DATA-DRIVEN DEVELOPMENT OF A ROADSIDE SAFETY MARKETING CAMPAIGN FOR TREE REMOVAL – PHASE I

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MwRSF Report No. TRP-03-375-18
July 17, 2018

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. TRP-03-375-18	2.	3. Recipient's Accession No.	
4. Title and Subtitle Data-Driven Development of a Roadside Safety Marketing Campaign for Tree Removal – Phase I		5. Report Date July 17, 2018 6.	
7. Author(s) Stolle, C.S., Ammon, T.J., Vargas, C.M., Yim, A., Faller, R.K., Lechtenberg, K.A., and Urbank, E.L.		8. Performing Organization Report No. TRP-03-375-18	
9. Performing Organization Name and Address Midwest Roadside Safety Facility (MwRSF) Main Office: Nebraska Transportation Center University of Nebraska-Lincoln 130 Whittier Research Center 2200 Vine Street Lincoln, Nebraska 68583-0853 MwRSF Outdoor Test Site: Nebraska Transportation Center University of Nebraska-Lincoln 4630 N.W. 36th Street Lincoln, Nebraska 68524		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. TPF-5(193) Supplement #82	
12. Sponsoring Organization Name and Address Midwest Pooled Fund Program Nebraska Department of Transportation 1500 Nebraska Highway 2 Lincoln, Nebraska 68502		13. Type of Report and Period Covered Final Report: 2014-2018 14. Sponsoring Agency Code NDOT RPFP-15-TREE-1 Fiscal Year 2014 (Year 25)	
15. Supplementary Notes Prepared in cooperation with U.S. Department of Transportation, Federal Highway Administration.			

16. Abstract

Since the 1970s, tree crashes have been one of the most common and deadly fixed-object fatal crash types, resulting in more than 3,000 fatal crashes and 3,500 fatalities each year. While fatal tree crashes could be prevented by removing trees adjacent to the roadway, an extensive national tree removal project would be unnecessary, cost-prohibitive, and would experience significant political resistance.

The Midwest Pooled Fund Program jointly funded a research study to develop marketing methods and approaches which would focus on tree removal, replacement, or relocation in the most critical areas. Researchers conducted an extensive background investigation into tree crashes, other available studies that reviewed and analyzed tree crash data, and various state DOT and local safety-related marketing campaigns. Researchers also investigated state and local recommendations for clear zone requirements adjacent to various road classes, and issued a survey to state DOTs to obtain local perspectives of marketing and advertising plans. Finally, researchers collected over 400,000 tree and utility pole crashes from 12 different states over a five-year period to analyze the crash data and tabulate results. Draft marketing and advertising plans were developed to demonstrate the type of safety advertising techniques and messages which could be used to inform and influence the public regarding the danger of roadside trees and the importance of tree removal.

17. Document Analysis/Descriptors Highway Safety, Trees, Clear Zones, Safety Improvements, Marketing Campaigns, Accident Statistics, Crash Records, Maintenance Practices		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 128	22. Price

DISCLAIMER STATEMENT

This report was completed with funding from the Federal Highway Administration, U.S. Department of Transportation and the Midwest Pooled Fund Program. The contents of this report reflect the views and opinions of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the state highway departments participating in the Midwest Pooled Fund Program nor the Federal Highway Administration, U.S. Department of Transportation. This report does not constitute a standard, specification, regulation, product endorsement, or an endorsement of manufacturers.

TITLE PAGE REFERENCES

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- Winter Haven Police Department, September 30, 2015. https://www.facebook.com/175433949189901/photos/a.202302449836384.52057.175433949189901/1007869895946298/?type=3&theater
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ACKNOWLEDGEMENTS

The authors wish to acknowledge the sources that made a contribution to this project: the Midwest Pooled Fund Program funded by the California Department of Transportation, Florida Department of Transportation, Illinois Department of Transportation, Indiana Department of Transportation, Iowa Department of Transportation, Kansas Department of Transportation, Kentucky Department of Transportation, Minnesota Department of Transportation, Missouri Department of Transportation, Nebraska Department of Transportation, New Jersey Department of Transportation, North Carolina Department of Transportation, Ohio Department of Transportation, South Carolina Department of Transportation, South Dakota Department of Transportation, Utah Department of Transportation, Virginia Department of Transportation, Wisconsin Department of Transportation, and Wyoming Department of Transportation for sponsoring this project. In addition, special thanks are given to Abby Poulas, Brock Schroder, Jay Tan, and Kyle Wengel for executing research tasks, assembling report elements, and designing initial marketing campaign approaches.

Acknowledgement is also given to the following individuals who made a contribution to the completion of this research project.

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J.D. Schmidt, Ph.D., P.E., Research Assistant Professor
R.W. Bielenberg, M.S.M.E., E.I.T., Research Engineer
S.K. Rosenbaugh, M.S.C.E., E.I.T., Research Engineer
Undergraduate and Graduate Research Assistants

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Florida Department of Transportation
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Federal Highway Administration
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in.	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short ton (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		FORCE & PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in.
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yard	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliter	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or “metric ton”)	1.103	short ton (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE & PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

GLOSSARY

Caltrans	California Department of Transportation
ConnDOT	Connecticut Department of Transportation
GDOT	Georgia Department of Transportation
MaineDOT	Maine Department of Transportation
MnDOT	Minnesota Department of Transportation
NCDOT	North Carolina Department of Transportation
NYSDOT	New York State Department of Transportation
ODOT	Oregon Department of Transportation
OhioDOT	Ohio Department of Transportation
PennDOT	Pennsylvania Department of Transportation
SCDOT	South Carolina Department of Transportation
MMUCC	Modified Minimum Uniform Crash Criteria
FHWA	Federal Highway Administration
IIHS	Insurance Institute for Highway Safety
NHTSA	National Highway and Transportation Safety Administration
NCHRP	National Cooperative Highway Research Program
TIGER	Transportation Infrastructure Generating Economic Recovery
HLDI	Highway Loss Data Institute
Sequence of Events	Tabulation of the events of a crash. Typically this is a numerical means of describing a crash in reasonably objective classifications. Alphanumeric codes are determined by each respective agency (e.g., Department of Public Safety or State Patrol), but often follows the convention described in MMUCC.
FHE	First Harmful Event; refers to the first impact in a crash in which damage occurred to the vehicle. NOTE: Selection of first harmful event may be subjective. FHE often includes impacts to non-redirective, low-energy capacity roadside hardware, such as delineators or curbs.

MHE	Most Harmful Event; refers to the event in an impact sequence in which the crash form coder (usually a responding officer) believed the most damage occurred and was the likely source of the most severe injury. MHE may be subjective, but is often considered a more accurate representation of the cause of injuries in a crash. In single-event crashes, MHE is identical to FHE.
GNSS	Global Navigation Satellite System; refers to any global satellite positioning service allowing a user to pinpoint a location on earth. The most common systems comprising GNSS are GPS, GLONASS, and GALILEO, although additional satellite constellations maintained by a variety of countries may also be valid.
GPS	Global Positioning System; global satellite system used to determine precise coordinates on earth using satellites maintained by the United States.
GLONASS	GLObal NAvigation Satellite System (Globalnaya navigatsionnaya sputnikovaya sistema); global satellite positioning system in the GNSS, maintained by Russia
GALILEO	European satellite system used for global positioning as a part of GNSS, maintained by the European Union.

1 INTRODUCTION

1.1 Background and Motivation

Every year, approximately 1 million vehicles leave the roadway in the United States (U.S.) and impact a fixed object, often referred to as a run-off-road (ROR) collision [1]. Although the number of fatal ROR crashes declined between 1970 and 2010, the number of fatal ROR crashes has remained steady at 10,000 fatal crashes per year since 2010, and has recently begun to rise again [2-3]. Trees are naturally-occurring and human-planted roadside objects that can be found adjacent to many roads throughout the U.S. and the world. The rigidity of roadside trees, their proximity to the sides of the roadways, and exposure (miles of roadway divided by traffic volume times number of trees) increase the likelihood that a roadway departure will result in a serious injury or fatal roadside tree crash. Tree crashes have been associated with approximately 3,500 fatalities and 3,000 fatal crashes each year since fatal crashes were first tracked in the 1970s [4].

In addition to injury and death rates associated with roadside crashes, trees also pose many litigious problems for federal, state, and local agencies. Since the late 1940s and early 1950s, courts have routinely ruled that it is the responsibility of whichever agency owns and maintains a road to ensure: (1) trees do not obscure critical infrastructure (e.g., STOP signs), sight lines, or intersections; (2) trees are properly maintained and dead branches and trees are properly and promptly removed; and (3) defects in government-owned property caused by trees (e.g., tree roots displacing sidewalks and damaging roadways and storm sewers) should be remedied in a reasonable timeframe. Anecdotal evidence suggests that trees create considerable difficulty during disaster relief efforts, such as hurricane response, due to a large volume of deposited debris and foliage accumulation that may block critical transportation paths and lead to unsafe travel conditions.

Although tree crashes dominate all other types of fatal ROR fixed-object crashes and are associated with concerns about liability, visibility, and safety elements unrelated to roadside departures, tree removal can be difficult due to resistance or opposition from private landowners, advocacy groups, landscaping professionals, arborists, and parks and recreation administrations. Safety advocates require effective methods and strategies to communicate the benefits associated with roadside tree removal or crashworthy safety treatments and minimize resistance from groups that are opposed to tree removal or treatment. The Midwest Pooled Fund Program funded a research effort intended to address these difficulties and to provide the groundwork for creating effective safety campaigns to greatly reduce run-off-road, fatal, fixed-object crash deaths associated with trees.

1.2 Objective

The objective of this research effort was to develop marketing strategies that would advise state departments of transportation (DOTs) and the public about the crash statistics and safety risks associated with roadside trees. In addition, this research investigated methods for prioritizing treatment of the hazard posed by roadside and median trees.

1.3 Scope

This research effort consisted of a series of tasks:

- A literature search was conducted to collect available crash, litigation, and safety research data, and compile previous research, guidance, and recommendations related to roadside trees for use in marketing and outreach efforts in a logical array.
- A survey of state DOTs was conducted to determine which marketing and outreach approaches have been successful in affecting tree removal or treatment.
- ROR tree crash data was collected from 12 states and analyzed to provide a perspective of the magnitude of annual tree crash severity.
- Marketing campaigns related to safety topics were researched and attributes of successful campaigns were identified and summarized.
- Preliminary drafts of promotional materials and marketing campaigns were developed using the marketing techniques identified in literature studies.
- A summary report was compiled describing the results of the literature review, maintenance and practices review, tort liability review, state DOT survey, crash data evaluation, and initial prototype campaign developments.

Initially, it was anticipated that the groundwork for the promotional and marketing campaign would be investigated and an external resource (i.e., a marketing firm) would provide quotes for the cost of campaign production and execution. The final marketing products, including video, image, or advertising content, was not anticipated. However, during execution of this project, recommendations for successful execution of the safety campaign were reviewed, and it was determined that this step would be beyond the scope of the current research effort. Instead, efforts were focused on the groundwork development to be extended and executed in one or more follow-up studies.

2 CRASH STATISTICS, PARAMETERS, AND COSTS

2.1 Domestic Crash Rates and Statistics

Roadway deaths are a common fatality in the U.S. In 2015, there were 35,092 fatalities due to motor vehicle crashes, which resulted in a total of 10.9 deaths per 100,000 people, and as mentioned previously, every year around 3,000 of these deaths are due to vehicular impacts with trees [5-6]. These yearly deaths due to vehicle/tree collisions make up around 8% of all fatal vehicular crashes [7]. Vehicle/tree crashes constitute between 25% and 28% of all fixed object ROR crashes, but constitute around 50% of all fixed-object roadway fatalities [6, 8-10]. ROR crashes with trees are generally more severe than other impact scenarios, and trees are abundant hazards which may grow larger and become more severe over time [11]. The distribution of fixed object crash deaths by object struck for 2013 is shown in Figure 1.

Vehicle/tree collisions make up between 25% and 28% of all fixed object ROR crashes, but are responsible for about 50% of all fixed-object roadway fatalities [6, 8-10].

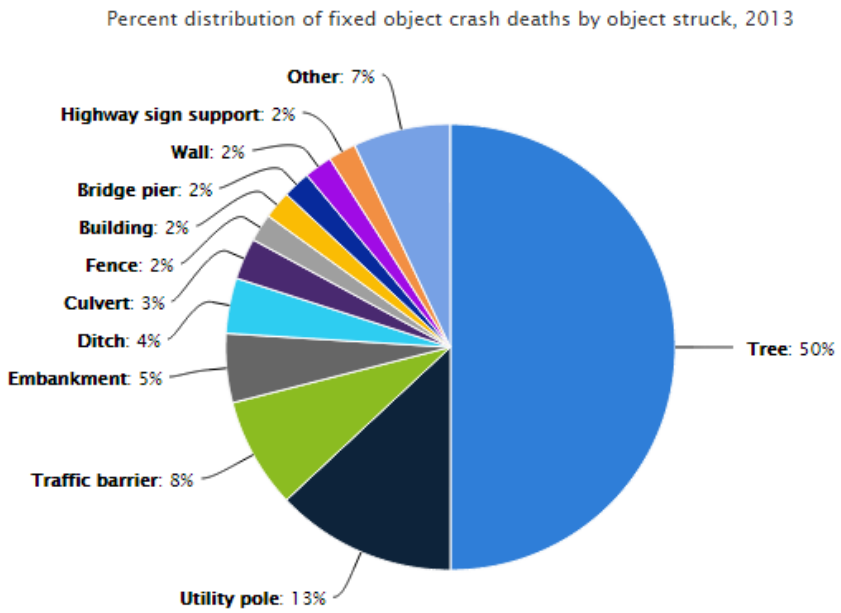


Figure 1. Percent Distribution of Fixed Object Crash Deaths by Object Struck [3]

2.1.1 Historical Crash Rates

History of the risks associated with roadside trees is well documented. During the 1974 energy crisis, deaths due to crashes with roadside trees remained constant even though all other traffic fatalities fell during this period [12]. A study completed in 1981 examined data from the U.S. and showed that for every fatal tree accident that occurs, on average 23 injury accidents and 15 vehicle-damage-only accidents will also occur [13]. Wolf and Bratton determined that of the 229 billion vehicle trips taken in 2001, 141,000 trips resulted in a tree crash [14]. It was estimated

that 1 out of every 1,250 drivers will be involved in a tree accident in any given year, and 1 out of 95 drivers will have a vehicle/tree impact at least once within their lives. About 10% of all vehicle/tree collisions result in a serious injury and about 55% result in property damage only [15].

It was estimated that in 2001, 1 out of 1,250 drivers were involved in a run-off-road crash with a tree, and approximately 1 out of every 95 drivers will crash into a roadside tree in their lifetimes [15].

A study completed in Michigan found that in 1976, 10,067 vehicle/tree accidents occurred and around half of these collisions resulted in serious injury or death [12]. From 1981 to 1985, trees accounted for only 2.8% of all vehicular accidents, but were responsible for 11.1% of all fatal crashes in Michigan during this time.

According to FARS data accessed by the Clemson researchers in 2008, 33% of all fatalities on South Carolina roads were caused by ROR impacts into fixed objects [16]. Of these crashes, 65% and 8% of these impacts were due to trees and utility poles, respectively.

Ogle, et. al, determined that nationally, approximately 8% of all fatal vehicular crashes are caused by vehicle/tree collisions. In South Carolina, ROR tree crashes account for as much as 25% of the total vehicular fatalities [17].

Nationally, tree crashes account for 8% of traffic fatalities. In South Carolina, tree crashes accounted for 25% of traffic fatalities [17].

Approximately 88 million utility poles are located along U.S. highways, resulting in thousands of utility pole crashes annually [6]. For example, in 1985 vehicular impacts with utility poles caused 1,522 deaths, 110,000 injuries, and 33,000 instances of property damage only when looking at the most harmful event [18]. This trend has continued. For example, in 2000, there were 1,103 fatalities and about 60,000 injuries related to vehicles impacting utility poles [19].

2.1.2 Roadway Geometrics and Traffic Volumes

Roadway geometrics can strongly influence the likelihood of departing the roadway and crashing into a tree or utility pole. A NCHRP study completed in 2003 by Neumen, et al. found that around 90% of vehicle/tree collisions occurred on two-lane roads and only around 5% occurred on four-lane roads [20]. This same NCHRP report found that approximately 77% of tree-related crashes are due to vehicles leaving the roadway on the outside of a horizontal curve.

Another important report dealing with the effect of average daily traffic (ADT) on vehicle/tree collisions was published in 2003 at California Polytechnic State University [21]. This report found that 61% of large vehicle/tree collisions studied occurred on non-freeway or expressway rural roads. This statistic is shocking, because only 25% of the total vehicle miles traveled (VMT) per day occurs on this type of road. Freeways and expressways experience approximately 24% of the total VMT per day, but only 10% of vehicle/tree collisions occur on this road type. Twenty-seven percent of vehicle/tree collisions occur on conventional urban roadways that handle 38% of the total VMT.

Near Huntsville, Alabama, 59% of tree crashes occurred adjacent to roadway curves, but curves accounted for only 5% of the road mileage [22].

Turner and Mansfield also discovered that curves were overrepresented in the vehicle/tree collision data set for Huntsville, Alabama [22]. Around 59% of all vehicle/tree accidents occurred on a curved section of road, which is startling because only 5% of the road mileage in Huntsville is curved. Based on mileage, the probability of being involved in a ROR collision with a tree on a curved road was 12 times larger than compared to a straight road.

Rural roads experience a disproportionate percent of vehicle/tree collisions [12]. For example, during the 1976 study completed by Holewinski and Zeigler, it was found that in Michigan, rural roads accounted for 81.6% of fatal vehicle/tree collisions, 70.8% of injury-producing accidents, and 65.8% of property damage-only accidents.

Another study published in 2010 qualitatively and quantitatively assessed factors contributing to tree-related crashes in South Carolina. Bendigeri, et al. discovered that approximately 62% of the fatal tree crashes in South Carolina occurred on rural roads and 37% took place in urban settings [16]. Ogle, et al. showed that 72% of all tree-related crashes and 78% of all vehicular impacts with utility poles in South Carolina occurred on curved sections of the road [17].

A study published in 1980 by Mak and Mason found that on urban highways, 36.9 pole accidents occurred for every 100 miles of road, but in rural areas this number dropped to 5.2 [23]. The authors surmise that this is most likely due to the increased amount of traffic on urban highways, because both urban and rural highways contained nearly identical rates of 3.4 utility pole accidents per billion vehicle/pole interactions. A vehicle/pole interaction is defined as any opportunity for a vehicle to strike a pole. Even though vehicle/pole impacts are more common in urban areas, the severity level seen in rural areas is substantially higher. In rural areas, 10.7% of the utility pole accidents resulted in severe to fatal injuries, but in urban areas this number dropped to 5.4%.

2.1.3 Time of Day, Lighting, and Environmental Effects

FARS data from 1988 and 1999 showed that 56% of all fatal tree crashes on U.S. highways occur at night [20]. Turner and Mansfield determined that tree accidents peaked at around 1 a.m., and 35% of all vehicle/tree accidents occurred between 11 p.m. and 3 a.m. [22].

2.1.4 Size, Location, and Proximity of Roadside Trees or Utility Poles

Trees within roadway medians are less common than trees located at or near clear zones on the sides of the roadway, but can be equally dangerous for errant vehicles. According to a study completed in 2003 at California Polytechnic State University, 3% of vehicle/tree impacts nationwide are due to trees placed in medians [21]. It is not recommended to increase street aesthetics by placing trees in the median, because the presence of trees is associated with a significantly increased accident rate.

Ziegler characterized the typical ROR crash involving roadside trees in Michigan as an accident involving a large tree within 30 feet of the road edge located in a drainage ditch or at the bottom of a downward grade [24]. The relationship between the distance from the edge of the road to the tree and accident frequency is shown in Figure 2. Overall, approximately 85% of the impacted trees were within 30 feet of the road, and the median diameters of trees involved in nonfatal and fatal collisions were 15 inches and 20 inches at breast height, respectively.

Approximately 85% of ROR tree crashes occurred within 30 feet of the road [24].

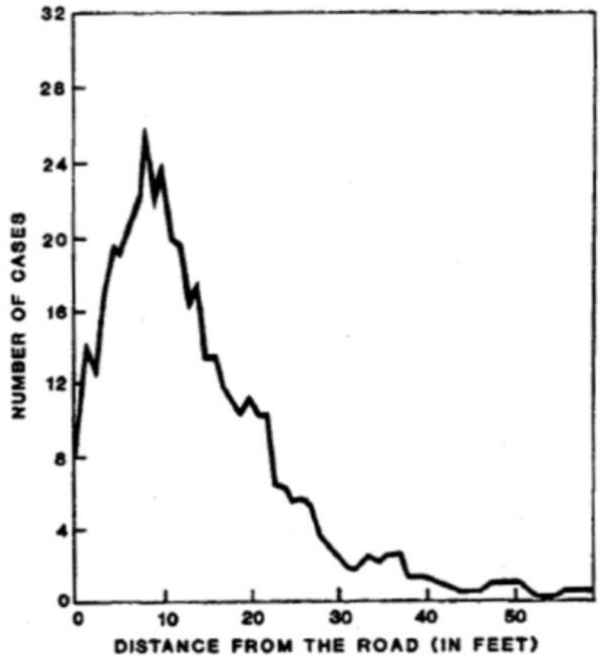


Figure 2. Accident Frequency vs. Distance from the Road [24]

Neuman, et al. attempted to understand the effect that tree offset and spacing between consecutive trees had on roadside tree crashes [20]. Road sections that contained 15 to 30% tree coverage, and trees placed between 0 and 12 ft from the roadway with an average ADT of 4,000 were found to average 0.25 tree crashes per mile of road per year. This study also found that as the ADT of a road increases, ROR tree crashes decrease as a percentage of all roadside fixed-object crashes.

In Alabama, 80% of tree crashes near Huntsville occurred within 20 feet of the roadway [22].

A study by Turner and Mansfield detailed the implementation of a clear zone project in Huntsville, Alabama [22]. In the course of their research, the authors discovered that 80% of the vehicle/tree collisions that took place in Huntsville occurred within 20 feet of the roadway. Researchers noted that a 4% reduction in ROR accidents could be obtained for each additional foot of clear zone space.

Iowa State University published a 2009 report that summarized the effects of clear-zones on safety performance in Iowa. This report stated that 90% of fixed object ROR crashes in the studied areas occurred on road segments where the clear zone distance was less than 5 feet. This relationship can be seen graphically in Figure 3. Additionally, the authors discovered that 90% of all fixed object crash costs originated from highways with clear zones less than 4 feet wide [25].

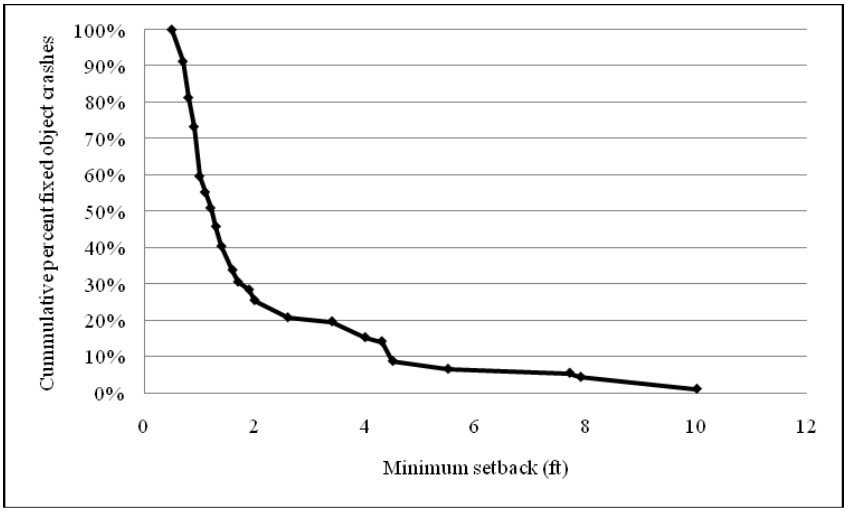


Figure 3. Cumulative Percent Fixed Object Crashes vs. Minimum Setback [25]

Ogle, et al., conducted an odds ratio test on ROR tree crash data in South Carolina [17]. The authors determined that a crash was 42 times more likely to occur if the minimum clear zone requirements are not met.

Mak and Mason also indicated that around 50% and 75% of all utility pole crashes involved poles placed within 4 feet of the road and 10 feet of the road, respectively. [23]. In addition, 7.4% of all crashes with utility poles result in serious injury or fatality.

50% of all utility pole crashes involve poles that are placed within 4 feet of the road and 75% of the crashes are from poles placed within 10 feet of the road [23].

2.1.5 Characteristics of Drivers Involved in Tree or Utility Pole Crashes

A highly referenced study published in Michigan in 1986 attempted to describe the typical individual involved in a ROR vehicle/tree collision [24]. This report found that over 60% of the fatalities experienced during ROR collisions happened to individuals who were under 35, 60% of involved individuals had been drinking, and more than two thirds of tree-related deaths during this study period occurred on weekends. The findings from this report paint a picture of individuals involved in ROR vehicle/tree collisions as young males generally between 20-25 years old, driving over the speed limit, and inebriated from 2:00 a.m. to 4:00 a.m. on a weekend.

Speed is an important factor in vehicle/tree collisions. The probability of an accident increases by an order of magnitude when a deviation of 15 mph above or below the posted speed

limit is observed [12]. Additionally, police have reported speeding more than any other violation for this type of roadway crash.

2.1.6 Utility Pole Recommendations

Mak and Mason recommended using as few utility poles as possible and placing them in locations where they are least likely to be impacted [23]. This practice could be achieved by demonstrating the cost-effectiveness and cost savings to utility companies associated with reduced pole replacement. They also recommended that newly-installed poles contain breakaway devices or be placed behind crash cushions and guardrails. *NCHRP Report 612 - Safe and Aesthetic Design of Urban Roadside Treatments* also contains useful recommendations for reducing vehicle-to-utility pole crashes [7]. This report suggests that newly-installed poles be placed as far as possible from active travel lanes to lessen the chances of impact and reduce sight restrictions experienced by the driver. Poles could be shared between utilities to lessen the overall pole density along the road and be delineated by retroreflective tape, though the author notes that this tape may attract impaired drivers.

Although moving utility poles farther away from the roadway may greatly improve the safety for errant motorists, utility companies have been hesitant to move utility poles en masse. Anecdotally, workers in utility pole companies reported that pole placement farther away from the roadway increases the difficulty associated with repairing or maintaining the pole, because the high-reach trucks are forced to drive into ditches or on slopes to reach the poles. In addition, there are concerns in rural areas where the poles may be at or near to the roadway's right-of-way. Lastly, moving a large number of poles could be time-consuming and costly, rendering areas without power or communication for an extended duration. When considering utility pole treatments, it should be recalled that public and private companies are subject to customer feedback, and if not liable for crash outcomes, may prioritize customer needs above roadside safety.

2.2 Crash Costs

A study published in 1999 found that collisions between vehicles and various roadside elements were responsible for one third of all fatalities along U.S. roads and accounted for approximately $80 billion annually in 1999 dollars [26]. In 2010, public revenues paid for around 9% of all motor vehicle crash costs, which represents a total public investment of $24 billion that added over $200 in taxes to every U.S. household [27]. Trees historically have made up a large chunk of the total estimated vehicle collision costs. For example, a 1981 report published by the National Highway Traffic Safety Administration (NHTSA) estimated that vehicle/tree impacts cost the U.S. around $1.25 billion in 1975 dollars [13]. In 1985, trees were estimated to cost U.S. citizens $12.5 billion in 1988 dollars [18]. In South Carolina alone, crash costs were approximately 1 billion dollars per year in the mid-2000s due to fatal ROR tree crashes alone [17].

When considering FHE, ROR crashes with trees were estimated to cost approximately $1.25B in 1975 and between $12.5B and $13.3B in 1985 [13, 18, 17]. Using MHE instead of FHE, tree crashes were estimated to cost $15B in 1985 [28].

The 1991 report "Harmful Events in Crashes" by John G. Viner quantified the cost of vehicular

impacts on U.S. roads in 1985 using 1988 dollars [28]. When trees are considered the first harmful event (FHE), it was estimated that vehicle-to-tree crashes cost society $13.3 billion; when the most harmful event (MHE) was considered, vehicle-to-tree crashes cost society around $15 billion dollars. Viner estimated that a nonfatal vehicle/tree injury, when considering the FHE, cost an estimated $64,000 and when the MHE is considered it cost individuals $75,000. It should be noted that FHE is the first event in a crash sequence in which the vehicle is damaged and/or an occupant is injured, and the MHE corresponds to the most significant and hazardous event in a crash sequence. ROR crashes with a single event (e.g., struck tree) have identical FHE and MHE, but crashes with multiple struck objects, including delineators, may underrepresent the severity of a tree impact in a crash sequence.

2.3 International Crash Statistics and Parameters

2.3.1 Australia

Australians have experienced preventable roadside destruction in the form of vehicular impacts with trees and tree derivatives. For example, 39% of all fixed object impacts in Australia are due to utility poles and 18% are due to trees, which can be seen in Figure 4. These rates can be compared with those seen in urban areas, where 48% of fixed object impacts are due to utility poles and 12% are due to trees [29].

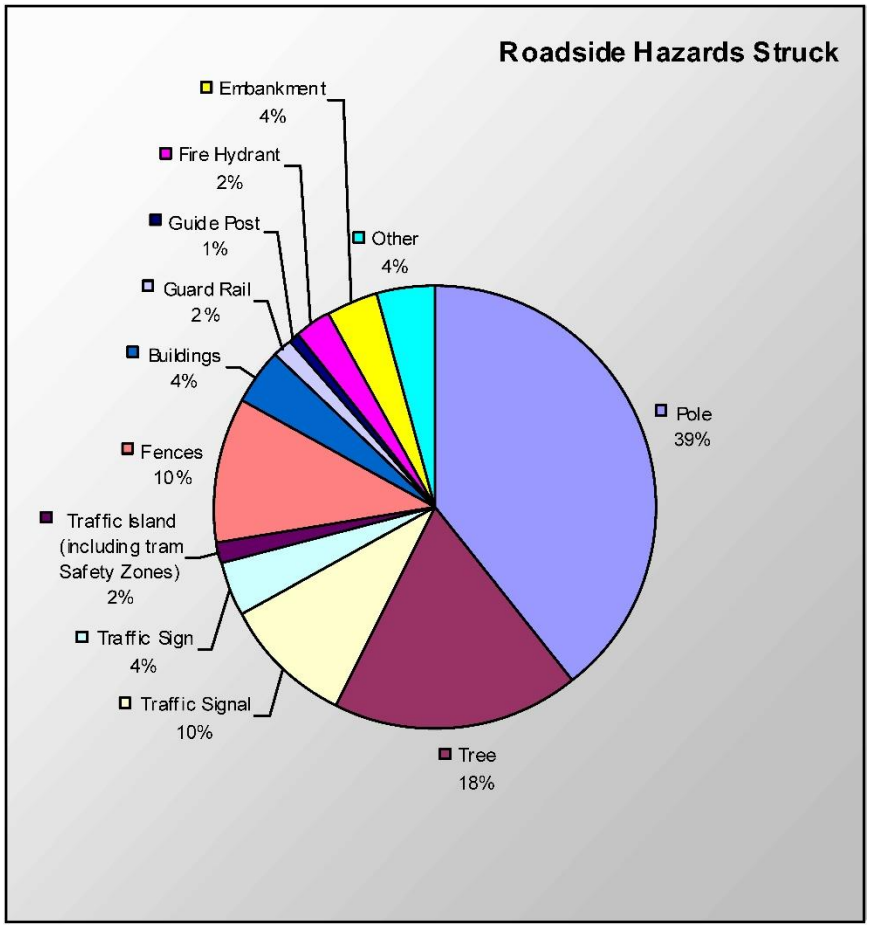


Figure 4. Percentage of Roadside Fixed Struck Hazards in Australia from 2001-2005 [29]

An Australian study completed in 1999 investigated the role of roadside hazards in road accidents in Southern Australia. This study found that more than half of all fatal road hazards that were involved in ROR crashes were within 3 m of the road, and 90% of the impacted hazards were within 9 m of the travelled way [30]. Another report completed in Australia showed that ROR casualty crashes could be reduced by 21% when clear zones were larger than 8 m compared to between 4 and 8 m [31].

2.3.2 United Kingdom

In the United Kingdom (UK), one out of every twelve roadway fatalities occurs due to a ROR crash with trees [32]. From 2000 to 2011, all roadway fatalities within the UK dropped by 35%, but vehicle/tree impacts only decreased by 18% during the same time period. Vehicular collisions with trees in the UK were four times more likely to result in a fatality then vehicular collisions with road signs.

From 2000 to 2011 all roadway fatalities within the UK dropped by an astounding 35%, but during the same time period vehicle/tree impacts only decreased by 18% [32].

2.3.3 Thailand

In 2012, researchers at Prince of Songkla University in Thailand published a paper with the aim of improving Thailand's roadside safety. This report discovered that from 2007-2010, fixed object roadside crashes in Thailand constituted a yearly average of 44% of all highway crashes. Additionally, 72% of all ROR vehicle impacts in Thailand are due to vehicle/tree collisions and 57% drivers involved in these collisions were driving over the posted speed limit [33].

2.3.4 Germany

A report by Vollpracht examined the traffic fatalities in Brandenburg, Germany from 1995 to 2005 [34]. During this time, the state experienced 2,380 fatalities and 14,592 serious injuries due to vehicle/tree collisions, which accounted for around 50% of all traffic fatalities. Vollpracht suggested that these deaths occurred because individuals wanted to retain the heritage of roadside trees instead of addressing and resolving the roadside safety problems.

A separate study published in Germany in 1997 showed that 42% of fatal accidents and 28% of serious injury accidents were due to individuals leaving the road and impacting fixed roadside objects [35]. During this time frame, 71% of the fatalities and 55% of the serious injury-producing ROR accidents were due to individuals impacting trees.

2.3.5 France

In 1995 in France, 31% of all fatal accidents involved a vehicle driving off of the road and impacting a fixed roadside object [36]. Fifty-six percent of the total ROR fixed object fatalities were due to vehicle/tree collisions. Approximately two thirds of these tree fatalities occurred on roadways which were deliberately lined with trees.

2.3.6 Poland

A 2014 presentation prepared by Polish road safety professionals was used to quantify the vehicle/tree collisions seen in Poland [37]. In 2003, vehicle/tree collisions resulted in 11% of all highway accidents and 17% of all highway fatalities. From 1989 to 2014, more than 20,000 people were killed in traffic accidents related to impacting a tree. Budzynski and Kazimierz state that they believe that current environmental regulations within Poland, designed to protect hermit beetles and moss that live in roadside trees, are leaving dangerous fixed objects alongside the road. The authors observed that governmental priorities suggested that hermit beetles and tree moss were more important than the lives of Polish drivers and passengers.

3 GUIDELINES & RECOMMENDATIONS FOR ROADSIDE TREE PLANTING, MAINTENANCE, AND REMOVAL

3.1 Domestic Clear Zone Guidelines

As automobile speeds increased with advances in vehicle technologies through the 1960s, empirically-driven guidelines for road and roadside safety were developed by the American Association of State Highway and Transportation Officials (AASHTO), formerly known as the Association of State Highway Officials (AASHO), in what became known as the "Yellow Book" [38]. The second version of the Yellow Book recommended minimum clear zone distances of 30 feet for high speed roads and 10 feet for rural speed roads based on an empirical analysis of roadside encroachment distances [39]. However, guidelines were primarily applicable for level roadsides. Current AASHTO recommendations for clear zone design consider roadside slopes and ditches as well as curvature are shown in Tables 1 and 2 and Figure 5 [9].

In a 2010 study, the Caltrans Division of Research and Innovation contacted individual states to discover if they were currently using the recommended AASHTO clear zone distances. Clear zone values for different states are summarized in Table 3 [40]. Note that the various state DOT responses contained in Table 3 reflect the practice at the time the data was collected in 2010 and may not reflect an individual state's current practice.

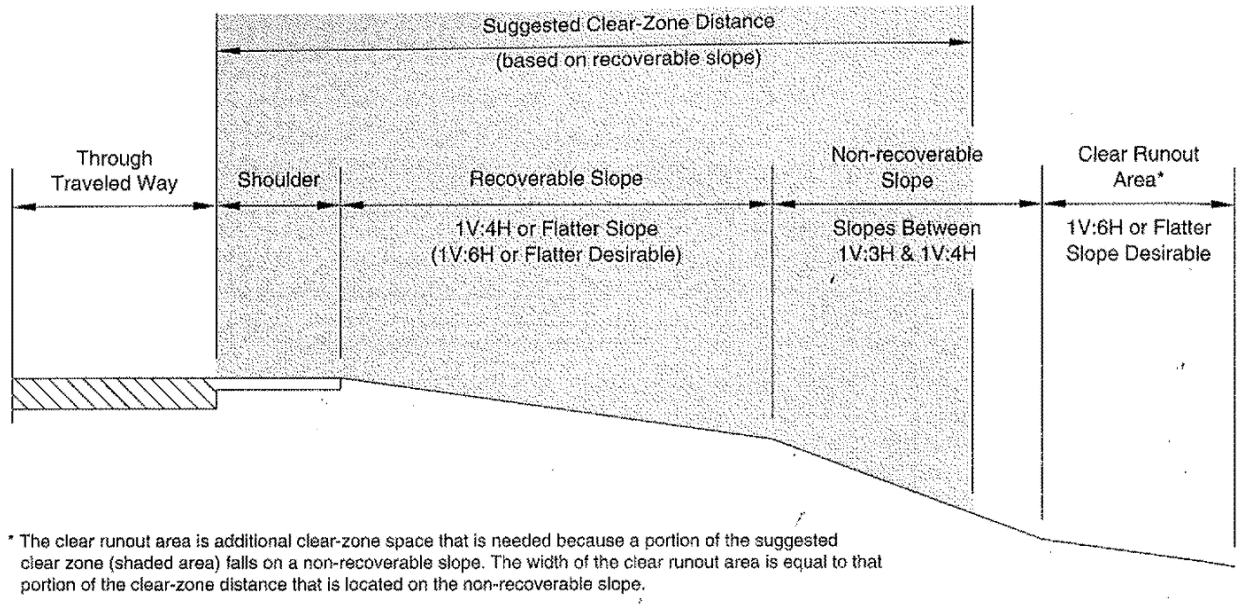


Figure 5. Clear Zone for Non-Recoverable Parallel Foreslopes (AASHTO RDG Figure 3-2) [9]

Table 1. Suggested Clear Zone Distances from Edge of Traveled Lane (RDG Table 3-1) [9]

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
≤ 40	Under 750[c]	7-10	7-10	[b]	7-10	7-10	7-10
	750-1500	10-12	12-14	[b]	12-14	12-14	10-12
	1500-6000	12-14	14-16	[b]	14-16	14-16	12-14
	OVER 6000	14-16	16-18	[b]	16-18	16-18	14-16
45-50	Under 750[c]	10-12	12-14	[b]	8-10	8-10	10-12
	750-1500	14-16	16-20	[b]	10-12	12-14	14-16
	1500-6000	16-18	20-26	[b]	12-14	14-16	16-18
	OVER 6000	20-22	24-28	[b]	14-16	18-20	20-22
55	Under 750[c]	12-14	14-18	[b]	8-10	10-12	10-12
	750-1500	16-18	20-24	[b]	10-12	14-16	16-18
	1500-6000	20-22	24-30	[b]	14-16	16-18	20-22
	OVER 6000	22-24	26-32[a]	[b]	16-18	20-22	22-24
60	Under 750[c]	16-18	20-24	[b]	10-12	12-14	14-16
	750-1500	20-24	26-32[a]	[b]	12-14	16-18	20-22
	1500-6000	26-30	32-40[a]	[b]	14-18	18-22	24-26
	OVER 6000	30-32[a]	36-44[a]	[b]	20-22	24-26	26-28
65-70	Under 750[c]	18-20	20-26	[b]	10-12	14-16	14-16
	750-1500	24-26	28-36[a]	[b]	12-16	18-20	20-22
	1500-6000	28-32[a]	34-42[a]	[b]	16-20	22-24	26-28
	OVER 6000	30-34[a]	38-46[a]	[b]	22-24	26-30	28-30

Notes:

a) When a site-specific investigation indicates a high probability of continuing crashes or when such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than those shown in Table 3-1. Clear zones may be be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

b) Because recovery is less likely on the unshielded, traversable 1V:3H fill slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of the slope. Determination of the width of the recovery area at the toe of the slope should consider right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of the slope. While the application may be limited by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 3-2. A 10-foot recovery area at the toe of the slope should be provided for all traversable, non-recoverable fill slopes.

c) For roadways with low volumes it may not be practical to apply even the minimum values found in Table 3-1. Refer to Chapter 12 for additional considerations for low-volume roadways and Chapter 10 for additional guidance for urban areas.

d) When design speeds are greater than the values provided, the designer may provide clear zone distances greater than those shown in Table 3-1.

