R Bruce Allison, PhD
ISA Board Certified Master Arborist

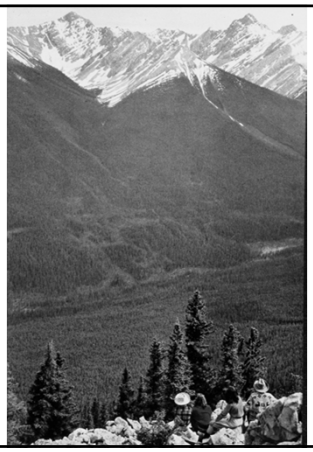
NEW TOOLS FOR TREE DECAY DETECTION

1. Trees Are Remarkable Organisms
2. Trees are Subject to Decay Creating Risks
3. Effective Use of Decay Detection Tools
4. Tomorrow's Tools

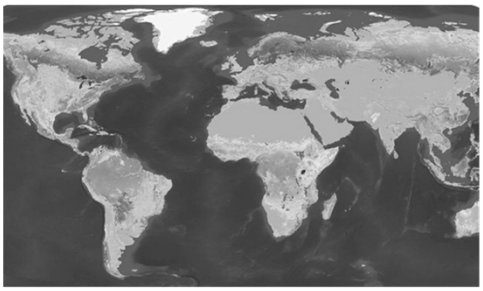
1. Remarkable Organisms

Sequoia sempervirens

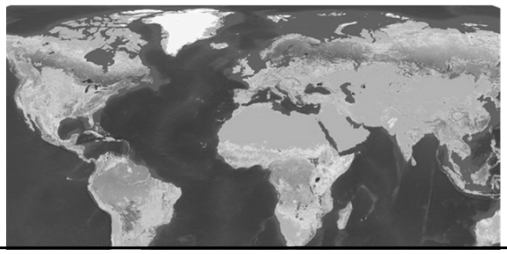
Bristlecone Pine (Pinus longaeva)



Crowther, TW “Mapping tree density at a global scale,” Nature September 2015

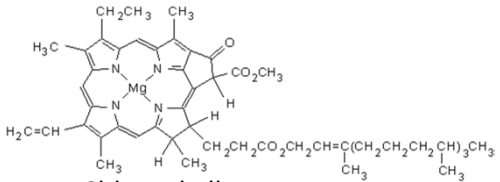


3.04 Trillion Trees: (43% tropical; 24% dense boreal areas; 22% in temperate zones.) Losing 15 billion annually, 46% loss to land use change, deforestation

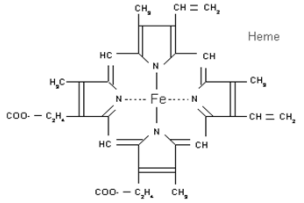


Co-Evolved with Humans

Chlorophyll and Hemoglobin



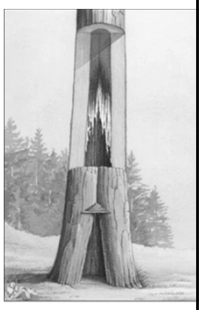
Chlorophyll



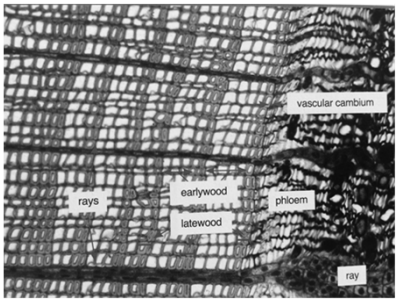
Hemoglobin: Heme

2. Tree Are Subject to Decay Creating Risks

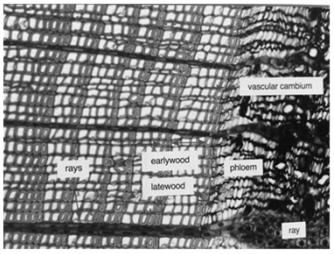
Wood decay fungi



Wood is secondary xylem composed primarily of cellulose and lignin



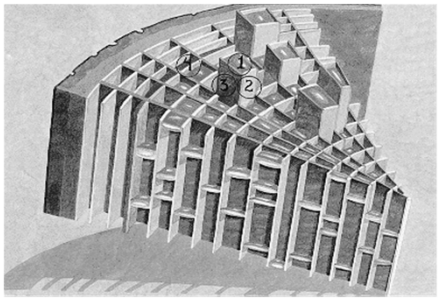
Whitish string-like cellulose adds strength and flexibility under tension; dark-colored lignin forms a rigid matrix of cell wall between the cellulose. Decay decomposes wood & strength.



