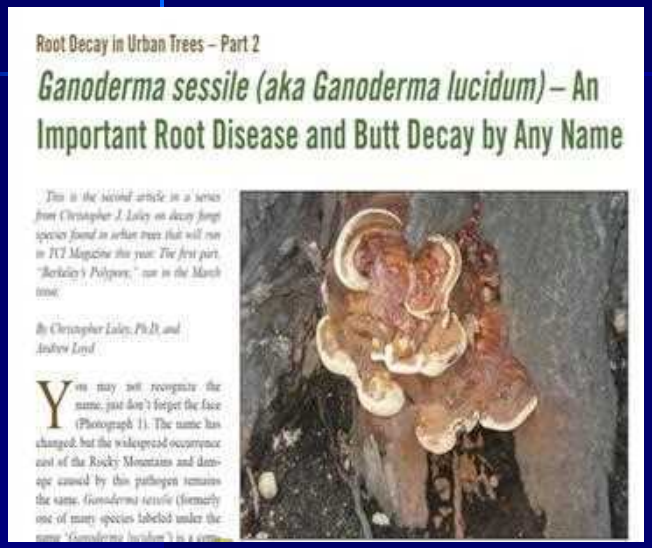
Assessing Trees With Decay

Christopher J. Luley, Ph.D.

Urban Forest Diagnostics LLC

chris@chrisluleyphd.com

chrisluleyphd.com
Treerot.com


Root Decay in Urban Trees – Part 2

Ganoderma sessile (aka Ganoderma lucidum) – An Important Root Disease and Butt Decay by Any Name

This is the second article in a series from Christopher J. Luley on decay fungi species found in urban trees that will run in TCI Magazine this year. The first part, "Berkeley's Polypore," ran in the March issue.

By Christopher Luley, Ph.D. and Andrew Loyd

You may not recognize the name, just don't forget the face (Photograph 1). The name has changed, but the widespread occurrence east of the Rocky Mountains and damage caused by this pathogen remains the same. *Ganoderma sessile* (formerly one of many species labeled under the name '*Ganoderma lucidum*') is a com-

Tree Care Industry Magazine
Root Decay Fungi 9 Part Series


Publications


SEX AND DECAY FUNGI

By Christopher J. Luley, Ph.D.

Let's have a frank talk about sex and reproduction in the fungi that cause decay in trees. The details may surprise some people, but the discussion will be, as they say, "safe" for work situations.

If you get this first important biological fact about sexual reproduction in decay fungi, the rest of the details will make a lot more sense. The fact is, a tree must be infected by spores twice for sexual reproduction to occur, as evidenced by devel-

Tree.

And, when infections are initiated by spores, sexual reproduction requires that hyphae of these two different mating types physically join within the tree. Thus, single-spore infections or different parts of the tree that never physically join together will not result in sexual


HERE COME

the Basidiocarps: Seasonal Fruiting of Decay Fungi

BY CHRISTOPHER J. LULEY, PH.D.

Just like the seasonal progression of flowering in higher plants, the annual appearance of fruiting [illegible] production of mushrooms, conks, brackets and other fruiting structures of

This synopsis represents my observations of the time during the growing season when mixed-decay fungi typically first appear. Most of my observations

fruiting. In addition, in southern climates some fungi may fruit well into the winter or at least continue to produce and release spores from fruiting bodies formed during the previous season.


Do You Hear What I Hear?
Part II: Field Application of Sounding

By Christopher J. Luley and Mike Ellison

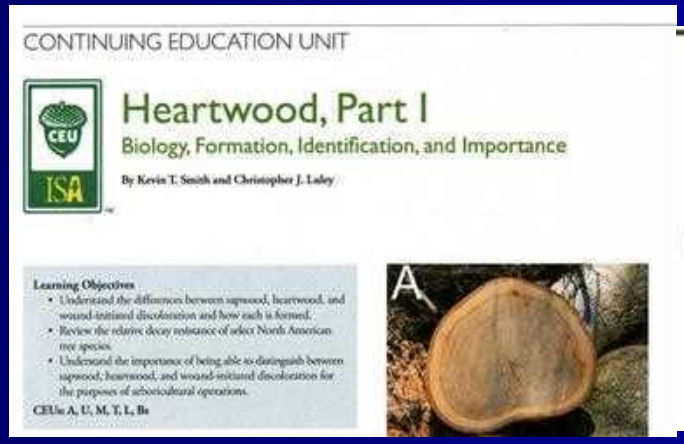
The Tools

How to Sound a Tree


CLIMBING INNOVATIONS & GEAR

2025

Ash to Ashes: Don't Be Part of the Process


CONTINUING EDUCATION UNIT

CEU ISA

Heartwood, Part I

Biology, Formation, Identification, and Importance

By Kevin T. Smith and Christopher J. Luley

Learning Objectives

- Understand the differences between sapwood, heartwood, and wound-initiated discoloration and how each is formed.
- Review the relative decay resistance of select North American tree species.
- Understand the importance of being able to distinguish between sapwood, heartwood, and wound-initiated discoloration for the purposes of arboricultural operations.

CEUs: A, U, M, T, L, Bs


Heartwood and Heart Rot, Part 1: Are they Important to Arborists?

Photo 1. Man has used the increased resistance of heartwood of some tree species for wood in service. Here, black-locust fence posts and white-oak rails have resisted decay in service for more than 20 years. Unless otherwise noted, all photos courtesy of Christopher Luley.

BY KEVIN T. SMITH, PH.D.; CHRISTOPHER J. LULEY, PH.D.; AND TOM GRAVES

Tree care professionals frequently assess or estimate the strength of wood within a living tree or standing snag. This is often quite infor-

Presentations and Handouts Available as .pdf's

Visual Identification Series (VIS) -Indicators of Stem/Trunk Decay in Trees

Introduction

Indicators of decay (IOD) suggest that internal decay or missing wood are present in a tree. Some indicators are positive and some are suggestive or potential indicators of decay. Arborists and urban tree managers need to be acutely aware of IOD's as they can provide evidence of decay that may require further evaluation using other decay detection methods. IOD are useful to help determine locations to test the tree for decay.

Positive Indicators

These indicators mean the tree has some degree of internal decay. The extent of decay can sometimes be visually estimated. Sounding with a mallet or probing depending on the indicator is recommended. Trees with positive indicators may have to be evaluated further using more advanced testing methods and tools.

Single Conks-Heart Rot

Numerous Small Conks-Sap Rot

External Cavities

Carpenter Ant Sawdust

Nesting Holes

Visual Evidence

Christopher Luley. Ph.D.. Urban Forest Diagnostics LLC chrisluleyphd.com

VIS Indicators of Structural Root Decay and Root Problems in Trees

Introduction-Indicators of Root Decay

Indicators of decay in structural roots are very important because roots are much less accessible. Root excavation may be needed to expose roots for decay testing in important situations. Whole tree failures from root decay can be catastrophic, so careful evaluation is critical.

Positive indicators of decay in roots

Positive indicators mean that some degree of structural root decay is present. The amount of decay may need to be verified with testing.

Conks or mushrooms on roots, or in soil and attached to roots

A limited number of decay fungi fruit directly from roots. Conks or mushrooms attached to woody roots are a positive indicator of decay. Most of the root decay fungi fruit on buttress roots or the butt or base of trees.

Conks on butt or buttress roots

Almost all the fungi that fruit on buttress roots or the butts (lower trunk) of trees also cause decay structural roots. Conks on the butt of a tree indicate structural root decay is present.

Basal Decay

This is a visual symptom of decay that is often observed on trees in urban areas that have been damaged by maintenance equipment or other wounding. The decay at the soil line indicates some degree of butt rot and structural root decay.

Christopher J. Luley, Ph.D Urban Forest Diagnostics LLC Chrisluleyphd.com

TreeRot.com

Photographing and Observations for Identifying Mushrooms and Conks

Taking the good photographs can greatly improve the chance of obtaining a more accurate evaluation or identification of the fungus growing on or around a tree. Some fungi are so common that a single good photograph is adequate for identification, while others require several and specific pictures of certain features. Some fungi cannot be identified from pictures and require fresh samples in good condition for microscopic evaluation.

The following are desired photographs requested for use of our diagnostic service. Examples are provided as a guide. If the fungus has gills under the cap (# 3 below) and is growing on the ground or lower trunk of the tree, the color of the spore print will be needed for identification (See #4).

1. General Habit: What the specimen looks like from several feet away. If the fruiting is higher in the tree use the zoom on your camera. Examples below.

2. Close up of top of the mushroom or conk.

Christopher J. Luley, PhD.

Mushroom-Conk Identification

Does the Tree Care Industry Need a Decay Inspection Standard?

By Christopher Luley

There are at least two sides to most every position and the question of the need for an industry-wide decay inspection standard is no exception. Decay inspections are performed in many different work situations in the tree care industry, such as during pre-climbing or work routines, sales calls for new or existing clients, in tree inventories or during formal risk assessments. These various situations may have different inspection processes for level of detail, interpretation and communication of result, and regarding the need for further inspection.

No Inspection Standards!
No Action Thresholds or or Limits!
No Predictive Ability!

Decay Assessment

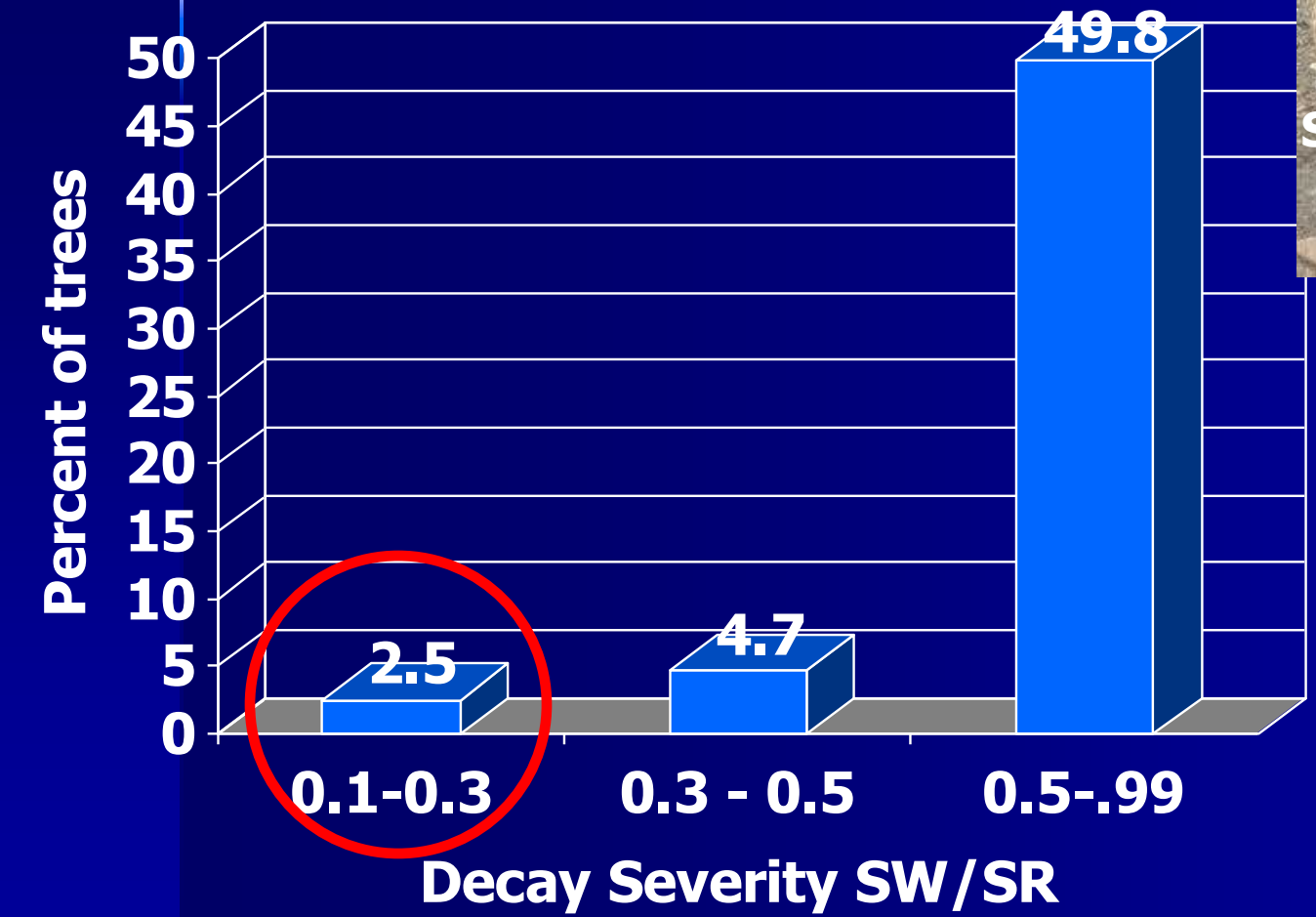
In Many Different Work Contexts

- Tree Inventory
- Risk Assessment
- Sales Calls
- Customer Service Visits
- Working Arborist
- Municipal Arborist
- Utility Arborist

Decay Severity

All Trees All Cities

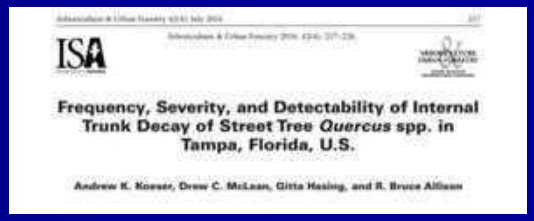
58% with decay




ISA

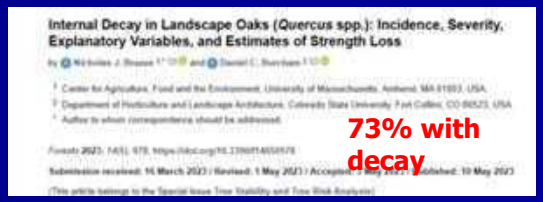
Frequency and Severity of Trunk Decay in Street Tree Maples in Four New York Cities

Christopher J. Luley, David J. Nowak, and Eric J. Greenfield


ISA

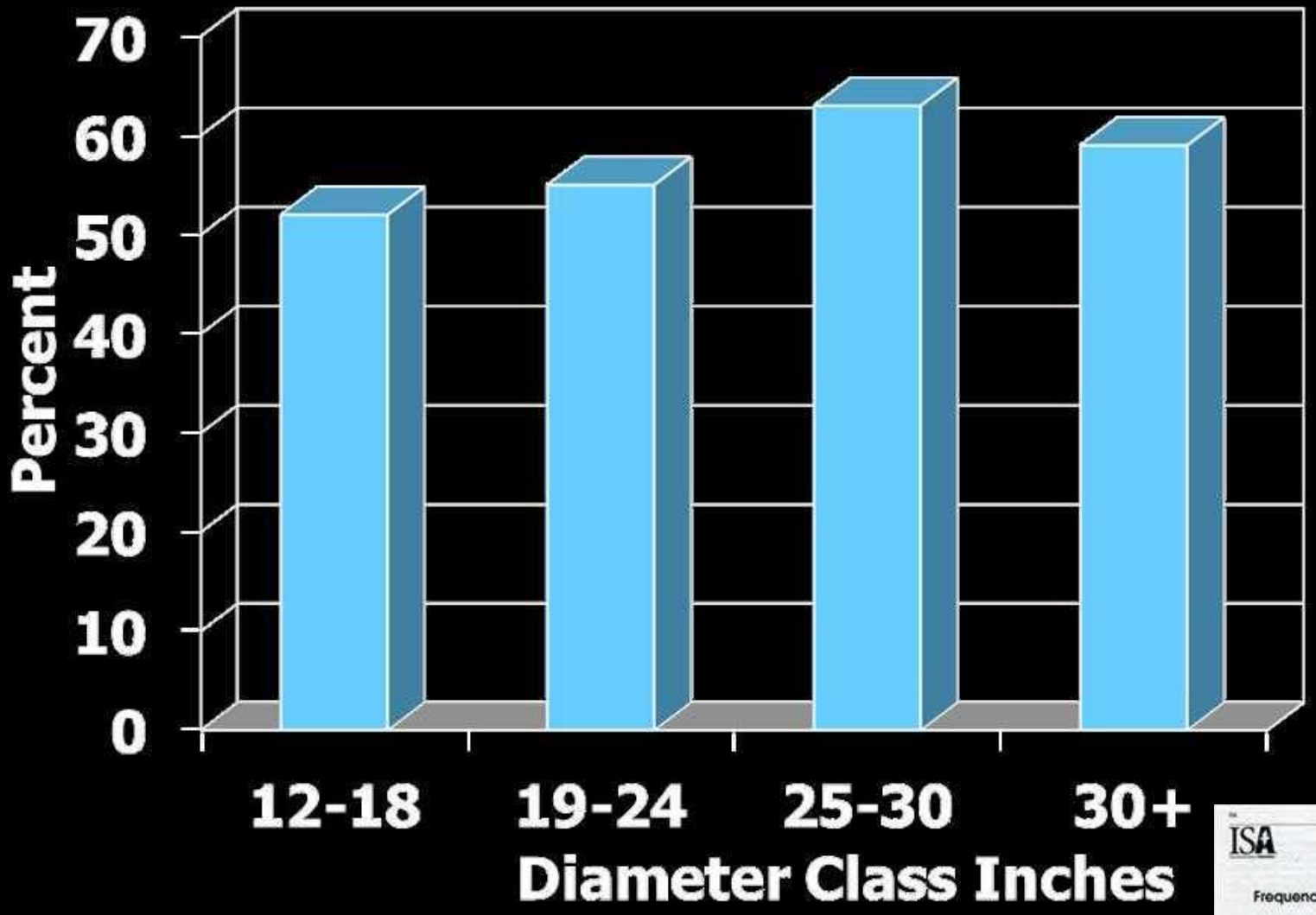
Frequency, Severity, and Detectability of Internal Trunk Decay of Street Tree *Quercus* spp. in Tampa, Florida, U.S.

