Vehicle/Tree Accident Risk and Management of Roadside Trees

By
Andrew J. Zeigler

Michigan Department of Transportation

Michigan Department of Transportation
Transportation Planning Services Division
425 West Ottawa Street
P.O. Box 30050
Lansing, Michigan 48909

Telephone: (517) 335-2634

A Paper Presented at the 66th Annual Meeting of the Transportation Research Board, January 1987; the 1987 Mid-Year Meeting of the Transportation Research Board; and Prepared for Publication in the Transportation Research Record (TRR)

ABSTRACT

Research conducted by the Michigan Department of Transportation (MDOT) has resulted in both safety and environmental recommendations for management of roadside trees. Intended for local and state road authorities, recommendations resulted from research that included analysis of nearly 500 vehicle/tree accident sites across Michigan.

Statistical analysis of vehicle/tree accidents in Michigan reveal, among other characteristics, that the typical driver may be intoxicated and/or unfamiliar with the road. Vehicle/tree accidents typically occur along winding rural roads with a vehicle leaving the pavement on the outside of a curve. No single feature of the road environment accounts for all the accidents that occur and cannot be used to determine the level of risk. The distance of the tree from the road is not sufficient by itself to determine the probability of a vehicle tree accident.

Treatment of locations should address both safety and environmental issues. High risk locations should be identified for treatment first, based on both accident history and potential accident frequency. Accident profiles have been developed to identify high risk locations, while eliminating random accident sites from consideration. Tree removal is only one of many alternatives that should be considered depending on site specific environmental and safety issues. Contact with adjacent property owners and judgement of the professional engineer is essential in the treatment process, rather than strict adhearance to set clearcut distances. Because safety versus environmental issues associated with roadside trees are expected to continue, the management process offered will be useful in addressing the vehicle/tree accident problem.

VEHICLE/TREE ACCIDENT RISK AND MANAGEMENT OF ROADSIDE TREES

The Michigan Department of Transportation (MDOT) has recently completed a Guide To Management of Roadside Trees.(1) This guide presents a step-by-step approach to identify and treat rural roadways having a high risk of vehicle/tree accidents. It is intended for use by state highway personnel and local road authorities responsible for maintaining roads. Both safety and environmental issues are addressed, along with alternative treatments to reduce the risk of vehicle/ tree accidents.

Prepared under a Federal Highway Administration (FHWA) grant for national distribution, this guide is a result of over ten years of comprehensive research.(2)(3)(4)(5) Defining the exact nature and extent of the vehicle/ tree accident problem on a statewide and site specific basis required supportive statistical analysis of accident data and field surveys of vehicle/tree accident sites.

Environmental and highway safety research consultants were employed to identify and evaluate the problem.(4)(6) Following study of the state of the art research, evaluation of five consecutive years of vehicle/tree accident data in Michigan, field surveys, and analysis of nearly 500 vehicle/tree accident sites across Michigan, a statistical basis for research findings and recommendations were developed. Subsequent evaluation and revisions by the MDOT were based on field testing by the Ingham County Road Commission (Michigan) and review by other Michigan county road agencies and transportation departments in other states.(2)

DEFINING THE PROBLEM

Trees are valued as a resource along our roadways. However, they have come under scrutiny in recent years as posing a risk. In Michigan, for example, review of accidents for the five year period from 1981 through 1985 revealed that while tree-related accidents constitute only about 2.8 percent of all accidents, they represent 11.1 percent of all fatal crashes.(7) A review of fatal accident involvement from 1978 through 1985, reveals that although crashes involving trees vary significantly by year, the absolute number seems to stay relatively constant.(7) (Figure 1)

Vehicle/tree accidents are not distributed evenly throughout a geographic area. In Michigan, for example, the vehicle/tree accident problem occurs with much greater frequency in the lower half of the lower peninsula. According to recent data on the cumulative number of vehicle/tree accidents for both local and U.S./State roads (fatal, injury, and property damage) from 1979 to 1983, they occurred with greater frequency in 13 counties.(7) These counties seem to include those associated with both higher population concentrations or density and greater vehicle miles traveled, as well as areas having roadside trees.

