

**ROADSIDE TREE RISK MANAGEMENT BY
STATE DEPARTMENTS OF TRANSPORTATION
IN THE MID-ATLANTIC REGION**

**A PILOT STUDY CONDUCTED BY THE
VIRGINIA TECH DEPARTMENT OF FOREST RESOURCES
AND ENVIRONMENTAL CONSERVATION**

**PRESENTED TO
VIRGINIA DEPARTMENT OF TRANSPORTATION**

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SURVEY COMPLIANCE

The survey data described in this report were collected in compliance with regulations and best practices of the Virginia Tech Institutional Review Board. The protocol approval documentation for this survey study is on file with the review board under case file 17-358. The protocol approval letter can be found in Appendix 2 of this report.

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EXECUTIVE SUMMARY

We conducted a pilot study in collaboration with Virginia Department of Transportation (VDOT) to ascertain current conditions and capabilities for roadside tree risk management by state departments of transportation (DOTs) in the Mid-Atlantic region. Our focus was specifically on risks associated with tree failure that result in debris falling into the roadway and possibly causing harm to pedestrians, cyclists, vehicles, or roadway infrastructure. The purpose of this study was to benchmark VDOT's operations relative to its peer agencies and to shed light on the prevailing standard of care for tree risk management amongst state DOTs. With this information, VDOT aims to evaluate its operations and identify opportunities to strengthen its existing capabilities.

We surveyed the statewide roadside vegetation management coordinator in Virginia and in the bordering states of Kentucky, Maryland, North Carolina, Tennessee, and West Virginia. We distributed a survey comprising 38 multiple-choice and short-answer questions to the respondents via email in April 2017. We developed the survey instrument in close consultation with VDOT and reference to industry standards, industry best management practices, and primary literature on tree risk management. In the survey, we examined four primary determinants of tree risk management conditions and capabilities: personnel, policies, procedures, and practices. Survey response data were examined to uncover basic themes, trends, and perceptions that might help clarify the prevailing standard of care for tree risk management amongst these state DOTs.

VDOT is the only state DOT that currently has an ISA Certified Arborist leading its statewide operations and the only state DOT where most DOT tree management personnel are both an ISA Certified Arborist and an ISA Qualified Tree Risk Assessor. Training on tree risk management for VDOT personnel is above average in terms of frequency, but it is difficult to ascertain from this survey whether VDOT's workforce is comparable to other states in terms of sheer numbers. VDOT was consistent with the majority of respondents in stating that resources and expertise for effectively managing roadside tree risk are inadequate, yet believing that the DOT is effective at managing roadside tree risk.

The policy situation with these DOTs was difficult to ascertain with a survey, and our study constraints did not allow us to delve independently into various state policy documents. The key finding is that the majority of state DOTs currently do not possess a tree risk management policy and have no intention to develop one. Although VDOT does not currently have a policy, it did indicate intent to develop one in the future. Most states (including VDOT) reported that they currently do not have a standardized process for either inspecting roadside trees or rating tree risk. State DOTs were very similar in their use of both drive-by and walk-by tree inspections. That most states only

occasionally utilize drive-by inspections should be a matter for further inquiry and clarification as it might indicate that trees are not receiving adequate inspection.

The expertise of DOT tree management personnel appears to be underutilized for selecting trees to be planted at the roadside and protecting trees from excessive impacts during roadway construction and maintenance. Not much could be gleaned from the survey about DOT tree removal practices other than removal decisions are not ceded to DOT contractors and are influenced by the opinions and demands of the public. Almost all DOTs (including VDOT) reported that their pruning practices are primarily reactive, addressing branch and crown defects after they have reached a potentially hazardous state. Further, most DOTs indicated that proactive pruning to prevent branch and crown defects is very underutilized (VDOT was slightly better, but still underutilized).

In the following report is a full description of the study rationale and methods along with a comprehensive reporting of the survey instrument and survey data. We provide interpretation and insights for the survey results along with a discussion of study limitations and aspects of the study needing further investigation. Where appropriate, we have described what we perceive to be inadequacies in tree risk management operations relative to industry standards, best management practices, and primary literature on tree risk management.

INTRODUCTION

Trees are a tremendous benefit to the built environment. At the roadside, trees increase perceptions of safety in both urban and suburban environments and significantly reduce individual driving speeds in suburban settings (Naderi et al., 2008). Roadside trees also buffer vehicular noise (Fang & Ling, 2003), absorb air pollution (Morani et al., 2011), and reduce stormwater runoff (Xiao & McPherson, 2002). Intuitively, these benefits should be greatest when suitable trees are planted in appropriate locations and are provided periodic maintenance. When poor choices are made, trees may damage roadway infrastructure (Naik et al., 2017) and create hazards for motorists in either roadway departure incidents (Fitzpatrick et al., 2014) or by falling into the roadway (Schmidlin, 2009). While these incidents are rare, they can result in significant personal injury and property damage (Ball & Watt, 2013). To ensure that roadside trees are assets rather than liabilities, qualified professionals must be tasked with their management and given appropriate resources to carry out their management duties.

State departments of transportation (DOTs) have a legal mandate to manage trees within the right-of-way of all state-maintained and certain federal highways to ensure the safety and convenience of pedestrians, cyclists, and motorists and to protect roadway infrastructure from damage. To balance the benefits and risks of roadside trees, DOTs employ various policies, procedures, and practices to ensure that trees are compatible with roadways and do not pose an unreasonable risk to people, property, or traffic flow. Their primary management activities include oversight of the planting and natural regeneration of trees, periodic inspection of trees to identify conflicts and hazards, and strategic removal and pruning of trees to mitigate conflicts and hazards. These activities are typically guided by industry standards of practice and best management practices (BMPs).

Roadside trees pose numerous potential hazards for the traveling public. Encroachment of trees on clear zones and sight distances are conspicuous hazards that are clearly addressed in federal and state design standards for highways (FHWA, 2017; VDOT, 2017). Greater uncertainty and inconsistency is encountered with issues of tree failure risk—all or part of a tree falling into a roadway and potentially causing harm. A number of factors precipitate these tree failure incidents: tree defects, inclement weather, site conditions, and past maintenance activities. DOTs seek to minimize these incidents by detecting, assessing, and correcting hazardous tree conditions. To ensure that they are reasonably fulfilling their duty to manage roadside tree hazards, DOTs need to understand their standard of care for tree risk management. The standard of care is the prevailing,

reasonably prudent actions that are taken to fulfill the tree management duty (Anderson, 1988). The standard of care is dictated by a number of factors:

- Regulations and policies
- Legal precedents
- Organizational capabilities and constraints
- National industry standards (e.g., ANSI, 2017)
- Arboricultural best management practices (e.g., Smiley et al., 2011)

Clarifying the standard of care for roadside tree risk management is important for several reasons. First, it provides a clear objective for planning and prioritizing risk management operations. Second, it aids in identifying and correcting deficiencies in these operations. Third, it reduces ambiguities about expectations for risk management and provides a clear benchmark against which an agency can be measured. The result is a more efficient and effective agency that has less exposure to liability claims associated with roadside tree failure incidents.

Recently, case law and legal settlements resulting from roadside tree failure incidents have brought to light concerns about the duty and standard of care for risk management (Bidwell, 2014; Mortimer & Kane, 2004). The Virginia Department of Transportation (VDOT) seeks to understand the prevailing duty and standard of care amongst DOTs so that it can identify opportunities to improve its statewide operations. As a first step, VDOT partnered with the Virginia Tech Department of Forest Resources and Environmental Conservation to study DOT operations in peer states of the Mid-Atlantic region. Our approach was to conduct a limited scope pilot study to delve into key aspects of DOT tree management to uncover basic themes, trends, and perceptions that might help clarify the prevailing standard of care and guide future research on this subject.

The basis for our study was a survey sent to DOT representatives with statewide vegetation management duties in Kentucky, Maryland, North Carolina, Tennessee, Virginia, and West Virginia. The conceptual framework for our survey was to benchmark current conditions and capabilities of these DOTs in four dimensions of tree risk management: personnel, policies, procedures, and practices. The number of personnel, along with their duties and qualifications, are an indication of the capacity to manage tree risk and with what level of proficiency. In this study, we were particularly interested in the arboricultural credentials and continuing education of personnel with direct tree management responsibilities. Policies are the various legal and operational documents that define an agency's scope of work and set expectations for fulfilling its mission. Of key interest here was whether state DOTs have a comprehensive tree risk management policy. Procedures are written

documents and customary approaches to making decisions or carrying out actions in an established or official manner. Procedures of interest to us were tree risk inspections, tree risk diagnostics, and tree risk rating systems. Finally, practices are the field application of disciplinary concepts and procedural techniques to achieve a particular objective. In this study, we were interested in tree consultation practices, use of tree removal and pruning to mitigate risk, and use of mapping and analytical tools to evaluate and forecast tree risk.

METHODS

We developed a survey comprising 38 multiple-choice and short-answer questions in consultation with VDOT (Appendix 1). The Virginia Tech Institutional Review Board (IRB) provided regulatory oversight for survey development and distribution to ensure that respondent rights were not infringed. The approval letter provided by IRB for our survey protocol can be found in Appendix 2. The survey instrument was divided into four main sections that corresponded with our conceptual framework for tree risk management as described in this report's introduction: personnel, policies, procedures, and practices.

Because this was a pilot study aimed at collecting baseline data to evaluate our conceptual framework, we distributed the survey to only one DOT official in Virginia and each of the five bordering states: Kentucky, Maryland, North Carolina, Tennessee, and West Virginia. Through inquiries with each state DOT, we identified a single staff member who, by virtue of title or scope of responsibilities, had the best perspective on roadside tree management in the state and could provide an accurate and thorough response to our survey.

Most of the DOT respondents selected for the survey had state-level roadside vegetation management responsibilities. In April 2017, we sent the survey in fillable PDF format to the respondents via email and asked them to complete the survey in a two-week timeframe. We received a completed survey from every respondent via email and then transcribed the survey data into a spreadsheet using a numerical coding system. The raw data from the survey are provided in Appendix 3 of this report.

RESULTS and DISCUSSION

Survey Respondent Demographics and DOT Characteristics

Characteristics of the survey respondents and their DOTs are shown in Table 1. Most of the respondents had state-level roadside vegetation management responsibilities. Self-reported position

duties and responsibilities varied in their detail and therefore were not construed as comprehensive descriptions, but rather as indicators of the respondents' scope of work. Four of the six respondents had educational background in agriculture, horticulture, or forestry, which suggests strong foundational knowledge in plant science and management among these personnel. The other two respondents were educated in management (TN) and engineering (WV)—skill sets oriented toward traditional DOT infrastructure operations.

