicative diagnosis sometimes appropriate**
- **Exclusionary diagnosis can be useful**

7

Five Step Process in Diagnosing Tree Diseases

- **Goes beyond simply looking at the tree and trying to identify cause**
- **Diagnosis may have high degree of uncertainty**
- **May still be useful**
  - **will lead to prognosis**
  - **educate client for future plantings and care of remaining trees**
- **Broad consideration of spatial and temporal trends in the disease syndrome**

8

Five Step Process in Diagnosing Tree Diseases

1. Pattern of mortality in time and space within the population of trees
2. Patterns of mortality in time and space for individual trees
3. Symptoms - foliar, branches, trunks, roots
4. Signs
5. Clinical diagnostic aids

9

What Must We Know To Diagnose Tree Diseases?

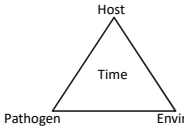
1. Host characteristics
2. Potential pathogens and their characteristics
3. Conditions that allow the disease to develop

10

What Must We Know To Diagnose Tree Diseases?

- **Host characteristics,**
- **Potential pathogens and their characteristics,**
- **Conditions that allow the disease to develop.**

The Disease Triangle



11

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

12

Example of an Abiotic Pathogen

Iron Chlorosis

- Caused by lack of iron,
- Particularly in high pH soils (> 7.0),
- 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.

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Examples of an Abiotic Pathogens

Herbicide Damage - Treaty Oak

Velpar®

Hexazinone - broad spectrum weed and brush control

14

Weed and Feed with Atrazine

Chlorophyl - inhibiting herbicide

Where Not to Use

"Do not apply under the branch spread (dripzone) of trees and shrubs….."

15

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.

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Examples of pathogens

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

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17

Vascular 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.**

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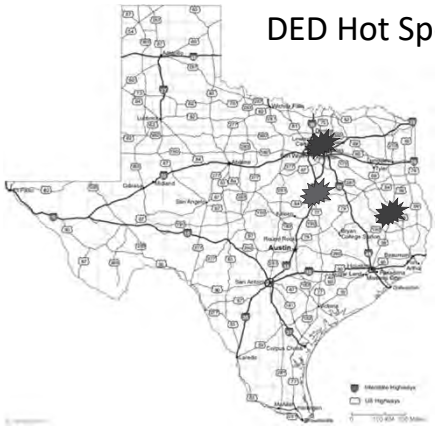
Dutch Elm Disease

The Pathogen

- *Ophiostoma novo-ulmi,*
- Vascular parasite,
- Invaded North America in mid 1920s,
- Spread throughout native elm population,

19

DED Hot Spots



20

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.

21

Dutch elm disease

Management

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

22

Common Foliar Problems on Trees in Texas

Powdery Mildew on oak

Leaf Curl on oak

Black Spot on elm

Rust on post oak

Fireblight on Bradford Pear

Virus on hackberry

23

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.**

24

Examples of pathogens

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

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Fungi
Bacteria
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25

Role of Environment in Tree Diseases
- the 3 factors

1. Predisposing factors
2. Inciting factors
3. Contributing factors

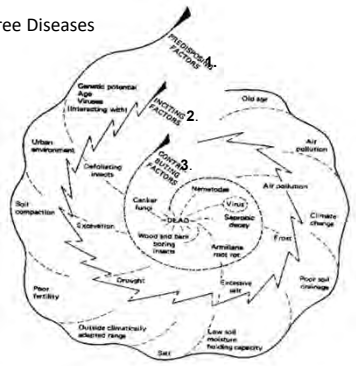

Fig. 1. Decline disease spiral (Reprinted with permission from Tree Disease Concepts by Paul D. Manion c 1991, Prentice-Hall, Inc., Englewood Cliffs, NJ).

26

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.**

27

Drought In Leakey, TX – Inciting factor

28

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……

29

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.

30

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,

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Cankers

Endothia gyrosa on oak

Hypoxylon atropunctatum on oak

Nectria canker on dogwood

32

Hypoxylon Canker

Pathogen, Hosts

- ***Hypoxylon atropunctatum*,**
- **a fungus, spread by wind blown spores,**
- **been found on oaks, elms, sycamores, pecans.**

33

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.

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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"

35

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.