Table 2. Horizontal Curve Adjustment Factor (AASHTO RDG Table 3-2) [9]

Radius m (ft)	Design Speed: km/h (mph)					
	60 (40)	70 (45)	80 (50)	90 (55)	100 (65)	110 (70)
900 (2,950)	1.1	1.1	1.1	1.2	1.2	1.2
700 (2,300)	1.1	1.1	1.2	1.2	1.2	1.3
600 (1,970)	1.1	1.2	1.2	1.2	1.3	1.4
500 (1,640)	1.1	1.2	1.2	1.3	1.3	1.4
450 (1,475)	1.2	1.2	1.3	1.3	1.4	1.5
400 (1,315)	1.2	1.2	1.3	1.3	1.4	-
350 (1,150)	1.2	1.2	1.3	1.4	1.5	-
300 (985)	1.2	1.3	1.4	1.5	1.5	-
250 (820)	1.3	1.3	1.4	1.5	-	-
200 (660)	1.3	1.4	1.5	-	-	-
150 (495)	1.4	1.5	-	-	-	-
100 (330)	1.5	-	-	-	-	-

Table 3. Domestic Clear Zone Guidelines [40]

State	Roadway	Median
Alaska	AASHTO: 30'	No shrubs or trees planted in medians; what is planted in medians only done by local municipalities who also maintain what they plant.
Arkansas	30' clear zone 10' transition zone	N/A
Delaware	AASHTO: 30'	Medians can be planted if there is sufficient space to safely maintain the plantings, and if there is appropriate resources for the maintenance. Major trees (> 4" cal. At maturity) are not planted in medians unless there is a barrier curb and sufficient driver recovery space.
Florida	36' of recoverable area	Curbs are not a factor < 45 mph – trees allowed > 45 mph – need full horizontal recovery area
Georgia	Rural: AASHTO Urban: ≤ 35 mph – 4; from curb face in central business district, otherwise 8' from curb face 40 mph – 10' from curb face 45 mph – 14' from curb face > 45 mph – outside clear zone	Rural: AASHTO Urban: ≤ 35 mph – 4; from curb face in central business district, otherwise 8' from curb face 40 mph – 10' from curb face 45 mph – 14' from curb face > 45 mph – outside clear zone
Hawaii	AASHTO: 30'	Median plantings of trees > 4" caliper must be greater than 8 feet in width, curbed, 35 mph posted speed.
Idaho	AASHTO: 30'	AASHTO: 30'
Iowa	AASHTO: 30'	Case by case basis
Kansas	AASHTO: 30'	Little median planting; in urban areas if 34-45 mph, curb and gutter, median 15-20' wide, 1.5-2.0" trees; larger trees planted beyond clear zone
Kentucky	AASHTO: 30'	Do not plant within medians
Maryland	AASHTO, pushing 50'	Requirements are 8" barrier curb, 16' total width for 6' setback
Michigan	AASHTO: 30' LA ROW no tree planting permitted on recoverable front slopes	20' minimum offset behind barrier curb 10' minimum at turn lane

Table 3. Domestic Clear Zone Guidelines [40] (Continued)

State	Roadway	Median
Minnesota	Loosely based on AASHTO guidelines for rural roads over 40 mph. Variable width based on average daily traffic (ADT), design speed, in-slope and curvature of road. Urban roads are usually decided by previous factors and others such as curb presence curb height, context sensitive design and municipal agreements.	Same as roadway. Planting of medians occurs more in urban settings than in rural settings.
Missouri	30' – 50' depending on speed, terrain and other roadside features	Generally no planting in medians unless medians are extra wide or have a low speed limit. May allow community to do this.
Montana	Rural: AASHTO	We typically do not plant trees in rural medians and have not planted any to date in the interstate median.
Nevada	AASHTO	4" caliper w/width; < 20' at 35-45 mph; no trees where speed limits are above 45 mph, presence of curbs immaterial. Context Sensitive Solutions applied on case-by-case basis.
New Hampshire	35' from EP (usually extra 5' of what AASHTO prescribes)	Same as roadway if have the width; if not, smaller ornamental trees; planting mainly for snow drift and headlight glare.
New Jersey	AASHTO	AASHTO Allowed with limiting factors
New York	AASHTO Freeways: 30' minimum Other highways: Clear zone commitment determined per project, based on speed, volume, accident history, project type and effort needed to create clear area.	AASHTO Freeways: 30' minimum Other highways: Clear zone commitment determined per project, based on consideration of speed, volume, accident history, project type and effort needed to create clear area.
North Carolina	AASHTO ≤ 35 mph (curb and gutter): Trees – 10' Large shrub/small tree – 5' Small shrub – 1' (to foliage) ≤ 35 mph (shoulder) Trees – 12' Large shrub/small tree – 8' Small shrub – 6' (to foliage) 35 mph – 45 mph (curb and gutter) Trees – 15' Large shrub/small tree – 8' Small shrub – 6' (to foliage) 35 mph – 45 mph (shoulder) Trees – 20' Large shrub/small tree – 10' Small shrub – 8' (to foliage) ≤ 45 mph (curb and gutter): Trees – 25' Large shrub/small tree – 20' Small shrub – 10' (to foliage) ≤ 45 mph (shoulder) Trees – 30' Large shrub/small tree – 20' Small shrub – 15' (to foliage)	AASHTO Median setback standards, per roadway qualifying characteristic, are the same as the standard roadway setbacks. Both standards are further qualified by minimum setbacks outside ditch lines and shoulder breaks.

Table 3. Domestic Clear Zone Guidelines [40] (Continued)

State	Roadway	Median
Ohio	Rural: AASHTO, primarily based on those from North Carolina; 50’ for interstates, 30’ for others Urban: N/A	Rural: AASHTO: Do not plant medians; exceptions: expressways depending on speed limit, curbs. Urban: N/A
South Carolina	AASHTO Interstates: 45’ minimum for trees ≥ 4” caliper at maturity 30’ for trees < 4” caliper at Maturity State routes: based on clear zone, 1.5’-26’ required	AASHTO On interstates, planting is discouraged, based on clear zone required. On state routes, based on clear zone, 1.5’-26’ required.
South Dakota	AASHTO: 30’ clear zone for rural, high speed highways 8’ to 30’ clear zone (calculated using AASHTO Roadside Design Guide) for suburban, intermediate speed highways 5’ desirable lateral offset measured from back of curb on urban, low speed highways	AASHTO We plant only shrubs and flowers in the median.
Texas	AASHTO: 30'	AASHTO: 30', generally allowed beyond clear zone
Utah	AASHTO Within the design clear zone: 4” diameter max. In urban areas where curb and gutter exists, larger trees are allowed outside 18” from face of curb.	AASHTO Within the design clear zone: 4” diameter maximum. Rarely plant trees I medians in rural areas.
Virginia	AASHTO: 30'	AASHTO 8’ minimum for canopy tree species, 1.5’ with a design waiver
Washington	Have formula developed by design that take into account ADT, terrain, cut or fill, and speed.	Same as for roadway.
Wyoming	Trees or large shrubs > 4” diameter at breast height (DBH) must comply with clear zone criteria AASHTO Rural Design sections. Any part of tree’s canopy within 2’ back-of-curb or rural taper pruned to maintain a minimum 19’ airspace over travel lane(s). Conifers and cottonwoods (Populus sp.) are not allowed within the right-of-way (R/W). Shrubs and ornamental grasses minimum 2’ setback back-of-curb and maximum 2.5’ height within restricted sight distances (i.e., intersections and accesses).	AASHTO clear guidelines here usually disallow woody plantings. Arid climate so woody plantings no generally feasible especially with winter sanding salt spray and no irrigation.

N/A – No guidance available

3.2 International Clear Zone Guidelines

The idea of a clear zone originated in the U.S. and much of the research has been completed here, but the concept has been accepted and built upon in many different countries. A study funded by the Federal Highway Administration (FHWA) and completed by researchers at the University of Mexico and the University of Alabama quantified different clear zone distances around the world [41]. Results of the international clear zone distance review is shown in Table 4. For example, western nations within this data set have generally quantified their own clear zone values, but Venezuela does not incorporate the clear zone concept within their design criteria and Yugoslavia follows AASHTO guidelines.

Table 4. Examples of International Clear Zone Guidelines [41]

Country	Examples of Clear Zone Criteria
Australia	Generally, all items such as poles and sign supports should be kept a minimum of 1 m clear of the outer edge of the shoulder.
Czech Republic	Obstructions must be placed behind a ditch or 0.5 m behind a curb.
France	7 to 10 m wide; eliminate all obstacles in clear zone or isolate them with guardrail.
Germany	Depends on design speed: > 70 km/h 1.25 m ≤ 70 km/h 1.00 m ≤ 50 km/h 0.75 m
Hungary	1.5 m (1.0 m in median) on freeways, 1.5 m on arterials, 0.5 m on minor or local roads.
Poland	Follows German procedures.
South Africa	Depends on road type: urban arterial 5.0 m urban collector 4.0 to 5.0 m rural 3.0 m
Sweden	Generally, rigid objects more than 10 m from the edge of the roadway are not shielded by guardrail.
Switzerland	Examples: 0.2 m to signal post, 1.0 m to horizontal and longitudinal obstructions, 0.25 m between bikeways or sidewalks and buildings.
United Kingdom	Generally, the 1.5 m minimum-width grassed verge is kept clear. Obstacles within 4.5 m of pavement edge are shielded by guardrail. On local roads there is a minimum distance of 0.6 m for signs.
USA	Based on vehicle speed, cut versus fill, and roadside slope. Typically 10 m for freeways. For high speed and rural clearances, see (*2*); for urban and low-speed clearances, see (*1*).
Venezuela	The "clear zone" concept is not embodied in the design criteria.
Yugoslavia	Follows AASHTO procedures.

3.3 Roadside Tree Maintenance and Guidelines

3.3.1 Roadside Tree Maintenance

The detrimental effect roadside trees have had on public safety both in the U.S. and around the world has been well documented over the last few decades, but injuries and deaths are not the only problems that arise due to trees along travelways. Trees can lessen visibility along roads, and

due to the difficulties associated with trimming trees, maintenance by trained professionals may be required [11, 42]. Dead limbs may fall on road users (vehicles, pedestrians, bicyclists) due to added weight of ice and snow; during extreme weather conditions, even healthy, live limbs can fall [43]. Trees also can contribute to uneven road surfaces and sidewalks when the concrete slabs are heaved upward by roots. This action causes an overall degradation of sidewalks and may affect the roadway [42].

48% of FEMA relief funds given out for these disasters went to debris removal, which is twice as expensive as any other disaster-related activity [17].

Debris removal is a major component of any large scale disaster relief in areas of high tree density. For example, during the development of a program for the North Carolina Division of Emergency Management that looked at seven major disasters between 1996 and 2000, researchers found that 48% of FEMA relief funds given out for these disasters went to debris removal, which is twice as expensive as any other disaster-related activity [17]. Although it is not possible to determine how much of the debris removal cost is related to roadside trees, anecdotal evidence provided by state DOTs indicate that roadside tree debris is particularly difficult as the fallen trees can block roadways, thereby straining the transportation network and hampering recovery and relief operations.

Trees can also form a canopy over the roadway that can cause the road to stay wet and slippery after a heavy rain or fog [44]. Leaves and needles that fall from trees during a strong wind or rain can contribute to the overall slipperiness of the roadway. Shadows cast by roadside trees in the winter can leave ice patches on the pavement that are very dangerous to motorists [43]. Trees may also reduce the overall effectiveness of street lighting, which can lead to more crashes [10].

It is recommended that maintenance crews cut saplings when they are small in order to prevent the public from developing emotional attachments to the trees. Further, even mid-size trees (e.g., 6 to 10 inches in diameter) can cause considerable damage to vehicle occupants and motorcyclists [20]. Small trees in the clear zone can be killed with a chemical spray, but it is recommended that trees larger than six feet tall be cut down, because the extreme color change resulting from herbicides may cause public concern [45].

3.3.2 Roadside Tree Guidelines

Some state DOT guidelines regarding trees are summarized in the following sections. Although many states possess some degree of consideration for maintaining, mowing, pruning, and removing trees, guidelines vary between states.

3.3.2.1 Ohio Department of Transportation

In July 2014, the Ohio Department of Transportation (OhioDOT) published a set of guidelines to be used by individuals landscaping along Ohio highways [46]. OhioDOT does not allow trees to be planted within 30 feet of the traveled way on clear zone graded sections. Trees are not to encroach the visibility of drivers, have trunks greater than 4 inches, or have canopies that encroach upon the road. Generally, a minimum 50-foot setback distance from the edge of traveled way within a loop ramp is considered an appropriate setback distance for mature tree heights over 18 inches.

3.3.2.2 Georgia Department of Transportation

Along rural roads in Georgia, trees and shrubs must be located outside of the established clear zone [47]. In urban areas with a posted speed limit of 45 mph, the lateral offset distance from the curb to the tree line is 14 feet; when speeds are between 40 and 45 mph, the distance is 10 feet; and in a commercial area with a speed below 35 mph, the distance is 4 feet.

3.3.2.3 Additional Examples of Tree-Related Guidelines

Some state DOTs, such as New York State DOT (NYSDOT), may consider written material from external agencies when deciding what practices to adopt. A course prepared at Cornell University, for example, attempted to summarize legal liabilities for the NYSDOT and other New York highway agencies by describing the duties of DOT employees [48]. In the course, liabilities regarding roadside shoulders, trees, and slopes are discussed in detail. For example, warnings are provided about trees with decay or damage, in that actual or constructive notice of a tree's condition may render the NYSDOT liable for damages in the event a limb or tree trunk falls on a roadway or vehicle. Such a document describes which actions a safety engineer may take to avoid litigation.

In other locations, guidelines involving tree litigation and maintenance may not be controlled or adopted by state agencies at all. In Pennsylvania, Kronthal's *Municipal Liability: Tree Roots & Sidewalk Slips and Falls* is an open resource summarizing some of Pennsylvania litigation regarding roadside tree safety, specifically as it applies to pedestrians [49]. Although the legal document is solely for an informational purpose to assist with identifying which claims are actionable and which are unsupported based on previous litigation, such summary documents may also assist DOTs with decision-making processes regarding the initial placement and maintenance of trees if the placement is deemed likely to precipitate into litigation.

3.4 Roadside Tree Recommendations

Many reports and individuals have recommended different solutions to the roadside tree problem, but the most common recommendation is to simply remove the trees from the clear zone. Roadways with small clear zones, particularly 10 or 15 feet, may observe benefits by extending the clear zone:

- A 5-ft extension can lower crash rates by 13%;
- An 8-ft extension can lower crash rates by 21%;
- A 10-ft extension can lower crash rates by 25%;
- A 12-ft extension can lower crash rates by 29%;
- A 15-ft extension can lower crash rates by 35%; and
- A 20-ft extension can lower crash rates by 44% [50].

One highly cited report, *A Guide to Management of Roadside Trees*, was published by Zeigler in 1986 [24]. Zeigler advocated for tree removal in the clear zone starting from areas of high risk and moving to areas of lower risk. This recommendation means that curved rural local road sections would be cleared first, followed by curved rural U.S./state road sections, straight rural local road sections, and finally, straight rural U.S./state road sections. Additionally, roads

with documented accident histories should be prioritized for tree removal. Nearly half of the analyzed vehicle/tree collisions that occurred on curved roads were at locations associated with at least one prior crash. Zeigler noted that if trees were kept within the clear zone there should at least be "safety gaps" within the tree lines that allowed motorists to drive between them. This idea was recommended because accident frequency and severity decrease as the distance between trees increases.

Turner and Mansfield's 1990 study, *Urban Trees and Roadside Safety*, contains many recommendations on how to prevent run-off-road crashes with trees [22]. First, the authors recommend attempting to keep vehicles from entering the clear zone through the usage of warning signs, rumble strips, or increasing pavement friction. To account for when a vehicle does leave the road, they recommend that no trees over 4 inches in diameter be kept within the clear zone and prioritizing the removal of trees on the outside of horizontal curves and at the bottom of ditches.

Volume 3 of NCHRP Report No. 500, *A Guide for Addressing Collisions with Trees in Hazardous Locations*, contains many useful recommendations for decreasing the number of vehicle/tree collisions on U.S. highways [20]. The simplest and potentially most effective suggestion in this report is to prevent trees from growing in hazardous locations, such as curves or areas that contain a crash history. The authors also recommend decreasing the posted speed limit and increasing police patrol near the high-crash frequency locations. Finally, improving both the highway safety management system and emergency medical and trauma services could potentially decrease the severity of ROR tree crashes.

3.5 Survey of State DOT Practices and Marketing Techniques

During the fall of 2015, a survey was sent to representatives or agencies in each of the 50 U.S. state DOTs requesting feedback regarding state tree maintenance practices, marketing techniques, and outcomes. Half of the state DOTs responded to the survey (25/50). The survey consisted of four questions, with each state DOT given an opportunity to explain their answers and provide additional feedback. The survey is summarized in Table 5.

Table 5. Survey Questions and State DOT Answers

Question	Yes	No	Did Not Answer
Has your State DOT or government agency utilized marketing campaigns (Ads, lobbying, brochures, etc.) to either raise public awareness of safety risks, including roadside trees or garner public support for safety treatments for hazards, particularly roadside trees, such as removal, relocation, or shielding?	1	23	1
Has your State DOT or government agency funded any safety improvement projects that have included roadside tree removal or relocation?	15	6	4
Does your State DOT or government agency utilize specific maintenance practices (i.e., mowing, trimming, removal, etc.) for addressing roadside trees located within the clear zone?	19	2	4
Has your State DOT or government agency conducted any crash data analysis studies to investigate safety risks involving roadside trees and/or utility poles (i.e., telephone and power)?	15	6	4

Survey results were surprising. Of the responding states, only one (4%) indicated that a concerted effort had been made to raise public awareness of the dangers of roadside trees and to garner support for tree removal projects.

Results of the maintenance and safety improvement projects were more encouraging. Approximately 80% of the responding states utilize specific maintenance practices to prevent or reduce new tree growth on roadsides, typically consisting of mowing and grubbing procedures. In comparison, guidelines were found online regarding tree removal and roadside vegetation management for 29 states in the U.S., as discussed in Section 3.3. More than half of the responding states noted safety projects which specifically identified tree removal in the requested safety improvements. In addition, the majority of the states (at least 60%) conducted crash data analysis observing the frequency of different types of fixed object roadside crashes that contributed to fatalities, including trees. Survey responses suggested that many of these studies to identify the specific causes of fatal crashes in states were connected to programs funded by the FHWA to evaluate ROR crash causes. Some states, such as Louisiana, were focus states in which crash data was being specifically filtered to look for ROR crashes. Other state DOTs included both focused studies on all crashes occurring in a geographic location (e.g., selecting 10-mile stretches containing several "black spots" and identifying every crash occurring on the roadway in that area), as well as distributed studies evaluating crash causes as a whole.

Nonetheless, four state DOTs specifically noted frustrations that either roadside trees were protected or the state DOT lacked the authority to perform tree removal for safety improvements. Although most states indicated that statewide safety plans developed at the DOTs identified tree removal as both a recurring need and frequently occurred in black spot analysis, survey results suggest that more expansive authority may be needed for the DOTs to perform tree removal or additional campaigns specifically targeting those with the authority to conduct tree removal may be necessary.

Nearly every state that responded that a program or existing effort was underway to control roadside tree growth also indicated that, apart from roadway construction or maintenance projects, tree removal or maintenance was the responsibility of agencies which conducted roadside vegetation control (e.g., mowing). Vegetation control may be public or directly controlled and funded by the state, or may be contract work with private or local governments. Several states noted that maintenance was challenging and at times insufficient to prevent new tree growth.

Some states provided useful and unique approaches to dealing with roadside trees, such as:

- Pennsylvania DOT maintains a "hit tree" list. In addition, state improvement funding allocated to the Low-Cost Safety Improvement Program (LCSIP) and some state money is allocated for tree removal each year [51].
- Michigan DOT utilizes a standard roadside vegetation manual to standardize roadside vegetation control and maintenance, including trees [52].
- Nebraska DOT applies tree removal and maintenance on every major roadway reconstruction or maintenance project [53].
- Oregon DOT utilized cut roadside trees to form natural dams and fish hatcheries in the Hazard Trees for Fish Habitat program [54].

- Minnesota DOT used mulch from felled roadside trees as a natural, ecologically-friendly erosion control feature in roadside ditches [55].

The state DOT survey provided an excellent snapshot of the challenges facing DOTs and confirmed the need for dedicated efforts specifically targeting tree removal.

4 STATE DOT AND INTERNATIONAL TREE REMOVAL EFFORTS

4.1 Introduction

Many state DOT and international agencies have conducted tree clearing projects. Reasons for clearing roadside trees include: complying with the Roadside Design Guide [9] clear zone or state or local clear zone policy to improve roadside safety; reducing maintenance on or near roadways; removal of dead or dying trees to avoid future safety, liability, and obstruction problems; or as part of roadway rehabilitation, widening/expansion, or improvement projects. This chapter includes examples of state DOT tree removal projects (Section 4.2), international tree removal projects (Section 4.3), and examples of state DOT tree removal campaigns (Section 4.4).

4.2 Domestic Tree Safety Projects

Although the survey of state DOTs indicated that the tree removal is not often directly or even indirectly advertised, many tree removal and safety projects have been conducted. Samples of some tree removal safety projects in various states are shown in the following sections.

4.2.1 Connecticut

The Connecticut Department of Transportation (ConnDOT) funded several projects to trim and cut down trees on I-91. In June 2015, a project was completed on a stretch of road extending from Deerfield to Greenfield [56]. In 2013, ConnDOT funded an effort to remove trees on a 6.91-mile segment of northbound I-91 spanning from Exit 17 to Exit 21 [57].

Table 6. Connecticut I-91 Tree Removal Project [56-57]

Project	**Tree Removal Project**
Start Date	2013
Completion Date	2015
Location	I-91 [Meriden, Middletown and Cromwell, 2013] [Between Deerfield and Greenfield, 2015]

Figure 6. Interstate 91 in Connecticut [57]

4.2.2 Maine

The Press Herald reported that the Maine State Department of Transportation (MaineDOT) funded an extensive tree and shrub cutting project along a busy stretch of the I-295 in Freeport in May 2015 [58]. John Cannell, MaineDOT's southern region manager, explained that the goal of the project was to replace the trees and shrubs with grasses that could be controlled by mowing instead of arduous tree cutting projects. Smaller-diameter bushes are less likely to abruptly stop an impacting vehicle, which reduces crash impulse load and allows errant vehicles to recover on the roadside.

Table 7. Maine I-295 Tree and Shrub Cutting Project [58]

Project	**Tree and shrub cutting project**
Start date	April 2015
Completion Date	May 2015
Location	I-295 [Exits 21 and 28, near Freeport]
Budget	$205,000

4.2.3 North Carolina

The North Carolina Department of Transportation (NCDOT) manages roadside vegetation through the its Vegetation Management division, which assisted with NCDOT's Clear Zone Improvement Program (CZIP) to assimilate safety, operations, and aesthetics by providing a 40-foot wide clear recovery zone adjacent to the road [59]. NCDOT's Vegetation Management division cleared the roadsides to a width of 40 feet, and planted native grasses, wildflowers, and low-growing trees to provide shade to inhibit the migration of the larger tree species. The implementation of CZIP would involve the removal of unwanted vegetation and the establishment of the native grasses, wildflowers and low-growing tree species. An example of the implementation of CZIP is shown in Figure 7.

Many clear zone improvement projects have been completed by NCDOT and the Vegetation Management division. One example of tree cutting conducted by NCDOT in which NCDOT cut down trees on exits 54 to 36 on interstate 77 in April 2011, and which received local news attention, is described in Table 8 [61].

Table 8. North Carolina I-77 Clear Zone Improvement Program [61]

Project	**Clear Zone Improvement Program**
Start date	January 2011
Completion Date	June 2011
Location	I – 77 [Exit 54 to 36, by April 25]
Budget	Projected: $0.5 million Maximum Budget: Up to $1 million

Figure 7. NDCOT Tree Planting and Management Plan [60]

4.2.4 Ohio

In 2014, OhioDOT funded an effort to remove trees adjacent to sidewalks leading up to schools [62]. OhioDOT planned to plant 31 new trees in the area in October 2014 after the tree removal project.

Table 9. Ohio Safe Routes to School Program [62]

Project	**Safe Routes to School**
Start Dates	June 2014
Completion Date	October 2014
Scale	Residential walkway
Budget	$0.4M
Scope	Proposal: remove 42 trees removed 21 trees, replanted 31 trees

4.2.1 Oregon

The Oregon Department of Transportation (ODOT) funded a project to remove 200 dead or dying trees at risk of collapsing onto Highway 101 between 2015 and 2017 [63-65]. The targeted section of roadway was lined with approximately 5,000 trees. To reduce waste, many of the

removed trees are being repurposed as natural dams or shelters for fish and forest animals. ODOT's commitment to improving safety by reducing tree crashes while contributing to ecologically-friendly activities reduces negative public backlash. An example of one of ODOT's tree removal efforts is summarized in Table 10.

Figure 8. Highway 101 in Oregon Demonstrating Tree Aging and Formation of Hazard Trees [63-65]

Table 10. Oregon Highway 101 Tree Removal Project [63-65]

Project	Tree removal
Start date	2015
Completion Date	2017
Location	Highway 101 [Cannon Beach's north entrance and Sunset Boulevard]
Plan	Remove 200 dead or dying trees out of 5000 trees 2015: remove 70 trees [55 trees removed in March] 2016: remove 70 trees 2017: remove 60 trees
Budget	$1 million [$7,300 adding crew cost]

4.2.1 South Carolina

In 2010, Post and Courier's analysis revealed a tree-lined segment of I-26 between Jedburg and Harleyville, South Carolina had twice the number of fatal crashes than a section between Charleston and North Charleston, although ADT was two to three times larger in the Charleston metro area [66]. There were 1,934 crashes resulting in 44 fatalities and 709 injuries that occurred on a controlled length of I-26 from 2007 through 2011, and half the crashes were ROR crashes [67-68]. The resulting tree removal project is summarized in Table 11. The South Carolina Department of Transportation (SCDOT) proposed cutting down 24 miles of trees that contributed to an unusually high fatality rate along the stretch of I-26 between mile markers 170 and 198 [69]. After debate, the local government and SCDOT agreed to remove seven miles of trees and install 12 miles of roadside cable barrier at I-26 between exits 194 and 169 [69-70].

Table 11. South Carolina I-26 Tree Removal Project [66-71]

Original proposal	Remove 24 miles of trees
Discussion	Meeting of the Berkeley-Charleston-Dorchester Council of Governments
Decision	Remove 7 miles of trees, install 12 miles of roadside cable barrier
Start date	January 10, 2015
Completion Date	Middle of August 2015
Location	Exit 194 to 169
Budget	$5 million

4.2.2 Georgia

Georgia DOT began a two-year, $62.5 million project to remove trees from major highways in Georgia [72-75]. Roadside safety was the primary reason noted by Georgia DOT for conducting the roadside improvement project, but DOT representatives also denoted the positive benefits associated with reduced road debris after hurricanes or tropical storms, which should expedite emergency response, cleanup, and disaster relief. The tree removal efforts created concern, frustration, and objection from citizens who perceive the project to be unnecessary, unsightly, and expensive. However, Georgia DOT noted that as of 2017, approximately 51% of fatal crashes in Georgia were single-vehicle crashes, and of those single-vehicle crashes, trees were the most common roadside fixed object struck. This project is expected to save dozens of lives and prevent thousands of crashes each year.

Table 12. Georgia Tree Removal Project [72-75]

Discussion	Roadside trees are being cut to reduce single-vehicle run-off-road crashes which constitute 51% of all Georgia traffic fatalities. Clearing trees will also result in substantial improvements to transportation and mobility after a hurricane or tropical storm.
Start date	2017
Completion Date	2019
Location	2,200 mi (3,540 km) on highways in Georgia
Budget	$62.5 million

Figure 9. Georgia DOT Tree Removal [74]

4.3 International Roadway Safety Projects

4.3.1 Poland National Road Safety Program

In Poland, tree crashes resulted in higher fatalities than alcohol-related road incidents, with tree crashes comprising 11% of all crashes in 2003, as shown in Figure 10 [37]. To reduce ROR fatalities, Poland developed an integrated program of road safety improvement called "GAMBIT" in 2007. GAMBIT was credited with saving 2,250 lives over nine years, as shown in Figure 11. The Polish government established new speed limits and improved visibility by cutting trees at intersections, improving road infrastructure, and implementing the AASHTO "forgiving roads" concept into designs [37, 76]. Some agencies relied on different methods to mitigate roadside safety and tree issues rather than cutting down trees, such as implementing national road improvement programs and installing crash cushions or guardrails.

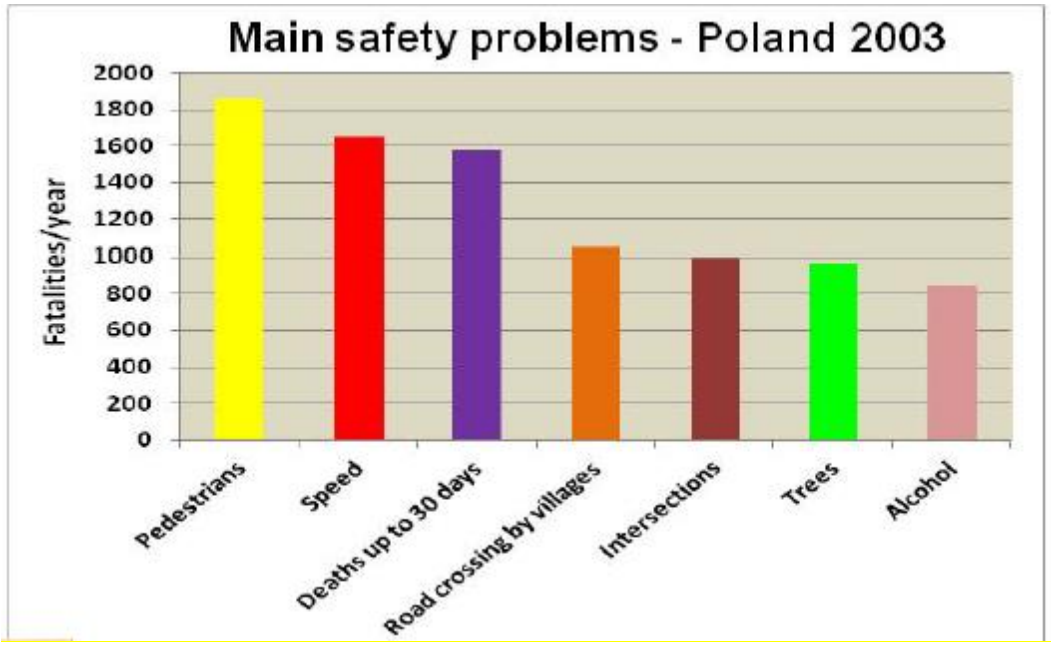


Figure 10. Main safety problems – Poland 2003 [37]

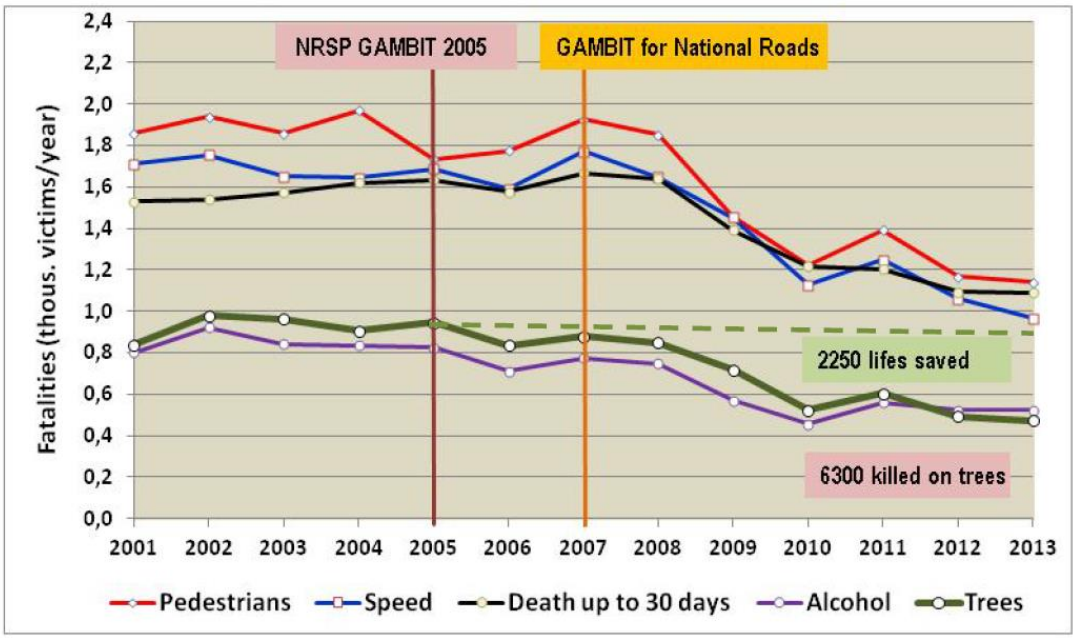


Figure 11. Effect of GAMBIT on Decreasing Number of Road Accident Fatalities [37]

4.3.2 France

In 1998, France completed a major project to construct 7,800 meters of guardrails, 13 frontage roads, and eight lay-by treatments in a 26.5-km section of the national road RN 134 in southwest France [77]. The project caused a significant reduction in tree crashes, fatalities, and

overall crash severity, as shown in Figure 12. The benefit-to-cost ratio of installing guardrail vs. the null option (i.e., the cost effectiveness of guardrail) was determined to be 8.69.

Many of France's historical roads have roots prior to modern automotive transportation. A corridor in France which is now a vehicular roadway was once a footpath of Napoleon's army [78]. France continues to grapple with the roadside safety risks imposed by trees in light of the public perception, ecological, aesthetic, and historical considerations for the trees [78].

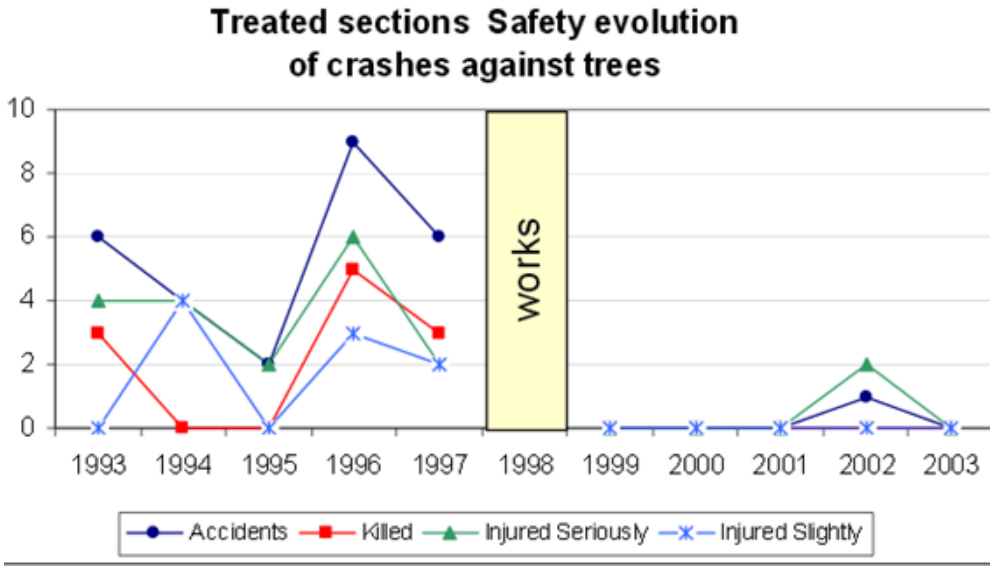


Figure 12. Treated Sections Safety Evolution of Crashes Against Trees [77]

4.3.3 Germany

In his report, "Road Safety and Tree-Lined Avenues – The Experience from West-Berlin and Eastern Germany," Vollpracht, a former road director in West Berlin, discusses tree-lined avenues in both urban and rural contexts [34]. Vollpracht identified environmental and ecological benefits as well as improved aesthetics because of roadside trees, and stated that driving behaviors could be indirectly affected by roadside trees. Nonetheless, trees were identified as a significant risk for crashes and fatalities. New guidelines in Germany call for a specified distance between trees and carriageways of certain speed limits, and where this is not possible, crash barriers must be installed. The author concluded that whenever feasible and not historically sensitive, trees should be removed from every roadside; if removal is not possible, shielding is preferred. In some locations with historical merit, alternative safety treatments may be required to accommodate the roadside trees.

4.4 State DOT Tree Removal Marketing Examples

Some state DOTs engaged in marketing campaigns to promote the positive benefits of roadside tree removal. An example of Oregon's public campaign to utilize roadside trees to improve the states ecology is shown in Figure 13 [79]. A public safety announcement about roadside tree clearing produced by Caltrans is shown in Figure 14 [80].

Figure 13. Oregon DOT (ODOT) Tree Management Program Advertisement [79]

Figure 14. Caltrans Tree Removal Marketing – News Flash [80]

5 ANALYSIS OF STATE DOT TREE AND UTILITY POLE CRASH DATA

5.1 Motivation

The literature review of crash data for trees and utility poles indicated a significant, widespread concern regarding trees and utility pole crashes. Because both trees and utility poles can be nearly rigid and are frequently found adjacent to the roadway, crashes may be both harmful and relatively frequent. However, most of the tree crash analysis studies available in literature focused on relatively small datasets; were conducted under varying economic, social, and political climates; and not all datasets were complete. The researchers desired to estimate the national average crash cost of tree and utility pole crashes based on average crash severity costs using crash data collected from many state DOTs through a similar time period. These parameters would provide a more robust, complete perspective of tree and utility pole crashes to ensure that crash cost estimates are representative of state and national averages. In addition, a large dataset would lead to more statistically significant conclusions regarding crash frequency and annual crash rates. This research would supplement the findings of FARS [4], which collects data for fatal crashes, and IIHS [2], which collects topographical data related to ROR crashes.

5.2 Methods and Procedures

Researchers at the Midwest Roadside Safety Facility (MwRSF) contacted state DOTs and requested information on crashes that involved a tree or utility pole over a five-year span between 2009 and 2014 (e.g., 2009-2013 or 2010-2014). Twelve state DOTs provided crash data for a total of more than 400,000 tree and utility pole crashes. Database fields provided by state DOTs are summarized in Tables 13 and 14. State DOT databases contained various parameters depending on data availability and safety interests. The parameters provided by each state varied, and no state database contained every field tracked in this study.

Table 13. Crash Data Parameters and Definitions

Crash Data Parameter	Definition
Crash ID	Unique case ID used to differentiate crashes; unique per state
Severity	Crash severity. Converted to KABCO whenever possible. For some states, injury noted as "I" for non-fatal injury and was not coded to KABCO.
Date	Crash date
Time	Crash time
County	County where crash occurred
City (includes nearby)	City name recorded if crash occurred within or in proximity to city
Longitude & Latitude	GPS coordinates of crash
Sequence of Events	Series of events which occurred prior to or during crash
Ambient Light	Ambient light at time of crash (e.g., daylight, dark/lighted, dark/not lighted)
Road Conditions	Road surface conditions at time of crash (e.g., dry, wet, icy)
Weather Conditions	Weather conditions at time of crash (e.g., clear, mist, rain, snow)
Road Material	Road material at crash location (e.g., asphalt, concrete, gravel)
Road Alignment (Curve or Grade)	Roadway alignment and elevation (e.g., curve left, sag, incline)
Road Classification	Roadway use (e.g., urban/municipal, rural, state highway)
Speed Limit	Speed limit at crash location
Vehicle Year, Make, Model	Vehicle data
VIN	Unique code used to assist with vehicle identification
Vehicle Class (Type)	Type of vehicle involved in crash (motorcycle, car, light truck, large truck)
Selt Belt Used	Seat belt use indication (per occupant)
Est Crash Cause	Police-reported estimate of major factors contributing to crash

Table 14. Summary of Data Types Provided in Crash Summary

Crash Data	States which Provided Data											
	IL	IN	KS	NH	NJ	NC	OH	OR	SD	UT	WA	WI
Crash ID	■	■	■	■	■	■	■	■	■	■	■	■
Severity	■	■	■	■	■	■	■	■	■	■	■	■
Date	■	■	■	■	■	■	■	■	■	■	■	■
Time	■	■	■	■	■	■		■			■	■
County	■	■	■			■		■	■	■	■	■
City (includes nearby)	■	■					■	■			■	■
Longitude & Latitude	■	■		■			■		■	■		
Sequence of Events	■		■			■						
Ambient Light	■	■	■	■		■	■	■	■	■	■	■
Road Conditions	■	■	■	■	■	■		■	■	■	■	■
Weather Conditions	■	■	■	■	■	■	■	■	■	■	■	■
Road Material		■							■			
Road Alignment (Curve or Grade)	■	■		■				■	■	■	■	■
Road Classification	■	■			■	■		■	■		■	■
Speed Limit		■				■		■	■	■		■
Vehicle Year, Make, Model	■				■					■	■	
VIN	■									■		
Vehicle Class (Type)	■					■						
Selt Belt Used												■
Factors Contributing to Crash (Estimated)	■		■			■		■		■	■	■

Crash data was sorted and organized into a table for analysis and comparison. Due to the large number of crashes collected, analysis of individual crash records was not possible. During data analysis, a number of observations were made:

- Some states provided redundant crash records for each occupant of the crashed vehicle. Only one crash record containing the maximum injury severity in a given vehicle was retained and analyzed.
- Injury data was often provided using a KABCO+U format:
    - K = killed or died within the reporting period of a crash report at a hospital;
    - A = severe injury resulting in loss of consciousness, incapacitation, permanent injury, extended hospitalization, or chronic pain;
    - B = moderate injury resulting in temporary incapacitation or loss of work which is not prolonged;
    - C = minor (sometimes denoted "possible") injury which may be treated on scene or in which an occupant is transported to a hospital and released, or in which treatment is refused;
    - O = property damage only (PDO), no major injuries reported which require treatment or hospitalization; and
    - U = unknown injury.

