<https://depts.washington.edu/hhwb/Thm_SafeStreets.html?fbclid=IwAR2j444PSDnrOjKb0nWsWndA99R0JelCPbwtXrvakdBveWEB-xGRmHDt3vs>

**Trees and Safety Studies**

What do we know about trees, crashes, and safety on urban streets? Only a few, and recent studies have investigated the effects of trees in urban transportation settings. Clear zones and other forgiving design practices have a less-than-clear relationship to safety in urban environments. There is a slowly growing body of evidence suggesting that the inclusion of trees and other streetscape features in the roadside environment may actually reduce crashes and injuries on urban roadways. Here is an overview of recent research.

**Natiowide Analysis**

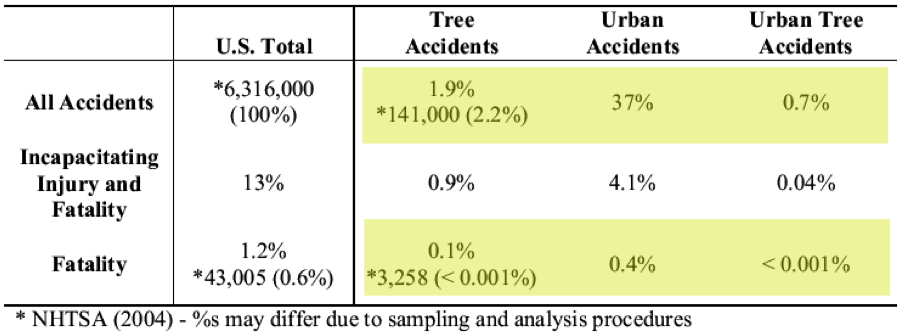
National accident data was analyzed in a typical year to better understand the circumstances of tree crashes and to explore the difference between urban and rural accident factors.22 The work was limited by the fact that little data about roadside vegetation is collected in national standardized crash reports (only 2 out of 91 report fields). This data gap is unfortunate as the national database is analyzed extensively by the transportation industry to inform national infrastructure policy and upgrade roadway design guidelines.

Traffic fatalities are currently the sixth leading cause of preventable death in the U.S.23 In 2006, a representative year, there were more than 38,600 fatal traffic crashes in the United States, resulting in the deaths of almost 43,000 people. Of these, 45% of all fatal accidents occurred in urban environments and 55% occurred on rural roads.

Trees are fixed objects, and crash outcomes involving them can be more severe, leading to serious injury and fatality. In 1999, 8% of all fatal crashes involved trees, and 23% of those occurred on urban streets. Fatal tree crashes were most prevalent on local rural roads, followed by major rural collectors.

Relative risk should be considered, across all U.S. miles traveled. There is, in fact, an inverse relationship between driving volume and accident trends. Most driver mileage is accumulated in urban settings while most accidents occur in rural settings. Drivers in the U.S. do 62% (about 1.6 trillions miles) of their driving in urban areas, but this driving accounts for only 37% of all accidents. Rural driving accounts for 38% of all miles driven but produces 63% of all accidents. Across approximately 233 billion vehicle trips taken in the United States in 2002, trees were involved in 1.9 percent of all crashes,24 and most of the crashes (61%) occurred in rural areas.

Table 1 presents information on the relative risk of a tree crash on urban streets. Far less than 1% of U.S. annual motorized vehicle crashes involve a tree on an urban street.24 Crash and fatality counts are important to recognize as any loss of life is tragic. Yet response strategies should address high-risk roadside conditions, rather than making sweeping generalizations. National safety recommendations indicate that rural two-lane roads should receive much of the focus in the development of programs to reduce tree-related driver fatalities.25

Table 1: National crash statistics involving trees.24

Driver choices and behavior have great influence over 1) the vehicle leaving the road, and 2) the outcome of any crash that may occur.26 Drunken driving is a factor in up to half of all traffic fatalities. Many crashes occur on weekends and during late evening hours, and often involve excessive speeds. Drivers traveling in excess of posted speeds are involved in about 30% of all traffic fatalities. Meanwhile, seat belt use reduces a driver’s risk of death in a crash by 42%.

**Local Sites and Studies**

Analyzing national data provides a coarse grain overview of accident risks and trends. Several studies have analyzed crash outcomes based on specific street and road conditions.

