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The Urban Forest in the Roadside: Public Values and Transportation design

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ABSTRACT: Trees in the urban roadside present a safety risk. While the crash rate with trees as compared to all vehicular accidents in the United States is about two percent, tree related accidents have a higher injury and fatality rate. This article presents two perspectives on the urban trees and transportation safety situation. First, two studies are described that establish the positive values that the driving public has for roadside trees in cities. Forested roadsides are judged to be high in visual quality. Such aesthetic responses are indicative of deeper, more significant psychological responses by drivers. Roadside nature is associated with driving stress reduction, and trees contribute to positive place perceptions. The second purpose of this article is to offer solutions for improved safety in forested transportation corridors. “Clear zone” requirements in the U.S. may be in conflict with public values, and an emerging policy of Context Sensitive Solutions urges transportation design that acknowledges community context and values. Based on prior publications, transportation design standards are presented that can reduce tree crash risk yet maintain opportunities to conserve and plant trees in the roadside. In this way communities can enjoy the beauty and extensive benefits of the urban forest, while experiencing safer driving environments.

Key Words: urban forestry, social science, transportation, public values, roadside, transportation design

INTRODUCTION

Urban forestry is gaining wider acceptance in cities around the world. Yet there are some institutions and organizations that may present obstacles to implementing urban forestry goals and programs. In some locales there is a tension between community values that are positive for urban trees, and the design standards of transportation agencies that discourage or limit the presence of trees in the roadside.

In the U.S. about 80% of the population now lives in urbanized areas. Many people rely primarily on personal vehicles for daily transportation, and spend an increasing amount of daily time driving. The driver’s experience of the roadside is an important aspect of the urban lifestyle. In recognition of the positive functions and benefits of roadside trees, ever more citizens and community organizations are calling for expanding the urban forest in the roadside.

Countering such community interests is the fact that roadside trees pose a safety risk. In the U.S. single-vehicle collisions with trees account for nearly 25 percent of all fixed-object fatal accidents each year, resulting in deaths of approximately 3,000 people, and making up about 48 percent of fixed-object fatalities (FHWA 1997). It is important to note that higher crash rates and fatalities are associated with all roadside fixed objects, such as utility poles and guard rails.

How do urban forestry and transportation professionals balance community values and safety risks with regard to roadside trees? This paper offers information to improve the dialog about this issue. Two studies have been done to evaluate the extent of public values for roadside trees in the U.S. The research demonstrates that the presence of trees is interpreted as being more meaningful than mere aesthetics. In addition the paper provides an overview of roadside design standards for trees, derived from the literature review that was conducted for a trees and traffic safety study. This paper both demonstrates the importance of roadside trees, and offers solutions to safety risk using design approaches.

BACKGROUND

Trees, Safety and U. S. Roadside Policy

The crash effects of trees along high speed, rural roadways are indisputable. Roads in less populated areas that have restrictive geometric designs and narrow, off-road recovery areas, account for a large percentage of the annual tree-related fatal crashes, followed by state and numbered highways having curved alignments (AASHTO 2002). Existing trees often pose greater risk than trees that have been placed along new or reconstructed roads.

The American Association of State Highway Transportation Officials (AASHTO) is a national organization that periodically issues updated versions of The Policy on the Geometric Design of Highways and Streets (2004a), known as the “Green Book.” Geometric design refers to the design of the visible dimensions of a highway or road, to create a facility “form” that is consistent and meets functional and operational needs, including road location, alignment and intersections. Green Book guidelines provide uniform standards for highway and road design, providing safety and operational consistency for highways and roads throughout the United States.

Use of a “clear zone” is a primary strategy for reducing fixed object collisions. Clear zones are swaths of land of prescribed width adjacent to road edges that are clear of fixed objects that may damage a vehicle on impact. Adequate clear zone enables a driver to safely return to the roadway or bring the vehicle to a safe, controlled stop. Green Book standards for clear zones primarily address non-urban conditions. A tree with trunk size of more than 100 mm (4 inches) DBH is considered a fixed object. A 9.0 meter (30 feet) clear zone width is recommended for high speed, high volume roads, while a minimum clear zone of 3.0 meters (10 feet) is recommended for low speed rural roads.

