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Horticultural Consulting, Inc.

ISA Certified Arborist Report

Submitted To:

Alameda Parks Department
2226 Santa Clara Avenue
Alameda, Ca. 94501

Project Location:

Lincoln Park
1450 High Street
Alameda, California

Submitted By:

Robert Booty, Registered Member # 487
ISA Qualified Tree Risk Assessor
The American Society of Consulting Arborists
ISA Certified Arborist WC-4286
October 20, 2022

Limits of Assignment

This assignment is limited to one Fig tree #347 located at Lincoln Park. My investigation involves a structural trunk evaluation using Sonic Tomography, Ground penetrating radar and Resistograph testing. Since trees can fail during unpredictable weather events this structural evaluation study and its recommendations are invalid during those abnormal times. Because trees continually change, this evaluation is valid only for the date of this inspection.

Disclaimer[1]

Although studies have shown ground penetrating radar and Sonic Tomography to have a high degree of accuracy[2] for below-ground root identification, these are not photographs but images of predicted root targets or changes in wood composition as in the case of trunk imaging . Arborist OnSite endeavors to use equipment that generates useful information to prepare reports that will reflect its best judgment in light of the facts as it knows them.

Assignment

I have been retained by Matt Nowlen who is superintendent for the parks department for the City of Alameda. Matt has a concern regarding a Fig tree at Lincoln Park that has visible decay. His concern is the possibility of an unexpected tree failure. I have been requested to use ground penetrating radar, Sonic Tomography and Resistograph testing to determine the internal structural condition of the tree.

Observations

I visited the site multiple times on and after July 6, 2022. The Fig tree (*Ficus species)* is located in the center of Lincoln Park in Alameda, California near a basket ball and pickle ball court. The tree currently appears to be in fair to good health. The tree is very popular in the park with people playing around it and climbing the tree on a daily basis. The tree has a trunk diameter measured from soil grade up to 4.5 feet, of 91 inches. The height[3] of the tree canopy is 67.3 feet. I did observe some upper canopy thinning and branch die-back but not a lot. The tree consists of five main co-dominate stems, estimated to be 24 inches in diameter each beginning approximately six feet up the main trunk. Some years ago there was a large branch tear-out near the base and in an upper stem both were co-dominant, that left areas of dead wood and decay; I did observe seasonal mushrooms at the base of the tear-out during my initial visit last fall. The co-dominant stems begin about 4.5 feet from grade and all have included bark[4]. Armillaria root disease was observed in the area of the tear-out at the base of the tree. The area appears to be over watered.

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[2] Nina Bassuk, "Ground-Penetrating Radar Accurately Locates Tree Roots in Two Soil Media Under Pavement" Arboriculture & Urban Forestry, International Society of Arboricultural 2011.

[3] Height measurement was obtained by using a Nikon Forestry PRO II Laser Rangefinder/Hypsometer.

[4] Included bark is when the bark essentially rolls in on itself, identifiable by a tight V shaped branch structure, creating areas of structure separation and weakness. These areas are typically seen in a co-dominant stem, and sometimes in limb structures.

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Discussion / Conclusions

This fig tree has a very complicated and weak structure. Even before decay set in the tree had problems with structural integrity; the decay has complicated the situation further. The tree has a massive base as its pedestal; this has been a leading factor over the years in stabilizing the tree. Originally the tree was part of an old estate many years ago before this park was established, so this tree could be well over 100 years old.

The five co-dominate stems that make-up the canopy is weakened by poor attachments to the main trunk containing included bark. There is approximately sixty feet of canopy above these attachments, and there have been two failures in the past involving these stems. Because decay is visible at these failure locations it is important to determine the spread of decay if any, and if it has weakened the stem attachment to the tree further, creating a risk of failure.

Using ground penetrating radar I performed a half circle scan on each of the five stem attachments that were accessible. I estimated the diameter of each of the stems to be about twenty-four inches each. Various amounts of decay were identified within each stem. Armillaria root disease enters the tree through the root system and decomposes roots. What appeared to be Armillaria was identified and documented. In light of this, ground penetrating radar was used on the visible surface roots around the tree to determine root health. In all cases what appeared to be decay was identified to various degrees in each root scanned. Because these stem and root diameter measurements were estimated and not able to be physically measured, the amount of decay can't be accurately determined, only its presence.

The use of Sonic Tomography and other wood testing methods

The accuracy of sonic tomography imaging can be affected by included bark. Usually sonic tomography would be applied at the lower buttress of the tree near the soil. In this case an abundance of included bark is located in this lower section of the tree. It was determined then to move the tomography testing to an area higher on the main stem avoiding much but not all of the included bark; the testing was performed five feet above grade. The tomography image indicated large amounts of decay.

However the area on one side and between sensors 5 – 16 could be affected by included bark which may affect the accuracy of the tomographic image in that area. Resistograph testing was used to test the actual wood density and composition next to these tomographic sensors. GPR was used to test the five stem attachments and surface roots around the tree for decay; to some degree decay was indicated in all instances. Fig trees have hard wood. The Resistograph testing conducted at the site of the tomographic and GPR testing indicated a consistent low wood resistance during the drilling. This could indicate decay pathogens have affected the integrity of the wood even in the areas suspected of having included bark.

Included bark causes structural weakness within the stem and over time will separate and essentially wedge the junction apart causing stem or limb failure. This separation also leaves a gap for water to get into the core of the stem, causing rot and catastrophic failure.

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This tree is no longer in its original environment as it was on an isolated estate many years ago. It's now in a city park visited by many, many people on a daily basis, with people sitting under it and children climbing into the tree. Given the inherent structure of the tree, the two previous stem failures were predictable. With the passing of time and now the indication that these stem attachments and root system are further weakened by decay pathogens the tree represents an unacceptable risk in the park to the public. I would consider removing the tree.

If it is determined to retain the fig tree

If it is determined to retain the fig tree in spite of the negative testing results, a few things can be done to reduce the risk, but not eliminate it.

1. Reduce the trees height by using thinning cuts.
2. Keep the canopy thinned to reduce canopy weight.
3. Install a cabling system to the five main stems using a hub and spoke system.
4. Install a short chain-link fence around the tree to prevent individuals from climbing into the tree.
5. Post signage on all four sides of the fence with the statement "keep out".

Recommendations

I would consider removing fig tree #347. Our testing indicated the tree has been affected by decay pathogens, including the root system. Because of this it poses an unacceptable risk to the public who use this park.

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If it is determined that the fig tree should be retained a short fence such as this one should be installed around the tree. This would help prevent the public from climbing into the tree and being injured. Signage should be attached to the fence indicating to “Keep Out”.

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This was a large co-dominant stem high up in the tree that broke off years ago. Decay has affected the area.

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Armillaria root disease (oak root fungus) this was collected at the large tear-out at the base of the tree. Same area mushrooms were observed last fall growing on dead wood.

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Sonic Tomography / Methodology

Sonic tomography detects defects in trees by measuring the velocity of sound waves as they pass through wood. Differences in velocity help determine areas of sound wood and areas of compromised wood, which has less elasticity and density than sound wood. This reduction in elasticity results in the inability of sound waves to take a direct path through the wood, indicating the presence of the wood being compromised by decay pathogens or other defects. The speed of sound is measured as it travels through wood and correlates with wood quality and strength and displayed in the following images it creates.

Using an array of electronic sensors, attached at specific and chosen locations around the trunk or scaffold limbs, sonic tomography creates a set of internal cross-sectional imaging maps of internal tree trunks or limbs. These maps may correspond to areas of decay, hollows, cracks, or other features that may reduce wood strength, and can be used to estimate loss of strength across the plane being imaged.

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The circumference of the tree was 23 feet 10 inches. We utilized 24 sensors placed 60 inches from grade around the tree to map the geometric lay-out of the trunk. A battery lower left in photo was used to power-up the system.

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Sensors 17 and 18 indicate the path to the heaviest concentration of possible decay within the lower stem failure of the trunk. This is the tension side of the tree. Note the tomography results on the next two pages.

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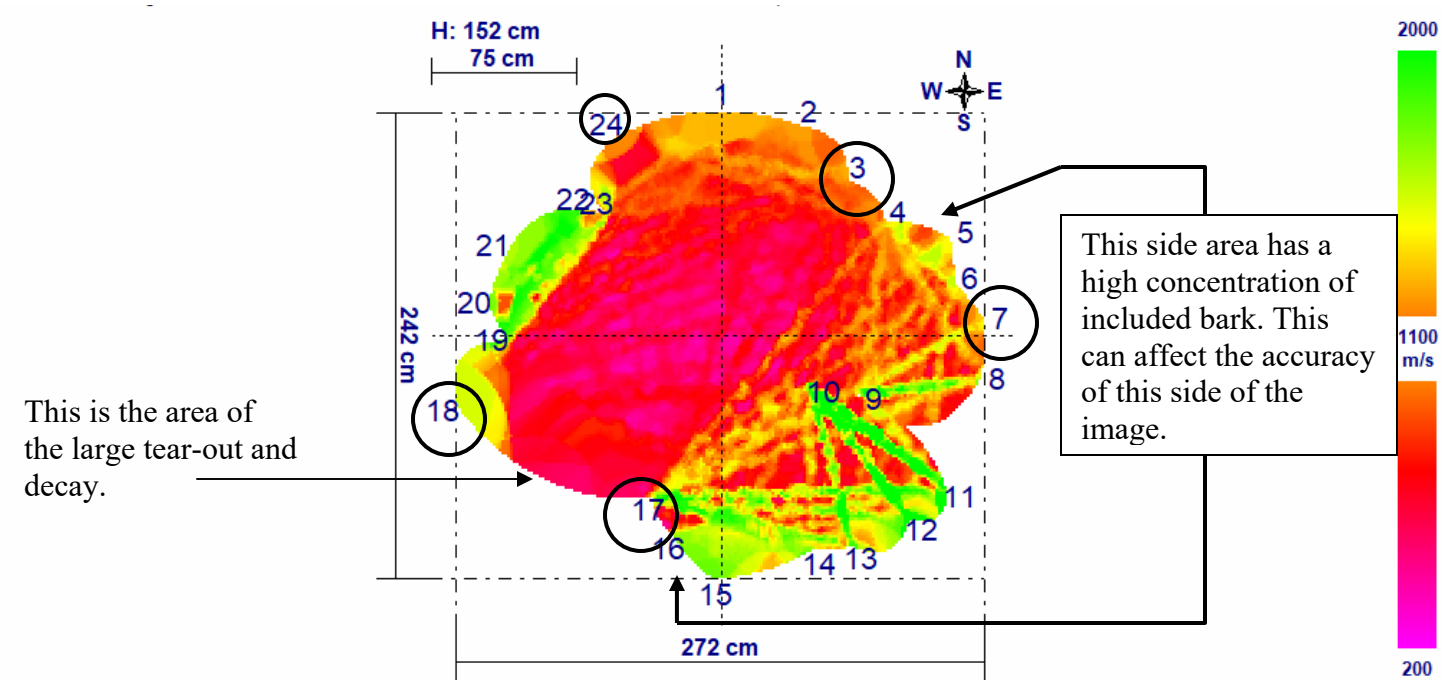
Lincoln Park, Alameda, California. Tomography Image Fig tree #347 Trunk Circumference 286 inches, imaging performed 56 inches from grade.



Numbers circled in black were sites of Resistograph testing.
The numbers represent the positioning of the tomography sensors around the tree.

Analysis Notes; this image was created by calculating the speed in which sound traveled through the wood in the trunk. Green indicates sound wood with no obstructions or decay pathogens that would slow the sound waves down in that area. The yellow reveals a slightly slower travel time indicating some degree of compromised wood. Red to orange indicates the slowest travel time for this image. This relates to a greater wood strength loss from wood compromised by decay pathogens.

