

# Advanced Tree Risk Assessment: Resistance Recording Drills<sup>1</sup>

Drew McLean, Andrew Koeser, and Gitta Hasing<sup>2</sup>

Tree risk assessments can be conducted at various levels depending on a client's needs, the resources available, or the goals of the assessment. The American National Standard (ANSI) A300: *Tree Risk Assessment Standard* and the International Society of Arboriculture (ISA) *Best Management Practices: Tree Risk Assessment* define three levels of tree risk assessment:

- Limited visual (or Level 1)
- Basic (or Level 2)
- Advanced (or Level 3).

The level of assessment required should be established with your client before any work begins. If tree conditions cannot be adequately assessed under the initial assessment level carried out, the assessor can recommend the use of a more advanced assessment level to gather the additional information required.

Advanced, or Level 3, assessments provide detailed information about specific tree parts, defects, targets, or site conditions. Tree assessments performed at this level are usually time intensive and more expensive to conduct, as they require specialized tools and/or skills. Advanced assessments typically are reserved for high-value trees or trees of historical importance. Level 3 assessments can include, but are not limited to:

- aerial crown inspections
- internal decay inspections
- subsurface root inspections
- measuring changes over time (e.g., leans)
- load testing or pull tests.

## Limited Visual and Basic Risk Assessments: A Closer Look

Though this series focuses on advanced (Level 3) risk assessment methods, limited visual and basic risk assessments are still important approaches for assessing tree risk in a variety of commercial, municipal, and utility arboriculture applications.

In a limited visual, or Level 1, assessment, the arborist performs a quick visual assessment (walk-by, drive-by, or aerial), typically looking for obvious defects (e.g., dead trees, broken branches, or large cavity openings). This level of assessment usually is reserved for rapid assessments of larger tree populations and is most commonly used for urban forestry and utility rights-of-way management. Limited inspections allow greater numbers of trees to be assessed on a more frequent basis relative to Level 2 and Level 3 assessments. A limited visual risk assessment may not include risk mitigation recommendations. It sometimes is used as an initial screening to help determine which trees need a higher level of inspection.

1. This document is EP504, one of a series of the Environmental Horticulture Department, UF/IFAS Extension. Original publication date October 2014. Visit the EDIS website at <http://edis.ifas.ufl.edu>.

2. Drew McLean, biological scientist; Andrew Koeser, assistant professor; and Gitta Hasing, senior biological scientist; Department of Environmental Horticulture, Center for Landscape Conservation and Ecology, UF/IFAS Extension Gulf Coast REC, Wimauma, FL 33598.

The Institute of Food and Agricultural Sciences (IFAS) is an Equal Opportunity Institution authorized to provide research, educational information and other services only to individuals and institutions that function with non-discrimination with respect to race, creed, color, religion, age, disability, sex, sexual orientation, marital status, national origin, political opinions or affiliations. For more information on obtaining other UF/IFAS Extension publications, contact your county's UF/IFAS Extension office.

A basic, or Level 2, assessment is the assessment level used by most arborists when performing tree risk assessments for private clients. The Level 2 assessments consist of a detailed visual inspection of a tree and its surrounding site and a complete analysis of the information gathered. During a basic assessment the arborist will walk completely around the tree looking for defects from the root crown to the canopy top. Basic risk assessments may include the use of some simple tools (i.e., binoculars, mallet, and probe) to help acquire information about any potential defects. A basic risk assessment also includes an analysis of the information collected during the inspection and a list of possible mitigation options. See Koeser et al. (2013) for more information.

## Resistance Recording Drills

Resistance recording drills are specialized pieces of decay detection equipment that may be used as part of an advanced risk assessment. While not required for tree risk assessment work, resistance recording drills have been shown to be effective in helping arborists detect and document internal tree decay in trees (Costello and Quarles 1999; Johnstone 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 visual documentation on drilling resistance for final reporting. Measurements are recorded at a 1:1 scale on wax paper or on receipt paper printouts, allowing a trained user to assess the condition of the tree part drilled in a minimally invasive manner. Some drill models record resistance data electronically for visualization and assessment with proprietary software suites.