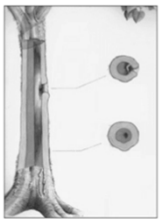
Dunstar, Tree Risk Assessment 2013, ISA p65

Alex Shigo, Plant Pathologist USDA Forest Service

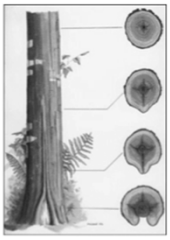
Codit-tree response to decay



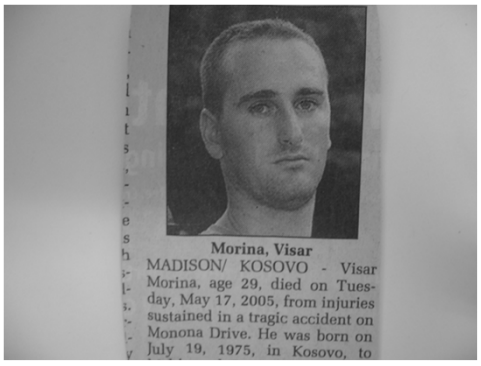
Decay at wound



Decay upward and inward



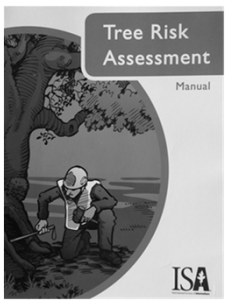
Monona Drive Honey Locust Failure
May, 2005

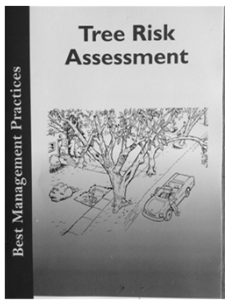


Morina, Visar

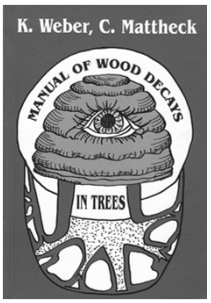
MADISON/ KOSOVO - Visar Morina, age 29, died on Tuesday, May 17, 2005, from injuries sustained in a tragic accident on Monona Drive. He was born on July 19, 1975, in Kosovo, to