Less distinct standards are provided for urban arterials, collectors and streets, as the space available for clear zones are typically restricted. Better research on urban roadside elements is needed, including trees (McGinnis 2001), particularly as standards have been “less rigorously derived” for urban settings (AASHTO 2004b).

While AASHTO promotes flexibility in application of the standards, engineers may take a conservative approach to maximize safety and capacity (Otto 2000). Design flexibility is needed to incorporate community concerns about the urban forest. A national movement within the U.S. transportation industry is Context Sensitive Solutions, and is an effort to incorporate local public values into roadway construction or expansion. An AASHTO guide to flexibility in highway design (2004b) notes that, "while clear zone dimensions are provided . . . , they should not be viewed as either absolute or precise. It is expected that . . . the design of the roadside is a site- or project- specific task for the designer . . . [and that] more than one solution may be evident or appropriate for a given set of conditions (p. 69)."

Public Response to Roadside Nature

A field of research, conducted by social scientists, reveals public values concerning nature in cities. Landscape assessment studies employ data collection techniques that explore stakeholders' responses to specified landscapes. Such studies show that trees and nature are associated with positive appraisals of urban places. Urban scenes containing trees (particularly large ones) are consistently highly preferred. Positive meanings and values are associated with the urban forest (Chenowith and Gobster 1990, Hull 1992). Natural amenities influence perceptions of urban place and function (Herzog 1989). Economics also come into play as both retail spending (Wolf in review) and commercial property rental rates (Laverne and Winston-Geideman) are boosted by the presence of a quality urban forest.

Landscape assessment has rarely been applied to the study of transportation landscapes. In one of the rare examples (Evans and Wood 1980) people judged simulations of proposed roadside residential along a highway development for scenic quality. "Cluttered" and "ugly" were terms drivers used to describe roadside development, while "pleasant" and "beautiful" were descriptions of highway corridors containing mostly vegetation.

Psychological theory suggests that other responses are associated with visual quality, such as affect, cognition and behavior (Kaplan and Kaplan 1989). For instance, roadside character can affect route choice. In one study people driving to a shopping center chose a scenic parkway route more often than a nonscenic expressway route, despite the parkway route having more stops and taking more time (Ulrich 1974). Drivers enjoyed views of nature and reported feelings of relaxation while on the parkway route.

Stress is a serious public health issue for urban dwellers. Commuting is one of the most stressful experiences of urban life. Stress response is documented for all driving experiences Increased blood pressure is associated with longer or more difficult commutes. Lowered job satisfaction, higher illness rates, absenteeism and lower performance on various cognitive tasks are all conditions found to be related to longer or more difficult commutes (Novaco et al. 1990).

Roadside landscape views can mitigate stress response. Based on prior studies of the restorative effects of nature views (Ulrich et al. 1991, Kaplan 1995), a science team pursued the effects of roadside character on stress response using physiological monitoring (Parsons et al. 1998). When presented in driving simulators, views of built-up, strip-mall style roadsides both slowed down and impeded driver recovery from introduced stressors. Subjects exposed to roadside nature scenes (forests or golf courses) returned to normal, baseline measures faster and had greater ability to cope with stressors. An "immunization effect" was discovered; exposure to a natural roadside setting decreased the magnitude of stress response to a later task.

Mean 4.52 (high), 0.76 SD

Mean 1.40 (low), 0.78 SD

FIGURE 1: Scenes of high and low preference.

PUBLIC VALUES RESEARCH

A limited set of prior studies suggests that views of roadside nature enhance conditions of both aesthetics and comfort for drivers. Two studies were conducted to explore these questions:

- How do the urban forest and other landscape elements contribute to the visual quality of the freeway roadside?
- How does roadside landscape affect place perceptions?

