# Developing Risk Assessment Standards and Specifications for a Distribution System: A Case Study

**By Jerry Bond, Sara Sankowich, and Christopher J. Luley**

The development of a tree risk assessment specification document provides the opportunity to examine how the current tree risk assessment standards and best management practices can be systematically incorporated into utility arboriculture. This article presents the results of a case study that is not only timely but might also prove useful to other utilities that are considering updating their tree risk assessment programs.

Figure 1. The tree risk program was designed to avoid tree-failure-related outages that might occur under "normal" weather conditions. The decay in this sugar maple (*Acer saccharum*) scaffold branch would increase the likelihood of failure under such conditions.

## Background

Unitil Corporation is a public utility holding company, headquartered in Hampton, New Hampshire, U.S., which provides local distribution of electricity and natural gas in the states of New Hampshire, Massachusetts, and Maine. It serves more than 101,400 electric customers and nearly 71,900 natural gas customers, and provides energy brokering and advisory services to large commercial and industrial customers in the United States. The electrical distribution system stretches 1,051 miles (1,691 km) in New Hampshire and another 560 miles (901 km) in Massachusetts, with landscapes ranging from dense–customer urban to sparse–customer rural.

Unitil decided to create a formal risk assessment specification. The goals set for this program were as follows:

- Adapt the recently published ANSI clause for tree risk assessment (ANSI 2011) and ISA's *Best Management Practices: Tree Risk Assessment* (Smiley et al. 2011) to a utility-specific tree risk program.
- Reduce predictable tree-caused electrical outages and improve Unitil's annual SAIDI and SAIFI measures of electrical performance.
- Avoid failure of defective trees under normal weather patterns with wind speeds less than 55+/- mph (89 kph) and, to the degree possible, reduce failure of defective trees under catastrophic weather conditions.
- Promote efficient and cost-effective tree pruning and removal.
- Adequately allocate funds to appropriate risk levels across Unitil's distribution service territory.
- Provide a documented means of developing consistency in tree risk assessment among assessors and throughout the risk management program.
- Specify methods to conduct assessments in the field, and estimate personnel needs and workloads required to complete projected risk mitigation work.

- Create means to document and assess the quality of the work performed.
- Develop material to support funding and workload requirements to be made available for internal managers and regulators.

Unitil's risk assessment specification targeted two broad audiences: 1) a direct audience composed of the utility's arborists, contractors, managers, etc.; and 2) an indirect audience composed of the public, regulators, media, and others. For different reasons, it is important that each audience be able to understand in detail the basis and method of Unitil's procedures to reduce tree-caused outages, raise reliability, allocate funding appropriately, and perform work in a cost-effective manner.

To reach such diverse audiences effectively, the specification would take form as two separate documents, sharing the same content and structure, but having a strongly divergent format and approach:

- A *Standards and Specifications* document to hold the program description, along with the references and literature citations supporting it; designed to be formal, detailed, text-based.
- A *Manual* for training and field use that is practical, easily accessible, and image-based.

The release of the tree risk standard by the American National Standards Institute, *A300 (Part 9 – Tree Risk Assessment)* (ANSI 2011), and *Best Management Practices: Tree Risk Assessment* by the International Society of Arboriculture (Smiley et al. 2011), offers new perspectives for developing risk standards and specifications for utilities (Kempter 2012). The recent *Tree Risk Assessment Manual* published by ISA also provides up-to-date field guidance (Dunster et al. 2013). Two key points, however, merit serious consideration in any effort to incorporate these new materials:

- Most utility tree risk programs were set up before the development of the new ANSI Standard (ANSI) and ISA Best Management Practices (BMP), meaning that the programs lack some of the new publications' most critical concepts.
- The ANSI A300 (Part 9) and the BMP booklet were developed primarily for risk assessors working with clients. They provide only minimal guidance for the programmatic development needs of utilities, and will require considerable adaptation.