Only one of the six respondents (VA) was a Certified Arborist by the International Society of Arboriculture (ISA), and only one of the five other respondents (KY) indicated intent to become a Certified Arborist (Table 1). We did not ask respondents to identify other professional credentials related to vegetation management that they might possess. Our primary interest was the Certified Arborist credential because it is the prevailing credential indicative of tree management expertise. Despite the lack of ISA Certified Arborists, the respondents self-reported a high level of expertise about roadside tree management. Five of the six respondents rated their expertise as intermediate to expert. The Tennessee respondent reported only basic awareness, which may be due to the respondent's educational background and narrow scope of work.

Staff size and personnel expertise are strong indicators of a DOTs capacity to manage roadside tree risk. Our ability to determine the number of personnel in each DOT with direct tree management duties (excluding field production personnel who trim and remove trees) was limited by our survey design. Our intention was to identify individuals in key planning, inspection, and supervisory roles whose primary focus is on roadside vegetation. Four of the six states (VA, KY, MD, and TN) reported staff sizes in the range of 12 (KY) to 34 (VA) individuals. West Virginia and North Carolina were outliers, each respectively reporting no personnel and over 100 personnel. In these cases, the respondents may have misinterpreted the question and either under- or over-reported staff sizes. As a follow-up to staff size, we also asked if a position description could be obtained for each staff position. Most states indicated that they would provide position descriptions upon request. An in-depth analysis of position descriptions was beyond the scope of this pilot study, but this type of analysis would provide more insight on personnel capabilities, particularly if coupled with some interviews to ask additional questions about personnel background and qualifications.

TABLE 1: Characteristics of survey respondents and the departments of transportation (DOTs) where they are tasked with roadside tree management.

	Virginia	Kentucky	Maryland	North Carolina	Tennessee	West Virginia
Position title of respondent...	State Roadside Vegetation Manager	State Administrator of Roadside Environment	Statewide Forest Mitigation Coordinator	Roadside Asset Vegetation Management Engineer	Transportation Manager I	Maintenance: Operations Section Head
Self-described position duties and responsibilities of respondent...	Interpret legislation and policy relevant to roadside vegetation management and then work with roadside personnel to develop and enforce procedures and best management practices.	Administer statewide programs for maintaining and improving the external environment of highway properties and other duties as required.	Plan review; compliance with Maryland tree laws; District support on active construction.	Supervise vegetation management, wetland mitigation, and landscape design & development sections; Coordinate program development and funding statewide; Coordinate NC wildflower program.	TDOT operations support.	Winter operations planning; interstate rest areas and welcome centers; statewide liaison to district maintenance engineers.
Educational and training background of respondent...	Horticulture	Agriculture	Forestry	Agriculture, Horticulture	Management	Engineering
Respondent is an ISA Certified Arborist...	Yes	No, but plan to become one	No, and do not plan to become one	No, and do not plan to become one	No, and do not plan to become one	No, and do not plan to become one
Self-described expertise in roadside tree management...	Intermediate	Advanced	Expert	Advanced	Basic awareness	Intermediate
Roadway miles tasked with tree management...	57,000	27,500	5,166	79,000	13,877	37,370
DOT personnel that have direct tree management duties...	9 District Roadside Managers and 25 Roadside Coordinators	12 Roadside Environment District Administrators	29 Residency Maintenance Engineers	100 County Maintenance Engineers and 14 Division Roadside Engineers	22 Operations District Supervisors	None

In addition to determining the number of tree management personnel, we also sought to understand the credentials of DOT staff and their ongoing training in tree risk management (Figure 1). Virginia distinguished itself from the other states by reporting that all DOT personnel with direct tree management responsibilities are ISA Certified Arborists and most are ISA Qualified Tree Risk Assessors (a specialized credential requiring three days of training followed by a competency exam; credential holders must requalify with a remedial course and exam every five years). Three states (MD, TN, and WV) reported that no personnel are Certified Arborists, while Kentucky and North Carolina reported very few personnel are Certified Arborists. None of these five states currently has DOT personnel who are Qualified Tree Risk Assessors. Frequency of personnel training on tree risk management varied widely. Three states (MD, NC, and WV) reported never doing such training. Kentucky reported training several times per year, while Tennessee reported training once per year. Virginia was intermediate among the states, reporting that training is provided once every few years.

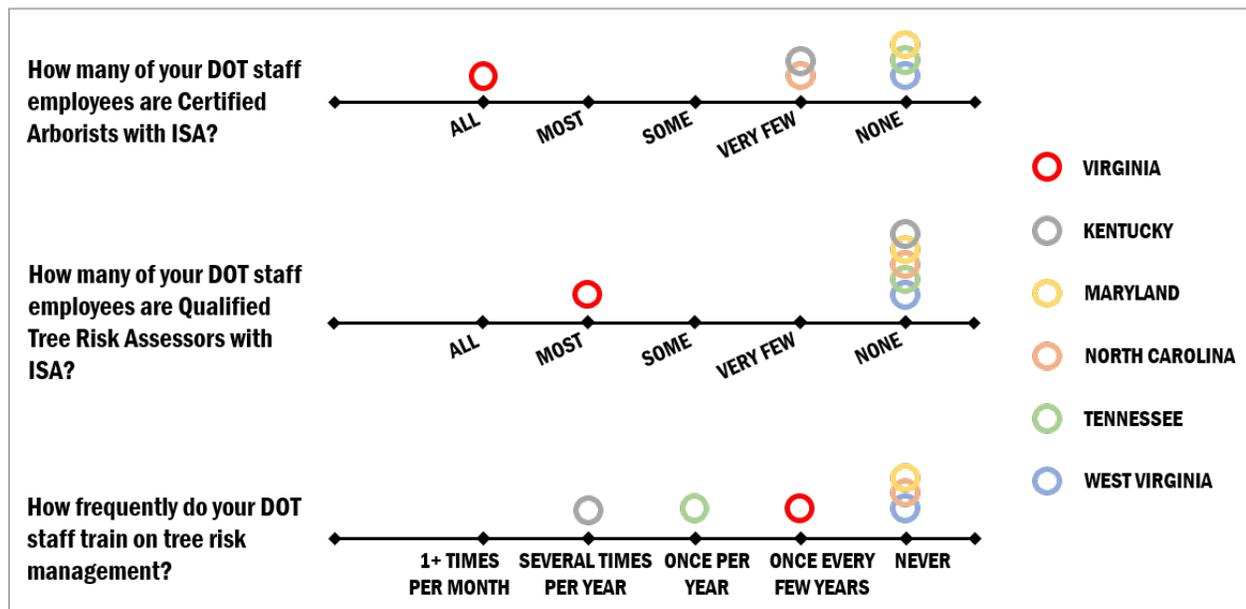


FIGURE 1: Qualifications and continuing education opportunities of DOT personnel with direct tree management responsibilities (excluding field production personnel who trim and remove trees).

Existing Conditions for Tree Risk Management

Roadway mileage under DOT supervision reported by the respondents (Table 1) ranged from 5,166 miles in Maryland (1,161 statewide inhabitants per roadway mile) to 79,000 miles in North Carolina (126 statewide inhabitants per roadway mile). Virginia had the second-highest roadway mileage at 57,000 miles (147 statewide inhabitants per roadway mile). The ratio of population to roadway miles, while an easy metric to calculate, is not a strong indicator of tree risk exposure. Road

use intensity (e.g., vehicles per day) would provide a better indication of target occupancy, which is used by risk assessors to judge the likelihood of a roadside tree striking a target in the event of a failure. A clear understanding of target occupancy is important for accurate risk rating because visual perceptions of occupancy by arborists have been shown to be greater than actual occupancy (Klein et al., 2016), which could lead to excessive intervention to mitigate perceived hazards. Additional considerations are the number, proximity, size, and type of roadside trees. All things being equal, a high density of large trees in close proximity to the roadway increases the likelihood of a significant tree failure incident. In the big picture of strategic tree risk management, careful consideration must be given to ensuring that management resources are allocated prudently and proportionate to risk exposure. With increasing numbers of trees and vehicles comes greater likelihood of a significant tree failure incident. Therefore, ensuring that there are sufficient qualified personnel to monitor and maintain roadside trees is an important aspect of the DOT's tree risk management duty.

We asked respondents about their perceptions of tree failure incidents and the DOT's capacity and efficacy for managing roadside tree risk. Roadside tree failure incidents appear to be uncommon in the surveyed states, with two states (NC and TN) reporting rare incidents and the other four states reporting occasional incidents (Figure 2). As a result, the emphasis placed on managing roadside tree risk was quite variable across the states. Only one state (KY) strongly agreed that risk management is a major emphasis, while four states (including VA) either agreed or were neutral that risk management is a major emphasis. Maryland disagreed that risk management is a major emphasis, but the reason for this is unknown. Perhaps Maryland views tree failure incidents as lacking necessary attention from state officials. The Maryland respondent also disagreed that the state DOT has the necessary resource and expertise to manage risk effectively and that the agency is effective at managing risk. West Virginia seemed to have similar viewpoints to Maryland in this regard. Interestingly, the Virginia respondent disagreed about having necessary resources to managing tree risk, yet agreed that the agency is effective at managing risk. Perhaps there is a perception that there are opportunities to improve VDOT's effectiveness with additional resources, particularly since managing tree risk is a major emphasis in that state.

Three states (KY, NC, and TN) agreed or strongly agreed that their DOT has necessary resources and expertise and is effective at managing tree risk (Figure 2). Two of these states (NC and TN) indicated that tree failure incidents are rare; therefore, the challenges for their agencies may not be as pressing as in other states. We could not conclude from this survey whether the rarity of incidents is due to effective management or favorable natural circumstances. On one hand, four of six states (including VA) either agreed or strongly agreed that their DOT is effective at managing

roadside tree risk, which would result in fewer incidents. However, aggressive measures to preclude trees from growing at the roadside could also reduce incident frequency (along with the numerous benefits provided by trees). It would be interesting to study how these states balance the competing interests of tree risk reduction and tree benefit provision at the roadside.