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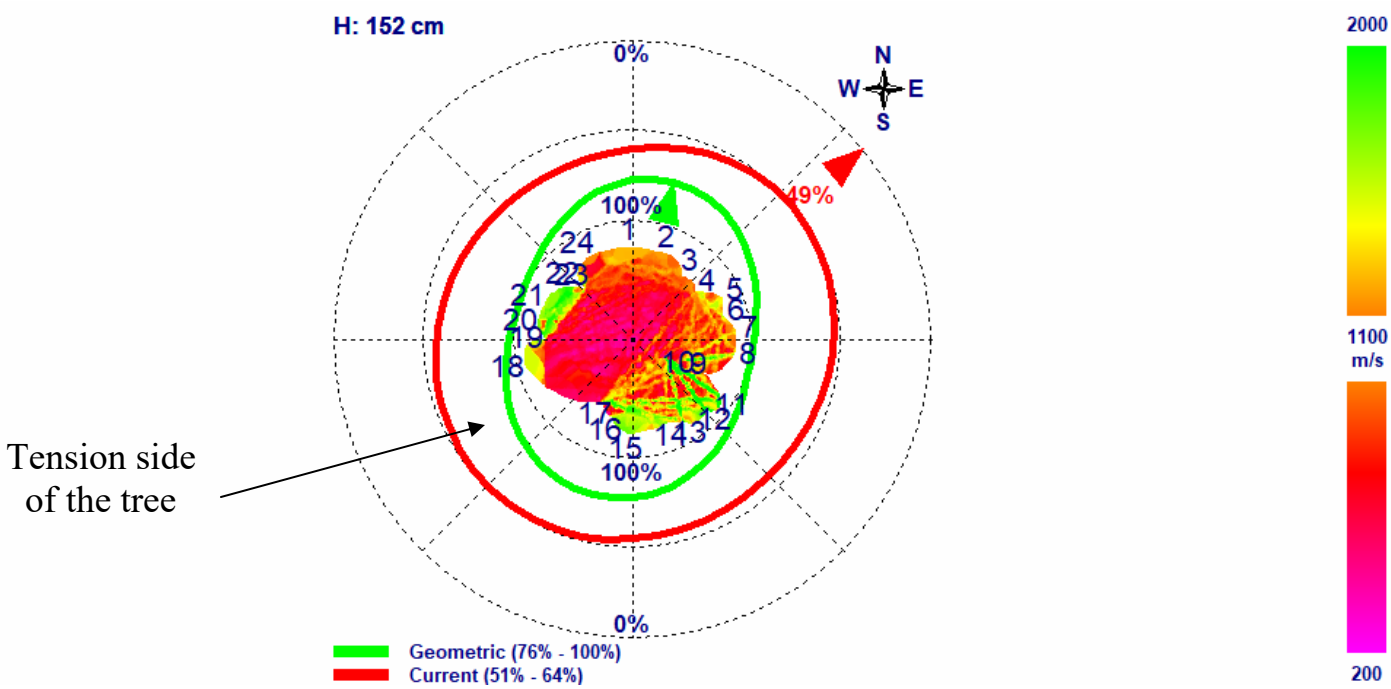
Wind loss reduction values of wood strength

Stability of trees, especially their strength, is not only affected by wood quality, but also by its geometrical form. Compared to a circular cross-section form, an elliptical cross-section can bear different loads, depending on the direction of force (wind). You can compare this to a board which can bear a higher load on its narrow side than on its broad side. Internal decay reduces the cross-sectional area of the trunk and therefore reduces the moment of resistance from wind. This software is based on this concept. It enables the assessment and visual presentation of the relative moment of resistance (wind) for trees with any cross-sectional geometry. Decayed areas are taken into consideration as well as different tension and compression strengths of wood under load. The red circle depicts the percentage of wood strength loss due to decay and its failure point under wind load. The green circle is the general geometric circumference of the cross-sectional trunk under investigation. A reduction of values to the 50% line means that the tree has lost 50% of its ability to resist wind loads.



Analysis Notes; The software calculated that this tree has lost 49 % of its ability to resist wind loads.
*This is not taking into consideration of root loss from disease.

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Resistograph Testing / Methodology

Resistograph testing is an advanced tree risk analysis procedure that is invasive. The device uses a very small but long drill bit (20 inches). As the drill enters the wood it measures the resistance it encounters as it passes through hard (healthy) wood (=high resistance) and into soft (decayed) wood (=low resistance), or hollow areas (=no resistance) in the trunk.

Ground penetrating radar was used higher up on the trunk, however due to the unusual shape of the trunk at the lower levels. The radar antenna was too large to be used due to the abrupt and uneven surfaces of the trunk which may then provide unreliable information.

So after the results of the imaging on the upper areas of the tree were completed, Resistograph testing was performed in the lower buttress sections of the tree. Together, this provided information that was needed for decision making. When the term; Compromised wood is used in the analysis it means decay pathogens have infected the wood and has begun digesting the lignin within its cell walls, creating a significant strength loss. The following pages contain the results of this testing.

Resistance Recording Drills

Resistance recording drills are specialized pieces of decay detection equipment that may be used as part of an advanced level 3 risk assessment. Resistance recording drills have been shown to be effective in helping arborists detect and document internal tree decay in trees (Costello and Quarles 1999; John stone et al. 2007). As the drilling needle (bit) passes through the wood of a trunk, branch, or root, the resistance it encounters is recorded. Sharp decreases in the resistance serve as an indication that a pocket of decay or a crack is present. As their name indicates, resistance recording drills provide a visual documentation on drilling resistance for final reporting. Measurements are recorded at a 1:1 scale involving an onboard computer with paper printouts available in the field, allowing the technician to partially assess the condition of the tree part drilled on site. Internal data is recorded electronically and saved for visualization and assessment with its software back at the office.

Note; Fig trees are hard wood. This would normally produce a high resistance during a drilling.

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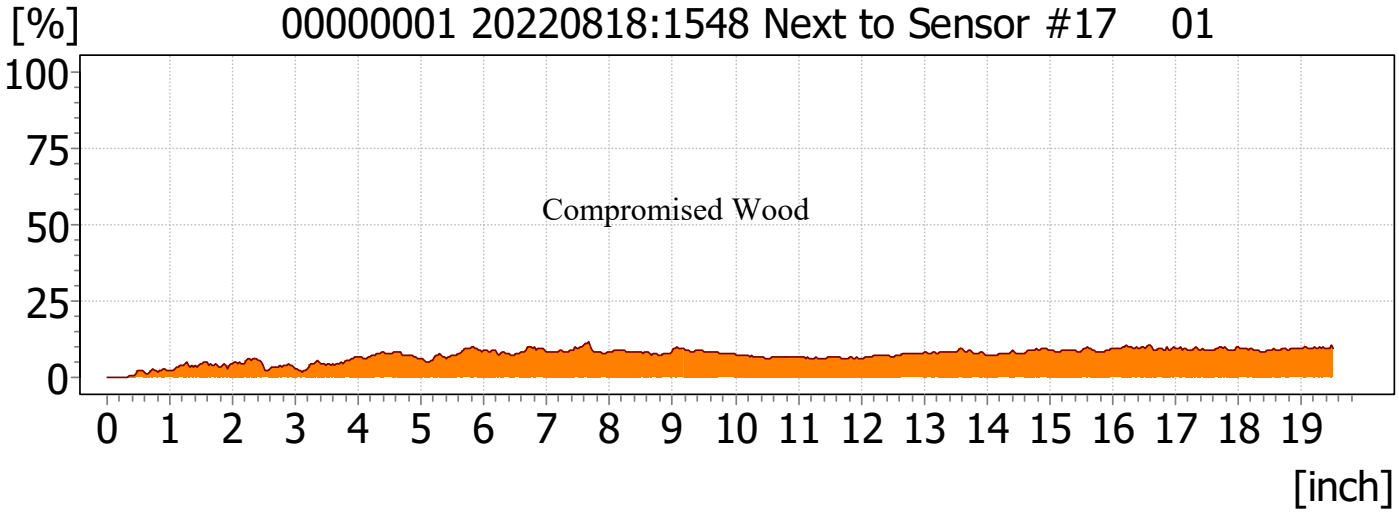
August 19, 2022 Fig Tree #347. Resistograph Drilling #1
Performed 60 inches from grade. Next to sensor #17 Trunk circumference 286 inches.



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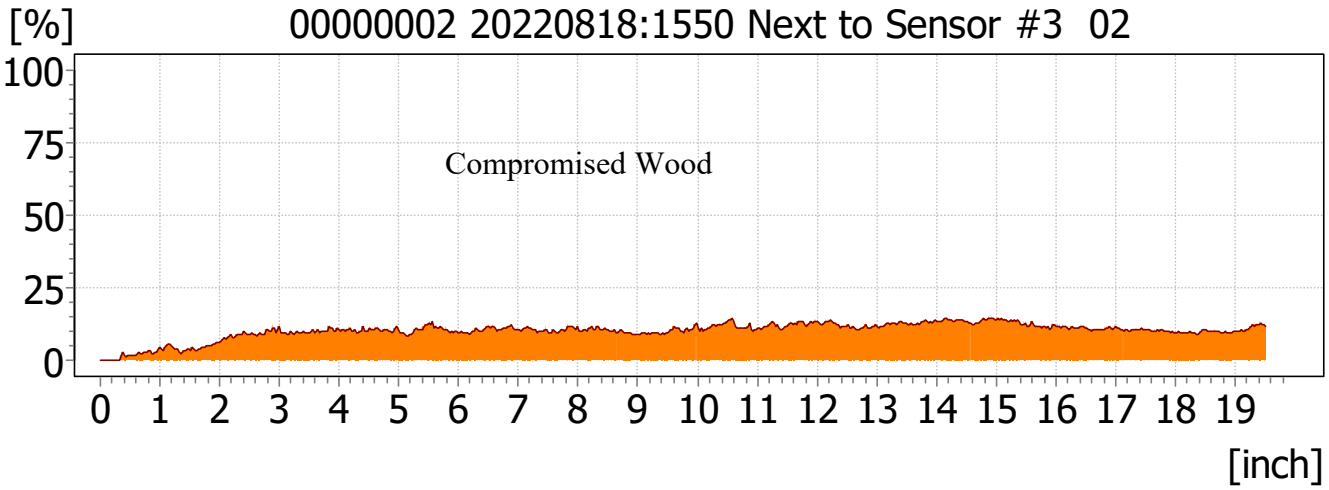
August 19, 2022 Fig Tree #347. Resistograph Drilling #2
Performed 60 inches from grade. Next to sensor #2 Trunk circumference 286 inches.



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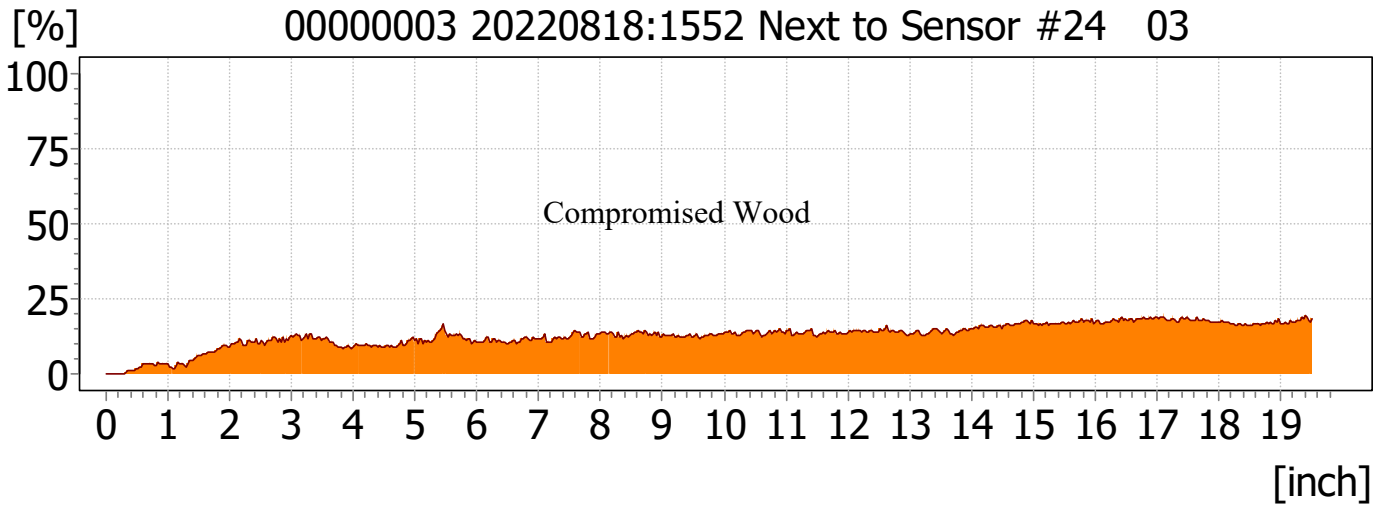
August 19, 2022 Fig Tree #347. Resistograph Drilling #3
Performed 60 inches from grade. Next to sensor #24 Trunk circumference 286 inches.