Research devoted to identifying, ranking, and tabulating the risk potential of many characteristics of vehicle/tree accidents was completed as part of this study. These characteristics fall into three categories:

1. Driver characteristics.
2. The road design, geometrics.
3. Trees and the roadside environment.

DRIVER CHARACTERISTICS(3)(6)

Traffic related research has drawn a profile of the driver most typically involved in run-off-road accidents. The driver is typically a young male between 20 and 25 years old. He is a weekend driver, out during the early morning hours between 2:00 and 4:00 a.m. He is driving faster than the posted speed limit, and may also be intoxicated and/or unfamiliar with the road.

Drinking is a common ingredient in vehicle/tree accidents. More than 60 percent of the drivers killed in vehicle/tree crashes had been drinking; less than 30 percent of the drivers involved in property-damage-only accidents were reported to have been drinking.

More than two-thirds of vehicle/tree collisions occur on weekends. Most of these accidents occur on Friday and Saturday nights between the hours of 2:00 and 4:00 a.m. the following day. Crashes are most frequent during the winter months, suggesting some correlation with longer periods of darkness and, perhaps, snow covered or icy roads.

Many of the factors that correlate with speeding, such as nighttime hours and young drivers, are also typical of run-off-road accidents.

THE ROAD ENVIRONMENT

Vehicle/tree accidents typically occur along winding rural roads with the vehicle leaving the pavement on the outside of a curve.(6) The road type and various physical features of the road (lane and shoulder width, traffic volume and direction, presence of curves, etc.), as well as the driver characteristics described above, determine the probability of running off the road.

Accidents involving trees are mainly a rural phenomenon, occurring most frequently on rural local roads.(3) Of the fatal accidents occurring during 1985, for example, 81.7 percent occurred on rural roads; 72.9 percent of the injury-producing and 70.7 percent of the property-damage-only vehicle/tree accidents occurred in unincorporated areas.(7)

Seventy-seven percent of tree-related accidents on curves occur at the "outside" of curves; that is, to the right of a left curve or the left of a right curve.(6) Inside curves account for 23 percent of the crash frequency. Most vehicle/tree crashes on curves involve right departures at left curves.

This study addresses two road classifications, rural U.S./State and rural local roads. Rural U.S./State roads are identified as rural arterial and major collector roads. These roads include all U.S. and State designated routes. Rural local roads include the remaining roads, generally maintained by local road authorities (County, township, etc.). Because of lower traffic volumes, these roads also include gravel surfaces, and are maintained to lesser standards than higher volume arterial, and some collector roads.

TREES AND THE ROADSIDE ENVIRONMENT(4)(6)

The typical vehicle/tree accident involves a larger tree within 30 feet (9.15 m) of the road edge. The tree is typically located in a drainage ditch or at the bottom of a downward grade. The target tree and its immediate surroundings (size, density, distance from the road, the presence of other obstructions, etc.) determine the probability of the vehicle striking the tree.

Although trees involved in accidents have been as far from the pavement edge as 90 feet (27.45m), 85 percent of the trees involved in vehicle/tree crashes were within 30 feet (9.15m) of the road edge.(6) (Figure 2)

A number of other factors may reduce or increase the probability of striking a tree as well as affect the severity of the crash. For instance, the presence of guardrails may change the character of the accident; road-side edge slope design may reduce the speed of a vehicle before it strikes a solid object; a drainage ditch may guide the vehicle directly into a tree.

ACCIDENT PROFILES

In trying a explain run-off-road accidents, no single feature of the road environment accounts for all the accidents that occur. The level of risk that is present along a roadside is not dependent upon any single feature. For example, the distance of the tree from the road is not sufficient by itself to determine the probability of a vehicle/tree accident. Accidents involving trees have occurred in a wide range of distances from the pavement's edge. Employing such one-dimensional models limits our ability to understand and, consequently, to prevent vehicle/tree accidents.

In developing this guide, identifying and ranking nonhuman factors that contribute to the risk of vehicle/tree accidents is an essential task. Two areas of the roadside environment must be considered: the actual roadway and the off-roadway environment.