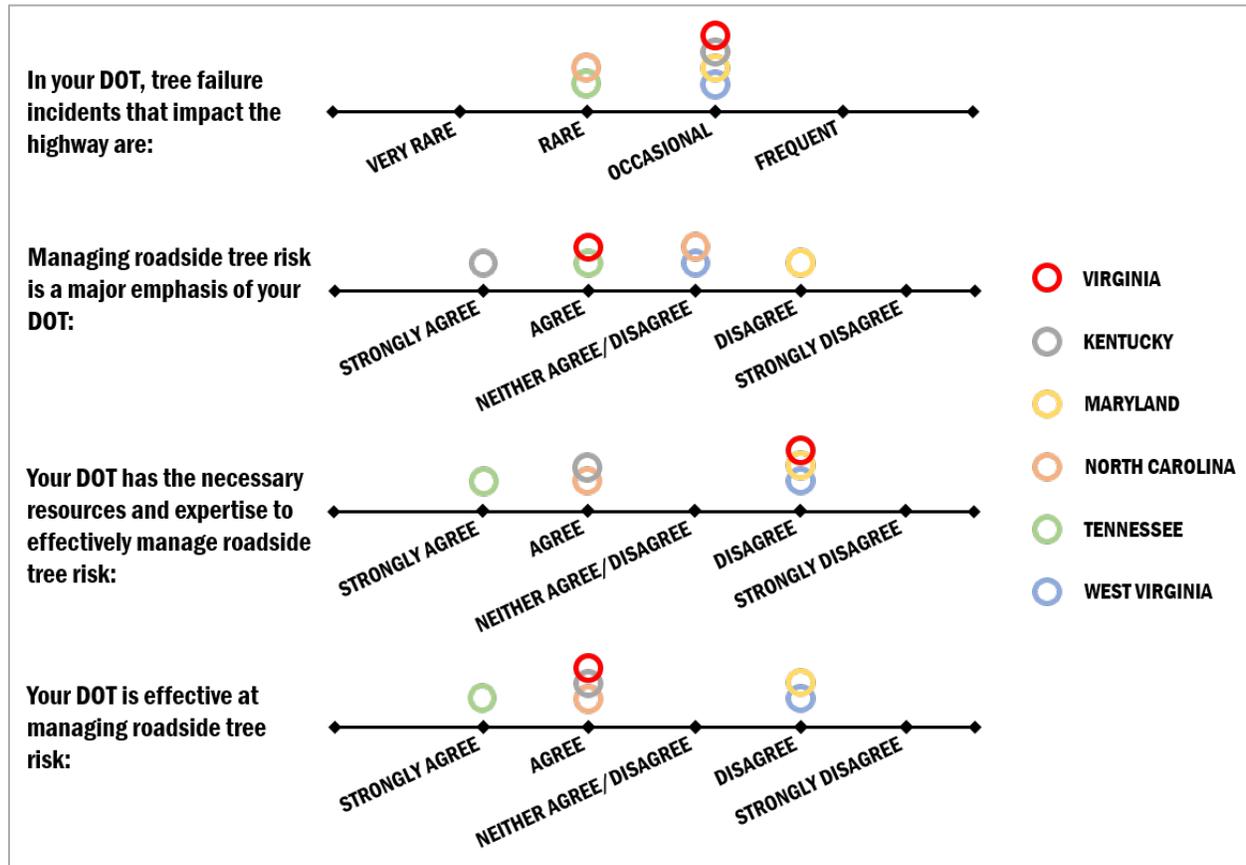


FIGURE 2: Survey respondent perceptions of tree failure incidents and the capacity and efficacy of their state departments of transportation in managing roadside tree risk.

Tree Risk Management Policies

State legislative statutes, agency administrative codes, and case law create a legal framework that compels DOTs to manage tree risk. For this reason, we asked the respondents to indicate whether these legal constructs exist in their states. None of the states indicated that tree risk management is addressed explicitly in either state statutes or administrative codes (data shown in Appendix 3). This was a very specific question that might be outside the bounds of the respondents' knowledge about state regulations. While it might be out of the ordinary for tree risk to be addressed specifically in state regulations, there most likely are regulations addressing DOT risk management more generally. This topic needs further examination to ascertain the duty and

standard of care that has been established for state DOTs through either statutes or administrative codes.

Prevailing professional standards and viewpoints on tree risk management indicate that organizations with a mandate to safeguard patrons and other assets should operate under a tree risk management policy. Agencies are accustomed to enacting policies to address critical organizational functions. For DOTs, tree risk management is a specialized function comprising technical procedures and practices that merit a policy. Without a policy, there is no clear expectation for how agency personnel will carry out procedures and implement practices aimed at detecting, assessing, and correcting hazardous trees. Inconsistencies arise across the agency and the organization may appear arbitrary and capricious in carrying out its tree risk management duties. For these reasons, having a policy is a prudent approach to clearly communicating the DOT's duty and standard of care to both internal and external stakeholders. However, creating a policy is a significant undertaking for an organization, particularly when dealing with a complex, dynamic topic such as tree risk management. Moreover, adopting a policy may force a "one size fits all" approach onto an organization with diverse personnel, clientele, and local management circumstances.

In our survey, four of six respondents reported that their DOTs do not have a tree risk management policy (data shown in Appendix 3). West Virginia indicated that its DOT has a policy; however, in the subsequent question, the respondent pointed out that the tree maintenance manual was the basis for the policy. Therefore, it is unclear whether West Virginia has a comprehensive policy or a narrow policy focused solely on risk mitigation through tree maintenance. Kentucky also reported that its DOT has a policy, but did not provide details about the basis for the policy. Curiously, three of the six states (MD, NC, and TN) indicated that their DOT not only lacks a tree risk management policy, but also does not plan to develop one.

Virginia was the only state that indicated intent to develop a tree risk management policy. We did not delve into the reasons that state DOTs lack a policy or intent to develop one. Perhaps a policy is viewed as unnecessary, particularly given that tree failures were reported as uncommon incidents, roadside tree risk management generally was not reported as a major emphasis of the state DOTs, and most respondents viewed their DOTs as effective in managing roadside tree risk. A policy of any sort can be a double-edged sword. While they can provide clarity on procedures and help hold personnel accountable for their management decisions, they can also create rigid bureaucracy that is inefficient and stifles nimble problem solving. Nevertheless, a cost-benefit analysis for adopting a tree risk management policy would be prudent for any state DOT.

Duty of care and standard of care for tree risk management are also shaped by extrinsic forces such as case law and legal precedents that come about through court opinions (Bidwell, 2014; Mortimer & Kane, 2004). Therefore, we asked the respondents if they were aware of any legal cases involving trees in their states that have influenced state regulations or agency policies. None of the states reported being aware of any influential legal cases (data shown in Appendix 3). This does not necessarily mean that such cases do not exist, simply that there is lack of awareness among respondents. Anecdotally, legal cases brought against state DOTs concerning roadside tree incidents are rare due to the immunity afforded to agencies by sovereign immunity. Under this legal principle, agencies and their employees are not subject to tort claims unless there is proof of intentional malfeasance or acting outside the scope of employment. In many states, recent Tort Claims Acts have limited or eliminated, at least in part, sovereign immunity (Matthiesen, Wickert, & Lehrer Law Firm, 2017). Sovereign immunity does not preclude a party seeking injunctive relief from the courts aimed at restraining or compelling a state DOT to take a particular action (Roberts & Associates, 2017). Therefore, as an example, a situation might come about where a party seeks injunctive relief to block removal of a tree that may have been insufficiently inspected or arbitrarily condemned for removal (or vice versa). The influence of case law on state DOT policies for tree risk management needs further investigation.

Tree Risk Management Procedures

We asked respondents about the tree risk inspection and diagnostic procedures used by their DOT personnel. These are procedures employed to detect and assess potentially hazardous trees. First, we asked respondents if their DOTs have a standardized, systematic process for periodically inspecting trees. Four of six respondents (MD, NC, VA, and WV) reported that their DOTs do not have a standardized inspection process and only one of them (VA) indicated intent to develop such a process (data shown in Appendix 3). Although both Kentucky and Tennessee responded that their DOTs have a standardized inspection process, neither state reported that they use Best Management Practices for Tree Risk Assessment (Smiley et al., 2011) for their inspections.

Although Virginia does not have a standardized inspection process, the respondent indicated that DOT personnel use the ISA Tree Risk Assessment BMP when inspecting trees. While this might sound contradictory, recall that most roadside tree managers with VDOT are Qualified Tree Risk Assessors by the ISA and therefore are familiar with the BMP and its use. Therefore, while VDOT does not consider its inspection process standardized, there is some level of conformance in inspection practices among personnel. Interestingly, only one of the five other states (KY) indicated intent to adopt the BMP for roadside tree inspections in the future. We could not determine from this survey

why state DOTs are reluctant to adopt the BMP at this time. There might be lack of need, motivation, or understanding of the BMP. Standardization of tree risk inspections is viewed as an important aspect of risk management (Eden, 2007), and the BMP can provide a straightforward, legitimate basis for standardization within a DOT.

The respondents reported that drive-by “windshield surveys” are used by DOT personnel for roadside tree inspections occasionally to frequently (Figure 3). We were surprised that only two states (KY and TN) indicated using drive-by surveys frequently since these surveys are very efficient and are widely accepted as the standard of care for roadside tree inspection (Rooney et al. 2005). States reporting lower use might not allocate a large portion of staff time to official inspections of this type given the demands on their time for work order processing and contractor supervision. Regardless, allocating additional time for drive-by surveys may be prudent, particularly on high-risk routes.

Most states indicated that walk-by “360° surveys” are only occasionally used for roadside tree inspections (Figure 3). West Virginia reported rarely using walk-by inspections. Limited use of walk-by inspections by DOTs is not surprising given that they are time-consuming and DOTs are constrained by personnel resources. The respondents may also view walk-by inspections as unnecessary given their perception that roadside tree failures are rare or because intensive assessment of trees is inconsistent with their approach to tree risk management. However, walk-by inspections reveal additional details about tree condition and have been shown to statistically increase the inspector’s perception of failure likelihood in comparison to a limited visual inspection (Koeser et al., 2017). With that said, DOT tree management personnel may not be qualified to conduct walk-by inspections and therefore the agency may be uncomfortable with assigning this duty. Certified Arborists and Qualified Tree Risk Assessors were nearly absent amongst all state DOTs except Virginia.

During walk-by inspections, diagnostic tools such as a mallet, probe, or drill may be required to further examine and evaluate tree defects. While these diagnostic tools can provide valuable information (van Wassenae & Richardson, 2009), they also take additional time and expertise that may not be available or warranted. Most of the state DOTs reported using diagnostic tools rarely (KY, NC, and TN) or never (MD and WV). Only VDOT reported using diagnostic tools occasionally, which might be an indication that the agency has more skilled personnel qualified to use the tools (most are Qualified Tree Risk Assessors) or that the agency places greater emphasis on tree risk assessment for directing mitigation decisions. Also, other state DOTs may prohibit their personnel from using diagnostic tools and instead opt to hire a consulting arborist when the situation dictates that an advanced assessment is needed.

