Trees & Risk Researcher Summit White Paper

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Executive Summary

• Currently, tree defect assessment methodologies are in the beginning stages of developing a scientific basis. While anecdotal and observational evidence may be needed to carry out risk assessments, more research must be conducted to verify the validity of common assumptions.
• Researchers in arboriculture must collaborate with scientists in other fields to establish a consistent view of risk assessment. This will provide insights as to how other industriesassess risk.
• Technology transfer serves as a bridge between the work done by researchers and field practitioners. Educational sources must be matched to their intended audiences. Opinions should never be presented as fact, and anecdotal evidence should never be portrayed as empirical evidence.

Introduction

All trees have the potential to fail. In the absence of a target, this failure is without consequence. However, in densely populated urban areas, any tree failure has the potential to cause injury, property damage, or even death. Removing all of a city's urban woody vegetation would be a drastic, yet an effective means of eliminating the risks associated with trees. However, trees provide benefits that outweigh the potential threats they pose. Just as automobiles remain a popular mode of transportation despite the potential for accident-related injury or death because they allow for quick and convenient travel. Similarly, large, mature trees are retained for their aesthetic, economic, environmental, and social benefits. These benefits improve the overall quality of living in urban areas, justifying their retention to those that may possibly be harmed or held liable if injury or damage were to occur as a result of tree failure.

The risk tolerances of municipalities, individual homeowners, and property managers will ultimately decide which trees will remain, which require mitigation measures, and which must be removed. It is the responsibility of arborists who specialize in risk assessment to help their clients make informed decisions with a thorough and systematic tree inspection and risk assessment.

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How does one determine which trees are truly hazardous and which may be worth retaining? What information regarding a tree's condition is needed to make this decision? How does one quantify strength loss associated to tree decay and defects noted during a visual tree assessment? How much strength is required for a tree to stay upright and intact given the various loading forces it is exposed to?

Tree hazard assessment is a practice wrought with uncertainties and unknowns. Much of the limited research used as the basis for Best Management Practices and risk assessment protocols have been adapted from research in other disciplines. Fewer studies investigate factors associated with open grown trees in urban environments. Where research voids occur, arborists rely on anecdotal evidence and personal experience to carry out risk assessments. However, common industry assumptions regarding tree stability and defect- or decay-related strength loss must be verified with empirical research. As coined by Jim Clark, Ph.D., tree risk assessors are currently "operating in a scientific void." Research is needed to improve the professionalism and validity to the assessments made by those in the field.

Tree Strength

Hazard assessments estimate two key factors: the potential for tree failure and the likelihood of the failure resulting in damage or injury of a target. Failure potential is assessed by comparing the loads and forces exerted on a tree or tree part and the strength of a tree or tree part.

The quantification of tree strength may be used to assess the failure potential of an individual tree or, given sufficient replication, used to create guidelines for practicing arborists. Current research has allowed for the quantification of strength loss in a tree given the presence of wood decay or tree defects. However, future research is needed to create robust whole-tree strength and stability models and quantitative assessment methodologies.

Tree Strength Research Priorities

- What is the effect of defects (decay, cracks, cavities, etc.) on tree strength?
- What is the effect of pruning on tree strength?
- What is the effect of species on tree strength? Does it vary with defect or defect severity?
- What is the effect of growth (normal, post-pruning) on tree strength?

To adequately model tree stability and hazard potential, research must assess what role species and species-specific wood properties have on overall tree strength. Furthermore, studies should investigate how tree strength varies in regard to defect presence and defect severity among species. While it is commonly assumed that defects such as decay, cracks, and cavities weaken trees, to what level does strength loss occur?

Routine management practices can dramatically affect tree structure or function. What is the effect of branch and root pruning – both intentional and unintentional? How does tree growth in response to pruning differ from normal growth in regards to branch or root strength? What are the impacts of cabling and bracing on load transmittance? Finally, how do management practices that enhance plant vigor influence tree strength?

External Forces and Factors

Structurally compromised trees often fail in severe weather. While decay and defects predispose trees to storm damage, extreme wind-, snow-, and ice- loading can lead to the failure of intact trees. Comprehensive models that factor in average weather extremes for a region are needed to assess tree strength requirements.