Utilities desiring to make use of the new ANSI clause and BMP booklet will also have to utilize literature sources outside these publications. As an example, recent literature about pruning and tree failure can be used to justify action under various consequence-of-failure scenarios that would greatly speed up and simplify field work. The bibliographies contained in two recent publications on pruning (Clark and Matheny 2010) and risk assessment (Matheny and Clark 2009) offer good sources for information on studies relevant to utilities.

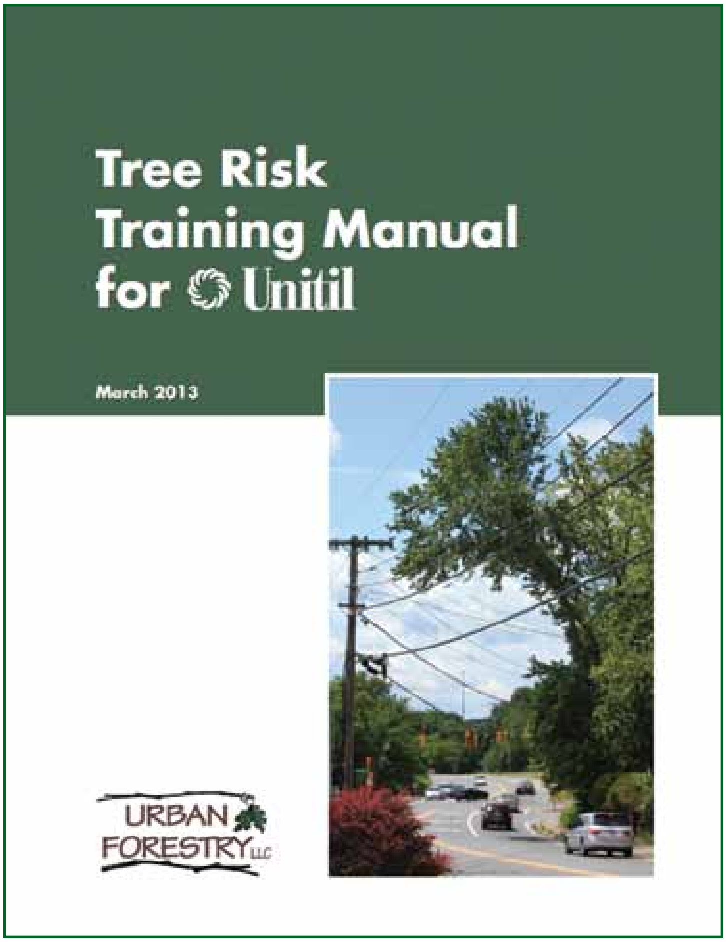


Figure 2. The tree risk program is guided by two essential documents: a *Standards and Specifications* manual, which defines the program and cites supporting literature and references; and a *Training Manual* that is designed for field and educational support

As the authors of Unitil's tree risk program materials, we wanted to pay careful attention to the effect of any risk assessment program on fieldwork. Unlike risk assessors in many other parts of the arboricultural industry, utility arborists have very limited time at any one tree given the large number of trees that require attention along utilities. It was therefore paramount that the result of our efforts be commensurate with actual work capacity and practices.

Finally, it is important to recognize the serious data quality issues that exist within many utility risk management programs (Wetteroff 2011). Most utilities believe that their efforts are sufficient, but that belief often lacks actual data (Brown 2009). Moreover, much of the data that does exist frequently relies on tree failure information from observers lacking appropriate training and experience.

This lack of data is exemplified in the commonly heard dichotomy between "hazard" and "healthy" trees. Not only is this dichotomy fundamentally invalid, since health and stability are distinct (biological and mechanical) issues, but the concept of "hazard tree" as used by

▶

many utility arborists is so broad that it tends to foreclose the very evaluation of failure potential that constitutes the essential element in the practice of risk assessment (Lonsdale 1999).

The tree risk program that developed contained the following sections.