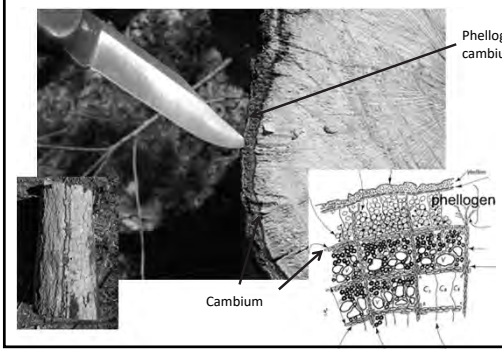
36

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.

37

Colonization by Hypoxylon

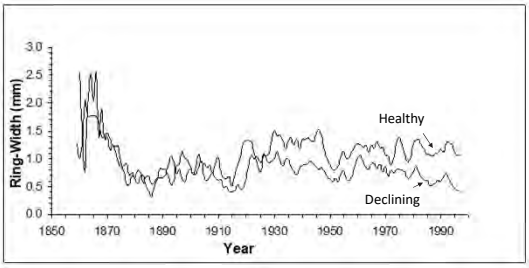


38

Colonization by Hypoxylon

39

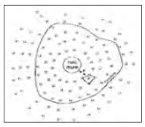
Average annual ring-width chronologies of health vs. severely declining post oaks



40

Hypoxylon Canker

Management



- Best Practices for maintaining healthy trees,
- Proper watering, ferilization, avoidance of stress,
- Note vertical mulching.

41

Bacterial Leaf Scorch

Pathogen, Hosts

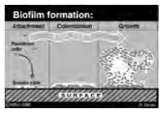
- *Xylella fastidiosa*,
- Xylem limited, fastidious bacterium,
- Many different strains,
- Oaks, elms, sycamores, mulberry, catalpa, maple, birch, sweetgum, many fruits

42

Bacterial Leaf Scorch

Disease Biology




- Spread by insect vectors,
- Produces biofilms,
- Sharpshooters,
- Limited by low temperatures,
- Stress probably involved to some degree.

43

Bacterial Leaf Scorch

Management


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

44

Ganoderma Root Rot

Pathogen, Hosts

- *Ganoderma* spp.
- Occurs statewide,
- A basidiomycete, produces “conks”,
- Wide host range on hardwoods, some conifers.

45

Ganoderma Root Rot

Disease Biology

- 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.

46

Ganoderma Root Rot

Management

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

47

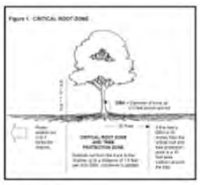
Managing Declines

- 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.

48

Vertical Mulching for Enhancing Tree Health

Objectives

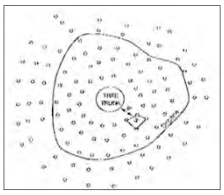


- Improve soil properties,
- Stimulate growth of root system,
- Increase tolerance to soil pathogens,
- Enhance growth of crown and tolerance to canker pathogens, heart rots, and other contributing factors.
- Pan, J.F. 1958. Effects of Vertical Mulching and Subsoiling on Soil Physical Properties. Agron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

49

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.**

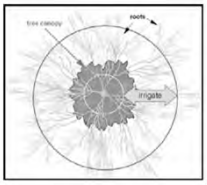


50

Managing Moderate to Severe Drought

Addressing the Predisposing and Inciting Factors

- Proper diagnosis is critical,
- Supplemental water,
  - for each inch of trunk diameter (width across) measured at knee height, the tree will need about 5 gallons. A 12" tree, then, would need about 5 x 12 = 60 gal of water,
  - the screwdriver technique,
- Do not prune trees during a drought?
- Do not plant trees during a drought?
- Do not fertilize during a drought!
- Mulching,
  - 3 to 4 inches,
  - do not bury the root system!!!
- Prompt removal of hazardous trees,
- Proper selection for replanting,
  - native, adapted plants.



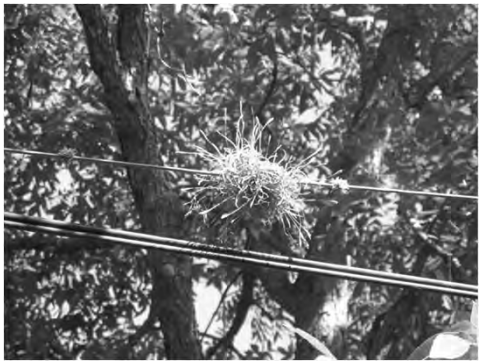
51

Other Random Problems and ……






52



Questions?