Studies indicate that the various roadway and off roadway characteristics of vehicle/tree accidents cluster in particular patterns associated with road type and alignment.(5)(6) These accident profiles identify potentially high risk sites so they can be treated.

The accident profiles relate to the road types identified earlier. They include both rural U.S./State roads, and rural local roads, along with the horizontal alignment (curved or straight sections) of these roads. Curved rural local roads are typically the higher risk, followed by curved rural U.S./State roads, then straight rural local roads and rural U.S./State roads.(1)

A comparison of the number of fatal vehicle/tree accidents was made in this study for U.S./State and local road classifications in Michigan.(7) (Figure 3) Measured by the number of fatal vehicle/tree accidents per 100 million miles traveled, curved local road sections are by far the highest risk. In 1985, for example, curved local roads, with 564.4 vehicle/ tree accidents per 100 million miles traveled, had nearly ten times the number of accidents as the next highest category of curved U.S./State roads with 57.9 accidents per 100 million miles. This is followed by straight local roads at some 21 vehicle/tree accidents, and, finally, straight U.S./State roads with 3.9 vehicle/tree accidents per 100 million miles traveled.

A program for the management of roadside trees should be focused on these road types. City streets have been excluded from this guide Because of the difficulty of defining "city streets" and a lack of data on vehicle/ tree accidents occurring along this road type.(1) Exceptions include rural U.S./State and rural local roads that pass through city limits, but more closely resemble rural conditions (i.e., no curbs).

CURVED RURAL LOCAL ROAD SECTIONS

Curved rural local roads constitute a substantially higher risk driving environment than do straight rural local roads. Most curved rural local road accident sites are found on left-hand turns with downhill grades, following a series of curves. The likelihood of an accident increases with tree density near the outside of the curve.(6) The impacted tree is often 20 feet (6.1 m) or more from the road edge.

CURVED RURAL U.S./STATE ROADS

In every case studied, accidents along curved rural U.S./State roads occurred on left-hand curves.(4) Most often, the fatal tree was in a grove of trees and was rarely the first tree struck. Typically, the vehicle ran down an embankment into a grove of trees. Almost half of the accidents studied occurred at the location of at least one previous serious vehicle/tree accident.

Treatment of curved rural U.S./State roads is more difficult than treatment of curved rural local roads. The trees tend to be even farther from the road edge.

As was the case with curved rural local road accidents, vehicles often miss a left turn and continue down a side slope into a tree. Slope of the road is a less critical factor on rural U.S./State roads than on rural local roads.

STRAIGHT RURAL LOCAL ROAD SECTIONS

Straight sections of rural local roads have accident profiles that are considerably different from curved sections. The distances of trees from the road edge tend to be appreciably less along straight rural local roads. Typically, the vehicle enters a ditch from a narrow and often unstable (i.e. soft) shoulder and is then channelled into several trees.

STRAIGHT RURAL U.S./STATE ROAD SECTIONS

The impacted trees along straight rural U.S./State road sections are farther from the road edge than trees along rural local roads. The ditches are usually wider and less likely to direct the vehicle into a tree. Another tree is usually struck first; the vehicle then careens into the fatal one.

SOLVING THE PROBLEM

How does one solve the vehicle/tree accident problem? A method for examining roadside vehicle/tree accident risk is necessary in areas where trees are along roads.

While a county or state may appear to have an existing vehicle/tree accident problem along specific road sections, many of these locations may simply reflect random accident occurrence. A policy to treat only existing accident sites (because of perceived legal or liability issues, and/or limited funding) is therefore likely to miss the majority of high risk locations. Many nonaccident sites will have a much higher potential risk, although not demonstrated within the last five years.

Sufficient resources do not exist to remove all roadside trees, nor would this be desirable. Resources do not exist to upgrade all roads or easily modify driver behavior. Therefore, those road sections with a high risk for a serious accident involving a tree must be identified for treatment.

Accident profiles just discussed allow one to identify potentially higher risk locations for treatment based on road type and alignment. Ranking by risk has been taken further to identify locations having vehicle/tree accidents that should not be considered random occurrences? To address this, average daily traffic volume (ADT) and the incidence of vehicle/tree accidents is taken into account. This allows one to more appropriately rank order locations that are more frequently traveled first.

