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Developing Risk Assessment Standards and Specifications for a Distribution System

Summary
This article examines one way that recent and authoritative tree risk assessment standards and best management practices can be systematically incorporated into utility arboriculture. The development of a tree risk assessment specification document for a particular utility provided us with an opportunity to bring together new research-based procedures and existing management systems. The result presents a case-study that is not only timely and inherently interesting, but also might prove useful to other utilities considering updating their tree risk assessment programs.

Background

Unitil is a public utility holding company, headquartered in Hampton NH, that 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 in New Hampshire and another 560 in Massachusetts, within a range of landscapes from dense-customer urban to sparse-customer rural.

Unitil decided to seek a formal risk assessment specification as a critical part of pursuing the following goals:

- Adopt the recently published ANSI Standard for Tree Risk (ANSI 2011) and Tree Risk Best Management Practices (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 (wind speeds less than 55+/- miles per hour), and to the degree possible reduce failure of defective trees under catastrophic weather conditions.
- Promote cost-efficient and -effective tree pruning and removal.
- Adequately allocate funds to appropriate risk levels across its distribution service territory.
- Provide a documented means to develop consistency in tree risk assessment among assessors and throughout the risk management program.
- Specify methods to conduct assessment work in the field, and estimate personnel needs and workloads required to complete projected risk mitigation work.
- Create means to document work completed and assess the quality of the work performed.
- Establish documented material to support funding and work load requirements available for internal management and Regulators.

Such a specification would actually target two broad audiences: 1) a direct audience made up of the utility's arborists, contractors, managers, etc.; and 2) an indirect audience composed of the public, regulators, media, etc. 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..

In order to reach such diverse audiences, it was decided that the specification would actually take form as two separate documents sharing the same content and structure, but having strongly divergent format and approach:

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

The release of the tree risk standard by the American National Standards Institute (ANSI 2011) and the Tree Risk Best Management Practices 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 the ISA also provides up-to-date field guidance (Dunster et al. 2013). Two key points, however, merit serious consideration in any effort to incorporate this new material:

- Most utility tree risk programs were set up before the appearance of the new ANSI standard (=ANSI) and ISA Best Management Practices (=BMP), meaning that they lack some of their most critical concepts.
- The ANSI and BMP were developed primarily for risk assessors working with clients. They provide only minimal guidance for the sort of programmatic development needed by utilities, and will require considerable adaptation.

Utilities desiring to make use of the new ANSI and BMP will also have to utilize literature sources outside these publications, since detailed specifications required for effective implementation of a tree risk program are absent. As an example, recent pruning and tree failure literature can be exploited to justify defect action levels under various consequence scenarios of failure that would greatly speed up as well as simplify field work. Helpful bibliographies have been published in the recent past on pruning (Clark and Matheny 2010) and risk assessment (Matheny and Clark 2009) that make it much easier to identify studies relevant to utilities.

We wanted to pay careful attention to the effect of any risk assessment program on field work. Unlike risk assessors in much of the rest of the arboricultural world, utility arborists have very limited time at any one tree. 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 (Wetteroff 2011). Most utilities believe that their efforts are sufficient; but that belief often lacks actual data about the efficacy of the risk assessment program (Brown 2009). Moreover, anecdotal evidence suggests that what data exist frequently rely on tree failure information from observers lacking appropriate training and experience.

This lack is exemplified for us in the commonly-heard dichotomy between “hazard” and “healthy” trees. Not only is that dichotomy fundamentally invalid, since health and stability are distinct (biological and mechanical) issues, but also the concept of "hazard tree" as used by many utility arborists is so broad that it tends to block the very practice of risk assessment. Importantly this work consists not simply in recognizing a defect, but in evaluating its failure potential for a specific individual member of a species on a particular site (Lonsdale 1999).

Components

The tree risk program we developed contained the following sections.

Overview

The beginning needed to be carefully handled, as we felt it necessary to establish a level of exactness. For this reason, 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 and the BMP. Absolutely central is 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.

Risk is the combination of the probability of an event occurring and its consequences

- Goals and means: an explicit treatment of realistic goals and efficient means also belongs up front. This is an appropriate location to 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 (by species, customers served, circuit outage history), adoption of targeted ground-to-sky pruning (e.g., to first recloser), etc.
- Limitations: we wanted to directly 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 (ANSI 2006). Following this standard, we 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 of circuits for residual tree risk following contractor work.

Scope of work

The Scope of work specification covers topics such as tree location and selection criteria, level and type of risk assessment, inspection interval, method of reporting, and mitigation (Sniley 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 followed the thrust of the new ANSI and BMP as critical documents for risk assessment, from field work to legal defense, and we wanted to take that into account for the Unitil specification.

We spelled out the definition and application of the following items:

- 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 product 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 Consequences category (customers served or equipment threatened), with the 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 program. As an example of how this actually came out in the final documentation, here is the Standard 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, 2) that no part of the ANSI or BMP identifies or outlines 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 a "hazard" trees as currently understood), but also judged for level of severity, i.e., whether arboricultural management action is warranted.

To facilitate field work, 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 the best practices of the arboricultural industry.

The Specifications document was populated with careful verbal descriptions and references for each defect. In the Manual, on the other hand, a single page was dedicated to each defect that relied rather on good quality images with detailed captions, as in this example:

Trunk – Lean

Imminent	Probable
--A tree with a lean and symptoms of partial root plate failure such as soil cracking around roots --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 a lean and the presence of a sapwood decay fungus on the base of the load-bearing side renders failure probable.

Such specific action levels bring the double advantage of improving the recognition and interpretation of defects, on the one hand, and restricting the necessary work on the other. Note the increased resolution gained in the situation represented in Picture 1 by proceeding beyond applying the unexamined label "hazard tree." Conducting actual risk assessment succeeded here in 1) identifying and understanding the indicators of sapwood decay fungi (Luley 2012), and 2) distinguishing between "imminent" and "probable" (per the BMP).

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 or not a tree will fail depends finally 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 with critical thresholds.
- Site: main concerns for us were soil, physical traits, biological agents, and disturbance history (human as well as natural). Disturbance may be the most significant factor in a 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 that into their risk program (e.g., Brown and Dominguez 2008). We constructed a table of species in Appendix that constitute 2% or more of the inspection population in Unitil territory, indicating the characteristics of each species that affect risk assessment ("failure profile").

To keep field work 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 one example of that approach in 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 and BMP do not specify how these factors should be included in a risk assessment, just that they should be included. This observation makes using recent published literature critical to the successful incorporation of these modifiers into a utility risk assessment program.

Organization specifics

Every utility will want to finish 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, etc.

Conclusion

The main thrust of this work was a revised approach to utility risk assessment in a distribution system. Fundamental concepts were adapted from ANSI and 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 first with training and establishing basic field application methods. From there, a practical review begins where arborist co-workers meet in the field and look at actual utility situations, and discuss risk assessment outcomes and 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 the utility climate, 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 that is utility tree risk assessment.

Outside the Unitil context, there will be much variation as utility companies begin the revision of risk assessment programs to accommodate the new standards and practices, since each utility is in a unique situation with regards to hazard trees. Some have highly developed hazard tree management programs, others 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 these issues.

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