Commercially available resistance recording drills are currently produced by two companies (Rinntech, St. Charles, IL and IML, Inc., Moultonborough, NH). Both manufacturers offer a range of models which differ primarily in their size and the length of the needle they can accommodate (which in turn determines the maximum drilling depth) and the manner in which resistance is recorded (electronically, manually on wax paper, or printed on paper). Some models offer higher levels of precision than others and are intended for research use. In some instances, these drills can be used to measure the annual growth rings of a tree, as early- and latewood have differing densities.

## Using a Resistance Recording Drill

This article serves as a photographic tutorial of a resistance recording drill and its use as part of an advanced tree risk assessment. While the IML Resistograph® is shown, this simply reflects its availability to the authors and should not be considered an endorsement of the product. The model pictured in Figure 1 is powered by a standard cordless drill. Alternatively, resistance recording drills may feature an integrated motor. In the model depicted, the drill chuck is connected to a series of gear wheels and clutch discs which help control the movement and speed of the drilling needle (Fig. 1). The drilling needle passes through a brass sleeve that is pressed against the trunk of the tree during use (Fig.1 and Fig. 2). A paper strip with a wax coating (similar to a scratch-off lottery ticket) is inserted at the top of the drill and marked with a metal recording stylus (Fig. 1). As the drilling needle moves, the recorder stylus plots the resistance of the drilling needle onto the wax paper for a 1:1 scale output.



Figure 1. IML Resistograph® model F500-S.  
Credits: Gitta Hasing



Figure 2. Close up of the drilling needle and the needle sleeve.  
Credits: Gitta Hasing

The particular model shown has two sensitivity settings for hardwood or softwood tree species (Fig. 3) as well as an electronic unit, located on the rear of the drill attachment casing, which records the drilling data electronically and allows data to be downloaded to a computer.

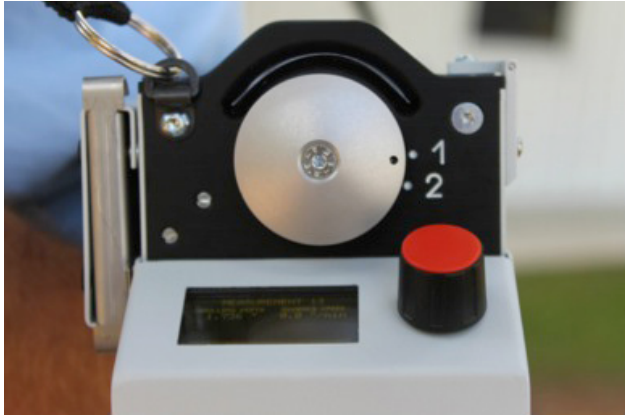


Figure 3. Close-up of the back of the IML Resistograph®. This unit has two sensitivity settings (for hardwood and softwood) and a data logger for recording resistance data.

Credits: Gitta Hasing

Prior to measurement, the sensitivity level is adjusted (if applicable) to match the wood type tested (hard- or softwood). After locating a tree section of concern, the user places the drill flush against the bark and pulls the drill trigger. The resistance recording drill is held as steady as possible while drilling into the tree. (Fig. 4). For small trees, the needle length may be sufficient to drill completely through the area of interest. Conversely, large trees may require multiple measurements toward the center of a tree to assess the level of decay present. Once a measurement is complete, the needle is reversed out of the tree and back into the unit. If possible, the needle can be pulled out to help conserve battery power.



Figure 4. Close-up of the IML Resistograph® in use.

Credits: Gitta Hasing

## Resistance Recording Drill Output and Interpretations

The resistance recording output shown in Figure 5 is printed on wax paper output at 1:1 scale. Read from right to left, the wax paper has vertical lines scaled in either inches or centimeters (inches shown) and four horizontal lines that represent the relative amplitude from 0 to 100%. Each tree species has a “typical” resistance drilling pattern for a healthy tree and some experience is required to interpret outputs effectively. In the output depicted below, non-decayed wood is associated with the areas of higher relative resistance (Fig 5). As the drilling needle reached decayed wood in a tree, the decrease in wood density resulted in a noticeable drop in resistance on the output printout (Fig. 5). Beyond this lower resistance, areas linked to decay often appear a flat areas with few vertical peaks (caused by growth rings).