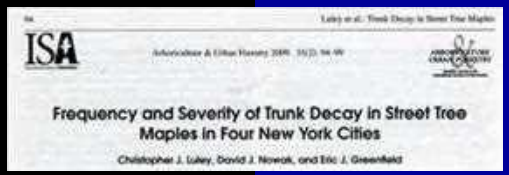
Andrew K. Koeser, Drew C. McLean, Gitta Hasing, and R. Bruce Allison


Internal Decay in Landscape Oaks (*Quercus* spp.): Incidence, Severity, Explanatory Variables, and Estimates of Strength Loss

73% with decay

Decay Incidence by DBH

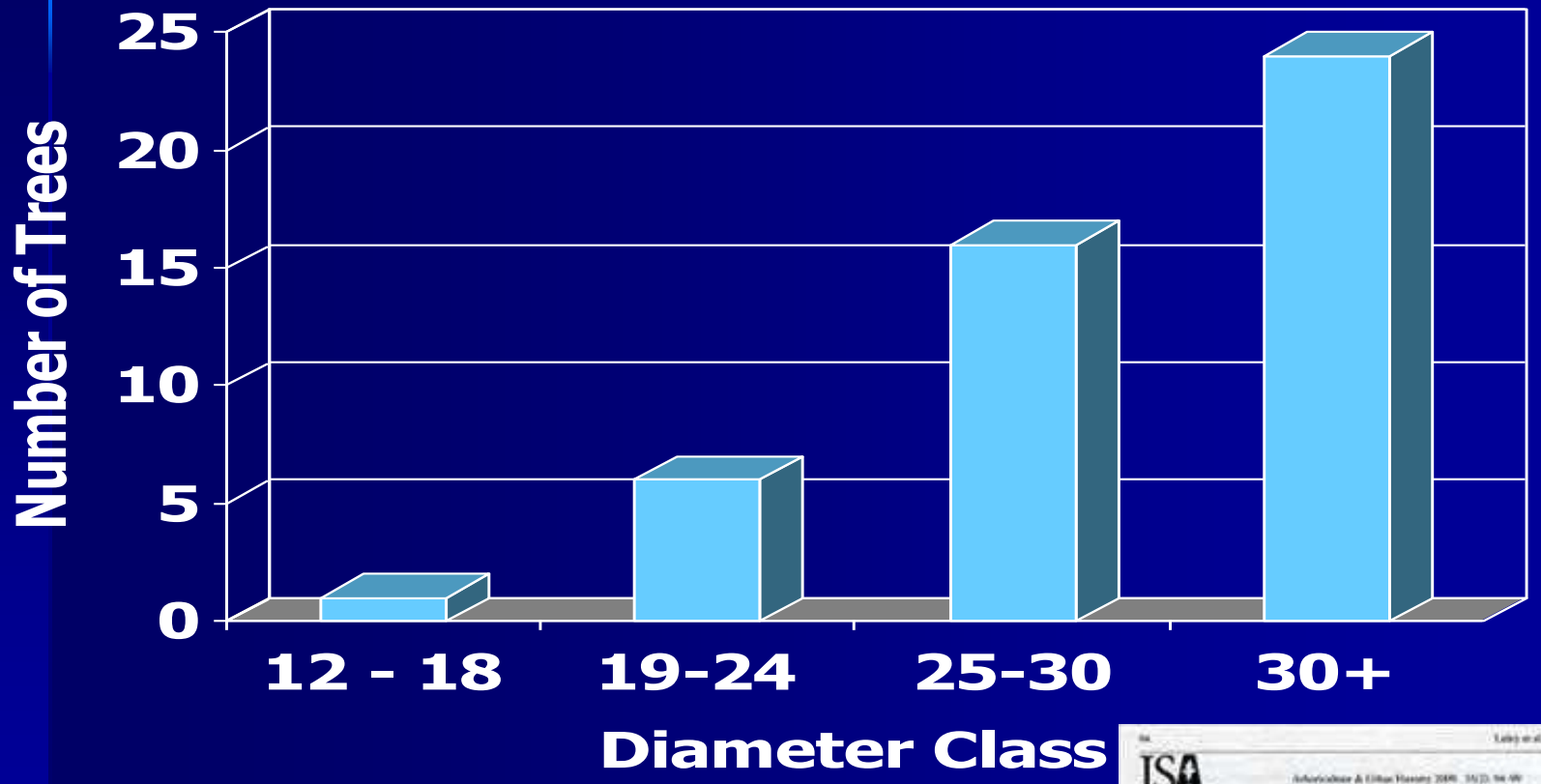


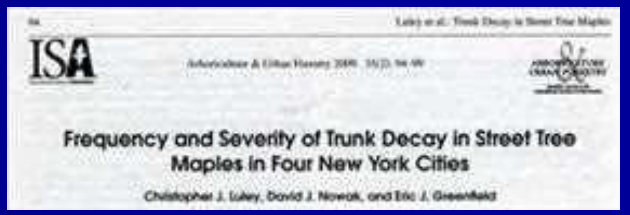

ISA

Frequency and Severity of Trunk Decay in Street Tree Maples in Four New York Cities

Christopher J. Luley, David J. Nowak, and Eric J. Greenfield

Decay Severity by Diameter t/R = 0.3 or less





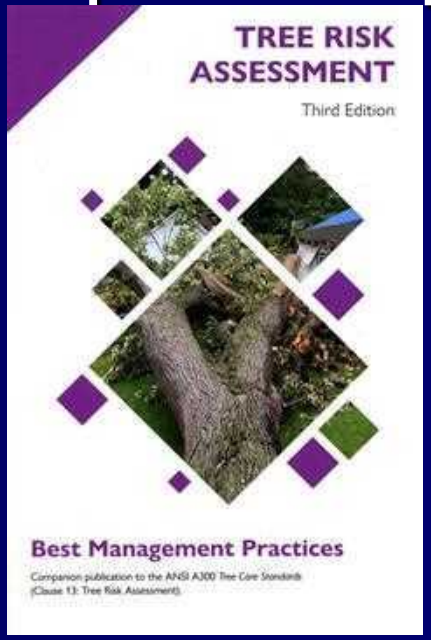
Decay can be severe in smaller diameter stems

Your Role

1. *Identify decay presence*
2. *Make initial assessment of severity*
3. *If needed, notify client in writing of need for action or additional evaluation*
4. *Monitor/Test/Remediate*
   -As contracted for
5. *Notify climber of risk potential if present*
   a. *This is a "different" assessment than environmental failure*

BMP Tree Risk Assessment 2023

- "There is no industry-standardized process for tree inspection" page viii



The purpose of a work site inspection is to identify and communicate site and/or tree conditions that may affect the scope of work, work procedures, and/or tree worker safety. Observations are communicated to the supervisor and other workers on the site. Work site inspection is not the same as tree risk assessment, nor are the same criteria necessarily used to determine conditions of concern.

Table 2. Comparison of tree risk assessment, tree inspection, and work site inspection.

	Tree Risk Assessment	Tree Inspection	Work Site Inspection
Purpose:	Provide information to assist with management decisions for the tree or the property	Gather information for tree care or management decisions	Identify and communicate site and/or tree conditions that may affect the scope of work, work procedures, and/or tree worker safety
Provides information to:	Tree risk manager	Tree owner or manager	Supervisor and other workers
Contract and/or scope of work agreed to prior to assessment or inspection?	Yes	Optional	Yes
Tree location identified?	Yes	Yes	Yes
Tree visually inspected?	Yes	Yes	Yes
Likelihood of failure, likelihood of impact and consequence categorized?	Yes, when using the ISA Tree Risk Assessment BMP methodology	No	No
Tree risk rating(s) developed?	Yes, based on scope of work	No	No
Risk mitigation recommended?	Yes, based on scope of work	Optional	Optional
Tree risk report presented or submitted?	Yes	No	No
Recommendation for reassessing the tree?	Optional	Optional, unless required by standards or jurisdiction	No

Decay in Urban Trees
Defect or just a Common Condition?

forests

MDPI

Article

Defective or Just Different? Observed Storm Failure in Four Urban Tree Growth Patterns

Andrew K. Koeser [1,*], Ryan W. Klein [2], Richard J. Hauer [3,4], Jason W. Miesbauer [5], Zachary Freeman [1], Christopher Harchick [2] and Brian Kane [6]

[1] Department of Environmental Horticulture, Center for Land Use Efficiency, Institute of Food and Agricultural Science, University of Florida-Gulf Coast Research and Education Center, 14625 County Road 672, Wimauma, FL 33598, USA
[2] Department of Environmental Horticulture, Center for Land Use Efficiency, Institute of Food and Agricultural Science, University of Florida, Gainesville, FL 32611, USA
[3] College of Natural Resources, University of Wisconsin-Stevens Point, 800 Reserve Street, Stevens Point, WI 54481, USA
[4] Urban Forestry, CN Utility Services, 5930 Grand Ave., West Des Moines, IA 50266, USA
[5] The Morton Arboretum, 4100 Illinois Route 53, Lisle, IL 60532, USA
[6] Department of Environmental Conservation, University of Massachusetts, 160 Holdsworth Way, Amherst, MA 01003-9285, USA
* Correspondence: akoeser@ufl.edu

Abstract: Practitioners who assess the risk associated with urban trees often factor in the presence or absence of visual tree defects when determining whether a tree may fail. Although these defects are a main fixture in many tree risk assessment systems and best-management practices, the research supporting their usefulness in predicting tree failure during storms is limited. When looking at past research involving populations of storm-damaged trees, several defects have never predicted failure (or have been associated with reduced rates of failure). In this study, we took a closer look at four such defects: codominant branches; branch unions with included bark; multiple stems originating from the same point; and overextended branches. After Hurricane Ian, we revisited 1518 risk-assessed trees where one of these four defects was identified as the primary condition of concern. Fourteen of these trees experienced branch failure during the storm (which hit the study area as a downgraded tropical storm). Upon closer inspection, none of these failures occurred at the defect of concern. Our findings indicate that none of the defects assessed appeared to increase the likelihood of tree failure in the species tested. Our results are in line with past research on these defects derived from post-storm assessments and analysis.

Keywords: bifurcation; cyclone; forks; hurricane; tree biomechanics; tree risk assessment; typhoon

check for updates

Citation: Koeser, A.K.; Klein, R.W.; Hauer, R.J.; Miesbauer, J.W.; Freeman, Z.; Harchick, C.; Kane, B. Defective or Just Different? Observed Storm Failure in Four Urban Tree Growth Patterns. *Forests* **2023**, *14*, 988. https://doi.org/10.3390/f14050988

- Condition or condition of concern?
- Maybe we are inaccurately representing this?
  - Only a defect in rare cases
- Cholesterol in humans

Three Levels of Assessment Based on a Scope of Work! Municipality or Company Policy?

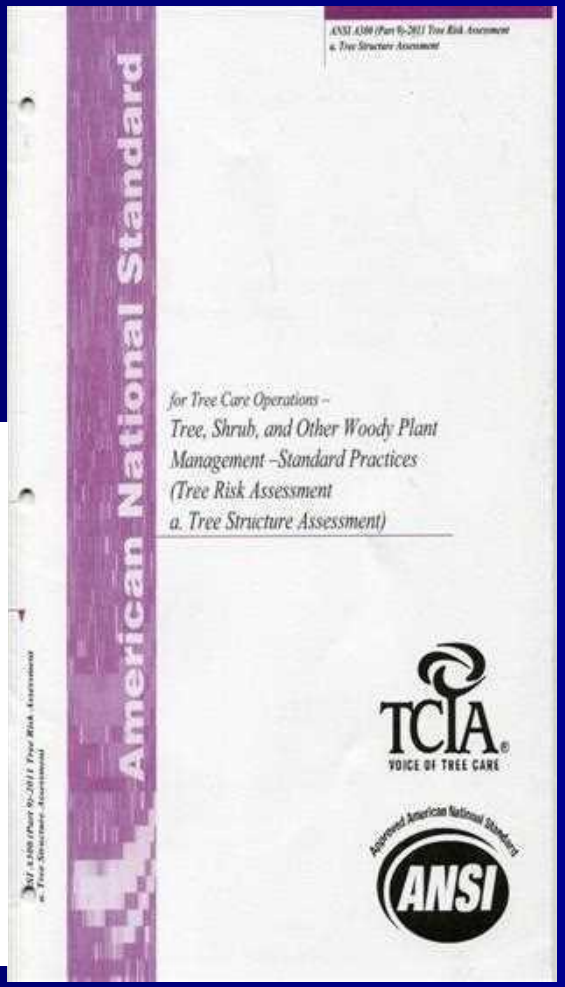
1. Limited Visual
2. Basic
3. Advanced

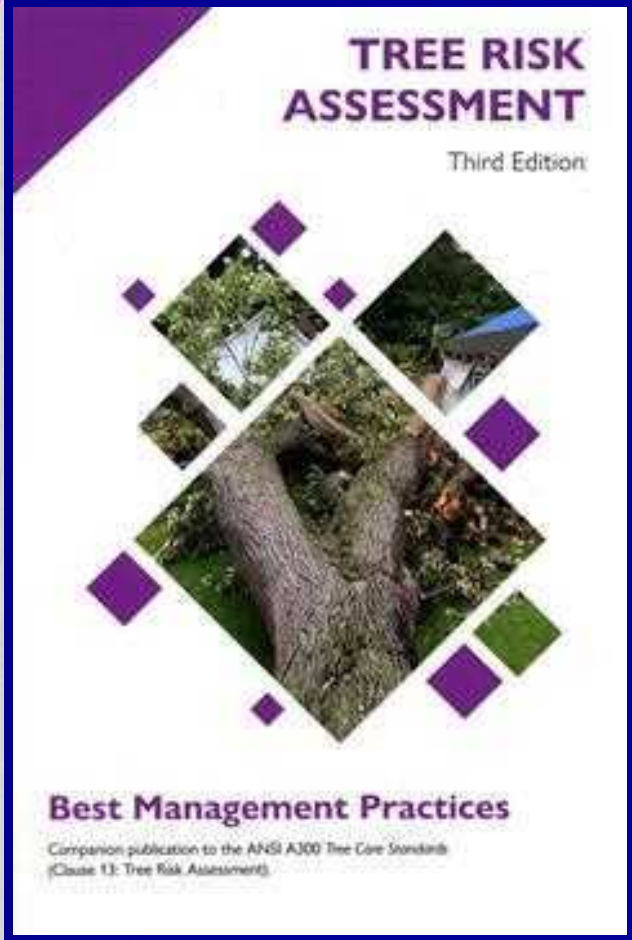
Re: Contract/Scope of Work for a Level 3 Tree Risk Assessment
Client: Joe Bean Dr., Rochester, NY 14612

