Texas Oak Wilt Qualification
May 25 - 26, 2023
Hye, Texas

May 25th

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* (page 3)
10:00-10:15	**Break**
10:15-12:30	**Oak Wilt Biology, Control Techniques & Extent in Texas**-*Appel, Texas A&M University* (page 17)
12:30-1:00	**Lunch**
1:00-1:30	**Five Step Diagnosis for Oak Wilt**-*Erin Davis, Texas A&M Forest Service* (page 42)
1:30-2:30	**Texas A&M Forest Service Practices & Protocols & the Oak Wilt Suppression Project**-*Dr. Demian Gomez, Texas A&M Forest Service* (page 49)
2:30-2:45	**Break**
2:45-4:00	**Oak Wilt in Relation to Other Tree Diseases, Freeze Damage & Drought Mimicry**-*Dr. David Appel, Texas A&M University* (page 56)

May 26 – Field

8:00-8:30	**Coffee**
8:30-9:30	**Diagnosis & Treatment Planning**-*Robert Edmondson, Texas A&M Forest Service*
9:30- 10:30	**Fungicide Injection Demonstration** -*Gene Gehring, ISAT, Emmett Muennink, Arborjet*
10:30 – 11:30	**Tissue Sampling** -*Dr. David Appel, Texas A&M University*
12:00-1:00	**Lunch at Inn on the River**
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

Oak Wilt Disease Cycle

Nitidulid Beetles

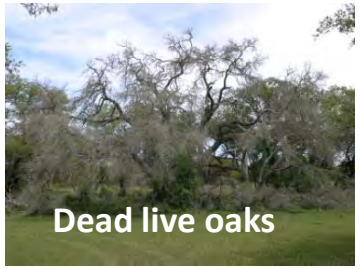
Mat Formation

No mats, no beetles

1. Red Oak Phase

Dead Red Oak
(next spring)

Contaminated
Nitidulids =
"Overland spread"



"Local spread" =
Rapid, spreading
Live oak mortality

wound

2. Live Oak Phase

Dying Red Oak
(Fall)

Healthy red oak

Common root
systems

Infected
Red Oak
(late summer)

Healthy live oak

Diseased
Live Oak

(early summer)
Infected
Red Oak

Root
connections

Prepared by D.N. Appel
Texas AgriLife Extension Service
2019

Tree Biology

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

ISA-T Oak Wilt Qualification Training
May 25 - 26, 2023
Glen Rose, TX

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

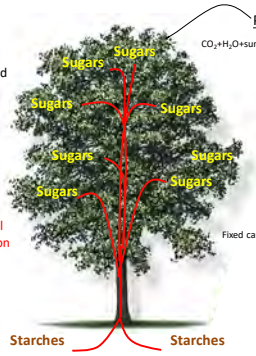
4

I. Tree Physiology and Resource Allocation

Photosynthesis

$CO_2+H_2O+sunlight \longrightarrow O_2$ + fixed carbon (sugars)

Resources, in the form of sugars and starches, needed for growth, reproduction, and host defense.



Cellular Respiration

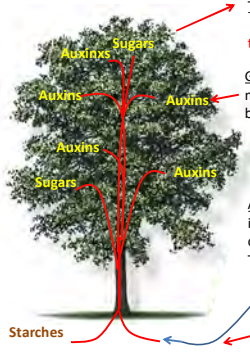
Fixed carbon + $O_2 \longrightarrow CO_2 + H_2O$ + biological energy

Water is a building material in photosynthesis, a reaction medium for cell chemistry and a transport medium.

5

II. Tree Physiology and Water Transport

Nutrients and Growth Regulators



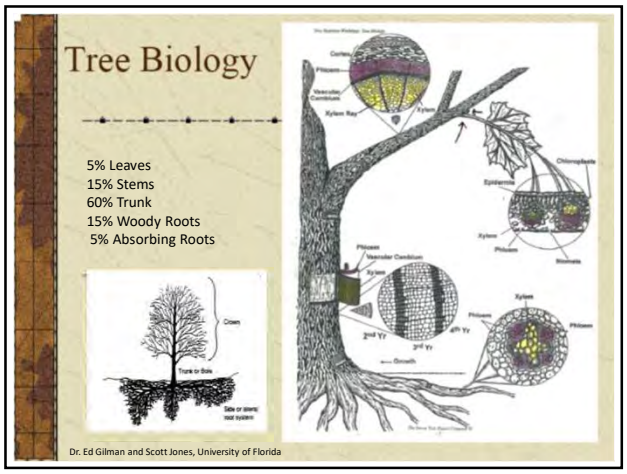
Transpiration from foliage is the driving force of water transport.

Growth regulators produced at apical meristems to insure proper form through branching patterns, types of foliage, etc.

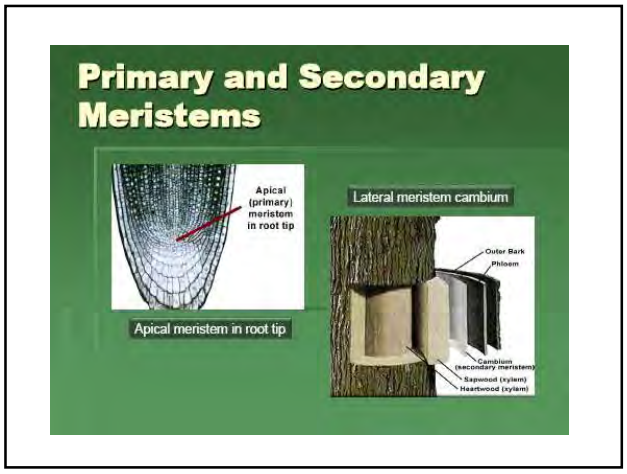
Absorption of water from soil is necessary to supply demand of the tree in response to Transpiration.

Macro- and micro nutrients absorbed with water N, P, K, etc.