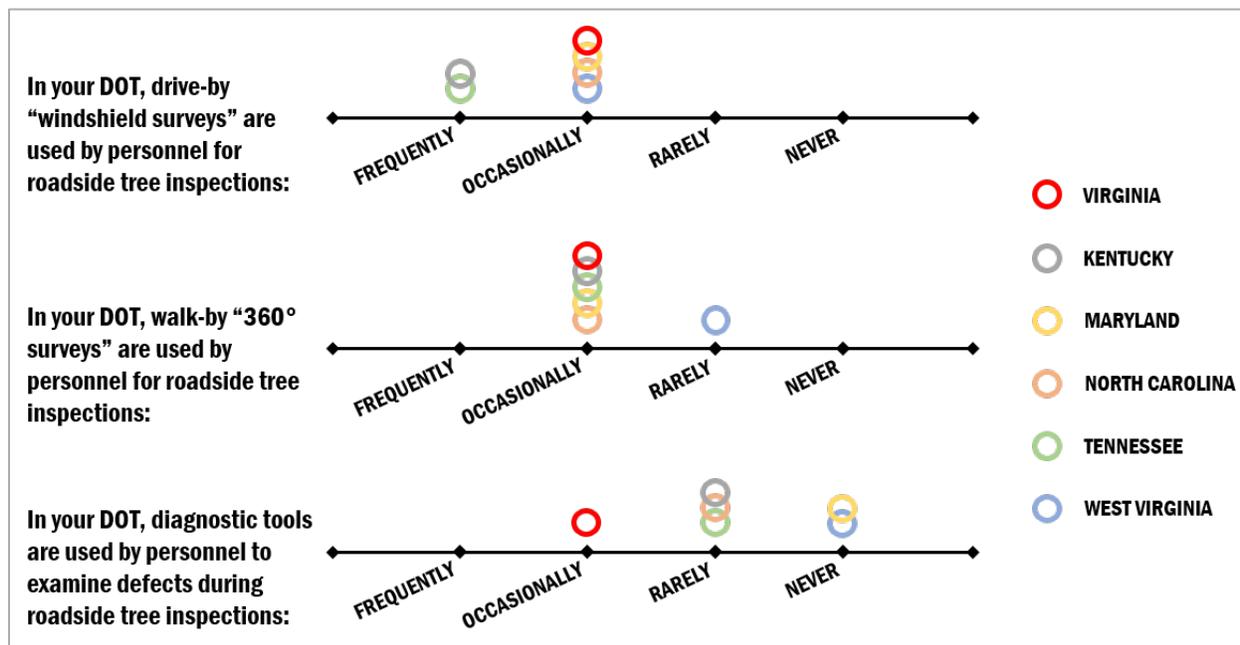


FIGURE 3: Tree risk inspection and diagnostic procedures employed by DOT personnel with direct tree management responsibilities (excluding field production personnel who trim and remove trees).

It is also possible that state DOTs, for sake of efficiency and expediency, may opt to remove trees with any visual indication of instability rather than invest time or resources into diagnostics-enhanced inspection. However, this may be contrary to ANSI A300–Part 9 (2017), which states in section 94 that a higher-level assessment (i.e., more sophisticated use of tools) should be considered when a lower-level assessment cannot sufficiently determine the severity of conditions or defects (ANSI, 2017).

The sheer number of roadside trees relative to DOT tree management resources makes walk-by inspections and diagnostic tools impractical for routine DOT operations. However, the finding that drive-by inspections are not used frequently by all state DOTs seems contrary to a reasonable standard of care. Roadside trees are very accessible for drive-by inspection and can be effectively screened for hazards using this technique (Rooney et al., 2005). Perhaps drive-by inspections are not used frequently because state DOTs rely on other means for detecting hazardous trees (e.g., notifications from road maintenance personnel, contractors, or citizens) or because they cannot justify using personnel for frequent inspections at the expense of other roadside management obligations. The manner and frequency of roadside tree inspections by state DOTs needs further study to clarify the standard of care and identify opportunities to improve this important aspect of tree risk management.

When operating within the scope of a tree inspection, tree management personnel are expected to analyze the level of risk posed by the tree (ANSI, 2017). Doing so may require use of a risk rating system—appropriate for the scope of work—that will ultimately guide risk mitigation decisions. Several risk rating systems have been proposed and implemented by tree care practitioners (Ellison, 2005). These systems use either quantitative (numerical scoring) or qualitative (hierarchical classification) approaches to assessing the likelihood of tree failure and harm to people or property. While the nuts and bolts of a risk rating system are left to the discretion of the assessor, the system should comply with ANSI A300–Part 9 in terms of conceptual process (ANSI, 2017). Because state DOTs have numerous personnel carrying out roadside tree risk assessments, they should not only strive to adopt an ANSI-compliant risk rating system, but also to standardize that system across the entire agency.

We asked the respondents if their state DOTs use a standardized tree risk rating system. None of the states has a standardized system and only two states (KY and VA) indicated intent to develop one (data shown in Appendix 3). It is not surprising that state DOTs lack a standardized risk rating system given that their personnel infrequently conduct tree inspections and many may not be qualified to use risk rating systems. Much like tree risk management policies, tree risk rating systems can also be a double-edged sword for a DOT. While rating systems can provide a systematic process for personnel to consistently assess and determine tree risk, they may also expose the DOT to scrutiny and litigation if they are not used properly. While ANSI A300–Part 9 lays out clear guidance about tree risk assessment in a general context, there does not appear to be a clear standard of care for whether DOTs must adopt a standardized tree risk rating system.

If DOT personnel are not available or lack qualifications to carry out tree risk assessments, DOTs might hire a consulting arborist under special circumstances. Respondents for four of the states (KY, MD, NC, and VA) indicated that their DOTs occasionally hire a consulting arborist (Figure 4). Tennessee rarely hires a consultant and West Virginia never hires a consultant. Our survey could not ascertain the exact circumstances for which a consulting arborist might be hired or what factors dictate the frequency of their hire. Because the decision to remove a roadside tree (or not) is often a point of disagreement between a DOT and the public, it may be that a consultant is hired to offer an objective, third-party opinion when a disagreement arises about the safety of a tree. There is no expectation per se, that a consulting arborist be hired to perform a tree risk assessment for a DOT; however, DOTs have a duty to ensure that risk assessments are carried out by qualified personnel, which may be lacking in some DOTs based on our survey.

Where private property is in close proximity to the roadway, it is not uncommon for privately owned trees to pose a risk to motorists or DOT assets. We found that most state DOTs occasionally

inspect private property trees (TN indicated rarely doing so). While legal liability for these types of trees varies (Beering & Scott, 2006), DOTs increasingly recognize that hazardous private trees can be a serious threat and that they have some measure of duty to address these hazards (TranSafety, 1997; Vance, 1988). The case law concerning hazardous trees on private property and the incumbent duty on DOTs to inspect or mitigate such trees is very sparse. Should an elevated duty exist for such trees, the burden on DOTs to increase the scope of their roadside tree inspections could be significant. More research is needed on this issue.

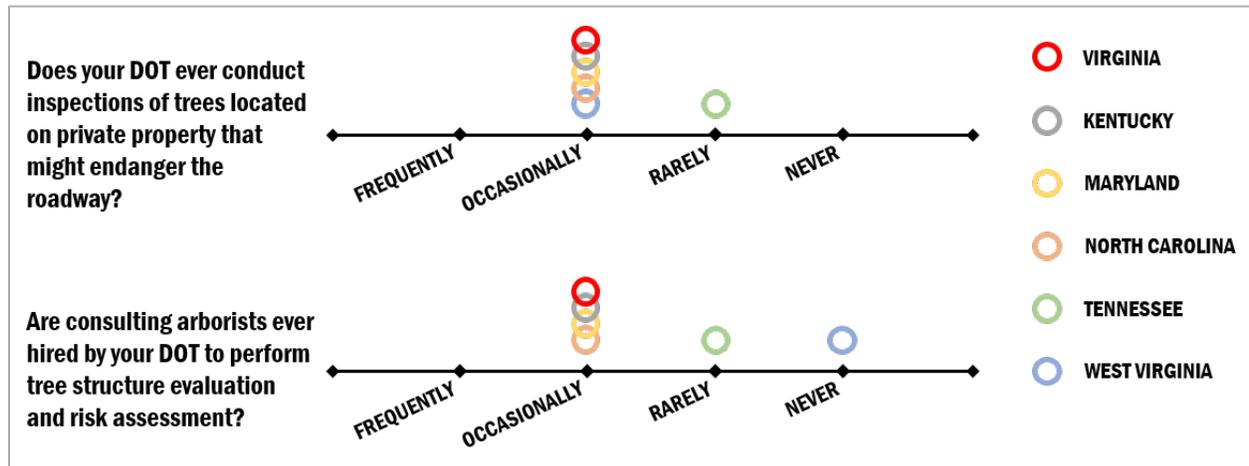


FIGURE 4: Frequency of tree inspections on private property or by hired consultants under the authority of state departments of transportation.

A comprehensive tree risk management program should address not only tree inspection and assessment procedures, but also systematic monitoring and analysis of tree failure incidents. Mapping and analytics are the future of managing risk in large tree populations (Poulos & Camp, 2010) and there is tremendous potential to improve roadside tree management with these decision support systems. We asked respondents if their state DOTs are using GIS or similar technology to analyze or manage roadside tree failure risks. None of the six state DOTs are currently using technology in this manner and only VDOT indicated intent to do so in the future (data shown in Appendix 3). There seems to be reluctance or incapability by DOTs to adopt technology for tree risk management at this time, but the reasons for this are unknown because we did not delve into the issue further with our survey. Mapping and analytics will become more commonplace in the future as practice catches up with science and as the workforce steadily elevates its level of technology competency. As a result, the standard of care for using technology for tree risk management will likely increase and DOTs should examine their capabilities in this regard.

At a more rudimentary level is simply documenting tree failure incidents in order to evaluate tree risk management operations and to limit liability exposure (Anderson & Eaton, 1986). Four of six respondents (MD, NC, TN, and WV) indicated that their state DOT does not document tree failure incidents and does not intend to do so in the future (data shown in Appendix 3). Tree failure incidents are documented by DOTs in Kentucky and Virginia. Although it was beyond the scope of this study, it would be helpful to understand how this documentation is performed and how the information is used. Again, it is not surprising that documentation is not widely utilized by state DOTs given the resources required as well as the potential legal ramifications of having tree failure incidents on file. There is understandable concern that such information might be held against an agency should questions arise about the conduct in handling an incident. However, documentation does not have to be burdensome or potentially incriminating to reveal useful information about tree failure incidents. In fact, it may not be necessary for tree management personnel to document incidents directly. There might be surrogate data available in DOT information management systems. For example, work logs of contractors or citizen service requests might reveal patterns in tree removal or pruning intensity that are indicative of tree risk in a particular roadside setting (Luley et al. 2002). Additionally, traffic incident reporting systems might be configured to track trees that fall into the roadway. In the aggregate and over long periods, these types of data might have predictive abilities for roadside tree failure incidents. This could enable DOTs to deploy resources for tree maintenance and risk mitigation more efficiently and expediently.