Figure 5. Close-up of a Laurel oak (*Quercus hemisphaerica*) slab with a wax paper output laid on top of it. The graph has been enhanced for this photograph.

Credits: Drew McLean

Figure 5 shows a slight increase in drilling resistance as the drill penetrated past the bark and continues into the sapwood of the tree. When the drill bit reached the large cavity a few inches into the slab, the relative resistance on the output profile dropped and leveled off until solid wood was reached again.

Resistance recording drills are just one means of quantifying internal decay in urban trees. Several other decay detection methods are listed and compared in Table 1. With practice, any of these can be used to further inform tree risk assessments beyond what can be noted through a visual inspection.

## Additional Resources

Costello, L. and S. Quarles. 1999. "Detection of wood decay in blue gum and elm: An evaluation of the IML-Resistograph and the portable drill." *Journal of Arboriculture* 25:311–317.

Johnstone, M., P. K. Ades, G. M. Moore, and I. W. Smith. 2007. "Predicting wood decay in Eucalypts using an expert system and the IML-Resistograph drill." *Arboriculture and Urban Forestry* 33(2):76–82.

Koeser, A. K., G. Hasing, D. McLean, and R. Northrop. 2013. "Tree Risk Assessment Methods: A Comparison of Three Common Evaluation Forms." Gainesville, FL: UF/IFAS. <http://edis.ifas.ufl.edu/ep487>.

Mattheck, C., K. Bethge, and W. Albrecht. 1997. "How to Read the Results of the Resistograph M." *Arboricultural Journal* 21:331–346.



Table 1. Methods currently used to detect internal decay.

Detection Methods	Basic or Advanced Assessment	Principle	Cost	Resolution	Advantages	Disadvantages
Sounding	Basic	A tree/tree part is struck with a rubber mallet. With practice, user can distinguish between the sounds made by solid and hollow wood.	\$	Low	Relies on simple and readily available tools. Quick screening tool when assessing internal decay	Limited ability to gauge the extent of decay. Some concern of damage to thin-barked species
Probing	Basic	A rod or measuring stick is inserted in a tree cavity to assess the extent of internal decay	\$	Moderate to High	Relies on simple and readily available tools.	Requires an opening (cavity) to assess internal decay
Cordless Drill	Advanced	A cordless drill with a small-diameter bit is used to drill into a tree. The user listens for changes in drilling resistance and looks for discoloration in wood shavings to locate internal decay	\$-\$\$	Moderate to High	Experienced users can accurately quantify decay. Relatively inexpensive.	Higher skill requirement than other forms of advanced detection.
Increment Borer	Advanced	An increment borer is a specialized tool for extracting tubular wood cores from trees. Once extracted, cores can be assessed for discoloration and tested for strength loss.	\$-\$\$	Moderate to High	Relatively easy to use. Core provides a visual record of assessment.	Wound is larger in diameter than those created by cordless drill or resistance recording drill. May be difficult to remove from tree if fully bored into a hollow.
Resistance Recording Drill	Advanced	<b>A small drill bit is used to drill into wood at a constant speed. The relative resistance encountered during drilling is plotted or recorded digitally.</b>	<b>\$\$-\$\$\$</b>	<b>High</b>	<b>Creates a physical/digital record of the assessment. Relatively easy to use.</b>	<b>Some experience needed to interpret outputs (e.g., partially decayed wood). Cost can be relatively high depending on model/features selected.</b>
Sonic Tomography	Advanced	A series of sensors is used to measure the time it takes sound to pass through a piece of wood. Solid wood transmits sound faster than decayed wood or hollows.	\$\$\$	High	Creates a digital record of assessment. Output is converted to an easy-to-interpret visual profile. Potential to create three-dimensional decay profiles.	May interpret cracks as larger areas of decay.