Survey was used for data collection in both studies, and each presented photographic images for respondent feedback. In each instance, base images were digitized and then edited with a computerized paint program to present varied landscape conditions for respondents to judge. Each survey was mailed to a random selection of licensed drivers within selected urban areas in the United States.

Results – Roadside Preference

The first survey was distributed to residents of residents of the metropolitan areas of Seattle, Minneapolis, Detroit, and Baltimore. The survey contained 36 images for preference rating (1=low, 5=high), made up of six ground-level images, each digitally edited to contain a six-point gradient of vegetation density. Several banks of verbal statements asked about various aspects of roadside management. A final page requested demographic information.

Three thousand surveys were mailed, followed by one round of reminder cards. There were 404 useable responses, and since 421 surveys were nondeliverable, the resulting response rate was 16 percent.

A full description of the methods and outcomes of this study were presented in an earlier publication (Wolf 2003); highlights are presented here. All 36 images were sorted by preference means. The high and low scenes are depicted in Figure 1. Generally, scenes depicting roadsides having no trees received low ratings. Higher scores are associated with increased density of trees (and resulting screening of adjacent commercial land uses). The public associates trees and reduced views of built settings with higher visual quality, as indicated by a three-point difference between high and low rated images.

Barren Edge
8 images
loadings .616 to .794
mean 1.56, 0.70 SD

Prominent Buildings
2 images
loadings .590 to.640
mean 1.66, 0.77 SD

Ornamental Frame
10 image
loadings .590 to .744
mean 2.71, 0.79 SD

Tree Buffer
2 images
loadings .497 to .674
mean 2.88, 0.86 SD

Tree Screen
7 images
loadings .419 to .797
mean 3.87, 0.74 SD

FIGURE 2: Image ratings categories

Factor analysis was used to extract categories based on patterns of image response. Five categories accounted for 57% of the total variable variance, and included 27 images. New dependent variables were constructed by aggregating mean values across all category items for each participant. Figure 2 presents the categories, in ascending order of mean preference.

The lowest rated category, Barren Edge, displays little roadside vegetation. Adjacent commercial property uses (buildings, large products) are highly visible. Buildings dominate the roadside view in the next low rated category. Higher ratings were given to Ornamental Frame, as installations of shrubs and trees soften visual obtrusiveness of built elements, and screen ground level views into the commercial zone. Dispersed trees visually buffer midground buildings or products and create a greater sense of visual balance between the built and natural elements of the scene in Tree Buffer. Having the highest ratings, Tree Screen depicts opaque tree groves that obscure what lies beyond the right-of-way. The viewer detects buildings but can't discern their commercial purpose.