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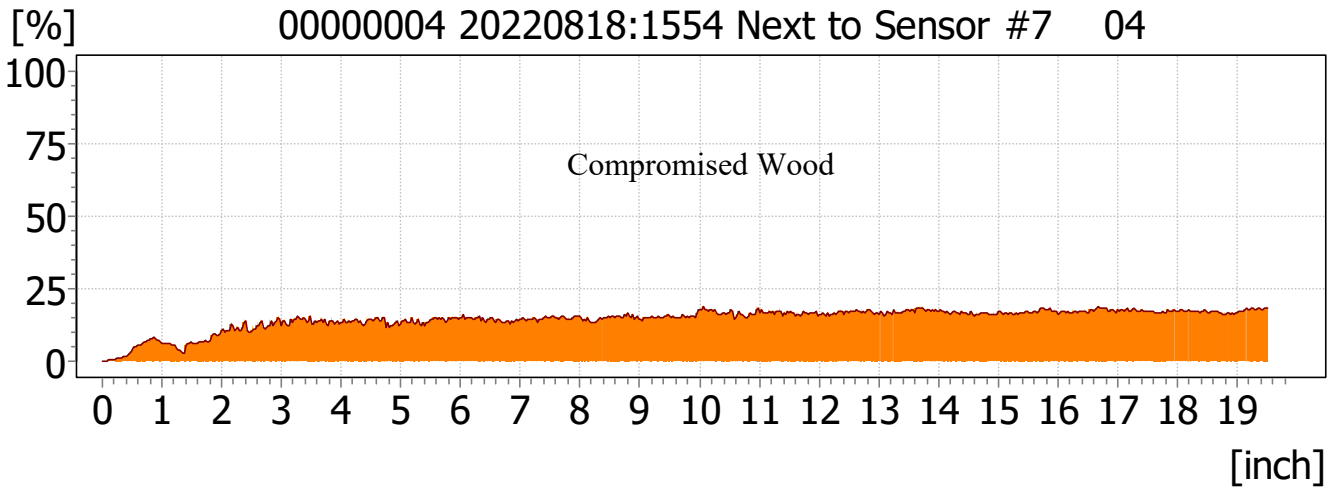
August 19, 2022 Fig Tree #347. Resistograph Drilling #4
Performed 60 inches from grade. Next to sensor #7 Trunk circumference 286 inches.



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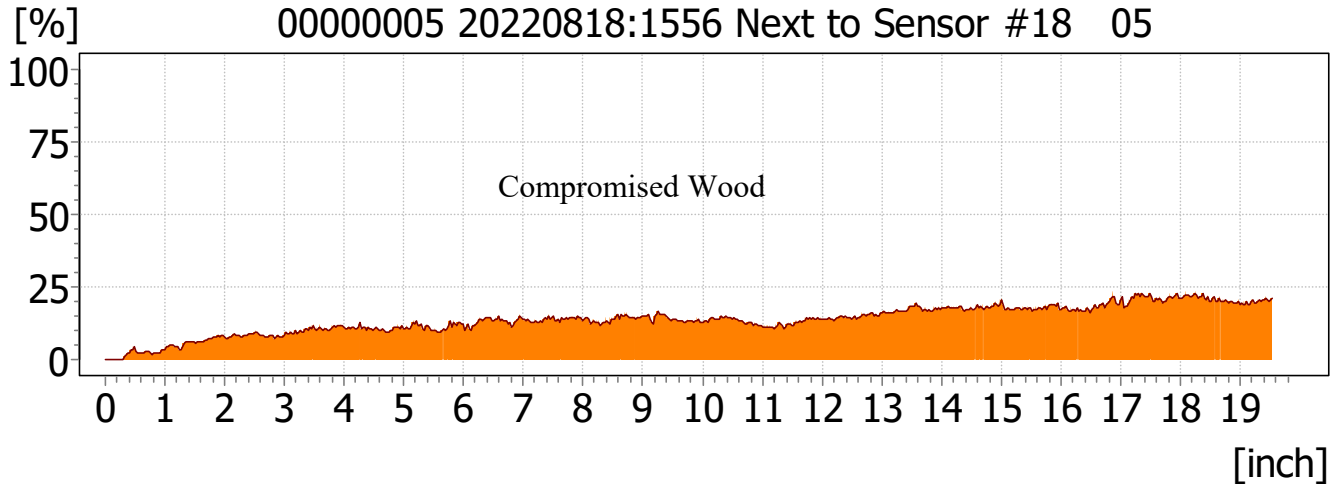
August 19, 2022 Fig Tree #347. Resistograph Drilling #5
Performed 60 inches from grade. Next to sensor #18 Trunk circumference 286 inches.



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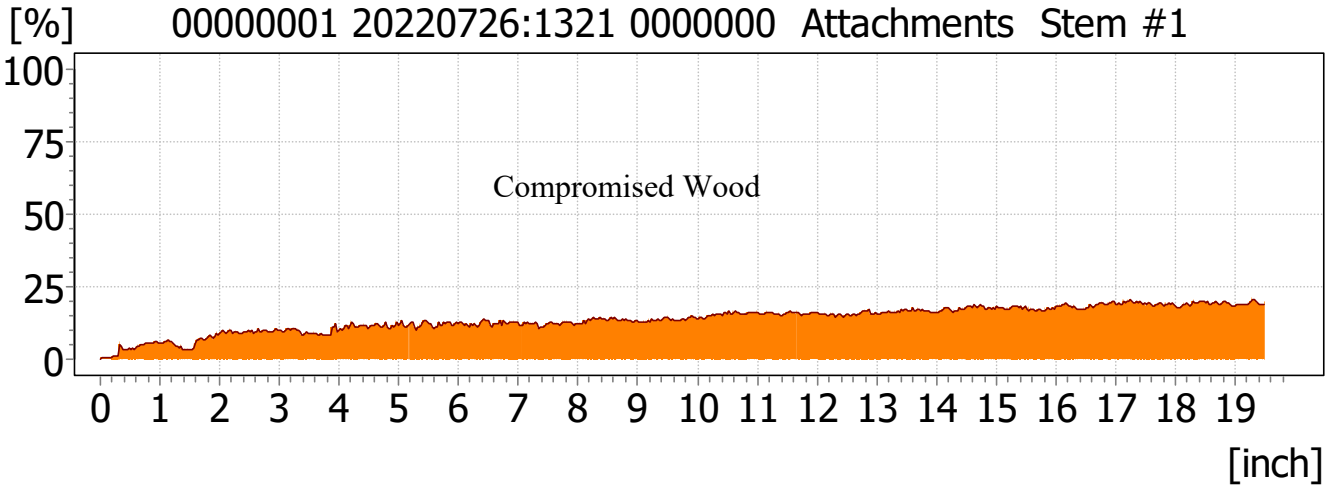
July 27, 2022 Fig Tree #347. Resistograph Drilling #6
Performed 6 feet from grade. Testing co-dominant stem attachment # 1



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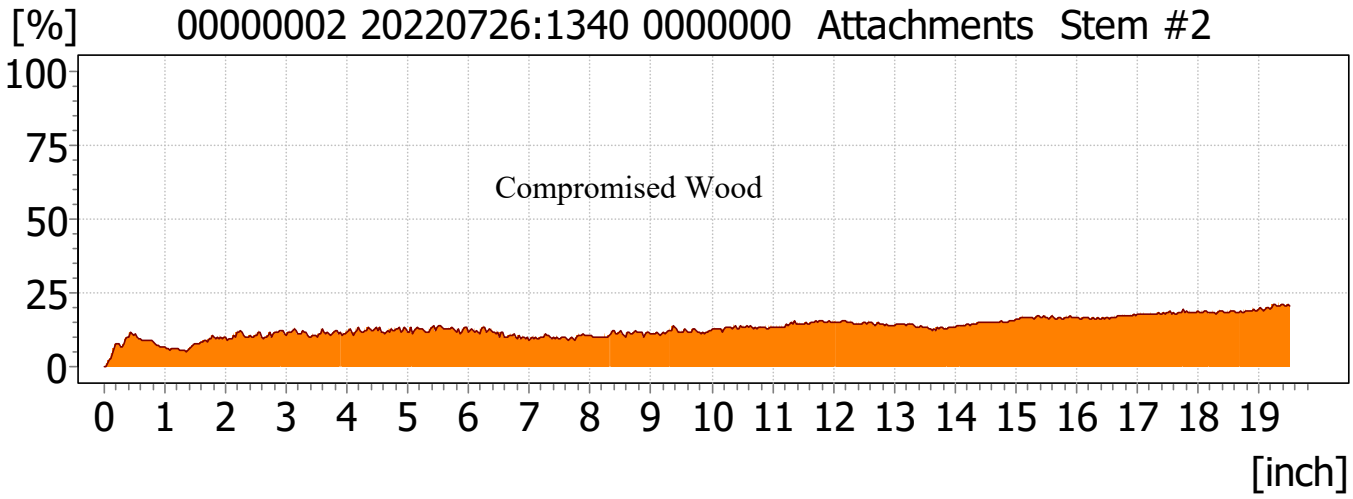
July 27, 2022 Fig Tree #347. Resistograph Drilling #7
Performed 6 feet from grade. Testing co-dominant stem attachment # 2



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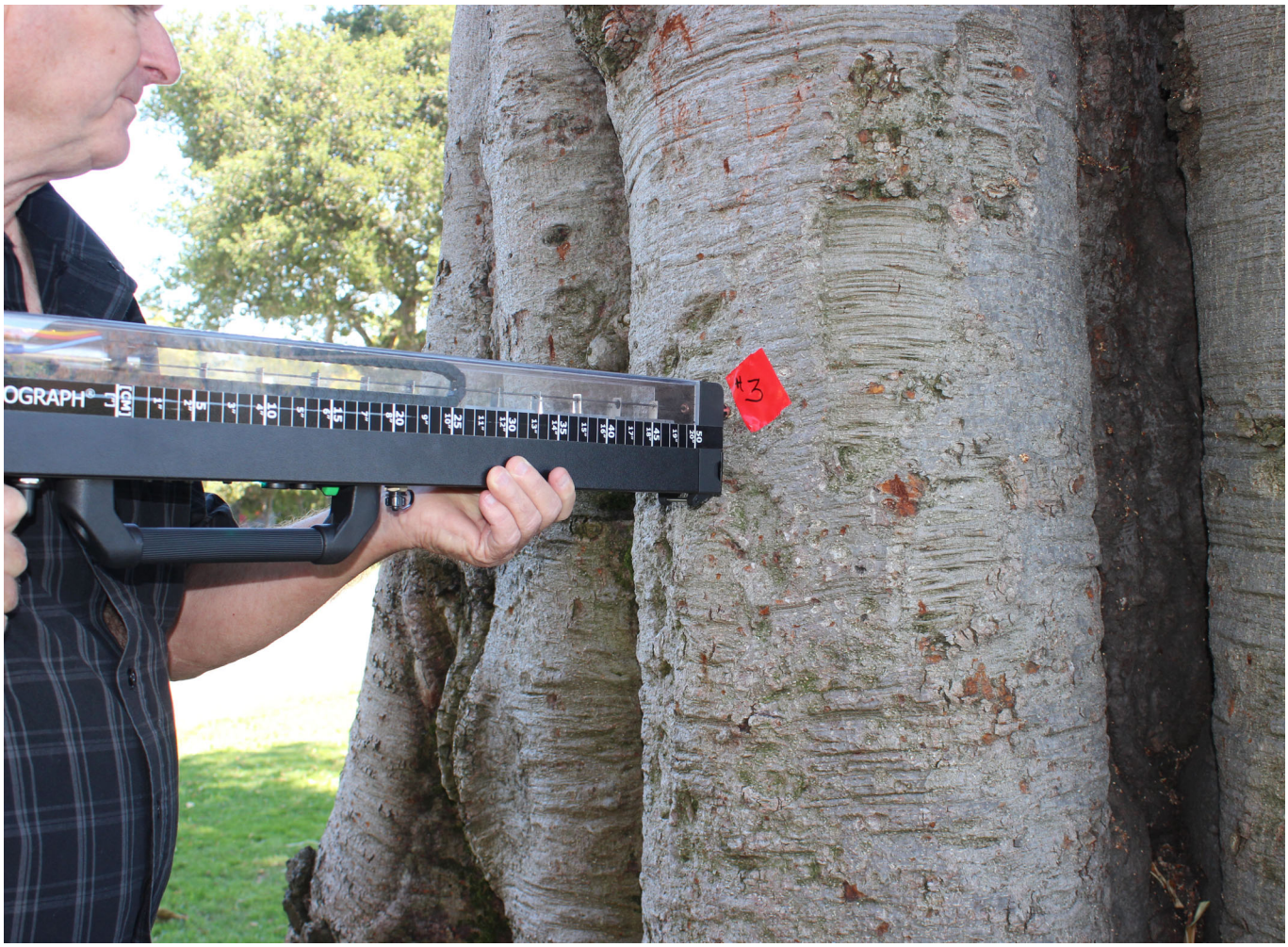
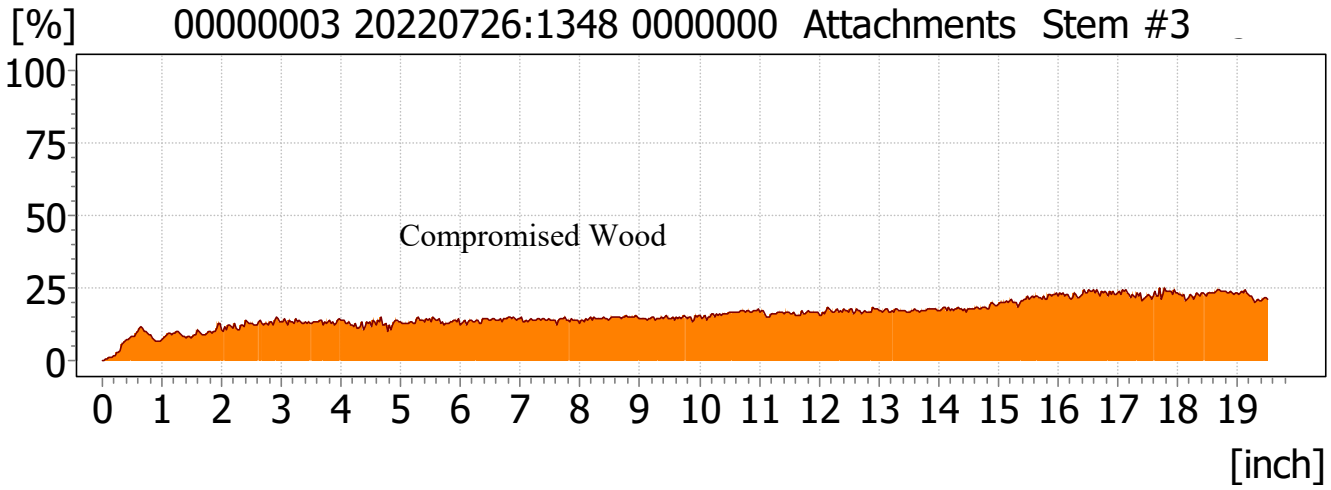
July 27, 2022 Fig Tree #347. Resistograph Drilling #8
Performed 6 feet from grade. Testing co-dominant stem attachment # 3