53

Cotton Root Rot

General Characteristics

- Pathogen: *Phymatotrichum omnivorum*
- Hosts: more than 2,000 plant species, mostly dicots
- Range: restricted to Southwest U.S. and Mexico
- Type: parasitizes cortex and phloem

54

Cotton Root Rot

Signs and Symptoms

- Occurs in expanding patches
- Causes multiple, coalescing, necrotic lesions on all sizes of roots
- Incipient symptoms are slight yellowing and bronzing of foliage
- Advanced symptoms consist of rapid wilting, necrosis, and death
- Produces mycelial strands, spore mats and sclerotia

55

Cotton
Root Rot
Symptoms

56

Mycelial Mats

Cotton
Root Rot
Signs

Rhizomorphs

57

Cotton Root Rot

Disease Cycle and Epidemiology

- Sclerotia initiate new infections – persist in soil for decades in absence of host.
- Spread through movement of sclerotia infested soil.
- Grows to adjacent plants by root contact.
- Prevalent in calcareous clay soils with pH of 7.0 – 8.5.
- Most likely to occur above 82° C

58

Cotton Root Rot

Control

?

59

Sudden Oak Death

General Traits

- **First appeared in 1995**
- **Has killed tens of thousands of oaks in northern California**
- **Also infects leaves and branches of rhododendron, bigleaf maple, and other related understory species**
- **Caused by Phytophthora ramorum**
- **Currently restricted to Oregon and California**
- **No controls available except prevention and quarantines**

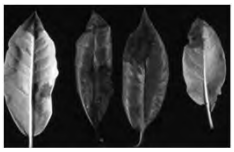
60

Sudden Oak Death

Symptoms

Oak Symptoms
- **Bleeding cankers**
- **Drooping of new growth**
- **Rapid browning of healthy crowns**

Foliar Hosts
- **Branch dieback**
- **Foliar leaf spots**
- **Twig cankers**
- **Wilting**



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Sudden Oak Death

Texas Nursery Survey

- **Cooperative USDA APHIS sponsored project**
- **Involves 6 Midwestern States**
- **Texas response involves survey of 50 nurseries distributed throughout state**
- **- standardized sampling protocol**
- **- isolation for *P. ramorum* and other *Phytophthora* spp. commonly found in Texas nurseries**
- **Also will involve survey for any suspect, unusual, or chronic undiagnosed oak problems**
- **Suddenoakdeath.tamu.edu**

62

TEXAS A&M FOREST SERVICE

ISA-Texas Oak Wilt Qualification Workshop

The Oak Wilt Suppression Project and TFS Practices & Protocols

Robert Edmonson
Biologist III, Certified Arborist

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."

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

2

Oak Wilt Resources

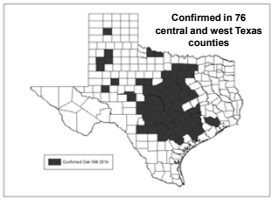
Texas Oak Wilt Information Partnership website:
http://texasoakwilt.org

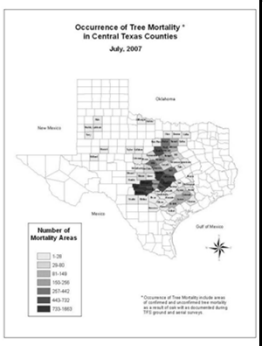
Texas A&M Forest Service website:
http://tfsweb.tamu.edu

***How To Identify and Manage Oak Wilt in Texas* brochure**

3

Oak Wilt Occurrence in Texas

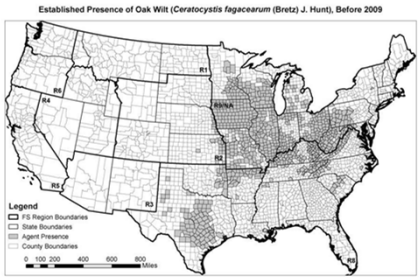




Verified by lab samples, aerial detection, and on-site inspections

4

Oak Wilt Occurrence in the US



5

Cost Shares

Cost-shares, disbursed through the Oak Wilt Suppression Project, may be available to private landowners for the following efforts:

Containment trenching around oak wilt centers

Pushing or rouging all oaks within the boundaries of cost-shared trenches

Removal of diseased red oaks in urban areas

Trenching cost-shares consist of 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 cost-shares consist of 40% of actual costs not to exceed $500.00 per cooperator per year.

