An Assessment of Ordinal Tree Risk Rating Systems

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Images of a crushed car or flattened house beneath a fallen tree tend to accompany articles on tree risk. This common image depicts an outcome of a tree part failure that does not convey the norm. The more typical scenario is depicted in Image 1: a failure occurs, even a significant one as pictured, and nothing happens. Unfortunately, much of our reaction to tree risk is driven by concerns regarding extreme situations where there is dramatic damage to property or harm to life. Furthermore, our understanding has been primarily informed through litigation and tree biomechanics. The former has more than likely skewed our perception of liability, and the latter addresses only one of the elements that determine tree risk. Perhaps due to these factors, the arboriculture profession tends to emphasize the extreme consequences of a tree part failure rather than the actual likelihood, or probability, of a negative event happening. This lack of attention to event probability jeopardizes the critical analysis of cases and weakens the understanding of tree-related risk. Tree risk assessments and management are complex topics and should be studied and discussed judiciously, not be guided by the extremes. Those of us within the profession who evaluate standing trees for risk need to be fully informed on this evolving subject.

Image 1 – A failed Silver Maple (*Acer saccharinum*)

A full discussion of this complex topic cannot be presented in one brief article. The purpose of this essay is to challenge arborists and consultants working both in private and public sectors to further their understanding of tree risk and apply more rigorous standards to their practice. One issue of consideration is the plethora of ordinal tree risk rating systems that have dominated our processes over the last two decades. The development of recent instruments such as the LANTRA Professional Tree Inspection qualification, Quantified Tree Risk Assessment (QTRA) and the transition of the International Society of Arboriculture (ISA) toward the Tree Risk Assessment Qualification (TRAQ) provides an opportunity to critically review our understanding of risk and specifically, the ordinal rating systems that have been used to date. Closer study of risk measurement concepts and ordinal rating scales suggests that current ordinal risk rating scales create an overreliance on interpretations drawn from these scales, and that newer forms of risk assessment may be more appropriate within the context of our profession.

The simplest definition of risk is the potential, feasibility, and/or probability of experiencing harm or loss. The assignment of risk anticipates or attempts to quantify the likelihood of an event occurring, which is typically viewed as a negative event when concerning trees. The risk determination of an individual tree involves the careful assessment and integration of four components: (1) the identification of the likelihood of a tree part to fail; (2) the time frame in which the failure is likely to occur; (3) a determination of the likelihood of that part striking a target or impeding service if it fails, and (4) an evaluation of the consequences if **both** likelihoods occur.

Our ability to reliably predict the likelihood of a tree part failure combined with the likelihood of the tree part striking a target will only strengthen as we seek ways to assess and measure these dimensions. Currently, the ability to identify tree risk is driven by mostly qualitative methods. By examining some of the weaknesses in current evaluation methods and tools, however, improvements can be made that may reduce inherent bias in qualitative evaluations. The United States Forest Service hazard rating system, the ISA Pacific Northwest Chapter TRACE program, and the ISA ordinal tree risk rating scales are examples of instruments for determining tree risk that are currently in use. They assign a score to three factors (i.e., size of part, potential of that part to fail, and target) and then combine the scores to derive a risk rating.

Despite the prevalence of their use in the field, the lack of empirical support for these instruments is concerning. Moreover, the interpretations drawn from these tools are often times accepted independent of any corroborating data points. Overreliance on one data point to form interpretations violates assumptions of measurement.

After a review of five ordinal rating scales, five measurement issues were identified that should be of concern to all within our profession. These are: (1) the use of category designations as mathematical representations, (2) the multiple concerns with the size of part classification, (3) the limited interpretation of risk, (4) the range compression that occurs when the composite risk rating is determined, and (5) additional bias inherent to some instruments.

1. Misapplication of Category Designations

Depending on the ordinal system used, one to five points are assigned to each of the three factors mentioned earlier.[1] The ISA system (Clark and Matheny, 1994), shown below in Table 1, assigns one to four points to each of the three factors. The composite risk rating is derived by adding the three factor scores together to obtain a number from 3 to 12. Higher scores are assumed to represent greater risk.