  For analysis purposes, it was assumed that crashes with "U" injury code were entirely PDO crashes. Thus, crash cost and severity results may understate actual injury contributions.
- Injury severities in crashes may be subjective; it is up to the responding officer to determine if injuries are A, B, or C severity. Furthermore, some "K" fatalities may be miscoded if the injured occupant remains in medical care for an extended duration. Fatality can result from medical complications, brain or spinal damage, prolonged loss of consciousness (i.e., non-responsive), or patient or caregiver (e.g., family) decisions to remove life support. Thus, actual fatal crash results may be underreported.
- For some state DOT databases, all non-fatal injuries (A, B, and C severity) were coded as "I." Data from state DOTs using "I"-injury data were considered independently from state DOT data which contained a complete KABCO distribution.
- Sometimes data was not available for every crash in a state. Reasons for data omission include: crash reports filled out later and not at the scene of a crash; data was not available or could not be measured; errors in data entry/coding; and data was accidentally omitted from a form.
- Causality could not be determined for crashes. If crashes involved trees in a series of events, researchers could not determine if the tree was the most harmful event (MHE) unless the state provided data to indicate MHE. In addition, it is not guaranteed that the MHE resulted in the most severe injury if multiple harmful events each resulted in injury. Because not every state provided the sequence of events and few states indicated which event was MHE, all crash data provided to researchers which were related to trees or utility poles were included in this analysis.

5.2.1 Crash Time

The approximate time of the crash was reported for most states. Crash time was converted to a 24-hour scale such that 0:00 occurred at midnight and started the day, and 23:59 corresponded to 11:59 p.m. at the end of the day. Crash times were collected into whole-hour bins ranging between 30 minutes prior to and 29 minutes after the tick of the hour (e.g., 14:30 to 15:29 were considered 15:00).

5.2.2 Crash Date

For more than 75% of the available data, both a crash date and crash severity were itemized. Researchers tabulated the number of crashes by date and sorted based on the maximum injury severity in each crash. Statistics were tabulated by month and a weighted month. Because months have variable numbers of days, the weighted monthly data was determined using a weighting factor applied to the monthly data:

$$\text{Weighting Factor} = \frac{365.2\ \text{days/year}}{12\,\frac{\text{months}}{\text{year}}\,N_{\text{month}}}$$

where N_{month} is the number of days in the given month. Note that for one of the years of available data (2012), the month of February had 29 days (i.e., it was a leap year). Thus, the average length of a year over each 5-year crash data period was 365.2 days/year, and the average number of days in February was 28.2 days.

5.2.3 Weather and Road Conditions and Crash Date

Prevailing weather conditions and road surface conditions were commonly-provided crash data. For most crashes, weather and road data were reasonably correlated (e.g., “rain” or “snow” were affiliated with “wet,” “slushy,” “icy,” or “snowy” roads; “clear” weather was affiliated with “dry” road). However, for some crashes, weather and road conditions were not obviously correlated (e.g., “dry” road with “rain” or “sleet” conditions). In addition, some data were believed to be outliers or possibly erroneous (e.g., “snowy” roads in July). The effort required to confirm the integrity of all data not obviously correlated and verify prevailing weather and road conditions with external data were beyond the scope of this study. Thus, researchers did not adjust weather or road conditions even when data were not well-correlated.

It should be noted that some weather events involved multiple adverse effects occurring simultaneously; for example, blustery or windy conditions also associated with snow or rain, or whiteout (i.e., obscured vision) combined with snow. A hierarchy was established to sort weather events into differentiated bins. Data were assigned a weather category using the following numerical order of importance:

1. If weather conditions included flurries, snow, sleet, or freezing rain, weather conditions were denoted as **Sleet / Snow**.
2. If weather conditions involved drizzle, rain, or hail and were not also associated with conditions identified in (1), weather conditions were denoted as **Rain**.

3. If weather conditions denoted strong winds, but were not associated with moisture falling (e.g., rain, snow, hail), weather conditions were denoted as **Blowing Wind/ Debris**.
4. If vision was obscured but not associated with strong, blowing winds or moisture (conditions 1 through 3 above), weather conditions were denoted as **Fog, Smoke, or Other Obscured Vision**.
5. If weather conditions were identified as clear, cloudy, partly cloudy, overcast, fair, etc., weather conditions were denoted as **No Adverse Weather Conditions**.
6. If weather conditions were not described by the above conditions, or were identified as "unknown," weather conditions were denoted as **Other/Unknown**.

5.2.4 Vehicle Data

In general, vehicle data was sparse for the surveyed states; four states provided specific vehicle data (year, make, and model). Of those four states, only one provided vehicle classification (e.g., passenger car, SUV); two provided the year, make, and model of the primary vehicle involved in the crash with a tree or utility pole; and one state provided complete vehicle data and VIN data. The four states that provided vehicle data, Illinois, Washington, Utah, and New Jersey, have diverse transportation demographics.

Vehicle types were sorted into five categories:

- Cars (small, mid-size, full-size, luxury, sporty, crossover)
- Light Trucks (SUVs, pickup trucks up to and including 1½ ton suspensions, vans)
- Large Trucks (pickup trucks with greater than 1½ ton suspensions, box trucks, single-unit trucks (SUTs), tractor-trailers, farm equipment, buses, etc.)
- Motorcycles
- Unknown (insufficient data to determine class of vehicle)

The associated number of crashes with known vehicle data (137,649 crashes) were significant, but because the percentage of crashes with "unknown" vehicle classification or which could not be determined (e.g., including errors such as Honda Camry; Chevrolet Magnum; Ford Tacoma) was significant, a comprehensive evaluation of the distributions of vehicles and injuries per vehicle make and model could not be completed with the available time and money. It is recommended that a more comprehensive evaluation of vehicle data be conducted at a later time.

5.2.5 Crash Location & Geography

For states that provided Global Navigational Satellite System (GNSS)[1] locations for the approximate locations of a crash, crash datasets were plotted using Google Earth to determine the locations of highest crash density. Although four states provided GNSS data in angular coordinates

[1] GNSS refers to the Global Navigational Satellite System, which may rely on transmissions with the Global Positioning System (GPS, maintained in the U.S.), Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS, similar to GPS and maintained in Russia), or Galileo (European system maintained by the European Space Agency (ESA) and Global Navigation Satellite Systems Agency (GSA), headquartered in Prague). GNSS data is typically provided as the angular position on the earth. Utah used the Universal Transverse Mercator (UTM) coordinates, which use an X-Y displacement coordinate frame from a reference location.

(i.e., longitude and latitude), Utah DOT provided data in Universal Transverse Mercator (UTM) coordinates with a reference origin of UTM Zone 12N, NAD83 [81].

Crash locations were sorted based on classifications provided by DOTs. Roadways were classified as "urban" (which included suburban) or "rural." Unfortunately, an objective set of criteria for identifying which streets or roads were urban or rural was not provided, and may vary for different state DOTs. In addition, more than half of the available state DOT data did not have sufficient information to classify crash locations as urban or rural. Although results were tabulated where available, project scope and budget did not allow a thorough evaluation of crash locations, and as such results are not reported herein.

Crash data was available for roadway geometrics for most crashes. Crash sets were segregated by curvature (straight/tangent, curve left, curve right, or curve with no direction noted) and grade (flat, uphill grade, downhill grade, crest, sag, or grade with no direction noted). Curvature and grade were typically independent and tabulated separately. Because time and project scope did not permit a thorough verification of curve and grade data, a lumped parameter analysis was performed using binary metrics (curved vs. non-curved and grade/sag/crest vs. non-grade).

5.2.6 Crash Cost Estimation

An attempt was made to estimate the annual average crash cost to individual states and to the entire U.S. resulting from tree and utility pole crashes. The estimated cost of each crash was assigned an estimated Present Value (PV) cost based on values provided in FHWA's *Value of a Statistical Life* (VSL) [82-84]. These crash costs were based on historical studies tracking lifetime costs, including loss of work and tax revenue, hospitalization, emergency response, crash cleanup, congestion to surrounding roadways, crash scene documentation by law enforcement personnel, and litigation. The 2012 VSL was used because it was approximately the median year of the provided crash data [82].

The VSL was provided in terms of a maximum abbreviated injury scale (MAIS), using MAIS 1 through 6 to assign severities and linking those severities to hospitalization costs. The MAIS injury costs were converted to KABCO injury costs using the Transportation Investment Generating Economic Recovery (TIGER) procedure [85]. The TIGER procedure uses a weighting factor to estimate the distribution of MAIS injuries for each KABCO injury level. For example, a "K" crash and MAIS = 6 (fatal) have a conversion factor of 1. In contrast, the "A"-injury category is approximated as a distribution of 3.4% of the MAIS 0 injury level, 55.4% of MAIS 1, 20.9% of MAIS 2, 14.4% of MAIS 3, 4.0% of MAIS 4, 1.8% of MAIS 5, and 0% of the MAIS 6 injury scale. The estimated percentage of costs associated with each MAIS injury level, as reported in the 2013 FHWA memo describing the 2012 VSL, is shown in Table 15 [86]. The complete table of MAIS-to-KABCO conversion factors used in the MAIS/KABCO Translator of the TIGER Benefit-to-Cost (BCA) Resource Guide is shown in Table 16. The resulting estimated KABCO injury costs are shown in Table 17.

Table 15. MAIS Injury Level Costs as a Percentage of Fatal Costs [86]

MAIS Ratio from Fatal VSL (FHWA 2013)						
0	**1**	**2**	**3**	**4**	**5**	**6 (fatal)**
(No Cost)	0.003	0.047	0.105	0.266	0.593	1.000

Table 16. MAIS/KABCO Translator – Table 4 [85]

KABCO Injury Scale	MAIS Level							SUM
	0	1	2	3	4	5	6 (fatal)	
	Scale Factor Contribution of MAIS to KABCO							
K	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	100%
A	0.03437	0.55449	0.20908	0.14437	0.03986	0.01783	0.00000	100%
B	0.08347	0.76843	0.10898	0.03191	0.00620	0.00101	0.00000	100%
C	0.23437	0.68946	0.06391	0.01071	0.00142	0.00013	0.00000	100%
O	0.92534	0.07257	0.00198	0.00008	0.00000	0.00003	0.00000	100%
U	0.21538	0.62728	0.10400	0.03858	0.00442	0.01034	0.00000	100%

Table 17. Estimated KABCO Costs based on 2012 VSL and MAIS-to-KABCO Conversion

Injury Scale	MAIS Injury Scale							TOTAL COST OF INJURY
	0	1	2	3	4	5	6	
	MAIS Injury Level Cost Contribution							
K	$0	$0	$0	$0	$0	$0	$9,100,000	$9,100,000
A	$0	$15,138	$89,424	$137,946	$96,485	$96,216	$0	$435,208
B	$0	$20,978	$46,611	$30,490	$15,008	$5,450	$0	$118,537
C	$0	$18,822	$27,334	$10,233	$3,437	$702	$0	$60,529
O	$0	$1,981	$847	$76	$0	$162	$0	$3,066
U	$0	$17,125	$44,481	$36,863	$10,699	$55,798	$0	$164,966

In addition to the data provided in Tables 15 through 17, researchers made several additional modifications to the data set:

- All crashes in which the severity was marked as “Unknown” were treated as PDO crashes (KABCO=”O”). This may underestimate total crash costs if the unknown injury severities were actually consistent with “K,” “A,” “B,” or “C” injuries.
- States which did not provide a differentiation between “A,” “B,” and “C” injuries according to KABCO each denoted injury crashes as “I” severity, which represented any non-fatal, non-PDO crash. For analysis purposes, the “I” injuries were considered equivalent to the KABCO “U” field shown in Tables 16 and 17. It should be noted that the “I” / “U” injuries were calculated using the National Safety Council procedure for estimating the cost of unintentional injuries [87].

5.3 Results

Crash results were tabulated for each state and datasets were combined and compared, when possible. A summary of the crash data collected from the 12 contributing state DOTs is provided in Table 18. Four state DOT data sets, consisting of Kansas, Ohio, Oregon, and Wisconsin, which were not associated with a complete KABCO injury scale, instead provided three injury tiers: fatal (K), injured (I), or PDO. A more thorough analysis of the data collected is provided in the following sections.

Table 18. Summary of Provided Crash Data

State DOT	Crash Data Years	Number of Crashes	Fatal (K) Crashes	Incapacitating (A) Injury Crashes	Percent of Tree and Utility Pole Crashes are Fatal	Percent of Tree and Utility Pole Crashes are A+K
Illinois	2009-2013	42,048	650	3,420	1.55%	9.7%
Indiana	2010-2014	25,039	165	623	0.66%	3.1%
Kansas	2010-2014	49,352	382	-	0.77%	-
New Hampshire	2009-2013	11,284	129	391	1.14%	4.6%
New Jersey	2009-2013	59,540	520	1,066	0.87%	2.7%
North Carolina	2010-2014	53,696	1,241	1,418	2.31%	5.0%
Ohio	2010-2014	91,072	1160	-	1.27%	-
Oregon	2009-2013	7,062	286	-	4.05%	-
South Dakota	2010-2014	1,943	18	129	0.93%	7.6%
Utah	2010-2014	8,662	92	316	1.06%	4.7%
Washington	2009-2014	30,470	466	1,323	1.53%	5.9%
Wisconsin	2010-2014	20,690	365	-	1.76%	-
Totals	**2009-2014**	**400,858**	**5,474**	**8,686***	**1.37%**	**5.4%**

* Data is from selected states. The number of incapacitating injury crashes in Kansas, Ohio, Oregon, and Wisconsin could not be determined. The actual number of incapacitating injuries is therefore much higher than the total shown. For example, if each state without "A"-injury data had a 5.4% severe crash percentage (A+K), the number of A-injury crashes for Kansas, Ohio, Oregon, and Wisconsin would be 2,283; 3,757; 95; and 752, respectively, for a total of 6,887 additional A-injury crashes. This number is larger than 75% of the sum of A-injury crashes in all of the other eight states.

5.3.1 Crash Time

The severity and crash frequency were strongly affected by the time of reported crash. A distribution of the injuries occurring in tree and utility pole crashes are plotted on a circular radar plot resembling a clock, as shown in Figure 15. It was observed that PDO and non-incapacitating injury crashes were most common during early morning commutes to work or school (6 a.m. to 9 a.m.) and during the drive home from work or school (2 p.m. to 6 p.m.). The distributions of PDO and non-severe injury crashes were approximately constant between 6 p.m. and 2 a.m., and declined to their lowest values between 3 a.m. and 6 a.m. In contrast, the distributions of severe crashes (i.e., incapacitating and fatal crashes) were lowest between 4 a.m. and 10 a.m., with peaks between 3 p.m. and 5 p.m. (driving home from school or work) and between 10 p.m. and 3 a.m.

The distributions were sorted and replotted with a focus on fatal crashes vs. all crashes, as shown in Figure 16. It was observed that fatal and all crash distributions were approximately equal between 4 p.m. and 9 p.m., and fatal crash percentages were higher than all crash percentages between 9 p.m. and 4 a.m.

Crash results suggest that the distribution of all crashes reflected hourly traffic volumes, such that crashes were less frequent when traffic volumes were lower, and more frequent when traffic volumes increased (e.g., high crash rates during morning and evening commutes). Fatal crash distributions suggested that deadly crashes became more common, on average, as each day progressed, resetting to a minimum value each morning at approximately 4 a.m. Based on contemporary social behaviors, these results suggest that fatal tree crashes may be strongly correlated with fatigue and alcohol consumption.

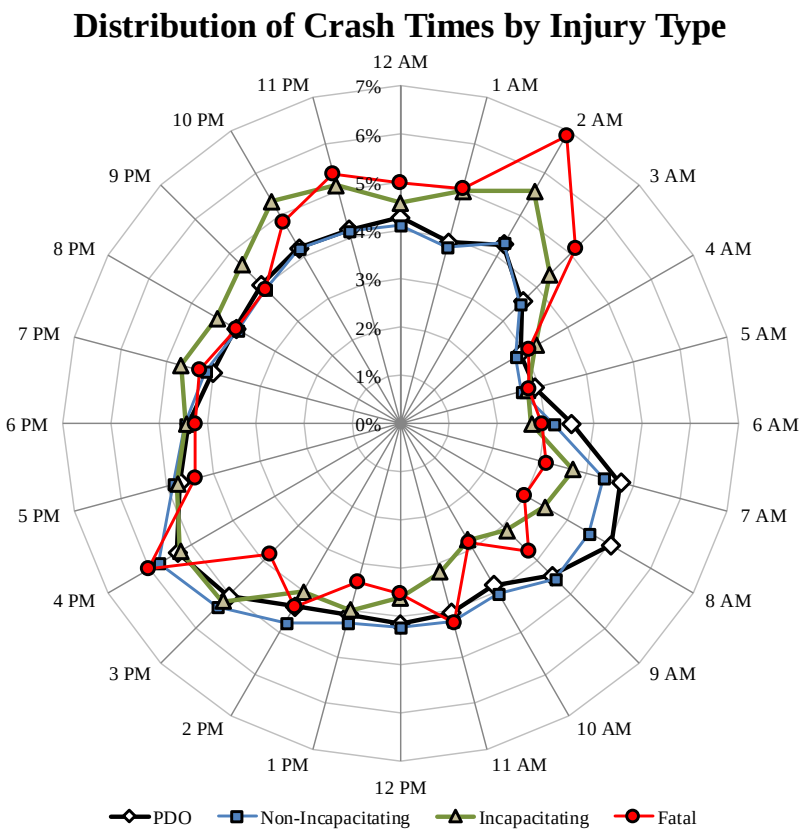


Figure 15. Distribution of Crashes by Time of Day and Injury Level

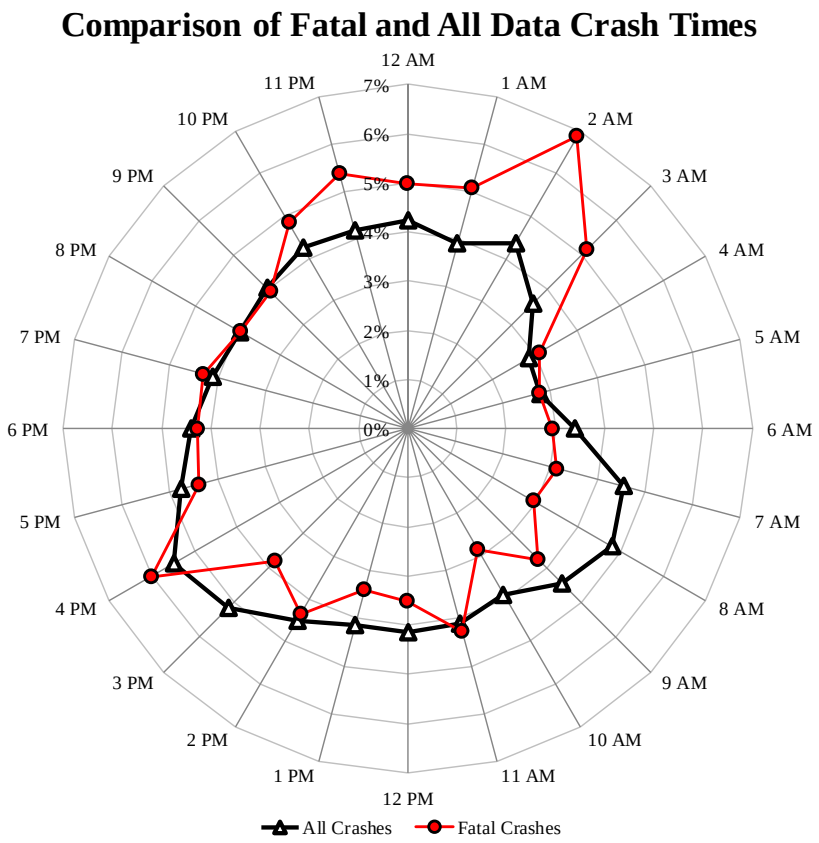


Figure 16. Comparison of Fatal Crash Distribution to All Crash Distribution by Crash Time

Next, the percent of all crashes which resulted in fatality (i.e., fatal crash percentage) was plotted with respect to time, as shown in Figure 17. Results were similar to the fatal crash distribution plot shown in Figure 16. Fatal crash percentages were smallest around 7 a.m. and 8 a.m., at less than 1% of all crashes. However, between 9 a.m. and 9 p.m., approximately 1.5% of all tree and utility pole crashes were fatal, and from approximately 1 a.m. to 3 a.m., the fatal crash percentage was above 2.0%. This statistic is sobering; results suggest that between 1 a.m. and 3 a.m., approximately 1 out of 50 crashes with a tree or utility pole results in at least one death.

Results suggest that between 1 a.m. and 3 a.m., approximately 1 in 50 crashes involving a tree or utility pole results in death.

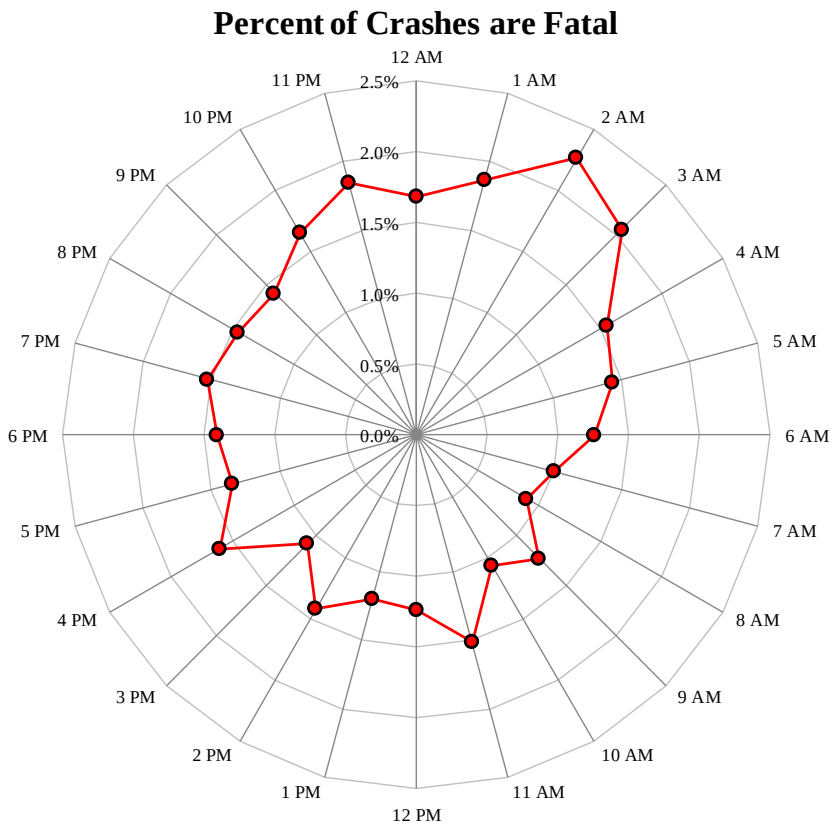


Figure 17. Fatal Crash Percentage as a Function of Time

5.3.2 Crash Date

The results of the crash date analysis are shown in Figure 18. It was noted that for "wintery" months of December, January, and February, the distribution of PDO crashes was considerably larger than during the rest of the year with more than 35% of all PDO crashes involving utility poles or trees occurring in those three months. PDO crashes involving a tree or utility pole were 72% more likely to occur during winter months compared to summer months. In contrast, the distribution of fatal crashes was lowest during the wintery months, but peaked during July (9.4%), August (10.0%), and September (9.1%). The distribution of incapacitating (A-injury) crashes was surprisingly constant from month-to-month, typically ranging between 7.5 and 9%. The weighted data calculated for each month is shown in Figure 19.

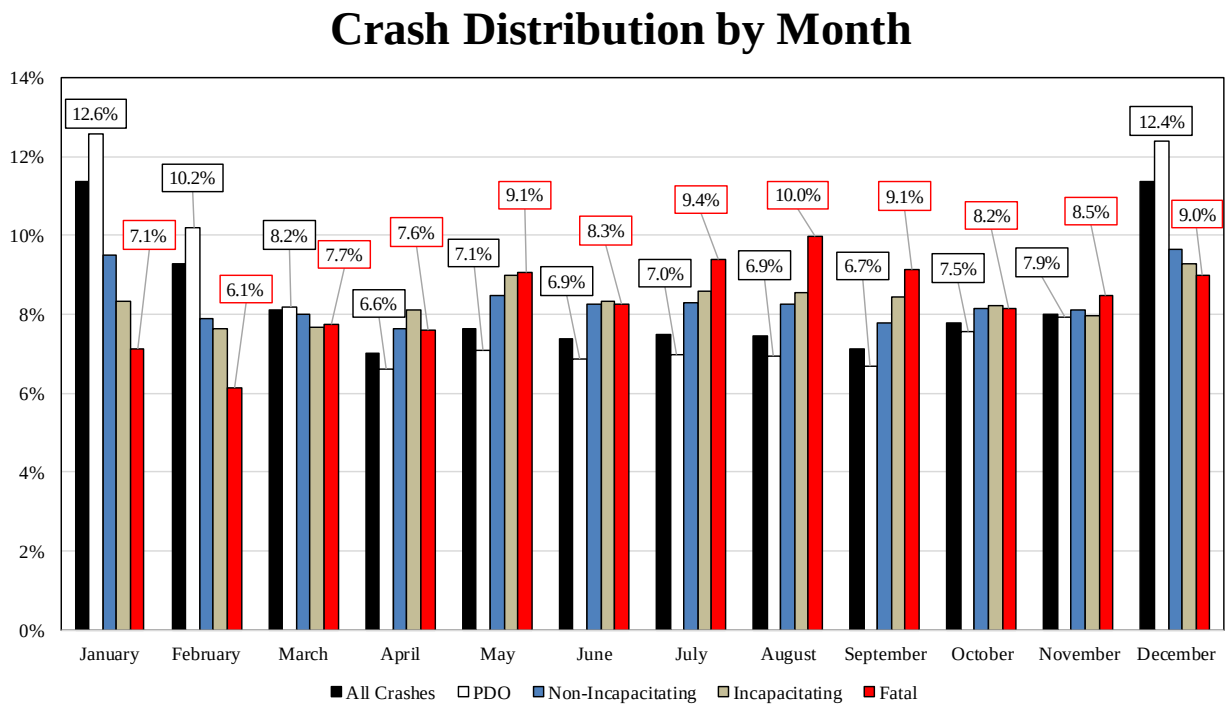


Figure 18. Crash Injury Distribution by Month

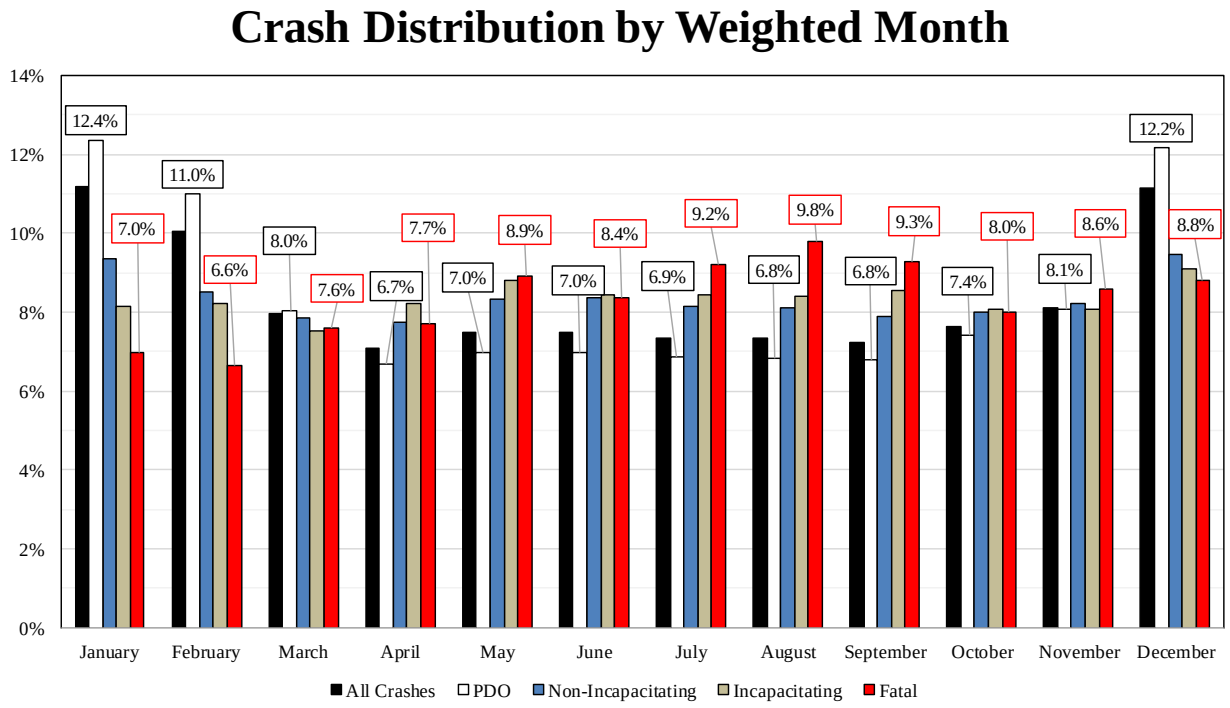


Figure 19. Crash Injury Distribution by Weighted Month

Crashes were lumped into months with similar weather patterns (December through February, March through May, June through August, and September through November), as shown in Figure 20. The three-month windows were approximately concurrent with winter, spring, summer, and fall seasons. Although data for all crashes was skewed toward winter months, with 32% of all crashes (any injury type) occurring between December 1 and February 28/29, fatal crashes were skewed toward summer months, with 28% of fatal crashes occurring between June 1 and August 31. Surprisingly, when severe crashes (i.e., incapacitating and fatal injury crashes) were considered, data was approximately flat throughout the year, suggesting that severe crash rates are independent of seasonal weather patterns. However, when considering the percentage of crashes occurring per season which are fatal (i.e., fatal crashes/total crashes, per season), many low-severity crashes in the winter compared to the summer led to a lower average severity in winter, but higher average severity in summer. Crash rates in the spring and fall were very similar for all data sets considered.

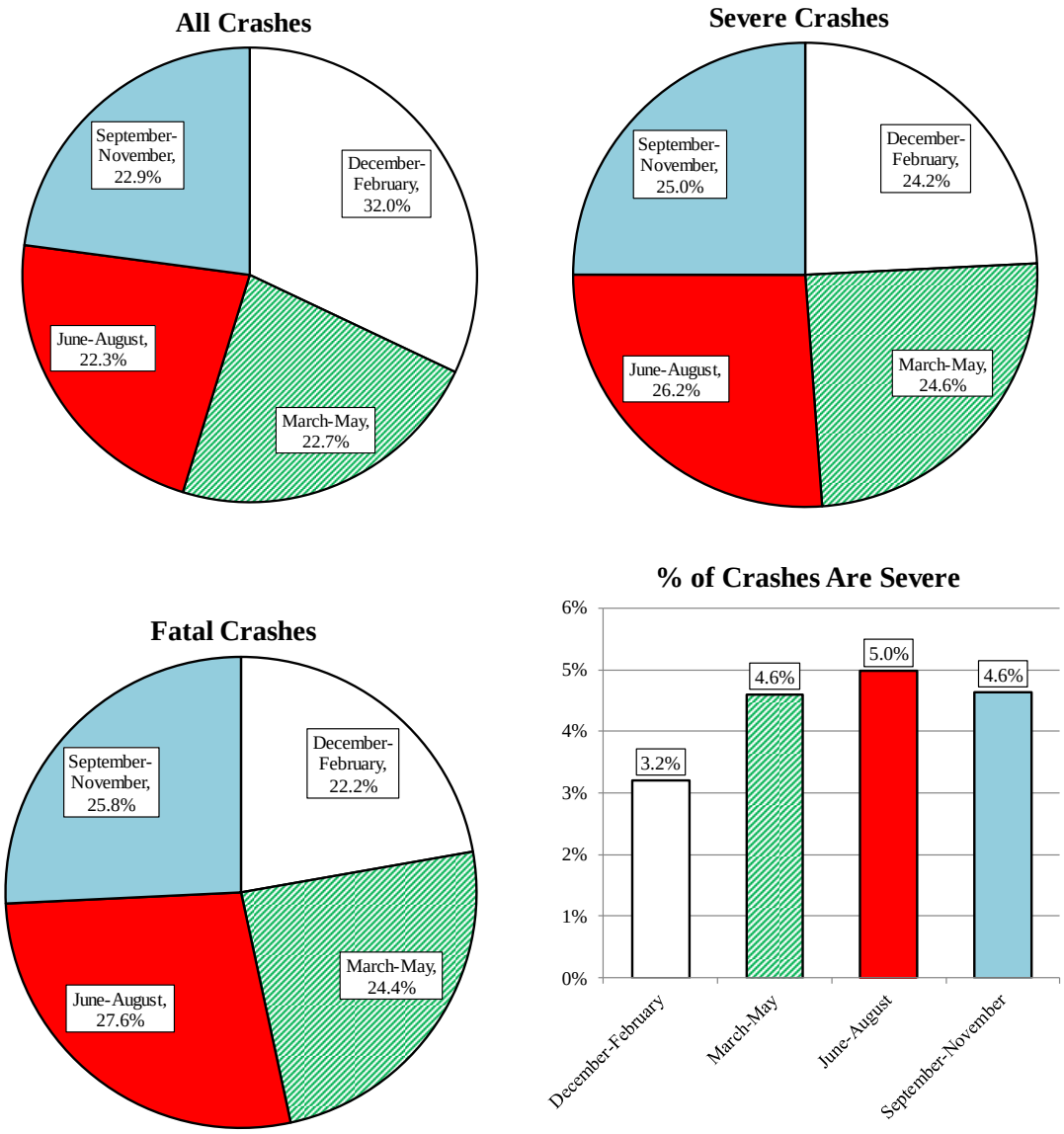


Figure 20. Distribution of Crash Severities by Season

5.3.3 Weather and Road Conditions

For the vast majority of crashes, no adverse weather conditions (such as rain, sleet/snow, fog/smoke/obscured vision, blowing wind/debris, and other/unknown) were present at the time of the crash, as shown in Figure 21. More than 87% of all fatal crashes and 84% of all incapacitating injury crashes were associated with no adverse weather conditions, although no adverse weather was associated with less than 75% of all crashes. Fatal crashes were approximately 19% more likely to occur when no adverse weather conditions were present compared to exposure to adverse weather.

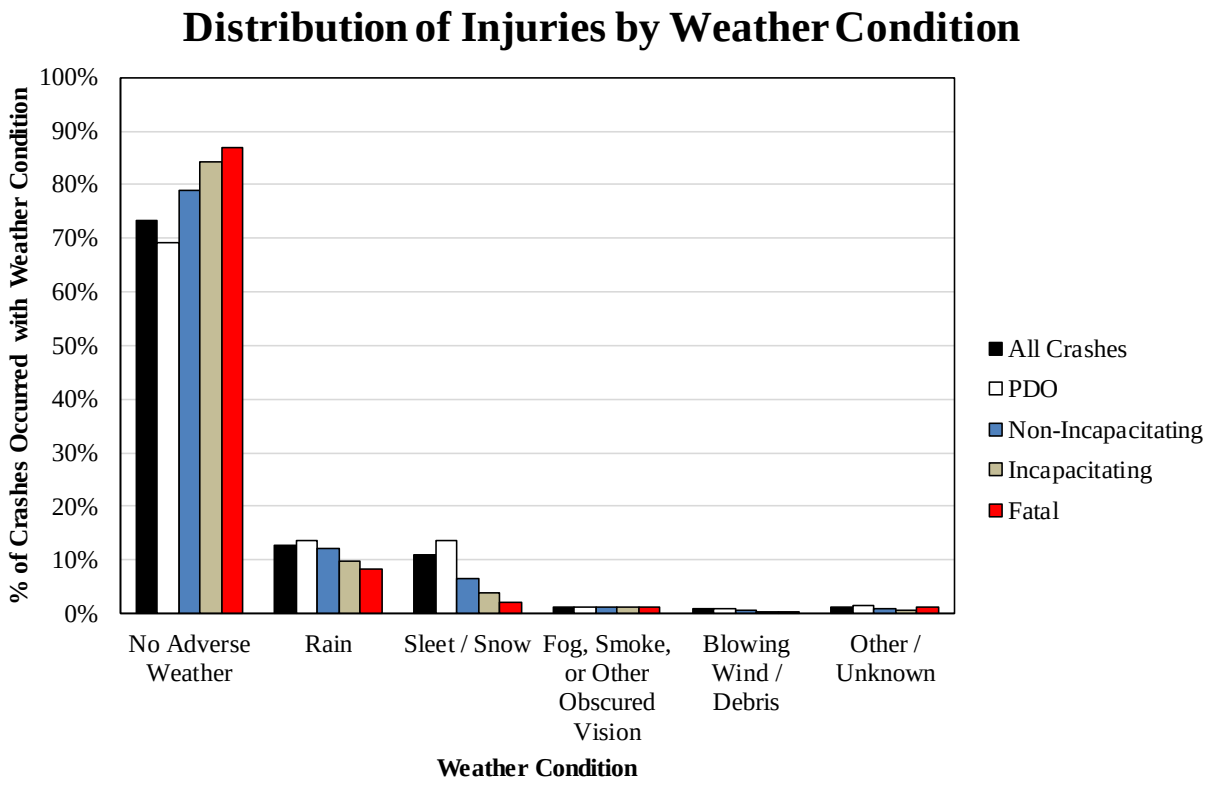


Figure 21. Distribution of Injuries by Prevailing Weather Conditions at Time of Crash

The distribution of injuries per weather type were also evaluated, as shown in Figures 22 and 23. It was observed that crashes were most severe for no adverse weather and obscured vision conditions, and were least severe for snow and blowing wind crashes. In general, it was observed that the percentage of PDO crashes was an excellent predictor regarding the average severity of crashes in each reported weather condition; as the percentage of PDO crashes increased, the percentage of severe crashes (A+K) generally decreased.