A study in Florida compared accident rates on a section of road having landscaping and other livability improvements with those on nearly identical roads that did not have streetscape enhancements.27 Crash reports were compared for 5 years in a matched comparison of street segments.

Conventional street safety guidelines maintain that increased numbers of objects in the roadside and constrained rights-of-way will increase accident rates. Yet, a road segment with landscape improvements appeared to be safer than a road segment having broader clear zones: for mid-block crashes (11% fewer), injuries (31% fewer), and fatalities (none versus 6). Pedestrian and bicyclist injuries were likewise fewer in the improved road sections. The investigator reported, “by any meaningful safety benchmark . . . . there can be little doubt that the livable section is the safer roadway.”

A related study focused on urban arterial roadways within small metropolitan areas.28 Precise measurements for widths of the roadway lane, median, shoulder, and unpaved fixed-object offset were compared across 5 years of crash data. Having wider paved shoulders increased crash rates, while wider fixed-object offsets had a mixed safety effect. The presence of a livable street treatment (a blend of pavings, outdoor furniture, trees and traffic calming devices) was associated with 67% fewer roadside crashes, 40% fewer midblock crashes, and 28% fewer reported injuries.

Looking more closely at the study results, it was found that 83% of tree and utility-pole crashes and 65% of the total crashes were located at the back edge of driveways and intersections.28 The majority of urban tree- and pole-related roadside crashes occurred when a driver attempted to negotiate a turn from the arterial roadway onto an intersecting driveway or side street (Figure 2). The crashes appear to be attributable to a combination of two factors: an arterial roadway designed to accommodate high operating speeds, and the presence of driveways and lower-speed side streets intersecting the arterial. Thus, tree crashes may not be due to random error, as currently assumed, but may be the consequence of designing roads for higher traffic speeds and situations that exceed some drivers’ capacity for vehicle control.

Figure 2: Crash locations: high speeds reduce turn control.28

**Traffic Calming?**

Other field studies have demonstrated a variety of changed behaviors and positive impacts on traffic and community safety in response to landscape enhancements.

In Germany, nine streetscape installations were assessed for relative affects on driving safety.29 In one case, a landscaped center strip with narrower traffic lanes was found to be effective in calming traffic and increasing traffic safety. After being built, overall accidents were reduced by 30%, the number of accidents with injuries was cut by about 60%, and accidents involving street-crossing pedestrians were reduced by about 80%. Streets having a landscaped center strip or median planting may alter drivers’ perception of lane width and therefore reduce driving speeds by way of a psychological effect.

Another study supports the perceptual effects of street-side trees.30 Using driving simulators, study participants took drives along digitally created streets: two urban and two suburban. For both urban and suburban settings one simulation contained streetscape trees and one simulation contained none. Drivers were asked to rate the roads for safety.

Both city form (urban vs. suburban) and landscaping form (presence or absence of street trees) along the roadway affected the participants’ perceptions of safety. The presence of trees had the stronger affect on safety perceptions. Suburban streets with trees were perceived as the safest, followed by urban streets with trees and then suburban streets without trees, and urban streets without trees were judged to be the least safe. Driving speed was also recorded. A significant drop in cruising speed (an average decrease of about 3 miles per hour) was detected for most drivers when trees were present on the suburban street (adequate data collection was not possible for the urban setting). An “edge effect” created by the presence of trees contributed to a sense of safety.

While not the central question of the studies, trees do seem to be associated with traffic calming. The link between reduced speeds and reduced accident rates is well-established. When an accident happens, there is greater likelihood of injury or fatality with higher speed - particularly if vehicle speeds are too fast for prevailing conditions.31

**Trees Reduce Crashes?**

Perceptual response may explain the findings of other studies that focused on crash incidence. Run-off-roadway crashes were examined to determine whether crash frequencies were associated with the characteristics of the roadside.32 Analysis along segments of a single arterial roadway in Washington State indicated that, in rural areas, trees and other roadside features were associated with an increase in the number of roadside crashes. Results in urban areas were radically different. Not only were trees not associated with crash increases, but the presence of trees was associated with a decrease in the probability that a run-off-roadway crash would occur. Generally, wide traffic lanes and wide shoulders were positively associated with a greater frequency of run-off-roadway accidents.