Table 1 - ISA Tree Risk Rating					
Size of Part		**Potential to Fail**		**Target**	
Score	Narrative	Score	Narrative	Score	Narrative
1	1 to 6”	1	Low	1	Low
2	6 to 18”	2	Medium	2	Moderate
3	18 to 30”	3	High	3	Frequent
4	>30“	4	Severe	4	Constant

The tree risk rating scales that are used are considered ordinal scales, in which numbers represent categories or rank. The numbers **do not** represent quantities. In other words, their assignment does not equal a mathematical relationship. They represent a group or range of data features. The practice of adding the individual category scores together to provide a composite risk rating

[1] The USFS system has an optional fourth factor that allows the assessor to assign two additional points if they feel it necessary.

oversimplifies the phenomenon of risk and suggests that simply adding categories together yields a valid quantification of comparative risk, which it does not. Adding the individual scores changes the use of the number from a category representation to a mathematical one, which is a measurement error.

2. Multiple Concerns Regarding the Tree Part Classification

Each ordinal rating scale requires the assessor to assign a number to the size of the part that is most likely to fail. As defined by the ordinal rating systems, larger parts are given higher scores. This practice has inadvertently focused our attention on the larger parts of trees as sources of failures. This is contrary to our understanding of the actual risk that may be present. Because of the greater number of smaller branches that exists in most trees, the potential for them to fail and cause harm on any average day is greater than the higher rated large parts. The law of averages suggests that over the course of an inspection interval, there is a greater chance of a significant small branch failing and causing harm than a larger branch. Cox (2009) identifies this as an "Error in Comparative Rankings" which, in this instance, means that higher risk ratings are actually given to features that have lower risk likelihood compared with others. Additionally, these instruments may have inadvertently directed arborists to associate heightened risk to larger tree parts while underemphasizing the significant risk potentially associated with smaller parts.

3. Constricted Understanding of Risk

One of the complicating factors particular to tree risk assessments is the large number of variables that can contribute to risk determination. Site, tree structure and environmental factors are the three broad categories that we must consider. However, within each of these three main categories are dozens of additional variables that contribute to risk assessment outcomes. Many of these variables place fluctuating stresses on the tree over time—affecting different parts of the tree at different times and intensities. Multiple parts on a tree have a potential to fail within an inspection period. In addition to these numerous failure potentials, target presence and placement also fluctuates greatly over the inspection period.

The ordinal rating systems have the profession selecting the single part most likely to fail when a target is present within a defined inspection period. This methodology constricts our understanding of risk by negating the range of potential events that could actually occur.

Our understanding of target within the ordinal systems is also oversimplified. The mere presence of a potential target within proximity to the subject tree suffices to rank the target. Details of target position, proximity, or location relative to the tree part of concern sees little discussion of depth. One consequence is that incomplete information can negatively skew data, where targets are rated higher than potential risk and the laws of probability would suggest.

4. Range Compression

In all of the ordinal rating systems it is possible that tree parts with obvious differences in risk can be assigned the same risk rating. Using the ISA system as an example, a five-inch branch that has a severe potential to fail in a constant use area has the same rating as a thirty-two inch branch with a low potential to fail in a constant use area. Both scenarios have a rating of "9," but the smaller branch has the most immediate risk associated with it. Cox (2009) defines this error as an example of "range compression"; that is, an identical rating is assigned to quantitatively very different risks.

An additional example of range compression is that a significant small branch can never have a composite risk rating greater than 9 on the ISA's 12-point scale, 10 on the TRACE 12-point scale, and 8 on the USFS 10-point scale. Numerous tree-related fatality and injury cases involve a branch five or six inches in diameter. All of the ordinal rating systems fail to capture the risk associated with tree parts that have the higher probability of failing by placing greater weight on the larger parts, which, in comparison, have a lower frequency of failures.