6

Cost-Shares

Items NOT eligible for cost-shares include:

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

7

Cost-Shares

The following criteria must be met in order 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)

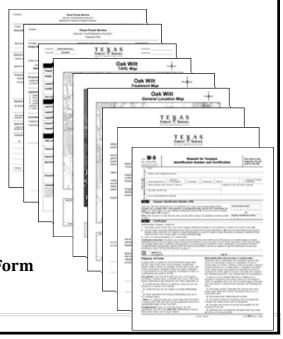
4) Compliance with Cultural Resources Preservation Act

8

Cost-Shares

As with all cost-share programs, there is an 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



9

Oak Wilt Suppression Project

Trenching Accomplishments

1988 - 2015

2877 Centers Trenched

4,008,000 Feet (762 miles) Trenches Installed

$2,980,449.00 Distributed Cost-Shares

$7,899,305.00 Total Costs

74% Trenching Success

10

Oak Wilt Suppression Project

Project Obstacles

No state-mandated funding

Small field staff for huge problem

Increasing population

Demand for staff's time from other programs

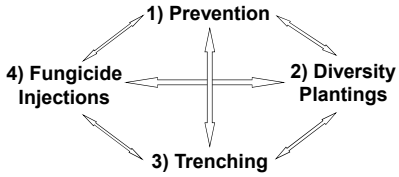
Cost of trenching has tripled since 1990

11

Oak Wilt Management

Early detection and prompt action are essential for successful management of oak wilt

There are four primary approaches used to manage oak wilt:



These measures will <u>not cure</u> oak wilt but can significantly reduce tree losses

12

Prevention

Purpose:

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

13

Prevention

Fungal mats are produced in the spring; therefore, avoid wounding oaks from February through June.

Regardless of season, immediately paint all pruning cuts and other wounds to oaks. This discourages contaminated sap-feeding beetles from visiting these wounds and introducing the oak wilt fungus into these trees.

14

Prevention

Destroy infected Red oaks to prevent fungal mat formation.

Do not salvage infected Red oaks for firewood!

15

Prevention

Transport and use only dry, well-seasoned firewood

Leave unseasoned wood on site one year/summer before moving

Do not store infected wood near healthy trees

Cover wood with clear plastic and bury the edges to prevent insects from leaving the pile

16

Tree Planting

Purpose:

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

17

Planting

Select trees that are native or adapted to the region

Select trees that are resistant or immune to oak wilt

Avoid planting monocultures; create diversity in the landscape

Avoid wounding oaks during planting

18

Some Recommended Trees



American smoketree
bald cypress
bigtooth maple
black cherry
bur oak
Carolina buckthorn
cedar elm
chinquapin oak
Eve's necklacepod
green ash
Lacey oak
little walnut
littleleaf leadtree
mescal bean
Mexican buckeye
Mexican plum
MX or TX redbud
netleaf white oak
pecan
Texas ash
Texas crab apple
western soapberry



19

TFS Tree Planting Resources

Central Texas Restoration and Recovery Program

West Texas Nursery

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

20

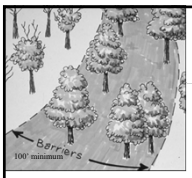
Trenching

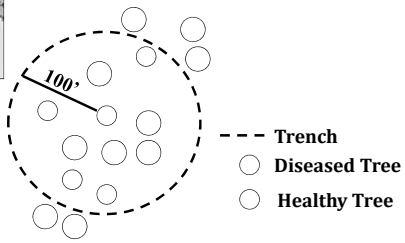
Purpose:

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)

21

Trenching





Trenches must be placed a <u>minimum</u> of 100 feet ahead of the disease and dug at least 4 feet deep (sometimes deeper) to sever all root connections

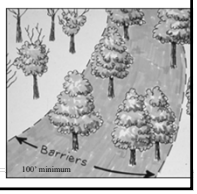
22

Trenching

Determine the disease perimeter using visual symptoms (pattern of mortality, leaf symptoms, etc.)