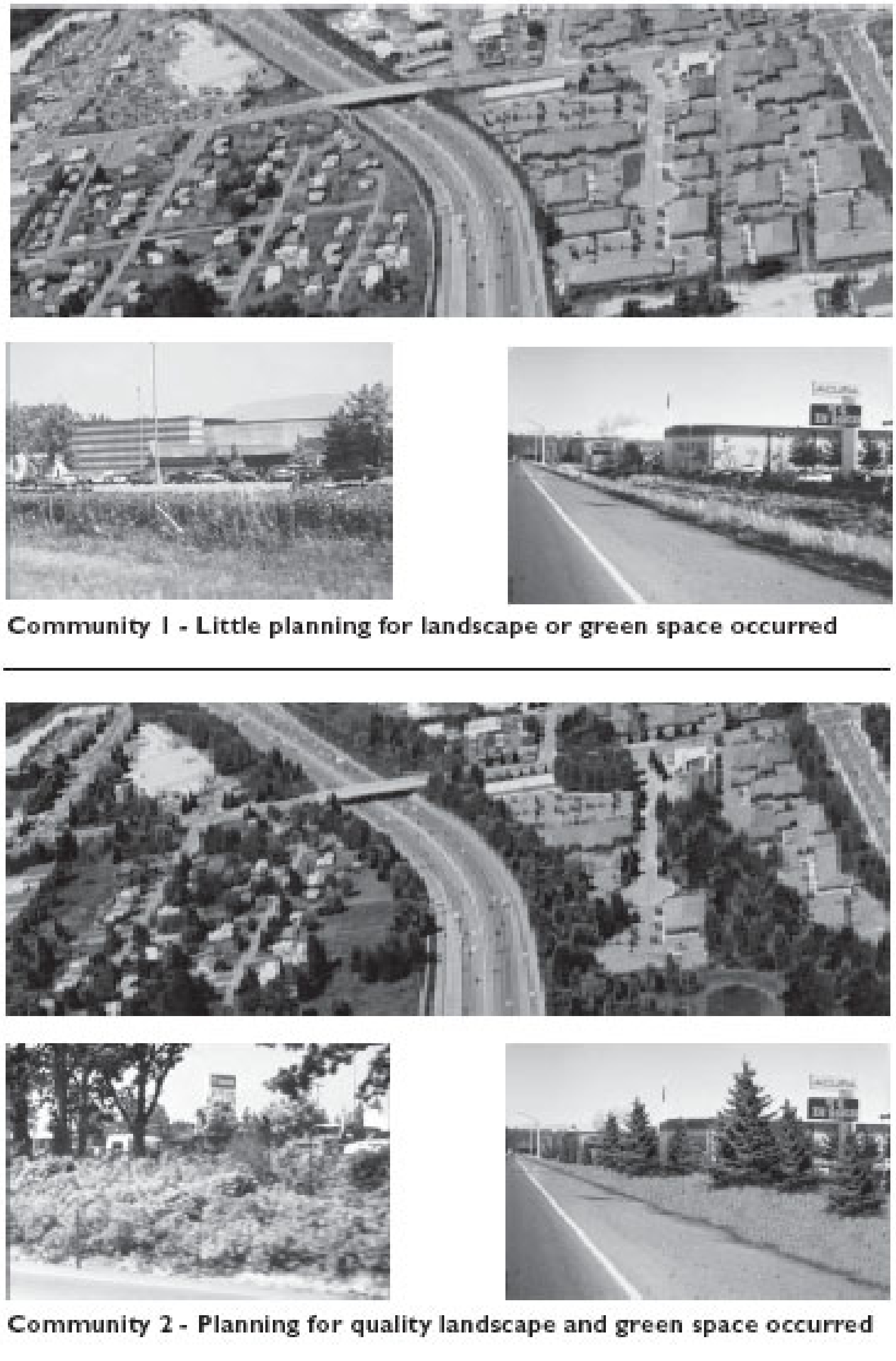

FIGURE 3: Community scenarios portrayed using digitally edited images.

Results-Community Perceptions
In a second survey a base image of an oblique aerial view of an urban freeway segment was digitally altered to depict two communities, one with little landscape character and one with more "greening" of high-speed roadside, arterials, and collectors (Figure 3). Each survey respondent was asked to complete two sets of verbal variables for each of two community scenarios, a set of contingent valuation questions, and demographic questions. One thousand surveys were mailed to residents of three mid-sized cities in Washington State. Response rate was sixteen percent, based on 113 responses (and 285 being nondeliverable).

Place Perceptions

Two sets of verbal items asked drivers about what they thought of each community as a potential place to shop, and as a general environment. Ratings choices ranged from "1" indicating "strongly disagree" to "7" specifying "strongly agree" with 4 as a neutral center. Factor analysis was used to extract categories, with three emerging for the "place to shop" variables, accounting for 67% of the total variable variance. Two categories emerged for "business environment explaining 59% of variance. Dummy variables were constructed by aggregating mean values by category items and participants, then compared across scenarios (Tables 1 and 2).

What do these tables tell us? First, when comparing the two communities, higher ratings are expressed for the "green" community on all place attributes. Appeal to both local and visitor consumers, and the general character of the shopping experience, were judged to be more positive in the "green" place. In addition, the commitment of merchants to community was also perceived to be greater in the green community.