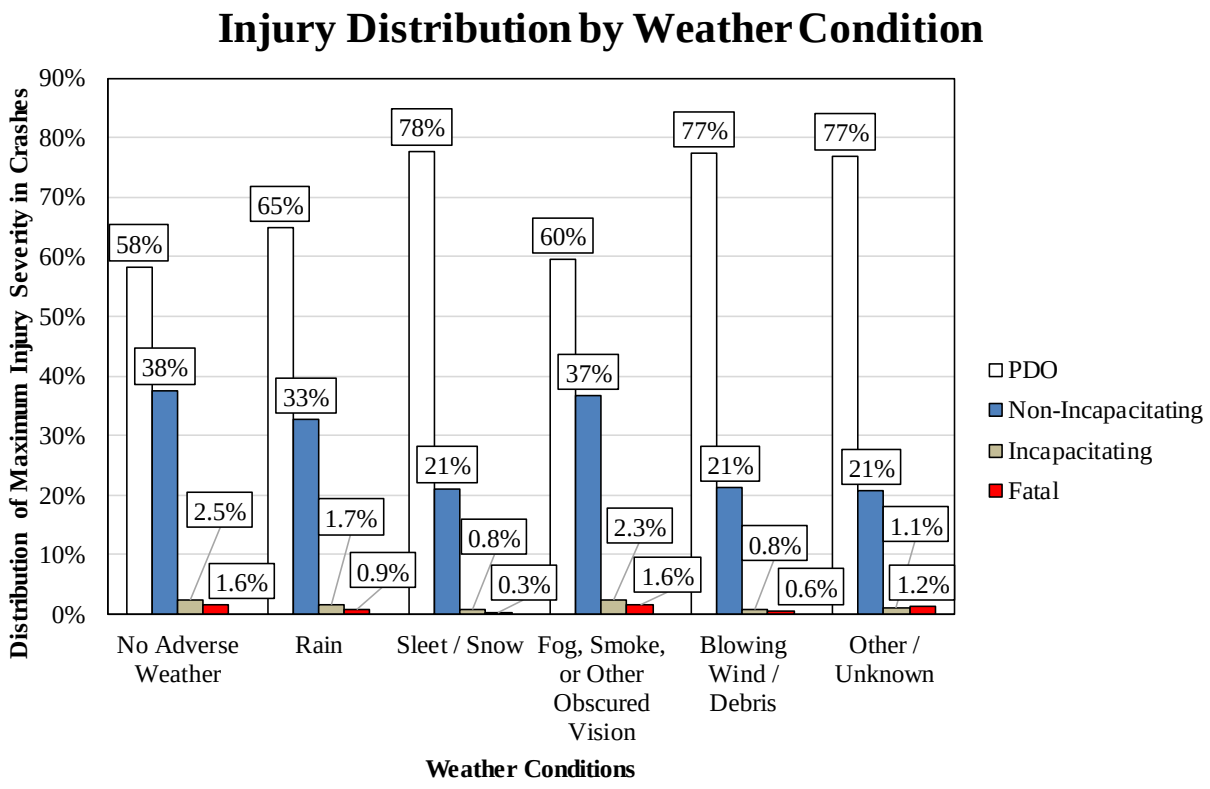


Figure 22. Distribution of Injuries by Weather Condition

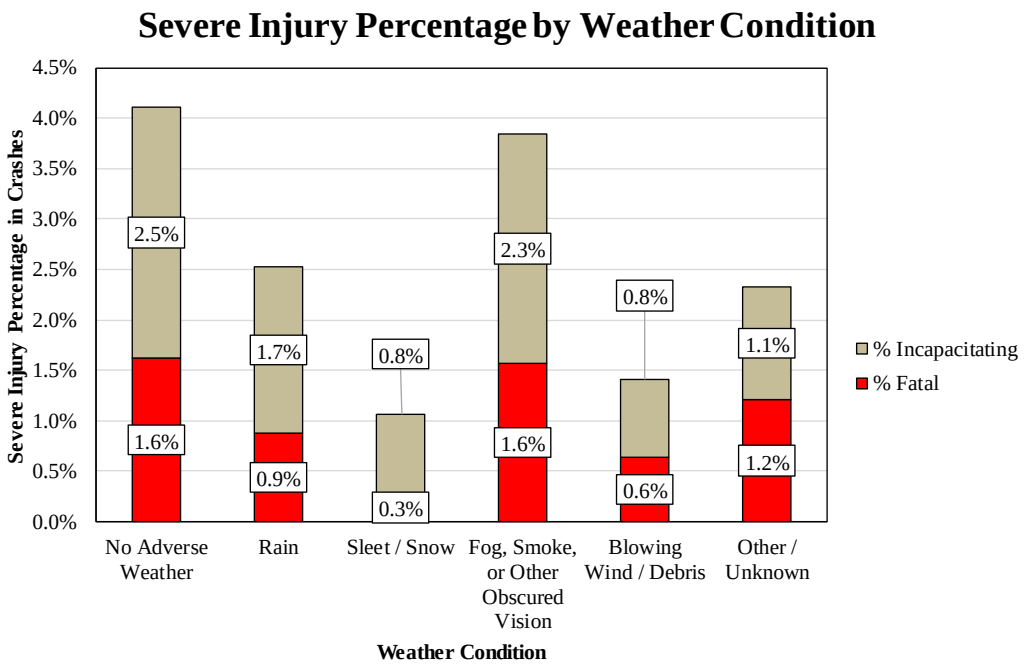


Figure 23. Severe Injury Percentages by Weather Condition

In particular, it was noted that the fatal crash rate (K-crashes divided by all crashes) during sleet or snowy conditions was only 0.3%, indicating a significant reduction in average severity during adverse, snowy weather conditions, as shown in Figure 23. The authors believe the low average severity during "wintery" weather is likely because of significantly reduced travel speeds. Similarly, when blustery or windy conditions were present, a similar reduction in average severity was observed, which is again likely attributed to increased caution and reduced travel speeds. In contrast, without adverse weather, severe crash rates were the highest, which may be associated with higher average travel speeds. Fog, smoke, or obscured vision crashes were also associated with a significant increase in average severity, which may be attributed to a reduced reaction time for drivers. It should also be noted that although fog is not typically associated with reduced vehicle-road friction, moisture-laden fog may culminate in slippery pavements, which could also reduce stopping capabilities. Foggy travel conditions, contributing to increased difficulty associated with discerning position on the roadway and anticipating upcoming turns, may lead to disproportionately high crash severities during crashes with trees and utility poles.

Road conditions were also considered, as shown in Figure 24. As with weather conditions, dry road conditions culminated in a greatly increased rate of severe crashes. Approximately 66% of incapacitating injuries and 71% of fatal injuries occurred when road conditions were noted as "dry." The ratio of fatal crashes in dry conditions to all crashes in dry conditions was 1.32. An odds ratio of fatal crashes to all crashes suggested fatal crashes were 2.09 times more likely in dry conditions than non-dry conditions.

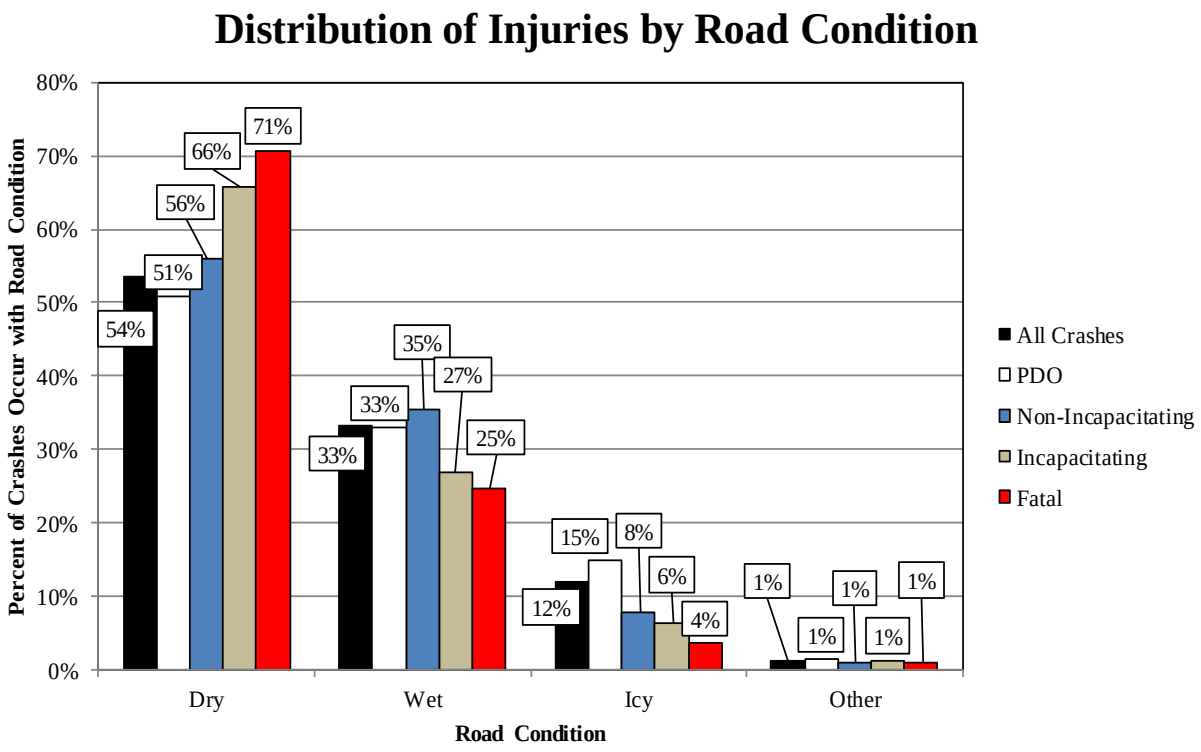


Figure 24. Distribution of Injuries by Road Conditions at Time of Crash

In general, PDO and non-incapacitating injuries had similar trends, except for during icy conditions. Approximately 15% of all PDO crashes were associated with snowy or icy conditions, compared to 8% of non-incapacitating injuries (B+C), 6% of incapacitating injuries (A), and 4% of fatal injuries (K).

5.3.4 Vehicle Data

Vehicles involved in crashes were tabulated by state and sorted according to crash severity. It was observed that the distribution of vehicle types varied based on the state, and the distributions appeared to be strongly related to the geographical region of the crash. For example, the following observations were made:

- Illinois and New Jersey are relatively flat states. Both have similar weather patterns (including wintery weather patterns in some parts of the states), geographies, and latitudes. As a result, the distributions of cars, light trucks, heavy trucks, and other vehicles were very similar between the two states.
- Washington State's climate is diverse, including wet coastland, forested areas, mountains, and plateaus. Although rain totals in western Washington are generally much, much higher than in eastern Washington in the mountains, there are still many trees in the eastern part of the state. Although Washington's western coastline experiences less snow, sleet, and freezing rain than Illinois, New Jersey, and Utah, the mountains and eastern part of the state are snowier than areas to the west. As a result, Washington's vehicle fleet reflected fewer passenger cars and more light trucks than Illinois or New Jersey.
- Utah is the most mountainous state that was surveyed. The population, like most of the water supply, is located between the mountains and in the valleys. However, regions in the valleys also receive the most snow per capita of any region surveyed in this study. As a result, Utah's crash data reflected the highest percentage of light trucks (43% of the crashes) and the lowest percentage of passenger cars (47%). Lastly, tree crashes were relatively infrequent for the population and land area of Utah compared to other states. This may be due to a reduced number of trees in the state compared to other states, unfavorable soil conditions for tree growth (e.g., sandy soil), and wide, obstacle-free roadside clear zones, as shown in Figure 25.

Crash results suggested that states with similar weather patterns and geographies produced similar distributions of vehicles involved in tree and utility pole crashes, as shown in Figure 26. To determine if the state DOTs experienced different average crash outcomes, injury distributions were determined for each vehicle type and compared, as shown in Figures 27 through 31. For cars, light trucks, and heavy trucks, injury distributions per vehicle type did not vary greatly between states. Variations for motorcyclists and other/unknown vehicle types varied considerably, but both groups were relatively underrepresented in crash data. It should be noted that "Other/Unknown" vehicle groups included all-terrain vehicles (ATVs), go-karts, light farm equipment or mowers, towed vehicles or trailers, and other unusual vehicle types which were difficult to classify.

Figure 25. Examples of Roadsides in Utah [88-89]

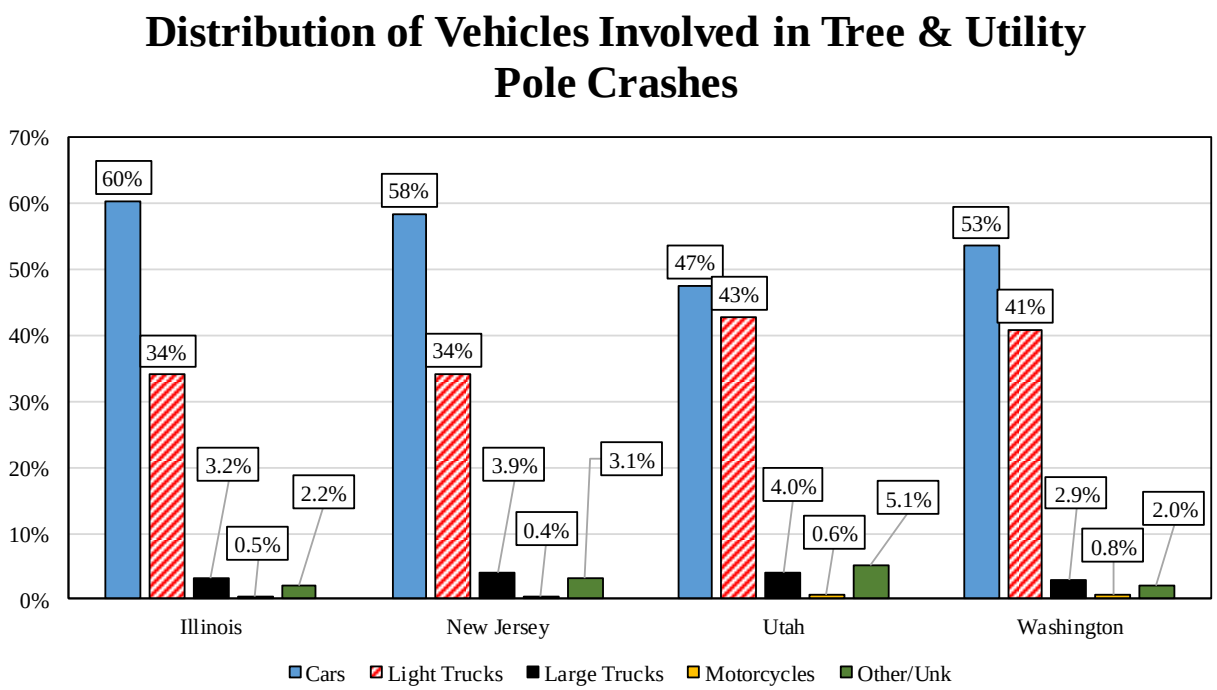


Figure 26. Distribution of Vehicle Types Involved in Tree and Utility Pole Crashes

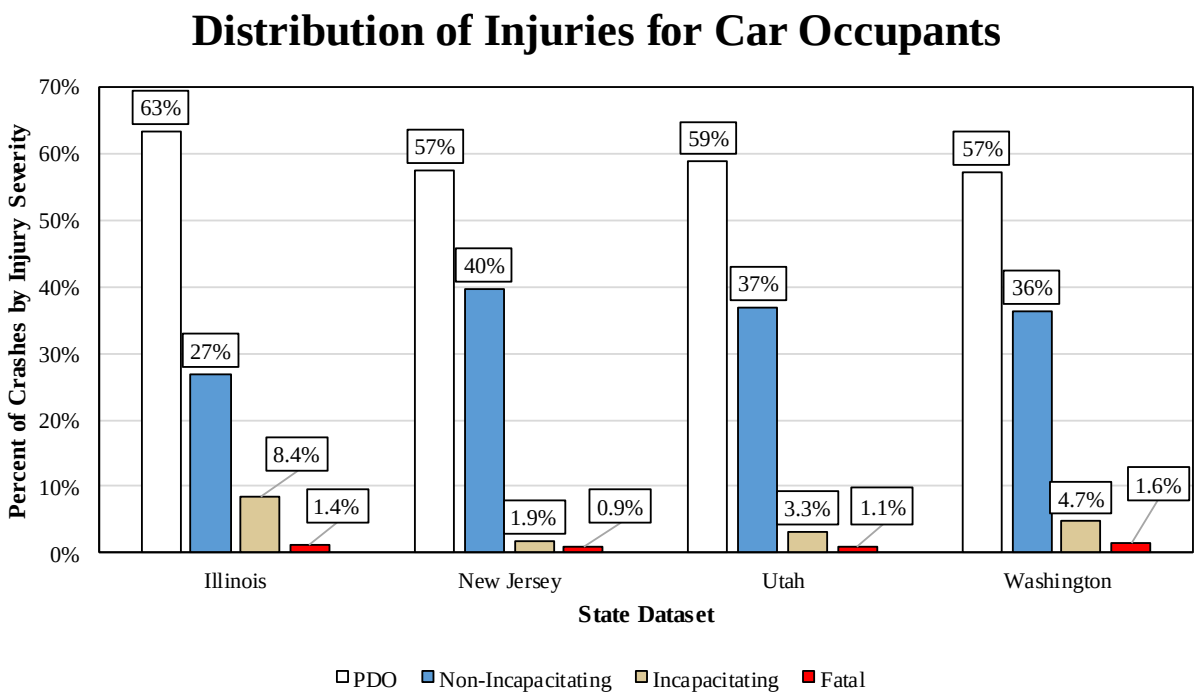


Figure 27. Distribution of Injuries for Occupants of Cars by State

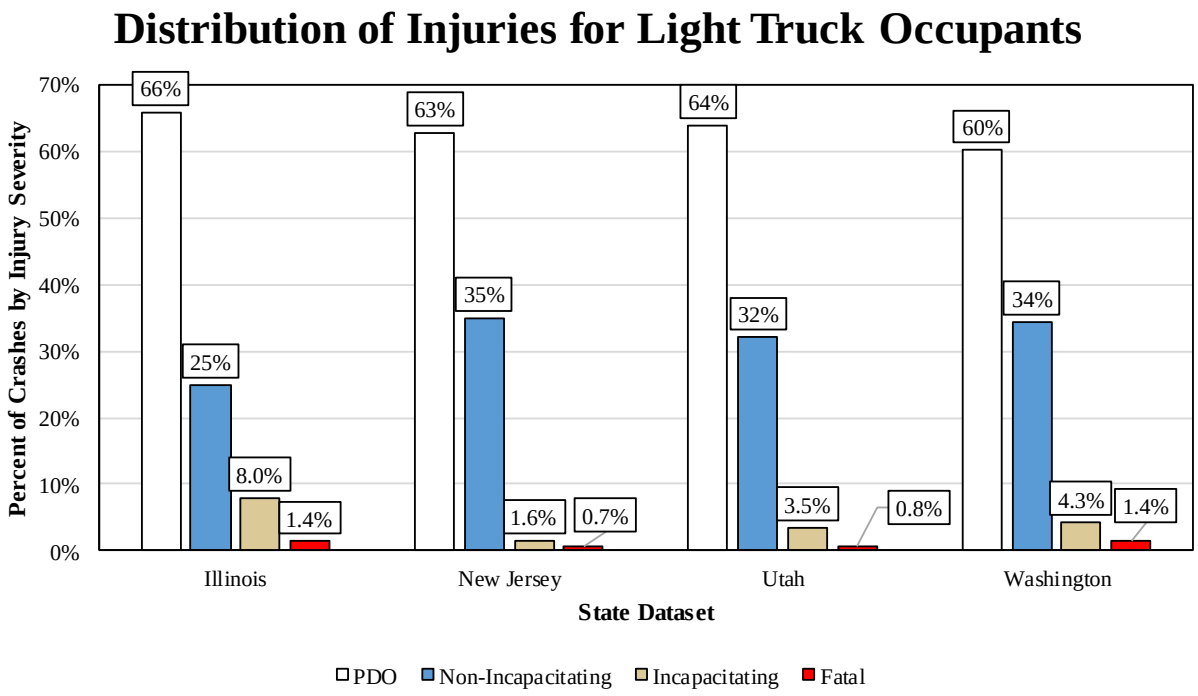


Figure 28. Distribution of Injuries for Occupants of Light Trucks by State

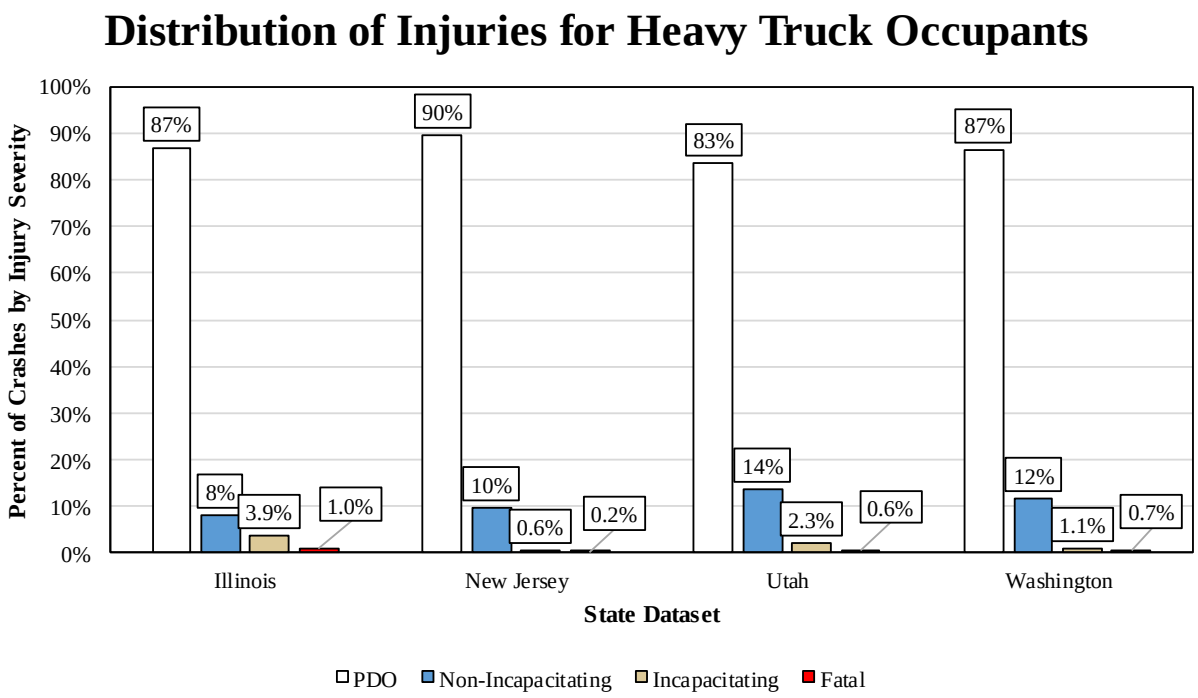


Figure 29. Distribution of Injuries for Occupants of Heavy Trucks by State

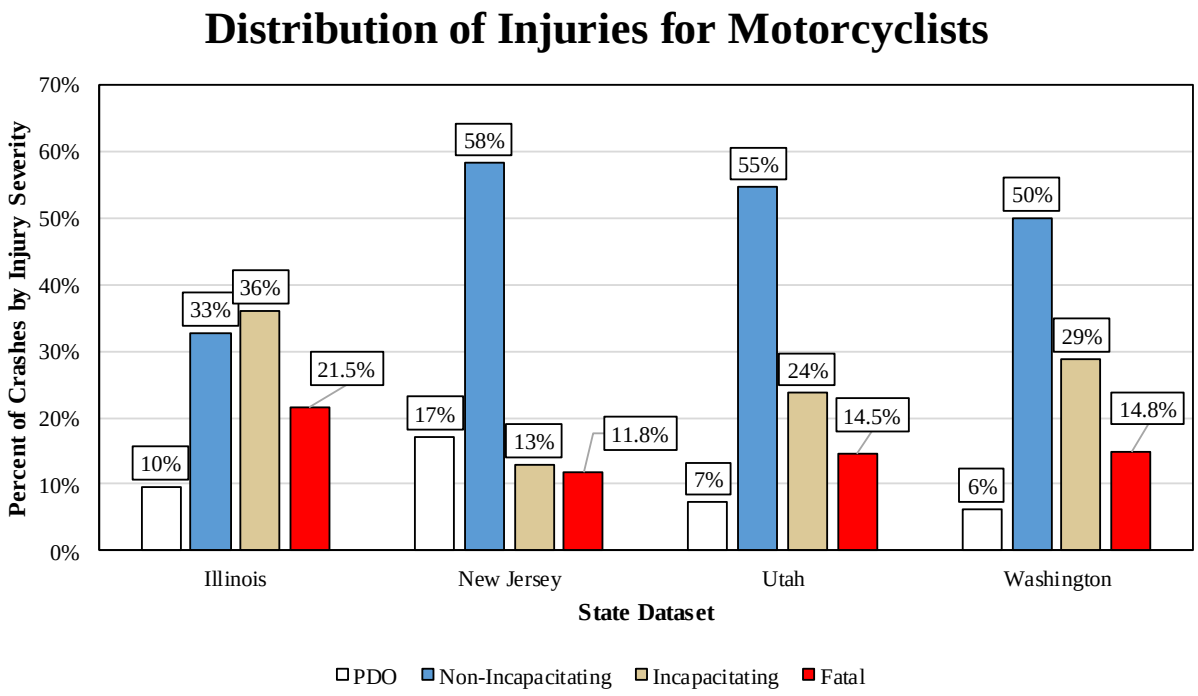


Figure 30. Distribution of Injuries for Motorcyclists by State

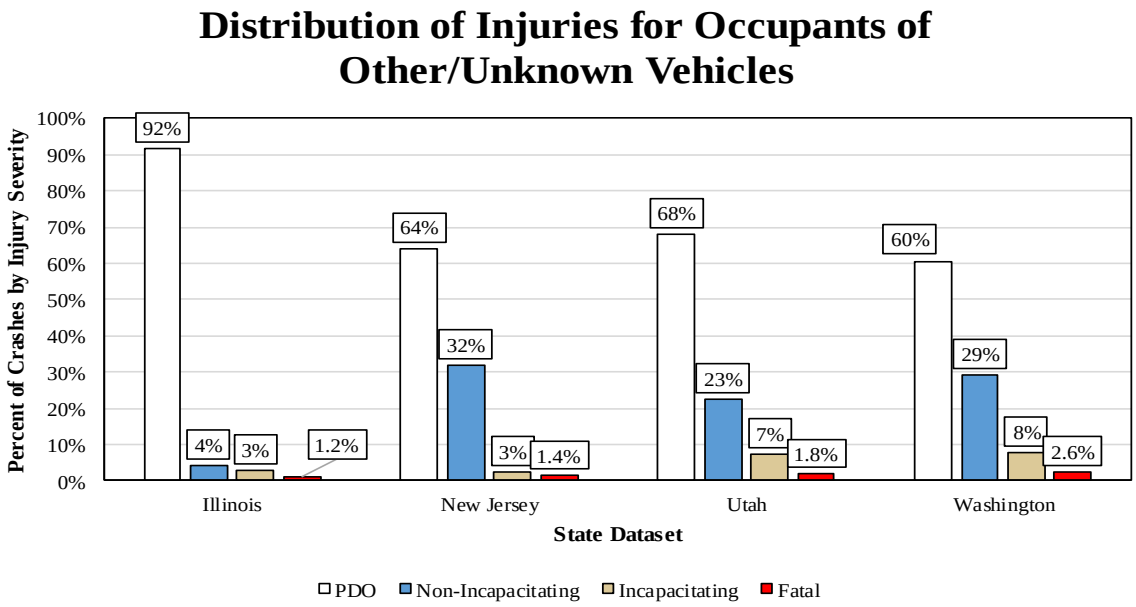


Figure 31. Distribution of Injuries for Occupants of Other or Unknown Vehicle Types by State

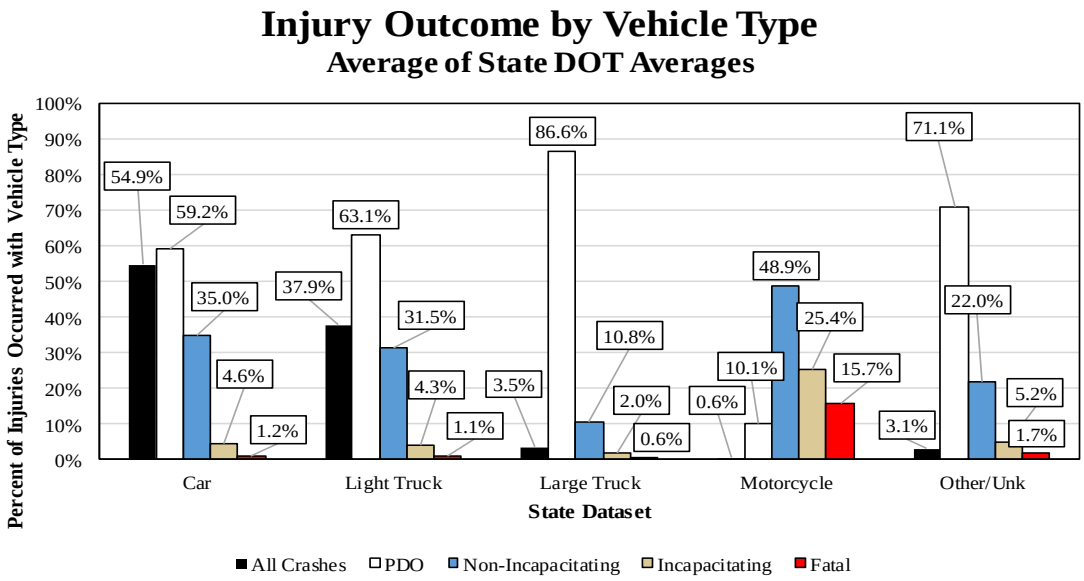
Surprisingly, Illinois data contained the highest percentage of PDO crashes for cars and light trucks (63% and 66%, respectively), but also contained the highest percentage of A+K severe crashes for cars and light trucks (9.8% and 9.4%). The percentage of incapacitating crashes in Illinois was approximately twice that of other states. Because the differentiation between injury classes in different states vary (i.e., the determination of A, B, and C injuries is subjective), it is possible that Illinois is using different criteria for determining A-injuries, thus leading to a higher crash severity.

As expected, injuries in heavy truck crashes were much less frequent and were less severe on average than for other vehicle classes for all states. This may be due to several factors:

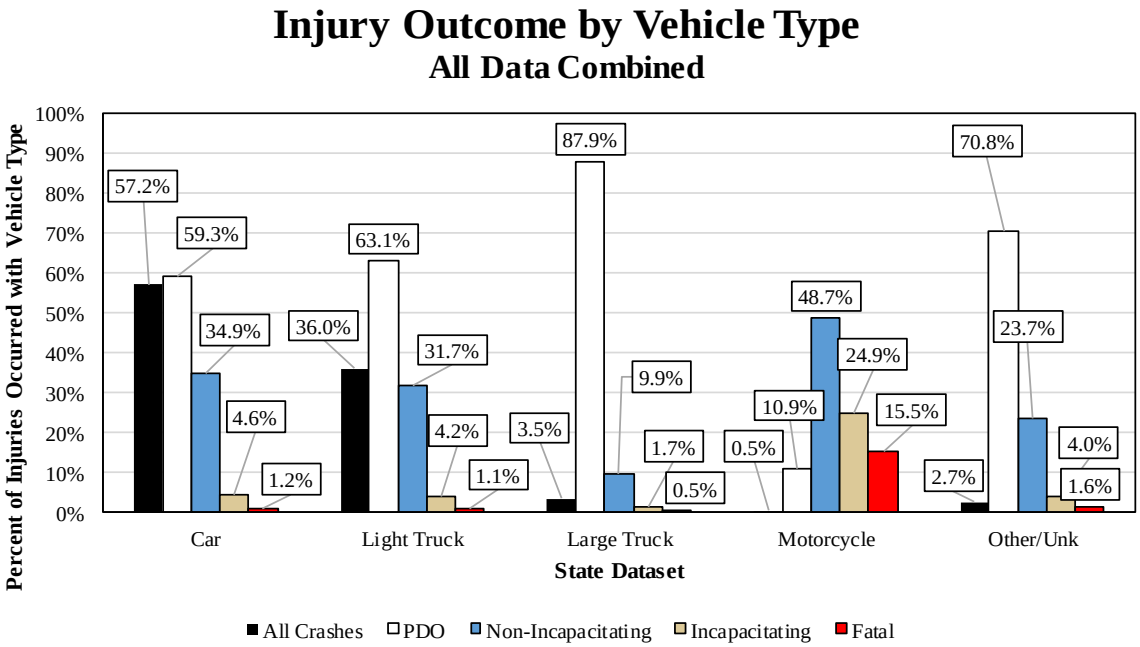
- Heavy vehicles are stiffer and heavier than other vehicles, meaning trees were more likely to yield, be damaged, or fracture during impact;
- Most large trucks have long front ends separating the driver from the tree, which could increase crush distance and reduce occupant compartment damage;
- Side-impact and non-tracking impacts (which are historically more severe) between large trucks and trees are unlikely because of the very large yaw moments of inertia and difficulty imposing a non-tracking yaw in a large truck; and
- Anecdotally, large truck crashes have been more commonly associated with driver fatigue than intoxication, drug use, or excessive speed. Fatigue-related crashes may be less severe on average than other aggravated crash types, particularly high-speed crashes.

Motorcyclists experienced a high risk of severe injury due to impact with trees and utility poles. Severe motorcyclist crashes represented between 25% (New Jersey) and 58% (Illinois) of all motorcycle crashes. It is likely that motorcycle crashes were disproportionately severe because motorcyclists do not benefit from an external, energy-absorbing, stiff, vehicle body shell. As such, the only protection from trees or utility poles is avoidance.

Next, data from all crashes was evaluated to compare injury rates per vehicle type using two methods: (a) average of state averages and (b) global averages. The average of state averages weighted results of each state equally, whereas the global average weighted each crash equally. The resulting global injury severities for crashes involving trees and utility poles are shown in Figure 32. In general, results of the average of state averages and the global average varied by less than 1% for each category. It was observed that cars and light trucks both have an average severe crash percentage (i.e., A+K crashes) of at least 5.3%, and while motorcyclist-to-tree or utility pole crashes only occur in 1/200 crashes, they are disproportionately severe with 40% of crashes with trees or utility poles designated as A+K.



(a)



(b)

Figure 32. Injury Distributions by Vehicle Types: (a) Average of State Averages (b) All Data Combined

Data from each injury type was separated and parsed by vehicle type, and the likelihood of that injury severity occurring with the designated vehicle was plotted, as shown in Figure 33. Surprisingly, the likelihood of each injury type occurring with each vehicle type was approximately equal to the percentage of crashes occurring with each vehicle type. For example, approximately 59% of all crashes involved a passenger car, and approximately 57% of all fatalities involved a passenger car. Despite only approximately 0.5% of all reported tree and utility pole crashes involving a motorcyclist, or approximately 1 out of every 200 tree or utility pole crashes, motorcyclists still accounted for nearly 7% of all fatalities in the database. Results indicate that there is a disproportionate severity associated with motorcyclist crashes with trees and utility poles.

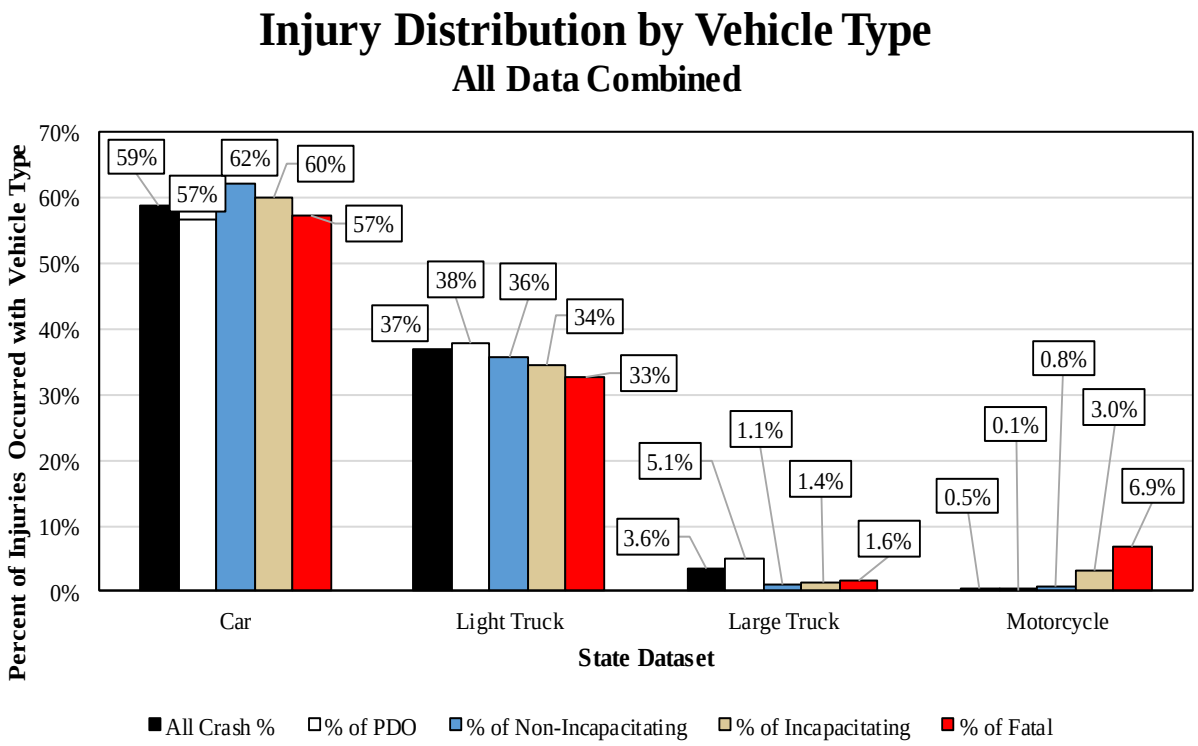


Figure 33. Percent of Injuries Occurred by Vehicle Class

5.3.5 Crash Location & Geography

Where available, crash locations using GNSS data were plotted for each state DOT. Google Earth crash data overlays are shown for Illinois, Indiana, New Hampshire, Ohio, South Dakota, and Utah in Figures 34 through 39, respectively. Google Earth was used to plot crash locations using a black-and-white, circular target marker per crash. Dense crash locations appeared as dark areas when plotted on the map, whereas individual crash markers could be discerned when crash frequencies were low and visible gaps existed between crash locations. Note that some crash location errors were observed in the Indiana and Ohio data sets: multiple crash locations recorded for Indiana were plotted in Kentucky, Ohio, and Illinois, and multiple crash locations for Ohio were plotted in Kentucky, West Virginia, and the Great Lakes.