I, Christopher J. Luley, Ph.D., Vice President/Pathologist, Tree Risk Assessment Qualified by the International Society of Arboriculture, of Urban Forestry LLC located at 6050 Hicks Rd. Naples, New York (hereafter, the "Consultant") agrees to provide Joe Bean of 38 Coffee Dr Rochester NY 14612 (585) 330-6577 (hereafter, the "Client") with services for tree risk assessment of one trees located on the Client's property. The evaluation will be conducted under the following agreed upon terms and Scope of Work:

1. The Consultant agrees to provide:

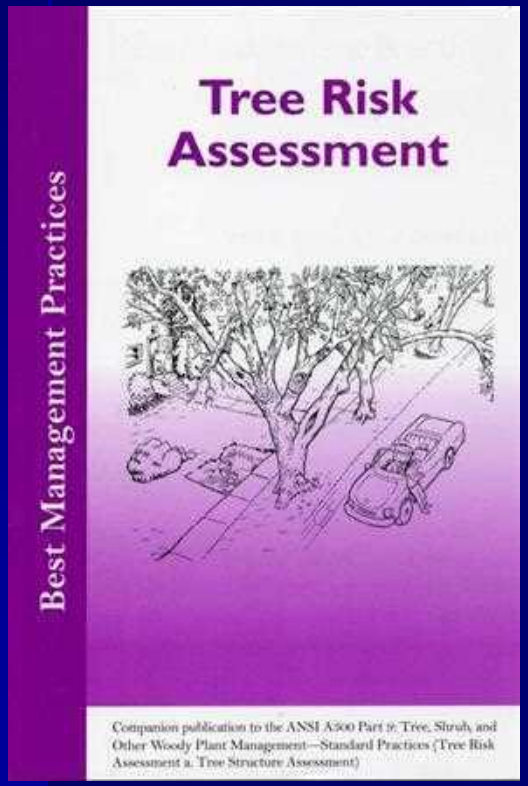
- A Level 3 Tree Risk assessment depending on agreement on site as defined in ANSI 2011 (Tree, shrub, and other woody plant management-standard practices. Tree risk assessment. a. Tree structure assessment. ANSI A300 (Part 9) – 2011. ANSI. Washington, DC) and ISA Best Management Practices for Tree Risk Assessment (Smiley, E. T., N. Matheny, and S. Lilly. 2011. Best Management Practices. Tree Risk Assessment. Champaign, IL) at the above referenced property.The Level 3 assessment with be with the





Process

- ANSI –Risk
- BMP Risk
- TRAQ



Level 2 Basic Tree Risk Assessment: Process for Assessing Decay

1. Is decay present?

Potential indicators of decay:

- old wounds and injuries
- response growth swellings
- cracks and seams
- oozing
- dead or loose bark
- sunken areas in the bark

Definite indicators of decay or missing wood:

- cavity openings
- nesting holes
- internal bee hives
- fungal fruiting structures
- carpenter ants

2. What is the significance of decay?

Basic assessment techniques to assess decay may include sounding and probing.

To determine the severity of decay, evaluate the following:

Load:

- crown density and area
- live crown ratio, taper
- wind strength and direction
- precipitation (e.g., rain, ice, snow)
- location of load
- response growth to load
- length of lever arm

Location and extent of decay:

- location (e.g., heartwood, sapwood, basal, root)
- in relation to cross section (e.g., center, off-center, cavity opening)
- in relation to defect or other condition (e.g., between codominant stems, tension side of lean)

Species profile:

- ability to compartmentalize
- wood density
- failure patterns

Response growth to decay:

- type of response growth (e.g., tension, compression, flexure wood, woundwood)
- amount of response growth (e.g., significant, minor, none)
- vigor of tree (consider tree species and age)
- age of tree wound or condition

Fungal profile:

- type of decay (e.g., white rot, brown rot, soft rot)
- aggressiveness of fungal species
- ability to penetrate Wall 4 of CODIT

Tree health:

- vigor of tree (consider tree species and age)
- dieback
- opacity (foliage density)
- live crown ratio

3. How does the significance of the decay affect likelihood of failure?

Increased likelihood of failure:

- significant load
- poor tree health
- insufficient response growth
- poor ability to compartmentalize
- aggressive fungal species
- critical location of decay

Decreased likelihood of failure:

- minor load
- good tree health
- significant response growth
- significant ability to compartmentalize
- slow-spreading fungal species
- non-critical location of decay

Source: Christopher J. Luley, Ph.D., Urban Forestry, LLC

Categorize Likelihood of Failure Within a specified time period

Likelihood of Failure	Likelihood of Impact			
	Very Low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very Likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

No Process!
No Thresholds!
~No Predictive Ability!

Likelihood of Failure Within Inspection Period

1. Failure potential
   - Imminent-Failure without additional load
     - No time frame
   - Probable-may be expected under "normal" weather conditions
   - Possible –unlikely under normal weather conditions
   - Improbable-may not fail in severe weather

Imminent- failure has started or may occur without additional load or under normal conditions

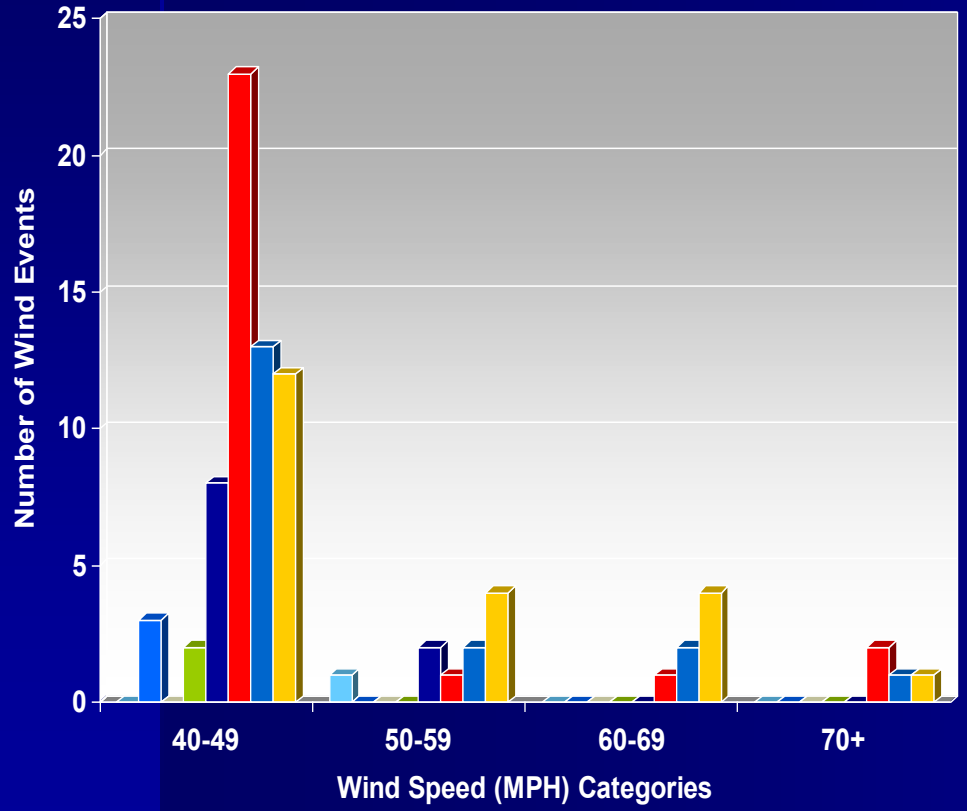
What are normal winds?

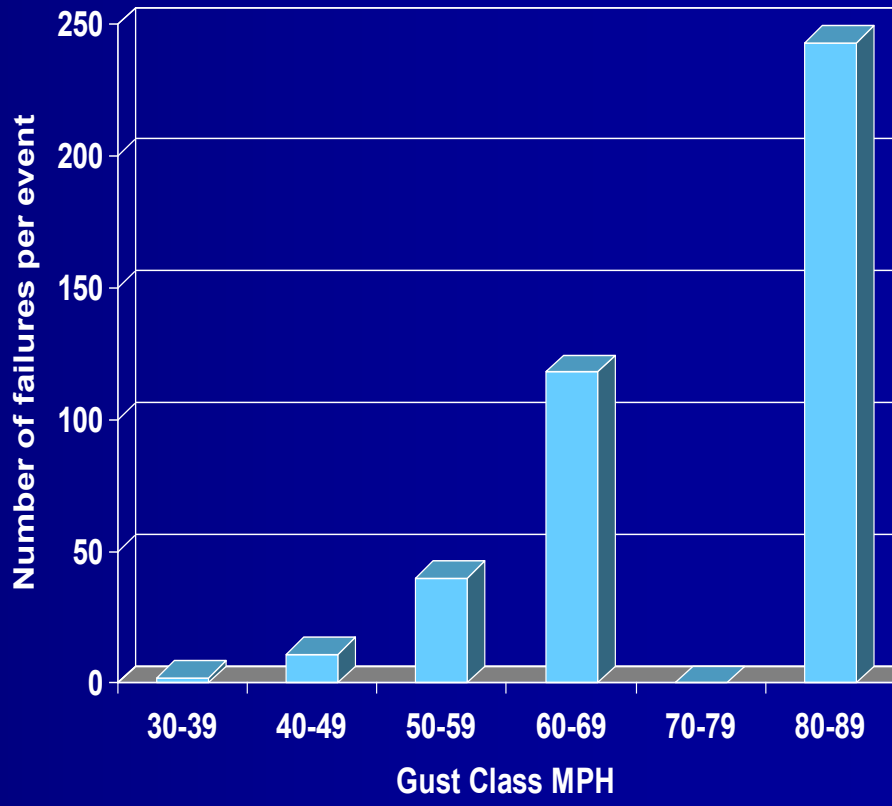
When do non-defective trees fail?

Previous BMP 47- 54 mph (leaf on)?

~55 to 63 mph Tree Damage Expected

2025





Failure Most Common when Leaves are on Trees

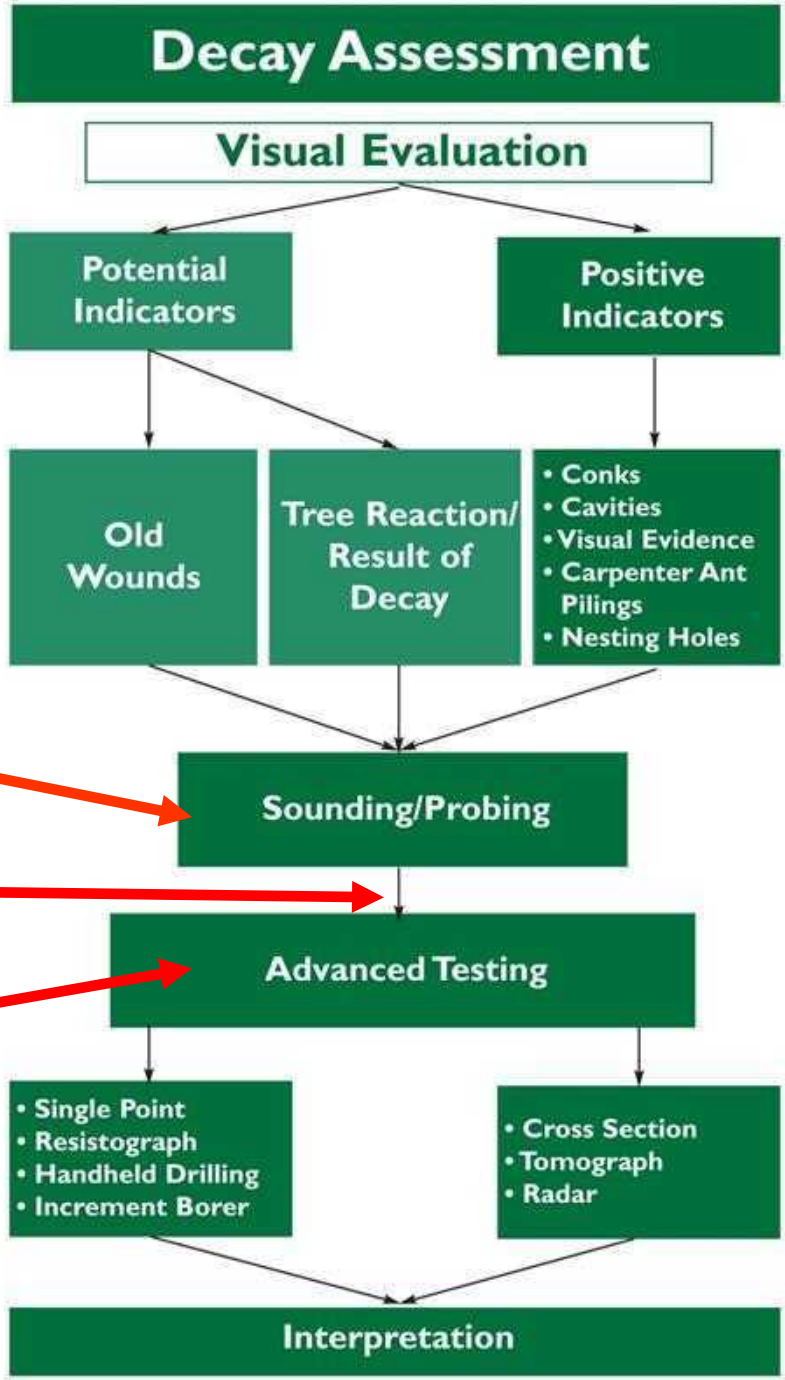
A Common Sense Approach

- Identification of decay indicators (signs/symptoms)
- How to do basic testing
- Advanced methods

- Step 1
  - Establish decay Presence/severity
- Step 2 "Basic"
  - Severity

Prognosis

- Step 3 "Advanced"
  - Severity



Basic Tree Risk Assessment: A Process for Evaluating Decay

1 Is decay present?

Potential indicators of decay:

- old wounds and injuries
- response growth swellings
- cracks and seams
- oozing
- dead or loose bark
- sunken areas in the bark

Definite indicators of decay:

- cavity openings
- nesting holes
- bee hives
- fungal fruiting structures
- ants (e.g., Carpenter ants)

2 What is the severity of decay?

Basic assessment tools and techniques:

- sounding
- probing

Evaluate the following:

Load:

- crown area and density
- crown live ratio
- wind
- precipitation (e.g., rain, ice, snow)
- load direction and location
- response growth to load
- length of lever arm

Location of decay:

- location (e.g., heartwood, sapwood, basal, root)
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Species profile:

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- ability to penetrate Wall 4 of CODIT

Tree health:

- vigor of tree (consider tree species and tree age)
- dieback
- opacity
- live crown ratio

3 How does the severity of the decay impact the likelihood of failure?

Increased likelihood of failure:

- significant load
- poor tree health
- insufficient response growth
- poor ability to compartmentalization
- aggressive fungal species
- critical location of decay to tree defect or condition

Decreased likelihood of failure:

- minor load
- good tree health
- significant response growth
- significant capability to compartmentalize
- slow aggressiveness of fungal species
- location of decay has minor impact on tree defect or condition

Source: Christopher J. Luley, Ph.D., Urban Forestry LLC

Decay Presence
Decay Indicators

- Identified in the ISA Tree Risk BMP
- Usually require additional inspection*
- Not all are created equal

