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Factors driving professional and public urban tree risk perception

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ABSTRACT

Urban tree risk assessment and mitigation is a process that is strongly influenced by professional experience, risk perception, and risk tolerance. While arborists and other tree risk assessors document all of the risk factors they see in an effort to provide their clients a comprehensive assessment of a tree and its surroundings, the homeowner or property manager ultimately determines what mitigation measures are adopted. Using photographed urban tree scenarios and conjoint analysis, we assessed the level in which seven commonly taught risk factors related to target, likelihood of failure, and consequences of failure contributed to risk ratings given by non-professionals, professionals, and advanced professionals. While risk ratings from all three respondent groups were influenced by the presence and severity of a tree defect and proximity to target, defect severity accounted for approximately half of the risk rating decision (48.5–55.3%). Some risk factors (e.g., tree size, tree species) had little influence on risk ratings. Findings from this research highlight the need to educate both the public and tree care professionals regarding the importance of risk factors beyond tree condition.

Tree risk assessment is a systematic process for identifying, analyzing, and evaluating risk associated with tree or tree part failure (Dunster et al., 2013). All commonly employed basic tree risk assessment methods are similar in that they consider three key factors: (1) likelihood of impact to target, (2) likelihood of failure, and (3) consequences of failure should a target be struck (Matheny and Clark, 1994; Pokorny, 2003; Ellison, 2005; Smiley et al., 2011; Dunster et al., 2013).

Targets are any people, property, or human-related activities that have the potential to be harmed, damaged, or disrupted if a tree or tree part fails (Smiley et al., 2011). Target occupation is the amount of time that one or more targets are present within range of a tree or its aboveground parts. Target occupation is one of the first considerations made by a professional when assessing tree risk and is considered by some to be the most significant factor in an assessment (Ellison, 2005). Targets such as fixed structures are always present, whereas pedestrians and vehicles are mobile and may vary in their occupancy of the site (Matheny and Clark, 1994). While many would conclude a tree with no potential targets has no associated risk (Dunster et al., 2013), there are still consequences associated with its failure (e.g., loss/creation of habitat or altered ecological services).

The likelihood of failure is the probability of a tree failing within a stated period of time (Dunster et al., 2013). Defects (e.g., wounds, decay, leans, poor branch architecture) increase the likelihood that all or part of the tree will fail (Kane, 2008; Hickman et al., 1995; Matheny and Clark, 1994). In addition, site conditions including soil hydrology, topography, exposure to the elements, and past construction events can increase the likelihood of failure (Smiley et al., 2011). Decisions made regarding the probability of a tree or tree part failing are only relevant for a specified period of time as trees can acquire new defects, existing defects can worsen, and response growth can strengthen weakened areas of the tree (Smiley et al., 2011).

Consequences of failure are a function of the value of the targets present and their potential for damage, injury, or disruption if struck (Dunster et al., 2013). The International Society of Arboriculture Tree Risk Assessment Best Management Practice (BMP; Smiley et al., 2011) groups all possible consequences into four categories: negligible, minor, significant, and severe. Negligible consequences are damages that result in minor repairs to low value targets (i.e. superficial damage to a small fence or disruption to landscape lighting). By contrast, severe consequences could include the hospitalization or death of a person, significant structural damage to an occupied house, or a large-scale power outage (Smiley et al.,

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2011). Many factors can influence the consequences of tree failure, including the size of the branch or tree striking the target, fall distance, and the presence of other trees or branches that can slow or prevent the impact of the failing branch or tree (Dunster et al., 2013).

In addition to sharing these three core considerations, all major risk assessment methods currently employed are similar in that they draw heavily on the assessor's past experience, professional judgment, and training when making decisions at each stage in the inspection process. In a proceedings article from the 2007 International Society of Arboriculture Australia Chapter annual meeting, Norris (2007) presented his thesis research which compared eight different risk assessment methods in a series of tests to gauge there sensitivity (to the various inputs) and variability. In one trial, 12 experienced arborists inspected trees (representing a range of targets and structural conditions) with each of the eight risk assessment methods. In comparing these results, he found that the evaluations of the arborists varied greatly. This was attributed to arborist's individual inherent attitudes toward risk (Norris, 2007).