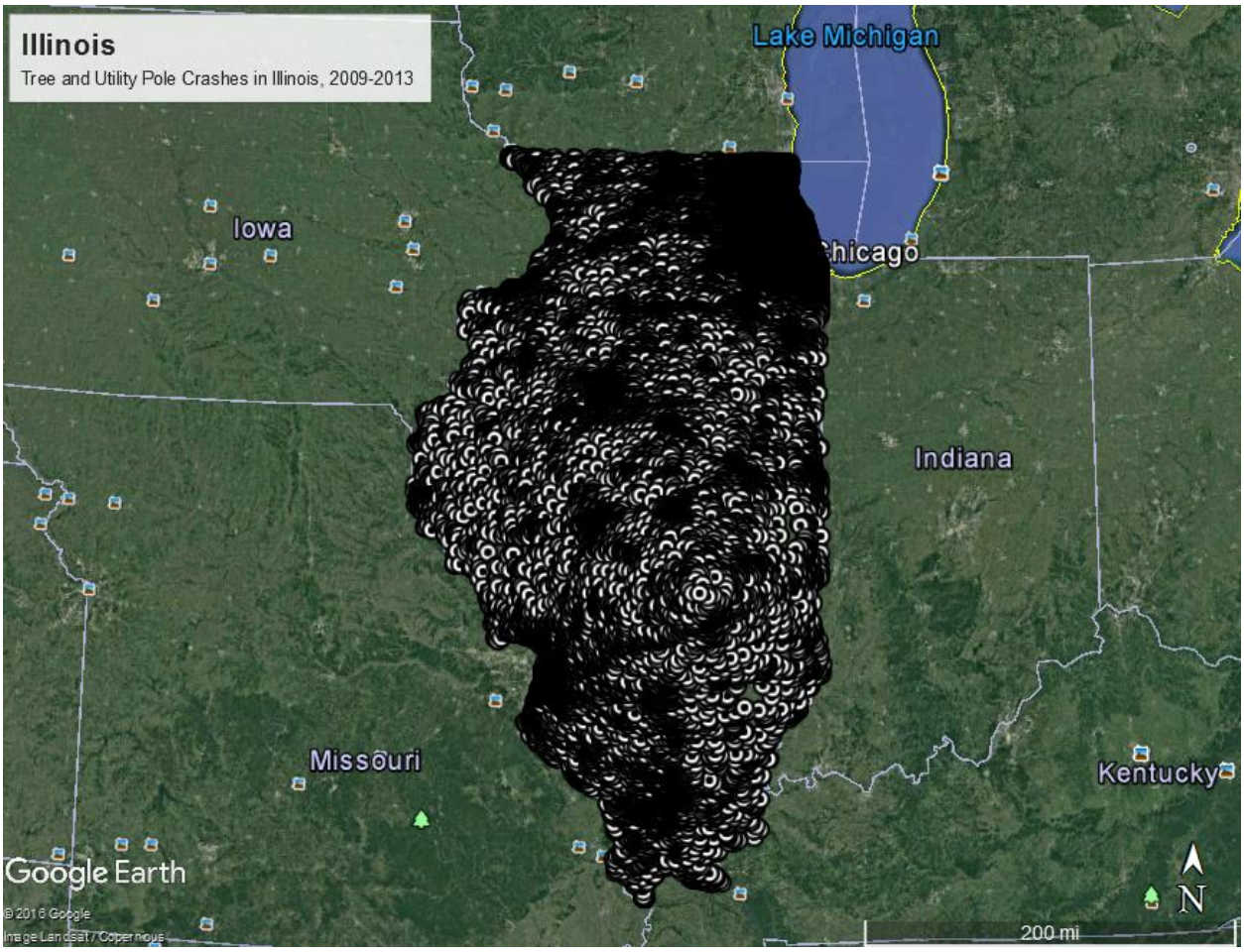


Figure 34. Tree and Utility Pole Crash Locations in Illinois, 2009-2013

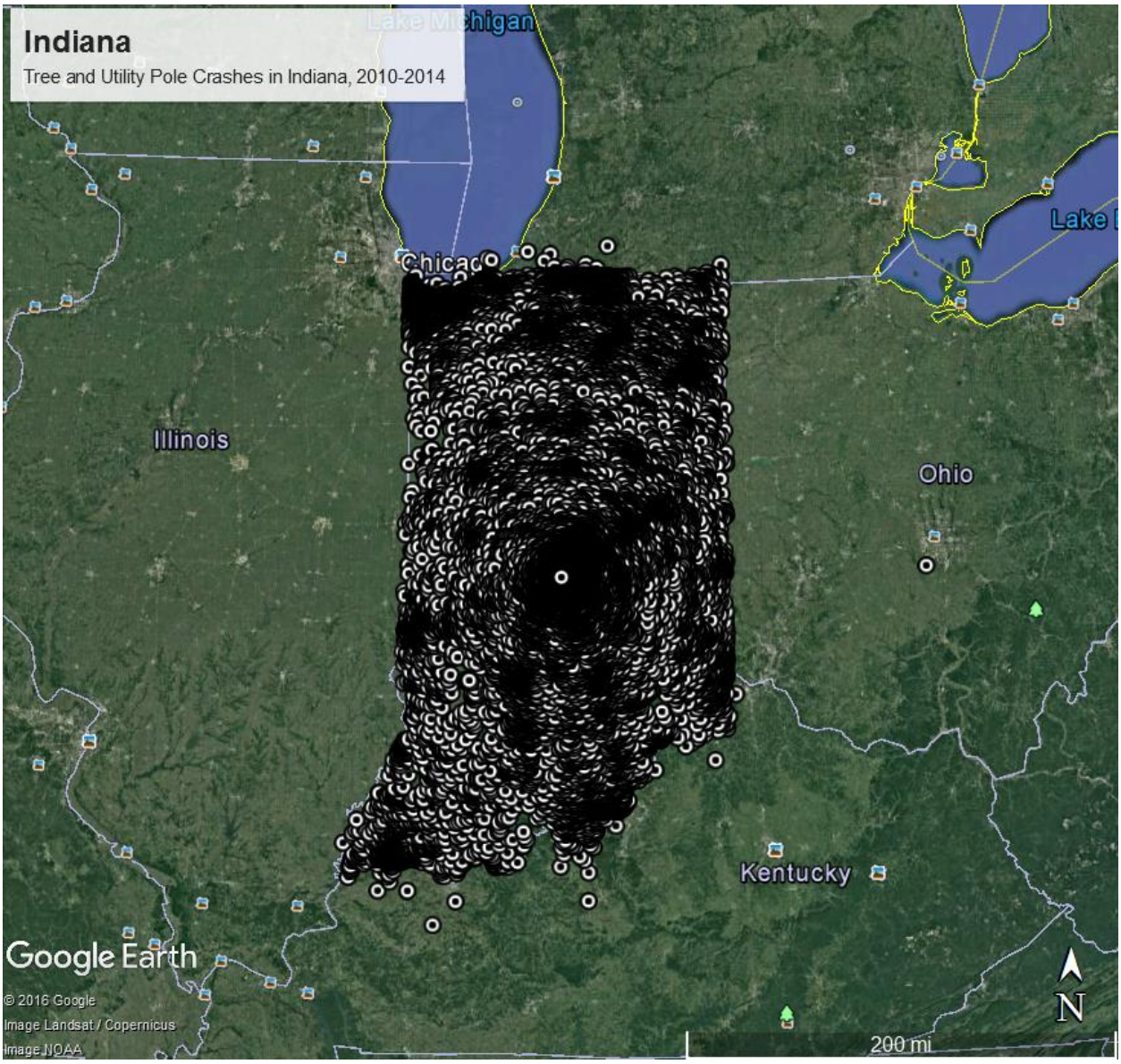


Figure 35. Tree and Utility Pole Crashes in Indiana, 2010-2014

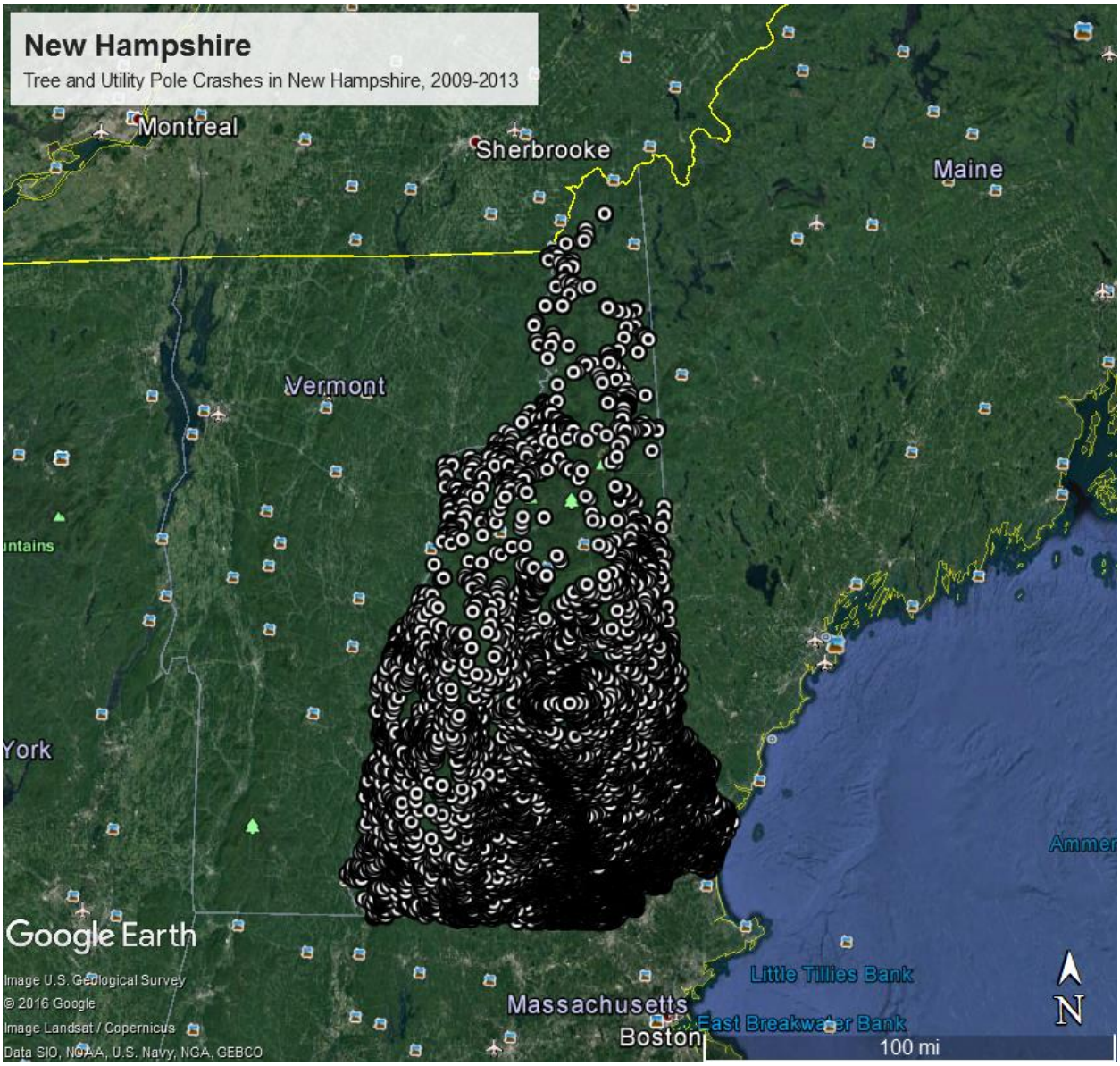


Figure 36. Tree and Utility Pole Crashes in New Hampshire, 2009-2013

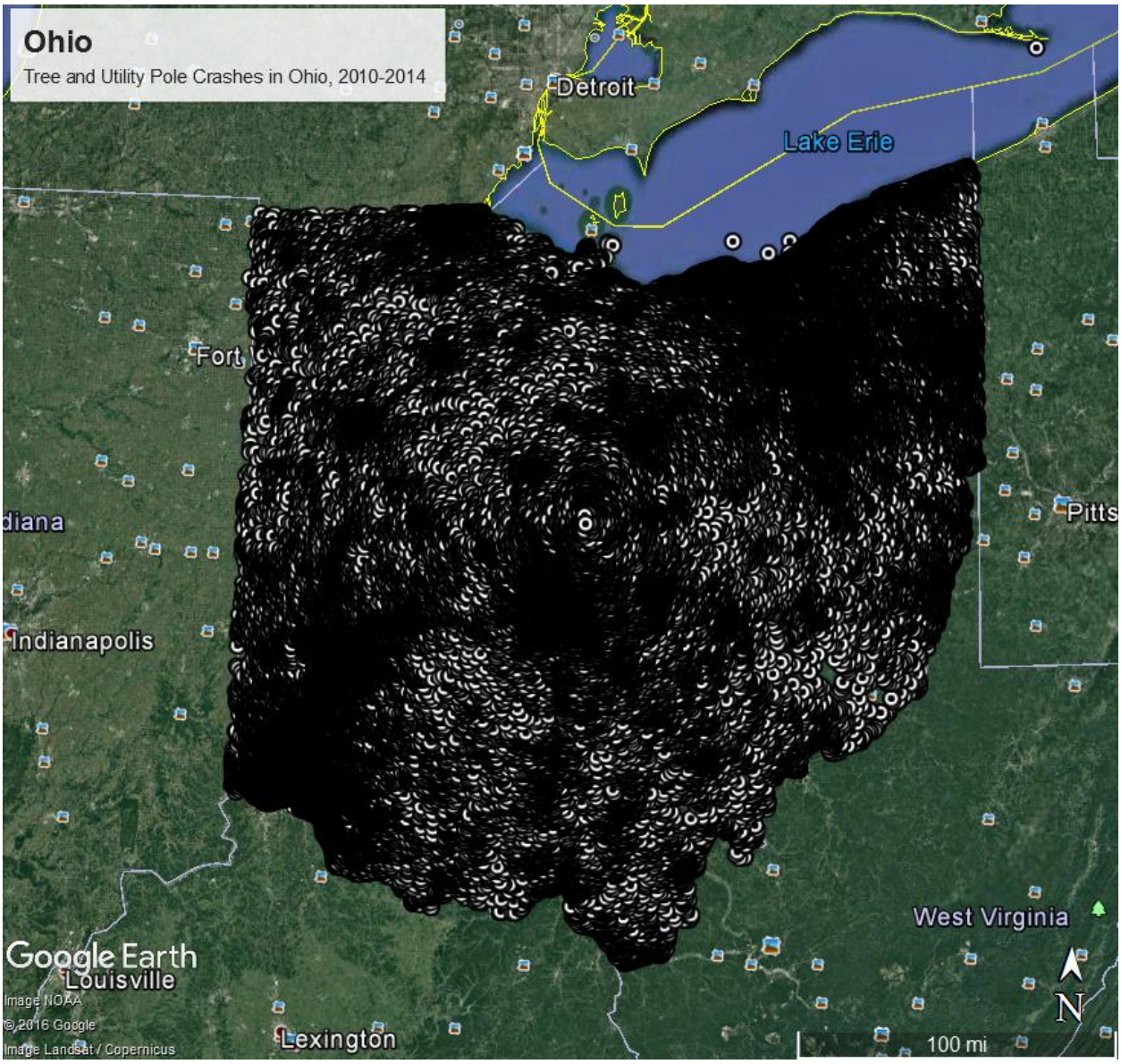


Figure 37. Tree and Utility Pole Crashes in Ohio, 2010-2014

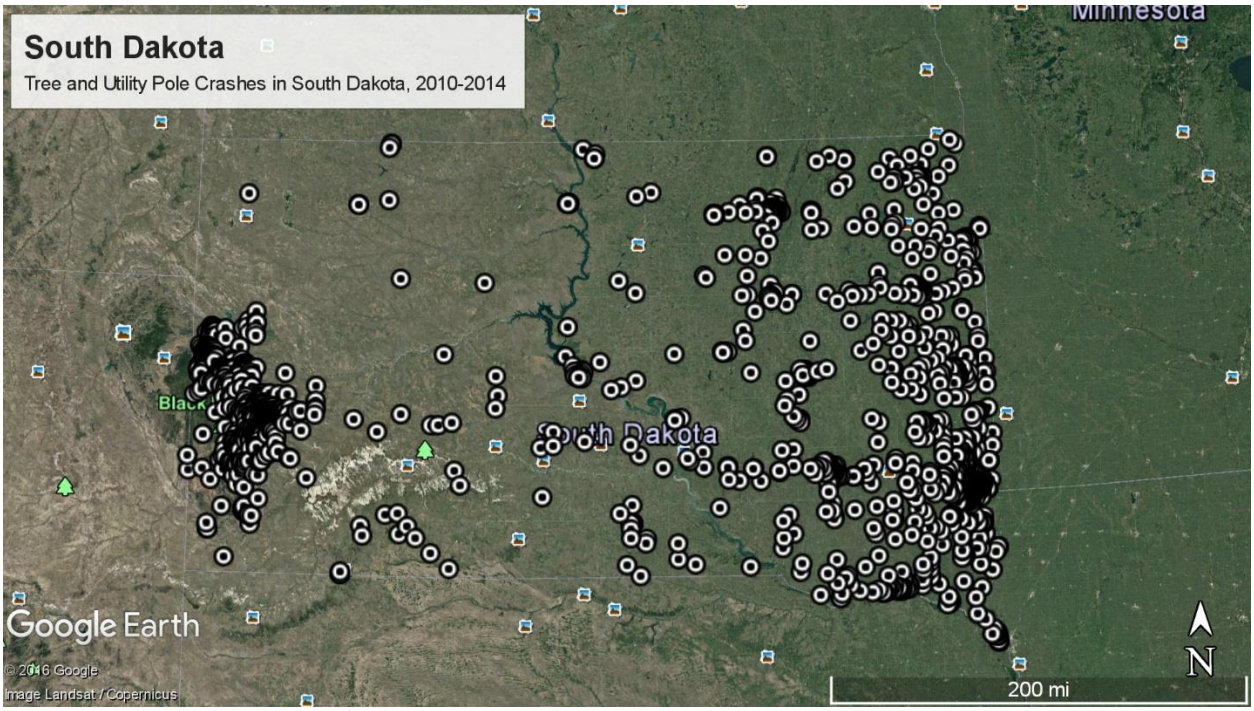


Figure 38. Tree and Utility Pole Crashes in South Dakota, 2010-2014

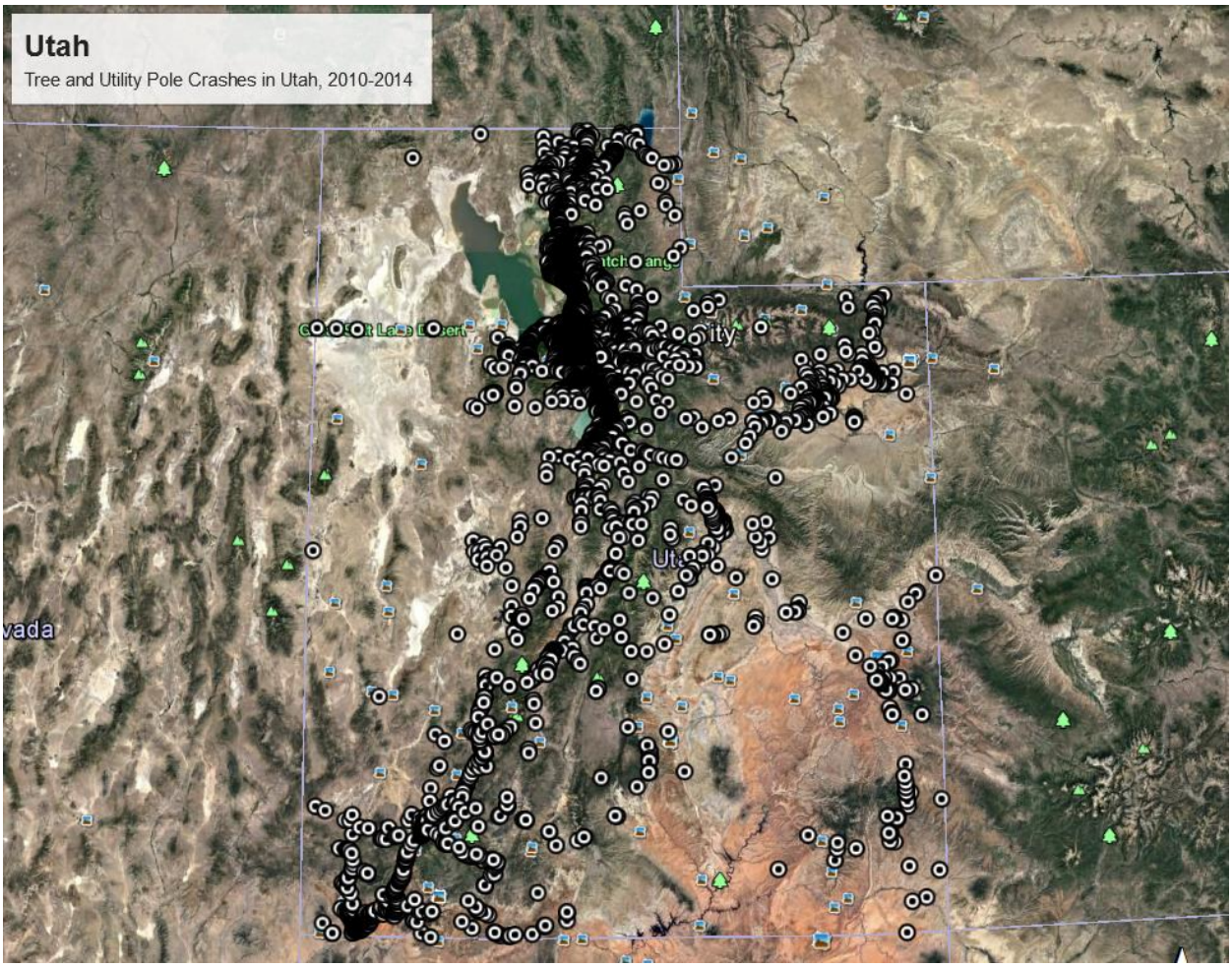


Figure 39. Tree and Utility Pole Crashes in Utah, 2010-2014

Based on the available GNSS data, it was evident that rainfall had a significant effect on tree and utility pole crashes. The Rocky Mountains and drier plains areas (e.g., Utah and South Dakota databases) had fewer tree or utility pole crashes, likely a result of a greatly reduced number of trees (i.e., reduced vegetation). For South Dakota, reduced ADT may also affect tree and utility pole crash results. In contrast, states such as Ohio, Indiana, and Illinois, which receive considerably more moisture and have higher tree densities and dispersed population centers, were associated with diffuse tree and utility pole crashes throughout the states.

Tree and utility pole crashes in Utah appeared to be highly concentrated in narrow geographic regions. Researchers investigated the crash distribution in the state using the 3D terrain capabilities in Google Earth. It was observed that crash locations were vastly more common in the valleys, between the Rocky Mountains, and near the I-15 corridor. Selected views of crashes which occurred in Utah as observed from several elevation points are shown in Figure 40.

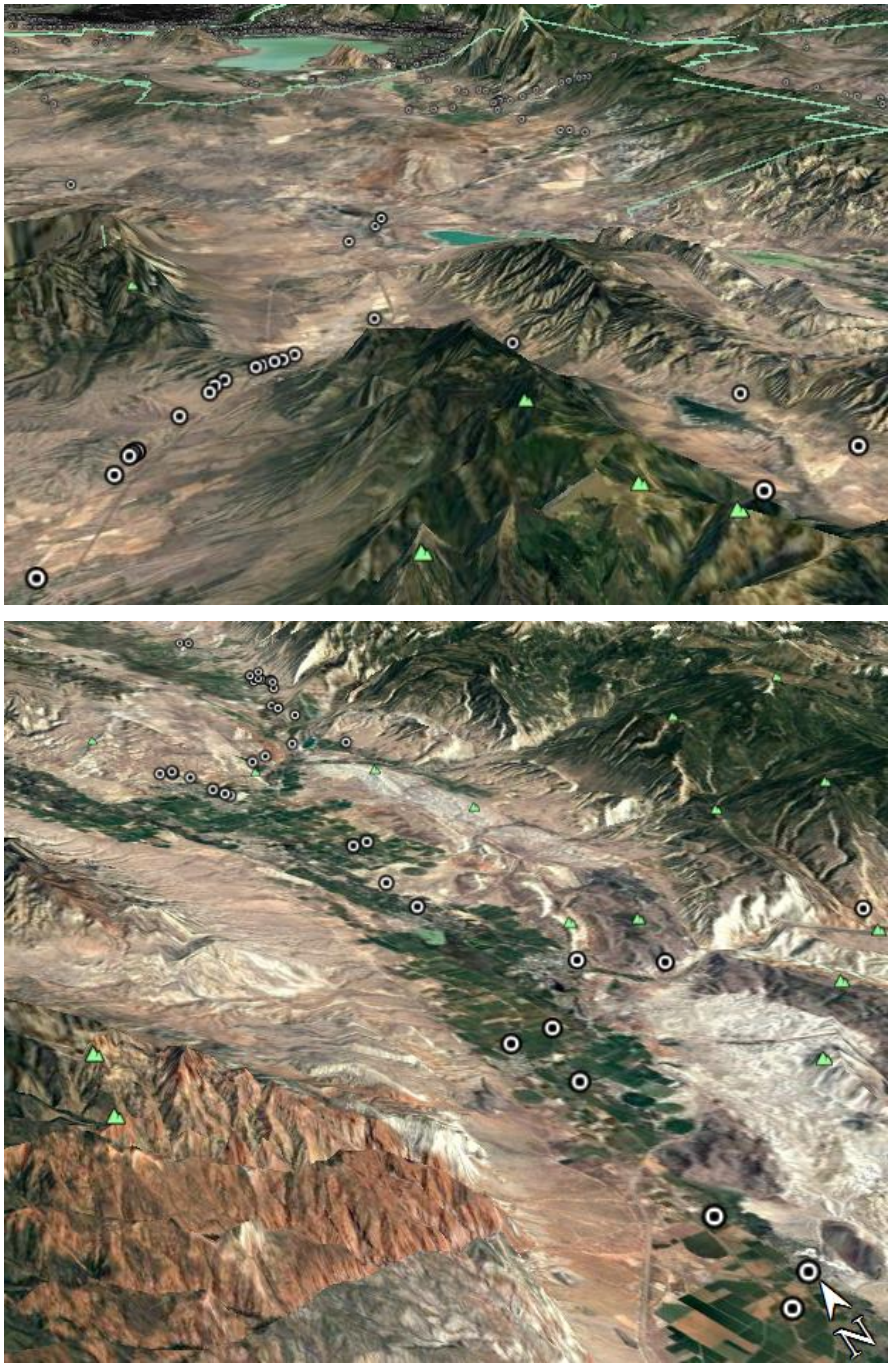


Figure 40. Selected Tree and Utility Pole Crashes in Utah

Next, severe crash data was plotted by roadway curve and grade classifications, as shown in Figures 41 through 44. It should be noted that in Figure 43, only approximately one-third of the available crash data (141,164 crashes out of 400,858) was associated with roadway curvature and grade data. The average crash severity of the reduced dataset was higher than the global database.

Severe crashes were much more likely to occur in conjunction with curves and grades than on tangent roads or without grades. While only 31% of all tree and utility pole crashes occurred at

a curve, nearly half of all fatal tree and utility pole crashes (44%) occurred at a curve. The fatal crash rate at curves was approximately 2.1%, whereas for tangent roads, the fatal crash rate was approximately 1.2%. An odds ratio of fatal crashes at curves compared to fatal crashes on tangent road sections indicated that fatal crashes were 75% more likely to occur at curves than on roadway tangents.

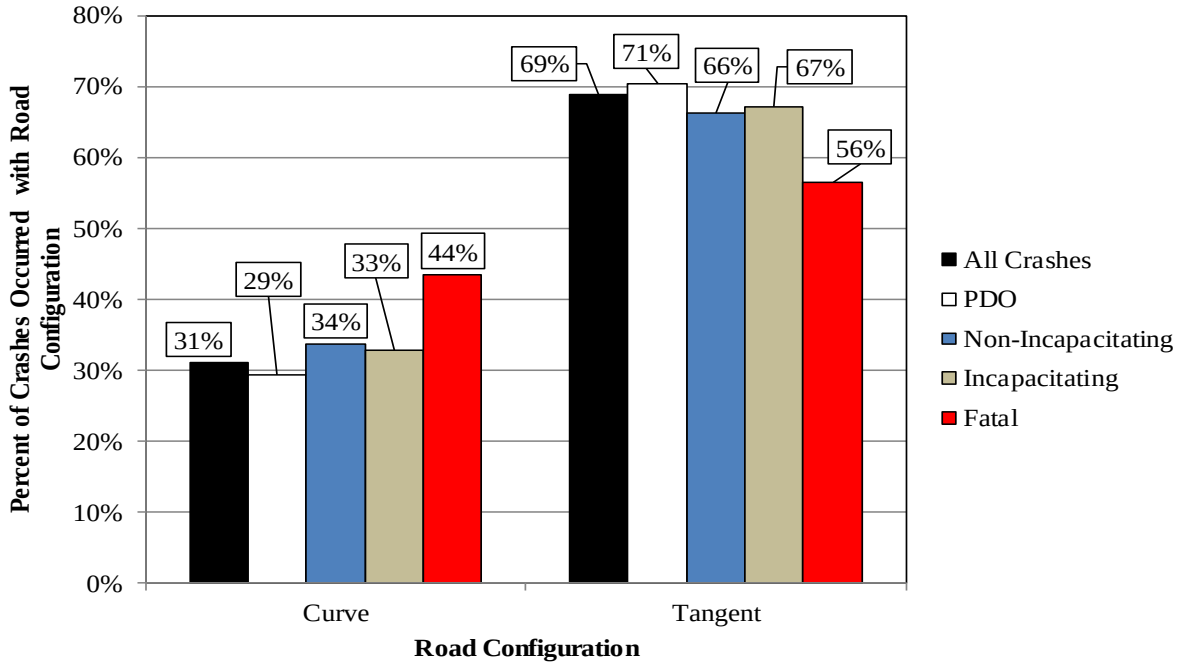


Figure 41. Percent of Injury Crash Types Associated with Curve and Tangent Roads

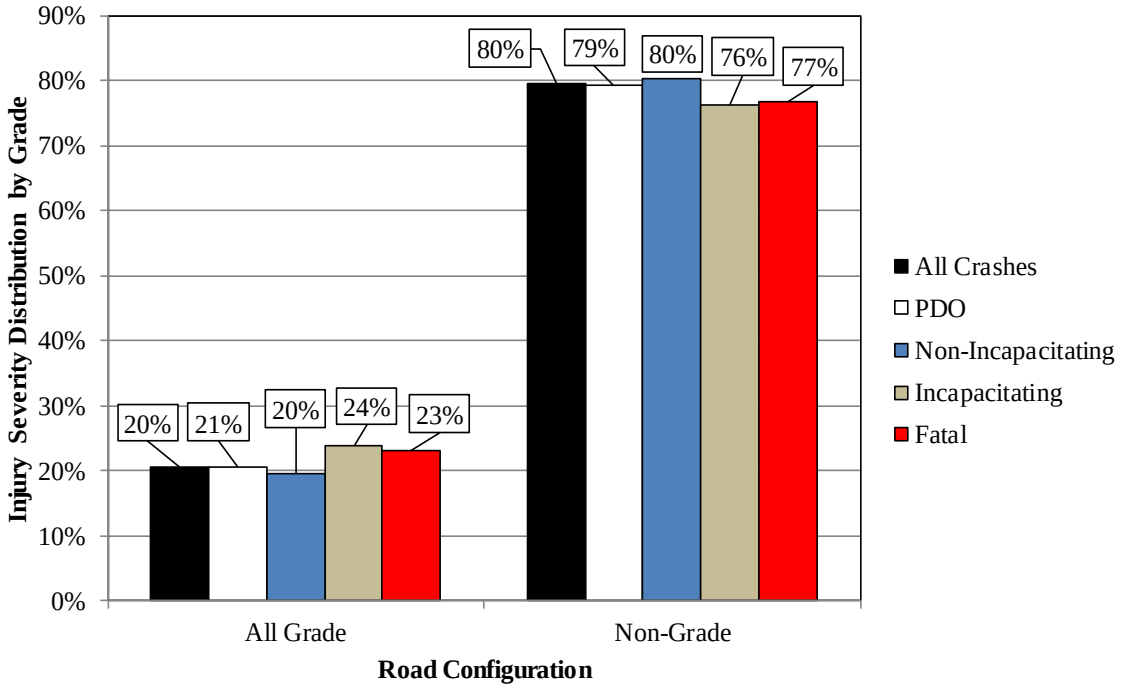


Figure 42. Percent of Injury Crash Types Associated with Grade and Non-Grade Roads

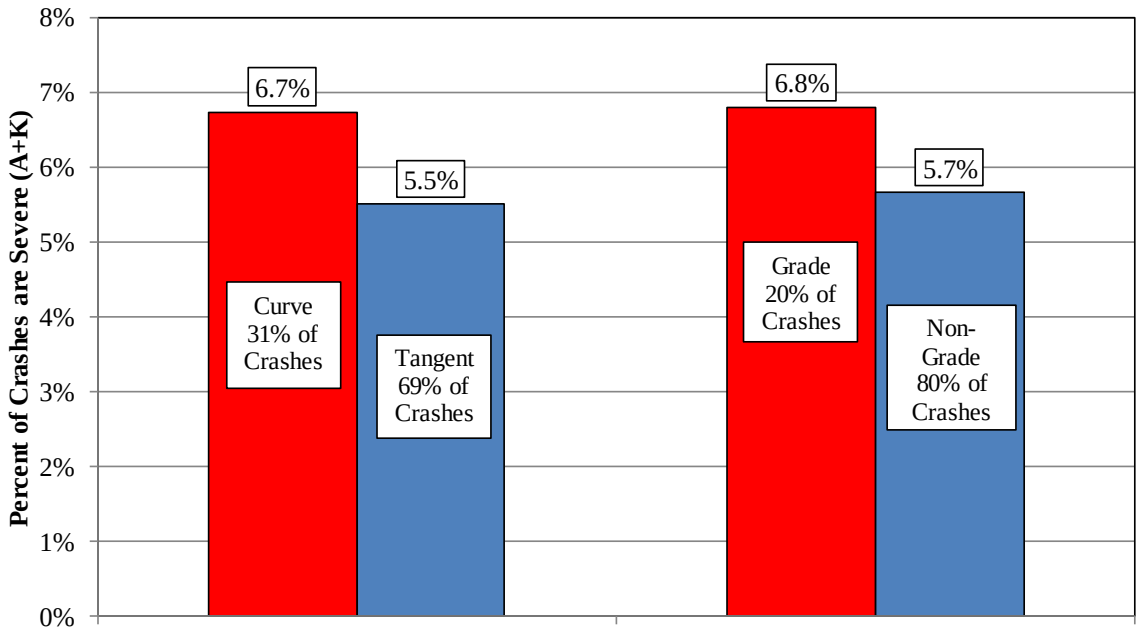


Figure 43. Percent of Crashes Are Severe Based on Road Configuration

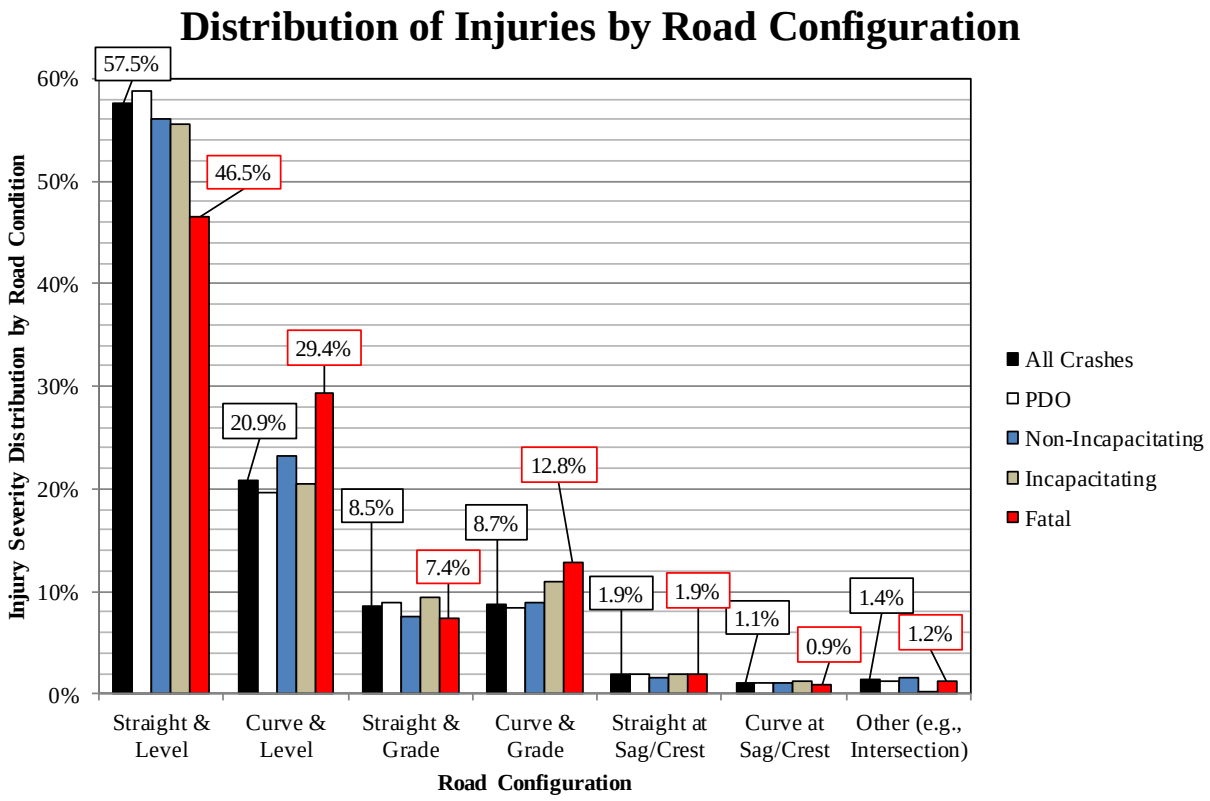


Figure 44. Distribution of Injuries by Road Configuration

Crashes on grades were also associated with an increase in average crash severity, as shown in Figure 43, but results were less disproportionate compared to curved road crashes, as shown in

Figure 42. Furthermore, the categories of crashes on grades associated with the highest number of severe injuries were curve & grade and curve at sag/crest, as show in Figure 44.

The straight and level road conditions were associated with the lowest percentage of severe tree and utility pole crashes (incapacitating and fatal injuries) compared to all crashes, whereas two road conditions – curve & level and curve & grade – were associated with the largest ratios of severe crashes with respect to all crashes. An evaluation of fatal crash rates, all crash rates, and the associated odds ratios comparisons of curves and grades is shown in Table 19.

Table 19. Crash Distributions and Odds Ratios for Roadway Curves and Grades

Road Configuration	**Fatal Crash Distribution**	**All Crash Distribution**	**Odds Ratio**
Tangent and Level	46.5%	57.5%	**-***
Curve and Level	29.4%	20.9%	**1.73** (Fatals on Curve/Level vs. Tangent/Level)
Tangent and Grade	7.4%	8.5%	**1.08** (Fatals on Tangent/Grade vs. Tangent/Level)
Curve and Grade	12.8%	8.7%	**1.82** (Fatals on Curve/Grade vs. Tangent/Level) **1.05** (Fatals on Curve/Grade vs. Curve/Level) **1.69** (Fatals on Curve/Grade vs. Tangent/Grade)

*Baseline for comparison

Odds ratios suggested that grades were slightly more severe than flat, level ground on average (1.08). Confidence intervals were not calculated for the odds ratios because the dataset contained a very large number of crashes, and the collection of state databases were not homogeneous within the state, or between states, thus the 95% confidence intervals are artificially narrow. Results confirmed the findings and recommendations described in NCHRP Report No. 500 [20] that tree removal and utility pole removal or relocation from curved roads is the top safety priority. Among curves, trees adjacent to or at roadway grades should be removed first.

5.3.6 Crash Cost Estimation

Crash costs were estimated using the TIGER Grant BCA charts to convert FHWA's estimated crash cost distribution in the MAIS injury scale to KABCO, as noted in Section 5.2.6. The resulting crash cost estimates for 2010 through 2013, the four years for which every state DOT provided crash data, are shown in Tables 20 and 21. Crash costs were calculated for state data which included unknown injury (C, B, or A from KABCO) as well as only for the states that provided full KABCO data.

Table 20. Summary of Crash Data – All State Data, 2010-2013

Year	No. Crashes	No. Fatal Crashes	Crash Cost Per State, Per Year, by KABCO Injury Level(1)					
			K	A	B	C	O	Injured, Unk(2)
2010	81,566	1,119	$848.6	$62.7	$70.0	$108.4	$12.8	168.8
2011	78,012	1,054	$799.3	$61.5	$65.5	$105.3	$12.2	164.4
2012	76,144	1,067	$809.1	$62.6	$62.0	$106.8	$11.7	163.7
2013	77,239	1,046	$793.2	$58.6	$58.1	$102.8	$12.3	153.3
Average Annual Crash Cost			**$812.6M**	**$61.3M**	**$63.9M**	**$42.5M**	**$12.3M**	**$162.5M**
Average Annual Total Crash Cost (Per State DOT)								**$1.1B**
Estimated Annual Total Fatal Crash Cost (Nationwide)								**$40.6B**
Estimated Annual Total Crash Cost (Nationwide)								**$58.3B**
Estimated Total Nationwide Cost for 2009-2014 Study Period								**$349.6B**

(1) "M" denotes millions of U.S. dollars. "B" denotes billions of U.S. dollars.
(2) Injury cost distribution for Unknown injury applicable for data from Kansas, Ohio, Oregon, and Wisconsin, which did not differentiate between KABCO injury levels A, B, or C.

Table 21. Summary of Crash Data – Only States with Complete KABCO Data, 2010-2013

Year	No. Crashes	No. Fatal Crashes	Crash Cost Per State, Per Year, by KABCO Injury Level(1)				
			K	A	B	C	O
2010	46,859	630	$716.6	$94.0	$105.0	$63.9	$11.1
2011	43,598	636	$712.1	$92.2	$98.3	$61.8	$10.1
2012	43,224	620	$705.3	$93.8	$93.0	$64.6	$10.0
2013	44,167	644	$732.6	$87.9	$87.1	$64.7	$10.5
Average Annual Crash Cost			**$716.6M**	**$92.0M**	**$95.9M**	**$63.7M**	**$10.4M**
Average Annual Total Crash Cost (Per State DOT)							**$0.98B**
Estimated Annual Total Fatal Crash Cost (Nationwide)							**$35.8B**
Estimated Annual Total Crash Cost (Nationwide)							**$48.9B**
Estimated Total Nationwide Cost for 2009-2014 Study Period							**$293.6B**

(1) Summary table excludes data from Kansas, Ohio, Oregon, and Wisconsin, which did not differentiate between KABCO injury levels A, B, or C.

Annual nationwide crash cost estimates varied by almost 20% when the unknown injury distributions were considered. Including state data with injuries of unknown severity increased the nationwide crash cost by $56 million. Results indicated a significant component of the annual cost associated with the unknown injuries ($162.5 million per year for injuries of unknown severity, compared with $61 million for A-injuries and $65 million for B-injuries). However, it was also observed that including state data from the additional four states of Kansas, Ohio, Oregon, and Wisconsin greatly increased the annual average predicted fatal crash cost (from $717 million to $813 million, an increase of 13%). It was noted that the four states without differentiated injury data (i.e., "A", "B", and "C"-injury crashes were coded as "I") contained a higher percentage of fatal crashes (K) than the other states with complete KABCO injury distributions. A comparison of the differences between state datasets is shown in Table 22.

Table 22. Comparison of State Data With and Without Differentiated Injury Data

States With Differentiated Injury Data:		**States Without Differentiated Injury Data:**	
Crashes	232,682	Crashes	168,176
Percent of All Crashes	58.0%	Percent of All Crashes	42.0%
Fatal Injuries	3,281	Fatal Injuries	2,193
Fatal Crash Percentage	1.26%	Fatal Crash Percentage	1.97%
Percent of All Fatals	59.9%	Percent of All Fatals	40.1%
Number of States	8	Number of States	4

The four states without differentiated injury data constituted more than 40% of the crash data and 40% of the fatal injuries. Because 12 state DOTs provided crash data, it was expected that the contributions of four states should sum to approximately one third of the total crashes and fatalities. Thus, the increased crash cost identified in Table 20 reflects the large number of crashes obtained from states without differentiated injury data, and also reinforces the need for the broadest possible collection of accurate crash data to predict national trends.

5.4 Discussion and Conclusions

Characteristics of tree and utility pole crashes were tabulated and analyzed. Utility pole crashes were considered with tree crashes because of the similar rigidity, size, and proximity of the roadside fixed objects. In addition, many utility poles are constructed from timber poles, such that utility poles have similar section strengths and sizes as roadside trees.

Most of the results of the tree and utility pole crash data analysis were unsurprising. Key findings include:

- Crashes are disproportionately severe at late-night hours, likely associated with a combination of driver fatigue, driver impairment (e.g., alcohol), and reduced visibility at night.
- Crashes with trees and utility poles were most common during winter months, but crashes were more severe on average during summer months. Moreover, more severe crashes occurred between April 1 and September 30 (183 days) than between October 1 and March 31 (182 days + 1 day for leap year).
- Adverse weather crashes (e.g., rain, snow, ice) were associated with reduced severity, likely as a result of reduced travel speeds and increased driver caution and attention. In contrast, foggy or impaired-driving conditions not associated with precipitation, such as rain or snow, were associated with a relatively high rate of severe crashes. This may be the result of high travel speeds despite low visibility, reduced reaction timing, or unexpectedly slippery roads.
- Passenger cars or vehicles were involved in more tree and utility pole crashes than light trucks (i.e., pickup trucks, SUVs, and vans). Passenger car crashes with trees and utility poles were more severe on average than light truck crashes (5.8% vs. 5.3%). Large truck crashes were rarely severe. Motorcyclist crashes with trees or utility poles constituted only 0.5% of the reported crashes, but were disproportionately severe (approximately 40% of reported crashes were A+K, and 7% of all tree and utility pole fatalities involved a motorcyclist).