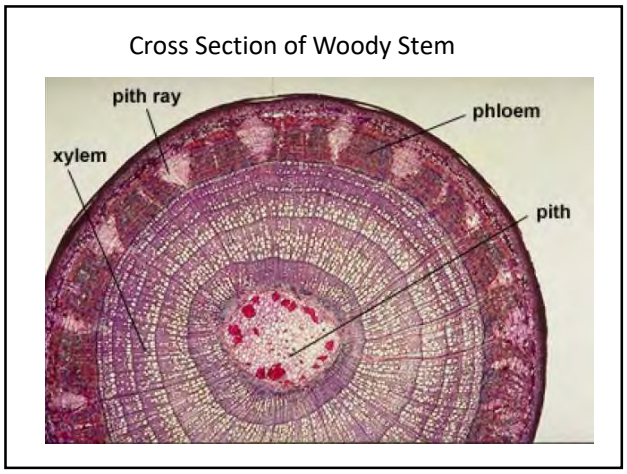
6


Tree Biology
5% Leaves
15% Stems
60% Trunk
15% Woody Roots
5% Absorbing Roots
Dr. Ed Gilman and Scott Jones, University of Florida

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)

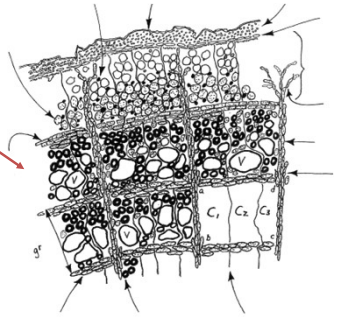
8


Cross Section of Woody Stem
pith ray
phloem
xylem
pith

9

Our secondary growth model:

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

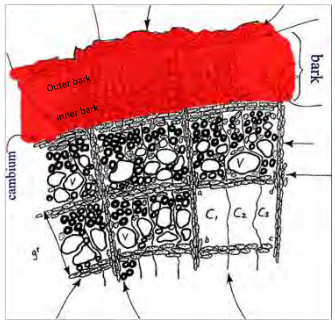


What can you identify?

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.

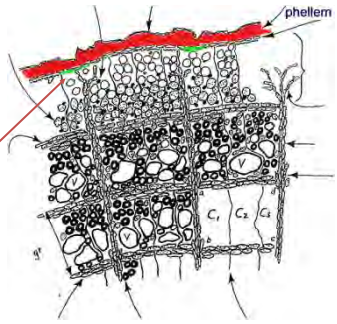
Phellogen development influences bark appearance.

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.

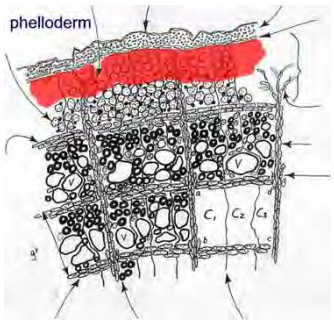


13

The Bark: periderm: phelloderm:

Phelloderm is active parenchyma tissue.

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

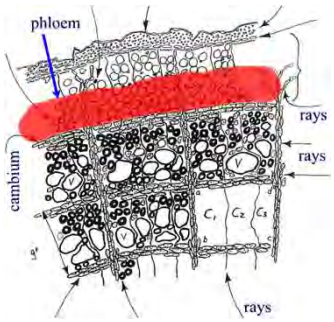


14

The Bark: phloem:

Phloem tissue makes up the *inner bark*.

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

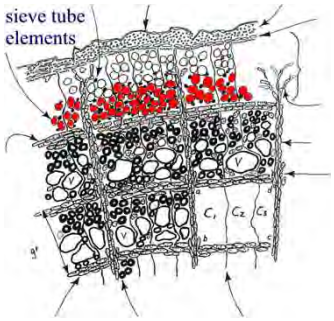


15

The Bark: phloem: sieve tube elements:

Sieve tube elements actively transport photosynthates down the stem.

Conifers have *sieve cells* instead.

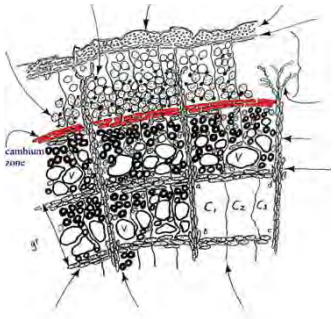


16

The cambium:

The cambium is the primary meristem producing radial growth.

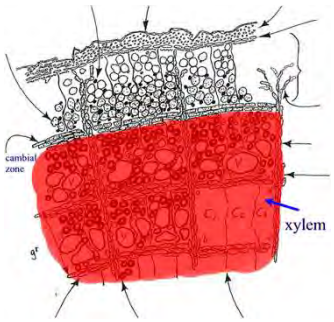
It forms the phloem & xylem.



17

The Xylem (wood):

The xylem includes everything inside the vascular cambium.

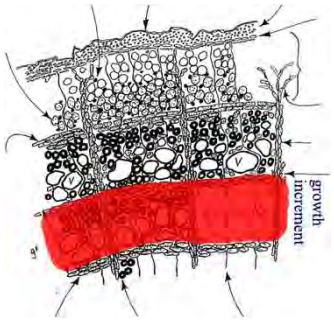


18

The Xylem: a growth increment (ring):

The rings seen in many trees represent one growth increment.

Growth rings provide the texture seen in wood.

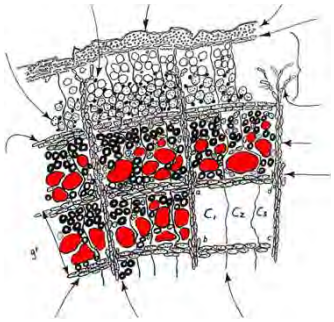


19

The Xylem: vessel elements:

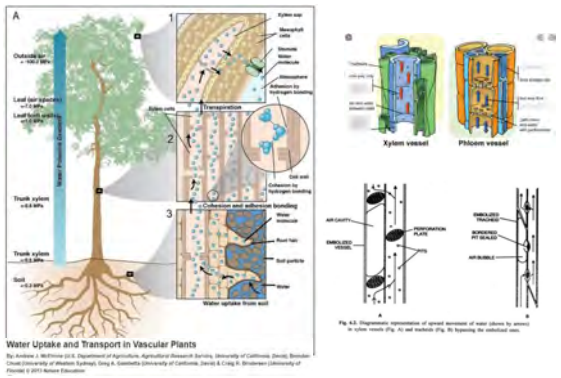
Hardwood species have vessel elements in addition to trachieds.