Indicators of Decay in Urban Trees

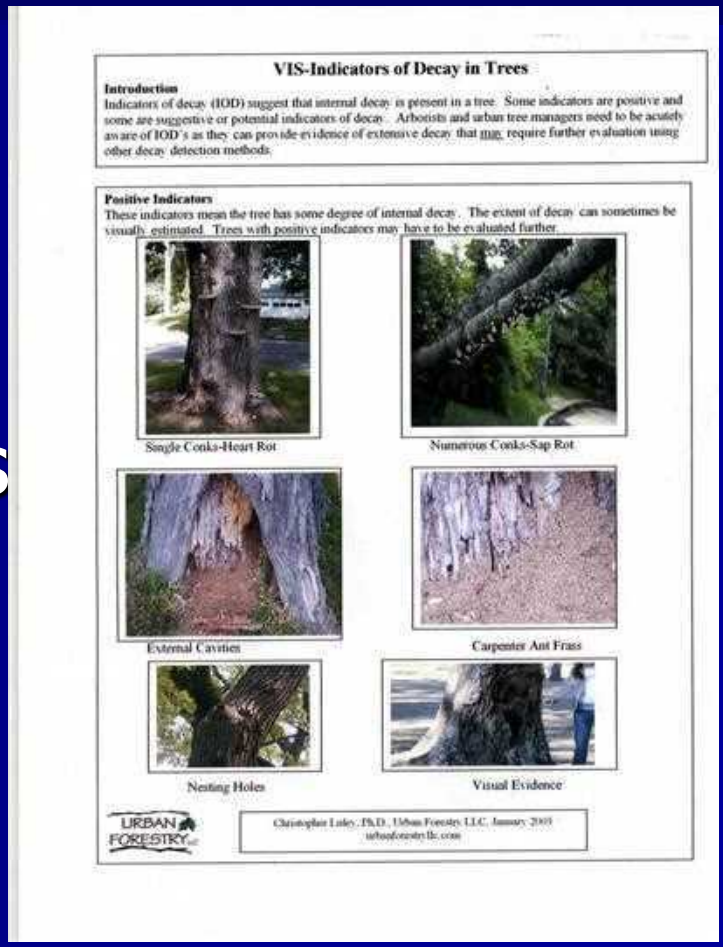
By Chris Luley

Decay indicators are symptoms and signs associated with the fungal deterioration of wood in trees. *Symptoms* of decay are deviations in normal growth patterns, while *signs* are evidence of the decay's causal agent, including fungal conks and mushrooms. Decay indicators have been used for a long time to assess trees for decay. Some indicators are species specific, while others apply to a wider range of tree species. This article will provide information on the concept, importance, and use of decay indicators in tree evaluation.

- visual evidence of decayed wood without the formation of cavities (Figure 2),
- carpenter ant colonies or sawdust pilings on stems or at the base of a tree
- the presence of nesting holes of insects, birds, or mammals

Positive or Definitive Indicators Missing or Decayed Wood

- Internal and External Cavities
  - Nesting holes
- Conks/brackets/mushrooms
- Visual evidence
- Carpenter ants/pilings



VIS-Indicators of Decay in Trees

Introduction

Indicators of decay (IOD) suggest that internal decay is present in a tree. Some indicators are positive and some are suggestive or potential indicators of decay. Arborists and urban tree managers need to be acutely aware of IOD's as they can provide evidence of extensive decay that may require further evaluation using other decay detection methods.

Positive Indicators

These indicators mean the tree has some degree of internal decay. The extent of decay can sometimes be visually estimated. Trees with positive indicators may have to be evaluated further.

Single Conks-Heart Rot

Numerous Conks-Sap Rot

External Cavities

Carpenter Ant Frass

Nesting Holes

Visual Evidence

URBAN FORESTRY

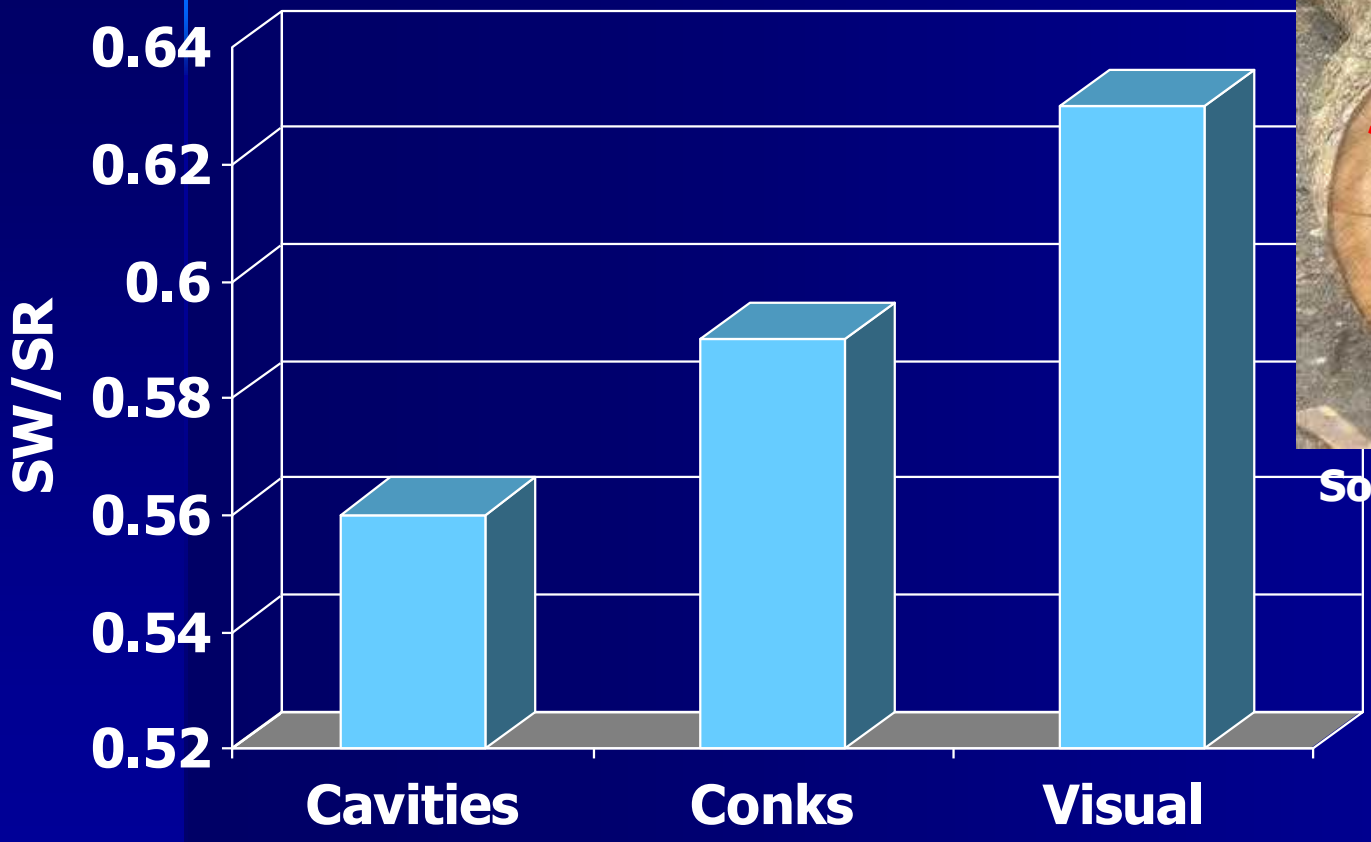
Christopher Luley, Ph.D., Urban Forestry, LLC. January 2005
urbanforestry llc.com

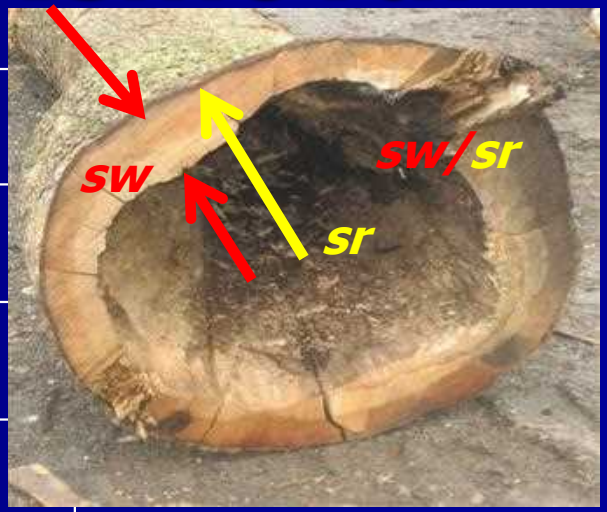
Positive or Definitive Indicators

Confirm decay is present
Significant legal implications
Policy for Inspection?

- Fungal fruiting structures (Conks, Brackets, Mushrooms)
- Cavities
- Visual Evidence
  - (Not in BMP)
- Carpenter ants

Positive Indicators SW/SR averaged 0.60 Does NOT mean Removal





Sound wood/ Stem radius

External Cavities
Size Does Not Matter!
Identify Decay as Present

Single or Few Large Conks

"Heart Rot"

- Some can decay healthy sapwood
- Some can kill bark and cambium
- Conks on butt may indicate buttress root rot

Heart rot- decay in the center of a stem (positional)

- No reference to presence of heartwood
- Pathogenicity of the fungus
- Decay of sapwood or not
- Meaningless term

Root Decay Fungi

- Some decay heartwood in roots
- Others kill and decay roots

Some Root Decay Fungi will primarily be in Roots!

Structural Root Decay
Bottom to Top of Root

Structural Root Rot

- Same tree below

Fruiting on Roots is Problematic

Sapwood or Sap Rot Fruiting

Multiple Small Fruiting Bodies

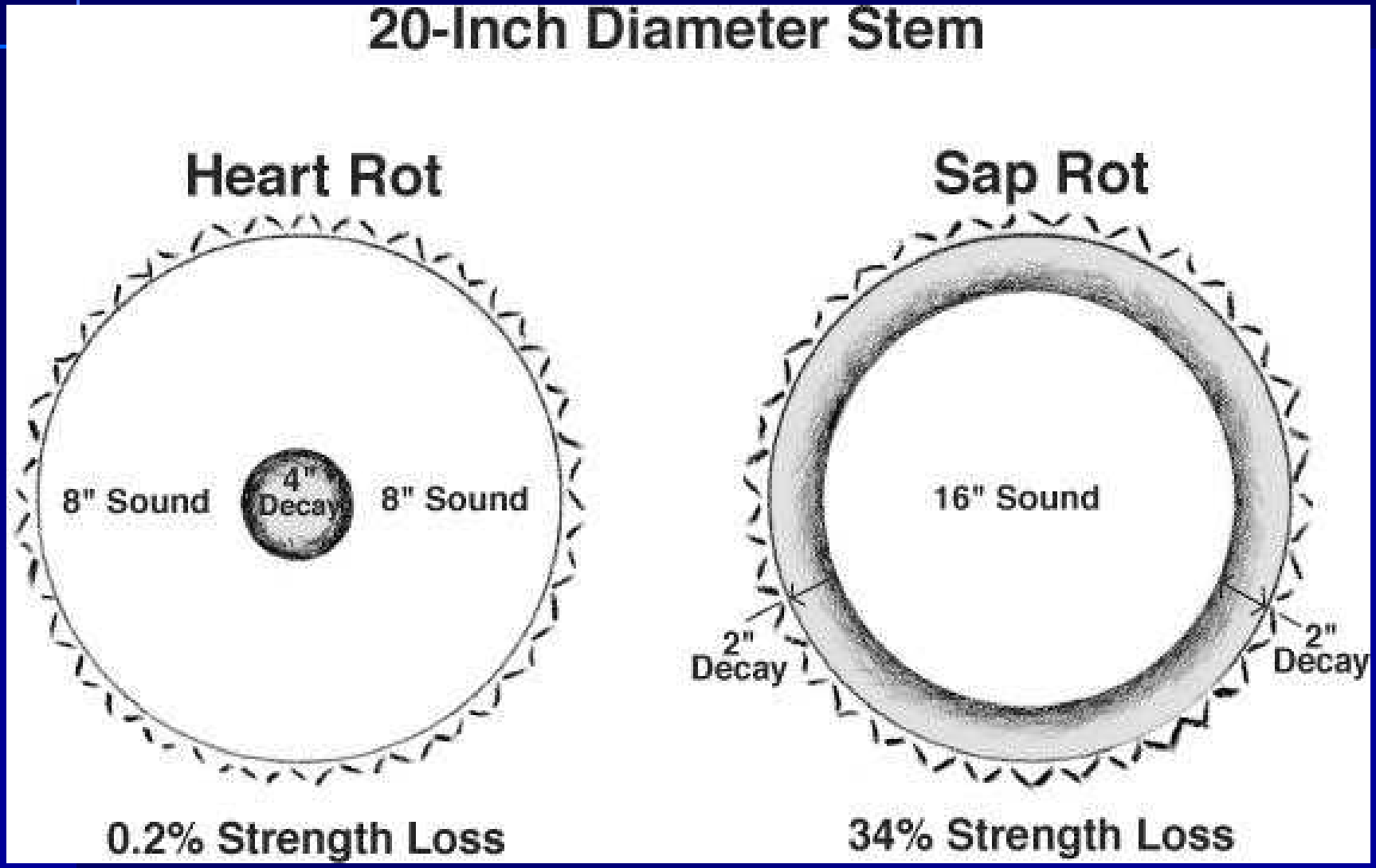
Sap Rot-Living Trees/Branches
-Dead Bark and Cambium
-Decay Progressing Outside In

Sap rots

- Many sap rot fungi can kill bark and cambium once established in wound
  - Canker fungi
- Can decay dead sapwood rapidly