Tree Risk Management Practices

Tree risk management practices are the activities undertaken to select sturdy roadside trees, protect them from injuries and disturbances that might predispose them to failure, and mitigate hazards when they are discovered. The types of trees that are planted at the roadside and the construction and maintenance activities that are carried out around trees can have a significant influence on tree failure incidents (Pokorny et al., 2003). For this reason, we asked the respondents how frequently their DOT tree management personnel consult with their agency colleagues about these activities (Figure 5). Tree managers tend to be consulted about tree selection more frequently than about construction and maintenance activities. Respondents from three states (KY, MD, and VA) reported frequent or occasional consultation about tree selection (Figure 5). However, the other three states (NC, TN, and WV) indicated that consultation was rare. Because most state DOTs have landscape architects on staff for roadside design, tree selection may not be in the purview of DOT tree managers. However, tree managers often have a wealth of knowledge and experience with tree

suitability for roadside plantings and could provide valuable input on the attributes of trees that make them less apt to develop defects or fail during inclement weather.

Half of the states reported rarely (NC and TN) or never (WV) having tree managers consulted about construction or maintenance activities that might impact trees (Figure 5). The other half (including VA) only reported occasional consultation. Earthmoving equipment used during roadway construction may cause tree injuries that decrease root anchorage (Smiley, 2008) and stem integrity (Smiley et al., 2012), possibly leading to tree failure in the future. Forest clearing during construction that isolates roadside trees and exposes them to increased loading from wind and precipitation is also a predisposing risk factor for tree failures (Mitchell & Ruel, 2015). We were not able to determine with this survey why consultation occurs infrequently. It seems that increased consultation with tree management personnel to review construction plans might be an opportunity for state DOTs to reduce tree failure incidents. With that said, these state DOTs may be hiring private consultants to carry out these duties rather than utilizing DOT staff, particularly if those staff members have limited expertise on tree responses to injury and best practices for managing construction around trees.

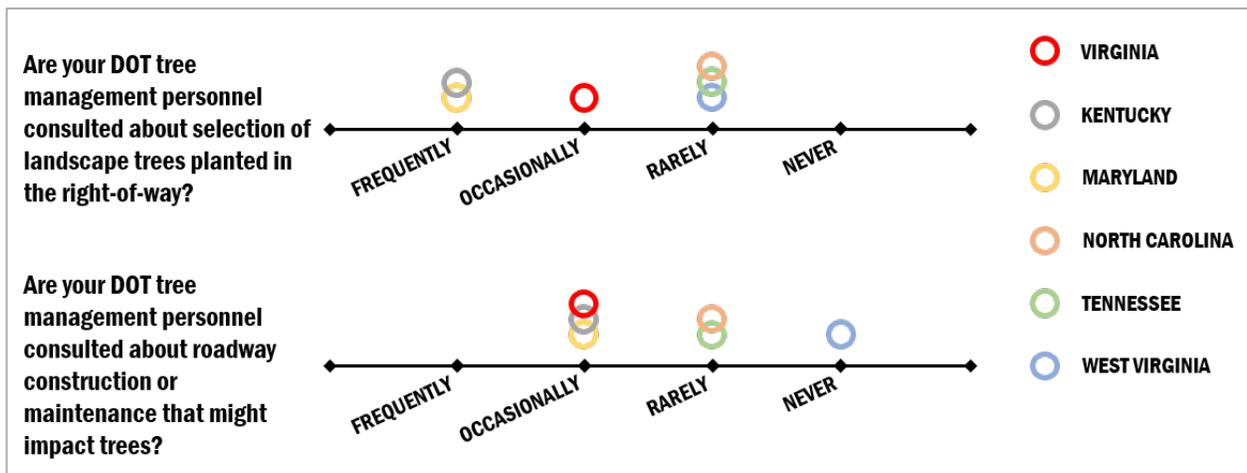


FIGURE 5: Frequency of consultation on tree selection and tree disturbance activities at the roadside by DOT personnel with direct tree management responsibilities (excluding field production personnel who trim and remove trees).

Roadside trees that are judged to pose an unreasonable risk of failure and harm to motorists or DOT assets are typically mitigated through removal or pruning. Removal is an extreme measure taken when the risk cannot be reduced to an acceptable level through pruning alone. The decision to remove a roadside tree is not easy. Doing so may come at considerable financial expense and may lead to traffic delays (due to setting up a roadside work zone) or public outcry about the loss of

desirable trees. There is also evidence that removing trees may increase failure risk of nearby trees by increasing their exposure to wind loading (Kane, 2008). In contrast, retaining a tree of questionable stability is irresponsible and may lead to litigation if harm is caused by the tree should it fail. Coming to a rational conclusion to remove a tree in a public setting is a complex process that must take into account varying perceptions of risk (Koeser et al., 2015) and balance the marginal gain in public safety with the marginal economic and environmental costs of removal (Fay, 2007). The prevailing expectation is that DOT personnel will make a reasonable and prudent decision that is in the best interest of the public and is consistent with industry standards and BMPs.

We delved into tree removal as a risk mitigation practice with the third question in part five of the survey (data shown in Appendix 3). The intent of this question was to ascertain who has tree removal authority and how they arrive at a tree removal decision. The question was structured to allow the respondent to choose as many answer options as applied to their DOT. Unfortunately, this resulted in some respondents giving contradictory answers that are difficult to interpret. For example, answer options #1 and #4 were intended to represent contrasting decision-making processes, in which option #1 denotes a perfunctory process of “cut first and ask questions later”, and option #4 denotes a methodical process in which a thorough inspection is performed to assess failure risk and target exposure to harm. The point of this contrast was to discern whether DOTs exercise judicious use of tree removal or make decisions based solely on the presence of tree defects, which may lead to unnecessary tree removals (Ellison, 2007). Unfortunately, three respondents checked off both options (KY, VA, and WV), so it is impossible to discern the prevailing approach to tree removal in those states. This may imply that the approach to tree removal is context dependent: in some settings, an expedient approach that errs on the side of removal may be taken and in other settings, a more measured approach that errs on the side of retention may be taken. It is worth noting that five of six states (omitting NC) checked off answer option #4, indicating that they employ tree removal after a thorough inspection (data shown in Appendix 3). Also, four of six states (KY, MD, TN, and VA) indicated that removing roadside trees to reduce failure risk is influenced by the opinions and demands of the public. The North Carolina respondent had the least revealing reply to this question, only agreeing with the statement that tree removal is at the discretion of DOT tree management personnel. No respondent indicated that tree removal is at the discretion of DOT contractors, which suggests that removal decisions are carefully controlled, either for fiscal or political reasons.

Pruning may be prescribed alternatively to removal when roadside trees have moderate to major defects confined to the crown. Common examples include dead, broken, or cracked branches; weak branch attachments with included bark; decayed branches; or over-extended branches. In

some situations, pruning may be used to alleviate failure risk associated with trunk or root defects whereby crown reduction or thinning reduces loading on the defective tree part (Gilman et al., 2008; Pavlis et al., 2008; Smiley & Kane, 2006). Pruning for risk reduction must be carefully prescribed by a qualified arborist using industry standards and BMPs.

We asked respondents how their state DOTs use pruning for tree failure risk mitigation. First, we asked if the state DOT has a policy or bid specification that describes roadside tree pruning standards. Having standards for pruning ensures that proper pruning cuts are used to achieve the risk mitigation objective and do not impair the tree’s health or appearance. Five of six respondents (omitting TN) indicated that their DOT has pruning standards described in a policy or bid specification (data shown in Appendix 3). Four of these five states (omitting WV) indicated that their pruning standards are based on ANSI A300–Part 1 (ANSI, 2008).

We concluded our survey by asking the respondents about the pruning practices employed by their DOTs for tree risk mitigation. Five of six states (omitting TN) indicated that their pruning practices are primarily reactive—addressing existing branch defects and failure risks discovered during routine inspections (Figure 6). Tennessee reported using a balanced mix of reactive pruning and proactive pruning, which aims to selectively remove branch parts early in tree development in order to prevent defect development and long-term failure risks. Four of six states (KY, MD, NC, and WV) reported that proactive pruning is very underutilized by their DOTs, whereas Virginia indicated that it is somewhat underutilized and Tennessee indicated that it is utilized appropriately (Figure 6).

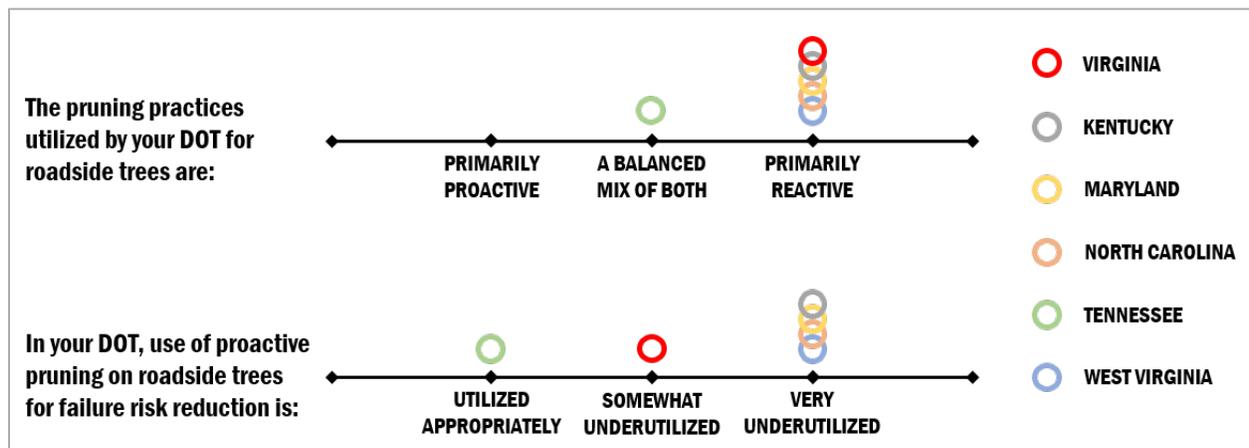


FIGURE 6: Characterization of pruning practices utilized by DOT personnel and contractors as either proactive (focusing on developing good crown structure so that trees are less likely to develop defects) or reactive (focusing on trees that have developed serious branch defects such as cracks, decay, and deadwood).