External Forces and Factors Research Priorities

- Wind, Snow & Ice
  - Weather Predictions
  - Interpreting Weather Damage
  - Microscale Models – from Generic to Specific
  - Climate Firmness and Adaption
  - Wind Speed & Tree Loading
- Transmission and Dissipation of Loads and Forces in the Tree
- Site Factors:
  - Slopes Aspect & Slope Position
  - Water Saturated Soil
- Failure in the Absence of Wind (Summer Limb Drop)
  - Changes in Load-resistance Scheme
- Classify Wind Loads into Categories
  — Develop Filters
- Develop Factors for Wind Loads that Account for:
  - Design Wind Speeds
  - Risk Zones
  - Exposure
  - Tree Species
- Rapid Changes in the Loading and Load Dissemination Due to:
  - Sudden Exposure After Clearcut
  - Pruning
  - Climate Change
  - Cabling

In addition, more accurate means of calculating overall tree strength are needed to make meaningful comparisons of strength and strength requirements. Whole-tree stability testing (such as pull-testing) typically involves the application of a constant force to a fixed point on a tree. However, wind speed and direction can fluctuate rapidly during storms. Also, tree limbs bend and flex; dissipating and transmitting wind loads. Future research must account for the erratic nature of wind and the various load dissipation mechanisms found in trees. This information must be used to improve existing wind loading models and stability assessment methods.

While other loading types (e.g., ice, snow) occur seasonally in some regions of the world, wind loading is more frequent and ubiquitous in nature and warrants greater attention in urban forestry management and research. Other disciplines, such as construction and engineering have measures in place to account for wind. Structures are given a design wind speed, which indicates the level of wind loading they can safely withstand over the course of their intended lifespan. A similar designation may one day be established for different tree species.

In determining tree strength requirements, researchers must account for historic extremes as well as emerging weather patterns in regard to climate change. Effects of climate change should be applied as trees and tree care professionals must adapt to new conditions, weather patterns, and disease or insect interactions. Also, weather patterns may differ in urban areas, where buildings alter wind patterns and hardscape raises ambient temperatures. The development of microscale climate models warrants further investigation, as they may may increase the accuracy of weather and storm damage predictions.

While historic weather trends can serve as baseline for establishing minimum tree strength requirements, accurate weather forecasts are needed to predict tree damage in the presence of rare and extreme weather events like tornadoes, down drafts, and hurricanes. These forecasts may be used to help mobilize utility and arborist crews and facilitate timely storm response efforts. Combining forecast information with urban forest inventory or rights-of-way survey data (e.g., species, condition, age, pruning cycle history, etc.) can further refine models designed to predict potential hotspots or "risk zones" prior to the onset of a storm. This can greatly reduce or limit interruptions to key services such as electrical distribution and emergency response.

Other external factors can have a major bearing on the stability of urban trees. Future studies should investigate the role of terrain (slope and aspect), soil water content (dry vs. saturated), wind exposure, and sudden environment changes (removal of nearby tree or construction of new structures) in tree failure. In addition, anomalies, such as summer branch drop on windless days are poorly understood and require further attention.

Consequences – Damages, liability, and loss of benefits

To obtain and maintain funding to support tree risk-related research, the costs, lost benefits, and liabilities associated with tree failures and current management practices must be documented and shown to outside groups. Storm damaged trees can cause a significant amount of damage to personal and public property. Power disruptions caused by tree failures can halt commerce and impact daily life. Tree removal and clean-up costs can be quite substantial in areas with heavy damage. To assess the consequences of storm-related tree failures, several questions should be addressed.

First, researchers and urban forest managers must quantify historic storm damage levels and identify common tree and environmental conditions present at the time of failure. There have been several initiatives to do this, most notably the California Tree Failure Report Program and later, the International Tree Failure Database. As practitioners continue to add information to these databases, patterns and trends may be identified that can help guide future research projects and management decisions. In addition to this failure information, researchers should investigate and analyze past court precedents. This would consist of a survey of legal cases involving tree failure and a summary of decisions regarding duty of care and liability.

While the actual risk posed by urban trees may be minimal, perceived risk may be much greater. Public perception can be quite powerful – driving policies and mitigation decisions. Public surveys should be conducted to gauge opinions regarding the risks associated with tree failure. The results of these surveys should be compared to actually damage and injury statistics to see how closely public perception reflects reality.

Research must also identify and quantify the benefits that will be lost when a tree fails and is removed. This information can be used to help justify preventative mitigation efforts such as cabling and bracing or lightning protection. After a storm, this information may be used to justify curative efforts and routine follow-up inspections of damaged trees rather than defaulting to tree removal. The development of risk: benefit ratio analysis guidelines and methodologies will serve to help substantiate decisions to invest in the preservation of large trees that provide significant environmental, social, and economic benefits.

Consequences – Damages, Liability, and Loss of Benefits Research Priorities

- Quantify historic damage due to tree failures – identify associated tree and environmental conditions.
- Identify and evaluate the significance and impact of the possible outcomes of tree failure (methods).
- Survey public opinion of the risk of tree failure and loss of benefits (perception of risk).
- Where are consequences of tree failure most significant and where should we focus our efforts in assessment (ranking targets)?
- Identify and quantify the benefits that are lost when a tree fails or is removed.
- Develop a tree risk:benefit analysis and methods to perform it (methods).
- Survey historic legal cases involving tree failure to summarize duty of care and liability.