Mode of Action is What is Critical

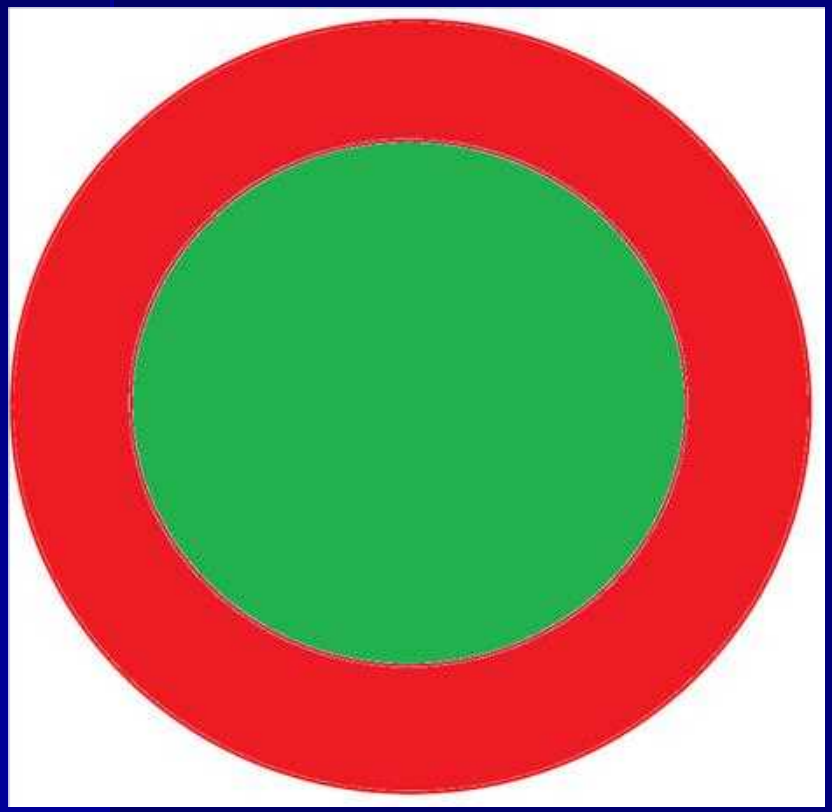
Sap Rot Importance
Stem Strength Loss



Effect is lower in larger stems
3 inches of sap rot

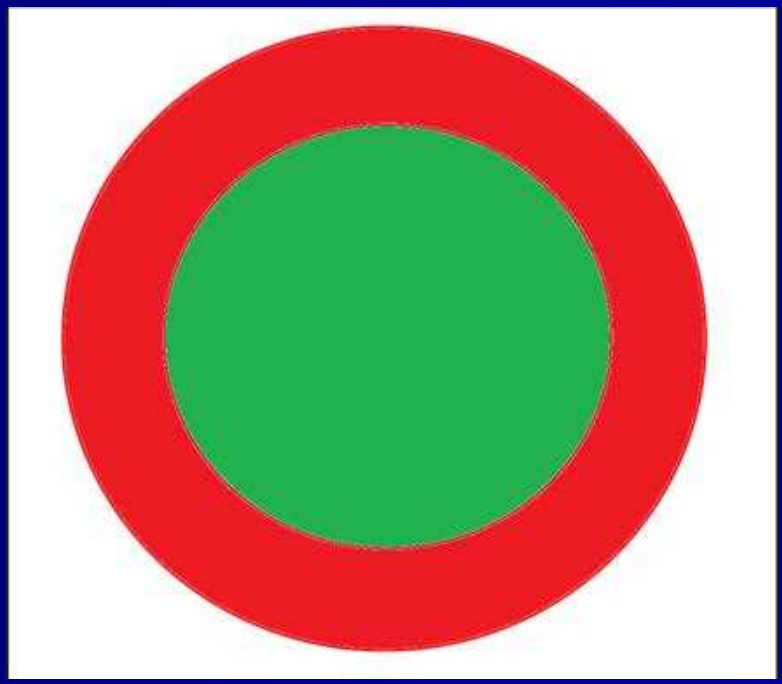
16-inch Stem

75% SL



8-Inch Stem

98% SL



Frank Rinn 2025

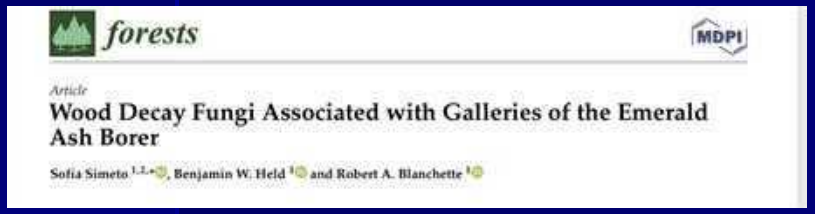
Ash Dilemma

UMN Research-Fungi from EAB Galleries


Fungal Biology
Volume 125, Issue 7, July 2021, Pages 551-559

Fungi associated with galleries of the emerald ash borer

Benjamin W. Held, Sofia Simeto, Nickolas N. Rajtar, Alissa J. Cotton, David N. Showalter, Kathryn E. Bushley, Robert A. Blanchette

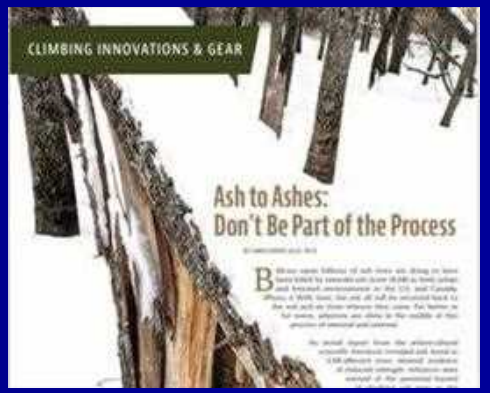

forests
MDPI

Article

Wood Decay Fungi Associated with Galleries of the Emerald Ash Borer

Sofia Simeto, Benjamin W. Held and Robert A. Blanchette

- Four Groups of Fungi
  - Sapwood decayers+
    - *Trametes versicolor*
  - Canker fungi
    - *Cytospora*
    - *Botryosphaeria*
  - Entomopathogenic
  - Mold fungi



EAB- Sapwood Decay starts when tree is still alive

- EAB galleries
- Woodpecker damage

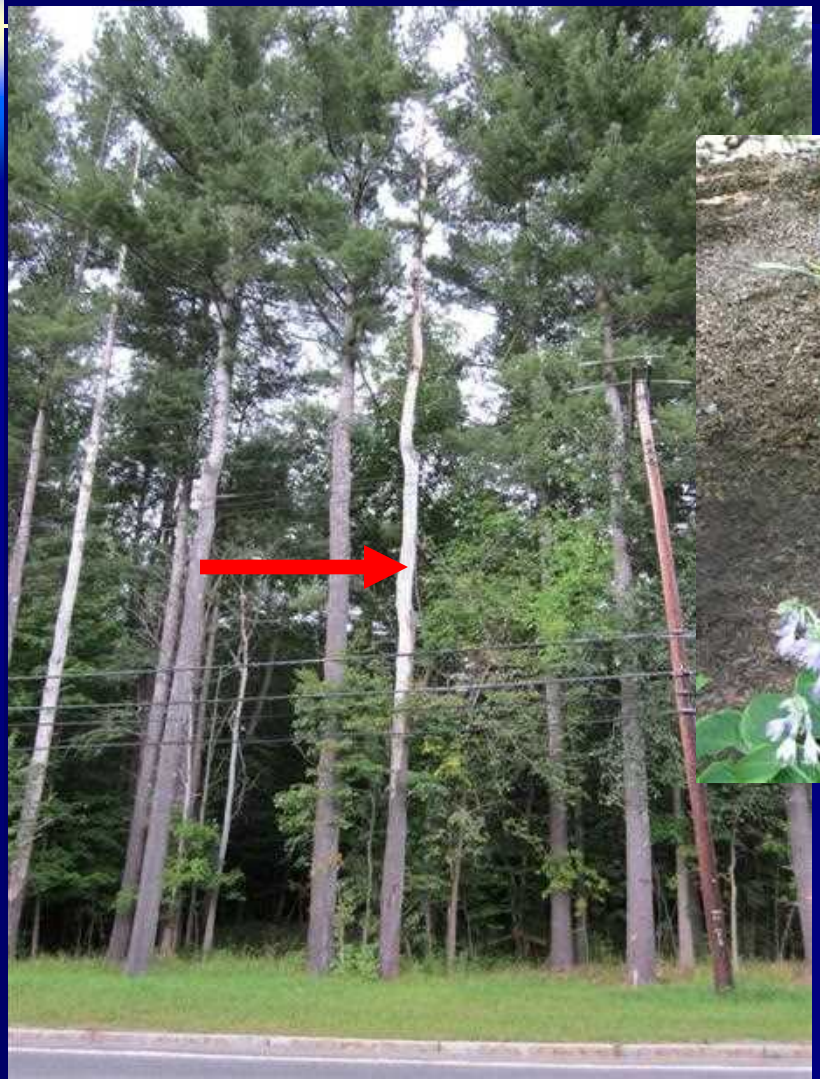
Trametes versicolor

Turkey Tail

EAB- Sapwood Decay starts when tree is still alive

- Decay often progresses most rapidly in roots
- Ash will fail anywhere after death

Sap Rot Can Progress Quickly-Dead Trees



Sap Rot will Proceed Quickly near the Ground

Risk Assessment Before Climbing

- 20% Crown loss in ash
- No Climbing (L. Purcell; PU Survey)

Sap Rot Assessment

- Safest=Assume the stem is completely decayed

Sap Rot
Fruiting can be absent!

Bark May be Intact!

Living Branches

Sap rot and Lightning Strikes

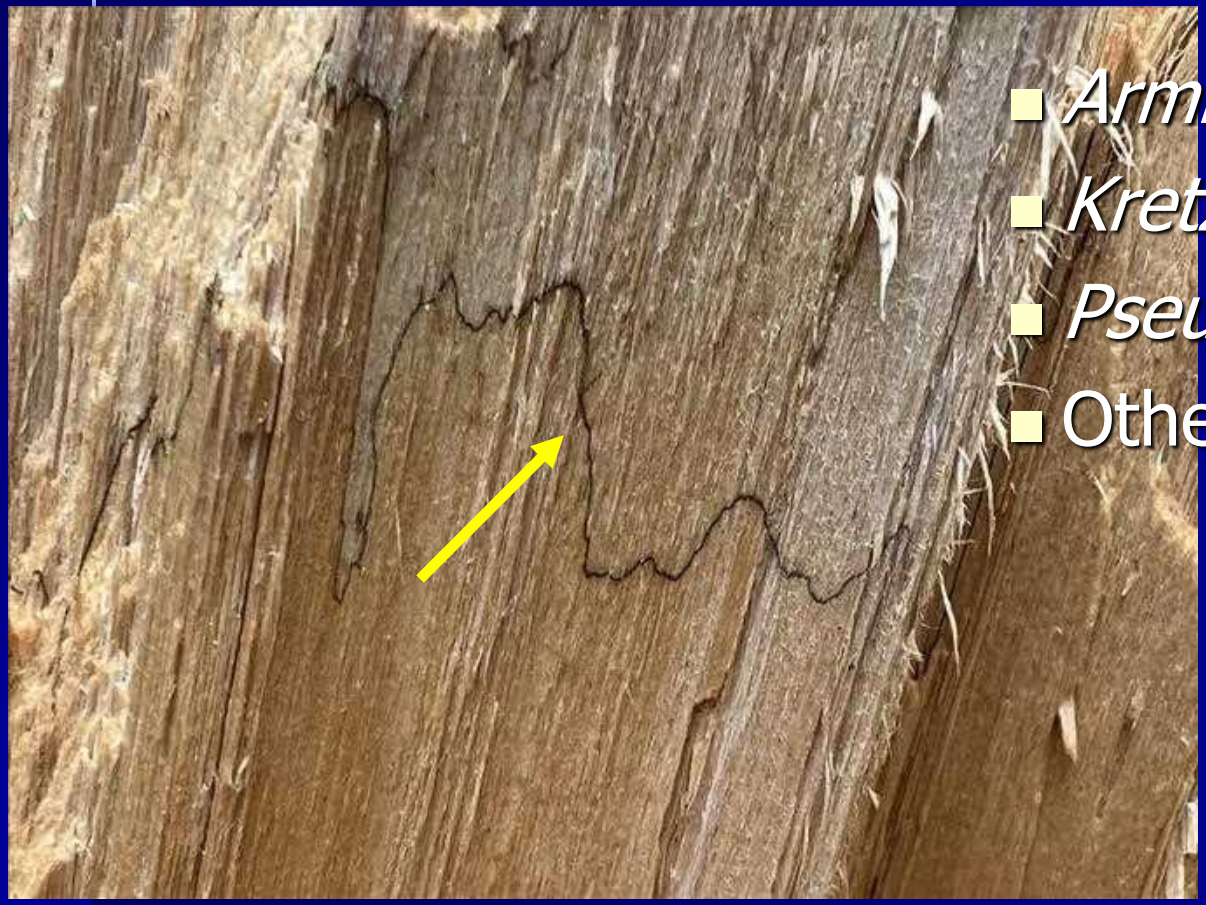
Case Hardening

- **The colour of the wound face** may also be used to determine internal condition. Dark wound faces can indicate more defect than dry, white-faced wounds, which usually have little decay or stain associated with them.

Case Hardening - Pellicle

Pseudosclerotial plates aka external zone lines

Zone Lines identify decayed wood even in incipient stages



- *Armillaria*
- *Kretzschmaria*
- *Pseudoinonotus*
- Other white rots

chrisluleyphd.com

CONTINUING

SAP·ROT

Introduction

When most arborists think of decay in trees, they think of heart rot, decay of the center of the stem. However, sapwood rot, or sap rot as it is commonly named, where the decay progresses from outside the stem toward the center, may be of more importance than heart rot, particularly for arborists that are working in trees. This article explores the biology and identification of sap rot decay and fungi, and why it is important to the working arborist.

Definition

Sapwood rot is the decay of woody stems that typically follows the death of the bark and cambium of living trees, or the decay that quickly follows tree death. Sap rot is so named because the decay initially occurs in the sapwood and progresses from outside the sapwood and toward the center of the stem (Figure 1).

Figure 1. Sapwood decay organisms invade trees after the bark and cambium have died. The decay proceeds from outside the stem toward the center.

Sap rot is somewhat of a misnomer because most sap rot fungi are able to decay the heartwood of a tree once the sapwood has been rotted (Figure 2). However, sap rot decay will be considerably slower when fungi reaches heartwood that has inherent decay resistance. This may occur in trees such as white oak (*Quercus* spp.), black locust (*Robinia pseudoacacia*), and red cedar (*Juniperus virginiana*), among others.

Biology

Positive Indicator of Decay

- Carpenter Ants Nesting
- Sawdust at tree base

PLATE 2

a. *Camponotus pennsylvanicus*

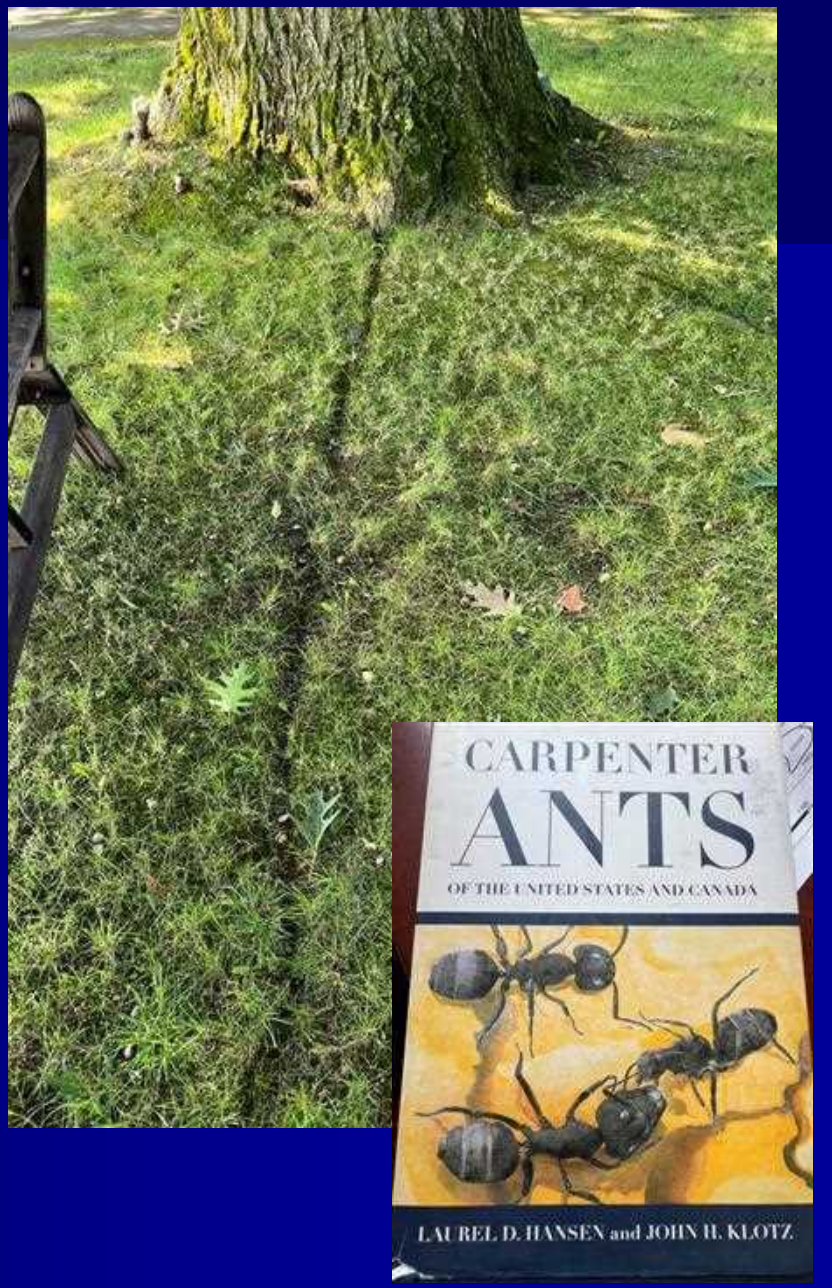
b. *Camponotus caryae*

c. *Camponotus clarithorax*

d. *Camponotus decipiens*

e. *Camponotus discolor*

f. *Camponotus essigi*



Positive Indicators

- Visual Evidence

Positive or Definitive Indicators

Decay is present and have Significant legal implications if present

- Fungal fruiting structures
- Cavities
- Visual Evidence (Not in BMP)
- Carpenter ants