- Crash rates at roadway curves were disproportionately severe. Curved roads were associated with both increased crash rates and increased severe crash rates. Crashes on non-level (i.e., grade) roadways were generally more severe when they occurred in conjunction with roadway curves. Crashes occurring on sloped tangent roads did not have an increased crash severity compared to crashes on level tangent roads.
- Annualized crash costs associated with tree and utility pole crashes summed to approximately $1 billion per state. During the six years for which data was collected (2009-2015), nationwide costs associated with tree and utility pole crashes were estimated at between $290 and $350 billion. Crashes with unknown injury severity were assumed to be approximately equivalent to PDO crashes and only one, highest-severity injury was evaluated per crash, which may underestimate total crash costs.
- Although most of the crash reports filled out by responding officers or agencies contained specific codes uniquely identifying trees separately from utility poles, mislabeling or miscoding the object struck still commonly occurs. For the purposes of this study, trees and utility poles were considered indistinguishable to maximize the probability of a robust dataset. It should be noted that utility poles are commonly located further from the road, on average, than trees (see Section 2.1.4 of this report) and are responsible for fewer fatalities each year; thus including utility poles could *decrease* the average crash severity identified in this study.

Annual crash costs to state DOTs was estimated at $1 billion. This crash cost is staggering. Moreover, when considering governmental agencies with financial strain, the recurring crash cost could be straining state budgets and resources as tree crashes are indirect costs that do not appear as a line item on a budget, but indirectly as tax revenue and emergency services costs. Tree and utility pole crashes constitute a significant recurring cost and may consume the resources of cash-strapped state agency budgets, including DOTs, but little effort has been expended to determine the national or statewide costs in a way that is clear and practical for budgeting committees. Budgeting committees can, however, incorporate the known cost of tree removal. Because the benefits of tree removal have been clearly documented for many years, even for very low volume roads with as few as 50 vehicles per day [90], is imperative that tree removal safety projects are expedited to reduce statewide crash deaths and annual financial burdens. Priority for tree removal and potential utility pole relocation should be given to rural, curved roads, particularly at roadway grades, and then proceed to roadway tangents with an emphasis in locations with crash histories.

Typically, there are unreported crashes with roadside features which cannot be accounted for in the database. Although some crashes may be "unreported" due to errors in digitizing, transmitting, or misplacing data that should have been reported, the majority of unreported crashes are the result of low severity "hit-and-run" events in which a driver does not report the crash and is generally uninjured or experiences minor injuries. Unreported crashes can skew a data set to be more severe (on average) than the actual number of total crashes would indicate. However, reported crashes are a subset of all crashes which occur per year; the actual total number of crashes is equal to the number of reported crashes plus unreported crashes. The result may be adjusted due to redundant records, mislabeling, or "lost" data. By only considering reported crashes and crash rates, the projected crash costs per state are *lower* than the actual crash costs, meaning that benefit-to-cost ratios may understate the benefits of some types of treatments and overstate the benefits of others. Tree removal is likely to reduce both unreported and reported crash rates as well as average ROR crash severities.

6 TORT LITIGATION

Roadside trees and utility poles have been the subject of lawsuits since automobiles were popularized and roadways were constructed for horse drawn carriages instead of vehicles. An excellent review of tree litigation prior to 1980 is provided by Vance [91]. Selected tree and utility pole lawsuits were summarized and are shown in Tables 23 through 31. Typically, lawsuits involving roadside trees or utility poles invoke at least one of the following claims:

- Tree location was unnecessarily hazardous and agencies were negligent when planting the tree or for not removing the tree to protect motorists;
- Agencies were negligent in failing to inspect a tree or limb for rot or damage, resulting in a vehicle struck by a falling tree or a falling tree limb;
- After falling on the roadway, agencies were negligent in removing the tree or tree limb in a reasonable amount of time;
- Tree branches overhanging roadway were a road defect, causing impact, injury, obstructed sight or may contribute to other vehicles' movements which may become threats to adjacent traffic; or
- Tree growth (natural or intentionally planted) obscured motorist vision of intersecting roadways and/or traffic control devices (e.g., STOP sign), contributing to unsafe driving behaviors by at least one driver which directly contributed to a crash;
- Pole placement was unnecessarily dangerous and thus constituted a road defect, and the agency was negligent in failing to remove or relocate the pole.

Many of the lawsuits successfully levied against a governmental agency were awarded based on the premise of negligence. These cases included events when an agency was notified of an issue regarding a tree and did not act (tree fallen in roadway, diseased or dead tree adjacent to roadway which required replacement, etc.), or when proper maintenance procedures (e.g., mowing and pruning) around critical locations like intersections were not followed, resulting in trees obscuring traffic control devices (e.g., STOP signs). Courts have routinely evaluated the merit of plaintiffs' claims against agencies for alleged failures of design, maintenance, or removal on the basis of notice supplied to the agency. Verbal or written information supplied to the agency which both identifies and locates a potentially hazardous condition is referred to as "actual notice." In many instances, in the absence of an actual notice supplied by a road user, landowner, governmental investigator, or other entity, the state can still be determined to be negligent due to "constructive notice." Constructive notice indicates that the hazard existed for a sufficient amount of time (e.g., dead and rotted roadside tree) that any reasonable frequency of roadside safety inspection would have detected and remedied an existing or potential hazard. The definition of what qualifies as "reasonable," in terms of the inspection frequency and quality of inspection provided, may be determined on a case-by-case basis by a jury or judge.

Case law will always persist to assist judges and juries when rendering verdicts to be consistent with previous cases. Still, it should be noted that much of the available case law arose prior to the completion of the modern highway and interstate system, installation of federal transportation guidance, and creation of transportation groups, including NHTSA, FHWA, and AASHTO. Contemporary guidance for proper roadside safety, funding to address those concerns, and the availability of resources to suggest proper roadside safety techniques may strongly

influence future tort law. Some transportation-related developments in the U.S. that have occurred since the start of case law addressing roadside trees are provided below:

- In 1956, U.S. President Eisenhower signed the *Federal-Aid Highway Act of 1956*, which first awarded federal funding for a nationwide, continuous network of roadways which previously did not exist [92]. Construction in the continental U.S. began immediately in 1956, and the original design of the highway system was completed in 1991. Additional construction, maintenance, and improvements continue in perpetuity.
- The U.S. Department of Defense (DOD) designated portions of state highways and interstate routes as part of the National Highway System (NHS), a high-mobility transportation network which could provide emergency high-flow transportation in the event of national need [93-94].
- AASHTO published the first de facto standard in roadside safety standardization, the *Roadside Design Guide* (RDG), in 1988 [95] which has been revised and updated four times, with the fourth revision released in 2011 [9]. As of 2016, these recommendations and practices have been widely accepted and implemented by every state in the U.S.

Prior to the publication of AASHTO's RDG, standards involving tree maintenance, care, placement, and removal (including dead and fallen trees or limbs) were evaluated on a case-by-case basis using laws, regulations, municipal ordinances, or other prevailing guidance issued by governing agencies. However, after publication and acceptance of the RDG, it has been invoked multiple times in lawsuits with varying degrees of success [91].

Roadside trees affect more than the motorists who may crash into them. Trees have been observed to damage curb, gutter, road, sidewalk, and stormwater systems, costing millions to replace and sometimes contributing to congestion and flooding [10]. The burden of tree maintenance and the liability associated with inadequate maintenance has been largely shouldered by governing agencies, including cities, counties, and states [96]. Unevenness in sidewalks also legally and financially affects private property owners, even if the roadside tree placement is compulsory and the private property owner asserts no ownership of the roadside tree [97-98]. Tree foliage decreases the effectiveness of urban roadway lighting by blocking street lights, as well as obscuring pedestrians, including children, from drivers' lines-of-sight, which can decrease a driver's reaction time and increase the risk of vehicle-pedestrian collisions [10]. State DOTs in disaster-affected areas noted that fallen trees constitute a significant safety risk by obstructing travel, complicating rescues, and are hazards to cleanup and utility crews.

Trees in close proximity to the roadway have few actual or perceived benefits or advantages when compared to trees located farther away from the road. Roadside trees are associated with considerably more safety risks for motorists, maintenance costs, and governmental agency resources required to maintain and eventually remove them. In order for roadside trees to be feasible for state DOTs with limited budgets, monetary allocations should be planned for tree maintenance and inspection; tree repair or replacement due to disease, infection, infestation, or impact (crashes); legal costs and settlements for killed or injured motorists and pedestrians; and repairs or replacement of transportation infrastructure (e.g., curbs, gutters, sidewalks, stormwater systems, roadways). Moreover, cleanup and repairs after weather events ("Acts of God") may be

adversely affected by roadside trees. Thus, additional budget allocation and time should be allotted if a significant number of roadside trees exist. Governmental agencies should anticipate the true cost of roadside trees when planning maintenance, improvement, safety, and planting projects.

Table 23. Selected Lawsuits in which Tree or Stump were Alleged to be Unnecessarily Hazardous

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Lapchenko v. State (1956): 2 Misc.2d 478 (1956)	A driver pulled to the shoulder of the roadway to make room for an oncoming vehicle when it struck a branch and jacknifed	Proper inspection and maintenance of the road and roadside would have identified the overhanging branch and removed the deficiency	The vehicle was within the statutory limits of size and movement on the roadside shoulder is not prohibited, therefore the state was negligent to ensure that lawful road users are protected from deficiencies on or adjacent to the roadway	Plaintiff
Harford v. State (1962): 17 A.D.2d 680 (1962)	A vehicle departed the roadway and remained off-road for more than 500 ft before crossing all lanes of the roadway and impacting a tree	Initial roadside departure and the prolonged departure on the side of the road were the result of a steep pavement edge drop-off, permitting accumulation of stone and gravel adjacent to the pavement, which reduced the vehicle's ability to safely return to the roadway	The State was determined to be negligent for allowing the steep pavement edge drop-off to persist, but prevented the plaintiff from recovering damages because the plaintiff is accused of improper use of the roadway by means of excessive speed and therefore was not entitled to recovery	Defendant
Godwin v. Government Employees Insurance Company (1981): 394 So.2d 751 (1981); No. 8052	Vehicle departed road, and while attempting to converge back to roadway, lost control due to the 2-3 in. pavement differential at the shoulder and veered across travel lanes, into tree	The pavement edge drop off at the shoulder was excessive and constituted an undue risk for vehicles operating at or near the shoulder	Court ruled that because the shoulder was not raised at the time of a recent roadway resurfacing project, the shoulder edge drop off constituted an unsafe condition, and it was the imperative of the government transportation agencies to ensure safe transportation for all road users	Plaintiff
Johnson v. County of Nicollet (1986): 387 N.W.2d 209 (1986); No. C1-86-70	Vehicle departed road due to slippery travel conditions, traveled down embankment, and struck tree, resulting in injuries	County of Nicollet was negligent for failing to install guardrail in potentially hazardous location (near embankment of river)	Court ruled that the County should not have relied on trees at the river's edge to stop cars from entering the river, as trees are themselves hazards, and that the County should have properly protected the hazardous location	Plaintiff
Williams v. Saratoga County (1943): Unk	Vehicle departed the roadway on a sharp curve and crashed into a cluster of trees, resulting in fatality	Advance warning for the curve and the hazard associated with failing to negotiate that curve constituted a dangerous condition and it was imperative on the County to properly notify drivers	The combination of the curve and trees in close proximity to the roadway constituted an unnecessarily dangerous condition and a defect, and the County was liable; this site had resulted in 10 crashes in the past, clearly demonstrating the dangerous condition that was in place	Plaintiff
Provine v. Bevis (1967): 70 Wn.2d 131 (1967); 422 P.2d 505	Vehicle collided with a tree stump located beyond the end of the roadway, resulting in injury	Plaintiff alleged that the street did not have proper delineation of the impending hazard and end of roadway	The lack of warning signs and/or devices was deemed a defect and the plaintiff was awarded	Plaintiff
Baran v. City of Chicago Heights (1969): 99 Ill. App. 2d 221 (1968); 240 N.E.2d 381	Vehicle departed roadway at end of T-intersection and collided with a tree, resulting in injury	The City of Chicago failed to install proper traffic delineation devices and the presence of the tree adjacent to the T-intersection created an unsafe condition	It was noted that the tree is a hazard and failure to delineate, shield, or protect it or other vehicles in the situation of a T-intersection constituted a defect	Plaintiff
Hubbard v. Estate of Havlik (1974): 213 Kan. 594 (1974); 518 P.2d 352	Vehicle departed roadway and collided with large tree, resulting in fatality	City was negligent for failing to fix the tree located outside of the right-of-way but close to the roadway, which due to the danger it imposed, constituted a defect	Case was dismissed as "without merit" for failing to prove the tree constituted a dangerous condition and defect	Defendant
Norris v. State (1976): 337 So.2d 257 (1976); No. 5526	Vehicle departed roadway at tight curve and collided with large tree, resulting in fatality	Plaintiff argued that the Louisiana Highway Department was negligent for sharp curve design with inadequate warning, leading to unnecessary risk for drivers	Court ruled that the Department was not negligent because a "reasonable and prudent driver" would not depart the roadway; it was outside of the right-of-way and the driver in this case was traveling at an excessive rate of speed	Defendant
Luceri v. County of Orange (2004): 144 A.D.2d 444; 534 N.Y.S.2d 9	Vehicle departed roadway and struck tree, resulting in injury	County should have removed roadside trees as they are hazardous to motorists, and thus the County demonstrated negligence	Tree was determined to be healthy and not at risk of falling, dropping limbs upon, or otherwise affecting motorists, and the County was not liable for negligence on behalf of driver when leaving the roadway	Defendant
City of Waco v. Killen (1933): Tex.Civ. App., 59 S.W.2d 940	Vehicle collided with a tree stump located beyond the end of the roadway, resulting in injury	The City of Waco was negligent to remove, shield, or delineate dangerous tree stump in the right-of-way, which constituted a defect	City of Waco was determined to have been negligent for failing to protect vehicle occupants from unnecessary risk	Plaintiff
Hendrick v. Kansas City (1933): 60 S.W.2d 704, 227 Mo. App. 998	Vehicle collided with stump located within the roadway	The City was negligent for failing to remove tree stump located within roadway	The city was determined to be liable for failing to remove, shield, or delineate stump in the middle or roadway, which was difficult to see at night	Plaintiff
Rafferty v. State of New York (1941): 261 App. Div. 80	Driver pulled vehicle off of the roadway and onto shoulder due to blinding lights from approaching motorist, and immediately crashed into tree	Permitting roadside tree to exist at or within boundary of shoulder constituted an unnecessarily hazardous condition, thus was a road defect and the State was guilty of negligence	Permitting a tree to remain in place was not deemed unnecessarily unsafe regardless of proximity to the roadway	Defendant
Fox v. Village of Nassau (1943): 266 App. Div. 1058, 44 N. Y. Supp. 2d 906	Vehicle collided with tree located within the roadway	The Village was negligent for allowing the tree remain inside of the roadway	The Court stated that "it was the duty of the village to remove the tree if it rendered or was reasonably likely to render public travel…unsafe"	Plaintiff
Goodrich v. Kalamazoo County (1943): 8 N.W.2d 130 (Mich. 1943); 8 N.W.2d 130, 304 Mich. 442	Vehicle departed the road and crashed into a tree, resulting in a fatality	The close proximity of the tree to the travelway (30 in. from road edge) and rigidity of the tree constituted negligence for an unnecessarily dangerous driving condition	Court ruled that allowing a tree to remain adjacent to the roadway did not constitute negligence and that the County has discretion for determining what roadside features may exist, irrespective of hazard; removing the tree was not required for the County to provide "reasonably safe" roadsides	Defendant
Taylor v. City of Cincinnati (1944): 143 Ohio St. 426, 55 N.E.2d 724, 729	Driver swerved to avoid encroaching vehicle from opposite direction and crashed into tree located within shoulder of roadway (i.e., 20 in. away from lane edge)	The tree was located in the right-of-way and was a rigid hazard, as such it was an unnecessary hazard and constituted a road defect; the City of Cincinnati was negligent for permitting tree to remain in location	Permitting a tree to remain in place was not deemed unnecessarily unsafe regardless of proximity to the roadway	Defendant
Meridian City Lines v. Baker (1949): 39 So. 2d 541; 206 Miss. 58	Vehicle swerved to avoid collision with other encroaching vehicle and crashed into a tree which protruded into travel lane	City of Meridian was negligent to permit rigid obstruction from intruding into travelway; intrusion constituted a road defect	City was determined to be negligent for failing to remove obstructing hazard	Plaintiff

Table 24. Selected Lawsuits in which Tree or Stump were Alleged to be Unnecessarily Hazardous

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Kinne v. State (1959): 8 A.D.2d 903 (1959)	Vehicle crashed into tree in close proximity to the roadway (3 ft), within the right-of-way, causing injury	State was negligent to remove obvious hazard to vehicles which depart the roadway, which constituted a road defect	State was not found to be negligent for allowing tree to be located adjacent to the roadway, and the Court affirmed that it was the prerogative of the state to use roadside land for whatever purposes it sees fit; this case overturned previous ruling finding state liable	Defendant
Harris v. State of Louisiana (2008): 997 So. 2d 849; 2008 La. App.	Vehicle lost control, departed road, and crashed into tree, resulting in passenger ejection and fatality	A dangerous pavement edge drop off near the location of the crash contributed to the driver losing control, and combined with the large tree adjacent to the roadway, constituted a defect	Pavement edge drop-off was significant contributor and DOTD was negligent to provide proper maintenance for roadway	Plaintiff
Peterson v. Transportation Dep't (1986): 154 Mich. App. 790 (1986); 399 N.W.2d 414	Vehicle lost control due to pavement edge drop-off and crashed into tree, causing injury	Department of Transportation was negligent to remove roadside tree, which was a rigid obstacle posing a hazard to road users, and that the pavement edge drop-off contributed to vehicle instability	The Court ruled that the pavement edge drop was likely a persistent condition and the Department had constructive notice to address the problem, but the distance between the impacted tree and the road (such that impact with the tree occurred with none of the plaintiff's wheels remaining on the shoulder) was not negligence on behalf of the Department and they were not responsible for hazards located well beyond the right-of-way	Plaintiff
Frederick Tinao v. City of New York (1985): 491 N.Y.S.2d 814; 112 A.D.2d 363	Vehicle ran off road and struck roadside tree, resulting in fatality	City failed to maintain streets and roadside shoulders and constituted negligence for failing to remove roadside tree	Although the City was determined to be negligent in caring for right-of-way in permitting the tree to grow at the shoulder location, the City's negligence did not contribute to the proximate cause of the crash, which occurred solely due to the decedent's intoxication and excessive speed	Defendant

Table 25. Selected Lawsuits in which Tree or Tree Limb Falls on Vehicle

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Hensley v. Montgomery County (1975): 25 Md. App. 361 (1975); 334 A.2d 542	Vehicle occupant was injured when a decayed tree limb fell through windshield on vehicle and struck occupant	Private landowner and County were negligent by failing to inspect trees on property to ensure no hazard existed for road users	Neither the landowner nor the County were deemed negligent because it was deemed too burdensome to inspect each branch of each tree adjacent to the roadway, and that a reasonable inspection would not have identified the hazardous branch which injured the vehicle occupant	Defendant
Israel v. Carolina Bar-B-Que (1987): 292 S.C. 282 (1987); 356 S.E.2d 123	Vehicle occupant was injured when a decayed tree limb fell on vehicle	Owner of private property was negligent to inspect and maintain upper branches of tree which overhung accessway	Court ruled that it was not an undue burden to expect private property owners to inspect and maintain trees with reasonable frequency, and that it is the imperative of private property owners to ensure trees on their properties do not pose a hazard to others	Plaintiff
Toomey v. State of Connecticut (1994): No. Cv-91-0057183s; 1994 Conn. Super. Ct. 1691	Rotted tree limb fell onto vehicle roof, resulting in two fatalities and major injuries	State failed to inspect and maintain tree which had an obvious defect (rot) which was clearly visible with any reasonable inspection	State was guilty of negligence, and failing to inspect tree did not constitute lack of constructive notice; condition was obvious and persisting for some time prior to the limb falling on a vehicle	Plaintiff
Valinet v. Eskew (1991): 574 N.E.2d 283 (1991); No. 06S01-9106-CV-484	Tree on private property adjacent to roadway fell on vehicle during storm, resulting in injuries	Private landowner was responsible for identifying hazard associated with decayed tree and was negligent to properly maintain tree to avoid hazard to adjoining motorists	The Court ruled that while property owners have a duty to inspect and maintain property to ensure it does not pose an undue hazard to others, motorists have no such duty to inspect and maintain the property of others, and as such all liability exists with Defendant	Plaintiff
Inabinett v. State Highway Department (1941): 196 S.C. 117, 12 S.E.2d 848 (1941)	Vehicle occupant was injured when a tree fell on vehicle	A large tree with a decayed trunk was located on private property adjacent to right-of-way, and South Carolina was negligent to remove the tree	South Carolina DOT was negligent because they were aware of the potential hazard to motorists and did not respond to ensure safety of travelers	Plaintiff
Messinger v. State (1944): 183 Misc. 811 (1944)	The limb of a decayed tree fell through a moving vehicle's windshield and seriously injured an occupant	The tree limb showed obvious sign of decay and the State was negligent not to properly care for and remove the tree limb to ensure safety of road users	Constructive notice was issued regarding the tree limb and the Court ruled that the State was liable for ensuring occupant safety for hazards within and outside of the road's right-of-way	Plaintiff
Mosher v. State (1948): 77N.Y.S.2d 643 (1948); 191 Misc. 804	Vehicle occupant was injured when a decayed tree limb fell on his vehicle	The limb which impacted the vehicle was alleged to be in hazardous condition prior to the crash and the state patrol officer's testimony that the limb was inspected and not determined to be dangerous was false	No constructive notice of a dangerous condition could be established, thus the State was not determined to be liable	Defendant
Barron v. City of Natchez (1956): 229 Miss. 276 (1956); 90 So.2d 673	Vehicle occupant was killed when a tree fell on vehicle	Although the tree was located on private property, the property owner had contacted the City and requested that it be removed; the tree was noted to be hazardous and decayed	The city was responsible for not removing tree with notice of hazard within a reasonable amount of time	Plaintiff
Albin v. National Bank of Commerce of Seattle (1962): 60 Wn.2d 745 (1962); 375 P.2d 487	Vehicle occupant was killed when a tree fell on vehicle	The county had actual or constructive notice that the tree constituted a hazard to motorists on a mountainous, rural roadway	The Court could not confirm that the State had constructive notice of the decayed nature of the tree and would not rule that inspection and care of mountainous roads was incumbent on the State	Defendant
Jones v. State (1962): 106 Ga. App. 614 (1962); 127 S.E.2d 855	Vehicle occupants were injured when a tree fell on vehicle	The tree was located adjacent to the right-of-way on private property but was badly decayed and in a dangerous condition, constituting negligence	The Court ruled that the State was aware of the dangerous condition of the tree and it was incumbent on the State to inspect and remove hazards both inside and outside of the right-of-way if it poses a hazard to motorists	Plaintiff
Miller v. County of Oakland (1973): Unk	Vehicle occupant was injured when a tree fell on vehicle	The County was liable for neglecting to remove a dead and decayed tree from the side of a county road in compliance with state statute requiring that the "improved portion of the roadway" (i.e., right-of-way) must be kept reasonably safe	County had constructive notice of the dangerous condition of the tree and was therefore liable for failing to remove the tree	Plaintiff
Husovsky v. United States (1978): 590 F.2d 944 (1978); Nos. 76-1533, 76-1534	Vehicle occupant was injured when a large, decayed tree limb fell on his vehicle	The Federal Government, which owned the land on which the tree was located, was negligent to maintain the tree	Washington, D.C. was determined to be responsible for caring and maintaining trees on property owned by the federal government within the city limits	Plaintiff
City of Birmingham v. Coe (1944): 31 Ala.App. 538, 20 So. 2d 110	Vehicle occupant was injured when a tree fell on vehicle	Tree within right-of-way was rotted at the root and branch structure, leading to safety risk, and the city was negligent to inspect and remove the hazard	Sufficient evidence existed to support premise that city should have been able to identify rot and remediate problem with a visual inspection	Plaintiff
City of Jacksonville v. Foster (1949): 41 So.2d 548 (1949)	Vehicle occupant was injured when a tree fell on vehicle	City of Jacksonville was negligent to inspect and maintain damaged, decayed tree	The Florida Supreme Court ruled that there was sufficient visual evidence to show the city was negligent to inspect and maintain tree located within right-of-way	Plaintiff
City of Bainbridge v. Cox (1951): 83 Ga. App. 453 (1951); 64 S.E.2d 192	Vehicle occupant was injured when a decayed tree limb fell on her vehicle	Roadside tree within right-of-way had substantial, visible decay and damage, constituting an unsafe condition, and the city was negligent for failing to maintain tree	Although the city did not have any formal position to inspect trees, the Court ruled that the city was not absolved its of responsibility for maintaining trees within the right-of-way	Plaintiff
Berkshire Mut. Fire Ins. Co. v. State (1959): 9 A.D.2d 555 (1959)	Vehicle occupant was injured when a tree fell on vehicle	Plaintiffs allege that typical inspection would have identified hazardous condition of the tree and remedied the hazard, constituting negligence	Court ruled that tree damage or decay would not have been observed during a reasonable visual inspection and that the determination of the damaged condition of the tree would have required much more burdensome inspection procedures	Defendant

Table 26. Selected Lawsuits in which Tree or Tree Limb Falls on Vehicle

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Edgett v. State of New York (1959): 7 A.D.2d 570 (1959)	Vehicle occupants were injured when a decayed tree limb fell on vehicle	Tree was in the right-of-way and subject to inspection and maintenance, and because the state had constructive notice of the hazardous condition of tree, New York State acted negligently by failing to maintain or remove hazardous tree	The Court ruled that the tree's location within the right-of-way and its branches located over the highway constituted a need for adequate inspection, maintenance, and care to ensure safety of road users	Plaintiff
Abelove's Linen Supply, Inc. v. State (1960): 20 Misc.2d 821 (N.Y. Misc. 1960)	Decayed tree limb fell onto tractor traveling down roadway, injuring driver	Tree was within the right-of-way and had been marked for removal for considerable time prior to the injury, thus the state was negligent for failing to remedy the defect in a reasonable amount of time	Court confirmed the allegation of the plaintiff	Plaintiff
Siegel v. State (1968): 56 Misc. 2d 918, 290 N.Y.S.2d 351 (N.Y. Ct. Cl, 1968)	Vehicle occupant was injured when a tree fell on vehicle	Visual inspection of a portion of the fallen tree revealed extensive damage from carpenter ants, which should have been identified through routine inspection and marked for removal, which constituted negligence by the State	Although an inspector for the State indicated that he had observed the tree, it was noted that the inspector did not exit his vehicle for a more thorough inspection, and the state was deemed to have had sufficient time and constructive notice to identify and remove the hazardous tree but did not	Plaintiff
City of Phoenix v. Whiting (1969): 10 Ariz. App. 189 (1969); 457 P.2d 729; No. 1 CA-CIV 645	Vehicle occupant was injured when a tree fell on vehicle	Tree which fell on vehicle was alleged to be in poor condition with insufficient root structure, and that reasonable maintenance and inspections would identify and fix the problem, indicating negligence on behalf of the City	The Court ruled sufficient constructive notice had been supplied to the city and that the city was liable for failing to respond to the degraded condition of the tree	Plaintiff
Rinaldi v. State (1975): 49 A.D.2d 361 (1975)	Vehicle occupant was killed when a tree fell on vehicle	State was negligent in failing to inspect and maintain tree located within right-of-way with visible damage, decay, and rot (e.g., the tree had a 12-in. diameter, but there was a decay hole through the tree)	Court ruled that the State had constructive notice of tree's condition and that the tree's hazardous condition persisted for longer than a reasonable amount of time to maintain and remove hazardous tree	Plaintiff
Diamond v. State of New York (1976): 53 A.D.2d 958 (1976)	Vehicle occupant was injured when a tree fell on vehicle	Tree was improperly inspected and the inspector failed to observe obvious signs of decay and damage to tree, because only one side of the tree was inspected, which constituted negligence	Because the tree inspection was completed by an individual who was walking at the time, the Court ruled that it was reasonable to assume a visual inspection would encompass the entire exterior of the tree and that failure to observe the obvious signs of rot and damage constituted negligence	Plaintiff
Marsh v. SCDHPT (1990): 395 S.E.2d 523 (1990)	Tree fell on vehicle, causing injury	Tree which fell had been leaning over highway and was visibly at risk of falling, and the State failed to inspect and maintain the tree, constituting negligence	Routine inspection, such as those occurring frequently in the location of the crash, should have detected the dangerous condition of the tree and the fungal growth which caused it to fall; therefore the State was negligent to properly care for roadside trees	Plaintiff
Patton v. Department of Transportation (1996): 546 Pa. 562, 686 A.2d 1302 (1997)	Tree limb fell onto moving vehicle, causing fatality	Pennsylvania DOT was negligent to remove a tree branch which overhung roadway and ultimately contributed to crash	Disputed claims; Lower Court found Pennsylvania DOT guilty of negligence, whereas the Appellate Court determined no actual or constructive notice existed. The Supreme Court noted the determination of actual or constructive notice was a question for the jury, and although not actual notice of the dangerous condition of the branch existed and constructive notice was in dispute, the State was not immune to charges of negligence because an obviously hazardous condition of a branch (overhanging the roadway) did not necessarily require actual or constructive notice to find the State liable	Retrial
Cline v. Dunlora South, LLC (2012): 284 Va. 102; 726 S.E.2d 14	Tree fell on vehicle, causing injury	Town of Dunlora and Virginia DOT were negligent to inspect and remove obviously rotted tree which remained in decayed condition on private property bordering roadway for years	The private landowner did not directly contribute to increasing the hazard to drivers on the adjacent roadway, and the Town and State were not liable for failing to inspect and remove tree on adjoining private property	Defendant
McGinn v. City of Omaha (1984): 352 N.W.2d 545 (1984); 217 Neb. 579	Tree fell on vehicle during storm, causing paralysis	Extensive decay observed in tree which fell on vehicle indicated the City failed to properly inspect and maintain tree adjacent to travelway, and created an unsafe traveling condition	Defendant failed to prove that proper inspection and maintenance of the tree would have prevented injury, as decay was not visible by street and not observed during typical inspection procedures	Defendant
Roman v. Stamford (1988): 16 Conn. App. 213 (1988)	Decayed tree fell onto vehicle, causing injury	Tree located in park belonging to Municipality fell under charter rule describing typical care for trees (both adjacent to and near the roadway) and the Municipality was negligent to inspect and maintain tree	Tree rot was not immediately obvious and did not constitute constructive notice, and no part of the tree which fell overhung roadway, therefore City was not liable	Defendant
Carver v. Salt River Valley Water Users Association (1969): 104 Ariz. 513 (1969); 456 P.2d 371; No. 9504-PR	Vehicle occupant was injured when a tree fell on vehicle	Maricopa County and the private landowner on which the tree was located were negligent in failing to inspect and remove a hazardous tree	Initially, damages were awarded to the plaintiff; both the Appeals Court and Supreme Court denied recovery on the premise that no constructive notice was issued and that it was not shown that a reasonable inspection of the tree would have identified the impending threat	Defendant
Commonwealth v. Callebs (1964): 381 S.W.2d 623 (1964)	Vehicle occupant was killed when a tree fell on vehicle	The tree which fell on the vehicle was badly decayed on the back side of the tree with respect to the roadway, and a reasonable inspection of the tree would have shown it to be unsafe; thus the Commonwealth was negligent in permitting the tree to remain	The Court denied the assertion that a reasonable inspection included walking around the circumference of the tree and noted that no sign of decay or damage was visible from the roadway, thus the Commonwealth was not liable	Defendant
Piety v. City of Oskaloosa (1958): 92 N.W.2d 577 (1958)	Vehicle occupant was injured when a tree fell on stopped vehicle	Top of tree which fell onto stopped vehicle would have been identified as weakened and hazardous during a reasonable inspection and that the City was negligent in failing to properly inspect and maintain tree on adjacent park property	No evidence was presented proving that damage to the tree was reasonable, there was no reason to suspect that the branch which fell was at risk, and no constructive notice was provided, thus the city was not negligent in duties	Defendant
Harris v. Vil of E. Hills (1977): 41 N.Y.2d 446 (1977)	Rotted tree limb fell onto vehicle roof, resulting in paralysis	It was the statutory duty of the village to maintain the tree and that the tree suffered from rot, posing an undue hazard to road users, and was not maintained or removed in a reasonable time	It was the sole duty of the Village to inspect and maintain trees, and the rot would have been discovered with any reasonable inspection; thus the Village was liable for negligence	Plaintiff

Table 27. Selected Lawsuits in which Vehicle Impacts Fallen Tree or Tree Limb in Roadway

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Caskey v. Merrick Construction Co. (2007): 41,662-CA	Vehicle impacted fallen tree in roadway which had been damaged by construction equipment	State DOT was negligent to identify and remove damaged tree which posed a public hazard	Court ruled that State performed statutory duty inspecting for decayed or rotted trees, and the State was not negligent for the fallen tree because the condition was in proximate timeframe to the crash and no actual or constructive notice existed of the condition of the tree	Defendant
Brown v. State of New York (1945): 2 Misc.2d 307 (1945)	Vehicle occupant was injured when a tree fell in front of a vehicle, causing a crash	Tree which was located outside of the right-of-way tall and decayed for some time and posed a hazard, constituting negligence on behalf of state	State had constructive notice of decayed condition of tree, and court ruled that it is the imperative of the state to ensure travel ways are free of hazard including from trees adjacent to right-of-way	Plaintiff
Fitzgerald v. State (1950): 198 Misc. 39 (1950)	Half of the split trunk of a decayed tree fell onto the road in front of a vehicle, injuring an occupant	The State of New York was negligent to remove the obviously dead and decayed tree, and that it constituted a hazard to motorists	The Court ruled that although the base of the tree was outside of the highway's right-of-way, the limbs of the tree clearly hung over the road and constituted an unnecessary hazard and it was the duty of the state to remove that hazard	Plaintiff
Rose v. State of New York (1953): 282 App. Div. 1099	A large tree fell across the roadway, contributing to a vehicular crash	The State of New York acted negligently in failing to diagnose the decayed and dangerous condition of the tree, which was located 6 ft outside of the edge of the right-of-way	The lower court awarded damages to the plaintiff, but the Appellate Courts denied recovery on the grounds that tree decay was internal and not obvious from external inspection, and boring into the tree to identify rot would be an excessive burden on the state	Defendant
Taylor v. Olsen (1978): 578 P.2d 779 (1978); 282 Or. 343	Vehicle collided with tree which fractured through the trunk and fell on roadway during windy day	Property owner was negligent in duty to inspect and maintain tree to prevent damage to motorists on adjacent roadway	Although the tree was rotted in the center, was very tall and partly leaned over the roadway, and was the only tree in the immediate vicinity which posed a hazard to passing motorists, rot could not have been identified with reasonable inspection procedures and neither the landowner nor the County were liable for failing to identify the hazardous condition of the tree	Defendant
Goranson v. State (1956): 3 Misc.2d 1020 (1956)	A tree split vertically at the point where the trunk diverged into two branches, and a vehicle collided with the fallen portion of the tree	The State of New York was negligent to maintain and inspect the aged tree (estimated 100 years old) which experienced significant rot at the trunk branching location	The State of New York was deemed negligent for failing to inspect and maintain tree given adequate constructive notice of deficient condition	Plaintiff
Lewis v. State of Louisiana, DOTD (1994): 642 So.2d 260 (1994)	Dead tree fell over onto highway causing crash, injury	State of Louisiana had duty to inspect and maintain trees which were reasonably close to the roadway and which constituted an undue risk for road users, even if trees were located on private property	State failed to properly inspect and maintain tree	Plaintiff
Wilson v. State, Through Dept. of Highways (1978): 364 So. 2d 1313 (1978); No. 6693	Tree fell on highway, causing crash and injury	The Department of Highways contributed to an unsafe roadway condition by not removing a tree deemed obviously hazardous and at risk to fall or cause collision	DOH failed to maintain tree and placed public at risk during maintenance of roadside trees	Plaintiff
Jessop v. Department of Transportation (2011): 2011-Ohio-3964	Vehicle impacted fallen tree limb resting on roadway, resulting in damage	State was negligent to inspect roadways properly and remove debris, and to maintain trees	Ohio DOT was not responsible for inspection nor maintenance of tree causing injury and no notice was given to the state indicating imminent risk to public	Defendant
Miller v. Department of Transportation (2008): 2008-03971-AD	Fallen tree on snow- and ice-covered roadway caused crash	State was negligent to identify hazardous tree and remove obstruction from roadway	Plaintiff could not demonstrate that the State had actual or constructive notice of decaying or fallen tree, and could not demonstrate that hazard could not be identified within reasonable stopping distance	Defendant
Porta v. State, State Board (1970): 242 So.2d 64 (1970); No. 8091	Hurricane caused tree to fall on roadway, causing fatal crash	State was negligent to remove tree which had fallen due to hurricane and was laying on the road, creating unsafe traveling condition	Decedent had passed by the tree which had fallen previously in the same day and was not unaware of the risks of traveling on roadways after hurricane (advised not to travel on radio, tv, etc), and the State was using all available personnel to clear roads, thus could not expect state to instantaneously fix all transportation problems created by hurricane	Defendant
Walker v. Dept. of Transp. & Development, Office of Highways (1984): 460 So. 2d 1132 (1984); No. 16641-CA	Tree fell across highway during ice storm, causing fatal crash	Department of Transportation and the Railroad failed to properly inspect and maintain tree, and that the tree was in a hazardous condition prior to the crash and placed road users at risk	Court did not concur with allegations of rot or distress in the tree prior to falling, and the tree fell by uprooting, not by failing through rotted or diseased wood; thus the DOTD and Railroad were not responsible for failing to anticipate and reconcile an unlikely scenario (tree fall)	Defendant
Julian v. State (1946): 187 Misc. 146, 148	The limb of a decayed tree fell onto the road in front of a vehicle, causing a crash which injured a vehicle occupant	Although the tree was located on private property, the length of the tree limb and the obvious, visible presence of decay contributed to an unsafe condition, and failure to remedy constituted negligence	Constructive notice was issued regarding the tree limb and the Court ruled that the State was liable for ensuring occupant safety for hazards within and outside of the road's right-of-way	Plaintiff

Table 28. Selected Lawsuits in which Vehicle Impacts Branch Overhanging Lane

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Valvoline Oil Co. v. Inhabitants of Town of Winthrop (1920): 235 Mass. 515, 521, 126 N.E. 895 (1920)	Vehicle was damaged after impacting a low-hanging branch over the roadway	Tree located adjacent to the road at sidewalk had low-hanging tree branches extending into the street, creating an unsafe travel condition	City was liable for failing to maintain safe roadways free of obstructions	Plaintiff
Northern Haulers Corporation v. State (1960): 12 A.D.2d 567 (1960)	Tractor-trailer damaged when it struck the limb of a tree protruding over the highway	No warning was provided regarding the low-hanging branch, thus the state was negligent to provide either reasonable notice of a deficiency for road users or to remedy the deficiency	The branch constituted a deficiency and a reasonable amount of time passed that the State was negligent for failing to remove the hazardous branch or provide advance warning within a reasonable period of time	Plaintiff
Robert Neff and Sons, Inc. v. City of Lancaster (1970): No. 69-62	Livestock trailer damaged when it collided with a tree limb protruding over a City street	The City of Lancaster was not in compliance with a state statute which required that streets be kept free of nuisances	The Court ruled that the state statute was enforceable not just to the surface of the street, but also to the space above it, and as such the City was in violation of the state statute	Plaintiff
Bimonte v. Town of Hamden (1971): 281 A.2d 331, 6 Conn.Cir.Ct. 608	Vehicle was damaged after impacting a low-hanging branch over the roadway	The overhanging limb constituted a highway defect	Court ruled that the low-hanging branch could be considered a highway defect and that the Municipality had sufficient time and advance notice to remedy the defect prior to the impact, thereby constituting negligence	Plaintiff
Green v. Borough of Freeport (1971): 218 Pa. Super. 334 (Pa. Super. Ct. 1971)	Occupant of a vehicle was injured when vehicle impacted a low-hanging, stationary branch	The Municipality was negligent in failing to ensure reasonable clearance for vehicles on the travelway	Court ruled in favor of the plaintiff on the grounds that the limb constituted an obstruction of the public way, which the municipality was under a duty to remove	Plaintiff
Mayor and Aldermen of the City of Savannah v. AMF, Inc. (1982): 164 Ga. App. 122 (1982); 295 S.E.2d 572	A towed trailer struck a low-hanging tree branch and was damaged	The low-hanging tree limb constituted a deficiency and should have been removed	The low height of the tree branch over a public travelway constituted a deficiency and the City was negligent to remove it	Plaintiff
Sanker v. Town of Orleans (1989): 27 Mass. App. Ct. 410	Motorcyclist turned to look over shoulder and hit a tree branch overhanging road, leading to loss of control and subsequent crash with utility pole resulting in fatality	Town was negligent to prune tree branch overhanging roadway and for the close proximity of the utility pole to the roadway	Although the Town and State had jurisdiction regarding what articles could be placed on the sides of the roadway and where they could be located, failure to properly care for roadside trees such as to prevent a motorcyclist from impacting a tree branch while remaining on the roadway constituted negligence	Plaintiff
Thompson v. State of Louisiana (1996): 688 So. 2d 9; 1996	Vehicle struck limb overhanging roadway, resulting in on-road crash and run-off-road crash with trees	The State was negligent to remove limb overhanging roadway, which contributed to the crash, and the presence of the roadside trees violated a safer roadside as denoted by AASHTO's 1977 RDG	The tree limb could not be deterministically shown to be present at the crash and there was no actual notice of removal, and the State possessed the right to utilize the roadside as it sees fit	Defendant