This is a remarkable outcome, as the presentations of community differed only in the degree and character of landscape. The images differ only in the amount and configuration of urban forest elements. There are no additional cues that would directly indicate social interactions of helpfulness or cooperation.

TABLE 1: Place to Shop Categories

Factor Categories^ & Items	Green Mean(SD)	Less Green(SD)	p <
Category 1: Local Shopper Appeal I'd stop here for gas and convenience goods local residents do much of their shopping here	**5.34 (0.99)**	**4.75 (1.27)**	**.001**
Category 2: Inviting to Visitors I'd stop here to see what shops are available is appealing to tourists	**5.07 (1.12)**	**3.37 (1.37)**	**.001**
Category 3: Shopping Experience business people are helpful and informative high quality brands are available wide selection of products and services	**5.02 (1.03)**	**4.23 (1.17)**	**.001**

^Principal Axis Factoring with Varimax Rotation, paired comparisons T-tests (*alpha*=.05/3=.015)

TABLE 2: Business Environment Categories

Factor Categories^ & Items	Green Mean (SD)	Less Green (SD)	p <
Category 1: Cooperative Merchants	**5.15 (0.83)**	**4.06 (0.92)**	**.001**
public & private organizations work together			
merchants care about the community			
businesses sponsor community events			
business people are community leaders			
Category 2: Fiscal Health	**3.27 (1.05)**	**3.89 (0.98)**	**.001**
seems to be struggling financially			
the crime rate is high			

^Principal Axis Factoring with Varimax Rotation, paired comparisons T-tests (*alpha*=.05/2=.025)

It seems that urban vegetation provides behavioral cues about social factors related to consumer behavior. Retailing studies have evaluated the role of "atmospherics" on shoppers' intentions and behavior, finding that indoor environmental elements such as music, product layout and store lighting all contribute to store image (Zimmer and Golden 1988). In turn, store image influences consumers' perceptions (Dodds et al. 1991). Prior research on nature and city streets supports the finding that both evaluative appraisals (Nasar 1998) and affective response (Sheets 1991, Smardon 1988) are boosted by the presence of trees.

Consumer Pricing

Retailing studies have also found that store settings with interactive, friendly sales personnel produced higher price acceptability in consumers (Grewal and Baker 1994). Is it possible that the visual quality of a place influences product price behavior?

The last set of response items was developed to assess the non-market, non-utility values of trees in community settings using contingent valuation method (CVM). O'Doherty (1996) regards CVM as a "monetized technique for eliciting public preferences." Contingent valuation surveys have been used to assess public willingness-to-pay (WTP) for urban and rural resource use, conservation, and restoration of environmental damage.

Respondents were asked to indicate the price they would be willing-to-pay for each of eight items (Table 3). Means were calculated for each item by scenario.

Response was consistent across all pricing variables, and repeated the patterns of perceptions response. From low-cost convenience goods to purchases representing major household investment, greater WTP was reported for the community having a greener landscape character. The results are also consistent with prior studies showing consumers are willing to spend 9 to 12 percent more for goods and services in central business districts having a forested streetscape (Wolf in review).

Results-Respondents

Respondents to the preference survey were somewhat younger than the U.S. population, but all age groups were adequately represented in both surveys. Gender distribution for both projects was approximately that of the U.S. population. Survey participants for both projects were somewhat more affluent than the general population.