Proactive pruning is a “stretch goal” for almost any organization, particularly a state agency, because it focuses on problems that could develop rather than those that currently exist. Most

agencies have a considerable backlog of reactive (mitigation) pruning and cannot justify extensive use of proactive pruning. Moreover, proactive pruning arguably requires greater knowledge, skill, and judgment than reactive pruning, which might drive up the unit cost of tree trimming contracts. However, proactive pruning may reduce long-term costs if trees become sturdier and are less prone to failure during inclement weather (Luley et al. 2002). DOTs appear to be making some use of proactive pruning, perhaps targeting its use to high-touch areas where expectations for tree sturdiness and appearance are greater. Limited use of proactive pruning is not necessarily an indicator of irresponsible tree risk management, but rather is an operational consideration for deploying limited resources to achieve overall risk reduction objectives for the DOT.

CONCLUSION

In this pilot study, we aimed to understand the prevailing standard of care exercised by state DOTs in the Mid-Atlantic region to manage risks associated with roadside trees. We utilized a survey distributed to the state roadside vegetation coordinator (or equivalent position) for each DOT to delve into aspects of tree risk management, touching on personnel, policies, procedures, and practices. From these responses, we were able to compare and contrast the states in their approaches to tree risk management and benchmark VDOT relative to its peers in the region.

Because this was a pilot study, we took a basic approach to obtaining information from each state DOT by utilizing a survey comprising 38 multiple-choice and short-answer questions. This was a very efficient approach to collecting information that has probably never been investigated in a systematic manner. With that said, our study method had several limitations that must be considered when interpreting these data:

- 1. Survey sampling frame.** We had limited time and resources to survey a large contingent of the DOT in each state. Therefore, we chose to survey the roadside vegetation management coordinator, believing that this respondent would have the best overall perception of the current conditions in tree risk management across the state. While overall perception is sufficient for understanding certain aspects of risk management, it tends to have an averaging affect across the state in question. This is helpful for understanding prevailing standard of care, but it does not provide insight on the range of conditions and capabilities that exist within a particular state. These nuances would be better uncovered by having multiple DOT respondents in each state, representing multiple geographic and demographic regions.

- 2. Respondent bias.** Asking agency representatives to answer questions intended to judge the conditions and capabilities within their agency is a trick endeavor for the researcher. Respondents might be hesitant to provide forthright answers for fear of casting their agency in a bad light or of bringing unwanted attention to possible deficiencies in the agency's operations. Bias could also exist if the respondents lack knowledge or awareness about certain issues within their agency. Their perceptions, as a state-level administrators, may not truly reflect local conditions in the field.
- 3. Instrument bias.** Proper design of a survey is critical for eliciting robust data from which strong inferences can be made. While we have considerable experience writing survey instruments, this particular survey was not subjected to beta testing prior to distribution to the DOT respondents given our limited time and resources. Beta testing can reveal issues with respondent comprehension of questions and/or answer options. We addressed our limitation in this regard by developing the instrument in close consultation with VDOT. Another possible issue is the reliability of our questions in revealing answers about the conditions and capabilities we sought to understand. We found no record of a similar survey having been conducted for state DOTs previously; therefore, we did not have a precedent for our conceptual framework or our instrument design. Instead, we drew upon a large body of literature looking at tree risk management surrogate settings such as public parks, utility rights-of-way, and municipalities.
- 4. Interpretation bias.** The limited scope of this study did not provide us much opportunity to ask follow-up questions on certain aspects of tree risk management that would benefit from further probing. In those cases, we were left to interpret the answers based on our understanding of DOT operations and tree risk management at large. We were careful not to overly speculate about the reasons behind answers, but did offer qualified assertions to possibly explain what we observed, mostly in hopes that it might help with formulating additional research questions to carry this line of study further. There was much nuance behind many of the survey questions that deserves further study. Structured interviews with DOT personnel and independent analysis of DOT documents (e.g., personnel position descriptions, policies, and operation guidelines) would be helpful in this regard.

From this study, we were able to gain insights on the prevailing standard of care for tree risk management by state DOTs in the Mid-Atlantic region. Our conceptual framework for this study laid out four dimensions of tree risk management conditions and capabilities: personnel, policies, procedures, and practices. Here we summarize our findings for each dimension:

- 1. Personnel.** The leadership of state DOTs in managing roadside vegetation appears similar in terms of educational background, scope of work, and self-reported tree management expertise. VDOT is the only state DOT that currently has an ISA Certified Arborist leading its statewide operations and the only state where most DOT tree management personnel are both an ISA Certified Arborist and an ISA Qualified Tree Risk Assessor. Training on tree risk management for VDOT personnel is above average in terms of frequency, but it is difficult to ascertain from this survey whether VDOT’s workforce is comparable to other states in terms of sheer numbers. VDOT was consistent with the majority of respondents in stating that resources and expertise for effectively managing roadside tree risk are inadequate, yet believing that the DOT is effective at managing roadside tree risk. This sounds contradictory, but implies that DOTs feel they are fulfilling their duty, but could improve effectiveness of their operations with additional resources.
- 2. Policies.** The policy situation with these DOTs was difficult to ascertain with a survey, and our study constraints did not allow us to delve independently into various state policy documents. The key finding is that the majority of state DOTs currently do not possess a tree risk management policy and have no intention to develop one. Although VDOT does not currently have a policy, it did indicate intent to develop one in the future. Lack of a tree risk management policy does not necessarily indicate dereliction of duty to manage risk, but could be an opportunity to improve DOT operations in terms of standardizing decision-making processes and field practices.
- 3. Procedures.** Tree risk management procedures are increasingly defined by ANSI A300–Part 9, which is the voluntary consensus standard for assessing tree failure risk in the United States. Procedural aspects of this standard have been further codified in the ISA Tree Risk Assessment Qualification and the ISA Tree Risk Assessment BMP. Most states (including VDOT) reported that they currently do not have a standardized process for either inspecting roadside trees or rating tree risk. State DOTs were very similar in their use of both drive-by and walk-by tree inspections. That most states only occasionally utilize drive-by inspections should be a matter for further inquiry and clarification as it might indicate that trees are not receiving adequate inspection. Related to this, the majority of DOTs reported rarely or never utilizing diagnostic tools during inspections, which might also indicate a lack of rigor in inspection duties. VDOT reported the highest use of diagnostics, perhaps due in part to the greater proficiency of VDOT staff in risk assessment procedures. It appears that all state DOTs could make improvements on their tree risk inspection and rating procedures.

4. Practices. The expertise of DOT tree management personnel appears to be underutilized for selecting trees to be planted at the roadside and protecting trees from excessive impacts during roadway construction and maintenance. While these duties are no doubt the primary responsibility of landscape architects, engineers, and consulting arborists, much could be learned about improving these duties through feedback from tree management personnel who deal with the repercussions of inappropriate tree selection and harmful tree disturbance. Developing a mechanism for dialogue amongst these agency elements could pay dividends for long-term tree management. Use of tree removal and pruning to mitigate risk deserves much further investigation beyond this pilot study. Not much could be gleaned from the survey about DOT tree removal practices other than removal decisions are not ceded to DOT contractors and are influenced by the opinions and demands of the public. Almost all DOTs (including VDOT) reported that their pruning practices are primarily reactive, addressing branch and crown defects after they have reached a potentially hazardous state. Further, most DOTs indicated that proactive pruning to prevent branch and crown defects is very underutilized (VDOT was slightly better, but still underutilized). Much research has been done on hazard reduction pruning in the context of municipal public spaces and utility rights-of-way in an effort to understand the frequency and intensity of pruning that minimizes incidents and maximizes return-on-investment. This is a topic ripe for further study by DOTs.

Based on this pilot study using a narrowly scoped survey as the primary mechanism for gathering data and evidence, VDOT appears to be on firm footing with its tree risk management program. Compared to peer DOTs in the Mid-Atlantic region, VDOT has highly qualified personnel, has similar policy conditions, and utilizes tree risk management procedures and practices in a comparable manner. We chose to use a peer benchmarking approach in this study because there is no clear standard of care for DOTs when it comes to tree risk management. Further, limited guidance can be gleaned from state statutes and administrative codes, and the case law on roadside tree failure incidents involving DOTs is scarce. Therefore, it is difficult to infer the standard of care for DOTs. We are left with construing the standard of care using the test of negligence liability: how would a reasonably prudent person act under similar circumstances? While following the conventions of peer agencies in operating a tree risk management program will not absolve a DOT from tree failure liabilities, benchmarking is a strong indication of the prevailing standard of care and serves as a reasonable guide until further clarity on duty and standard of care becomes evident in legal and industrial guidance documents.

WORKS CITED

- Anderson, L. M. (1988). Legal liability for defective trees in the United States. *Landscape and Urban Planning*, 15(1-2), 173-184.
- Anderson, L. M., & Eaton, T. A. (1986). Liability for damage caused by hazardous trees. *Journal of Arboriculture*, 12(8), 189-195.
- ANSI. (2008). American National Standard: Tree, Shrub, and Other Woody Plant Management – Standard Practices (Pruning), A300 (Part 1). ANSI, Washington, DC, 33 pp.
- ANSI. (2017). American National Standard: Tree, Shrub, and Other Woody Plant Management – Standard Practices (Tree Risk Assessment a. Tree Failure), A300 (Part 9). ANSI, Washington, DC, 14 pp.
- Ball, D. J., & Watt, J. (2013). The risk to the public of tree fall. *Journal of Risk Research*, 16(2), 261-269.
- Beerling, P. S., & Scott, J. R. (2006). Premises Liability and Your Trees. *Vineandbranch.net*. Retrieved 2 June 2017, from http://www.vineandbranch.net/Premise_liability_4-9-07.pdf.
- Bidwell, L. D. (2014). Of trees, vegetation, and torts: re-conceptualizing reasonable land use. *Catholic University Law Review*, 62(4), 1035-1060.
- Eden, N. (2007). Towards a national standard for tree risk inspections. *Arboricultural Journal*, 30(2), 127-136.
- Ellison, M. J. (2005). Quantified tree risk assessment used in the management of amenity trees. *Journal of Arboriculture*, 31(2), 57-654.
- Ellison, M. (2007). Moving the focus from tree defects to rational risk management—A paradigm shift for tree managers. *Arboricultural Journal*, 30(2), 137-142.
- Fang, C. F., & Ling, D. L. (2003). Investigation of the noise reduction provided by tree belts. *Landscape and Urban Planning*, 63(4), 187-195.
- Fay, N. (2007). Towards reasonable tree risk decision-making?. *Arboricultural Journal*, 30(2), 143-161.
- FHWA. (2017). Design Standards - Design - Federal Highway Administration. *Fhwa.dot.gov*. Retrieved 1 June 2017, from <https://www.fhwa.dot.gov/programadmin/standards.cfm>.
- Fitzpatrick, C. D., Harrington, C. P., Knodler, M. A., & Romoser, M. R. (2014). The influence of clear zone size and roadside vegetation on driver behavior. *Journal of Safety Research*, (49), 97-e1.