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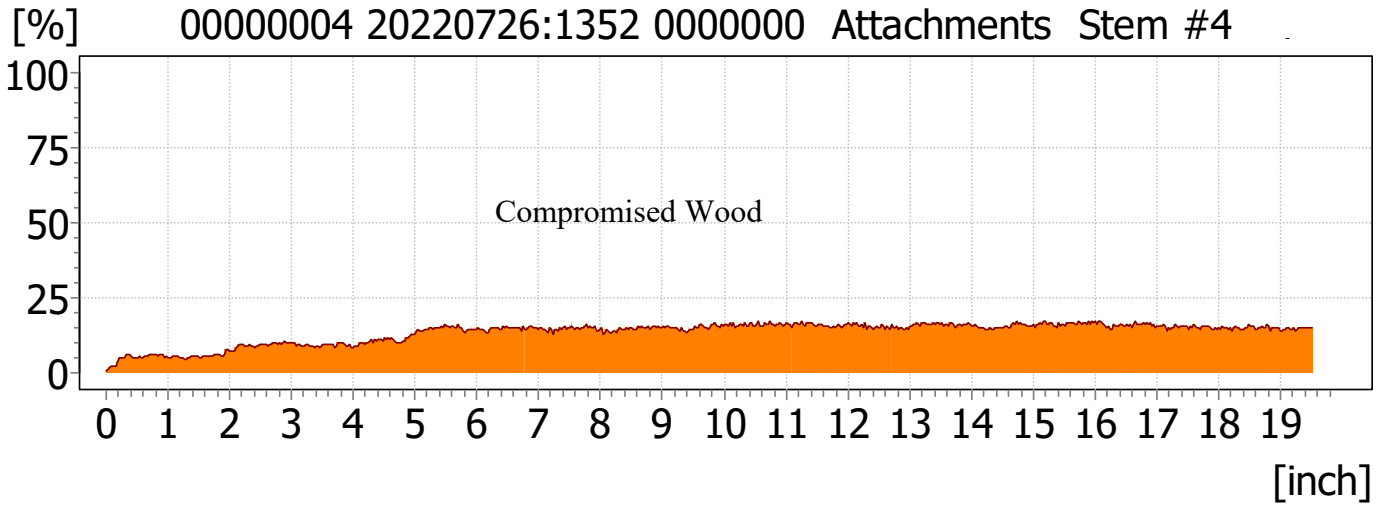
July 27, 2022 Fig Tree #347. Resistograph Drilling #9
Performed 6 feet from grade. Testing co-dominant stem attachment #4



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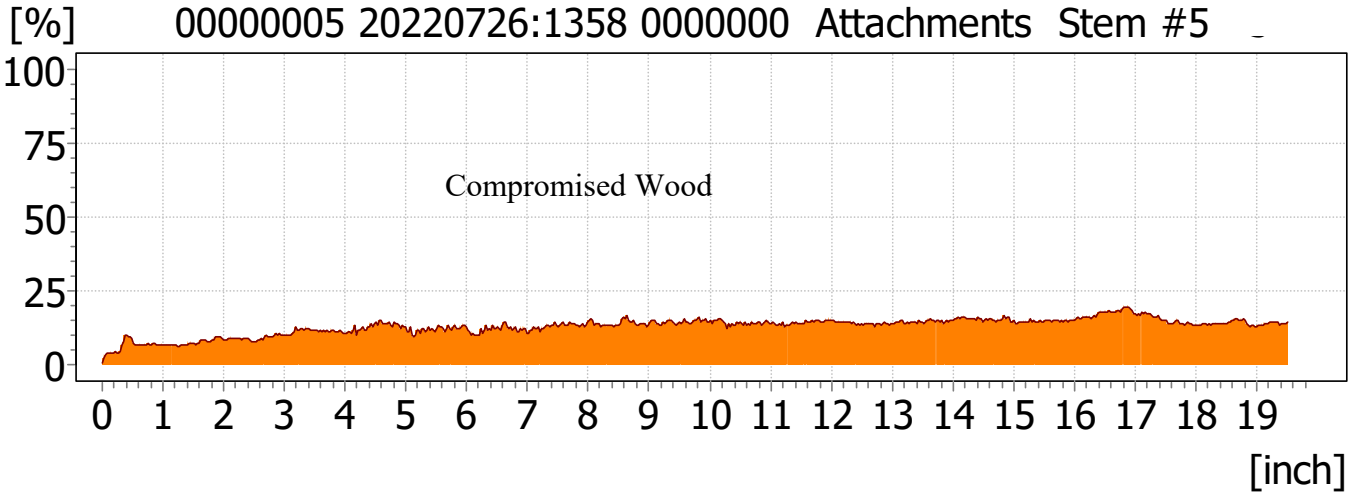
July 27, 2022 Fig Tree #347. Resistograph Drilling #10
Performed 6 feet from grade. Testing co-dominant stem attachment #5 left side



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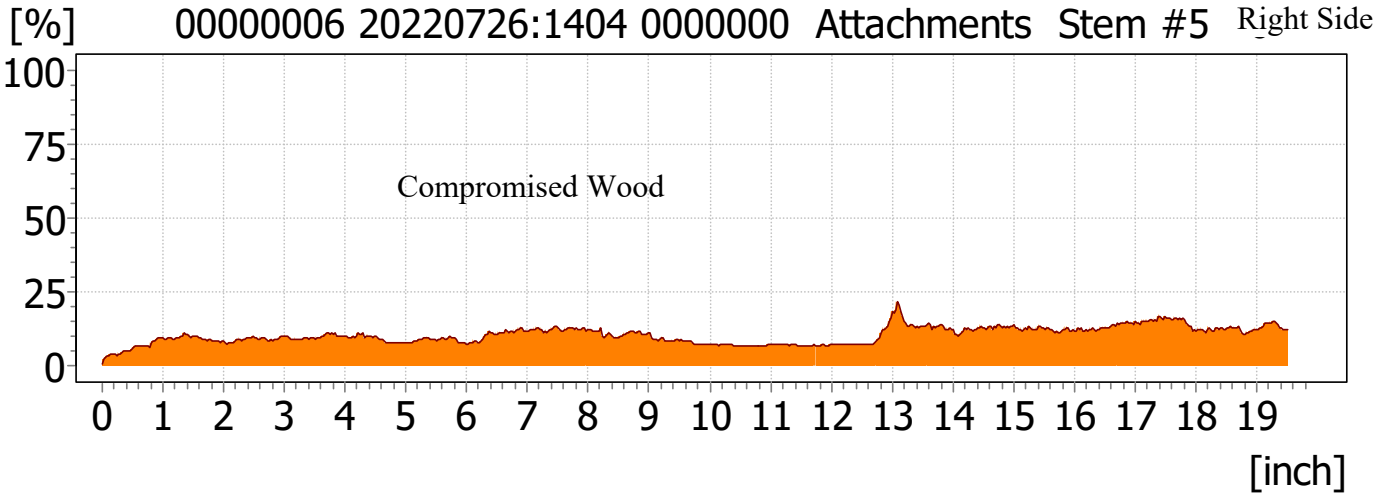
July 27, 2022 Fig Tree #347. Resistograph Drilling #11
Performed 6 feet from grade. Testing co-dominant stem attachment #5 right side



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Methodology

How does it work?

Ground-Penetrating Radar (GPR) is an established technology that has been used worldwide for over 60 years. Radar is an object-detection system that uses *electromagnetic waves* – specifically *radio waves* – to identify the range, altitude, direction, or speed of both moving and fixed objects. When an electromagnetic wave[5] emitted from a small surface transmit antenna / receiver encounters a boundary between objects with different electromagnetic properties, it will reflect, refract, and or diffract from the boundary in a predictable manner. Radar waves or signals are reflected especially well by materials of considerable *electrical conductivity.*

The radar signals that are reflected back towards the antenna are the desirable ones that create the image and make radar work. The radar signal detects water in the root system of the tree and can distinguish this water from water in the surrounding soil matrix. An air-filled tree trunk (*with a decayed hollow*) or a partially air-filled incipient (early stage) decay zone inside a cell wall within a tree are excellent reflectors for detection by GPR systems. Use of GPR instrumentation for internal tree trunk decay detection and below ground root locating is one of its latest uses in the field of tree risk assessment.

Its uses today seem endless. When you look at the weather report, you are looking at a weather radar scan; it will tell you where the heaviest amounts of rain will fall in your area. It works like this, the radar signal, as it passes through the clouds is reflected back to a transmit receiver antenna that measures the density of the moisture in them and the speed they are traveling. You can then determine approximately when it will start raining and how much rain will fall in a given area. Radar is used in aviation, automobiles, law enforcement and locating objects below ground.

How does radar distinguish between decayed and healthy wood?

Wood decay fungi[6] decompose lignified cell walls in living wood tissue by using enzymatic and non-enzymatic systems. In time this creates a microscopically detectable hollow or void within the cell walls of the wood, thereby reducing normal wood strength. Radar imaging can identify these small microscopic changes (voids) in the wood composition; they reflect a radio wave from them. It's the loss of the woods mechanical strength by these wood digesting organisms that is inherently linked to hazardous situations, often resulting to injuries or property damage.

Ground penetrating radar is one of the latest non-invasive forensic technologies used for wood decay analyses; its sensitivity to hollows, internal cracks or voids enables it to detect and create an image of these small internal molecular changes in wood density and composition. Incipient decay or *early-stage* decay is the very beginning of the biodegradation process of living wood tissue by decay causing pathogens; radar imaging can detect these minute early changes.

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[5] Daniels, D.J. 1996, Surface-Penetrating Radar. The Institute of Electrical Engineers, ISBN 0-85296-0.

[6] Giovanni Nicolitti, Paolo Gonthier, Fabio Guglielmo and Matteo M. Garbelotto 2009. A Biomolecular Method for the Detection of Wood Decay Fungi: A Focus on Tree Stability Assessment. Arboriculture & Urban Forestry, Scientific Journal of the International Society of Arboriculture.