Notice their location in the growth rings of this tree



20

Water Movement in Trees

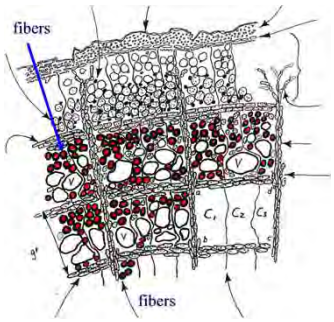


21

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.

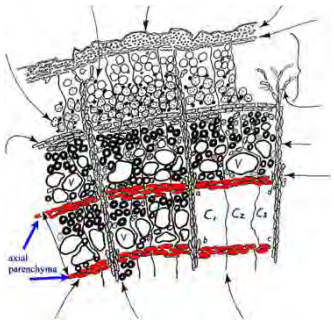


22

The Xylem: axial parenchyma:

Axial parenchyma is living tissue!

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

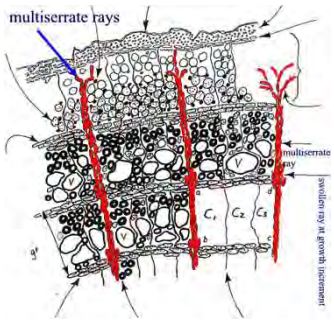


23

The Xylem: rays (multiserrate & uniserrate):

Rays are radial parenchyma cells.

Parenchyma cells give rise to adventitious tissues.

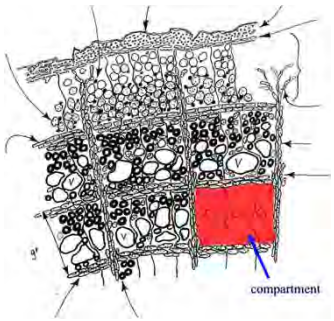


24

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?

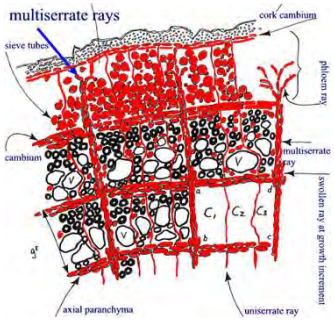


25

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.

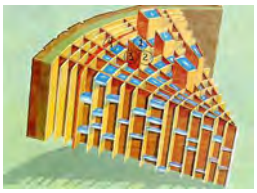
27

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



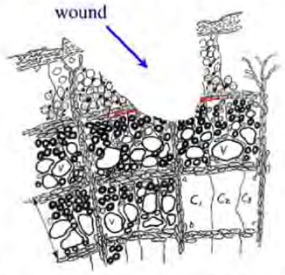
28

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.

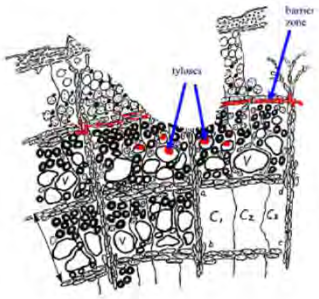
29

Wound Response in a Deciduous Tree



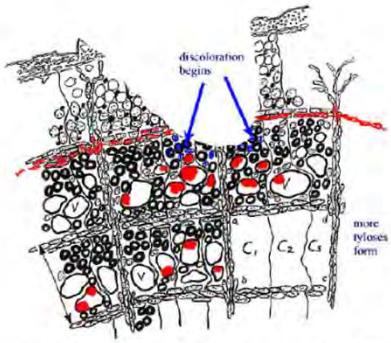
A wound was created through the bark, phloem, cambium, and the youngest xylem.

30



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.

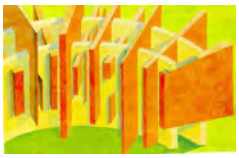
31

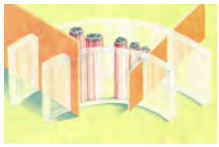


Tissue near the wound site (blue zone) on the interior of the barrier zone begins to darken and discolor.

32

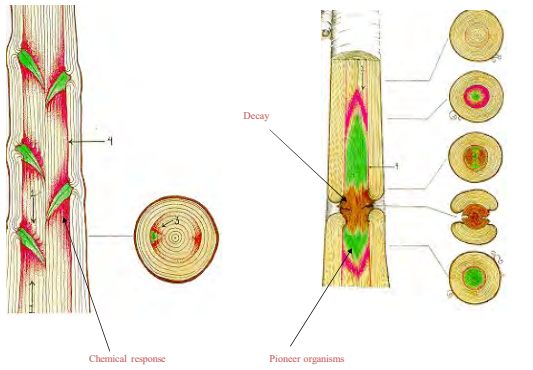
More CODIT Perspectives





33

More CODIT Perspectives



34

More CODIT Perspectives

Figure 45 Angiosperm *Ganoderma applanatum*

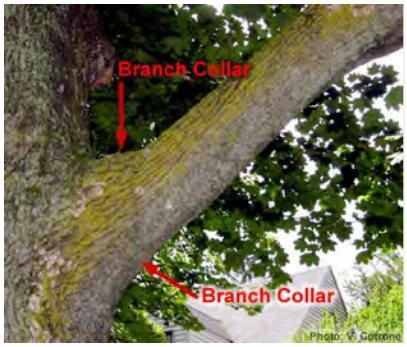
35

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.

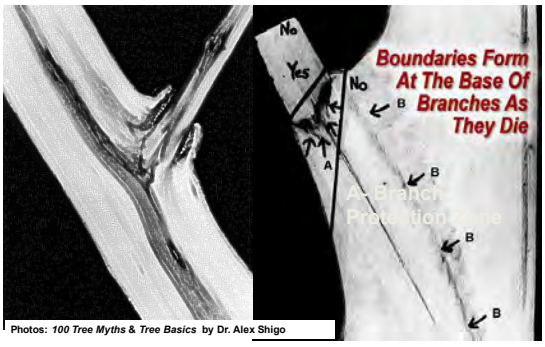
36

Branch Attachment
Branch Collar



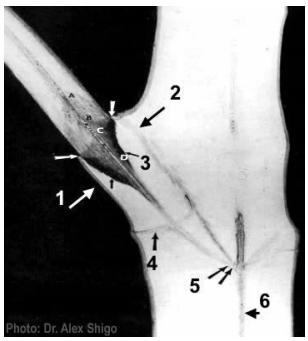
37

Tree Biology
Branch Attachment



38

Tree Biology
Branch Protection Zone



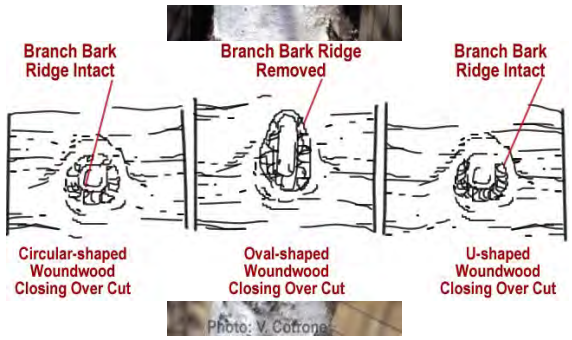
1. Branch Collar
2. Branch bark ridge
3. Branch protection zone
4. Dormant bud
5. Pith protection zone
6. Pith

