

The Effectiveness of Tree Risk Assessment on Electric Utility Distribution Systems

By Chris J. Luley, Urban Forestry, LLC, Sara Sankowich, National Grid USA, and Jerry Bond, Urban Forestry LLC

Does tree risk assessment on distribution systems, where trees that are at an elevated risk of failure are selectively identified and removed or pruned, “work”, in the sense that it is cost effective and produces increased reliability? The question is worth asking since there are scant quantitative data on this important topic. In fact, a recent review of the tree risk literature, sponsored by the International Society of Arboriculture (ISA) contains only a couple of citations about tree risk assessment impact on utility management, and only one on distribution in particular (Simpson and Van Bossuyt 1996 in Matheny and Clark [2010]). The ISA Utility Arborist Certification Guide (O’Callaghan et al 2002) includes a mere two pages on risk assessment, referencing a single dated publication. This article will briefly evaluate a number of common perceptions that determine whether or not investment in risk assessment is worthwhile.

1. Individual tree risk assessment is not the same as a risk assessment program

TRUE! This is not a minor issue. Programs have specifications, training, certification, quality control, administration and policy, and revisions. Without a program, risk assessment may not produce the desired result because there is no way to establish standards, promote consistency, monitor quality and measure results. Each utility needs to set its own standards for their risk programs, since no standards have been established in any meaningful way within the utility or arboricultural industries, and individual utility requirements may vary. Some basic but very important issues that require documentation and action are:

- Protocols for inspection
- Action thresholds based on risk tolerance
- Training and quality control
- Administration, policies and revisions for the program

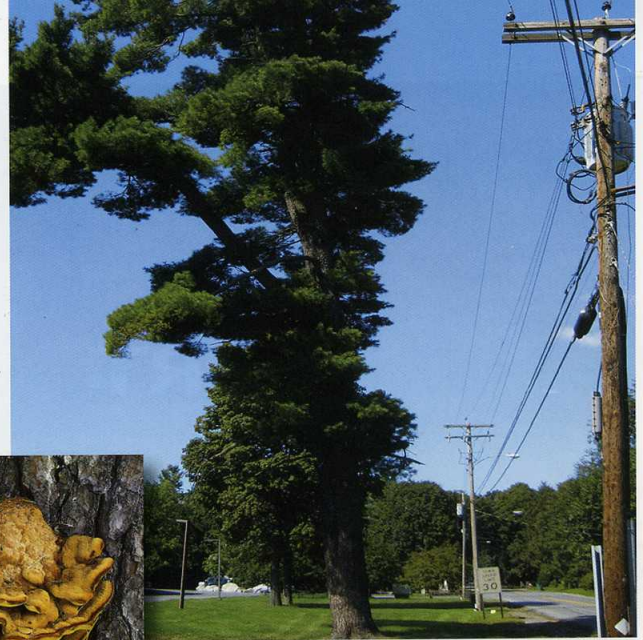
One study identified a significant problem simply in having consistent results among evaluators independent of the risk assessment system used (Norris 2007). This alone could derail any risk assessment not executed within a defined program.

2. Risk trees are already identified well enough during clearance operations

FALSE! Many utilities are realizing that the majority



Good risk assessment will not miss the signs of root rot that should put this white pine on the removal list despite its “normal” appearing foliage. The tree is infected with a root and butt rot pathogen as evidenced by the fruiting body.



of their risk tree-related outages (defined as an interruption caused by a tree with an identifiable defect that potentially could have been predicted) come from outside the trim zone (Finch and Allen 2001; Guggenmoos 2009). Failure to address this simple element of risk along distribution lines will not produce effective results from a risk assessment done during pruning operations.

Any trained arborist who walks a recently pruned distribution line has no trouble finding seriously defective trees that have just been cleared. Relying on regular maintenance crews to identify and act on defective trees is unlikely to produce consistent results, because many defects such as internal decay are hidden and require a higher level of training and inspection to identify. Risk assessment programs should establish the level and methods of inspection deemed necessary for each tree defect type.

3. Pruning programs are more valuable than risk programs

MYTH! Although the exact proportion depends on company and region, whole tree failures and large branch failures typically cause the majority of tree-related interruptions. Excluding major storm events, slightly more than 70% of tree related interruptions in 2007 and 2008 came from whole tree failures in the National Grid New York service area. During storms, branch failures become a more important factor, increasing rapidly with wind speed (Luley et al. 2002). This is even more significant because many of the branches and trees causing interruptions are commonly not dead but in full leaf. At National Grid, 85% of the trees targeted for removal or pruning under the risk assessment program are live trees.