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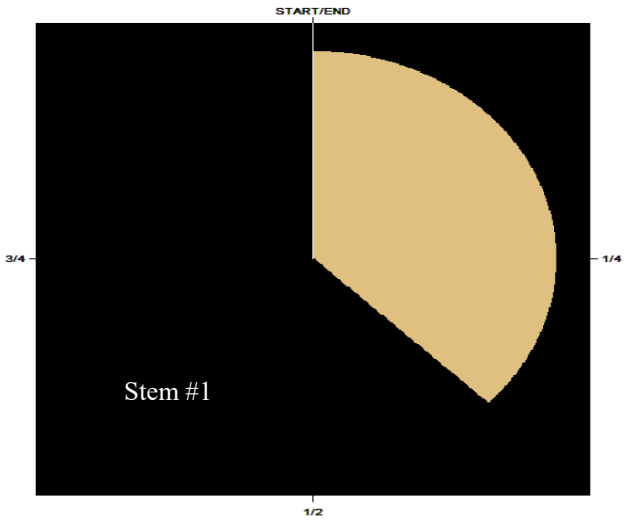
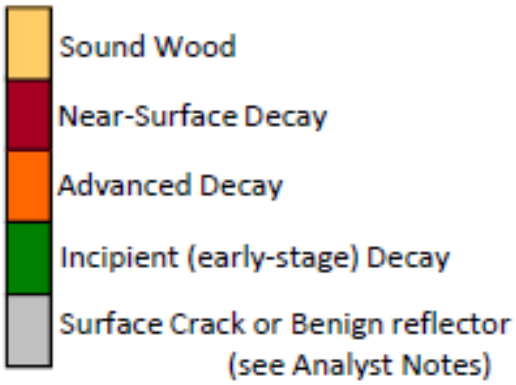
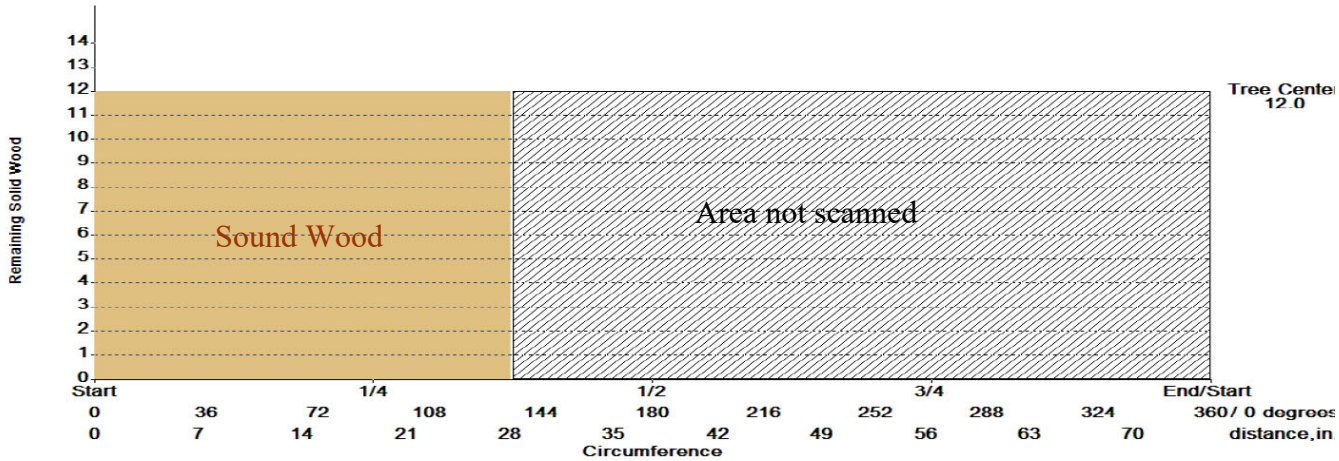
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Sector trunk Scan 1 performed 80 inches from grade. Estimated diameter 24 inches.







Analyst notes; No decay detected.

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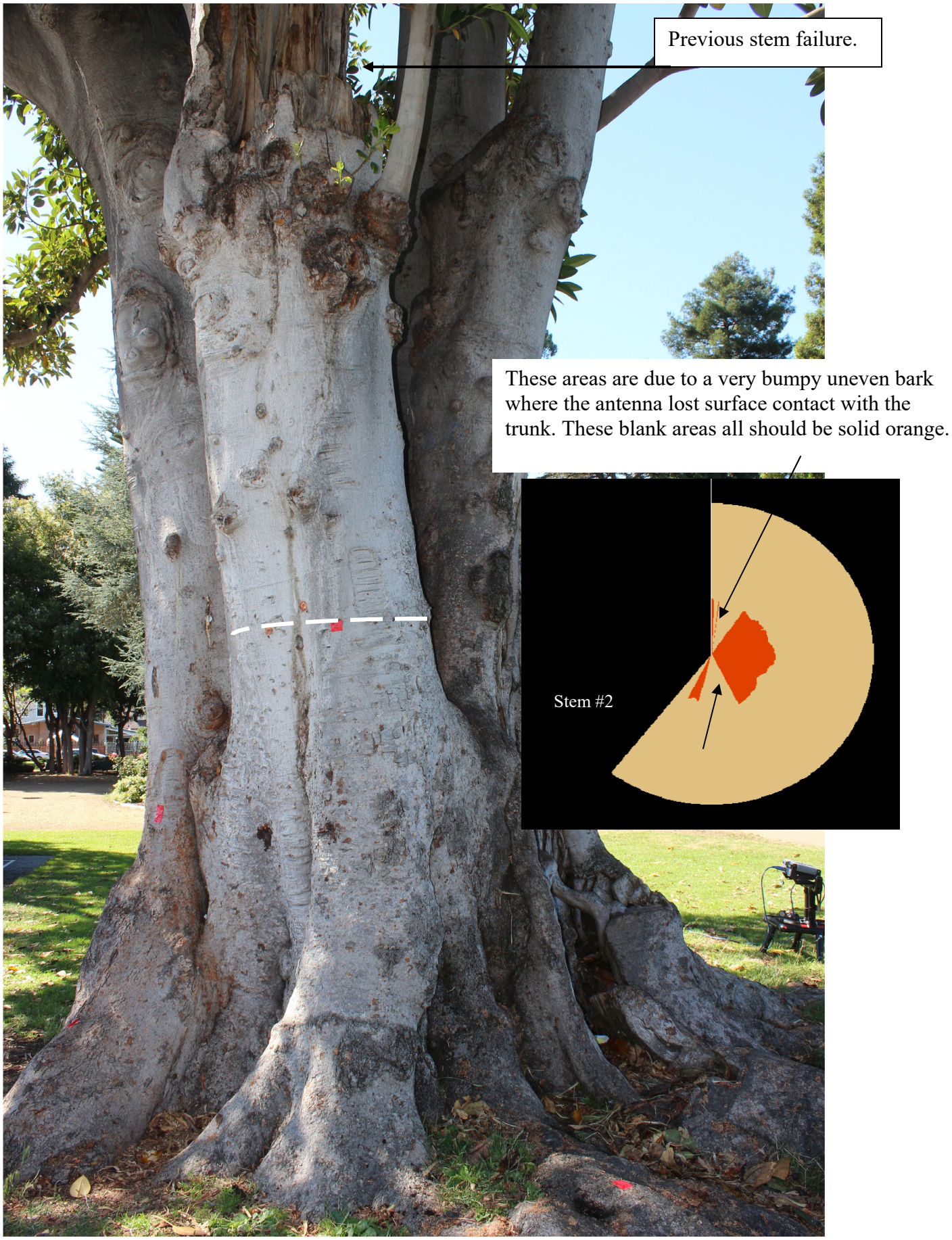

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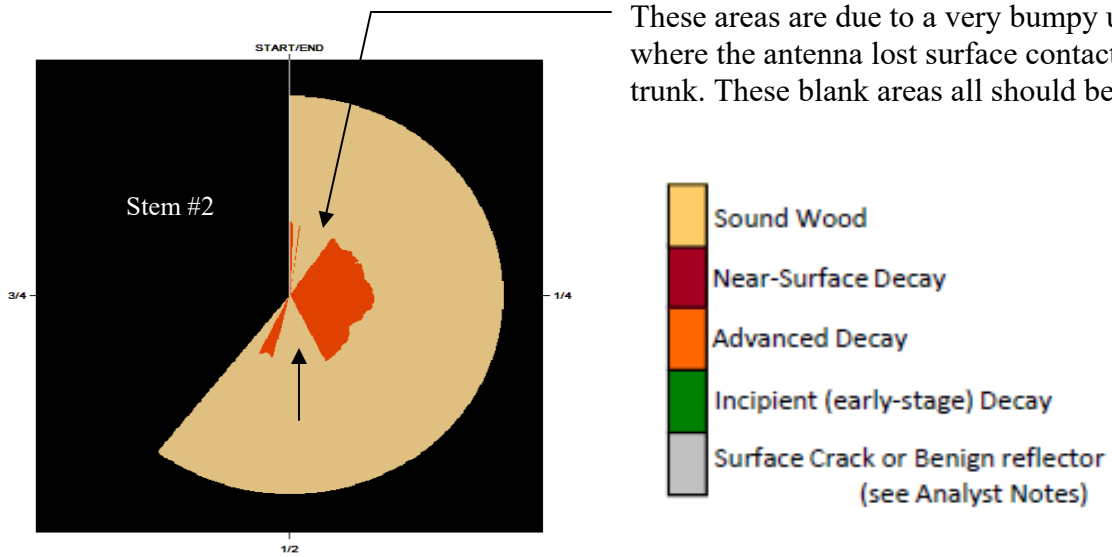
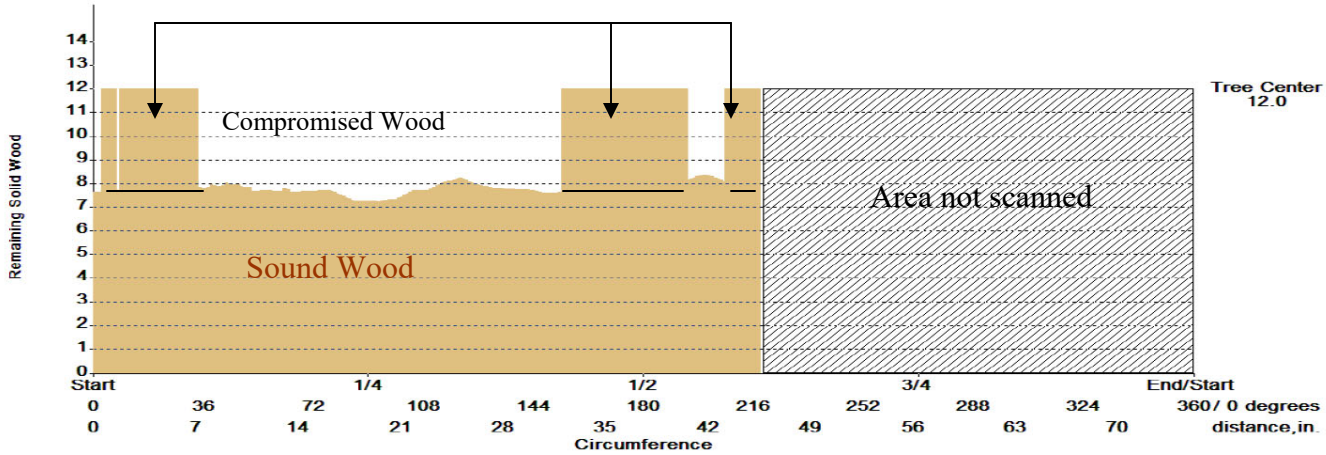
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Sector trunk Scan 2 performed 80 inches from grade. Estimated diameter 24 inches.



These areas are due to a very bumpy uneven bark where the antenna lost surface contact with the trunk. These blank areas all should be solid orange.

Antenna lost contact in these areas



Analyst notes; Decay detected. Average sound wood 8 inches.

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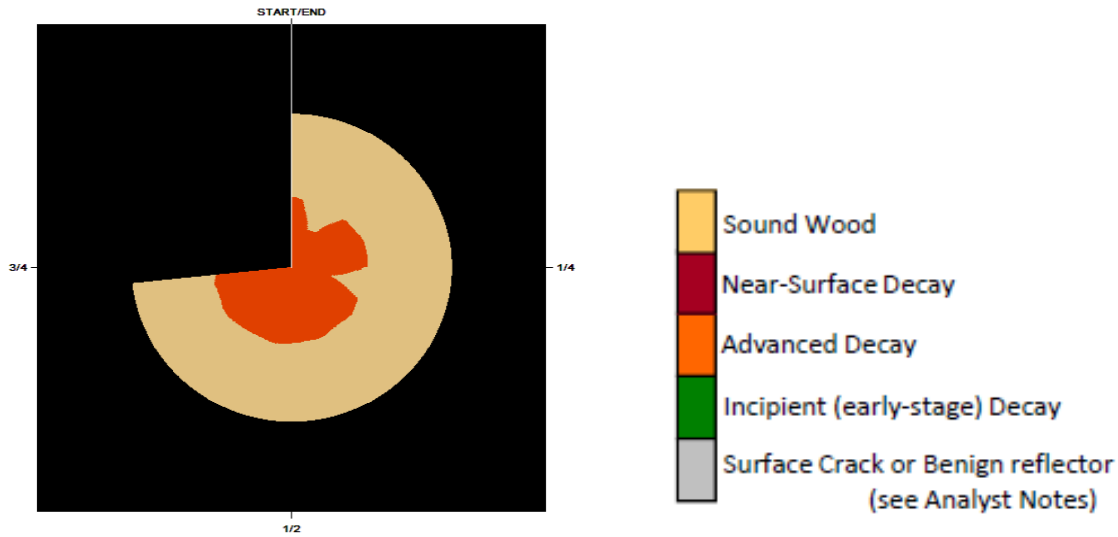
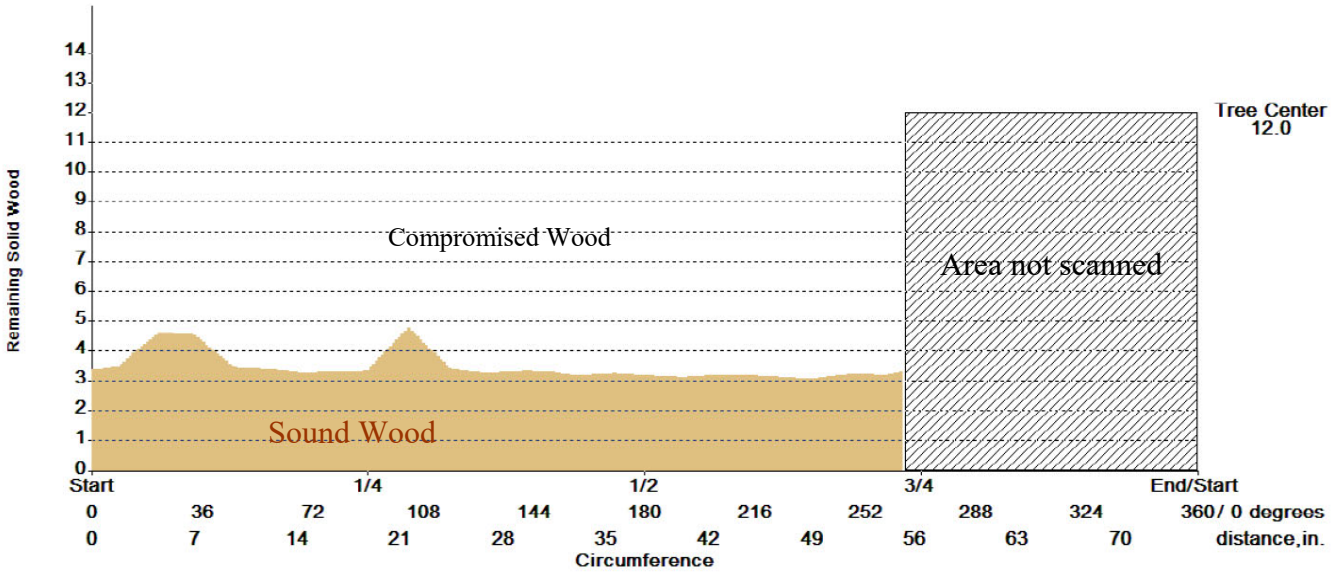
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Sector trunk Scan 3 performed 80 inches from grade. Estimated diameter 24 inches.