Locate the trench at a minimum of 100 feet from the disease perimeter (measured from the drip line, not trunks)

Make any necessary adjustments for utilities, fences, roads, etc.



23

Trenching

Equipment choice should be based on site characteristics (soil depth, substrate, terrain, etc.) and not solely on meeting minimum depth requirements.

24

Trenching

Install the trench to a minimum depth of four feet. Adjustments may be necessary if significant time has passed since initial trench layout.

25

Trenching

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

26

Trenching

Monitor for breakouts

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

27

Injection

Purpose:

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

28

Injection

Injection is used to protect high-value oaks in advance of an expanding oak wilt center

The best candidates for treatments are healthy or non-symptomatic live oaks within 50' to 150' from symptomatic trees

Injection does <u>not</u> stop root transmission of the fungus!

29

Injection

Success depends upon the health of the tree, application rate, and possibly the injection technique.

30

Injection

Several products are currently labeled and registered for this treatment; however, macro-injections of Alamo® have been <u>scientifically proven</u> effective and continue to be the industry and TFS standard.

31

Other Products and Methods

32

Criteria for Successful Injections

Reliable

Verifiable documentation of research results

Must increase survival of treated trees over natural population

Safe

Economical

Reasonably easy to apply

<u>Legal to use!</u>

33

Injection

Measure tree to determine dosage

Measure diameter at 4.5' from the ground

Circ." / 3 = diameter" (approximately)

34

Injection

Expose the root flare

Fungicide distribution is maximized by treating in the flare

35

Injection

Various tools and methods can be used to accomplish this task

36

Root Flare Injection Advantages

Bark is thinner below the soil line

Increases the number of potential injection sites

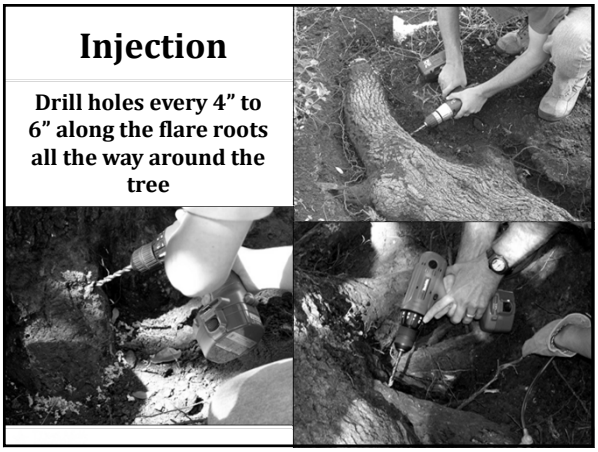
Spreads out the wounding, especially if future injections are needed

Research has demonstrated superior distribution of the fungicide in the tree

37

Injection

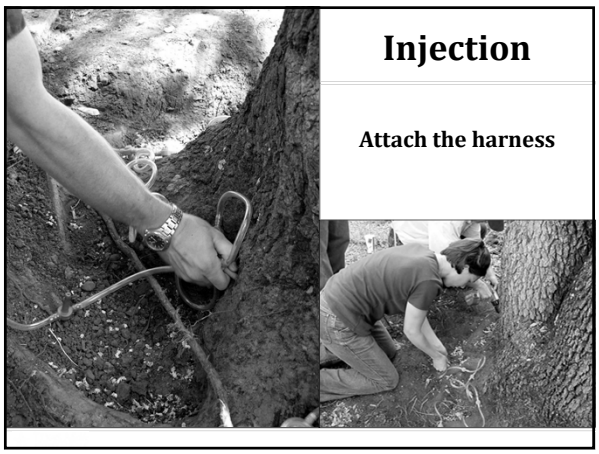
Drill holes every 4" to 6" along the flare roots all the way around the tree



38

Injection

Attach the harness



39

Injection

Mix fungicide solution

10-20 ml of fungicide per 1" trunk diameter in 1 liter of water per 1" trunk diameter