Every utility has a clearance program, yet few have true risk assessment programs. From a regulatory relationship perspective, having a risk assessment program in combination with a pruning program also adds benefit. The risk assessment program makes proving prudent use of ratepayer dollars straightforward because it clearly delineates action thresholds based on risk tolerance, and ensures that money is being spent in areas that provide the biggest reliability return for the least cost. The risk assessment program is also a valuable tool in educating the public and explaining to customers why tree removal is targeted for their area. Clearly, risk assessment does not mean just finding dead trees and branches.

4. Most outages occur during storm events where risk programs are not effective.

MYTH! Two factors need consideration. First, branch failures (Luley et al. 2002) and whole tree failures (Smiley et al. 1998) increase dramatically in winds that gust higher than about 50 mph (Figure 1). Second, speed and frequency are inversely related: the vast majority of “high” wind events hover in the 50 mph area and below (Luley et al, 2002). A risk program can help “harden” a distribution system by reducing failures that occur at wind speeds less than 50 mph.

Failures that occur in “non-defective” trees, i.e., trees that have been deemed to have acceptable levels of risk when winds are in excess of 50 mph, cannot be reduced by any tree risk program. However, elimination of defective trees using a risk program will reduce the number of failures in catastrophic weather events.

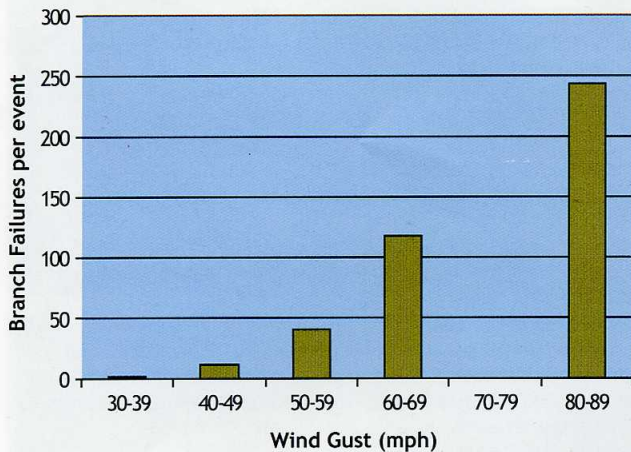


Figure 1. Branch failures in wind gusts (maximum daily 5-second average) in the city of Rochester, NY from 1992-1999 during the period when leaves were on trees (reproduced from Luley et al. 2002, with permission from ISA). Note: no data for 70-79 mph category.

5. Risk assessment programs are too costly when applied over large distribution systems

MYTH! When risk is managed with consideration of the number of customers served, decisions on how to cost-effectively develop risk assessment programs can become more realistic. Portioning risk tolerance

so the least risk and greatest expenditures are applied where the number of customer served is the greatest can dramatically alter how costly and effective risk programs are (Table 1). This approach is also needed to achieve reliability gains from risk assessment; less risk is tolerable when more customers are present or where other factors such as cost of repair or sensitive customers are issues.

Distribution Segment	Level 1	Level 2	Level 3
No. Customers Served	High	Moderate	Low
Inspection Intensity	High	Medium	Low
Acceptable Failure Potential	Low	Medium	High

Table 1. A simple matrix showing how customers served, inspection intensity, and failure potential can be used within a risk program to more cost effectively segment a distribution system.

6. Risk assessment is a solution for all tree-related failure types

FALSE! Any expectation that risk assessment can consistently address outages caused by small branch failures, for instance, is unlikely to be realized. Such failures are exceptionally hard to predict because they often occur on branches without obvious defects, live branches produce most of the faults (Goodfellow 2007), branches sail from trees further behind the line as wind speeds increase (Darveniza et al 2007), and simple changes that occur with annual growth can result in new failures. Infrastructure hardening may be the only effective way to address outages from small branch failures (Finch 2008).

7. Risk assessment will produce stable results once completed.

FALSE! Just as clearance pruning requires periodic cycles to produce desired clearances, risk assessment also requires periodic inspection cycles to be effective. Trees are dynamic by nature, and even more so when managed intensely: growth, changes in decay extent from fungi, altered loading patterns, pruning, and mortality will render any risk assessment ineffective with time.