Potential Indicators of Decay

- Two Types of Indicators

1. Potential-decay might be present

Potential Indicators

1. Old wounds

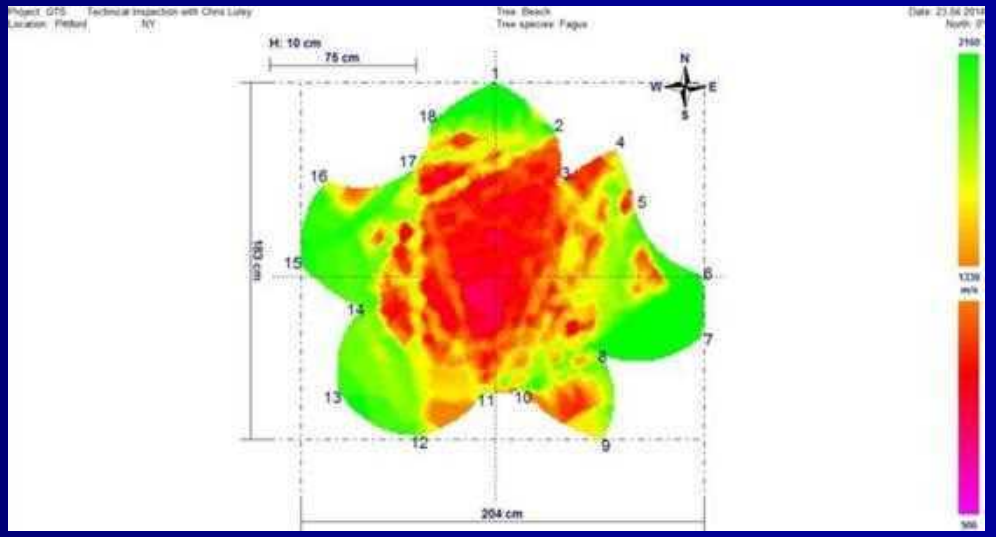
2. Tree reaction to internal decay (Response or adaptive growth)

Potential Indicator of Decay Response or Adaptive Growth

- Response or Adaptive growth
  - **Tree is reacting to decay or mechanical stress on marginal fibers**
  - **Wood quantity and quality**

Torpedo Bat

Seldom Show Adaptive Growth to Brown and Soft Rot



Conifers-Response growth (bulges) seems rare

Most decay fungi in conifers are brown rots

Potential Indicators
Bottle Butt

Response Growth

- Wood in Response Growth is different than normal sapwood
  - Some indication it is stronger
- Response growth is both positive and negative

Response or Adaptive Growth
Tree Body Language

- Make the biological-mechanical connection
- Response growth
  - Tree is reacting to decay or other mechanical stress

Phloem Exposure

Basic Tree Risk Assessment: A Process for Evaluating Decay

1 Is decay present?

Potential indicators of decay:

- old wounds and injuries
- response growth swellings
- cracks and seams
- oozing
- dead or loose bark
- sunken areas in the bark

Definite indicators of decay:

- cavity openings
- nesting holes
- bee hives
- fungal fruiting structures
- ants (e.g., Carpenter ants)

2 What is the severity of decay?

Basic assessment tools and techniques:

- sounding
- probing

Evaluate the following:

Load:

- crown area and density
- crown live ratio
- wind
- precipitation (e.g., rain, ice, snow)
- load direction and location
- response growth to load
- length of lever arm

Location of decay:

- location (e.g., heartwood, sapwood, basal, root)
- in relation to cross-section (e.g., center, off-center, cavity opening)
- in relation to defect or condition (e.g., between codominant stems, tension side of lean)

Species profile:

- capability to compartmentalize
- wood density
- failure patterns

Response growth to decay:

- type of response growth (e.g., tension, compression, flexure wood, woundwood)
- amount of response growth (e.g., significant, minor, none)
- vigor of tree (consider tree species and age)
- age of tree wound or condition

Fungal profile:

- type of decay (e.g., white rot, brown rot, soft rot)
- aggressiveness of fungal species
- ability to penetrate Wall 4 of CODIT

Tree health:

- vigor of tree (consider tree species and tree age)
- dieback
- opacity
- live crown ratio

3 How does the severity of the decay impact the likelihood of failure?

Increased likelihood of failure:

- significant load
- poor tree health
- insufficient response growth
- poor ability to compartmentalization
- aggressive fungal species
- critical location of decay to tree defect or condition

Decreased likelihood of failure:

- minor load
- good tree health
- significant response growth
- significant capability to compartmentalize
- slow aggressiveness of fungal species
- location of decay has minor impact on tree defect or condition

Source: Christopher J. Luley, Ph.D., Urban Forestry LLC

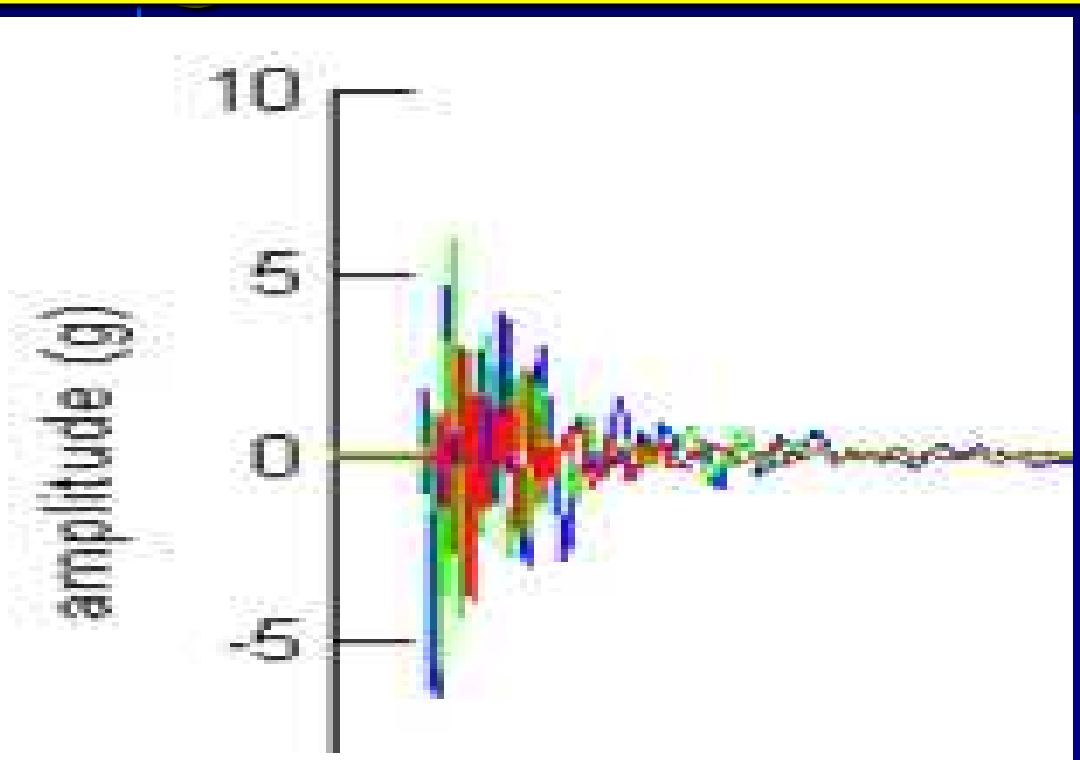
Step 2. Decay Severity Sounding Basic Assessment

- **Sounding Mallet**
  - Rapid test of decay indicators
  - 58% with decay

Sounding Tools

- 12 oz Plastic Mallet
  - Preferred
- Hammer **will** cause damage on thin barked trees

Vibration Pattern or Sound Wave
Long Duration Low Frequency



Arboriculture & Urban Forestry 2011. 37(5): 191–199

Preliminary Evidence for Using Statistical Classification of Vibration Waveforms as an Initial Decay Detection Tool

Anthony N. Mucciardi, Christoper J. Luley, and Kevin H. Gormally

1. Pulse Duration
2. Rise Time
3. Impulse Duration
4. Amplitude Mean
5. Amplitude Std Dev
6. Amplitude Skew
7. Amplitude Kurtosis
8. Shape Mean
9. Shape Std Dev
10. Shape Skew
11. Shape Kurtosis

Do You Hear What I Hear?
Part II: Field Application of Sounding

By Christopher J. Luley and Mike Ellison

The Tools

Our experience shows that mallets or hammers in the 10 to 16 ounce weight range, with heads made of nylon or hard plastic, are the most effective for identifying changes when sounding a tree (Figure 1). These tools are often sold as woodworking hammers and may have interchangeable hard rubber and plastic heads. For the field arborist, use of the hard-plastic end produces the best results. Many arborists also use large-faced, rubber mallets, but these are less likely to produce clear and definitive results. However, many variations in types of mallets are in use, and individuals should find the tool they are comfortable with that produces the best results for them.

Figure 1. A 12-ounce woodworking hammer (left) works well for sounding. We recommend the use of the hard plastic (yellow) side of the tool. The "Thor hammer" (right), with a hardened nylon head, is widely used for sounding in the United Kingdom and Australia.

How to Sound a Tree

If care is not exercised, sounding can cause damage to the phloem and vascular cambium, as well as to the cortex of thin-barked trees. While *any* hammer can cause damage to a tree if sufficient force is used, an arborist can usually avoid such damage by taking care and by not using heavy, metal hammers and excessive force when striking. Particular caution is advised on thin- or smooth-barked trees, as anecdotal evidence indicates that they are more susceptible to damage from hard strikes (Figure 2), especially in spring when the cambium is active. Some species, such as the Moreton Bay fig (*Ficus macrophylla*), are highly susceptible to damage, and again caution should be exercised.

The force required to strike a tree during sounding is best described as light tapping, as compared to stronger strikes that might be used during hammering, or when driving a nail into wood. Thick-barked trees, or those with denser wood, may require a little more force to be applied. However, a general rule is to use no more force

Sounding not Useful
Sap Rot Decay

Step 2. Probing

Step 2. Probing

- Inserting a sharpened metal probe into cavities or other areas suspected to have decay
- Can be quantitative to some degree

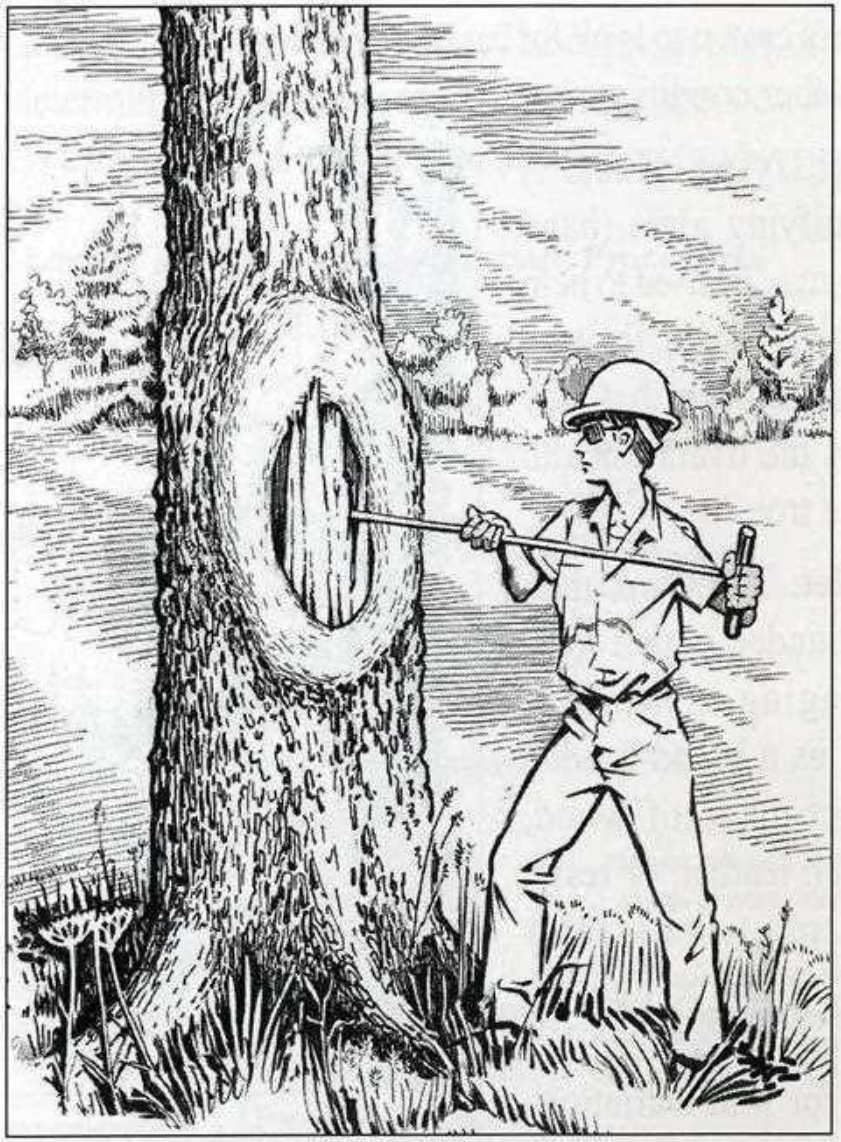


Figure 2. Probing. The tree risk assessor can use a stiff, small-diameter rod or stick to probe into cavity openings to estimate their size and extent.