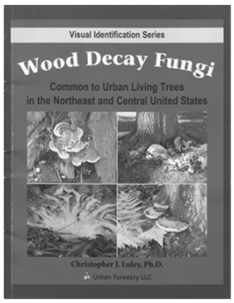
Tree Risk Assessment Standards



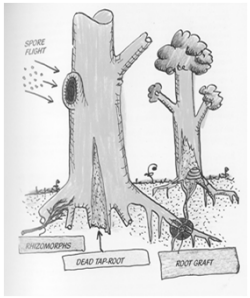


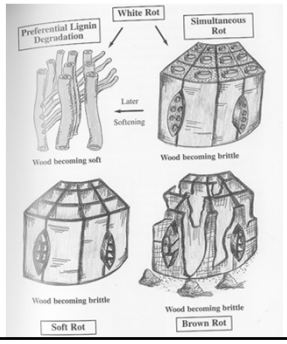
Decay species identification



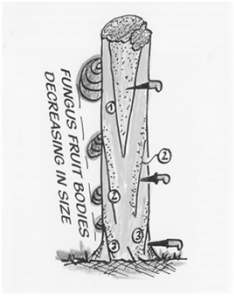


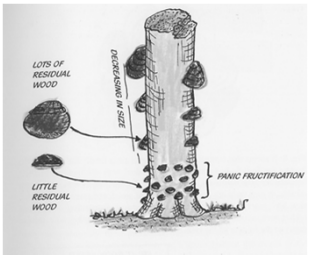
Point of entry and wood degradation



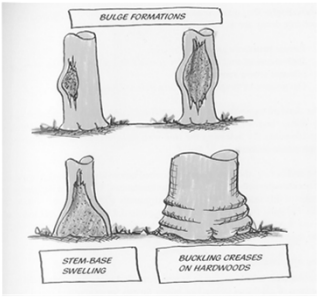


Size and location of fruiting bodies

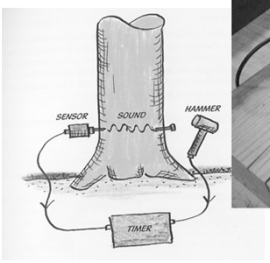




Bulges and bottlebutts

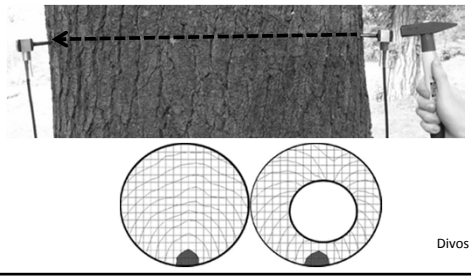


3. Effective Use of New Tools: Stress wave timers



2. Stress Wave Timing *Decay detection*

- ❑ Perpendicular to grain
- ❑ Impact-induced



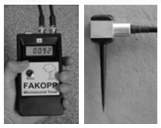
Divos

Reference stress wave velocity and transmission times in radial direction

Species	Radial stress wave velocity (m/s)	Radial stress wave transmission time (μs/ft)
Beech	1670	183
Black fir	1480	206
Larch	1490	205
Linden	1690	180
Maple	1690	180
Oak	1620	188
Poplar	1140	267
Scotch fir	1470	207
Silver fir	1360	224
Spruce	1410	216

239A Stress Wave Timer
Metriguard, Inc.
www.metriguard.com

FAKOPP Microsecond Timer
FAKOPP Enterprise
www.fakopp.com

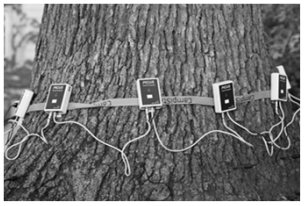


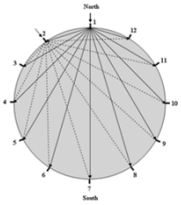
Sylvatestduo
CBS-CBT
www.sylvatest.com

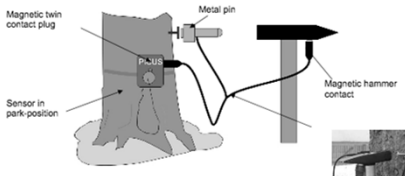
TreeCheck Sonic Wave Tree Decay Detector

Acoustic Tomography

- Employs multiple sensors (8-32) to measure stress wave transmission time at multiple directions
- Creates image of distribution apparent acoustic velocity in the cross section