Another study compared accidents before and after placement of landscape improvements on five arterial roadways in downtown Toronto, Canada.33 Based on 3-year pre- and post-treatment analysis, features such as trees and planters in the urban roadside (and within the clear zone) resulted in reduced numbers of mid-block crashes on all test roads. The numbers of crashes decreased 5% to 20% on studied roads, while mid-block crashes generally increased throughout the city. Did trees “cause” the reductions? The study couldn’t confirm that interpretation, but the presence of a well-defined road edge may cause drivers to be more attentive and cautious.

A study of Texas urban roads compared accident records before and after planting over 3-to-5 year time spans.34 Analysis showed a 46% decrease in crash rates across the 10 urban arterial and highway sites after landscape improvements were installed. The number of collisions with trees were reduced by 71%. All types of roadside treatments - roadside landscaping, median landscaping, and sidewalk widening with tree planting - positively affected vehicle safety outcomes. A marked decrease in the number of pedestrian fatalities was also noted – from 18 to 2 after landscape improvements, though the number of pedestrian incidents increased overall near median plantings.35 There are limitations to an after-the-fact study, yet results suggest that landscape may be an integral part of the safety management of urban roads. The science team noted that “the landscape not only contributes to greater aesthetic compatibility between the urban environment and the highway but may contribute to a safer street.”

Not all studies demonstrate the positive effect of trees in urban street safety, but, at the very least, they indicate that a blanket policy of tree exclusion on city streets is not necessarily warranted. A California study examined safety outcomes in the presence of large trees in curbed medians of conventional highways that are also principal streets in developed urban and suburban areas.36 The study modeled collision frequency and severity with highway and traffic characteristics, with and without median trees (analyzing 14,283 collisions occurring on 58 miles of state highways over 6 years). It was found that large trees in medians are associated with more collisions and increased severity, but that some associations were statistically weak. There was also decreased frequency of head-on and broadside collisions. Lower speeds and larger side clearances were not found to mitigate the increased collision impacts associated with median trees.

**Other Road Elements**

Other urban road features have been studied. A safety study concluded that “boulevards cannot be shown to be less safe than comparable normal streets” within selected study cities in the U.S. and Europe.37 While considering traffic volumes, accident rates on major urban tree-lined boulevards were reduced by up to 61% when compared to similar urban control sections without trees. Nonetheless, a Washington D.C. boulevard was found to have an equal to greater accident rate compared to multi-lane streets. While data were not as complete for similar European cities, it was found that boulevard accident rates were comparable or lower than those of control streets, and that boulevards do not reduce the volume of through traffic (though Barcelona was one exception).

The role of intersection sight lines in accident rates has also been studied.38,39 Transportation manuals recommend designing for clear sight triangles at intersections, with vegetation removal hundreds of feet down each block. The purpose is to eliminate any object above sidewalk level that would interfere with a driver’s field of vision. This engineering policy has resulted in widely used limitations on street trees near intersections but little regulation of other possible obstructing elements.

One California study tested whether or not street trees near intersections are a safety problem. Computer modeling techniques were used to vary the locations of trees, parked cars, and newspaper racks, and four different video clips were tested in driving simulations. Participant reactions indicated when moving cars became visible, and the response data was analyzed. The researchers found that street trees—if properly selected, adequately spaced, and pruned for high branching—do not create a notable visibility problem. On-street parked cars, particularly large ones such as SUVs, create substantially more of a visibility problem, and newspaper racks near intersections diminish visibility, as they are at driver eye height. Street trees planted close to intersections, spaced as little as 25 feet apart, and pruned so that horizontal limbs and leafing start about 14 feet off the ground did not present a visibility safety hazard.

**Conclusions**

Recent research adds new perspectives on roadside vegetation and traffic safety. Road design and engineering standards (more accurately regarded as guidelines) favor a design philosophy of “forgiving” roadsides that provide wide shoulders and clear offsets. Most of the research basis for these prescriptions was done on rural roadways in past decades. Thus urban transportation design is largely premised on the operating assumptions and characteristics of rural roads and highways.