A more responsive approach, therefore, is to consider both expected accident occurrence and locations of significant accident frequency to determine priorities for field verification and treatment. This would address both long term prevention (10-20 years), while being responsive to locations having a significant accident history.

To do this, accident history over the last 3-5 years should be used to identify locations of particularly high vehicle/tree accident frequency. For example, when the actual vehicle/tree accident frequency along a road section is significantly higher than what is expected (based on both probability and local accident data), these should not be considered random accident locations. Instead, the number of accidents may indicate a real and statistically significant deviation from this expectation. The threshold, or the number of vehicle/tree accidents that represent a statistically significant deviation from the expected, can be calculated for each location. For those locations meeting or exceeding this threshold, the actual number of vehicle/tree accidents (equated per year) may be used to determine the priority for treatment. This will identify both straight road sections as well as curved road sections that have an unusually high vehicle/tree accident frequency (risk).

A method for examining roadside vehicle/tree accident risk was developed in this study and involves five tasks.(1)(2) (Figure 4) It enables the road engineer to identify road sections by risk for priority treatment. The method can be used to consider both potential risk and accident frequency for any location.

Developed for practical application, the methodology is presented as a step-by-step procedure. It can be completed manually, or programmed for use with the aid of a computer as part of an already existing accident data system for analysis.

Along with both safety and environmental concerns, the procedure is based on driver characteristics, factors concerning the road environment and characteristics of roadsides with trees. (Figure 4)

TASK 1: PREPARE A BASE MAP AND PLOT ROADWAY INFORMATION

The first task is broken into six steps. This task creates a base map or computer file for interactive use. Identified are rural roads by type (rural local, rural U.S./state), ADTs, curved road sections, locations of past vehicle/tree accidents, and locations of natural and cultural significance that may be affected along the roadside. This may include champion trees, locations of endangered plant species, and historic sites. The base map or computer file would exhibit or list this type of information.

Areas of natural and cultural significance in Michigan, for example, are available through an existing "Natural Features Inventory" from the Michigan Department of Natural Resources (MDNR). Similar inventory or heritage programs are available in other states.

Any particular county road system may include four hundred or more high vehicle/tree accident risk locations. However, less than half of these, and probably not more than the top 10 to 20 percent would reasonably be considered as part of a 3 to 5 year program of priority safety improvement. A computer based file could, of course, accommodate a much more comprehensive inventory system.

TASK 2: ASSIGN PRIORITIES FOR FIELD VERIFICATION

Divided into four steps, the second task determines the order in which to field check the high risk road sections. The step-by-step approach allows one to consider both potential risk and actual accident frequency. A master county (or state) map (or computer listing) is developed that pin points locations of high risk. This is then used to identify sections rank ordered by risk for field review and treatment.

TASK 3: FIELD VERIFY THE HIGH RISK ROAD SECTIONS

Using the priority listing established in Task 2, high risk road sections should be field reviewed first. This provides a more cost effective approach to confirm or eliminate potential road sections for treatment. It avoids a random approach of both field review and treatment.

A field verification form is filled out for each road section location. This form is used to identify the location and record all the pertinent safety, environmental, and other considerations that may have a bearing on the treatment to be selected. This may include discussion with the adjacent property owners concerning the location as well.

TASK 4: SELECT APPROPRIATE TREATMENTS

Alternative treatments for each of the higher risk road sections are next selected. This involves a review of the field verification forms and listing of higher risk road sections to determine and/or confirm appropriate treatments. The treatment(s) selected should be based on a simplified benefit/cost analysis of the alternatives considered for the site(s).

Roadway and roadside treatments that may be considered to reduce the risk of vehicle/tree accidents include:

Pavement Marking

Delineators and Advance warning signs

Advisory speed signs

Designation of special purpose roads

Superelevation or modification of road cross-slope

Shoulder widening and paving

Tree removal

Guardrails

Regrading ditch sections

Slope Alterations

Protective plantings

Road relocation/realignment

The feasibility and effectiveness of any treatment, including tree removal, will depend on specific application and whether treatments are used in combination or individually.