## Overview

In order to establish a foundation for this work with a level of exactness and accessibility for our audience, we developed four major points:

- **Definitions:** since this aims to be a true specification, all terms need to be defined as precisely as possible. Especially important are new terms introduced by the ANSI Standard and ISA's BMP publication, including the concept of risk itself (Smiley et al. 2011), since prioritizing by the level of risk (instead of the presence of hazard) constitutes a critical change to industry practices. *Risk is the combination of the probability of an event occurring and its potential consequences.*
- **Goals and means:** an explicit statement of realistic goals and efficient methods also belongs up front. This is an appropriate location to introduce and consider the suitability of suggestions made in recent utility literature: collection of reliable post-storm data, creation of a hazard tree database based on observations by trained observers, prioritization of work (e.g., by species, customers served, circuit outage history), adoption of targeted ground-to-sky pruning (e.g., to first recloser), etc.
- **Limitations:** it is important to address the limitations of risk assessment because its effectiveness appears to be undermined by recent utility studies (e.g., Primrose et al. 2010; Guggenmoos 2011). It may well be prudent for many utilities to demonstrate how an improved tree risk assessment program could increase reliability on its particular distribution system.
- **Quality control:** Integrated Vegetation Management programs should include a quality QA/QC program, per ANSI's A300 (Part 7) (ANSI 2006). Following the Standard, it is critical to include specified items such as creating an annual report summarizing circuits assessed and trees identified, random sampling circuits for adherence to risk assessment specifications and assessing circuits for residual tree risk following contractor work.

## Scope of Work

The scope-of-work section covers topics such as tree location and selection criteria, level and type of risk assessment, inspection interval, method of reporting, and mitigation (Smiley et al. 2011). For each location within the distribution system, a scope of work is defined based on the consequences of failure (number of customers served and/or potential physical damage to utility hardware). A primary emphasis of the Unitil program was to establish a scope of work that lowered risk tolerance where consequences were high, and raised it where consequences were low. This approach was guided by the ANSI A300 (Part 9) and ISA BMP as they outline how risk tolerance affects risk rating, from fieldwork to legal defense, and we wanted to take that into account for the Unitil specification.

The definitions and applications of the following items were detailed:

- **Target:** people, property, or activities that could be injured, damaged, or disrupted by a tree failure. In the context of the Unitil tree risk program, this generic definition was explicitly restricted to all elements of the physical system used to distribute electricity.
- **Consequences:** a function of the value of the target and the amount of injury, damage, or disruption (harm) that could be caused by the impact of the failure. Since risk is a combination of a target impact and its consequences, management of consequences is well-suited as the means to increase reliability as measured by SAIDI and SAIFI.
- **Inspection population:** a subset of the trees near conductors that will form the object of a particular risk assessment. This subset is defined in the system adopted for Unitil by the number of customers served or importance of equipment threatened, with the

**Table 1.** A critical component of the tree risk program was the development of a detailed scope of work. In this table, one part of the scope of work, definition of the "inspection population," is identified based on the damage potential (consequences of failure) and is defined here using potential number of customers interrupted if an event were to occur.

| Customer category/ Damage potential | Inspection population |
|---|---|
| High | All danger trees |
| Moderate | Hazard trees only |
| Low | Only hazard trees whose bole lies at least partially within the distance established for the line-clearance zone |

option of consulting other factors, such as maintenance history or circuit/segment significance. Inspection methods and intervals also needed to be clarified, particularly since they vary in the Unitil system.

Detailed standards and specifications were developed for all other aspects of the required scope of work for the Unitil program. As an example of how this actually came to be in the final documentation, here is the phrasing we adopted for inspection interval:

**Standard:** *Risk assessments should occur on a regular, recurring basis when justified by the level of risk or target value (Smiley et al. 2011), and it is the responsibility of the controlling authority to schedule repeat assessments (ANSI 2011). Assessments should be based on existing vegetation, expected growth rates, and action thresholds (ANSI 2006).*

This was followed by a specification table listing how various intervals, from 1 to 5 years, would be used—a table that could also prove important when dealing with regulators, media, and the general public. It is important to note that 1) the scope of work will be unique to each utility developing a risk management program, and 2) no part of the A300 (Part 7) or BMP publications identify or outline such critical details within a utility context.