Analyst notes; Decay detected. Average sound wood 3 inches.

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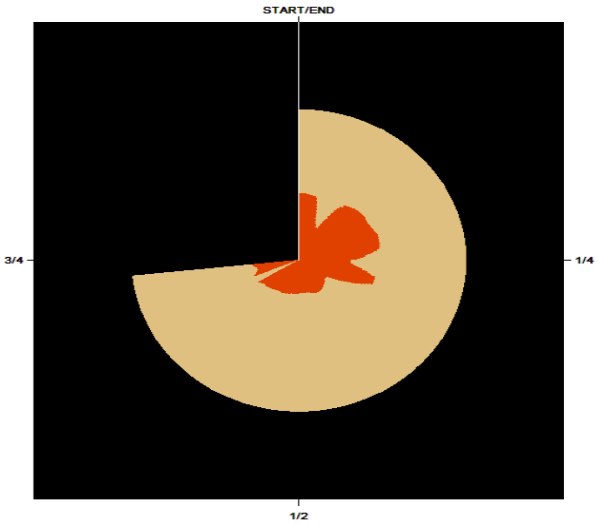
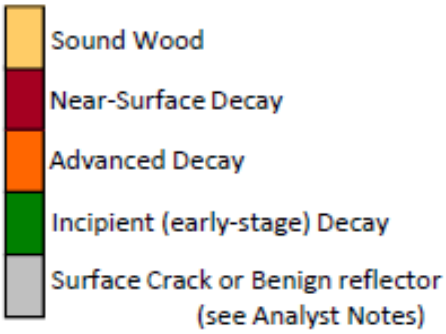
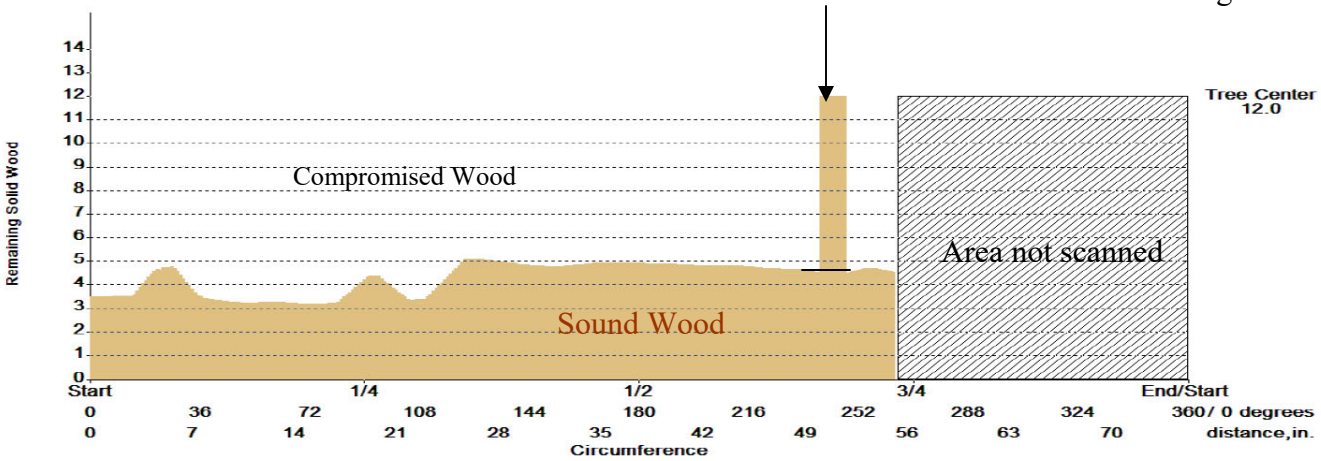
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Sector trunk Scan 4 performed 80 inches from grade. Estimated Diameter 24 inches.





This area is due to a very bumpy uneven bark where the antenna lost surface contact with the trunk. This blank area all should be solid orange.



Analyst notes; Decay detected. Average sound wood 3-5 inches.

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July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Half circle root Scan 5 performed over buttress root. Estimated diameter 24 inches.

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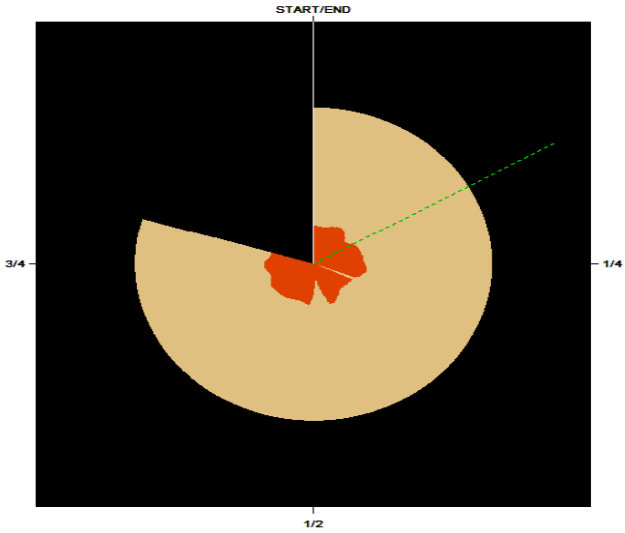
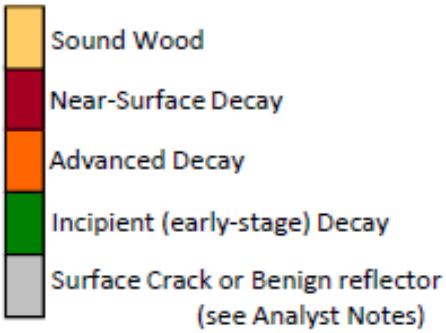
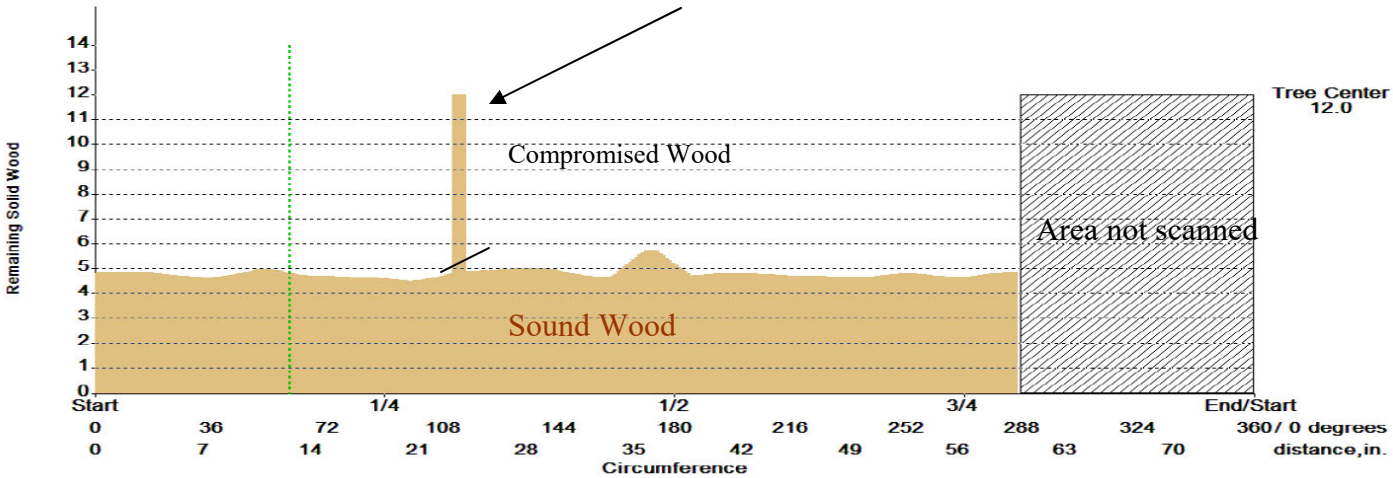
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Half circle root Scan 5 performed over buttress root. Estimated diameter 24 inches.





This area is due to a very bumpy uneven bark where the antenna lost surface contact with the wood. This blank area all should be solid orange.



Analyst notes; Decay detected. Estimated sound wood 5 inches.

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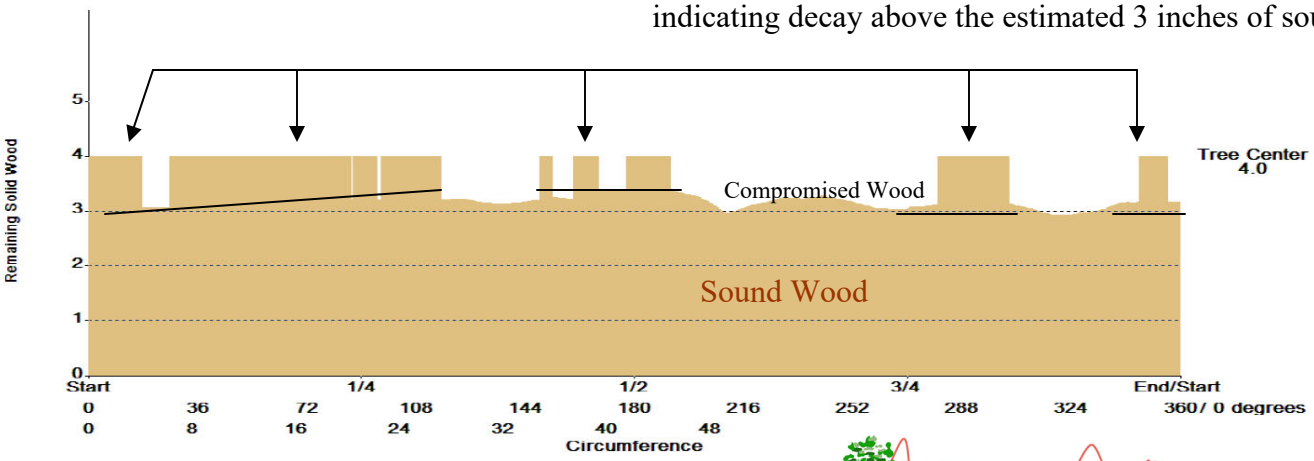
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 6 performed over exposed surface roots above soil.
Estimated root diameter 8 inches.

- Sound Wood
- Near-Surface Decay
- Advanced Decay
- Incipient (early-stage) Decay
- Surface Crack or Benign reflector (see Analyst Notes)

These areas are due to a very bumpy uneven bark and should be ignored; this is where the antenna lost surface contact with the wood. Everything should be solid orange indicating decay above the estimated 3 inches of sound



Analyst notes; Decay detected within root system.