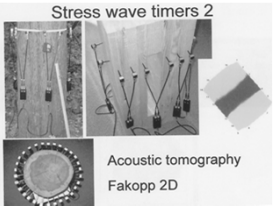


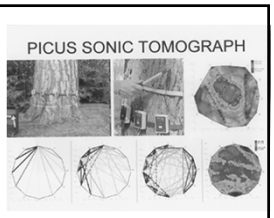


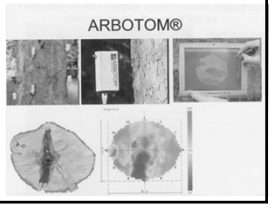


Taping on the pin

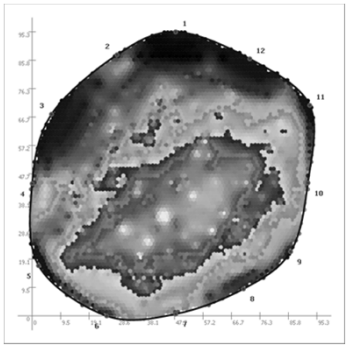
Acoustic tomography

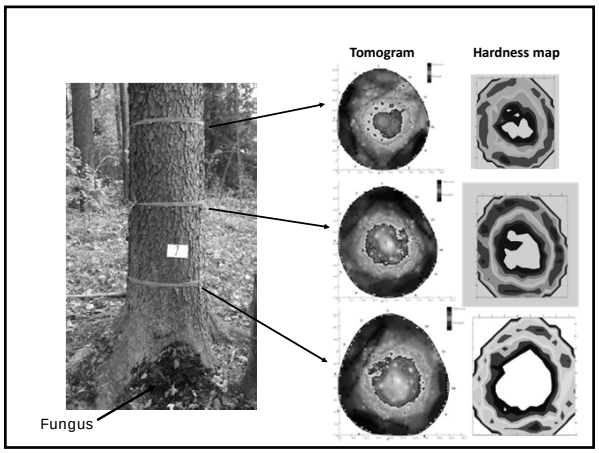




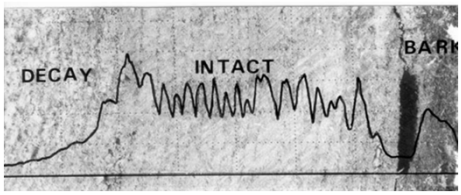


200cm





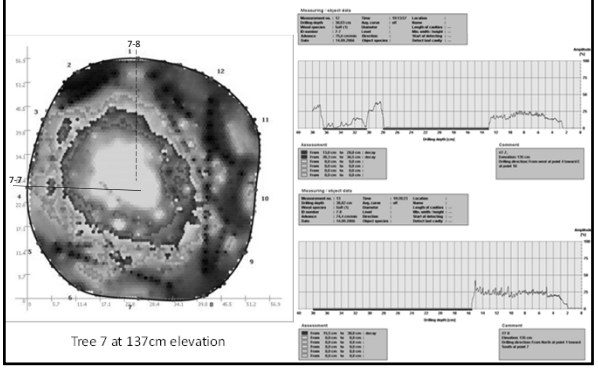
Bark, intact tree rings and decay



- Intact wood => high wood density => high drill resistance
- Decay => lower density => lower drill resistance => low profile values
- Even differences between hard late wood and soft early wood zones of tree rings are visible

Frank Rinn 2005

Decay Detection Observations



Tree 7 at 137cm elevation

Capitol Park Tree Stability Study

Tests and Tools to Measure

- Visual Tree Assessment

Tests and Tools to Measure

- Fakopp Microsecond Timer Test

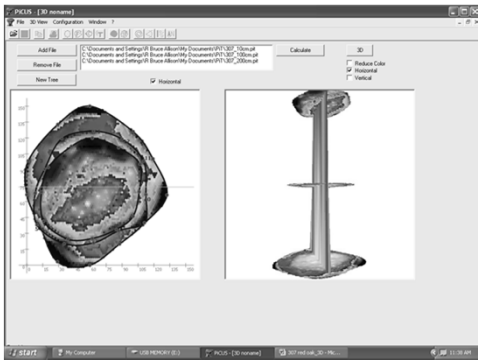
Tests and Tools to Measure

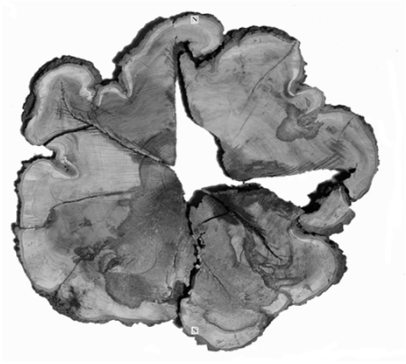
- Picus Sonic Wave Test

Tests and Tools to Measure

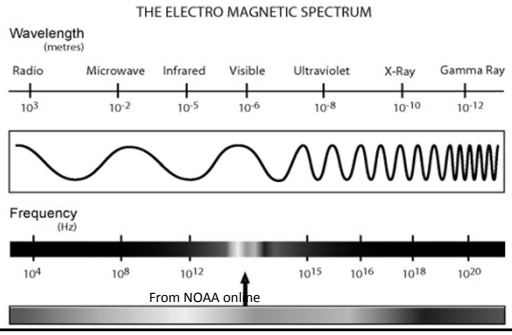
- Resistograph

3D Image



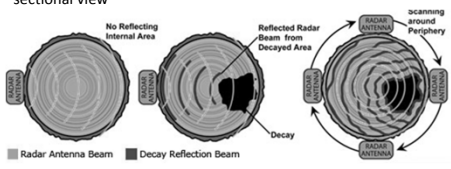


4. Tomorrow's Tools

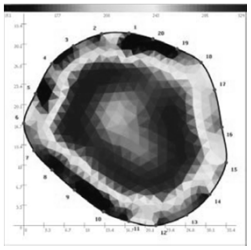


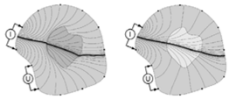
Other tools:
Ground-Penetrating Radar (GPR)

- Well-established in geological and environmental engineering fields
- Novel and new application in tree inspection
- Multi-elevation circumferential scans and single point inspections possible
- Detect cavities and decayed wood
- Image of predicted internal cross-sectional view



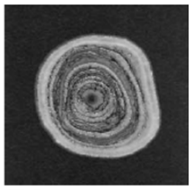
Other tools:
Electrical Impedance Tomography (EIT)