## Defect Protocol

Risk assessment requires that structural defects on trees that could impact the conductors not simply be recognized (the definition of "hazard" tree as commonly used by utility arborists) but also judged for likelihood of failure.

To facilitate fieldwork, we set clearly defined action levels for utility arborists in the field, something that has not been established within the utility or general arboricultural industry. Recommendations were presented in table format for structural defects based on "imminent" and "probable" failure likelihoods under normal weather conditions (i.e., excluding rare events) within the designated inspection period. These action thresholds were derived as much as possible from the scientific and other published literature; where published literature was unavailable, we based the designated action threshold on our extensive experience with best practices in the arboricultural industry.

### Trunk – Lean

| Imminent | Probable |
|---|---|
| • A tree with a lean and symptoms of partial root plate failure, such as soil cracking around roots.<br>• Presence of active cracks in buttress roots or new trunk cracks. | • The presence of a lean along with other trunk or root defects considered to be probable. |

*Picture 1. Probable likelihood of failure. The combination of lean and the presence of a sapwood decay fungus on the base of the load-bearing side renders failure probable.*

Figure 3. To facilitate fieldwork and quality control, a set of clearly defined defect actions levels was provided. As shown here, the recommendations were presented in an illustrated table for each type of structural defect.

▶

The *Specifications* document was populated with careful descriptions and references for each defect. The *Manual*, on the other hand, included a single page dedicated to each defect with quality images and detailed captions.

Specific action levels bring the double advantage of improving the recognition and interpretation of defects, on the one hand, and reducing the work necessary on the other. Note the effect of avoiding the unexamined label, "hazard tree," in the situation represented in Figure 3. Conducting an actual risk assessment succeeded in 1) identifying and understanding the indicators of sapwood decay fungi (Luley 2012), and 2) distinguishing between "imminent" and "probable."

Figure 4. Risk modifiers (e.g., site, exposure, species, tree health) that affect the likelihood of failure or target impact were developed to allow the risk assessor to account for these important factors in the field. Here, this leaning black locust (*Robinia pseudoacacia*) shows a crown with traits of critical health and lacking damping lateral branches—traits that would bear on the evaluation of risk by raising the failure potential.

## Risk Modifiers

The assessment of the stability of trees or tree parts based on observed defects must often take other factors into account in order to reach a judgment about likelihood of failure—this is one of the most significant results of risk assessment research over recent decades. In this project we call such factors *modifiers* and use them to raise or lower defect classifications.

Factors other than tree defects that affect a risk assessment can be grouped into four categories:

- **Load:** a generic term describing the effect of various forces acting on a structure. Whether a tree will fail depends, in the final analysis, on the load it experiences, because load varies to a much greater degree and over a much shorter time period than the severity of any defect upon which it might act.
- **Health:** a measure of the tree's ability to marshal genetically determined defenses to compensate for strength loss due to defects, as well as to respond to damage or load. The most convenient method of judging a tree's health is to examine its crown traits (Bond 2012), for which we supplied a small analytic table showing critical thresholds.
- **Site:** main concerns for us were soil, biological agents, and disturbance history (human as well as natural). Site disturbance may be the most significant modifier in a utility's distribution system, since human activities, ranging from urban development to utility pruning, unavoidably alter direction and magnitude of forces on remaining trees.
- **Species:** the failure profiles of local species plays a strong role in risk assessment, and some utilities have already incorporated them into their risk program (e.g., Brown and Dominguez 2008). We constructed a table of species, in an appendix, that constitute two percent or more of the inspection population in Unitil's distribution area, indicating the characteristics of each species that affect risk assessment ("failure profile").