39

Tree Pruning
Thinning or Removal Cut

40

Tree Pruning
Wound Closure



41

Tree Pruning
Wound Dressings

42

Oak Wilt

ID, Control, and Prevention

2021 Qualified Arborist Training
May 25 - 26, 2023
Glen Rose, TX

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

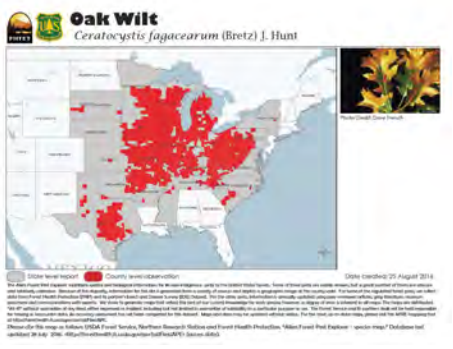
TEXAS A&M AGRILIFE EXTENSION

1

Origins of Oak Wilt

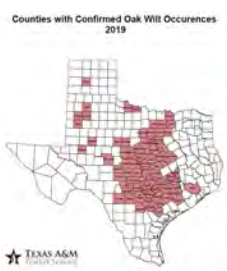
- First described in 1941
  - Wisconsin
- Probably a disease reported as early as the 1890s
  - North Central states
- Also probably a disease of live oak in Austin, TX in the 1930s

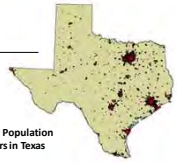
2



3

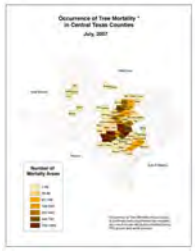
Range of Oak Wilt in Texas and Impact on Major Population Centers





4

The Impact of Oak Wilt



Urban Areas (< 1 acre)

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

5

The Impact of Oak Wilt

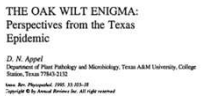
Ecosystem Impact

- Golden cheeked warbler

6

The impact of oak wilt

- Historically one of the more enigmatic pathogens in the history of North American tree pathology,
- Origins of the pathogen are unknown,
  - Reproductive processes are very unusual
- Aspects of the pathogen resemble those of an invasive pathogen
  - Dutch elm disease, Chestnut blight
  - Red oak susceptibility (introduced) vs. resistance in white oaks (native)
  - Evidence for Central or South America:


THE OAK WILT ENIGMA:
Perspectives from the Texas Epidemic

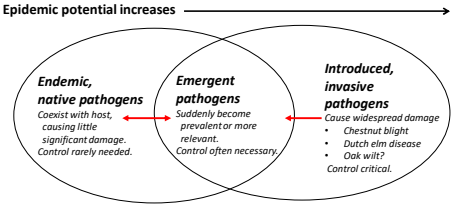
D. N. Appel
Department of Plant Pathology and Microbiology, Texas A&M University, College Station, Texas 77843-2132


The Origin of *Ceratocystis fagacearum*, the Oak Wilt Fungus


Jennifer Juzwik, Thomas C. Harrington, William F. MacDonald, and David N. Appel

7

Tree Pathogen Types (biotic) in Terms of Impact



8

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

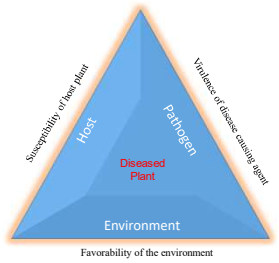
Species Composition and Stand Structure

- 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.

9

What is Plant Disease?
The Disease Triangle

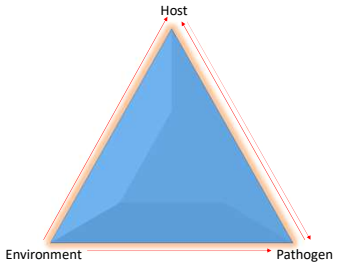
- Host
- Pathogen
- Environment



10

Interacting Factors in Tree Disease

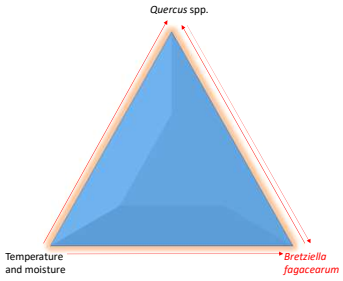
Single, virulent, biotic pathogen



11

Interacting Factors in Tree Disease

Single, virulent, biotic pathogen



12

Cause of Oak Wilt

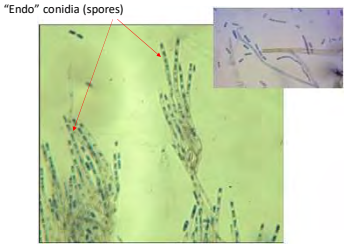
- First described as *Chalara quercina*
- *Endoconidiophora quercina*
- *Ceratocystis fagacearum*
- *Bretziella fagacearum*

13

Oak Wilt Biology, Interacting Factors

Bretziella fagacearum

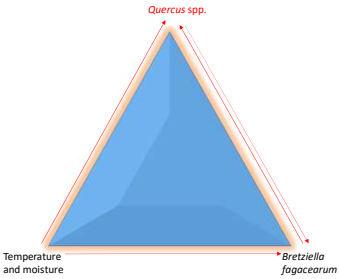
- A fungus (Ascomycete)
- Mostly parasitic, but also saprophytic
- A vascular parasite
- Produces two kinds of spores
- Forms mats of tissue under bark on certain trees
- Heat sensitive
- Origin unknown