TABLE 3: Reported Product Pricing Between Community Scenarios

Product/Service*	Green Mean (SD)	Less Green (SD)	% Diff	^p <
take-out sandwich for lunch	4.93 (1.71)	4.49 (1.52)	10	.001
flower bouquet	17.16 (10.97)	15.61 (10.64)	10	.001
pair of sunglasses	18.87 (15.30)	15.78 (12.36)	20	.01
sit-down dinner for two	34.08 (12.65)	30.69 (12.49)	11	.001
lightweight jacket	38.04 (15.90)	34.82 (13.85)	9	.001
pair of sports shoes	47.07 (21.45)	43.81 (20.25)	7	.005
motel room for 2, one night	62.78 (15.48)	57.09 (14.71)	10	.001
house, 3 bedroom/2 bath	145K (39.5K)	131K(36K)	11	.001

U.S. dollars (1999), outlier prices excluded, ^paired comparisons T-tests (*alpha*=.05/8=.0063)

When asked, "What is the size of the community you live in?" Most of the preference survey respondents live in large cities, or suburbs of such places. As was intended, most of the community perception participants lived in small cities (20,000 to 100,000 population). Weekly driving habits were also surveyed. The majority of respondents in each survey reported spending fewer than ten hours per week in a motorized vehicle. The community survey respondents spent proportionately more of that vehicle time on urban freeways.

Statistical comparisons of respondent characteristics to preference, perception, and pricing variables were conducted and few sustained relationships were identified. It appears that people of diverse age, income, residence and driving behavior hold similar public values for the roadside urban forest. Of particular interest was the relationship of respondent income to pricing response in the community survey. Past CVM research suggests that income bias is minimal for reasonable pricing exercises (Mitchell and Carson 1989). Only one item of the list - flower bouquet - was valued higher by individuals having higher income, suggesting that that the pricing exercise is income stable, making it valuable for future research.

DISCUSSION AND IMPLICATIONS

The purpose of the two studies was to provide input on public values for planning and managing urban freeway roadsides, using scientific approaches. The roadside landscape may have a proportionally greater impact on drivers than more expansive public lands (such as large parks and reserves), due the frequency and duration of driving activity. Respondents judged roadsides having increasing amounts of trees and vegetation to have a greater degree of visual quality. Survey participants also indicated psychosocial inferences about the character of a place, based on its level of green-ness. The more landscaped community was characterized as being a more appealing place for shoppers, including positive merchant traits and product quality. The greener place was judged to also be a more favorable environment for new businesses.

Social psychology is the study of how small groups of people interact and are influenced by each other. In our interactions with others we constantly assemble various bits of information and, mediated by our experiences and knowledge, form impressions of others (Leyens and Fiske 1994). We rely on perceived traits to infer a person's behavior, evaluate a person, and guide decisions about how to interact with that person (Wyer and Lambert 1994).

Survey results suggest that built settings evoke similar evaluative responses. Respondent's ratings go beyond immediate physical traits, to include inferences about social and psychological interactions. Social psychological concepts of "social attribution" and "impression formation" readily translate to a person's interpretations of urban spaces and places, perhaps leading to certain actions and behaviors.

Context Sensitive Solutions

A national policy of Context Sensitive Solutions (CSS) has emerged in the U.S., as it is recognized that flexible design, guided by an inclusive decision process, contributes to better transportation projects. Highway projects once focused almost exclusively on faster travel times and safety, and were perceived as having adverse impacts on communities through which they passed (NCHRP 2002). Recent publications of federal agencies provide ideas, options, and examples of ways to design more environmentally friendly highways without compromising safety and mobility. They stress the importance of early public participation, identifying community interests, and creative thinking to achieve community friendly highway design (Moler 2002).

Nonetheless, design standards issued by AASHTO (2004a) continue to take precedence in most states (and subsequently, local jurisdictions). While such standards have increasingly acknowledged context-based considerations, transportation planners often adopt conservative interpretations. There is still much to be done before the use of flexible transportation design standards becomes the norm and not the exception.

One need is better recognition and understanding of community interests, including urban forestry (Otto 2000). As the Flexibility in Highway Design guidebook (FHWA 1997) states, "Trees are an important aspect of community identity and carry a great deal of emotional ties with the residents. If communities consider existing trees a valuable resource, alternatives to complete eradication should be pursued. These include installation of traffic barriers, lowering of the design speed, or even complete redesign of the facility to incorporate trees . . . In general, transportation designers must balance safety with other community values when considering facility design and tree preservation."