Gilman, E. F., Masters, F., & Grabosky, J. C. (2008). Pruning affects tree movement in hurricane force wind. *Arboriculture and Urban Forestry*, 34(1), 20-28.

Kane, B. (2008). Tree failure following a windstorm in Brewster, Massachusetts, USA. *Urban Forestry & Urban Greening*, 7(1), 15-23.

Klein, R. W., Koeser, A. K., Hauer, R. J., Hansen, G., & Escobedo, F. J. (2016). Relationship between perceived and actual occupancy rates in urban settings. *Urban Forestry & Urban Greening*, 19, 194-201.

Koeser, A. K., Klein, R. W., Hasing, G., & Northrop, R. J. (2015). Factors driving professional and public urban tree risk perception. *Urban Forestry & Urban Greening*, 14(4), 968-974.

Koeser, A. K., Hauer, R. J., Klein, R. W., & Miesbauer, J. W. (2017). Assessment of likelihood of failure using limited visual, basic, and advanced assessment techniques. *Urban Forestry & Urban Greening*, 24, 71-79.

Luley, C. J., Sisinni, S., & Pleninger, A. (2002). The effect of pruning on service requests, branch failures, and priority maintenance in the city of Rochester, New York, US. *Journal of Arboriculture*, 28(3), 137-143.

Matthiesen, Wickert, & Lehrer Law Firm. (2017). State Sovereign Immunity and Tort Liability in All 50 States. Mwl-law.com. Retrieved 2 June 2017, from <https://www.mwl-law.com/wp-content/uploads/2013/03/STATE-GOVERNMENTAL-LIABILITY-IN-ALL-50-STATES-CHART-GLW-00211981.pdf>.

Mitchell, S. J., & Ruel, J. C. (2015). Modeling windthrow at stand and landscape scales. In *Simulation Modeling of Forest Landscape Disturbances* (pp. 17-43). Springer International Publishing.

Morani, A., Nowak, D. J., Hirabayashi, S., & Calfapietra, C. (2011). How to select the best tree planting locations to enhance air pollution removal in the MillionTreesNYC initiative. *Environmental Pollution*, 159(5), 1040-1047.

Mortimer, M. J., & Kane, B. (2004). Hazard tree liability in the United States: uncertain risks for owners and professionals. *Urban Forestry & Urban Greening*, 2(3), 159-165.

Naderi, J. R., Kweon, B. S., & Maghelal, P. (2008). The street tree effect and driver safety. *ITE Journal on the Web*, 78(2), 69-73.

Naik, B., Matlack, G., Khoury, I., Sinha, G., & McAvoy, D. S. (2017). Effects of Tree Canopy on Rural Highway Pavement Condition, Safety, and Maintenance: Phase 1 (No. FHWA/OH-2017/18). Ntl.bts.gov. Retrieved 5 June 2017, from https://ntl.bts.gov/lib/61000/61700/61746/Effects_of_tree_canopy_on_rural_highway_pavement_condition_safety_and_maintenance.pdf.

- Pavlis, M., Kane, B., Harris, J. R., & Seiler, J. R. (2008). The effects of pruning on drag and bending moment of shade trees. *Arboriculture and Urban Forestry*, 34(4), 207-215.
- Pokorny, J., O'Brien, J., Hauer, R., Johnson, G., Albers, J., Bedker, P., & Mielke, M. (2003). *Urban Tree Risk Management: A Community Guide to Program Design and Implementation*. USDA Forest Service Northeastern Area State and Private Forestry, St. Paul, Minnesota. NA-TP-03-03.
- Poulos, H. M., & Camp, A. E. (2010). Decision support for mitigating the risk of tree induced transmission line failure in utility rights-of-way. *Environmental management*, 45(2), 217-226.
- Roberts & Associates. (2017). Overview of Sovereign Immunity in Virginia. RobertsLaw.org. Retrieved 2 June 2017, from http://www.robertslaw.org/sovereign_immunity_in_virginia.htm.
- Rooney, C. J., Ryan, H. D. P., Bloniarz, D. V., & Kane, B. C. P. (2005). The reliability of a windshield survey to locate hazards in roadside trees. *Journal of Arboriculture*, 31(2), 89-94.
- Schmidlin, T. W. (2009). Human fatalities from wind-related tree failures in the United States, 1995–2007. *Natural Hazards*, 50(1), 13-25.
- Smiley, E. T. (2008). Root pruning and stability of young willow oak. *Arboriculture and Urban Forestry*, 34(2), 123-128.
- Smiley, E. T., & Kane, B. (2006). The effects of pruning type on wind loading of *Acer rubrum*. *Journal of Arboriculture*, 32(1), 33-40.
- Smiley, E. T., Kane, B., Autio, W. R., & Holmes, L. (2012). Sapwood cuts and their impact on tree stability. *Arboriculture and Urban Forestry*, 38(6), 287-292.
- Smiley, E. T., Matheny, N., & Lilly, S. (2011). *Best Management Practices: Tree Risk Assessment*. International Society of Arboriculture, Champaign, 81 pp.
- TranSafety. (1997). Legal problems: the liabilities of roadside maintenance. *Road Management & Engineering Journal* (July 1997 issue). Usroads.com. Retrieved 2 June 2017, from <http://www.usroads.com/journals/rmj/9707/rm970703.htm>.
- van Wassenae, P., & Richardson, M. (2009). A review of tree risk assessment using minimally invasive technologies and two case studies. *Arboricultural Journal*, 32(4), 275-292.
- Vance, J. (1988). Liability of State for Injury or Damage Occurring in Motor Vehicle Accident Caused by Trees, Shrubbery, or Other Vegetative Obstruction Located in Right-Of-Way or Growing on Adjacent Private Property. *Selected Studies In Highway Law*, 4. Retrieved 1 June 2017, from <https://trid.trb.org/view.aspx?id=301466>.
- VDOT. (2017). Location and Design Division. Virginia.gov. Retrieved 1 June 2017, from <http://www.virginiadot.org/business/locdes/rdmanual-index.asp>.

Xiao, Q., & McPherson, E. G. (2002). Rainfall interception by Santa Monica's municipal urban forest. *Urban Ecosystems*, 6(4), 291-302.

APPENDIX 1: Survey Instrument

Virginia Tech Dept. of Forest Resources
and Environmental Conservation

QUESTIONNAIRE ROADSIDE TREE RISK MANAGEMENT

Introduction

State departments of transportation (DOTs) have authority and responsibility to manage roadside trees for the safety and convenience of the traveling public. DOT staff, contractors, and consultants utilize an assortment of policies, procedures, and practices to detect, assess, and correct hazardous tree conditions. To ensure that they are reasonably fulfilling their duty to manage roadside tree hazards, DOTs need to understand the standard of care for tree risk management. A standard of care is the prevailing, reasonably prudent actions that DOTs take to fulfill their tree management duty. This standard of care is defined and delineated by a number of factors:

- Regulations and policies
- Legal precedent
- Organizational capabilities and constraints
- Industry standards
- Arboricultural best management practices

Establishing the standard of care for roadside tree risk management is important for several reasons. First, it provides a clear target for planning and prioritizing risk management operations. Second, it aids in identifying and correcting deficiencies in these operations. Third, it reduces ambiguities about expectations for risk management and provides a clear benchmark against which agencies can be measured. The result is a more efficient and effective agency that has less exposure to liability claims associated with roadside tree incidents.

Scope and Aim of this Questionnaire

This questionnaire examines the standard of care employed by Mid-Atlantic DOTs in managing risks associated with roadside trees. Roadside trees can create numerous hazards for the traveling public. Encroachment of trees on clear zones and sight lines are prominent hazards that are clearly defined and addressed through traffic engineering standards and state and federal regulations.

Greater uncertainty and inconsistency is encountered with issues of tree failure risk—all or part of a tree falling into a roadway and potentially causing harm to motorists. A number of factors precipitate these tree failure incidents: tree defects, weather, site conditions, and past maintenance activities. DOTs seek to minimize these incidents by detecting, assessing, and correcting hazardous tree conditions. In this questionnaire, we aim to understand how DOTs go about managing tree failure risk by examining four operational areas: personnel, policies, procedures, and practices. With this information, we hope to frame the bounds of the standard of care that prevails in Mid-Atlantic DOTs.

We are requesting that you complete the enclosed questionnaire that addresses policies and practices revolving around roadside tree risk management in your state. Your participation in this study is voluntary and your responses to the questionnaire will remain confidential to Virginia Tech indefinitely. Your responses to the questionnaire will never personally identify you and responses will only be reported in the aggregate across all respondents.

PLEASE TURN TO THE NEXT PAGE TO BEGIN THE QUESTIONNAIRE

Questionnaire, April 2017

1 of 9

Questions about DOT Background

1. Please list your official DOT position title:

2. Please briefly describe the scope of your position duties and responsibilities:

3. Are you a Certified Arborist with the International Society of Arboriculture?

- Yes
- No, but plan to become one
- No, and do not plan to become one

4. How would you describe your educational/training background?

- Forestry
- Horticulture
- Engineering
- Management
- Other (list)

5. How would you describe your level of expertise in roadside tree management?

- Basic awareness
- Novice
- Intermediate
- Advanced
- Expert

6. For how many miles of roadway does your agency have roadside tree management responsibilities?

7. In your DOT, tree failure incidents that impact the roadway are:

- Frequent
- Occasional
- Rare
- Very rare

8. Managing roadside tree risk is a major emphasis of your DOT:

- Strongly agree
- Agree
- Neither agree or disagree
- Disagree
- Strongly disagree

9. Your DOT has the necessary resources and expertise to effectively manage roadside tree risk:

- Strongly agree
- Agree
- Neither agree or disagree
- Disagree
- Strongly disagree

10. Your DOT is effective at managing roadside tree risk.

- Strongly agree
- Agree
- Neither agree or disagree
- Disagree
- Strongly disagree

Questions about Tree Management Personnel

1. How many of your DOT personnel have direct tree management duties (excluding field production personnel who cut and trim trees)? If possible, please list these position titles and the approximate number of individuals in each position statewide.

2. Could you provide us with a generic position description for each of these position titles?

- Yes
- No

3. How many of these DOT staff employees are Certified Arborists with the International Society of Arboriculture?

- All
- Most
- Some
- Very few
- None

4. How many of these DOT staff employees are Qualified Tree Risk Assessors (TRAQ Qualified) with the International Society of Arboriculture?

- All
- Most
- Some
- Very few
- None

5. How frequently do your DOT staff employees go through formal continuing education on tree risk management specifically?

- One or more times per month
- Several times per year
- Once per year
- Once every few years
- Never

Questions about Tree Risk Policies

1. Is tree risk management addressed explicitly in either statutes or administrative codes adopted by your state legislature?