14

Interacting Factors in Tree Disease

Single, virulent, biotic pathogen



15

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)

16

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 (≠ Immune)

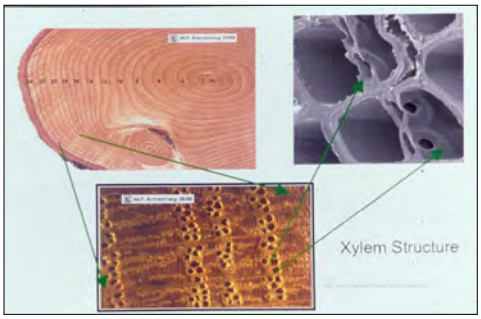
Q. sinuata var. breviloba	Shin Oak
Q. laceyii	Lacey Oak
Q. polymorpha	Mexican white oak
Q. stellata	Post Oak

LIVE OAKS= variable

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

17

Tree Structure



18

Vascular System of Trees

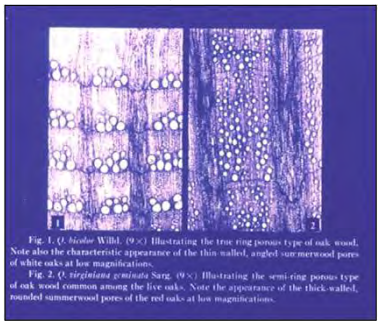


Fig. 1. *Q. bicolor* Willd. (9×). Illustrating the true ring porous type of oak wood. Note also the characteristic appearance of the thin-walled, angled summerwood pores of white oaks at low magnifications.

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.

19

How do oaks die?

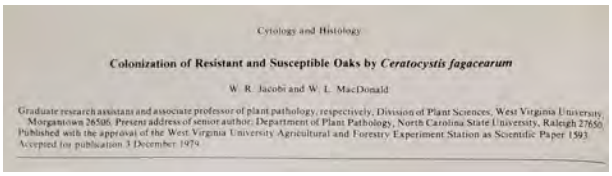
- Parmeter, J.R., Kuntz, J.E., and A.J. Riker. 1955. Oak wilt development in bur oaks. Phytopathology 46:423 – 435.
- Infected bur and white oaks in Wisconsin…:
  - "…rarely die…"
  - symptoms on "…scattered branches only…"
  - less than 1% typically die.
- Infected red oaks…":
  - "…rapid and complete wilting…",
  - death comes quickly for infected trees,
  - members killed in large "pockets".
  - nearly 15% typically die.

OAK WILT DEVELOPMENT IN BUR OAKS[1]

J. R. Parmeter, Jr., J. E. Kuntz, and A. J. Riker

20

More Recently (1980)



Cytology and Histology

Colonization of Resistant and Susceptible Oaks by *Ceratocystis fagacearum*

W. R. Jacobi and W. L. MacDonald

Graduate research assistants and associate professor of plant pathology, respectively, Division of Plant Sciences, West Virginia University, Morgantown 26506. Present address of senior author: Department of Plant Pathology, North Carolina State University, Raleigh 27650. Published with the approval of the West Virginia University Agricultural and Forestry Experiment Station as Scientific Paper 1593. Accepted for publication 3 December 1979.

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

21

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."

22

Article de synthèse / Review article

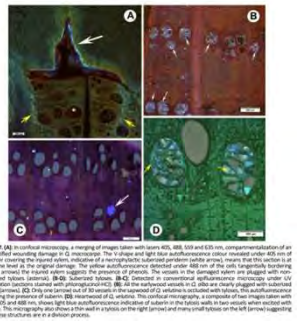
Review and new insights into wood anatomy that help understand and control oak wilt

Danny Rioux, and Martine Blais

PHYTOPROTECTION [103] : 1-25

"The aptitude of white oaks to readily form tyloses might explain why they are more resistant than red oaks to oak wilt."

"Turkey oak (*Q. laevis*) is a red oak species not quickly killed after artificial inoculations with *B. fagacearum* in South Carolina (Tainter and Ham 1983). This oak reacts to oak wilt by forming densely stained parenchyma cells together with vessels blocked by tyloses, interpreted as discontinuous barrier zones (wall 4) that hinder the progression of the pathogen (Tainter and Fraedrich 1986)."