Design Standards

Two general approaches to improving roadside safety have emerged: deterrence and mitigation (Mak 1995). Deterrence features reduce the likelihood that drivers will leave the road, and include rumble strips, warning signs, and guardrails. Mitigation focuses on mechanical attributes of roadside elements and assumptions about driver fallibility. The basic premise is that people will continue to drive off the road, so the fewer and friendlier objects they might hit, the better.

Fixed Object Technologies

Trees are often regarded as fixed objects that cannot be physically redesigned, and since they possess no inherent technological benefit, it is often thought best to simply remove them. While outright removal may lead to a reduction in injurious roadside accidents, the broader benefits that trees provide or their value to communities is not taken into account. Current engineering standards regarding trees are largely constrained by a narrow understanding of trees' potential contributions to the safety of the urban roadside environment and their role in community design. Transportation engineers have done little to develop detailed understanding of how trees can be safely integrated into the roadside environment.

Extensive research effort has been directed to developing roadside object technologies, such as breakaway poles and energy absorbing guardrails. Meanwhile, trees have been largely neglected as an engineering problem. Trees are another potential roadside technology. Research about the physical properties of various trees and their roadside placement would enable roadside design that integrates plant life as a safety feature (Zeigler 1986).

This concept has been applied in a limited way in Australian urban roadsides (Rigby 1988). The Traffic Authority of New South Wales addressed an increasing number of accidents along busy roads and in areas with accident-prone geometry by developing a tree planting policy. Minimum distances from the roadway were specified for certain tree species, as the Authority differentiated between the physical characteristics of different tree species in relation to accident outcomes. Emphasis was placed on improving driver visibility and selecting frangible (meaning breakable) trees for stretches of road that were more prone to run-off-road accidents.

Location Analysis

Another approach is to do roadside conditions analyses. Ziegler (1986) conducted an extensive analysis of tree accidents in Michigan State and noted general patterns of tree crashes. Accidents involving trees are mainly rural phenomena, occurring most frequently on rural local roads. Of the fatal accidents involving trees 82 percent occurred on rural roads. About 10 percent of the fatal tree accidents occurred in urban areas.

It is important to note that at this time, nearly twenty years later, little data has been accumulated on the potential tree risk on urban roadways (Bratton and Wolf 2004). The lack of available data is compounded by loose definitions of “urban” roads in major U.S. crash databases.

Returning to the Michigan study, it was found that the most common environment for an accident is on a windy and rural road, with the vehicle leaving the road on the outside of the curve. Fatal tree accidents are more closely associated with larger trees. For fatal tree accidents the median tree diameter DBH was 20 inches; median size in nonfatal tree accidents was 15 inches DBH.

The report concludes with an analysis process that can be used to examine and respond to the risk of tree/vehicle crashes. The process generates a city or county-wide map for tree risk assessment and accident monitoring:

1. Prepare a base map and plot roadway information. Note high risk road geometry situations (e.g. wide curves) and plot past vehicle/tree accidents. Plot significant trees (historic, significant, large size, endangered) and areas of cultural significance that include vegetation.
2. Assign priorities for field verification of highest accident potential, with emphasis on accident incidence and tree locations (including condition or hazard assessment).
3. Verify high risk through field inspections.
4. Select appropriate treatments. Consider implementation, maintenance and replacement or repair costs.
5. Verify applicability of treatments in field conditions. Confirm costs analysis. Consider contingencies of property ownership, and environmental effects.
6. Perform selected treatment. Notify property owner(s).

The transportation engineering community adheres to a rigorous process of technology development and refinement. Empirical valuations of current crash conditions are done, followed by development and testing of technologies intended to lessen driver injury. Finally, field test implementations of the technology are conducted to determine driver and crash responses. These research and development procedures should be applied to the concerns of urban trees and traffic safety (Sullivan 2001), and incorporate the input of arboricultural and urban forestry scientists. A tree-oriented research and development program would enable more communities to more safely integrate trees into their urban transportation networks.

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