How a professional or homeowner perceives risk affects their view of the real risk associated with a given tree (Freudenburg, 1988; Slovic, 1987). Moore (2014) illustrated that much of the time, requests for tree removals are based on unsubstantiated fear. Property owners, while influenced by the evidence and professional recommendations provided, ultimately have the final say regarding what mitigation (including removal) is required. Perceptions of risk and acceptable risk play key roles in this decision. A greater understanding of how the lay and professional public view the hazards posed by urban trees is needed to help guide risk assessment research and education efforts.

Ratings-based conjoint analysis is a process where various product scenarios are rated by respondents to assess what attributes garner the most interest. Beyond assessing the relative importance of product attributes, the partial-worth scores derived from this analysis can be used to gauge whether interest is increased or decreased by a specific level within that attribute (Karniouchina et al., 2009). As such, it is used for both product development (to help determine what features are needed to pique the interest of an intended consumer group) and in marketing (to prioritize what features are highlighted on packaging and advertisements). Using conjoint analysis, horticultural market researchers have asked respondents to rate perceived interest for various product scenarios to gauge, among other things, consumer interest in sustainable packaging and environmentally friendly plant production practices (Hall et al., 2010; Behe et al., 2013).

For this paper, conjoint analysis has been adapted to assess what attributes impact risk rating rather than consumer interest rating. This study had two main objectives: (1) Determine if tree care professionals and the general public perceive risk differently, and (2) Determine which factors related to target, likelihood of failure, and consequences of failure influence risk perception within the populations of interest. Results can be used to help guide public and professional education efforts.

1. Materials and methods

1.1. Visualizations and survey tool development

For this study, six different attributes were selected to gauge which tree and site factors drive perceived risk (Table 1). These attributes were selected to address the three key components of tree risk assessment: (1) likelihood of impact, (2) likelihood of tree failure, and (3) consequences of failure (assuming impact is made with a target). In addition, neighborhood income level, which is not a direct consideration in a risk assessment, was included as a comparison to the other five, relevant attributes (listed under "other" in Table 1).

Table 1
Risk Attributes and levels assessed.

Risk factor	Attribute	Level
Target	Proximity to target	Out of range
		In range
		Overhanging
	Target type	Person
		Car
		Structure
Likelihood of failure	Tree species	*Q. virginiana* (live oak)
		Q. laurifolia (laurel oak)
	Defect severity	Unlikely to fail in severe weather[a]
		May fail in severe weather[b]
		May fail under normal weather conditions[c]
Consequences of failure	Tree size	Large
		Medium
Other	Neighborhood income level	High-income
		Medium-income
		Low-income

[a] Presented as such to survey respondents, but shortened to "no defect" in results and discussion.
[b] Presented as such to survey respondents, but shortened to "moderate defect" in results and discussion.
[c] Presented as such to survey respondents, but shortened to "extreme defect" in results and discussion.

Each attribute had at least two different levels for comparison (Table 1). Given the levels and attributes selected for evaluation, 11 parameters required estimation in our final model. A factor of three questions per parameter (i.e. a total of 33 risk scenarios) was chosen to ensure sufficient degrees of freedom for analysis (Sawtooth Software, 2002). These scenarios were selected from all possible combinations of the various attribute levels using the caFactorialDesign() function in R (Bak and Bartlomowicz, 2012). A fractional, non-orthogonal design was selected.

Each of the tree risk scenarios was then staged and photographed. As trees are more likely to fail during storm events, photographs were shot on overcast days and altered with picture editing software (Photoshop Elements 12, Adobe Systems Incorporated, San Jose, CA, United States) to add a rain effect. In addition, targets beyond the main target of interest (i.e. adjacent cars or structures) were blurred out or removed as appropriate. Descriptive text for the attribute levels displayed accompanied each photographed scenario (Fig. 1).

Prior to the experiment, the survey tool and associated visualizations were pre-tested by two academic colleagues. After incorporating their revisions, the survey materials were further pretested by a mix of professionals and non-professionals. With minimal changes suggested by this second group, their data were later included in the final study data set.

1.2. Measures and procedures

The survey was administered in person using a paper form and slide presentation software. Prior to assessing the risk scenarios depicted in the images, respondents were asked to complete a modified Domain-Specific Risk-Taking (DOSPERT) scale (Blais and Weber, 2006) to assess their perceived level of risk for three scenarios related to health/safety and three domain-specific scenarios related to finance (Table 2). Respondents were then asked to view the 33 tree and target scenarios while the corresponding descriptive text was read aloud. For each scenario respondents were instructed to select an intuitive risk rating (i.e., a gut-level assessment of risk associated with scenario depicted) ranging from