Risk Assessment Methods

Research should be conducted to improve our understanding of existing risk assessment practices and to create better methods. A review of risk assessment methods in other fields may be helpful in determining which risk assessment processes may be used. Do the other fields attempt to quantify risk or do they rely on explicit expert judgment or subjective assessment criteria? Do they utilize a combination of subjective and objective factors?

While differences in risk assessment methodologies may influence a professional's recommendation regarding a potentially hazardous tree, a significant amount of variation can be attributed to the assessor. Personal biases based on past experiences and beliefs can have a dramatic effect on assessment methodologies that have subjective components. Even risk assessment methods that are largely quantitative can vary depending on how and where measurements are made on the tree. Research must investi-

Risk Assessment Methods Research Priorities

- What training is required increase consistency in tree risk assessments among different arborists?
- What methods are used in other fields and which are applicable (or not) to arboriculture?
- What methods are used in other fields to quantify and/or make explicit expert judgment. What role does subjectivity play in these risk assessments?
- Is there a correlation between risk predictions from existing assessment methods and actual future tree performance?
- What is the validity, reliability, and consistency of risk assessment methods currently in use in arboriculture?

gate ways to effectively train people in order to increase consistency in tree risk assessments. One may need to question the ability of those identified as industry experts or the soundness of assessment protocols when large discrepancies and variations continue to persist in hazard tree assessments.

In addition to consistency, the validity and reliability of risk assessment methods currently in use in arboriculture must be assessed. Research must identify what correlation exists between risk predictions from commonly used assessment methods and actual future tree performance.

Selection of a standardized risk assessment methodology will depend on several factors. How much time is justified for an assessment? What are the added costs associated with more intensive methods? How do these costs compare to the benefits gained? Not every tree will require a thorough assessment. Researchers and experts must develop criteria to identify which trees are of greatest concern and develop a list of characteristics for use in the field. All things equal, the simplest and least expensive method will gain the greatest support among those in the industry practicing hazard tree assessment.

Tech Transfer and the Future of Tree and Risk Research

Technology transfer is an essential link between the work of researchers and field practitioners. For new methods and technologies to gain widespread use in the industry, target audiences must be identified and educational efforts must be tailored to meet the needs of these groups. Practicing arborists may not find peer-reviewed journal articles useful resources given the cost associated with accessing these works and the complexity of the content. Researchers and educators in private, academic, and nonprofit institutions can play a critical role, gathering and synthesizing research publications and disseminating the information in a more applicable and easily understood format.

Arborists still gain much of their continuing education from conferences, workshops, and seminars. While these venues can be highly effective means of delivering scientific and practical information regarding trees and risk, there is little oversight regarding the quality of the information presented. Conferences at the national- and international-level typically have a selection and review process in place when choosing talks for their educational programs. However, depth of this review varies and cannot guarantee the validity of all of the information conveyed by a given speaker. Local or regional conferences may not have a review process in place at all. While it is impractical (if not impossible) to review all presentation content prior to an educational session, attendees should be made aware that the information presented may not be empirically-based or peer-reviewed. Efforts should be taken to prevent presenters from passing off personal opinions as fact and anecdotal evidence as empirical research.

Other technology transfer outlets include trade publications, books, online and computer-based resources, Best Management Practices (BMPs) and industry standards. All can be effective means of conveying information. However, when used in combination, they will likely have the greatest effect on industry-wide behaviors.

In the absence of research, a tech transfer piece, such as a BMP, would rely on currently available information to provide practitioners with a practical guide for defect and risk assessment. Deficiencies in information would be noted and serve list of research needs. Each individual factor could be the subject of numerous studies or addressed through a peer-reviewed literature review or white paper. Over time, as the scientific voids associated with risk assessment are filled the information contained in the BMP will have a greater scientific backing.

To help foster the continued interest in tree and risk-related research, connections must be made with those industries that must deal with the effects of tree failures on a routine basis. Utility companies spend significant sums of money responding to and preventing service disruptions caused by trees. Insurance companies often cover damages incurred when tree failures cause property damage or injury. Both these groups may potentially gain from tree and risk-related research and may support research efforts if approached in an effective manner.

The number of researchers addressing questions in arboriculture and urban forestry are limited. Even fewer focus on tree and risk-related research. More research funding is needed to attract up-and-coming scientists. In addition to attracting new arboriculture researchers, scientists from other backgrounds (engineering, meteorology, risk) must be recruited to gain a wider range of expertise and share additional insights from related fields.

Summary

The practice of tree risk assessment continues to rely heavily on anecdotal evidence and subjective assessment factors. This reality must be acknowledged and accepted for the time being. However, arborists and researchers must continue to work towards developing assessment protocols supported by empirical research. Some aspects of risk assessment may always be subjective in nature. However, the development of robust tree strength and wind loading models will lead to better quantification of evaluation factors and greater accuracy in risk assessments.