Portable CT scanner
Habermehl & Ridder (1976-8) using Cs-137

Fig. 3: Mobile CT-Scanner MCT 3



CT slice

Portable x-ray CT scanner
Morio Onoe et al. (1984), University of Tokyo

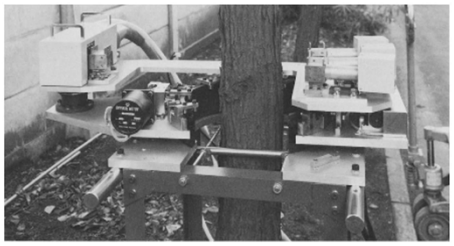
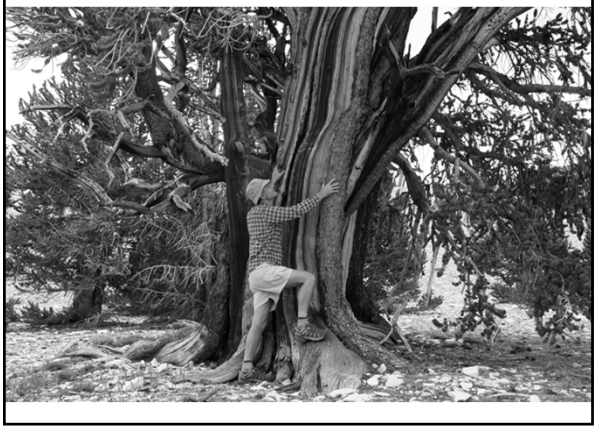
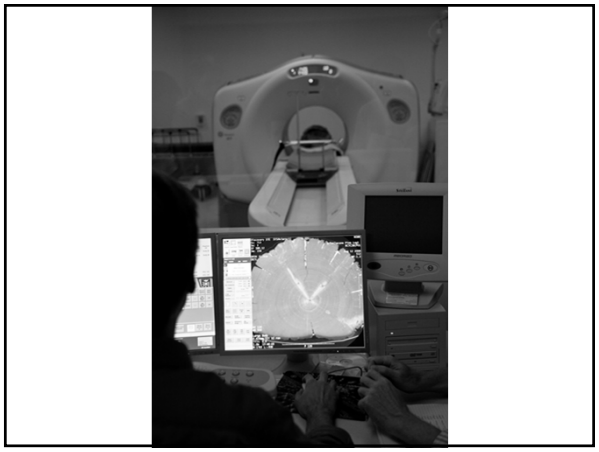
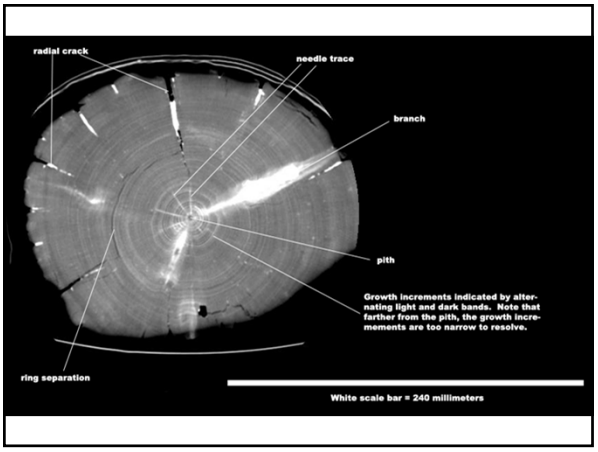
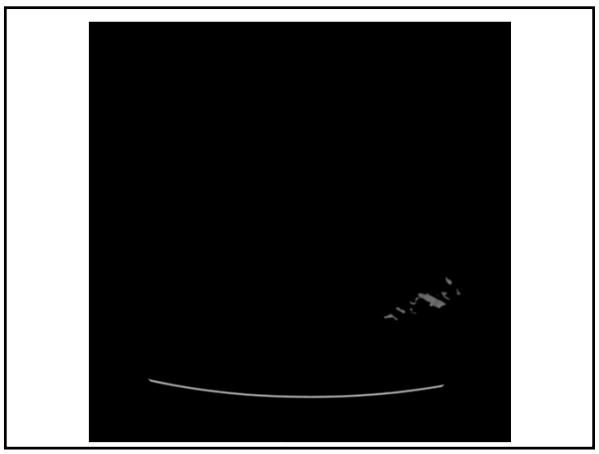


Fig. 1. A portable CT measuring a Japanese cypress tree.



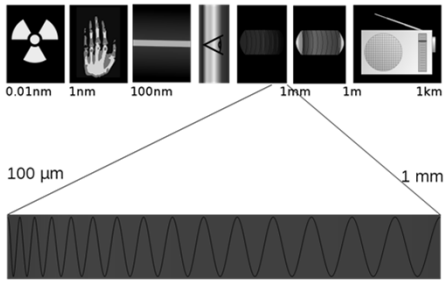






Terahertz

between 300 gigahertz ($3x10^{11}$ Hz) and 3 terahertz ($3x10^{12}$ Hz)
-Between microwave and far infrared light wavelengths



Terahertz CT imagery of a tooth and maple samara