- Yes
- No
- Unsure

2. Does your DOT have an agency policy that addresses tree risk management explicitly?

- Yes
- No, but we plan to develop one
- No, and we do not plan to develop one
- Unsure

3. If your DOT has a tree risk management policy, may we obtain a copy of it?

- We do not have a policy
- Yes
- No

4. If your DOT has a tree risk management policy, which of the following guidance documents were used in writing the policy (check all that apply)?

- We do not have a policy
- American National Standards Institute (ANSI) A300–Part 9, Tree Risk Assessment Standard
- International Society of Arboriculture’s Best Management Practices for Tree Risk Assessment
- US Forest Service Guide to Urban Tree Risk Management
- Other guidance document (list name)

5. Are you aware of any recent legal cases involving tree failure incidents in your state that have influenced either your state code or your agency policy?

- Yes
- No
- Unsure

Questions about Tree Risk Procedures

1. Does your DOT use GIS or similar technology to analyze/manage roadside tree failure risks?

- Yes
- No, but we plan to in the future
- No, and we do not plan to in the future

2. Does your DOT have a standardized, systematic process for periodically inspecting roadsides for tree failure risks?

- Yes
- No, but we plan to develop one
- No, and we do not plan to develop one

3. In your DOT, drive-by “windshield surveys” are used by personnel for roadside tree inspections:

- Frequently
- Occasionally
- Rarely
- Never

4. In your DOT, walk-by “360° surveys” are used by personnel for roadside tree inspections:

- Frequently
- Occasionally
- Rarely
- Never

5. In your DOT, diagnostic tools (mallet, probe, drill, etc.) are used by personnel to examine defects during ground-level roadside tree inspections:

- Frequently
- Occasionally
- Rarely
- Never

6. Does your DOT use the International Society of Arboriculture’s Best Management Practices for Tree Risk Assessment when conducting roadside tree inspections?

- Yes
- No, but we plan to in the future
- No, and we do not plan to in the future

7. Does your DOT have a standardized risk rating system that is used by personnel during roadside tree inspections?

- Yes
- No, but we plan to develop one
- No, and we do not plan to develop one

8. If your DOT has a standardized risk rating system, may we obtain a copy of it?

- We do not have a system
- Yes
- No

9. Does your DOT ever conduct inspections of trees located on private property adjacent to the right-of-way that might endanger the roadway should a failure occur?

- Frequently
- Occasionally
- Rarely
- Never

10. Does your DOT document tree failure incidents in order to evaluate and improve its tree risk management operations?

- Yes
- No, but we plan to in the future
- No, and we do not plan to in the future

11. Are consulting arborists ever hired by your DOT to perform tree structure evaluation and risk assessment, either before or after tree failure incidents?

- Frequently
- Occasionally
- Rarely
- Never

Questions about Tree Risk Practices

1. Are your DOT tree management personnel consulted about selection of landscape trees that are planted in the right-of-way or around other DOT assets?
 - Frequently
 - Occasionally
 - Rarely
 - Never

2. Are your DOT tree management personnel consulted about roadway construction or maintenance projects that might impact the health or integrity of existing trees in the right-of-way?
 - Frequently
 - Occasionally
 - Rarely
 - Never

3. In your DOT, removing trees to reduce failure risk is (check all that apply):
 - The default course of action if a tree has any observable defect
 - More common in rural areas where there is less opposition to tree removal
 - More common in urban areas where there is greater risk of harm to motorists
 - Considered carefully by looking at the severity of defects and likelihood of failure and harm to motorists
 - At the discretion of DOT tree management personnel
 - At the discretion of DOT contractors
 - Influenced by the opinions and demands of the public

4. Does your DOT have a policy or bid specification that describes roadside tree pruning standards?
 - Yes, and it is based on the current version of the American National Standards Institute (ANSI) A300-Part 1, Pruning (2008)
 - Yes, but it is based on another guidance document (list name)
 - No, but we plan to in the future
 - No, and we do not plan to in the future

5. How would you describe the pruning practices used by your DOT for roadside trees?
- Primarily proactive, focusing on developing good crown structure so that trees are less likely to develop defects
 - Primarily reactive, focusing on trees that have developed serious branch defects such as cracks, decay, and deadwood
 - A balanced mix of proactive and reactive pruning
6. In your DOT, the use of proactive pruning (i.e., structural pruning to prevent branch defects from developing) on roadside trees is:
- Utilized appropriately for failure risk reduction
 - Somewhat underutilized for failure risk reduction
 - Very underutilized for failure risk reduction
7. Please share with us any comments you have about these particular questions or aspects of tree risk management that you think have not been addressed in this questionnaire.

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

VIRGINIA TECH DEPT. OF FOREST RESOURCES AND
ENVIROMENTAL CONSERVATION

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APPENDIX 2: IRB Approval Letter



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: April 5, 2017 

TO: Eric Wiseman, Kyle Austin Harvey

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Roadside Tree Risk Management

IRB NUMBER: 17-358

Effective April 5, 2017, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at: <http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Exempt, under 45 CFR 46.110 category(ies) 2,4**
Protocol Approval Date: **April 5, 2017**
Protocol Expiration Date: **N/A**
Continuing Review Due Date*: **N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

APPENDIX 3: Survey Raw Data

(Note: answer options for the survey multiple-choice questions shown in Appendix 1 have been numerically coded here to correspond with the option ordering (e.g., the first answer option in the list is coded 1, the second answer option is coded 2, etc.)).

Question	Kentucky	Maryland	North Carolina	Tennessee	Virginia	West Virginia
Part 1, Q1	Roadside Environment State Administrator.	Statewide Forest Mitigation Coordinator	Roadside Asset Vegetation Management Engineer	Transportation manager 1	State Roadside Vegetation Manager	Maintenance - Operations Section Head
Part 1, Q2	Administers statewide programs for maintaining and improving the external environment of highway properties and performs other duties as required. This information is provided on job class specification sheet.	Plan reviews, compliance with MD Tree Laws, District support on active construction {incomplete response}	Supervise the Vegetation Management, Wetland Mitigation and Landscape Design & Development Sections; function as a resource for agronomic issues statewide; coordinate program development and funding statewide; Coordinate the North Carolina Wildflower Program.	TDOT Operations Support	Responsible for Statewide Vegetation Management Program with respect to policy, best practices, statutes, regulations.	Currently responsible for Winter Operations Planning, Interstate Rest Areas and Welcome Centers. Statewide liaison to District Maintenance Engineers.
Part 1, Q3	2	3	3	3	1	3
Part 1, Q4	5; BS in Agriculture	1	5; Masters of Science in Crop Science with minor in Horticulture.	4	2	3
Part 1, Q5	4	5	4	1	3	3
Part 1, Q6	27,500 CTLM	All state owned roads in MD.	Approximately 79,600 miles (1327 interstate, 5,566 US routes, 8,170 NC routes, 64,522 secondary routes).	13,877 miles	57,000 road miles	37,370
Part 1, Q7	2	2	3	3	2	2
Part 1, Q8	1	4	3	2	2	3
Part 1, Q9	2	4	2	1	4	4

Question	Kentucky	Maryland	North Carolina	Tennessee	Virginia	West Virginia
Part 1, Q10	2	4	2	1	2	4
Part 2, Q1	There are 12 roadside Environment district administrators in Kentucky, one per district. (also in job class specification sheet)	29 - Typically the Resident Maintenance Engineer at each shop.	County Maintenance Engineers (100) and their employees (number unknown to me); Division Roadside Department (14 Engineers, 41 technicians, 65 supervisors, 145 transportation workers, and 11 temporary employees); 8 central unit staff.	Operations District Supervisors: 22	9 District Roadside Managers and approximately 25 Roadside Coordinators. No information on Area HQ staff that may be involved.	None.
Part 2, Q2	1	2	1	1	1	2
Part 2, Q3	4	5	4	5	1	5
Part 2, Q4	5	5	5	5	2	5
Part 2, Q5	2	5	5	3	4	5
Part 3, Q1	2	3	2	2	2	3
Part 3, Q2	1	3	3	3	2	1
Part 3, Q3	2	1	1	1	1	2
Part 3, Q4	{No answer}	1	1	1	1	5; Covered in our Maintenance Manual.
Part 3, Q5	3	2	2	2	2	2
Part 4, Q1	3	3	3	3	2	3
Part 4, Q2	1	3	3	1	2	3
Part 4, Q3	1	2	2	1	2	2
Part 4, Q4	2	2	2	2	2	3
Part 4, Q5	3	4	3	3	2	4
Part 4, Q6	2	3	3	3	1	3
Part 4, Q7	2	3	3	3	2	3
Part 4, Q8	1	1	1	1	1	1
Part 4, Q9	2	2	2	3	2	2
Part 4, Q10	1	3	3	3	1	3

Question	Kentucky	Maryland	North Carolina	Tennessee	Virginia	West Virginia
Part 4, Q11	2	2	2	3	2	4
Part 5, Q1	1	1	3	3	2	3
Part 5, Q2	2	2	3	3	2	4
Part 5, Q3	1,3,4,5,6,7	4,7	5	4,7	1,2,3,4,5,7	1,4
Part 5, Q4	1	1	1	4	1	2; We have statewide tree trimming and removal contracts.
Part 5, Q5	2	2	2	3	2	2
Part 5, Q6	3	3	3	1	2	3
Part 5, Q7	{No answer}	{No answer}	We will be glad to provide job descriptions for the various positions (question 2, page 4/9) if necessary. However, none of these job descriptions address risk tree management responsibilities specifically. As a general rule, we endeavor to manage trees when they are small by applying select herbicides. We utilize both dormant stem treatments and applications to trees during the growing season. On average we spend \$1 million annually on tree herbicide applications, \$7 million on mechanical tree control	{No answer}	{No answer}	Our tree management is primarily handled at the organizational level and to some extent the district level. It is mostly a reactive seat of the pants approach. About 15 years ago we had a tree fall on a motorist and there was a push in the aftermath to be more proactive, but the energy quickly dissipated and we reverted to a reactive approach. We have a lot of trees that need managing but our workforce and our budget limits us on what we can do.

Question	Kentucky	Maryland	North Carolina	Tennessee	Virginia	West Virginia
			<p>and \$14 million on mechanical tree control. Over the years, with reductions in budgets, trees have been allowed to encroach toward the travel lanes. We see the impact lack of management has caused. A recent tree removal contract focused on pushing the tree line back 35 feet from the ditch along an interstate route. This operation cost \$19,000 per shoulder mile. There is simply not enough funds to perform this function everywhere it is needed. Of course, responses in this survey do not include downed trees as a result of inclement weather (hurricanes, snow/ice events, etc.). We would be very interested in the results of this regional survey, too. Thank you for asking us to participate.</p>			