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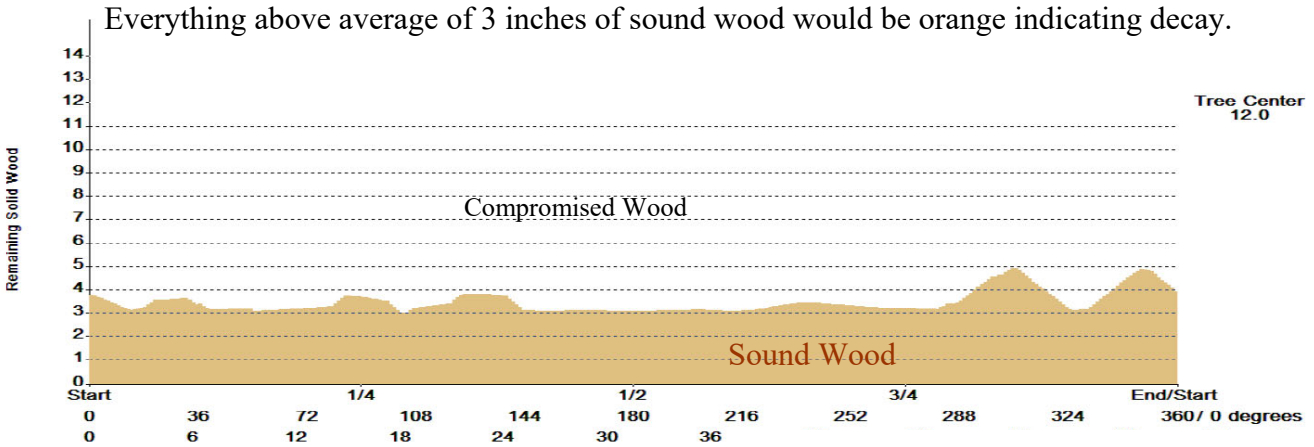
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 7 performed over exposed surface roots above soil.
Estimated root diameter 24 inches.

Everything above average of 3 inches of sound wood would be orange indicating decay.



Analyst notes; Decay detected within root system.

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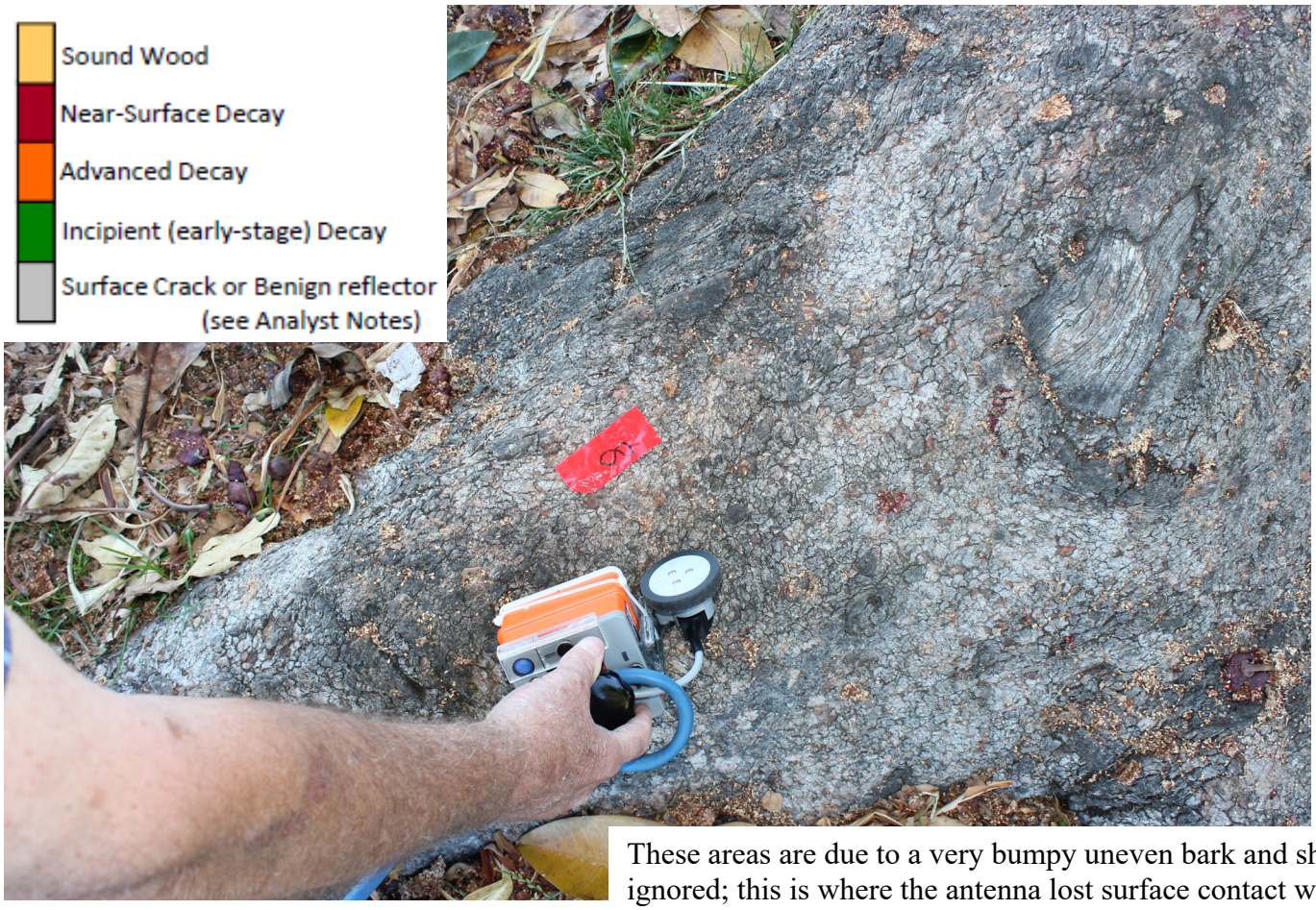
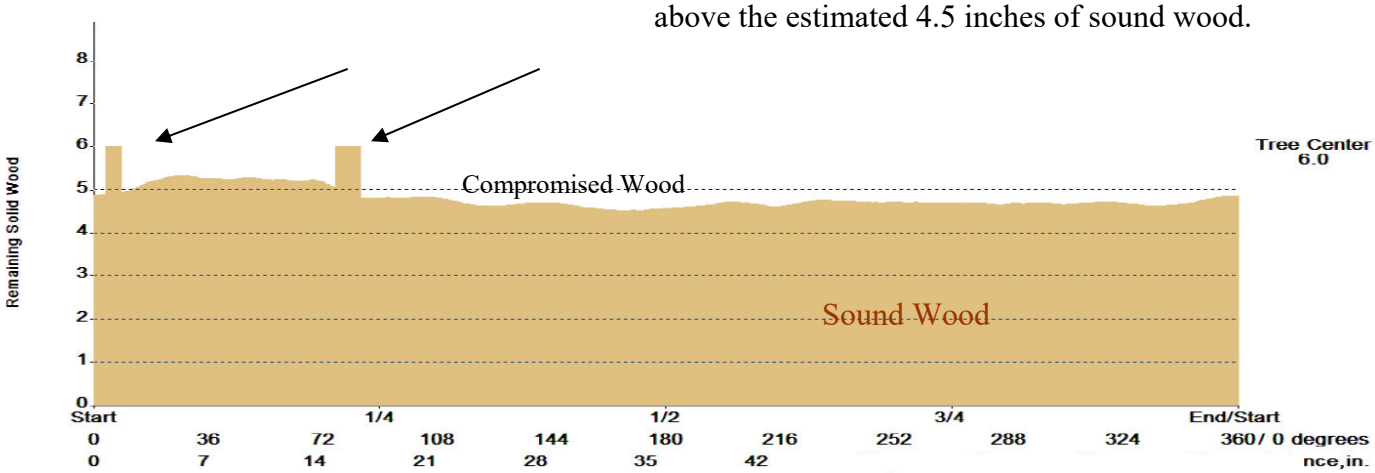
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 8 performed over exposed surface roots above soil.
Estimated root diameter 12 inches.



These areas are due to a very bumpy uneven bark and should be ignored; this is where the antenna lost surface contact with the wood. Everything should be solid orange indicating decay above the estimated 4.5 inches of sound wood.



Analyst notes; Decay detected within root system.

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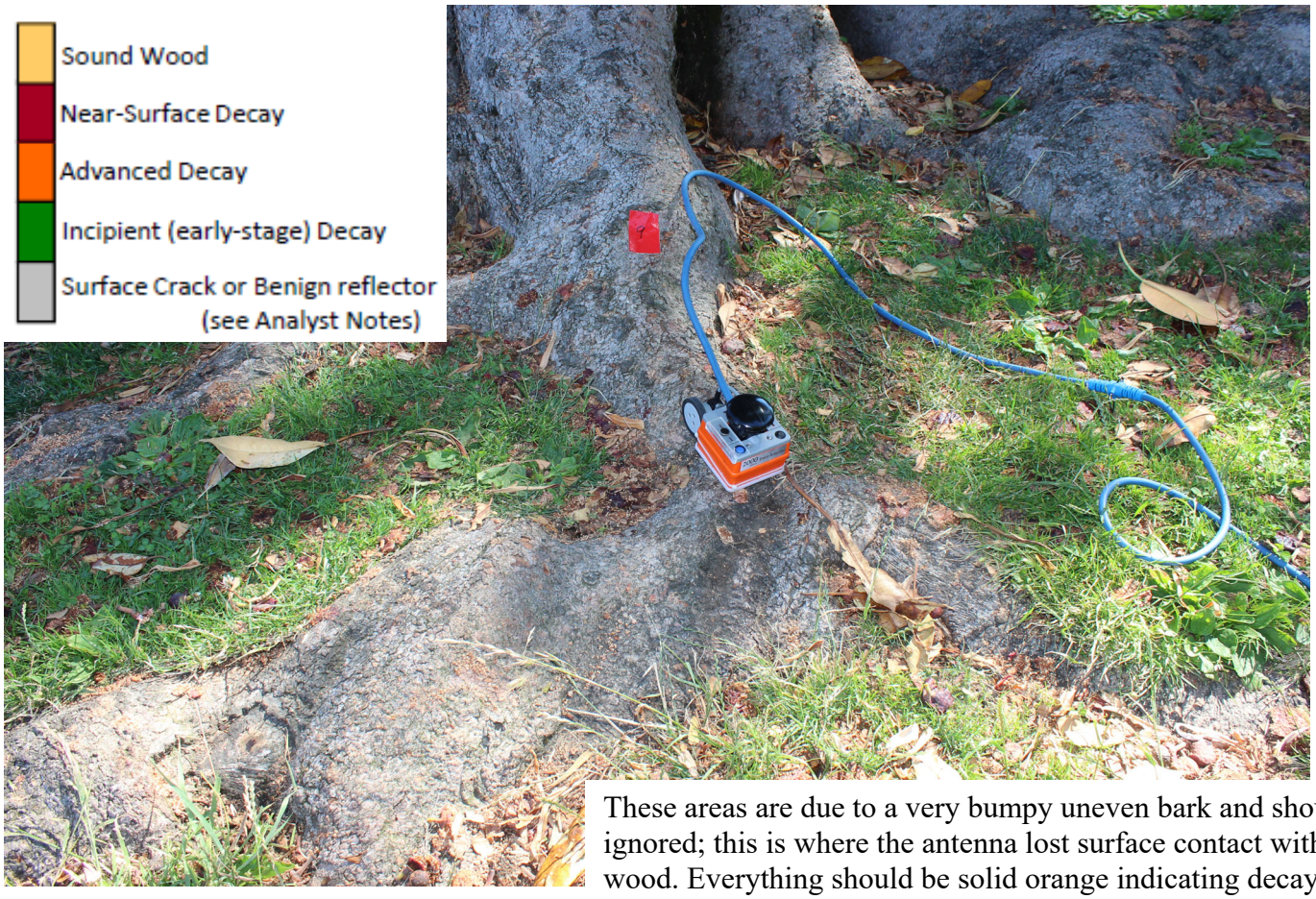
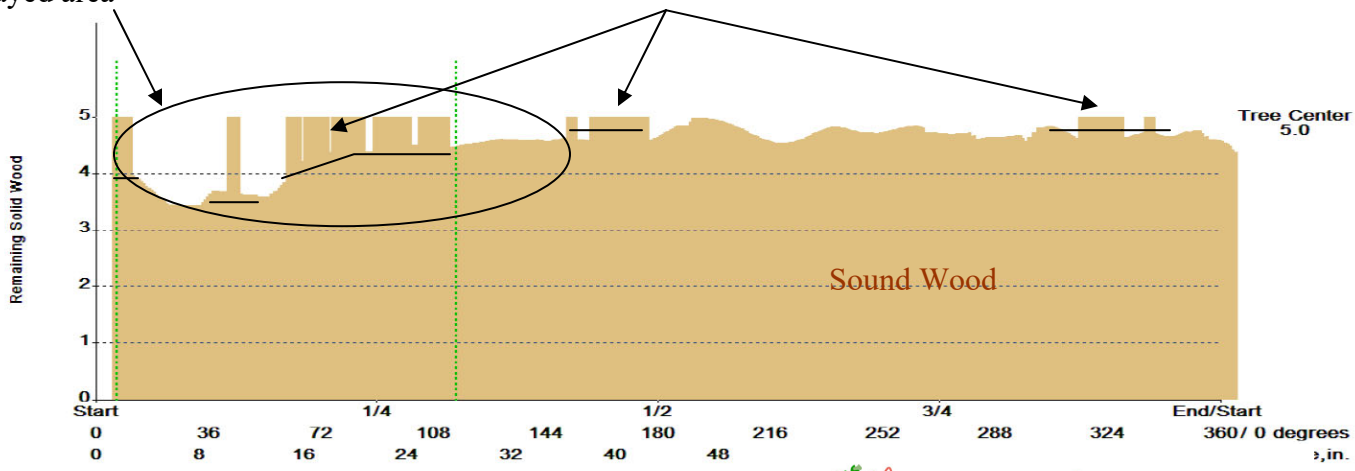
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 9 performed over exposed surface roots above soil.
Estimated root diameter 10 inches.