To keep fieldwork manageable, we only presented material that a utility arborist could actually use quickly and effectively. In the *Manual*, we accomplished this by using unambiguous photographs and captions to get our point across. Here is a typical caption from the section on health, as reflected in crown characteristics:

> *Picture 2. The upper crown of this white ash displays vitality and opacity levels of only 20%–40% of normal, indicating a critical state of health that increases the likelihood of failure over the next inspection period.*

Note again that the ANSI Standard and ISA's BMP appropriately do not specify how these modifiers should be included in a risk assessment, just that they should be included, making the use of recent published literature critical to the successful incorporation of these modifiers into a utility risk assessment program.

## Organization Specifics

Every utility will want to conclude its specifications with a range of organization-specific concerns about operational aspects. We addressed topics that would be important within the Unitil context, such as training, scheduling, data acquisition, specification review, and revision.

## Conclusion

The main thrust of this work was a revised approach to utility risk assessment in a distribution system. Fundamental concepts were adapted from the A300 (Part 7) and the BMP: risk, scope of work, levels of assessment, and the centrality of consequences. Circuit-specific consequences drive selection and location of trees to be inspected, method and intensity of tree risk assessment, and tolerance for risk. It is important to recognize that risk assessment is not identical to risk management. A tree risk specification makes up only one part of the creation and application of policies, procedures, and practices used to identify, evaluate, mitigate, monitor, and communicate tree risk (Smiley et al. 2011).

Within Unitil, this revised risk assessment program is currently being implemented—starting with training and establishing basic field application methods. From there, a practical review begins where arborist coworkers meet in the field and look at actual utility situations, and discuss risk assessment outcomes and the actions to be taken. As implementation progresses, arborists will conduct peer review on a semi-annual basis, and assist the System Arborist with an annual review and assessment of the overall program and the risk levels identified.

As trees in the urban forest are not static, neither are utility practices, regulatory environment, and municipality involvement. Just as importantly, research and development are always continuing and growing as well. For this reason, Unitil will endeavor to constantly review these program documents, goals, and objectives to keep them current with the ever-changing and evolving process of utility tree risk assessment.

Since each utility is in a unique situation with regards to hazard trees, there will be much variation outside the Unitil context, as utility companies begin the revision of risk assessment programs to accommodate the new standards and practices. Some utilities have highly developed hazard tree management programs, others have a good program with opportunities for improvement, and some do not effectively manage hazard trees (Brown 2009). Nevertheless, we hope that this description will be of interest and use to others who are thinking about the issues binding risk assessment standards and distribution systems.

Figure 5. The program promotes consistency of assessment among assessors and defines the assessment methods used. In some cases, sounding with a mallet for decay is required.

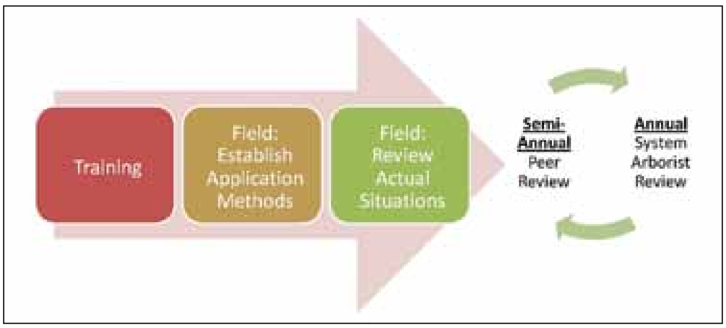


Figure 6. Implementation for risk assessment standards and specifications.

**References**

ANSI. 2006. *Tree, shrub, and other woody plant management standard practices. Integrated vegetation management. a. Electrical utility rights of way. ANSI A300 (Part 7).* ANSI, Washington, D.C. 16 pp.

ANSI. 2011. *Tree, shrub, and other woody plant management-standard practices. Tree risk assessment. a. Tree structure assessment. ANSI A300 (Part 9).* ANSI, Washington, D.C. 14 pp.