Dig (aka) Probe into Sapwood Decay

Sap Rot Assessment

- Use a sharp tool and pick to reach solid wood

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- [illegible] the bark

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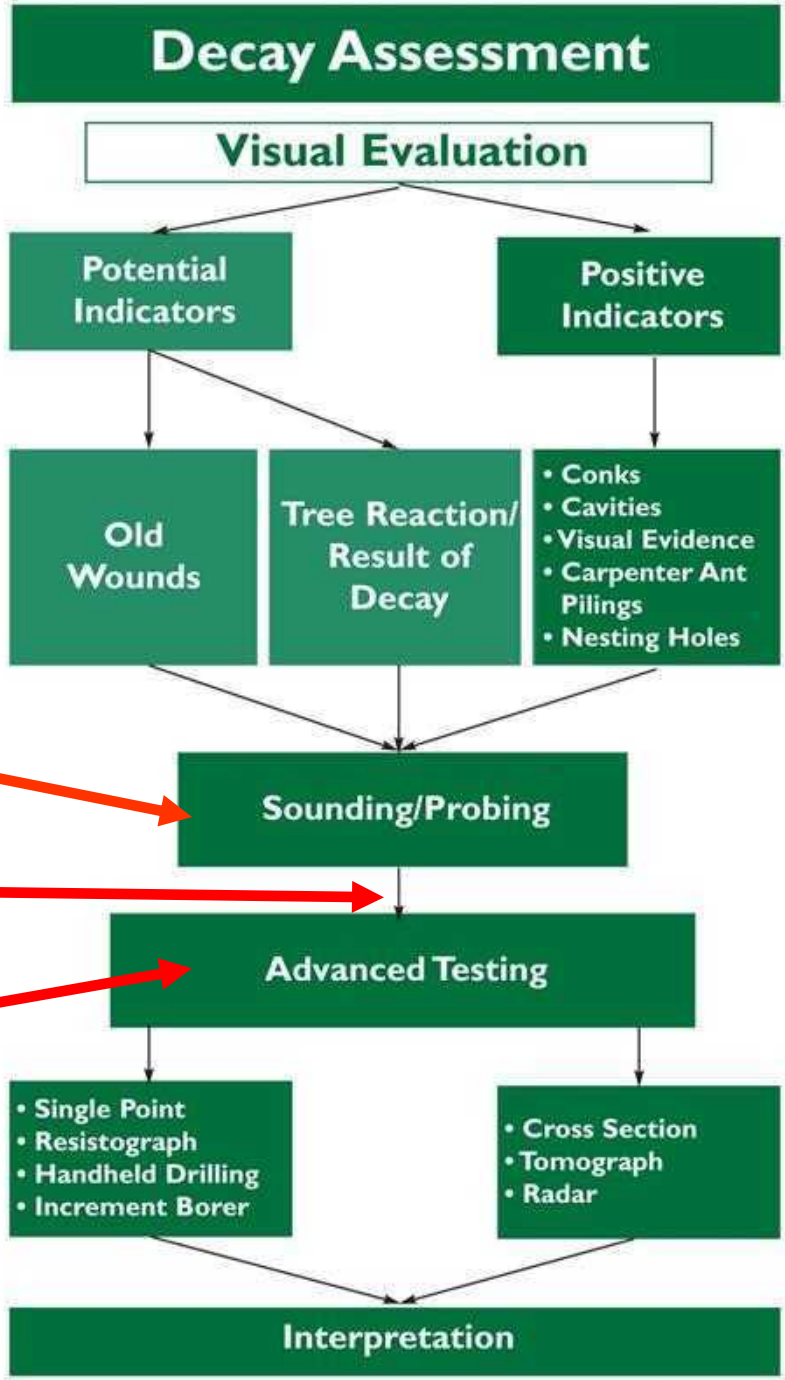
Source: Christopher J. Luley, Ph.D., Urban Forestry LLC

- Step 1
  - Establish decay Presence/severity
- Step 2 "Basic"
  - Severity

Prognosis

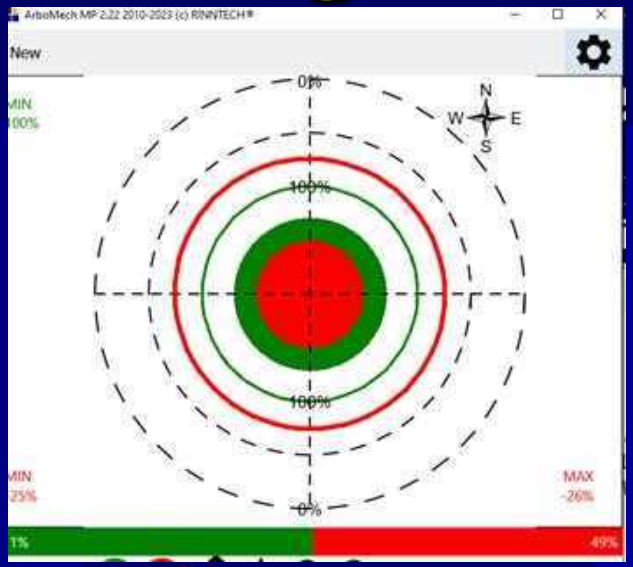
- Step 3 "Advanced"
  - Severity



Change in Decay Relative to Diameter Over Time - Prognosis

Two Factors- Measurements?

1. ***Diameter growth***
2. ***Decay advancement***
   - ***Towards bark!***
3. ***Time***



Biology Trumps BioMechanics

1. Even LARGE amounts of decay do not threaten tree stability or biological health
   - Up to 80% of their radius
     - Greater amounts if the load is reduced?
2. Ultimately what predicts failure likelihood
   - Biological health
     - Tree diameter growth rate (Secondary)
     - Tree internal response to decay
   - Decay fungus/host interaction

Biology Trumps BioMechanics

1. Stability of Barrier and Reaction Zones
2. Change in Decay Relative to Diameter

Problem

Most Failures occur when "Tipping point" is reached

- Massive amounts of decay

Biological Health
Barrier and Reaction Zone Strength
Diameter Growth
Importance of Plant Health Care

Root Decay

May produce No crown symptoms!

Apoplast-Symplast Relationship

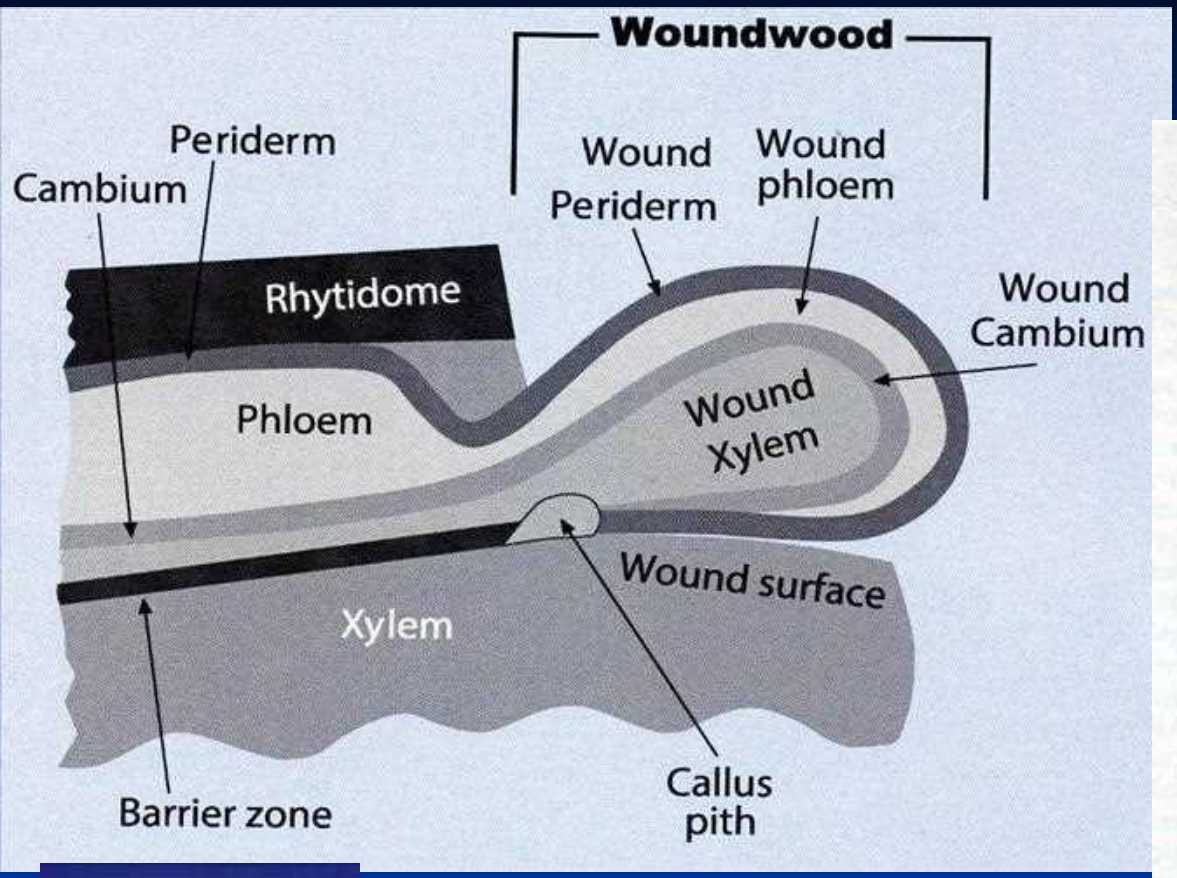
Decay often has minimal impact on Biological Health

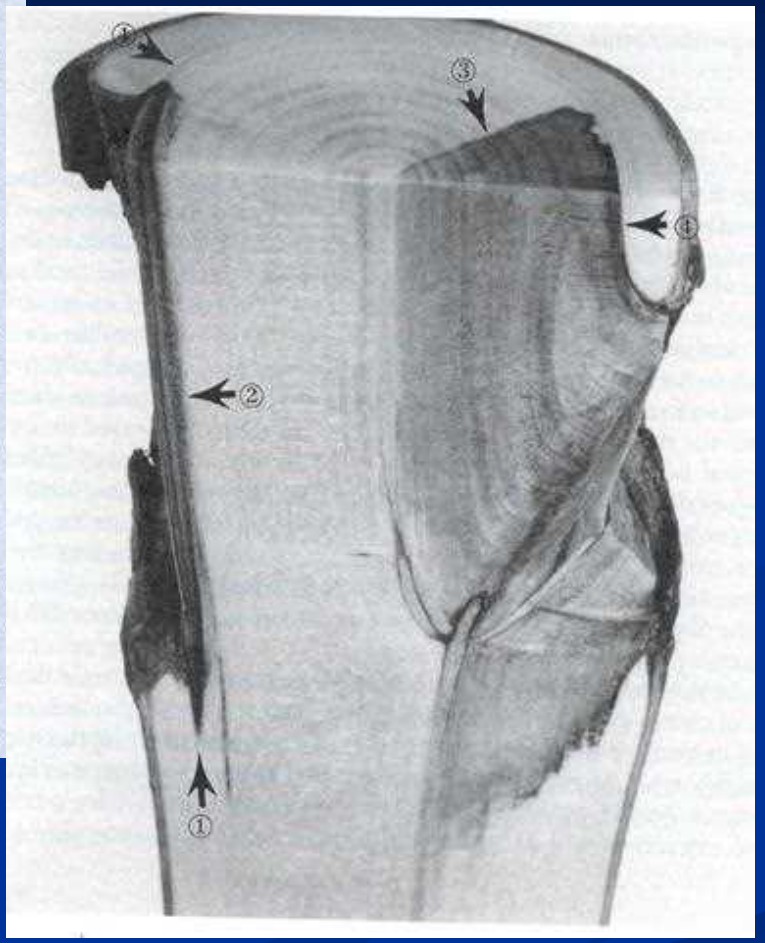
Tipping Point

How is decay progressing relative to Diameter Increase?

Presence/Absence of Response Growth -Woundwood

Decay Management
CODIT and Wound Closure are supported by Biological Health
Absence of Woundwood


Woundwood
Periderm
Cambium
Wound
Periderm
Wound
phloem
Rhytidome
Wound
Cambium
Phloem
Wound
Xylem
Wound surface
Xylem
Barrier zone
Callus
pith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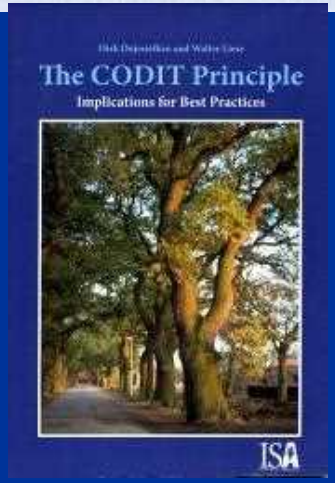
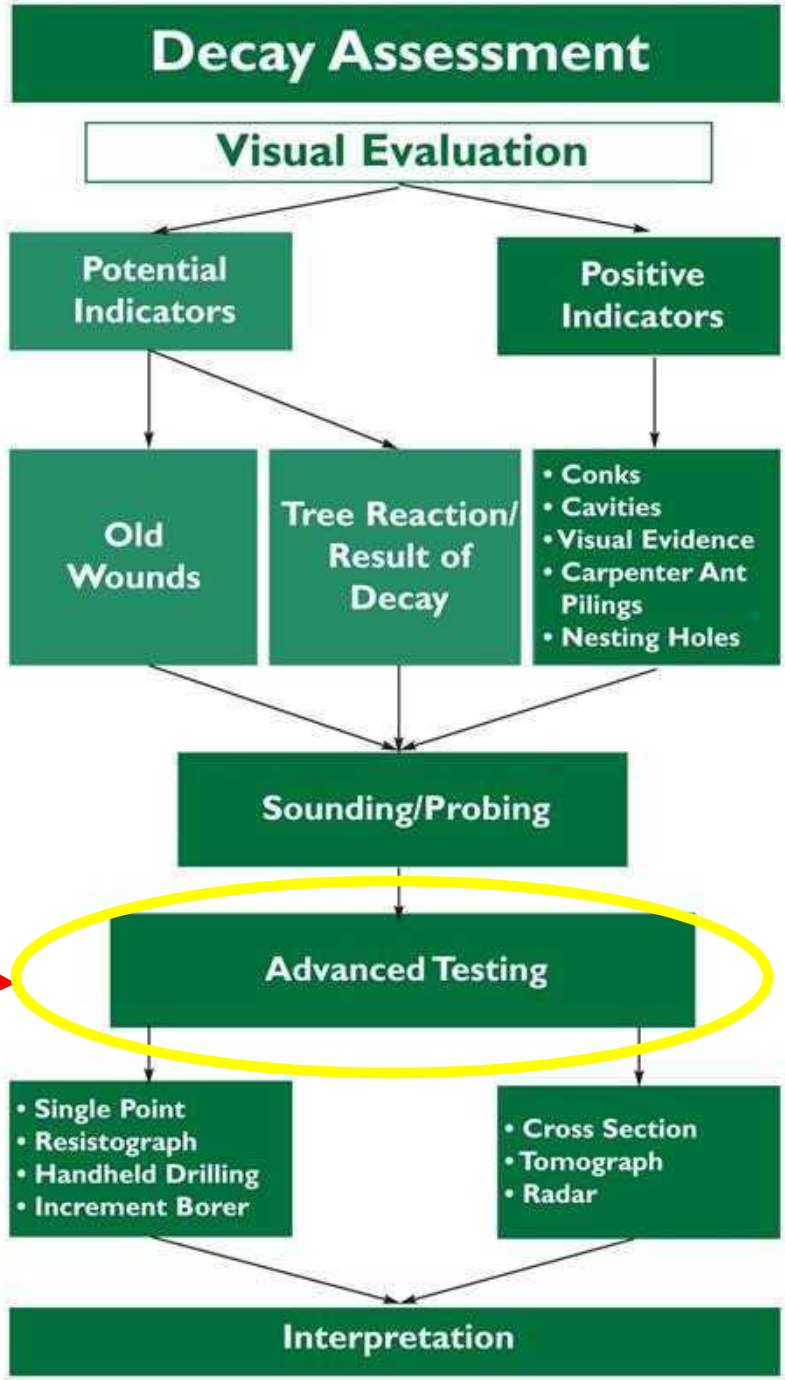

The CODIT Principle
Implications for Best Practices
ISA

Diagnostics
Absence of ww

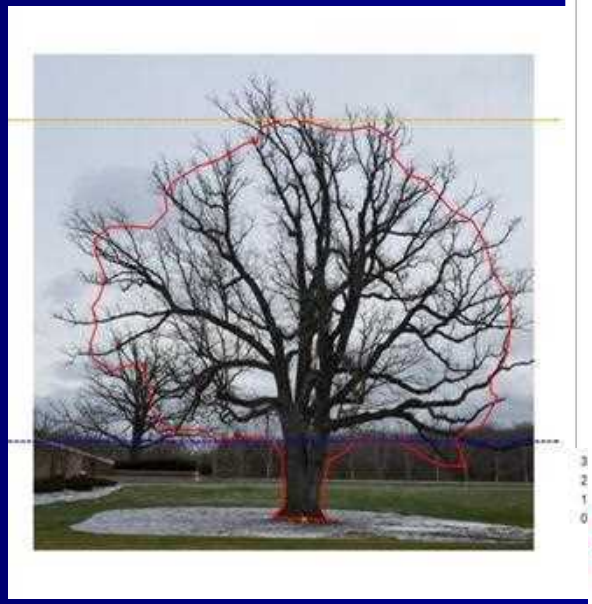
Point of no return

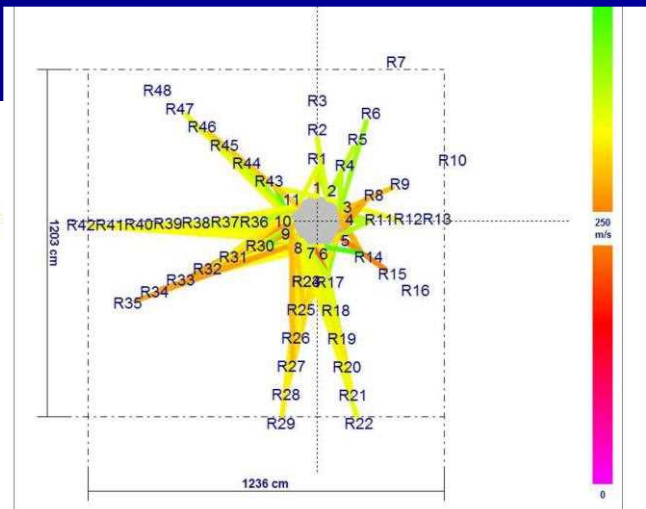
- Step 1
  - Establish decay Presence/severity
- Step 2 "Basic"
  - Severity
- Step 3 "Advanced"
  - Severity