40

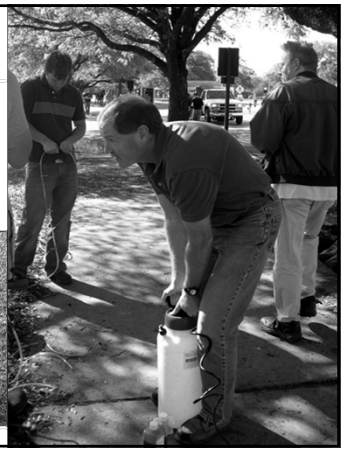
Injection

As with flare root excavation, various methods and equipment can be used to achieve the same results

41

Injection

Pressurize the system to 15-25 psi



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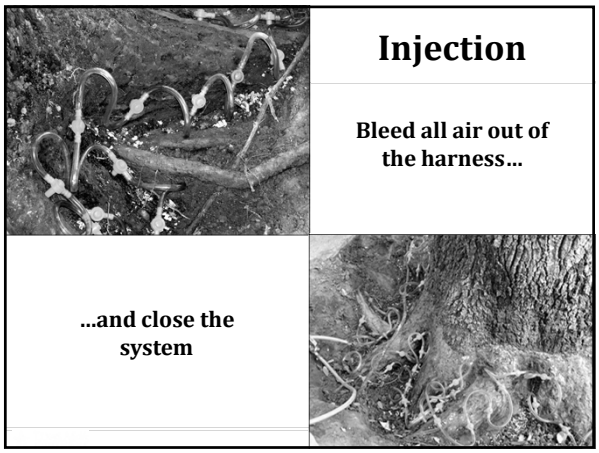
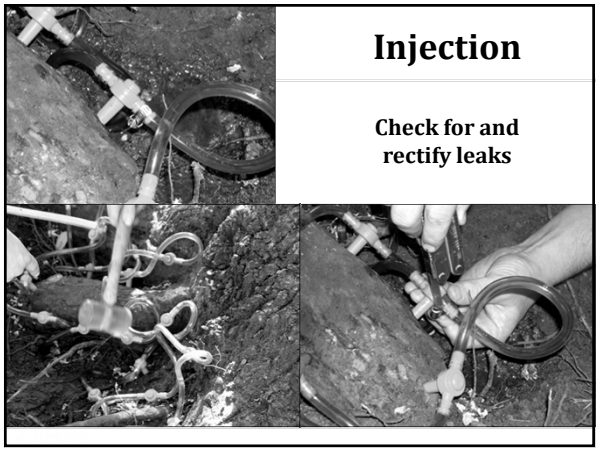
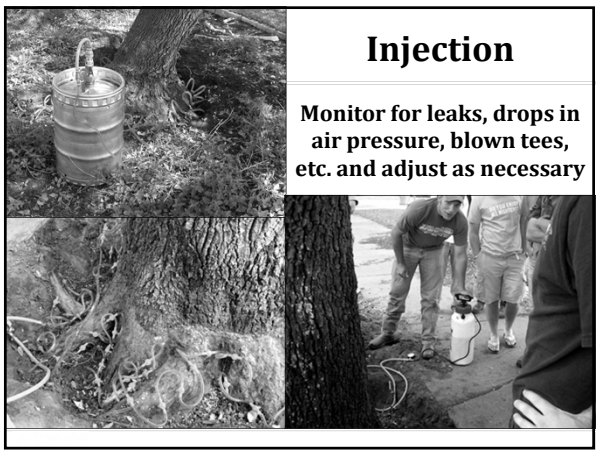

Injection
Bleed all air out of the harness…
…and close the system

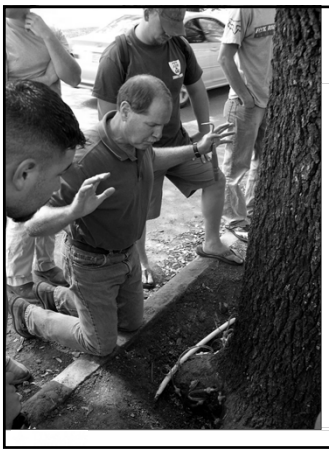
43


Injection
Check for and rectify leaks

44


Injection
Monitor for leaks, drops in air pressure, blown tees, etc. and adjust as necessary

45



Injection

Do whatever else you deem necessary to increase your chances of success…

…such as blessing the harness…

46

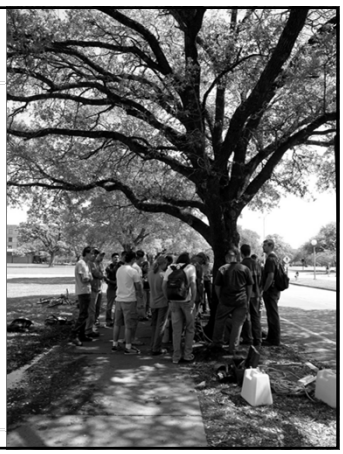
Injection

…or calling in the marines

47

Injection

So, how many Aggies does it take to treat a tree?