5. <u>Inherent Instrument Bias</u>

The output generated from ordinal tree risk rating instruments may inadvertently reflect bias resulting from their initial design. Several current tools offer examples of this. For example, the USFS instrument permits the addition of two discretionary points per professional judgment to facilitate mediation, while not exceeding the range of the scale (Albers, 2002). This feature violates the reliability of the instrument, as it does not provide the same measurement over repeated applications. Furthermore, it is particularly problematic across raters, given varying rater discretion. Another example of bias is evident in the mitigation fields present in TRACE and versions of the National Park Service instruments. These require the provision of a mitigation recommendation that directly or indirectly relates to the risk rating score. Depending on the agendas or personal biases of the assessors, ratings could be assigned based on user bias or preference. Two examples of such bias in action would be 1) a road maintenance crew rating trees as higher in risk because it guarantees an assigned mitigation of action, and 2) a conservation manager, who may have a limited understanding of tree hazards, rating a tree lower on the risk scale to guarantee wildlife habitat.

Another measurement concern present in current tree risk assessment tools is that the size of part classification present in all rating instruments introduces error if the categories' ranges are not mutually exclusive. Ranges are mutually exclusive when data points cannot belong to more than one category within a given attribute (Price and Chamberlyne, 2008). A violation of the category exclusivity standard is apparent in the ISA rating system, where a 6-inch tree part can reside within two categories (i.e., 1"–6" and 6"–18").

A final consideration is that there appears to be no research to support the development of the size of part category ranges for any of the ordinal rating systems evaluated. This is particularly problematic given the emphasis on higher scores in the ratings and the potential for error in the user's interpretation that this allows.

<u>Discussion</u>

Within the arboricultural profession, the understanding of the concepts of tree risk are evolving and becoming more refined. The LANTRA Professional Tree Assessment Qualification, QTRA, the recent release of the ISA's Tree Risk Assessment BMP, and the launch of the Tree Risk Assessment Qualification serve as four examples where this evolution is providing an opportunity for arborists, consultants, and municipal foresters to enhance their understanding of this complex topic. Past instruments, though flawed, have provided important initial insights into tree risk assessments and have galvanized user focus on the responsibility to protect the users of public and private green space.

TRAQ, as an example, is not without its limitations. Without a method of quantification, "*categorizations of relative severity cannot necessarily be made objectively—independent of subjective risk attitudes—for uncertain consequences*" (Cox, 2013). However, TRAQ addresses some of the bias inherent in the ordinal rating systems by (1) eliminating the size of part factor and making it an element of determining consequences, (2) evaluating the likelihood of failure and of striking a target as processes independent of each other, and (3) providing for the assessment of multiple tree parts and targets.

In litigation, risk trees are most often viewed in terms of absolutes—the tree part was either a hazard or not. However, it is understood that risk is about uncertainty, and the arborist profession is likely to develop poor policies or interpretations when tree risk is considered in absolute terms.

In many failure litigation cases, consultants are willing to assign a post-failure risk understanding to the pre-failure tree. In many of these instances, unless very strong, visually overt defects are present, the expert treads dangerously close to being an advocate for the attorney rather than an impartial expert by assigning higher ordinal ratings than would or could have been assigned prior to the failure. As professionals, we bear the difficult task of assigning risk ratings to a biological feature with potentially dozens of variables at play. It is essential that arboricultural professionals understand that post-failure knowledge of a tree may influence the ratings assigned after the fact. It is rare to have a tree that can be considered a hazard in absolute terms.

The purpose of this discussion is not to diminish the expertise or contributions of past instrument developers, as the field of arboriculture is indebted to them for their focus on this compelling issue of risk. Rather, the concepts presented here are intended to afford balance in the assessment process. Instruments will always generate data, but it is the role of the assessor to make interpretations from measurements. An overreliance on the numbers generated from the use of these scales may skew the understandings of risk. Given the qualitative nature of our rating systems, arborists must base their interpretations on findings from multiple instruments, their specific contextual constraints, their education, and new scientific findings. In this way, the profession's individual and collective understanding of risk will mature.

Active urban forestry professionals know from experience that most tree part failures result in little or no damage or injuries, although there is little research available to validate this understanding. The field requires research to further our processes for and understandings of identifying tree part failure potential, and there should be an increase in field-based research specific to documenting the potential of striking a target and subsequent consequences. Professionals and practitioners in urban forestry and arboriculture will be better able to analyze, understand, articulate, and manage the risk potential associated with individual trees and the system-wide urban forest once guidance has been provided by such research.

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