Bond, J. 2012. *Urban tree health. A practical and precise estimation method. Visual Identification Series.* Urban Forest Analytics LLC., Geneva, New York, U.S.

Brown, R. 2009. Hazard trees: Benchmark survey and best practices. Final Report. Prepared for the Public Utility Commission of Texas Project No. 36375. Quanta Technology, August 2009. 48 pp.

▶

Brown, E., and P. Dominguez. 2008. Eliminating tree-caused outages. Transmission and Distribution World. Vegetation Management Resource Center. <http://tdworld.com/vegetationmanagement/eliminating_treecaused_outages>

Clark, J., and N. Matheny. 2010. The Research Foundation to Tree Pruning: A Review of the Literature. *Arboriculture & Urban Forestry* 36(3):110–120.

Dunster, J. A., Smiley, E. T., Matheny, N., and S. Lilly. 2013. Tree Risk Assessment Manual. International Society of Arboriculture, Champaign, Illinois, U.S.

Goodfellow, J., and W. Peterson. 2011. Trees and Reliability. Transmission and Distribution World.

Vegetation Management Resource Center: June 1, 2011. <http://tdworld.com/vegetationmanagement/tree-conductor-conflicts-20110601/index.html>

Guggenmoos, S. 2003. Effects of tree mortality on power-line security. *Journal of Arboriculture* 29:181–196.

Guggenmoos, S. 2011. Tree-related electric outages due to wind loading. *Arboriculture & Urban Forestry* 37(4):147–151.

Kempter, G. 2012. ANSI Standard Helps Utilities Manage Risk. Transmission and Distribution World. Vegetation Management Supplement: June 1, 2012. <http://tdworld.com/vegetationmanagement/ansi-vm-standard-06012012>

Lonsdale, D. 1999. Principles of tree hazard assessment and management. Research for Amenity Trees, No. 7. London, The Stationery Office. 388 pp.

Luley, C.J. 2012. Indicators of decay in urban trees. *Arborist News* 21(3):18–20.

Matheny, N., and J. Clark. 2009. Tree risk assessment: What we know (and what we don't know). *Arborist News* 18(4):28–33.

Primrose, N., F. Kelly, and A. Anderson. 2010. Report to the Maryland Public Service Commission on the Progress of the Maryland Electric Reliability Tree Trimming Council (MERITT) in Addressing Commission Order #79159 Regarding Recommendation for Specific Actions that Utilities Can Take to Best Manage Privately Owned Trees Adjacent to and within Utility Rights-of-Way. Maryland Department of Natural Resources, Annapolis, Maryland, U.S. 20 pp.

Smiley, E.T., N. Matheny, and S. Lilly. 2011. Best Management Practices. *Tree Risk Assessment .Companion publication to ANSI A300 Part 9: Tree, Shrub and Other Woody Plant Management—Standard Practices (Tree Risk Assessment a. Tree Structure Assessment).* International Society of Arboriculture, Champaign, Illinois, U.S.

Wetteroff, J. 2011. Tree risk assessment and reliability. Transmission and Distribution World. Vegetation Management Resource Center. <http://tdworld.com/vegetationmanagement/reliability-safety/tres-risk- assessment-0211>



*Jerry Bond is an ISA Certified Arborist® with TRAQ Qualification who works as owner and consultant for Urban Forest Analytics LLC in Geneva, New York, U.S.*

*Sara Sankowich is an ISA Certified Arborist® and is the System Arborist at Unitil, a public holding company headquartered in Hampton, New Hampshire, U.S., which provides electric and natural gas distribution services in the New England area.*

*Christopher J. Luley, Ph.D., is a TRAQ Qualified tree pathologist and vice president at Urban Forestry LLC in Naples, New York, U.S.*



*Photos courtesy of the authors.*

*The authors wish to thank John Goodfellow and Brian Skinner for their helpful comments and suggestions of an earlier draft of this article.*