23

Local Spread

Graft vs. Common Root System

24

Local Spread

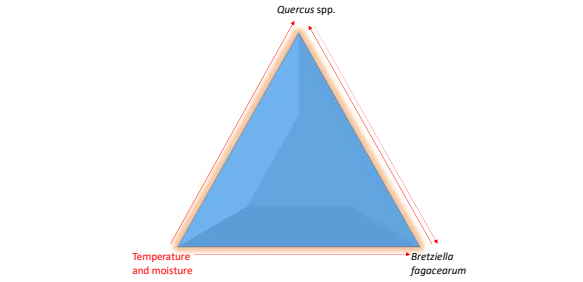
- Root grafts

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

25

Interacting Factors in Tree Disease

Single, virulent, biotic pathogen



26

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

27

Fungal Mats

28

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

29

Fungal Mats

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

30

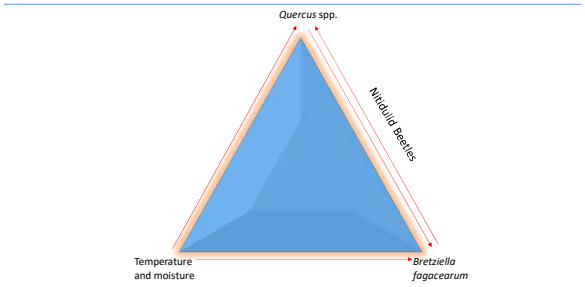
Beetle Spread

Nitidulid Beetle

31

Interacting Factors in Tree Disease

Single, virulent, biotic pathogen



32

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

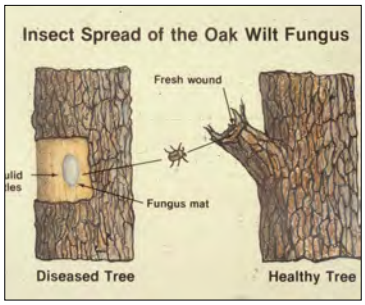
33

Beetle Spread

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

34

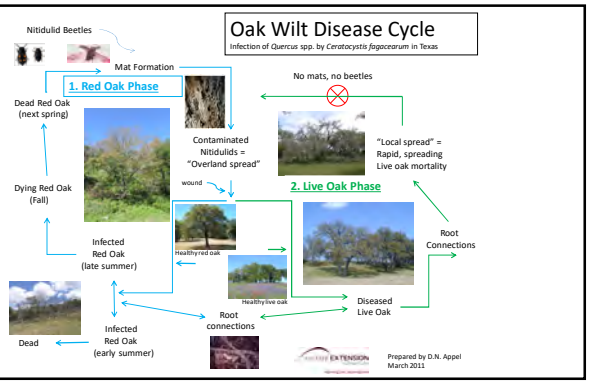
Beetle Spread



35

Part II – Disease Cycle, Control

36



37

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

38

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

39

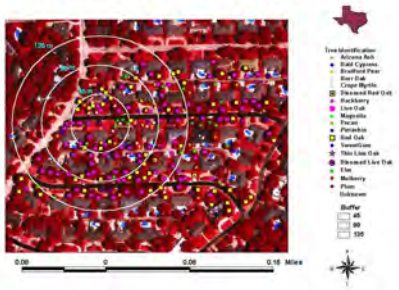
Oak Wilt Diagnosis

1. Pattern of disease in the population of trees

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

40

Potential risk of spread by C. Fagacearum



41

2. Pattern in individual trees

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

Variable rates of death, 15 – 20% survival

Rapid death (weeks), 0% survival

42

3. Foliar symptoms

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

43

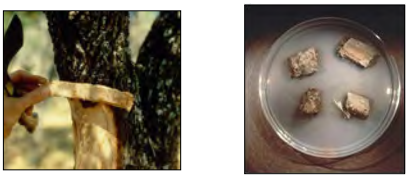
4. Presence of fungal mat

Only red oaks

44

5. Taking Samples

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



45

http://plantclinic.tamu.edu/

46

TPDDL capabilities

- General microscopy

47

Packaging for Oak wilt

48

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

49

Pruning – paint wounds

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

50

51

Tree Pruning
Wound Dressings

52

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

53

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

54

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

55

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)


56

Trenching – Types and Placement


Belt Trencher


Back Hoe


Ripper Bar


Rock Saw

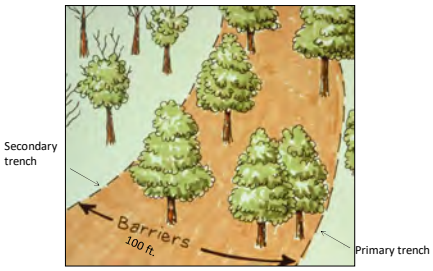
57

Trenching – Types and Placement

Within trench - you want to remove all host material

58

How to Place a Trench



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

60

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

61

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

62

Fungicide – Technique and Implementation

Fungicide

Injection equipment

Trees being injected

Double helix bit

Green T

63

The High Volume, Low Concentration Injection Process

64

Alternative Products and Techniques

65

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.

66

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

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?

68

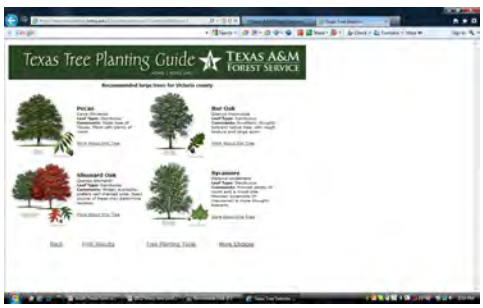
69


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

70


Texas Tree Planting Guide
TEXAS A&M FOREST SERVICE

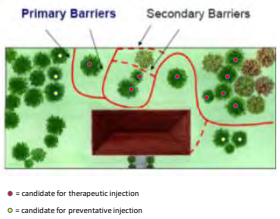
71


Texas Tree Planting Guide
TEXAS A&M FOREST SERVICE

72

73

Decision Making for Oak Wilt Treatment



74

75

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

Pattern of Mortality

Diagnosis in a Stand of Trees

Live Oak Center

Red Oak Center

3

Pattern of Mortality: live oaks

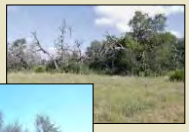
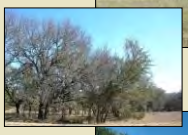
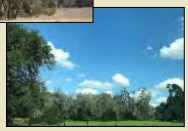
First consider:
What species are affected? Is it only oaks? Or are other species affected as well, like elms and junipers?

Then look for:
"Old" dead
- These trees will only have main branches remaining
- Likely where the disease center began

"New" dead
- Dead but still retaining smaller twigs on branches

Symptomatic
- Dieback, leaf loss, leaf symptoms

Healthy
- Currently unaffected

4

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

5

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)

6

Foliar Symptoms in Live Oaks

Veinal chlorosis and necrosis

7

Foliar Symptoms in Live Oaks

Vein banding “interveinal necrosis”

8

Foliar Symptoms in Live Oaks

Tip burn and
marginal necrosis

9

Foliar Symptoms in Red Oaks

Bronzing or water soaking

10

Foliar Symptoms in White Oaks

Chinkapin oak

Lacey oak

Monterrey oak

Take samples

11

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

12

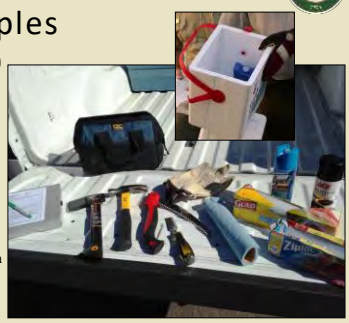
Taking Samples

- Bole or branch samples
- Confirms presence of pathogen

13

Taking Samples

Ice Chest & Ice packs (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



14

Taking Samples

For Best Results

- Select trees that are fully symptomatic but not dead
- Take both bole and branch samples but do not place them in the same bag
- Include symptomatic leaves with branch samples
- Keep everything sterile, separated and cool

Do not mix samples from different trees in the same bag

15

Taking Samples

- Select branches that are 1-2" in diameter with foliar symptoms
  and/or
- Cut windows into the tree down to the sapwood with hatchet