Table 29. Selected Lawsuits in which Tree Obstructed View of Intersection or Traffic Sign (e.g., STOP)

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Barton v. King County (1943): 18 Wn.2d 573, 576-77, 139 P.2d 1019 (1943)	Bicyclist and truck collided at intersection, resulting in injuries	High vegetation at intersection of county roads was unsafe due to lack of ability to perceive vehicles on cross roads	The court ruled that applying a standard of care and maintenance which would be to low-speed, county locations would impose an unbearable financial burden and would result in an abundance of new lawsuits in the wake of the ruling	Defendant
Owens v. Town of Booneville (1949): 206 Miss. 345; 40 So.2d 158	Two vehicles collided at intersection	High vegetation at intersection of city roads was unsafe due to lack of ability to perceive vehicles on cross roads	The defendant was not liable for vegetation obscuring vision at intersections and it was incumbent on the operator of the automobile to exercise just caution	Defendant
Dudum v. City of San Mateo (1959): Civ. No. 18104. First Dist., Div. Two. Feb. 5, 1959	Two vehicles collided at an intersection, resulting in injury	View of a stop sign was obscured by a large tree and shrubbery growing on private property adjacent to the city street	Court determined that the placement of the stop sign obscured in part or whole by private property was indistinguishable from a defective sign, and therefore constituted negligence	Plaintiff
Stanley v. South Carolina State Highway Department (1967): S.C. 153 S.E. (2d) 687	Two vehicles collided at an intersection, resulting in injury	High vegetation in right-of-way obscured vision and constituted a defect in the state highway system	Failure to maintain or remove vegetation in the right of way, including that which obscured vision, did not constitute an inherent defect in the state highway system	Defendant
Brown v. State Highway Commission (1968): 444 P.2d 882; No. 45,084	Three vehicles collided at an intersection, resulting in fatality	The Kansas State Highway Commission was negligent to trim a tree which was obscuring the stop sign, contributing to the fatal crash	The state was responsible for maintaining the installation, maintenance, and visibility of traffic control devices such as stop signs, including trimming vegetation	Plaintiff
Hidalgo v. Cochise County (1970): 13 Ariz. App. 27 (1970)	Two vehicles collided at intersection	High vegetation at intersection of county roads was unsafe due to lack of ability to perceive vehicles on cross roads	The court ruled that applying a standard of care and maintenance which would be to low-speed, county locations would impose an unbearable financial burden and would result in an abundance of new lawsuits in the wake of the ruling	Defendant
Bakity v. County of Riverside (1970): 12 Cal.App.3d 24 (1970); 90 Cal. Rptr. 541	Two vehicles collided at intersection	City of Riverside failed to maintain vegetation (trees) on private property which blocked view of stop sign at intersection	The City of Riverside had a duty to ensure adequate view of stop sign despite vegetation growing on private property	Plaintiff
De LaRosa v. City of San Bernardino (1971): 16 Cal.App.3d 739 (Cal. Ct. App. 1971)	Two vehicles collided in an intersection at night	View of a stop sign was obscured by a 30-ft walnut tree and shrubbery growing on private property adjacent to the city street	Although the tree was located on private property, maintenance and visibility of critical infrastructure such as signage is critical and failure to do so constituted negligence	Plaintiff
Stewart v. Lewis (1974): 292 So.2d 303 (1974); No. 9668	Two vehicles collided at an intersection, resulting in injury	Plaintiff was unable to see approaching vehicle because trees obstructed view	Louisiana Department of Highways was negligent in maintaining clear lines of sight on roadways and tree growth created an unsafe condition	Plaintiff
Coppedge v. Columbus, GA (1975): 213 S.E.2d 144, 134 Ga. App. 5	Two vehicles collided at an intersection, resulting in injury	City of Columbus was notified of trees obstructing a stop sign, which contributed to several crashes at the intersection, therefore constituting negligence	The City of Columbus was in error for not maintaining a clear and unobstructed view of signage, and lower courts were remiss in dismissing the case	Plaintiff
Boyle v. City of Phoenix (1977): 115 Ariz. 106 (1977); 563 P.2d 905	Bicyclist and vehicle collided at intersection, resulting in injuries	High vegetation at intersection of city roads was unsafe due to lack of ability to perceive vehicles on cross roads	The court ruled that the city had no safety or maintenance obligation to the injured party and was not liable	Defendant
First Nat'l Bank v. City of Aurora (1978): 71 Ill. 2d 1 (1978); 373 N.E.2d 1326	Two vehicles collided at an intersection, resulting in injury	View of a stop sign was obscured by a tree	Because the tree was within the right-of-way and obscured the vision of the stop sign, the city of Aurora was negligent in failing to take appropriate action to ensure safety of road users	Plaintiff
Bentley v. Saunemin Township (1980): 83 Ill. 2d 10 (1980); 413 N.E.2d 1242	Two vehicles collided at intersection, resulting in fatality	The Saunemin Township was negligent to maintain visibility of a stop sign, which was obscured by tree branches from a tree adjacent to a Township road	Township is responsible for ensuring the visibility of the sign and had a duty to maintain the tree which obscured it	Plaintiff
Lorig v. City of Mission (1982): 629 S.W.2d 699 (1982); No. C-978	Two vehicles collided at intersection	View of a stop sign was obscured by several trees and tree limbs	The Supreme Court of Texas ruled that the obstruction of a STOP sign from view by trees and branches constituted negligence and that it was a duty on the city and state to maintain clear vision of roadside signs	Plaintiff
Armas v. Metropolitan Dade County (1983): 429 So. 2d 59 (1983); No. 81-2598	Two vehicles collided at intersection	Dade County and City of Miami were negligent to maintain vegetation (tree) on private property which grew up and obscured view of stop sign	Overruled first court's ruling in favor of defendants; court ruled that city and county had duty to ensure visibility of publicly-owned stop sign and to ensure public safety on travelway	Plaintiff
Fretwell v. Chaffin (1983): 652 S.W.2d 755 (1983)	Two vehicles collided at intersection	View of a stop sign was obscured by several trees	Obstructed view of the stop sign was not distinguishable from a defective sign, and as a result, the City of Knoxville, TN was negligent for not removing the obstructing trees or limbs	Plaintiff

Table 30. Selected Lawsuits in which Tree Obstructed View of Intersection or Traffic Sign (e.g., STOP)

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Kenneally v. Thurn (1983): 653 S.W.2d 69 (1983); No. 16523	Two vehicles collided at intersection	Accident occurred by reason of the City's failure to correct the "condition" of a STOP sign being obscured from view by the presence of crape-myrtle bushes growing on private property adjacent to the intersection.	The intermediate Court of Appeals rendered the City of San Antonio accountable under the Tort Claims Act.	Plaintiff
Town of Belleair v. Taylor (1983): 425 So.2d 669 (1983); No. 82-1236	Two vehicles collided at intersection	View of intersecting lanes was impaired by improperly-maintained vegetation (trees) in median	Town was negligent to maintain vegetation owned and under care of town	Plaintiff
Jezek v. City of Midland (1980): 605 S.W.2d 544 (1980); No. B-8917	Driver navigated partially into intersection to see if cars were approaching on the intersecting roadway and was struck by another vehicle	Tree overgrowth at the intersection of the roadways was so obtrusive to driver vision that drivers were routinely forced to partially enter intersection in order to see around trees; this constituted an unnecessarily hazardous condition and was a road defect	City had constructive notice of the dangerous condition of the trees but failed to remove trees causing sight obstruction and was therefore liable	Plaintiff
Sanchez v. Clark Cty (1988): 44 Ohio App. 3d 97 (1988)	Overhanging tree limbs obscured oncoming traffic from view, causing crash and fatality	County was negligent for failing to maintain sign and to prevent vegetation from obscuring vision of the sign	County was negligent because the sign was the property of the County, and although the tree branches which obscured sign were from an adjacent property and not County property, it was the duty of the County to ensure motorists can see traffic control devices	Plaintiff
Texas Dept. of Transp. v. Olson (1998): 980 S.W.2d 890; 1998 Tex. App.	Vehicle ran stop sign and struck motorcyclist, who was obscured by tree at intersection	TXDOT was negligent to provide clear view of intersecting roads, obscuring motorist and contributing to crash	DOT was negligent to maintain vegetation and ensure adequate view of traffic control devices (STOP sign)	Plaintiff
Texas Dept. of Transp. v. Pate (2005): 170 S.W.3d 840; 2005 Tex. App.	Tractor-trailer impacted and killed occupants of vehicle obscured from sight by tree overgrowth at intersection	High vegetation at intersection of city roads was unsafe due to lack of ability to perceive vehicles on cross roads	The duty to maintain intersections and stop signs was not a defect in the roadway but was a statutory duty of maintenance; thus the State was negligent by failing to provide reasonable sight distance	Plaintiff
Twomey v. Commonwealth (2005): 444 Mass. 58; 825 N.E.2d 989	Vehicle ran stop sign causing crash and fatality, due to tree growth at sign location	High vegetation at intersection of city roads was unsafe due to lack of ability to perceive vehicles on cross roads	The Court noted a broad definition of "defect" in previous cases of tort involving the roadway and determined that there was no distinction between other road defects and obscured traffic control devices	Plaintiff
Carr v. City of Lansing (2003): 259 Mich. App. 376; 674 N.W.2d 168	Trees obscured stop sign causing crash and fatality	County was negligent for failing to maintain sign and to prevent vegetation from obscuring vision of the sign	Sovereign immunity and the contextual definition of "highway" and its duties and responsibilities rendered the City not negligent for failing to maintain visibility of signage	Defendant

Table 31. Selected Lawsuits Involving Utility Pole Proximity to the Roadway

Case ID	Events	Plaintiff Allegation(s)	Ruling	Awarded T
Zacherer v. Town of Wakefield (1935): 291 Mass. 90 (1935)	Vehicle lost control and departed roadway, colliding with a utility pole located approximately 3 ft from the road edge	It was alleged that the pavement surface had greatly deteriorated and the shoulder had become uneven such that the driver's ability to negotiate a curve was compromised, which constituted a road defect and negligence on behalf of the Municipality	Court denied recovery on the grounds that road maintenance and repair, as well as utility pole maintenance and repair, is intended to maintain a reasonably safe path but that there was tolerance for some degree of degradation	Defendant
Trabisco v. City of New York (1939): 280 N.Y. 776	A vehicle collided with a utility pole spaced 3 ft from the road edge, resulting in injury and fatality	The vehicle did not leave the roadway under negligent conditions but rather to avoid impact with a vehicle traveling in the opposite direction, and the location of the pole did not provide for adequate room to negotiate and safely return to the roadway; utility pole placement was therefore a roadway defect	It was determined that the placement of the pole within the roadway's right-of-way constituted a defect and that reasonable use of the roadway, such as what occurred during this crash, was made more hazardous by the location of the pole; the City was therefore liable for placing the pole in a hazardous location	Plaintiff
Russell v. State (1944): Unk	Vehicle collided with utility pole located 10 ft from the roadway while avoiding another vehicle, resulting in fatality and injury	Location of the utility pole was unsafe (10 ft from road) and contributed to crash, and the State was negligent for permitting the utility pole to remain adjacent to the roadway	State was determined to be negligent in permitting a rigid obstruction to be located adjacent to the road	Plaintiff

7 REVIEW OF MARKETING STRATEGIES AND CAMPAIGN RESULTS

7.1 Introduction

Governments have launched marketing campaigns targeted at road safety since automobiles were manufactured. According to a meta-analysis[2] of 67 research studies across 12 countries, the weighted average effect of road safety campaigns is 9% with a 95% confidence that campaigns reduce the number of road accidents by 9% (± 4%) [99]. Many of the road safety marketing campaigns reviewed for this report utilized a fear appeal strategy, which is defined as "a persuasive message that attempts to arouse fear in order to divert behavior through the threat of impending danger or harm" [100]. Roadside safety marketing is unique compared to other marketing campaigns due to its common use of the fear appeal.

Nelson and Moffit concluded that roadside marketing programs should require "understanding of the problem, including factors that predispose, and reinforcing the target behavior," which has strong similarities to other marketing projects for promoting products or desired behavior [101]. The goal of this review is not only discussing different opinions on fear appeal marketing for roadside safety, but also discovering the best marketing strategies to promote roadside safety. Five major factors to be considered when designing roadside safety marketing campaigns in a more cost-effective and efficient way include: (1) design, (2) content, (3) time (frequency and duration of exposure to campaign), (4) channels and media, and (5) targeting and audience for road safety social marketing.

7.2 Campaign Design

Multiple studies concluded that campaign approaches should include a combination of multi-channel advertisements, law enforcement, education, and using various forms of new technology [102-104]. The World Health Organization concluded that road safety campaigns were able to influence behavior only if used in conjunction with legislation and law enforcement [104]. Reductions in fatalities were not sustained when educational, informational, and public marketing approaches were conducted independently of each other.

The *Community Guide* concluded that legislation and education using mass media make social campaigns more effective [105]. According to the World Health Organization and other research, education by trusted professionals generated the greatest result for social marketing campaigns [105-107]. For instance, when trusted professionals educated the public for a hospital-led promotion in the UK, self-reported helmet use among 11–15 years olds living in the campaign area increased from 11% at the start of the campaign to 31% after five years ($p<0.001$) and cycle-related head injuries in the under 16 years age group fell from 112 per 100,000 population to 60 per 100,000 population in the campaign area [106].

According to Wundersitz's 2010 report, mass media alone is unlikely to produce large behavioral changes. However, when it is used in conjunction with other campaign methods, mass media may greatly support road safety campaigns, as shown in Table 32 and Figure 45 [102].

[2] Meta-analysis, used in context of marketing and advertising campaigns, refers not to a study conducted with new data, but rather an assessment of multiple, inter-related advertising and promotional campaigns (typically safety related) and an objective set of criteria used to determine the successfulness of each campaign.

Delaney also emphasized the effectiveness of integrated campaigns. In his report, Delaney found that integrated campaigns, especially the combination of public relations and law enforcement, were very effective in supporting campaign initiatives [108]. Likewise, a meta-analysis conducted by Elvik, et al. showed that mass media campaigns have almost no effect in terms of reducing the number of road accidents without the addition of enforcement and/or education, as shown in Table 32 and Figure 45 [103-104]. However, legislation may experience a diminished return if it is not combined with effective enforcement, as shown in Figures 46 and 47 and Table 33, according to a meta-analysis of 67 research studies spanning 12 countries [99].

Table 32. Observed Effectiveness of Road Safety Campaigns on Reducing Car Crashes [103]

	Effect of road safety campaigns on road accidents	95% confidence interval
General effect	-9%	(–13; –5)
Mass media alone	1%	(–9; +12)
Mass media + enforcement	-13%	(–19; –6)
Mass media + enforcement + education	-14%	(–22; –5)
Local individualised campaigns	-39%	(–56; –17)

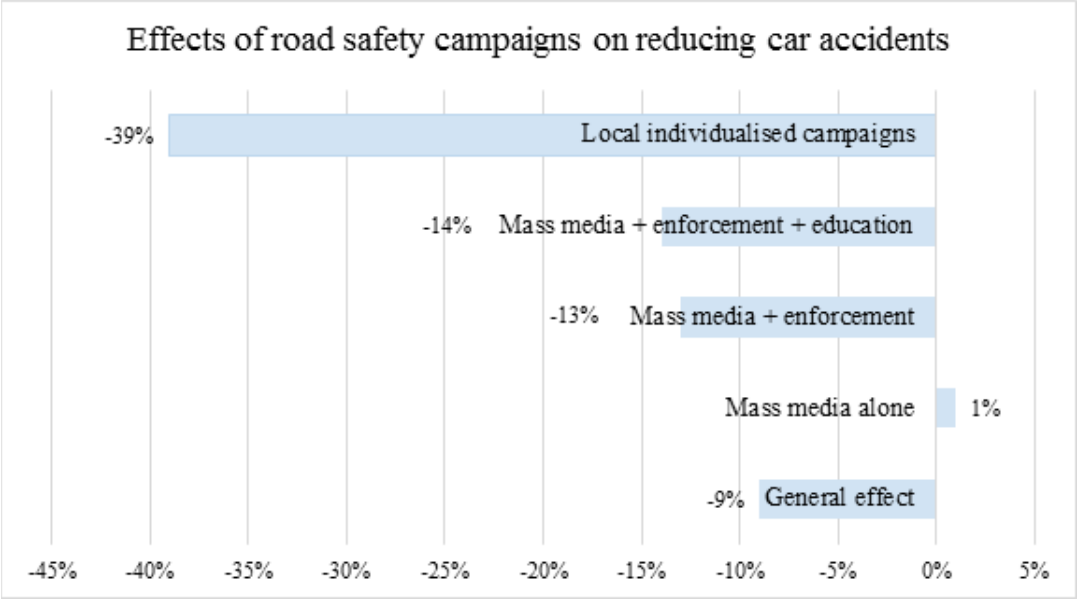


Figure 45. Effects of Road Safety Campaigns on Reducing Car Accidents, 2009 [104]

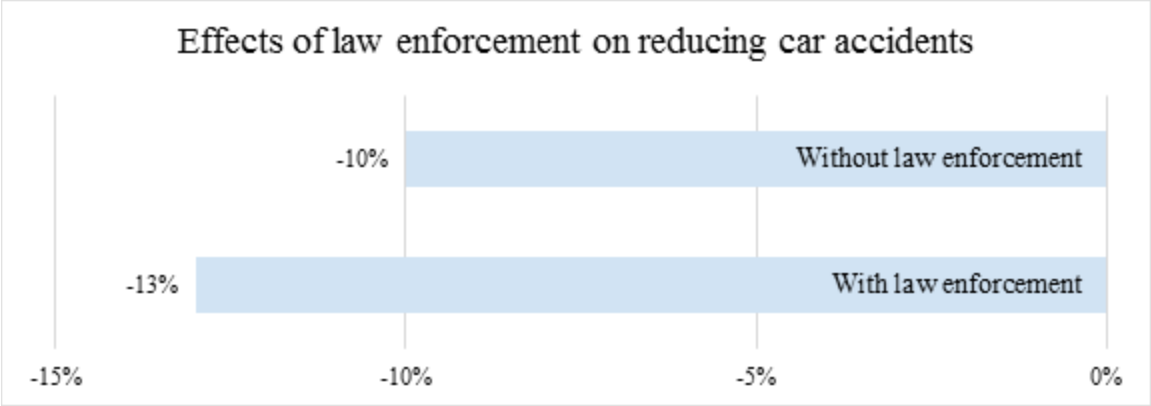


Figure 46. Effect of Law Enforcement on Reducing Car Accidents, 2009 [99]

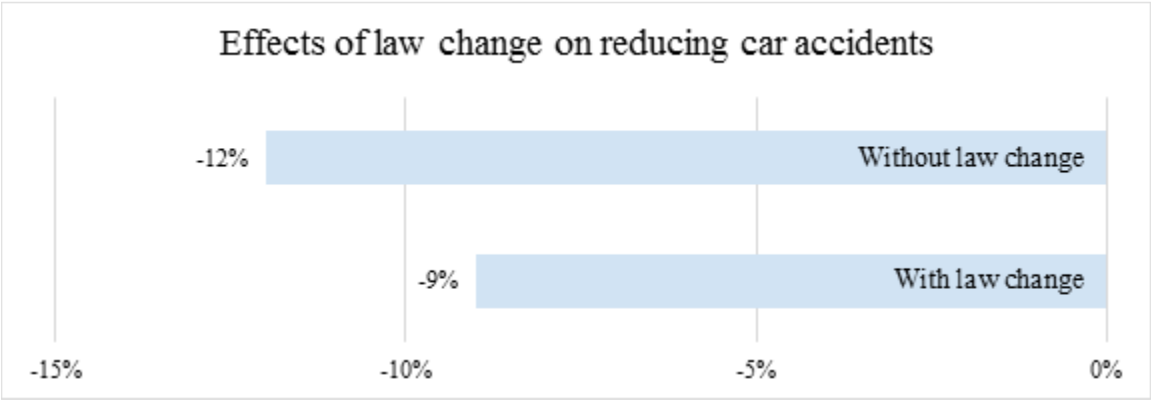


Figure 47. Effect of Law Change on Reducing Car Accidents, 2011 [99]

Table 33. Effects of Changes in Laws and Law Enforcement on Reducing Car Crashes, 2011 [99]

Delivery variable	Variable level	No. effects	Test of heterogeneity		Proportion of statistical weight	% change in accidents		
			Cochrane's *Q*	*p*		Lower 95%	Estimate	Upper 95%
Accompanying measure	Enforced							
	Yes	80	386	<.001	0.77	−16	−13	−9
	No	34	165	<.001	0.23	−16	−10	−3
	Law change							
	Yes	9	50	<.001	0.15	−17	−9	0
	No	107	531	<.001	0.85	−16	−12	−9

7.3 Content

Fear appeals are one type of emotion-based marketing approach. In general, studies indicate that campaigns with an emotional appeal were more effective than solely focusing on rational appeal, which explains why many roadside safety campaigns previously used fear appeals. A meta-analysis of 67 studies and 119 results from 12 countries showed that when emotional and rational content was combined, it generated a larger reduction in accident rates than rational content alone, as shown in Figure 48 and Table 34 [99]. One of three major conclusions from Delaney, et al.'s "A Review of Mass Media Campaigns in Road Safety" was that "campaigns that use emotional rather than rational appeals tend to have a greater effect on the relevant measure of effect" [108]. Information-based and educative campaigns have also been associated with less effective campaigns. Wundersitz, et al. suggested motivating the audience with different types of appeals for effective road safety marketing rather than only providing them with information [102].

Nonetheless, campaigns still need to include specific information to induce behavioral changes. Particularly, studies have shown that specific and simple messages suggesting desirable behavior with positive motivation can be the most effective way of conveying messages [109-110].

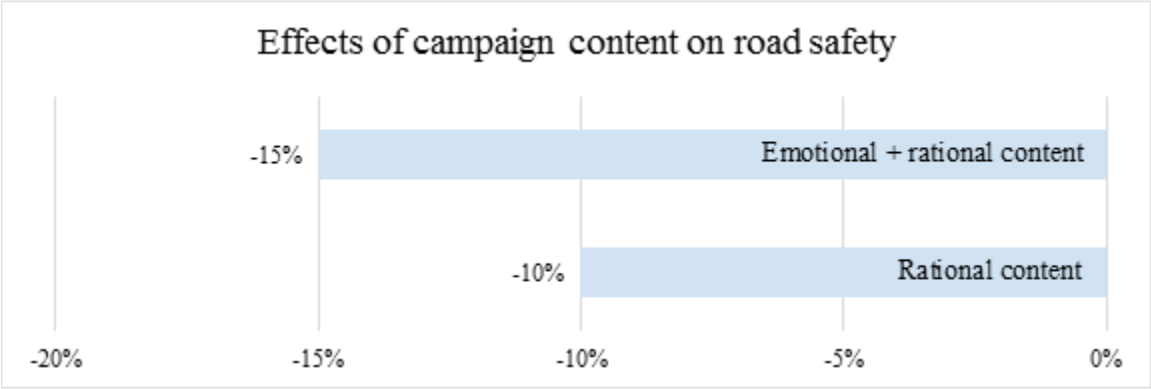


Figure 48. Effect of Campaign Content on Reducing Car Accidents, 2011 [99]

Table 34. Effect of Content on Reducing Car Crashes [99]

Content variable	Variable level	No. effects	Test of heterogeneity		Proportion of statistical weight	% change in accidents		
			Cochrane's *Q*	*p*		Lower 95%	Estimate	Upper 95%
General content	Emotional	4	–	–	0.07	–	–	–
	Rational	52	203		0.5	–14	–10	–5
	Emotional + rational	29	282	<.001	0.35	–21	–15	–7

The result of developing positive emotions during roadside safety campaigns has been approved and supported by many studies, as well as the Rossiter & Percy's Model [110], whereas the effectiveness of negative emotional appeals for behavioral change is unclear [102]. When researchers reviewed evidence relating to the effectiveness of fear appeals in improving driver safety, they discovered that advisements with a fear appeal generated mixed and inconsistent reactions [111-113]. The examination of the effectiveness of fear appeals is still inconclusive, despite the amount of research that has been conducted to clarify its efficiency [102]. According to the LaTour and Zhara Model, the extent to which the audience reacts to a fear arousal approach cannot be measured, therefore an optimum level of fear arousal cannot be identified [108]. Donovan, et al. suggested that this is due to the fact that there is no absolute measurement of fear [114].

The effectiveness of the emotional appeal in road safety marketing yields diverse results depending on gender. Studies showed that women are more likely to respond to fear appeals with the desired reaction than men [114-115]. Lewis, et al. also stated that women tend to process and react to negative information more than men do in general, as shown in a campaign to reduce driving at excessive speeds [113, 115]. However, males respond more favorably to positive emotional appeals than females [116]. Positive emotional appeals, such as humor, may be more persuasive than fear appeals for males during road safety campaigns [113].

Social psychologists offered theoretical explanations for the different reactions to positive and negative emotional appeals between genders [111-113]. According to theories of information processing based on a selectivity hypothesis, positive emotional appeals tie to centric themes of advertisements and are most impactful for males who selectively process cues; negative emotional appeals generate feelings of consequence and future impact and are more easily processed by females [117]. Experimental evidence collected by Elliott suggested that threat appeal advertisements that advise drivers on safe driving appeared more effective than pure fear appeal advertisements that only attempt to stimulate feelings of fear, shock, or grief [118]. Elliott concluded that road safety media campaigns should use the fear appeal with caution instead of simply shocking people.

7.4 Campaign Duration (Time and Exposure)

Optimizing a campaign's duration and the audience's frequency of exposure can both maximize the campaign's effectiveness and minimize the cost. At a minimum, audiences must be exposed to a campaign three times to reach a minimum effectiveness threshold. Still, care must be taken to not be too aggressive or sustained. Researchers recommend that industry standards not be exceeded with roadside safety campaign exposure frequency [102]. Roadside campaign duration was more effective when it was short term and in repeated cycles [105, 119-122]. Smith's evaluation of 119 road safety campaigns results and their effect on the number of car accidents using 67 studies from 1975 to 2007 found that campaigns running less than a month were most effective in reducing accidents (Figure 49 and Table 35) [109].

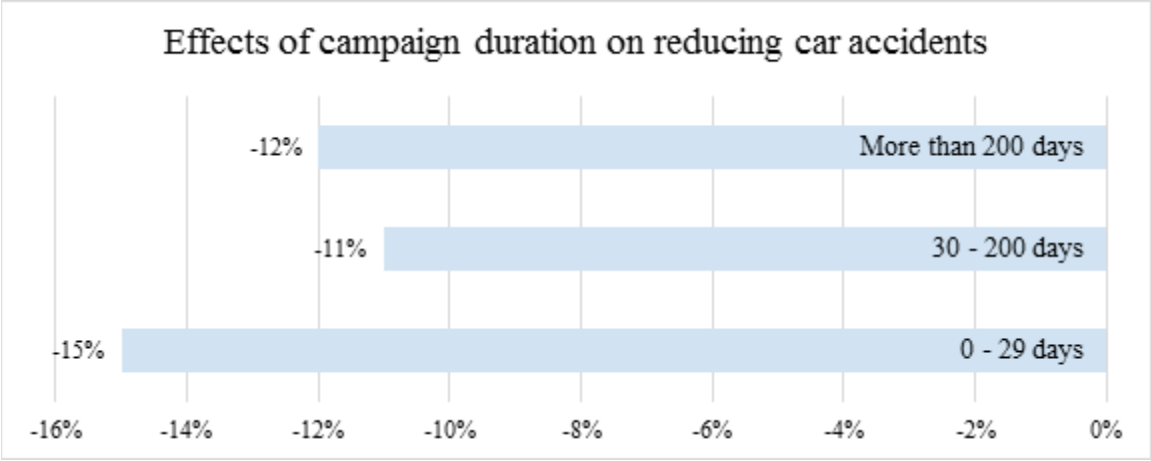


Figure 49. Effect of Campaign Duration on Reducing Car Accidents [109]

Table 35. Effect of Campaign Duration on Reducing Car Accidents, 2011 [109]

Content variable	Variable level	No. effects	Test of heterogeneity		Proportion of statistical weight	% change in accidents		
			Cochrane's *Q*	*p*		Lower 95%	Estimate	Upper 95%
Duration (days)	0–29	7	5	0.54	0.03	–21	–15[a]	–9
	30–200	47	151	<.001	0.3	–16	–11	–6
	More than 200	64	425	<.001	0.67	–16	–12	–7

7.5 Channels and Media

Which marketing channel would be the most effective for roadside safety marketing campaigns? Choosing the right marketing channels for a campaign is necessary to effectively access different targets with various content. There are many marketing channels and media outlets, including online and offline, but according to meta-analysis, not every form of media works effectively for road safety campaigns [99]. According to Phillips, et al., personal communication was the most effective marketing channel for road safety campaigns, as seen in Figure 50. Furthermore, there is evidence that people with lower levels of education are less likely to be reached with mass media messages [104]. This is not due to a lack of comprehension of the message, but people with lower degrees of education are less likely to pay attention to information conveyed through mass media campaigns [123]. Newspapers, leaflets, and roadside delivery, such as variable message signs, were not effective marketing channels to decrease crash rates, whereas the use of television and radio reduced accident rates, but the effect was not very significant [99]. Video and cinema were the next most effective marketing channels, behind personal communication. Utilizing only mass media is not very effective in decreasing the number of car

accidents, but local individualized and personal communication was the most effective in different studies, as seen in Tables 32 and 36 [99, 103-104].

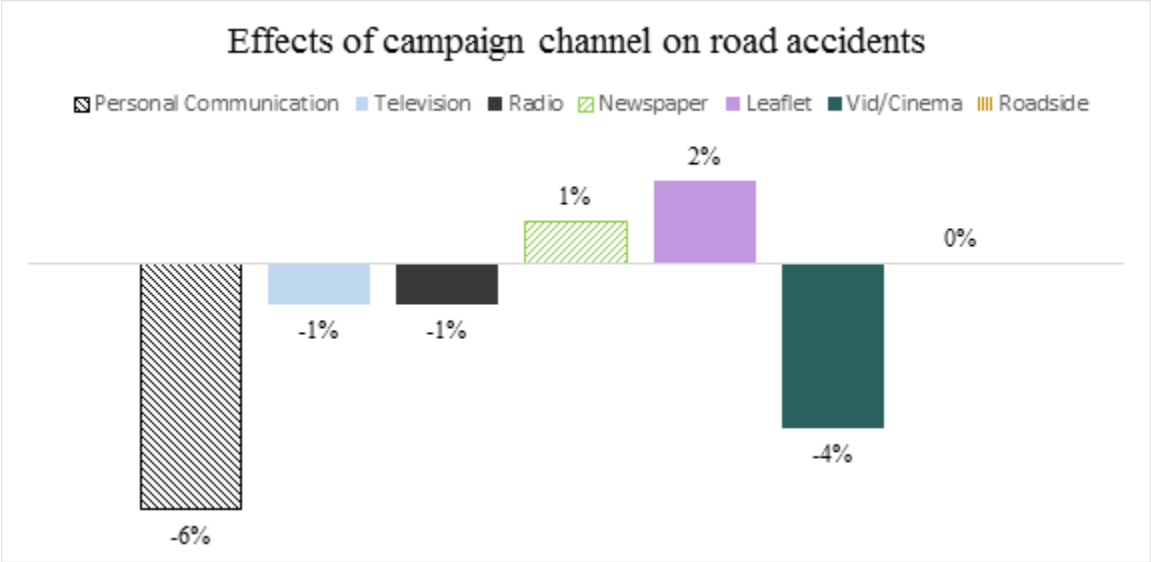


Figure 50. Effect of Campaign Channel on Reducing Car Accidents, 2011 [99]

Table 36. Effect of Campaign Channel on Reducing Car Accidents, 2011 [99]

Delivery variable	Variable level	No. effects	Test of heterogeneity		Proportion of statistical weight	% change in accidents		
			Cochrane's *Q*	*p*		Lower 95%	Estimate	Upper 95%
Personal Communication	Yes	27	135	<.001	0.18	−23	−16	−9
	No	90	446	<.001	0.82	−14	−10	−7
Media - Television	Yes	97	549	<.001	0.86	−15	−12	−8
	No	19	28	0.06	0.14	−14	−11[a]	−8
Media - Radio	Yes	83	413	<.001	0.69	−15	−12	−8
	No	33	162	<.001	0.21	−17	−11	−4
Media - Newspaper	Yes	82	381	<.001	0.75	−15	−11	−7
	No	33	180	<.001	0.25	−18	−12	−5
Media - Leaflet	Yes	40	231	<.001	0.42	−16	−10	−5
	No	75	345	<.001	0.58	−16	−12	−8
Media - Vid/cinema	Yes	15	26	0.03	0.06	−19	−15[a]	−10
	No	101	548	<.001	0.94	−15	−11	−8
Media - Roadside	Yes	32	178	<.001	0.38	−12	−12	−6
	No	84	393	<.001	0.62	−12	−12	−8

[a] Based on fixed effect model

7.6 Targeting and Audience

Regionally-scoped campaigns to decrease roadside crashes have demonstrated greater success compared to nationwide or local campaigns, as shown in Figure 51 and Table 37 [99]. Hoekstra and Wegman's study showed that local individualized campaigns decreased crash frequency by 39% [104]. Localized and small-scale targeting may be more effective than targeting bigger audiences when it comes to road safety marketing campaigns. In addition, advertisement costs do not need to be high; when researchers evaluated the impact of road safety advertisement and television commercial advertisement production costs ranging from $15,000 to $250,000, low-cost talking head testimonials performed equally well when compared to their far more expensive counterparts, as seen in Figure 52 [114]. Therefore, a large budget for road safety advertisements may be made unnecessary by targeting regionally-scoped audiences and using testimonials in advertisements.

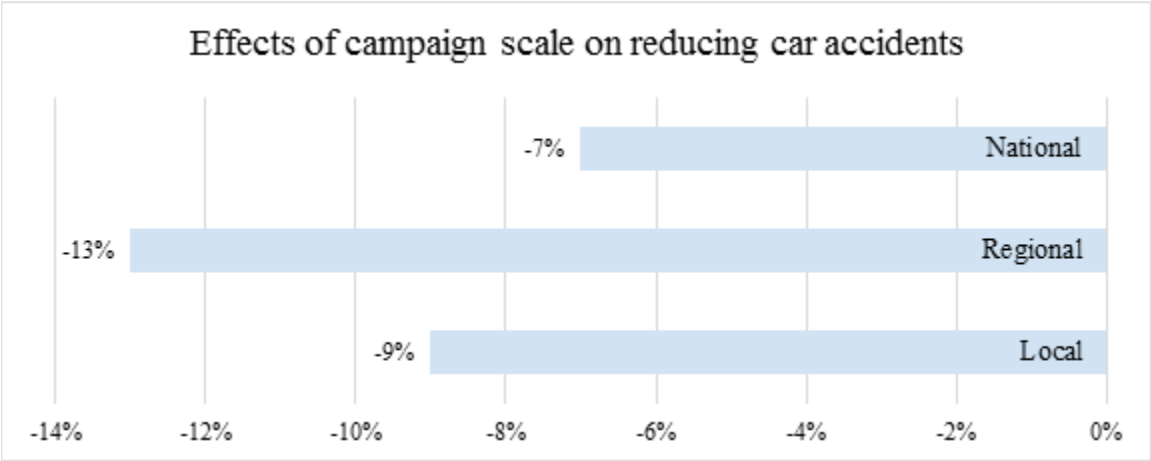


Figure 51. Effect of Campaign Scale on Reducing Car Accidents, 2011 [99]

Table 37. Effect of Campaign Scale on Reducing Car Crashes, 2011 [99]

Content variable	Variable level	No. effects	Test of heterogeneity		Proportion of statistical weight	% change in accidents		
			Cochrane's *Q*	*p*		Lower 95%	Estimate	Upper 95%
Scale	Local	23	75	<.001	0.16	–17	–9	–1
	Regional	79	442	<.001	0.72	–17	–13	–9
	National	16	37	0.001	0.12	–13	–7	1

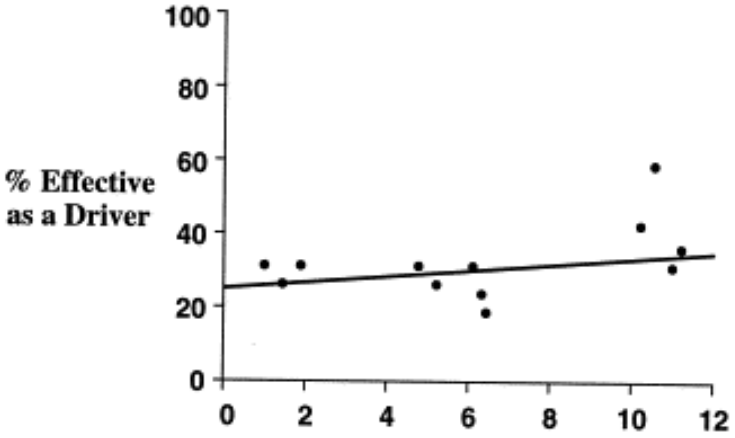


Figure 52. Advertisement Impact by Production Costs Ranking [99]

7.7 Summary and Conclusions

An enhanced campaign designed with crafted content, timing, channels, and targeting should be considered. Road safety campaigns can be highly effective even with limited marketing funds by targeting local groups and implementing short-term campaigns [99, 105, 119-122]. Short-term campaigns were more favorable than long-term campaigns by approximately 4%, as seen in Table 35.

A combination of mass media advertisements, law enforcement, and education was suggested by most researchers [102, 104]. In addition, a number of studies showed that advertisements should not only use content with emotion appeal, but also use content that includes desired behaviors to create an effective road safety campaign [99, 108]. It should be noted that males and females are more likely to positively respond to different types of emotional appeals: males reply more favorably to positive emotional appeals while females respond to fear-based appeals [102, 111-116]. Road safety advertisements should reach an audience a minimum of three times during campaign periods to change the audience's behavior. Personalized roadside safety campaigns such as invitations, talking in person or through phone calls, and/or mailings can be the most effective way for road safety social marketing campaigns to succeed [102].

An effective marketing campaign should be integrated with law enforcement and education [99, 102-105]. Without a combination of all of these factors, the roadside safety campaign may not be as effective as desired. Therefore, campaign messages, including educational messages and encouraging law enforcement activity, are necessary for successful road safety marketing. At the same time, marketers should recommend that professionals get involved in roadside safety education and make the desired impact on changing laws and law enforcement.

While this chapter focused primarily on general strategies for safety marketing campaigns, Chapter 8 addresses specific applications to roadside trees.

8 TREE MARKETING RECOMMENDATIONS AND EXAMPLES

8.1 Initial Developments of Tree Removal Campaigns

The literature review of roadside tree removal marketing campaigns and related research were used to generate the initial phase of a marketing campaign. The objective of the campaign is to successfully advertise safety improvements for the roadsides, including roadside tree removal, in such a way that the resistance from the general public and advocacy groups opposed to tree removal is minimized.

A list of target demographics and their significance was assembled and is shown in Table 38. Target groups included a broad category (general public) as well as very specific groups of individuals (e.g., environmental groups and local authorities). Vulnerable road users, defined as individuals who may not benefit from a stiff, structural, outer car body, such as motorcyclists, bicyclists, and pedestrians, were also denoted. In addition to identifying which groups could be reached, the motivation for outreach to each specific group was identified. It should be noted that the list is not comprehensive and represents only the first stages of the marketing campaign funded by the Midwest Pooled Fund states.

Next, researchers reviewed the results of the marketing and campaign research and developed marketing plans which were consistent with the characteristics of successful safety marketing campaigns, as shown in Table 39. When feasible, messages were worded with positive reinforcement and often utilized colloquial or contemporary cultural references to synergize with the audiences. In addition, messages were often designed for specific target groups. It should be noted that the marketing approaches shown in Table 39 are examples and should not be considered the final, recommended marketing approaches.