More recent urban driving studies use paired comparisons of the same roads, driving simulation response, pre- and post-treatment tests on corridor installations, and data review across collections of comparable road segments.3 Preliminary findings are that that there is a positive correlation between certain types of landscape treatments and reduction in crash rates. Trees and landscape in the roadside can have a positive affect on driver behavior and perception, resulting in better safety performance.34

Results suggest two important issues. The first is that trees in urban roadsides may be associated with reduced crash rates. Why? While not completely understood, the presence of street trees may provide an “edge effect” or psychological cue to drive more slowly. Fewer crash incidents, and less severe injury outcomes, are associated with slower vehicle speeds. Secondly not all road segments are alike; there are differences in crash rates at intersections, on the outside of curves, along medians, and midblock. Planning and design for livable cities should include roadside vegetation and trees that are placed appropriately, based on actual crash risk rather than generalized assumptions.

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**References**

1. Wolf, K.L. 2006. Roadside Urban Trees: Balancing Safety and Community Values. *Arborist News* 15, 6:56-58.

2. Federal Highway Administration. 2010. Context Sensitive Solutions/Thinking Beyond the Pavement. Accessed March 14, 2010: http://www.contextsensitivesolutions.org/content/topics/what\_is\_css/

3. Macdonald, E., R. Sanders, and P. Supawanich. 2008. *The Effects of Transportation Corridors’ Roadside Design Features on User Behavior and Safety, and Their Contributions to Health, Environmental Quality, and Community Economic Vitality: A Literature Review (Final Report)*. University of California Transportation Center, Berkeley, CA, 211 pp.

4. Kaplan, R. 1983. The Role of Nature in the Urban Context. In I. Altman, and J.F. Wohlwill (eds.), *Behavior and the Natural Environment*. Plenum, New York, 346 pp.

5. Schroeder, H.W. 1989. Environment, Behavior and Design Research on Urban Forests. In E.H. Zube, and G.T. Moore (eds.), *Advances in Environment, Behavior and Design, Vol. 2* (pp 87–117). Plenum, New York.

6. Wolf, K.L. 2003. Freeway Roadside Management: The Urban Forest Beyond the White Line. *Journal of Arboriculture* 29, 3:127-136.

7. Wolf, K.L. 2005. Business District Streetscapes, Trees and Consumer Response. *Journal of Forestry* 103, 8:396-400.

8. Wolf, K.L. 2008. Community Context and Strip Mall Retail: Public Response to the Roadside Landscape. *Transportation Research Record* 2060:95-103.

9. Ulrich, R.S. 1974. *Scenery and the Shopping Trip: The Roadside Environment as a Factor in Route Choice*. Unpublished doctoral dissertation, University of Michigan, Ann Arbor, MI.

10. Novaco, R.W., D. Stokols, and L. Milanesi. 1990. Objective and Subjective Dimensions of Travel Impedance as Determinants of Commuting Stress. *American Journal of Community Psychology* 18:231–257.

11. Ulrich, R.S., R.F. Simons, B.D. Losito, E. Fiorito, M.A. Miles, and M. Zelson. 1991. Stress Recovery During Exposure to Natural and Urban Environments.*Journal of Environmental Psychology* 11:201–230.

12. Kaplan, S. 1995. The Restorative Benefits of Nature: Toward an Integrative Framework. *Journal of Environmental Psychology* 15:169– 182.

13. Knopf, R. C. 1987. Human Behavior, Cognition, and Affect in the Natural Environment. In D. Stokols and I. Altman (eds.), *Handbook of Environmental Psychology, Vol. 1* (pp. 783-825). Wiley, New York.

14. Hull, R. B. 1992. Brief Encounters with Urban Forests Produce Moods That Matter. *Journal of Arboriculture* 18:322-325.

15. Parsons, R., L.G. Tassinary, R.S. Ulrich, M.R. Hebl, and M. Grossman-Alexander. 1998. The View From the Road: Implications for Stress Recovery and Immunization. *Journal of Environmental Psychology* 18, 2:113–140.

16. Gulian, E., G. Matthews, A.I. Glendon, D.R. Davies, and L.M. Debney. 1989. Dimensions of Driver Stress. *Ergonomics* 32:585-602.

17. Cackowski, J.M., and J.L. Nasar. 2003. Restorative Effects of Roadside Vegetation: Implications for Automobile Driver Anger and Frustration. *Environment and Behavior* 35:736-751.

18. AASHTO (American Association of State Highway and Transportation Officials). 2004. *A Policy on Geometric Design of Highways and Streets, 5th Edition*. AASHTO, Washington, DC, 872 pp.

19. AASHTO (American Association of State Highway and Transportation Officials). 2002. *Roadside Design Guide, 3rd Edition*. AASHTO, Washington, DC, 344 pp.