16

Taking Samples

- Using chisel and mallet, collect strips of sapwood for sampling
- Paint wounds when complete



17


Taking Samples

- Bag & label everything and keep cool
  - *Do not freeze at any point*
  - *Do not leave out in the sun or in vehicle*
- Complete diagnosis form D-1178 as thoroughly as possible
- Send sample to lab as soon as possible


Plant Disease Diagnostic Form

18

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

@TFSCentralTX

20

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

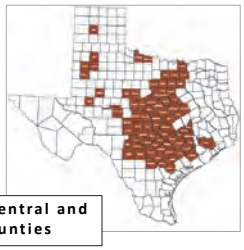
Oak Wilt Suppression Project

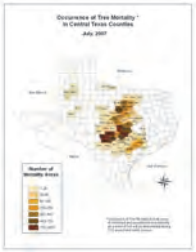
"The overall goal of the Texas A&M Forest Service's Cooperative Oak Wilt Suppression Project is to **minimize the spread of oak wilt** (*Bretziella fagacearum*) in **central Texas**"

TFSWEB.TAMU.EDU

2

Oak Wilt Occurrence in Texas





Confirmed in 76 central and west Texas counties

TFSWEB.TAMU.EDU

3

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.EDU

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 **public awareness and 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

6

Regional Areas

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

TFSWEB.TAMU.EDU

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 cost-shared 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.EDU

9

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

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

12

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.EDU

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.EDU

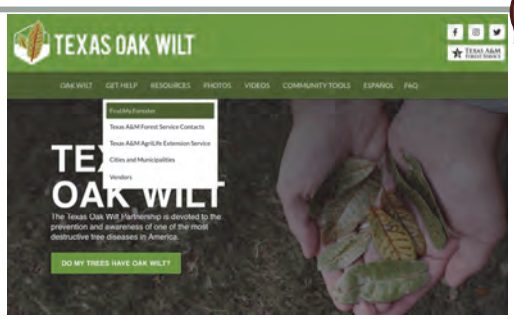
15

Public Education and Awareness

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

TFSWEB.TAMU.EDU

16



TFSWEB.TAMU.EDU

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

TFSWEB.TAMU.EDU

18


TEXAS A&M
FOREST SERVICE
Central Texas – Texas A&M Forest Service
@TFSCentralTX
@TFSCentralTX
Thank You!
Demian F. Gomez
linktr.ee/demiangomez
Regional Forest Health Coordinator
Texas A&M Forest Service
TFSWEB.TAMU.EDU

19


CONSERVE. PROTECT.
LEAD.
TEXAS A&M FOREST SERVICE
1915

20

Oak Wilt in Relation to Other Tree Diseases

ISA-T Oak Wilt Qualification Training
May 25 – 26, 2023
Glen Rose, TX
June 8 – 9, 2023
Fredericksburg, TX

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

TEXAS A&M AGRILIFE EXTENSION

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,
  - difficulties in laboratory isolation,
- How does it relate to Dutch elm disease?
  - why do we use insecticides to control DED but not OW?
- Why isn't OW more devastating?

2

Examples of Common 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

3

Examples of pathogens

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

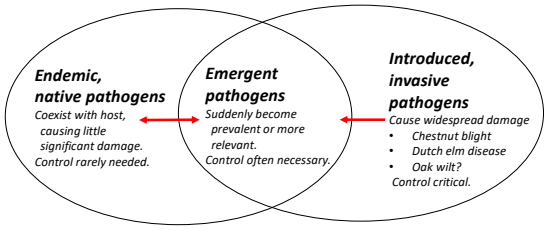
Biotic Pathogens
Fungi
Bacteria
Viruses
Nematodes
Phytoplasmas
Parasitic flowering plants

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

4

Tree Pathogen Types (biotic) in Terms of Impact

Epidemic potential increases →



5

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.

6

Examples of an Abiotic Pathogens

Herbicide Damage - Treaty Oak

Velpar®

Hexazinone - broad spectrum weed and brush control

7

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.

8

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 a commercial lab may be necessary (TPPDL, RAL, etc.)

9

Comparison of Oak Wilt and Drought Symptoms in Live Oak Trees

Oak Wilt

Drought

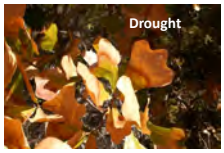
10

Comparison of Oak Wilt and Drought Symptoms in Live Oak Foliage

11

Foliar Oak Wilt Symptoms in Red Oak

vs. Drought



12

Overwatering

Mimics Oak Wilt Symptoms

13

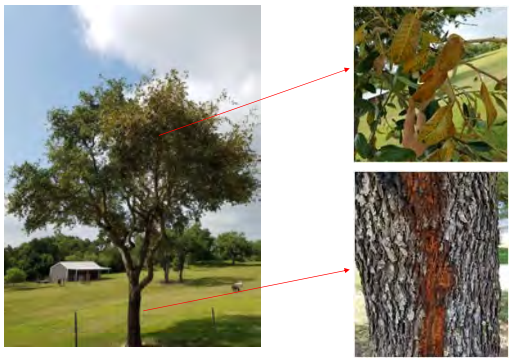
Freeze Damage

Mimics Oak Wilt Symptoms

14

https://discussions.texasbowhunter.com/forums/showthread.php?t=596358

Community Forum of TexasBowhunter.om



15

Examples of Biotic Pathogens

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

16

Foliar Disease vs. Vascular Wilts

Note the Contrast

- Highly localized in tree,
- Rarely cause death of mature trees,
- Straightforward, simple disease cycles,
- Long term, sustained epidemics rare,
- Rarely economic problems,
- Control measures often unwarranted.

- Systemic throughout tree,
- Often lethal
- Can have more complex disease cycles,
- Under right conditions, long term epidemics can be sustained,
- Can be destructive and costly,
- Elaborate controls are often needed.

17

Foliar Diseases - Pattern in Crown

Tubakia dryina

Formerly known as
Actinopelte dryina

Starts in the bottom and moves up

18

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.**

19

Vascular Diseases

How does oak wilt compare to other similar diseases?