These areas are due to a very bumpy uneven bark and should be ignored; this is where the antenna lost surface contact with the wood. Everything should be solid orange indicating decay above the estimated 3.5-4.5 inches of sound wood.

Decayed area



Analyst notes; Decay detected within root system.

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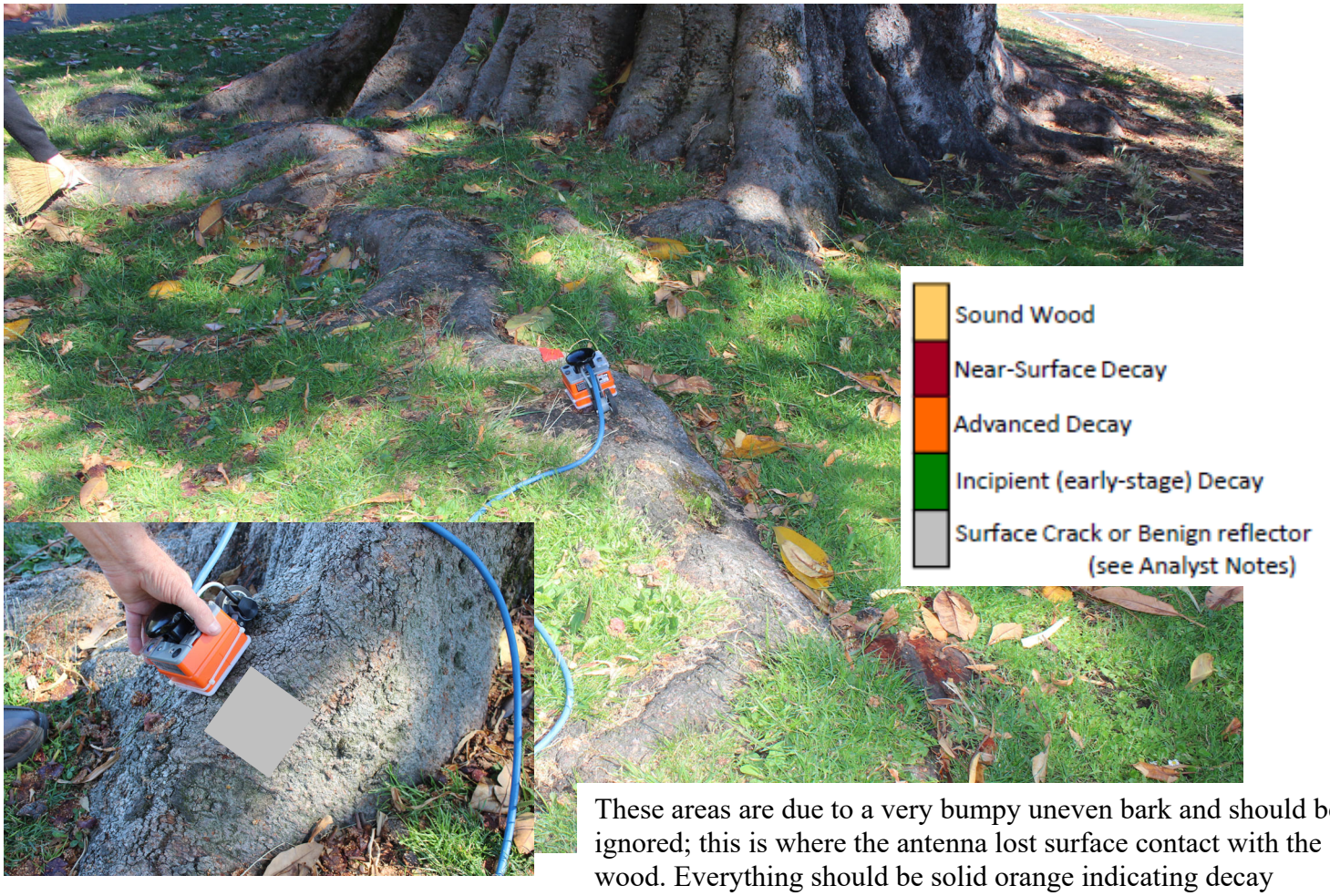
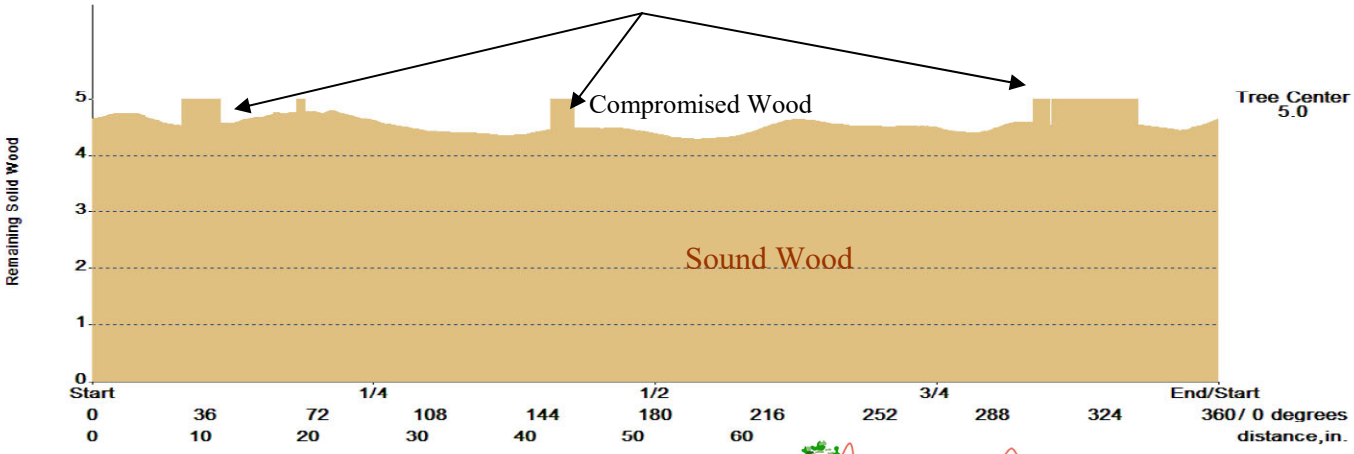
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 10 performed over exposed surface roots above soil.
Estimated root diameter 10 inches.



These areas are due to a very bumpy uneven bark and should be ignored; this is where the antenna lost surface contact with the wood. Everything should be solid orange indicating decay above the estimated 4.5-5 inches of sound wood.



Analyst notes; Decay detected within root system.

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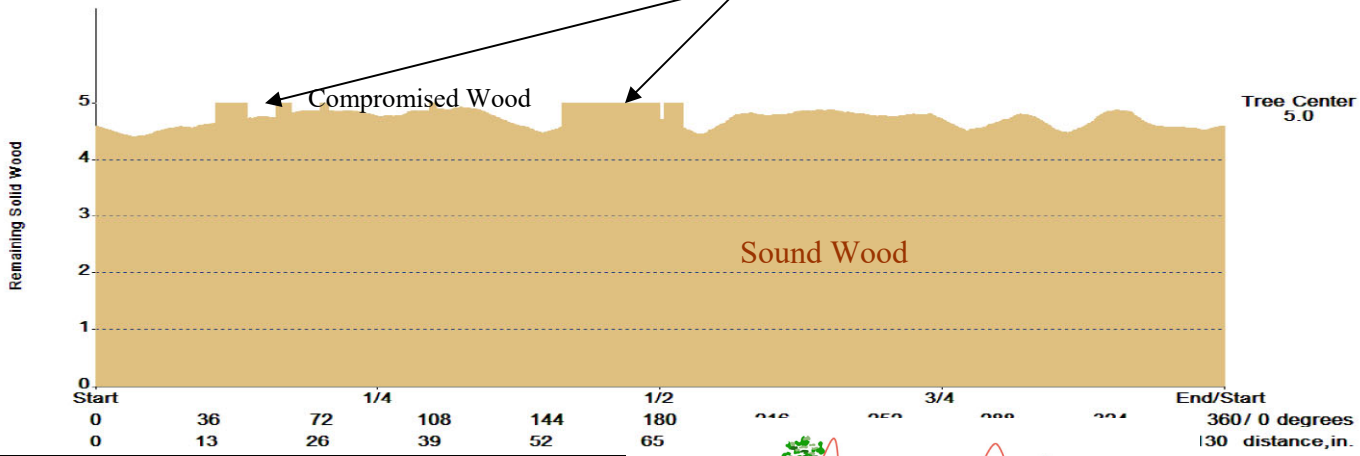
July 6, 2022 Lincoln Park, Alameda, Ca. Fig tree #347
Linear root Scan 11 performed over exposed surface roots above soil.
Estimated root diameter 10 inches.

These areas are due to a very bumpy uneven bark and should be ignored; this is where the antenna lost surface contact with the wood. Everything should be solid orange indicating decay above the estimated 4.5 inches of sound wood.



Analyst notes; Decay detected within root system.

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Arborist Disclosure / Performance of Services

1. Disclosure. Arborists are tree specialists who use their education, knowledge, training and experience to examine trees, recommend measures to enhance the beauty and health of the trees and attempt to reduce the risk of living near trees. Arborists cannot detect every condition that could possibly lead to the structural failure of a tree.

Since trees are living organisms, conditions are often hidden within the tree and below ground. Arborists cannot guarantee that a tree will be healthy or safe under all circumstances, or for a specific period of time. Likewise, remedial treatments cannot be guaranteed. Trees can be managed but they cannot be controlled. To live near trees is to accept some degree of risk and the only way to eliminate all risk associated with trees is to eliminate all trees.

Assumptions and Limiting Conditions

1. Any legal description provided to the consultant is assumed to be correct. No responsibility is assumed for matters legal in character nor is any opinion rendered as to the quality of any title.
2. The consultant can neither guarantee nor be responsible for accuracy of information provided by others, information not provided or disclosed.
3. The consultant shall not be required to give testimony or to attend court by reason of this consultation/reports unless subsequent written arrangements are made, including payment of an additional fee for services.
4. Loss or removal of any part of this report invalidates the entire report/evaluation.
5. Possession of this report or a copy thereof does not imply right of publication or use for any purpose by any other than the persons(s) to whom it is addressed without written consent of this consultant.
6. This report represents the opinion of consultant, and the consultant's fee is in no way contingent upon the reporting upon any pre-determined findings.
7. Sketches, diagrams, graphs, photos, ect., in this report, being intended as visual aids, are not necessarily to scale and should not be construed as engineering reports or surveys.
8. This report has been made in conformity with acceptable evaluation/diagnostic reporting techniques and procedures, as recommended by the International Society of Arboriculture.
9. No tree described in this report was climbed, unless otherwise stated. Arborist OnSite® cannot assume responsibility for any defects which could only have been discovered by climbing. A full root collar or root crown inspection, consisting of excavating the soil around the tree to uncover hidden defects or disease involving the root collar and major buttress roots, was not performed, unless otherwise stated. Arborist OnSite® cannot accept responsibility for any root defects which could only have been discovered by such an inspection.

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Certification of Performance

I, Robert Booty, certify:

- That I have personally inspected the tree(s) and/or the property referred to in this report, and have stated my findings accurately. The extent of the evaluation and or appraisal is stated in the attached report and the terms and conditions;

- That I have no current interest in the vegetation or the property that is the subject of this report, and I have no personal interest or bias with respect to the parties involved;

- That the analysis, opinions and conclusions stated herein are my own, and are based on current scientific procedures and facts;

- That my compensation is not contingent upon the reporting of a predetermined conclusion that favors the cause of the client or any other party, nor upon the results of the assessment, the attainment of stipulated results, or the occurrence of any subsequent events;
- That my analysis, opinions, and conclusions were developed and this report has been prepared according to commonly accepted arboricultural practices;

- That no one provided significant professional assistance to the consultant, except as indicated within the report.

I further certify that I am a Registered Member of the American Society of Consulting Arborists, and I am an International Society of Arboriculture Certified Arborist. I have been involved in the practice of arboriculture and the care and study of trees for over 50 years.

Signed: Robert Booty

Date: October 20, 2022

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