48

Questions

???

49

Thank You!

Robert Edmonson

Biologist III / Certified Arborist

Texas A&M Forest Service

TEXAS A&M FOREST SERVICE

50

TEXAS A&M FOREST SERVICE

ISA-Texas Oak Wilt Qualification Workshop

Five Step Diagnosis for Oak Wilt

Robert Edmonson
Biologist III, Certified Arborist

1

Diagnosis – 5 Step Process

Diagnosis in a stand of trees (pattern of mortality)
Diagnosis in individual trees
Foliar symptoms
Presence of fungal mats
Taking samples

2

Diagnosis in a Stand of Trees

Live Oak Center

Pattern of Mortality

Red Oak Center

3

Diagnosis in Individual Live Oaks

Rapid defoliation

Death in 3 to 6 months

Spread to adjacent trees

No fungal mat formation

~ 5 - 15% survival rate

4

Diagnosis in Individual Red Oaks

Maintain dead leaves, then defoliate or drop green leaves

Death in 4 to 6 weeks

Possible spread to adjacent trees

Possible formation of fungal mats

100% mortality (no survivors)

5

Foliar Symptoms in Live Oaks

Veinal chlorosis / necrosis

6

Foliar Symptoms in Live Oaks

Tip burn / Marginal necrosis

7

Foliar Symptoms in Red Oaks

Bronzing or water soaking

8

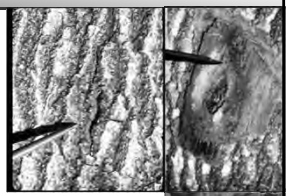
Presence of Fungal Mats

Fungal mats contain spores

Form only on RED oaks

Form under bark

Can have multiple mats per tree



Produce a sweet odor like rotting fruit

Mat production accelerated by cool, moist weather (springtime in Texas)

Trees infected in fall / winter produce mats

9

Taking Samples

Bole or branch samples

Confirms presence of pathogen

10

Taking Samples

Equipment

- **Ice Chest & Ice (bagged)**
- **Pole Pruner / Saw**
- **Hand Saw**
- **Wood Chisel**
- **Hatchet**
- **Mallet / Hammer**
- **Freezer Bags (gallon & quart)**
- **Lysol®**
- **Spray Paint**
- **Gloves & Safety Glasses**
- **Plant Disease Diagnostic Form**
- **Pen / Sharpie®**
- **Clipboard**

11

Taking Samples

12

Taking Samples

For Best Results

Select trees that are fully symptomatic but not dead

Take both bole and branch samples but do <u>not</u> place them in the same bag

Include symptomatic leaves with branch samples

Keep everything sterile, separated and cool

Do <u>not</u> mix samples from different trees in the same bag

13

Taking Samples

Cut windows into the tree down to the sapwood with hatchet

14

Taking Samples

Using chisel and mallet, collect strips of sapwood for sampling

15

Taking Samples

Bag and tag everything and keep cool

Complete diagnosis form as thoroughly as possible

Send sample to lab as soon as possible

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Taking Samples

Do:	Do NOT:
Select appropriate trees	Sample dead trees
Keep everything sterile	Drop tools & samples on ground
Keep samples cool	Mix branch and bole samples or mix samples from different trees
Complete diagnosis form	Let samples get wet, freeze samples, or let samples heat up and dry out
Ship to lab ASAP	
Paint wounds upon completion	

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Taking Samples

For more information:

Texas Plant Disease Diagnostic Laboratory

http://plantclinic.tamu.edu

979-845-8032 / 979-845-6499 fax

plantclinic@ag.tamu.edu

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Thank You!

Robert Edmonson

Biologist III / Certified Arborist

Texas A&M Forest Service

TEXAS A&M FOREST SERVICE

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