- **Some of the most damaging of all tree diseases,**
- **Usually rapid, often fatal,**
- **Some are introduced, exotic pathogens,**
  - **Fusarium wilt of Mimosa**
  - **Verticillium wilt**
  - **Bacterial leaf scorch (BLS)**
    - **often confused with OW**
- **Usually vectored by insects.**
  - **why is oak wilt controlled differently from Dutch elm disease?**

20

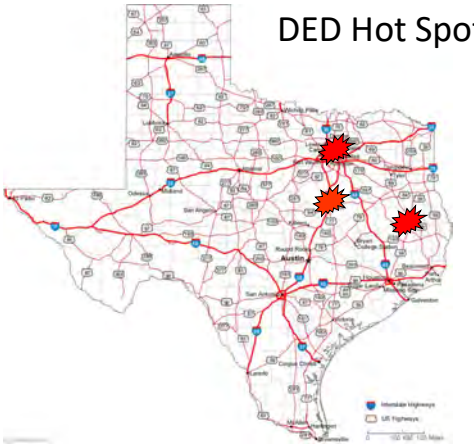
Dutch Elm Disease

The Pathogen

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

21

DED Hot Spots



22

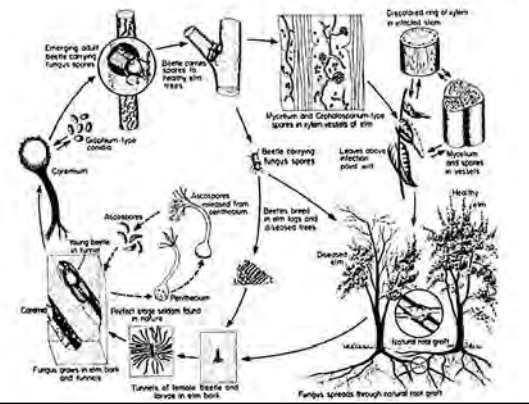
Dutch elm disease

Disease Biology

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

23

Disease Cycle – Dutch elm disease



24

Dutch elm disease

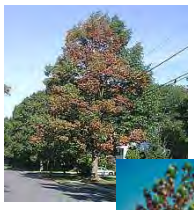
Management – compare to oak wilt

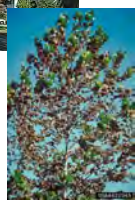
- Detection,
- Isolation,
- Removal,
- Disposal,
- Injection,
- Host resistance.

25

Bacterial Leaf Scorch

Pathogen, Hosts





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

26

Bacterial Leaf Scorch

Disease Biology

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

27

Bacterial Leaf Scorch

Management

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

28

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
The most common of tree disease, syndromes
May occur on any species of trees
Symptoms usually similar for different species and locations

29

Epicormic Shoots

Water sprouts, suckers

- Produced in response to trauma,
  - bad pruning,
  - stress, e.g. drought, root loss, etc.,
- Arise from suppressed buds under bark,
- Loss of apical meristems,
  - lack of auxins,
- Branches are weak, easily break,
- Symptom of a tree in distress.

30

Role of Environment in Tree Diseases

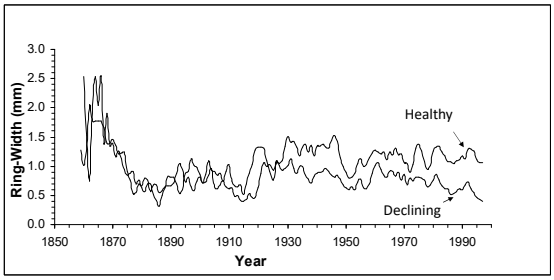
- the 3 factors

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).

31

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



32

Rapid Decline of Post Oak

Symptoms/signs

- Rapid appearance of chlorotic (yellow) and necrotic (brown and dead) leaves throughout the entire tree crown,
- Leaves remaining attached to twigs, but the trees were dead or nearly so,
- Groups of dead and dying trees,
- Multiple factors responsible,
  - Will vary from one location to next,
  - Often go unnoticed in early stages.

33

Can Oak Wilt be Confused With Oak Declines?

Not in the red oaks, but in the live oak survivors – yes!

34

Drought In Leakey, TX – Inciting factor

35

Freeze – another inciting factor

36

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.

37

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.

38

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,

39

Cankers

Endothia gyrosa on oak

Hypoxylon atropunctatum on oak

Nectria canker on dogwood

40

Hypoxylon Canker

Pathogen, Hosts

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

41

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.

42

Commonly Held Opinions and Observations of Hypoxylon Canker

How does this compare to oak wilt?

- "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"

43

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.

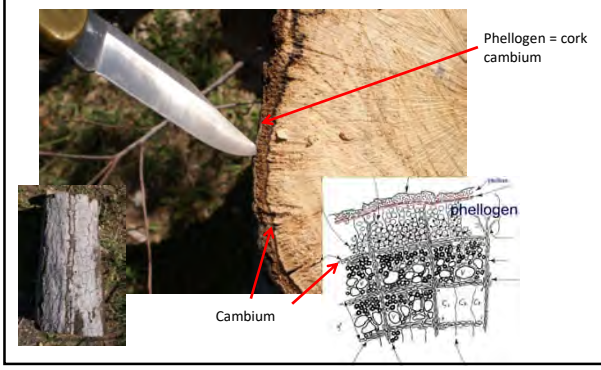
44

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.

45

Colonization by Hypoxylon



46

Colonization by Hypoxylon

47

Ganoderma Root Rot

Pathogen, Hosts

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

48

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.

49

Ganoderma Root Rot

Management

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

50

Managing Declines

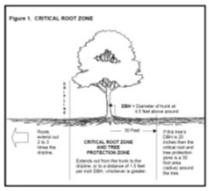
and the Contributing Factors

- 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®,
  - plant growth regulator,
- Remedial pruning,
- Proper pruning,
- Reduce stress.

51

Vertical Mulching for Enhancing Tree Health

Objectives

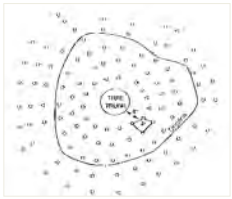


- Improve soil properties,
- Stimulate growth of root system,
- Increase tolerance to soil pathogens,
- Enhance growth of crown and tolerance to canker pathogens, heart rots, and other contributing factors.
- Pan, J.F. 1958. Effects of Vertical Mulching and Subsoiling on Soil Physical Properties. Agron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

52

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.**



53

Questions?

54