Table 38. Examples of Marketing Strategies and Techniques

Target Group	Why Target this group?
General Public	Roadside trees affect public safety (everyone has the same risk of injury)
	Broad audience
	General education: most are unaware of the dangers trees pose
	Can be "called to action," can write to representatives and lawmakers
	May be willing to volunteer for tree moving/removal projects
	Need to be aware of government actions regarding trees (removal, placing barriers, other possible issues)
Insurance Industry	"Key stakeholder" - in the event of a crash, insurance must pay out for claims
	Interest in lowering cost and frequency of crashes, monthly customer costs
Parents	Moms: large buying power, key influence in spreading message to other parents
	Dads: tech-savvy, play a role in reducing/preventing children's risky behaviors as pedestrians and drivers
	Can relate to parents of car crash victims; those who have lost children are more likely to speak out
Youth	Personal safety risks (young drivers are statistically more likely to be involved in crashes and with higher severity)
	Developing advocacy for safe roadsides can translate into proactive support throughout lives
	High interest in activism
	High priority on cultural relevance
Seniors	Testimonies - seniors may be able to recount harrowing stories involving roadside trees (injuries, deaths of loved ones, etc.)
	Children and grandchildren drive on streets and seniors can help to protect younger generations
	More vocal in front of legislatures and city councils - may be allies to foment change
Vulnerable Road Users	Motorcyclists most likely to die in tree crash (fatal injury risk higher than other vehicle types per crash)
	Strongly affected by falling or fallen trees or tree limbs during storms
	Group which is most affected by low-hanging branches and may be obstructed if obscured from other drivers' sights
Property Owners	Liability risks (landowners are principally responsible for roadside trees even if maintained by city)
Governors / State Legislatures	Able to directly influence policies
	Large platform and significant attention paid to issues addressed by legislature and governor
	May apportion special funds or alter DOT funding to address roadside tree concerns
Local Authorities	Most fatal tree crashes occur on rural two-lane streets, which are in jurisdiction of local authorities
	Resistance to safety improvements is significantly reduced at local level
Lawyers	Brute force method of making change by holding agencies economically liable if roadside tree policies/practices shown to be inadequate
	Plentiful lawyers seeking to "distinguish" from field and, possible that lawyers will identify roadside tree policies as focal litigation point
Environmental Groups	Traditionally, environmental groups have been staunchest opponents of tree removal projects
	Cooperation with these groups could strengthen support for safety projects
	Can create solutions which will benefit safety and environmental causes equally (i.e., symbiosis)

Table 39. Examples of Marketing Approaches and Relevant Target Audiences

Methods	Audience	Example Descriptions	Example Themes and Slogans
Bus Stop Shelters	General Public, Parents, Vulnerable Road Users	Image of a car crash into a tree (e.g., a car wrapped around a tree)	Let's make roadsides more forgiving.
		Lenticular printing: image changes as you view the ad from different angles. Example: roadside tree with and without car crash	C**harm**ing…or **Harm**ful?
			"So **pristine**…So **dangerous**"
			Trees are the invisible road threat.
		Image of a car crash into a tree with etches in tree to symbolize the number (tally) of crashes/fatalities. Substitutions for tallies: roadside crosses, memories/tributes	Don't wait for loved ones to become marks on the bark. Stand up for safe planting practices.
Advertisements on Buses (e.g., wraps)	General Public, Parents, Vulnerable Road Users, Youth, Seniors, Environmental Groups	Content may depend on size of ad. **Small banner**: Show simple crash statistics (e.g., 330,000 tree crashes annually) and reference a safety webpage or resource for more info **Large wrap**: transition from road with large tree adjacent to junkyard of crashed vehicles	Save a life: demand that trees be planted further from the road. Room to Recover – or a Recovery Room?
Billboards	General Public, Parents, Youth, Vulnerable Road Users, Property Owners, Governors, State Legislatures, Lawyers, Environmental Groups	Two half-opaque images. Top: roadside trees damaged by vehicle; Bottom: highway with spacious clear zones	Don't leave the wrong impression. Imagine a safer roadside.
		Image of roadside with many trees fades to similar or same roadside without trees in clear zone	Build a safer roadside
		Image of a highway that curves into a densely wooded area. Trees located head-on from viewer's point of view	Roadside trees can kill. Plant responsibly.
		Images of unwanted contacts (awkward hugs, an animal invading a person's personal space, car wrapped around tree)	Unwanted contact is never okay. You can stop dangerous roadside tree crashes.
		Images of marred/damaged/burned trees near side of road (obvious or subtle signs of vehicle-to-tree crash)	Give the trees room to breathe.
			Stay out of the tree's personal space.
			Keep drivers out of trees' comfort zones.
			Don't leave the wrong impression!
			A growing threat to your safety
			Move the trees and save your lives!
Dedicated Websites	All groups	Advocacy websites (e.g., roadside tree safety website) Informational websites which could be shared with insurance, government, DMV, or environmental agencies	Making transportation safer, smoother, and more efficient The REAL cost of roadside trees
Web Advertisements	All groups	Pop-up adds (e.g., pop-up with four images of trees placed in non-obvious locations, such as in the middle of a stairway/escalator, on a football/baseball field/under basketball hoop, on an airplane runway, and next to the side of the road) Scrolling banners with tree crash information, link to dedicated websites	Pop-up ad message: Trees in strange places – can you spot them? To save your paper greens, keep your leafy greens far from the road.

Table 39. Examples of Marketing Approaches and Relevant Target Audiences (Continued)

Methods	Audience	Example Descriptions	Example Themes and Slogans
Social Media (e.g., Facebook, Instagram, Twitter)	All groups	Tweet or message tree crash stats once a day/week/month Running clock (app?) that shows approximately how many people have died since January of same year due to tree crashes	Every three hours in the United States, someone dies because of a run-off-road crash with a tree.
		Keep database of tree crash photos (public domain) and remind people of frequency and danger of tree crashes	Tree crashes cost nearly $1 billion per state. What percentage of your tax dollars are lost because of street trees?
Guerrilla Marketing Campaigns	Parents, Youth, Seniors, Governors, State Legislatures, Local Authorities, Environmental Groups	Tying black ribbons around trees involved in fatal collisions (or other colors for non-fatal collisions, based on severity)	Eight new ribbons are added to trees per day to represent the people killed in roadside tree crashes
		Place a vehicle involved in real tree crash next to tree close enough for pedestrians to walk to display and look (could include dummies)	The real consequences of run-off-road crashes
		Stage a "death-in" around trees using paid/unpaid volunteers to represent deaths caused by tree crashes (alternative to volunteers: mannequins, stuffed body bags, dummies)	How many more have to die?
Yard Signs	Parents, Vulnerable Road Users, Property Owners	Clip art of car crashed into tree with red slash/circle superimposed; haggard-looking mortician to side	Give us TREE FREE STREETS
PSAs/Mailers/ Fact Sheets	All groups	Various accidents involving roadside trees, visual aid for clear zone concept, and pie chart detailing causes of single-vehicle collisions	"Put trees further from the road so I can stop putting up gravestones."
			Improperly maintained trees can kill motorists and destroy property
			More than 330,000 tree and utility pole crashes nationwide each year, averaging 6,700 crashes per state.
			Right Tree, Right Place, Right Decision
			Roadside **R**ecovery **R**oom saves lives
			Streets with trees planted outside the clear zone remain *aesthetic, livable,* and most importantly, **safe**.
		Images of parent carrying child on shoulder, crying on shoulder, and lifting/moving team. Follow-up with roadside shoulder and tree (being cut down, marked to remove, etc.) - Specific message for parents	You've been the shoulder they've sat on, the shoulder they cried on, and the shoulder to help them carry their burdens. Now protect them with a safer roadside shoulder too.
		Road and roadside with trees, and a hospital room in relief	Give them room to recover, or they'll need a recovery room.
		Appearance like a movie flyer. Movie poster is similar to Texas Chainsaw Massacre. Should contain information and contacts for state DOTs, local agencies, etc.	Coming to a road near you: Texas (*fill in with correct state*) Chainsaw Redemption, here to clear your roadsides and save your lives.

Table 39. Examples of Marketing Approaches and Relevant Target Audiences (Continued)

Methods	Audience	Example Descriptions	Example Themes and Slogans
Meetings, presentations, round table events, town halls	Vulnerable Road Users, Governors, State Legislatures, Local Authorities, Environmental Groups	Text: slogan and banner reading "Plant a tree this Arbor Day where it can't be hit by cars. You can help keep drivers and trees safe by planting no less than 10 feet from the road." Pictured: rural road with acceptable clear zone; "Tree City USA" logo	Trees need room to **grow**. Cars need room to **slow**.
Campus Posters	Youth	Image of street lined with trees but spaced far from road	Trees and streets can live in peace, man. They just need a little personal space.
Sports Events or Ads in Movie Theaters	General Public, Parents	Example of banner ad/PSA at basketball game	Move it (the tree) or die!
			Move a tree, save a child!
			Move a tree, save a life!
Gas Station Ads (GP)	General Public, Parents, Youth, Seniors, Vulnerable Road Users	Ads may be placed on pumps, on small stands above the pumps, as scrolling ads at TVs, etc.	Trees and cars don't mix. Give a little shoulder room for recovery.

8.2 Examples of Marketing Products

Several design concepts in Table 39 were created for visualization purposes. Examples are shown in Figures 54 through Figure 56. A complete set of marketing examples created for illustration purposes is shown in Appendix A.

Figure 53. Example of Billboard

Figure 54. Example of Postcard, Mailer, or Online Ad

Figure 55. Example of Bus Advertisement

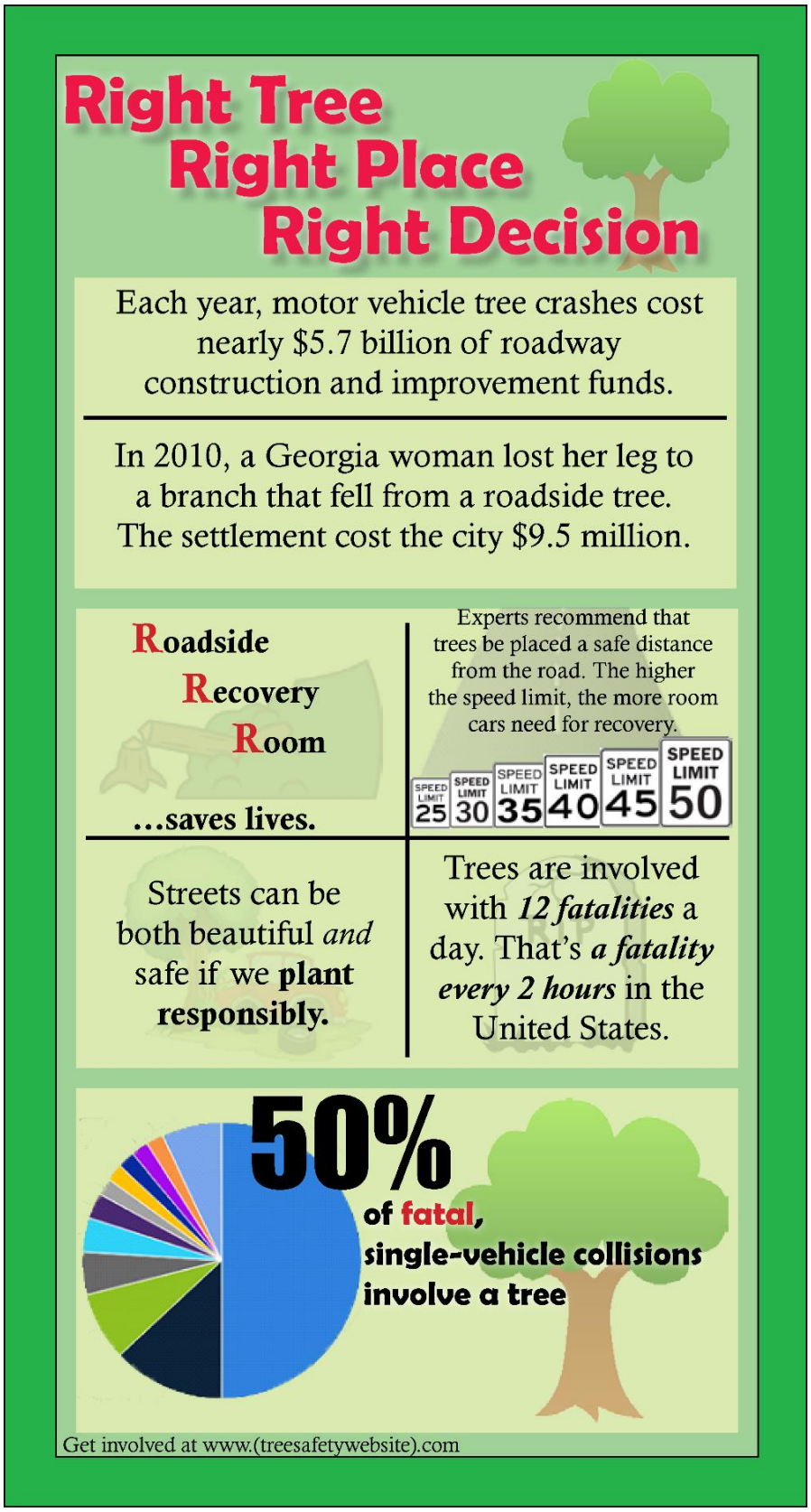


Figure 56. Example of Mailer, Campus Flyer, or PSA at Meeting with Local Authorities

8.3 Discussion and Recommendations

It is important to note that marketing is best conducted at a very personal level. As noted in Chapter 7, broad marketing campaigns may have a limited return, whereas marketing techniques with personal appeal or which relate to people individually have greater effectiveness. Thus, researchers developed a series of recommendations to assist with selecting the best messages for use with marketing and advertising campaigns.

- Localize the problem. National statistics may be impressive and effective, but tree removal in a local area should have a local message too. Consider the audience and who will be affected per tree removal effort and craft a message for them.
- Identify the "competition." It is helpful to know who could (or will) oppose a roadside tree removal effort, and if possible, collaborate with each individual or group before advancing a public plan.
- Focus on the positives. Although roadside trees may be inherently dangerous, risk alone is insufficient to convince skeptics that roadside tree removal is necessary. It should be noted that smoking (both marijuana and tobacco) are widely known to be hazardous to health, but people continue to smoke in perpetuity. By maintaining a focus on how individuals, the general public, or special interest groups will benefit from roadside tree removal (e.g., reduced tax expenditures, improved transportation mobility, etc.), the messages will be better received.
- Compromise. Removing roadside trees does not need to be heavy handed. If possible, arrange a compromise with disaffected parties to alleviate concerns. (Excellent examples of DOTs working with groups which may otherwise be opposed include ODOT with Hazard Trees for Fish Habitats program; NCDOT with the CZIP concept; and MnDOT mulching roadside trees for use as environmentally-friendly, erosion-control features.)
- Take advantage of opportunities. Road resurfacing, shoulder repairs, utility maintenance, and other projects may affect trees. Limited marketing is required if it can be shown that roadside tree removal is important or necessary to complete maintenance or service work.

9 SUMMARY AND CONCLUSIONS

The Midwest Pooled Fund Program funded a research study to evaluate best practices for developing the foundations for successful safety marketing campaigns to address roadside trees. The research study consisted of five distinct phases:

- Literature Review
- Evaluation of State DOT Tree & Vegetation Maintenance Plans and State Survey
- Crash Data Collection, Analysis, and Crash Cost Estimation
- Initial Developments Supporting Marketing Campaigns
- Summary Research Report

The literature review consisted of several distinct topics: crash data evaluation and analysis; review of state DOT standards and operations; crash cost data; litigation summary and analysis; and safety and general marketing research and analysis. For analysis purposes, utility pole crashes were separated from tree crashes when possible, but during crash data analysis, trees and utility poles were jointly considered due to intrinsic similarities, such as rigidity and proximity to the roadway.

It was observed that crashes involving trees have dominated ROR fatal crash data since records were first kept in the late 1970s with the adoption of FARS. The IIHS and HLDI annual tabulation for severe run-off-road crashes have ranked trees as the most common and severe roadside fixed object every year data was available. Moreover, research by Mak [23] suggests that tree crashes may cost billions of dollars annually in crash costs. Those costs are both direct (e.g., expenses related to emergency response, investigation, medical expenses, and cleanup) as well as indirect (e.g., loss of tax revenue, loss of productivity from workers delayed due to road and/or lane closure, grief and affected time for families and friends of loved ones, and damage to recoverable and taxable property).

Annual average costs for state DOTs was estimated at approximately $1 billion, per state, for a total annual nationwide tree and utility pole crash cost of between $45 and $55 billion.

Crash data analysis revealed that tree and utility pole crashes numbered over 400,000 in twelve surveyed states covering a five-year period and resulting in an estimated 6,700 tree and utility pole crashes per state, per year. Non-fatal and non-incapacitating injury crashes with trees were most common between 6 a.m. and 6 p.m., whereas severe crashes (involving at least one fatal or incapacitating injury) peaked during the afternoon drive home, from approximately 4 p.m. to 6 p.m., as well as in the late night hours between 9 p.m. and 3 a.m. Crashes involving light trucks (pickups, vans, and SUVs) were slightly less severe, on average, than passenger cars. Crashes involving motorcyclists were very severe on average, ranging between low and high severe crash percentages of 25% and 58%. Crashes located adjacent to roadway curves were significantly more severe on average than crashes adjacent to roadway tangents, and although the grade of the roadway (including sag and crest profiles) affected crash severities and frequencies, the effect of grade was believed to be much less significant overall than the effect of road curvature. Annual average costs for state DOTs was estimated at approximately $1 billion, per state, for a total annual nationwide tree and utility pole crash cost of between $45 and $55 billion.

Litigation involving trees revealed that, over time, courts have considered governmental agencies increasingly liable for tree-related hazards to road users. Courts have deemed the following situations to constitute a road defect or negligence on behalf of the government agency:

- Damaged or decayed limbs, trunks, or entire trees which fall onto the road or road user (e.g., vehicle), so long as actual or constructive notice of the damaged tree or limb is provided, or a sufficient time has passed in which the agency was expected to observe and remedy the decayed condition;
- Obstructed visibility at intersections due to tree growth;
- Partial or completely obstructed view of critical traffic safety infrastructure, including signs (e.g., STOP signs); and
- Significantly damaged or perturbed infrastructure (roads and sidewalks) such that traversing the roads or sidewalks could incur vehicle damage, personal injury, or loss of control, so long as constructive notice is provided or that the condition has existed for a sufficient amount of time that the responsible agency should have been aware of the issue and had sufficient time to remedy the infrastructure damage.

Moreover, courts have routinely ruled that government agencies are liable for trees located beyond the right-of-way if the trees obstruct, interfere, or injure users within the right-of-way (e.g., hanging branches obscure roadside signs, or tree limbs from trees on adjacent private property fall onto moving vehicles). Despite safety guidance discouraging roadside fixed objects such as trees, government agencies have not typically been found liable merely for the presence of roadside trees, including those which are in close proximity to the roadway and which are unshielded. Courts have deemed that government agencies have the right to determine what artifacts and constructions can exist on the roadsides. In addition, damage to trees deemed the result of storms or which would not normally be identified in the course of reasonable maintenance and inspection procedures, which culminate in limbs or trees falling on or in front of vehicles, have not typically been considered a fault, defect, or liability of the state.

However, it is uncertain if the current litany of actionable claims against government agencies would persist in congress with historical precedent. Most of the historical claims involving trees, including the hazard associated with trees in close proximity to the roadway, were filed prior to the broad acceptance of AASHTO's *Roadside Design Guide*, which is currently in its 4th edition. Moreover, safety initiatives, such as the World Health Organization's *Decade of Action* program, specifically targeted common roadside safety problems, including roadside trees, as a focus for reducing traffic deaths. Over time, safety practices have improved, and it is no longer considered an unbearable financial burden for government agencies to address roadside hazards. Current and past litigation has sustained a government agency's right to place trees adjacent to the roadway, but a single lawsuit in which this historical precedent is overturned could result in an economically overwhelming progression of wrongful death and negligence lawsuits.

Lastly, initial developments were recommended in support of an eventual roadside tree removal or safety treatment campaign. The content of the marketing campaigns, approaches, target audiences, and methods were based on a literature review of previous successful marketing campaigns, with an emphasis on safety-related campaigns. Researchers developed ideas and examples of marketing applications. It is anticipated that future research studies could use those ideas as the initial platform to create and complete the framework for successful roadside tree safety marketing campaigns.

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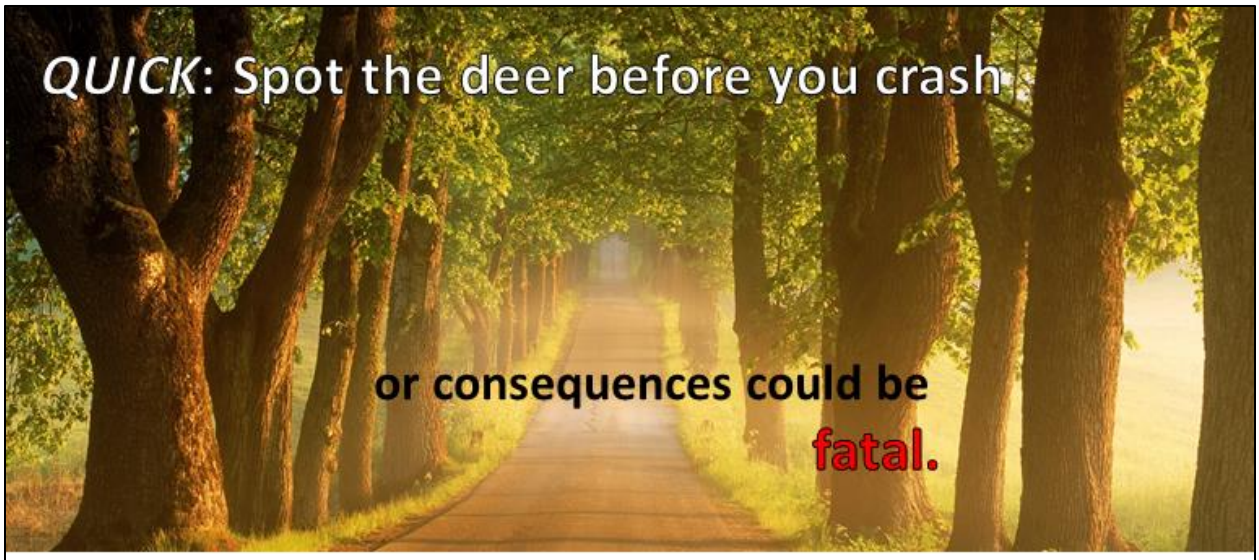
APPENDICES

Appendix A. Marketing Examples Drafted by MwRSF Researchers

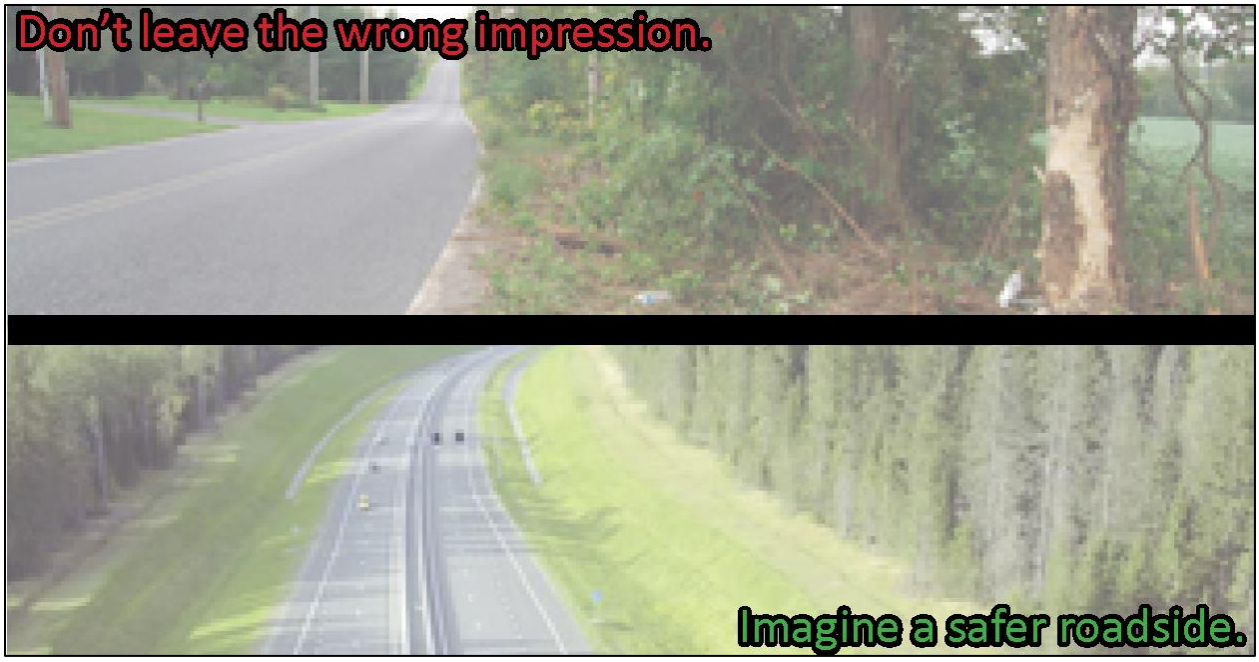
Note: All websites and phone numbers in the following marketing drafts serve as placeholders for official contact information.

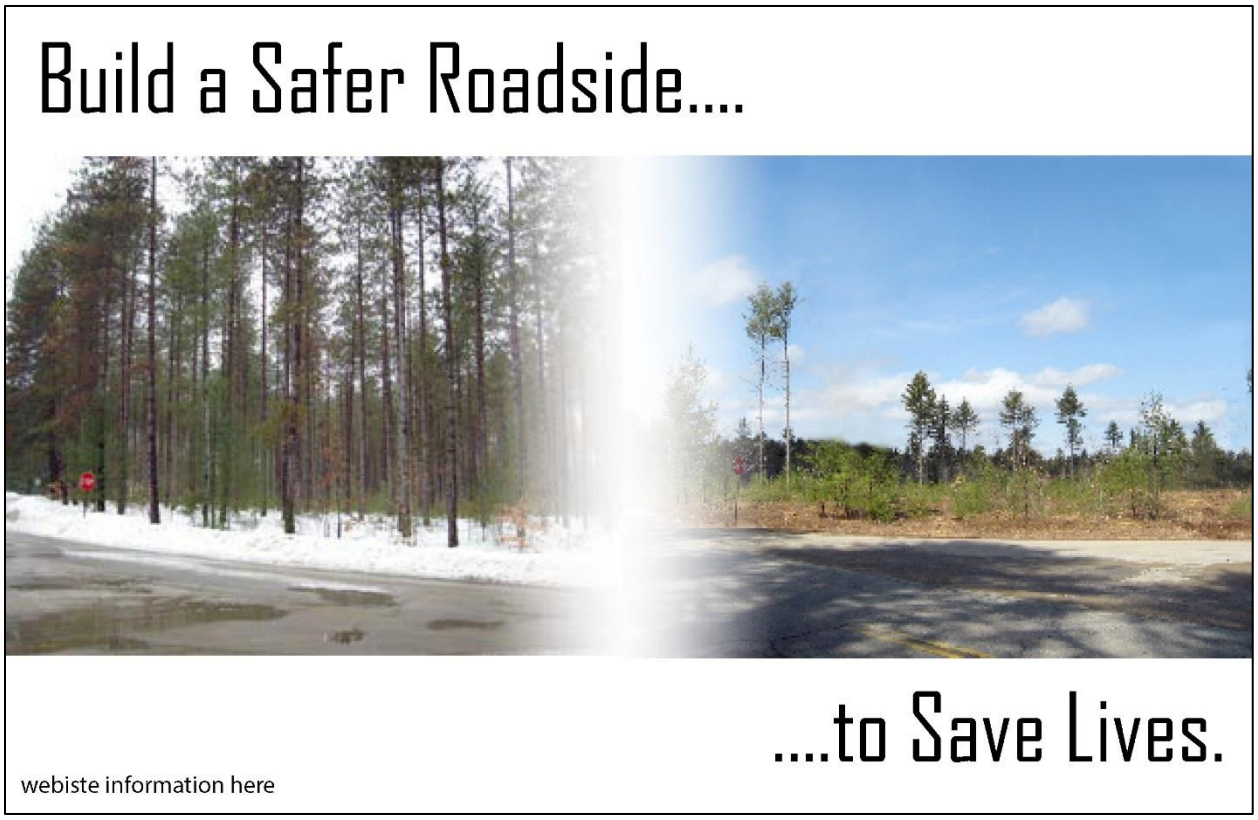
Billboards:



Trees hide animals and people from cars. Hitting them could have disastrous consequence; swerving and hitting a tree could be worse. Demand more space between trees and the road. Visit asaferroadside.com

Billboards:

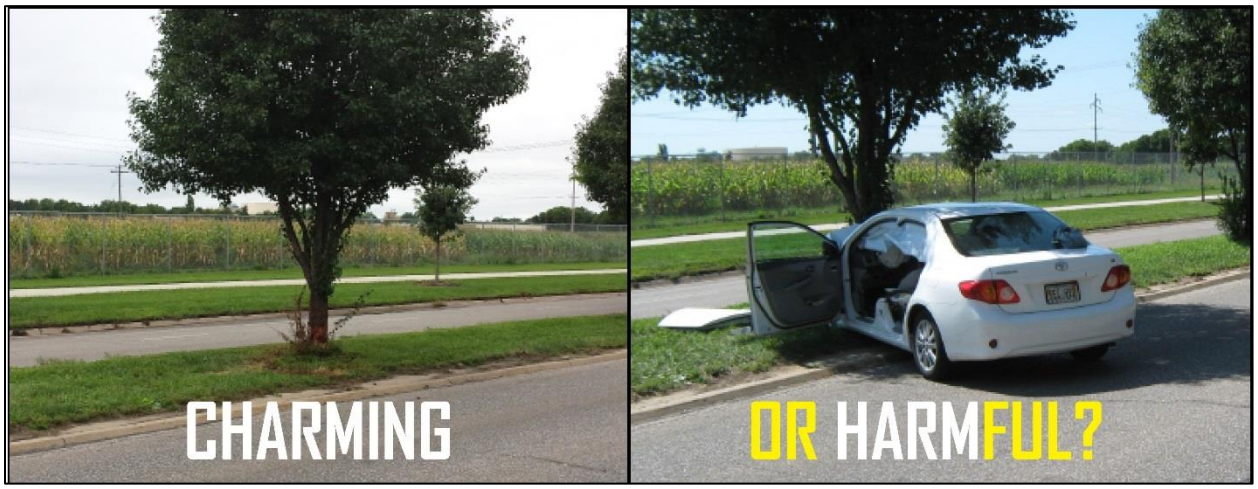

Don't leave the wrong impression.
Imagine a safer roadside.


Build a Safer Roadside....
....to Save Lives.
webiste information here

Billboard:

Bus Advertisement:

Bus Stop Advertisements (includes Lenticular Printing):



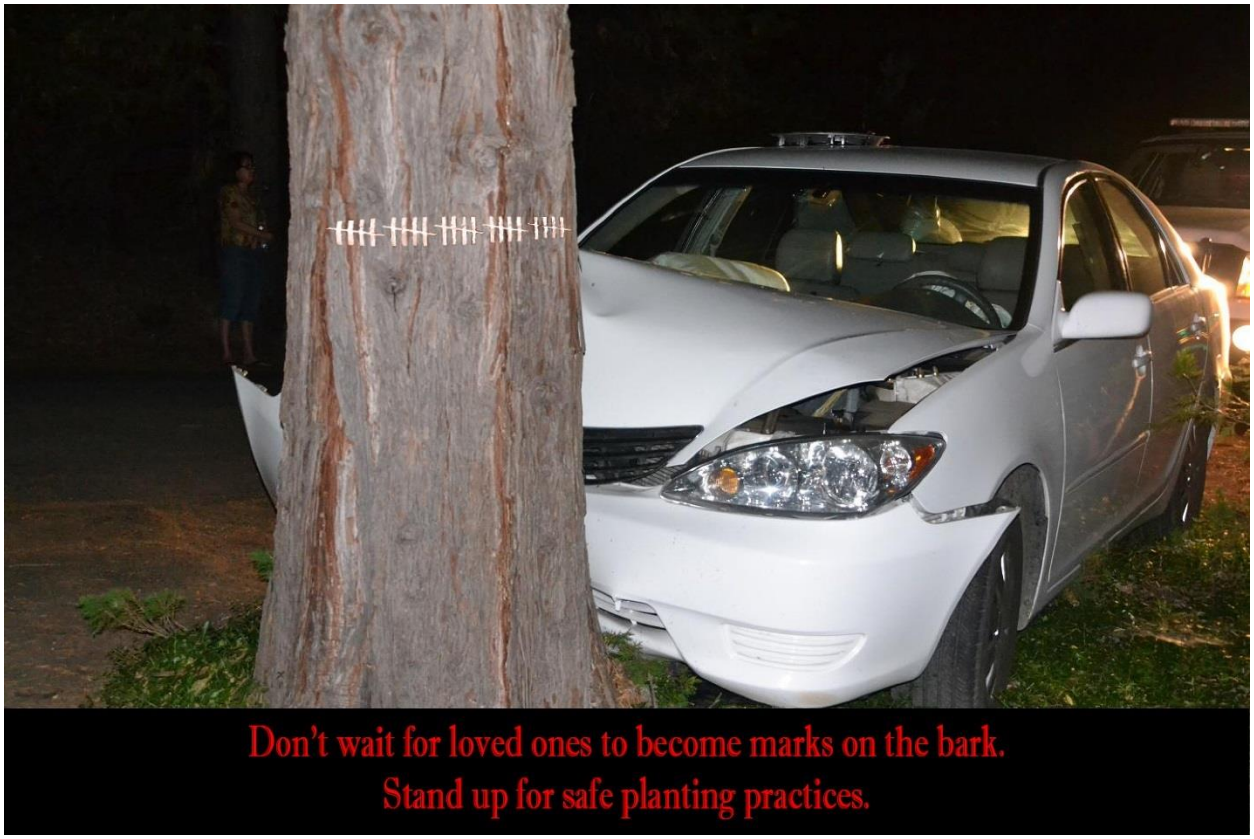
Bus Stop Advertisements:

Magazine, Online, or Movie Theater Ads:

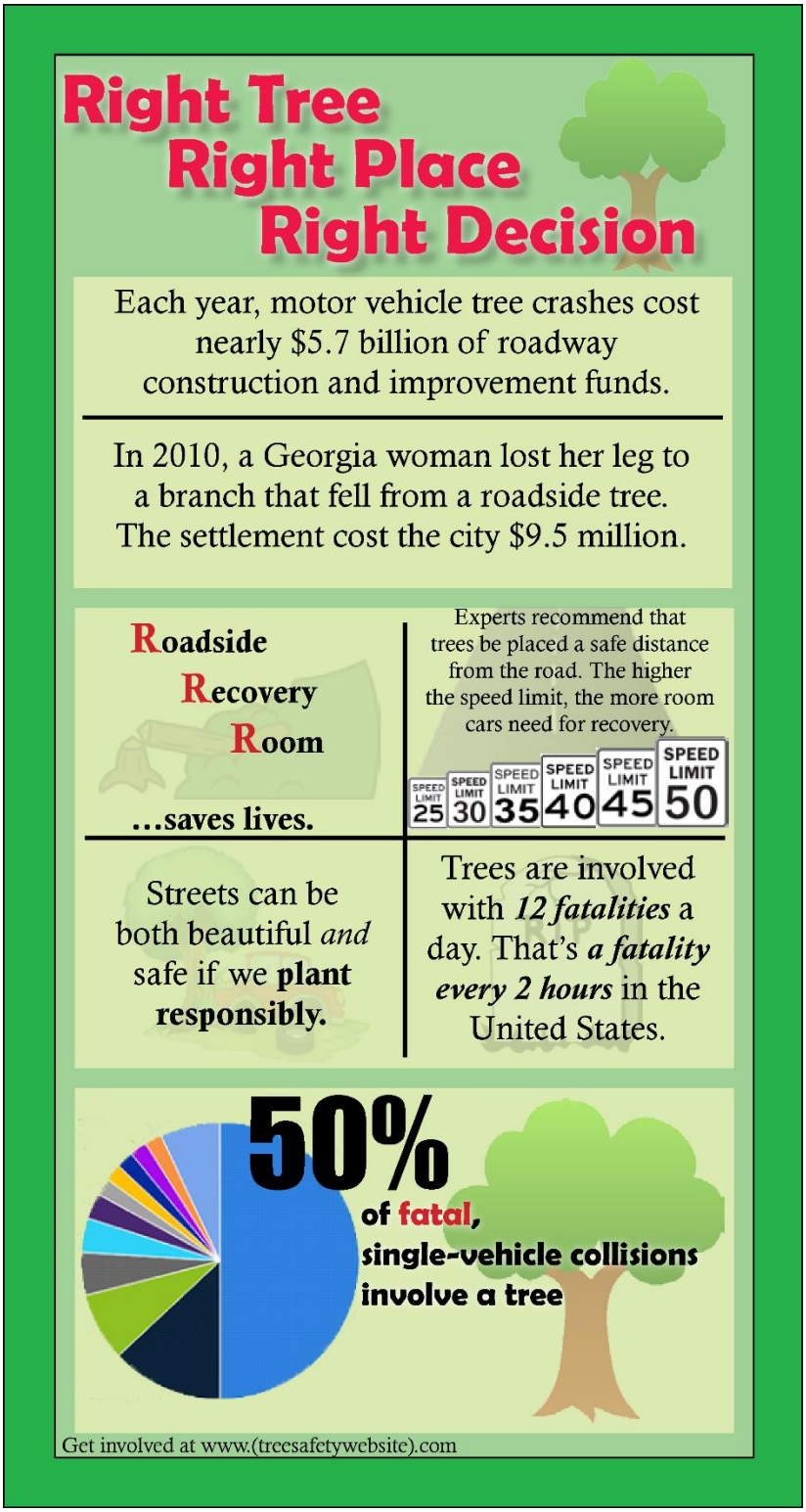
Magazine, Online, or Movie Theater Ads:

Magazine, Online, or Movie Theater Ads:

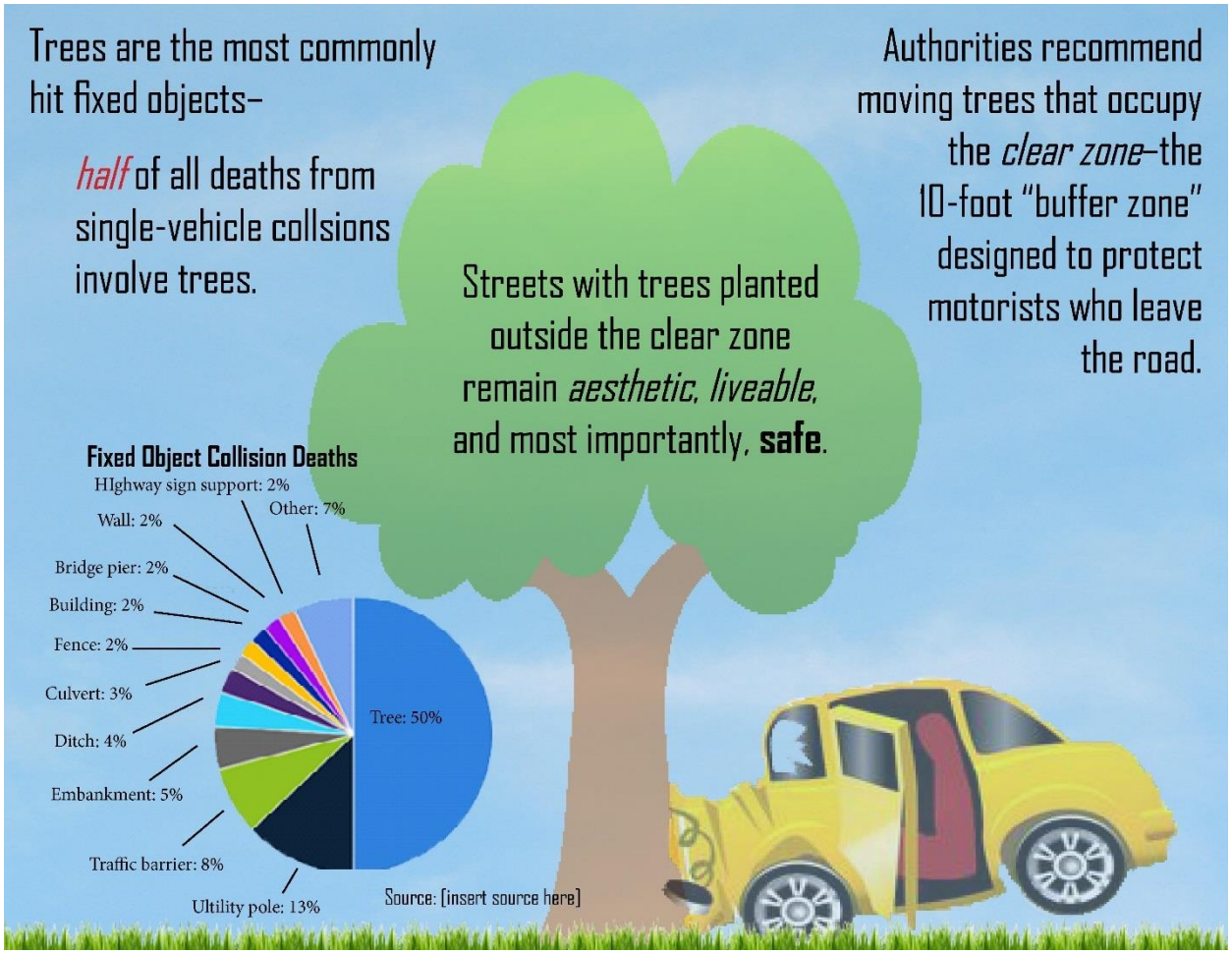
Magazine, Online, or Movie Theater Ads:



Flyers, PSAs, Handouts, and Pamphlets (e.g., for meetings with Local Authorities, Governors, State Legislators, etc.):



Flyers, PSAs, Handouts, and Pamphlets (e.g., for meetings with Local Authorities, Governors, State Legislators, etc.):



Flyers, PSAs, Handouts, and Pamphlets (e.g., for meetings with Local Authorities, Governors, State Legislators, etc.):

Appendix B. Further Reading

The following resources are recommended for further reading:

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