Advanced Methods Level 3

- Point Drilling
  - Handheld drilling and resistance drilling
  - Increment borer
- Tomography
  - Trunk testing
  - Root -ArboRadix
- Tree Radar
  - Trunk
  - GPR
- Root Crown Excavation
- Static Pull Testing
- Wind Load Analysis
- In situ motion sensor

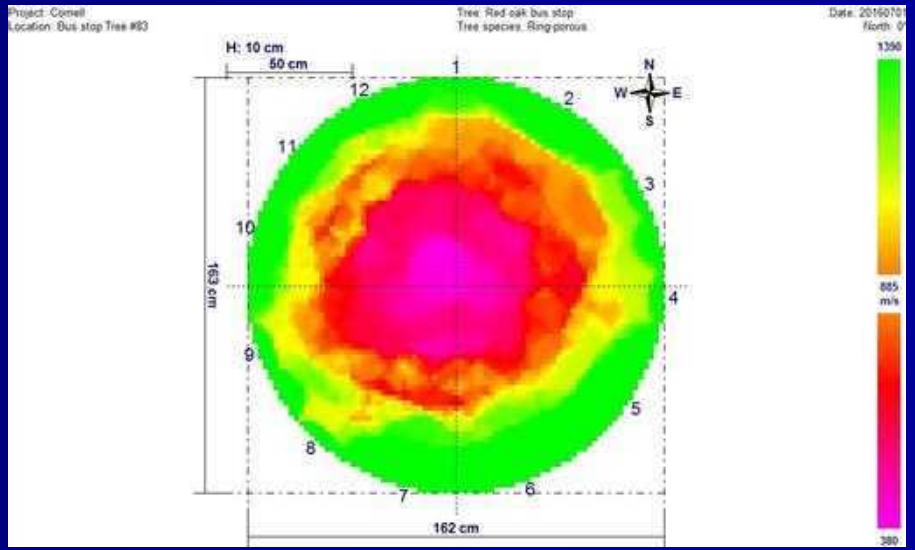




Advanced Testing

Establish a baseline to determine progression

- Even if moderate or low amounts of decay
- **One data point not often helpful**



Biology Trumps BioMechanics

1. Stability of Barrier and Reaction Zones

2. Change in Decay Relative to Diameter

Problem

Fruiting on Roots is Problematic

Nothing from Industry

Potential types of "root rots"

1. **Root Cambial Killers**
2. **Cambial Killers and Structural Decay**
   - **Killing bark and cambium**
   - **Decay woody roots/butts**
3. **Root and/or Butt Decay**
   - **Structural decay (heart rot type)**
4. **Feeder/woody root (non-structural) issues**
   - **Disease, Soil, or Site related causes**

Cambial Killers (Woody Roots)
-Primarily kill bark and cambium
-May 'not' cause structural decay

- Usually expressed initially as acute and then progressive biological health deterioration
- *Phytophthora sp.*
- *Desarmillaria caespitosa*

Phytophthora sp. "Plant Destroyer" Water Molds

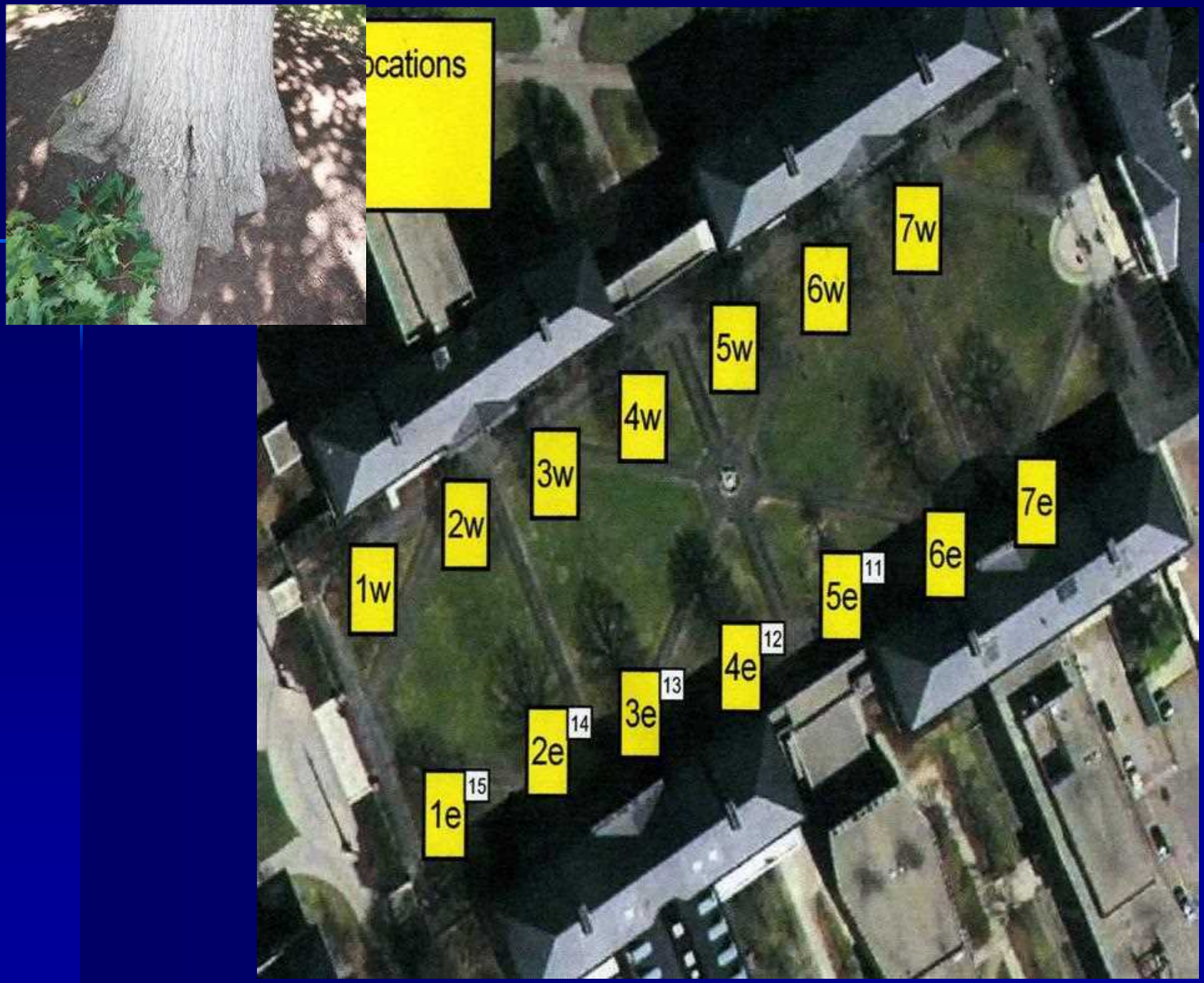
Phytophthora sp. Killing Bark and Cambium

Cracking and Bleeding

Bark and Cambium Death

Bark and Cambium Death Tree Decline- Red oak

Previous Cambial Damage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7w
6w
5w
4w
3w
2w
1w
7e
6e
5e
11
4e
12
3e
13
2e
14
1e
15

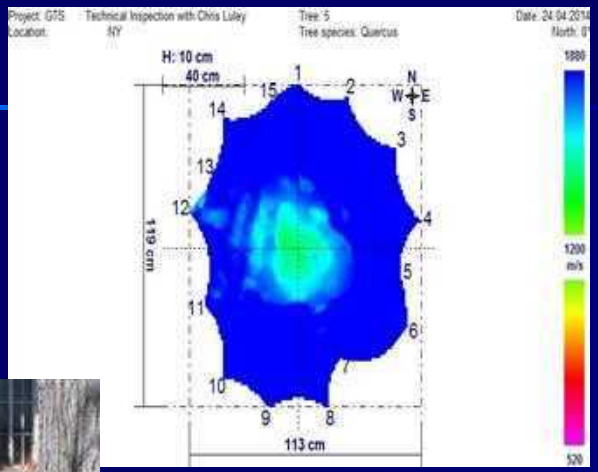
Root Collar Exam!

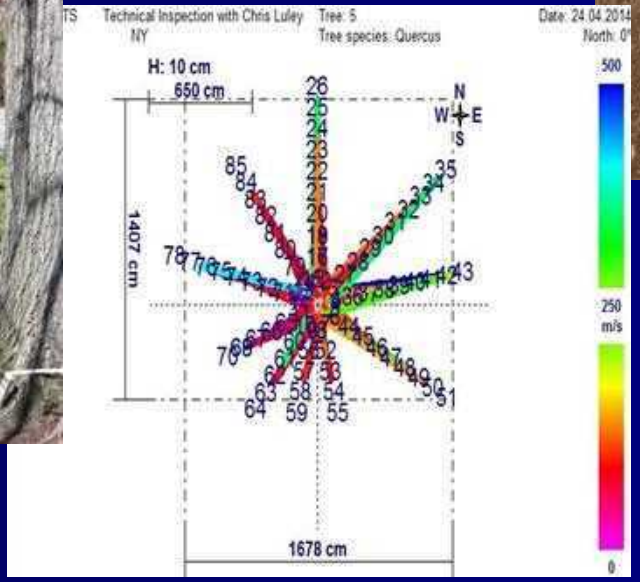
Phytophthora sp.

Pocket diagnostics

Phytophthora sp. Killing Bark and Cambium

Secondary Wood Decay



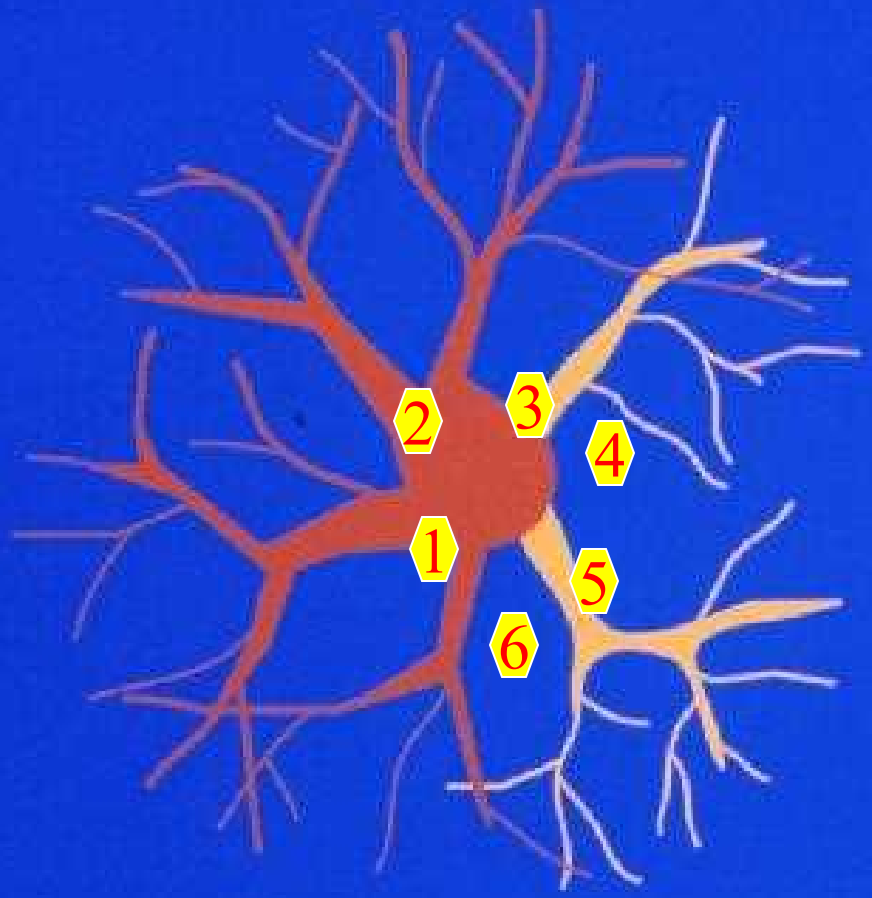


Expose Structural Roots

Root Collar Exam!

Drill Exposed Roots

Root Decay or Cutting Cut 2/6 = 1/3



Root System Loss

A single branch root =
altered health and vigor

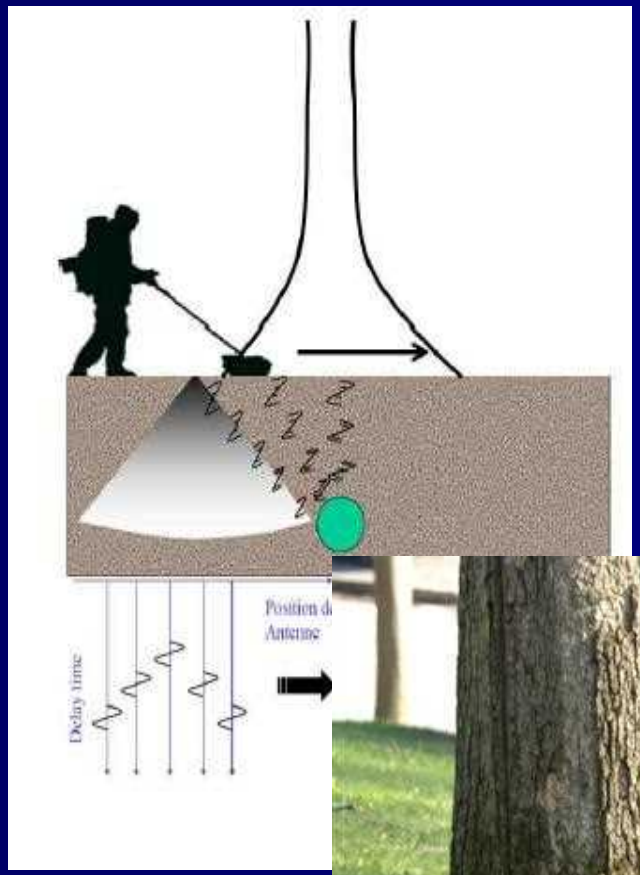
Two or more branch roots =
declining and unstable tree

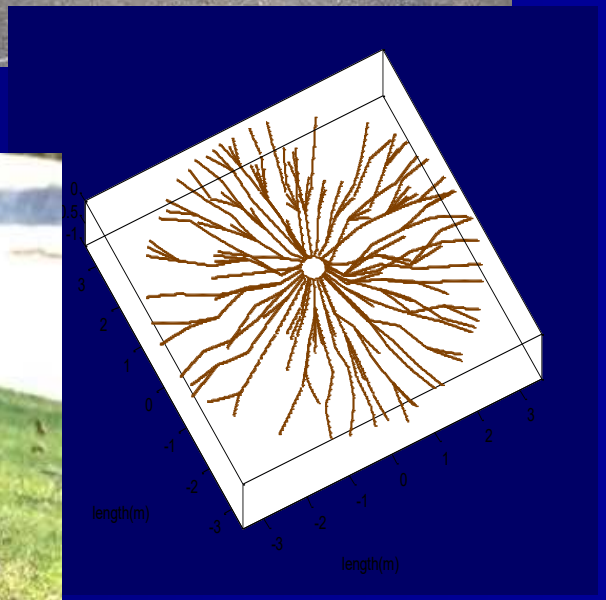
Root Decay-Root Failure High Winds (Smiley et al 1998)

- HIGH (Possible) RISK
  - Decay or cutting of more than 1/3 of structural roots
- SERIOUS (Probable) Risk
  - Decay or cutting 1/2 roots or more of roots

Structural Root System v. Adventitious Root System

Presence/Absence of Roots GPR Tree Radar





ArborTom Tomography