20. McGinnis, R. 2001. *Strategic Plan for Improving Roadside Safety*. National Cooperative Highway Research Program (NCHRP) Web Document 33 (NCHRP Project G17-13). Washington, DC.

21. Otto, S. 2000. Environmentally Sensitive Design of Transportation Facilities. *Journal of Transportation Engineering* 126:363–366.

22. Wolf, K.L., and N.J. Bratton. 2006. Urban Trees and Traffic Safety: Considering U.S. Roadside Policy and Crash Data. *Arboriculture and Urban Forestry* 32, 4:170-179.

23. Mokdad, A.H., J.S. Marks, D.F. Stroup, and J.L. Gerberding. 2004. Actual Causes of Death in the United States, 2000. *Journal of the American Medical Association* 291, 10:1238–1245.

24. Bratton, N.J., and K.L. Wolf. 2005. Trees and Roadside Safety in U.S. Urban Settings, Paper 05-0946. *Proceedings of the 84th Annual Meeting of the Transportation Research Board*. Transportation Research Board of the National Academies of Science, Washington DC.

25. Neuman, T.R., R. Pfefer, K.L. Black, K. Lacy, and C. Zegeer. 2003. *Guidance for the Implementation of the AASHTO Strategic Highway Safety Plan: Volume 3: A Guide for Addressing Collisions with Trees and Hazardous Locations*. NCHRP Report 500. National Cooperative Highway Research Program, Washington DC, 73 pp.

26. Evans, L. 2002. Traffic Crashes: Measures to Make Traffic Safer Are Most Effective When They Weigh the Relative Importance of Factors Such as Automotive Engineering and Driver Behavior. *American Scientist* 90:244–253.

27. Dumbaugh, E. 2005. Safe Streets, Livable Streets.*Journal of the American Planning Association* 71, 3:283-300.

28. Dumbaugh, E. 2006. Design of Safe Urban Roadsides: An Empirical Analysis. *Transportation Research Record* 1961:62-74.

29. Topp, H.H. 1990. Traffic Safety, Usability and Streetscape Effects of New Design Principles for Major Urban Roads. *Transportation* 16:297-310.

30. Naderi, J.R., B.S. Kweon, and P. Meghalel. 2008. The Street Tree Effect and Driver Safety. *ITE (Institute of Transportation Engineers) Journal* 78, 2:69-73.

31. Ewing, R. and S. Brown. 2009. *U.S. Traffic Calming Manual*. APA Planners Press and American Society of Civil Engineers, Washington DC, 256 pp.

32. Lee, J., and F. Mannering. 1999 (December). *Analysis of Roadside Accident Frequency and Severity and Roadside Safety Management*. Washington State Department of Transportation, Olympia, WA, 137 pp.

33. Naderi, J.R. 2003. Landscape Design in the Clear Zone: Effect of Landscape Variables on Pedestrian Health and Driver Safety. *Transportation Research Record* 1851:119-130.

34. Mok, J.-H., H.C. Landphair, and J.R. Naderi. 2006. Landscape Improvement Impacts on Roadside Safety in Texas. *Landscape and Urban Planning* 78:263-274.

35. Mok, J.-H., H.C. Landphair, and J.R. Naderi. 2003. Comparison of Safety Performance of Urban Streets Before and After Landscape Improvements. *Proceedings of the 2nd Urban Street Symposium (Anaheim, California)*. Transportation Research Board, Washington DC.

36. Sullivan, E.C., and J.C. Daly. 2005. Investigation of Median Trees and Collisions on Urban and Suburban Conventional Highways in California. *Transportation Research Record* 1908: 114-120.

37. Jacobs, A., Y. Rofe, and E. Macdonald. 1994. *Boulevards: A Study of Safety, Behavior and Usefulness, Working Paper 625*. University of California, Institute of Urban and Regional Development, Berkeley, CA, 128 pp.

38. Macdonald, E, A. Harper, J. Williams, and J.A. Hayter. 2006. *Street Trees and Intersection Safety, IURD Working Paper 2006-11*. Institute of Urban and Regional Development, University of California, Berkeley, CA, 103 pp. Accessed October 2009: http://repositories.cdlib.org/iurd/wps/WP-2006-11.

39. Macdonald, E. 2008. The Intersection of Trees and Safety. *Landscape Architecture* 78, 2:54-63.