8. Utility management practices affect biomechanics and may increase risk

TRUE! Utility management practices often increase tree outage risk by affecting exposure to loading from wind, ice and snow, reducing the stability of tree and branch until new secondary growth can accommodate the changes. First, pruning and tree removal can initially increase failure potential because of the new loading scenarios for branches or trees exposed by the removals. Second, clearance pruning usually directs growth towards the end of branches, which increases end-loading and the length of the “lever-arm.” Both of these effects are undesirable from a biomechanical standpoint because they increase stress on lower tree parts. ▶

9. Non-tree related factors can have a considerable effect on tree risk assessment outcomes

TRUE! Several factors such as site (which includes soil, stand composition and history, topography, etc.), line orientation, and edge-effects make utility risk assessment somewhat unique, and can directly affect outcomes from risk assessment. These factors are mostly difficult to quantify or have unknown impacts. For example, line-orientation relative to prevailing winds would seem to be a significant factor affecting branch and tree failure on distribution lines, yet little has been quantified to help make informed decisions where this may be a factor. Edge effects relative to ice damage and wind induced failures are well known

Utility trimming practices can dramatically impact the biomechanics of branches and trees and may increase the potential for failure. Clearance pruning has resulted in all the foliage being on the end of the limb over the distribution line, effectively increasing the lever arm and potential for failure.

in the forestry literature, and it would be reasonable that they are also important in utility risk assessment.

10. Research voids exist that make risk assessment difficult

TRUE! The absence of quantitative published data makes informed judgments about the potential gains from risk assessment programs in utility arboriculture difficult, though one older study suggested that a risk assessment program was valuable (Simpson and Van Bossuyt 1996). Many utilities have internal studies and data that they may be using to help guide risk decisions. However, experience shows these data may have statistical or design issues that make critical interpretation difficult. Further, few data exist where individual factors such as line orientation or tree species are held constant so they can be evaluated and used in risk assessment programs.



Site factors and edge effects are important in utility risk assessment and consideration of how they interact with exposure, tree species, pests, microclimate, and other factors is important in determining risk along distribution lines.

We hope that this quick review of common perceptions will raise useful questions and provide insight for anyone implementing or considering risk assessment on distribution systems.

References

- Finch, K.E., and C. Allen. 2001. Understanding Tree-Caused Outages. EEI Natural Resource Conference. Apr. 2001. Palm Springs, CA.
- Finch, K. 2008. The Role of Line Construction in Tree Outage Performance. A Prescriptive Reliability Model. Presentation to the Trees & Utilities Conference, Orlando FL, April 8, 2008. <http://tinyurl.com/5fwhja>
- Goodfellow, J. 2007. Tree Initiated Faults and Interruptions, an Update on Ten Years of Research. Presentation at the IEEE Power Engineering Society Distribution Committee meeting, Orlando, FL, January 2007. Accessed July 2 2008 through personal communication.
- Guggenmoos, S. 2009. Managing tree-caused - electric service interruptions. UAA Quarterly 17(4):4-9.
- Luley, Christopher J., Nowak, David J., and Eric J. Greenfield. 2009. Frequency and severity of trunk decay in street tree maples in four New York cities. *Arboriculture & Urban Forestry* 35(2):94-99.
- Luley, C. J., S. Sisinni, and A. Pleninger. 2002. The effect of wind gust on branch failures. *Tree Structure and Mechanics Conference Proceedings. How Trees Stand Up and Fall Down*. Smiley, E. T., Coder, K. D. eds. Pgs. 103-109. Champaign, IL: ISA
- Matheny, Nelda, and James Clark. [2010] Review of risk assessment literature. In press. To be published online in the series "ISA Science and Research Committee Literature: Review Series Website" at <http://www.isaarbor.com/publications/arbResearch.aspx>.
- Norris, Martin. 2007. Tree Risk Assessments - What Works - What Does Not - Can We Tell? A review of a range of existing tree risk assessment methods. *SAAC Conference Perth 2007*, pp. 1-29. <http://tinyurl.com/yjqwzco>
- O'Callaghan, Dealga, Ham, Donald, Charlton, Philip, and Ryan Brockbank. 2002. Utility specialist certification study guide. Champaign, IL: ISA. 84pp.
- Simpson, Peter, and Rufin Van Bossuyt. 1996. Tree-caused electric outages. *Journal of Arboriculture* 22, no. 3: 117-121. <http://tinyurl.com/yj8pvd3>
- Smiley, E.T., T.R. Martin and Bruce R. Fraedrich. 1998. Tree root failures. In *Landscape Below*
- Ground II: Proceedings of an International Workshop on Tree Root Development in Urban Soils. D. Neely and G. Watson, Eds. Champaign, IL:ISA. Pp. 131-137.