Alternatives that improve the design characteristics of the road should be investigated first. Such treatments as pavement marking, superelevation correction and shoulder paving make it easier for motorists to stay on the road.

Improvements which should be considered next are those which involve the roadside. From a safety standpoint, the most effective treatment may be tree removal. This is generally the least costly and the simplest to accomplish. However, as I will discuss shortly, tree removal is sometimes not an appropriate treatment because of a number of environmental constraints.

Other treatments such as guardrail, ditch regrading and slope alterations also provide a more forgiving roadside for motorists who inadvertently leave the road. These need to be considered as well and may provide suitable alternatives to tree removal. Combinations of alternatives that improve both the design characteristics of the road and create a more forgiving roadside, would provide the most complete improvement.

When selecting the appropriate treatment to alleviate the risk of of run-off-road accidents, keep in mind that the interaction of the driver, the vehicle, and the roadway is a complex relationship. Therefore, combinations of treatments, rather than one treatment used exclusively, are more likely to alleviate the risk of vehicle/tree accidents.

Environmental factors also need to be considered in the selection of treatment to reduce risk.(1)(8)(9) Following the consideration and/or application of various alternatives, it may then be appropriate to consider tree removal and/or grading and slope changes, etc. If tree removal is an appropriate alternative to reduce the risk, certain environmental factors need to be considered before a final decision is made or action is taken. These considerations should include issues associated with ownership, endangered/ threatened species and unique habitats, tree species size, historic vegetation, erosion/sedimentation, safety, and mitigation of environmental imapcts. These factors are not to be taken lightly and may represent the most significant hurdle before any safety or maintenance program can be carried out.

TASK 5: PERFORM TREATMENT(S) SELECTED

The last task is to perform treatment(s) that have been selected. This involves contacting property owners and adjacent owners, securing property owners permission to perform the selected treatment, and performing the treatment. This is particularly important in locations adjacent to residences, nature areas, plant preserves, parks or landscaped areas, and designated scenic roads.

This should be done not only to promote good public relations, but also to facilitate implementation of maintenance programs by helping to identify or avoid environmentally sensitive or controversial locations.

MAINTENANCE

Continued maintenance of the higher risk roadsides cannot be over emphasized. Maintenance of these higher risk roadsides as clear zones is necessary to avoid future safety problems and increasing vehicle/tree accident risk as vegetation naturally reestablishes itself along the roadside. Without a maintenance program, a much more costly tree removal and/or treatment program would again have to be implemented. This is why it is important to emphasize the need for maintaining the roadside once it is cleared or treated. Brush and tree maintenance programs developed from this guide should be integrated into the responsible department's overall maintenance program.

CONCLUSIONS

Safety versus environmental and liability issues associated with roadside trees are expected to continue. These are serious issues and cannot easily be solved.

The vehicle/tree accident problem predominantly exists along curved rural local road sections. With limited resources available to improve roadside safety, it becomes important to focus these resources on a priority risk basis. Treatment must take into account both safety and environmental issues for effective management of roadside trees.

ACKNOWLEDGEMENTS

The author of this guide deeply appreciates of contributions by the many persons and agencies involved in the preparation of the guide. I must also acknowledge the many individuals that made major contributions toward development of methodologies, collection of data, analysis, and technical writing presented in 1979 as part of the original guidelines. Special thanks are due the Federal Highway Administration (FHWA), Office of Research Development and Technology for its contracting with the Michigan Department of Transportation (MDOT) for preparation of the guide. William Burchfield, Engineering Superintendent, and Harold Judd, Superintendent of Traffic and Safety for the Ingham County Road Commission (Michigan), are to be commended for field testing the guidelines.

I also want to acknowledge the contributions of the following task group individuals representing various divisions within the Michigan Department of Transportation whose guidance has enabled this project to be completed: Jay Bastian, Roadside Development Section; Dick Blost, Traffic & Safety Division; Larry Holbrook Materials & Technology Division; Jan Raad, Environmental Liaison Section; Gerald Ritchie, Local Services Division; and Ross Wolfe, Maintenance Division.

The County Road Association of Michigan, and its Engineering Review Committee are acknowledged for their interest and review of the guide.

The contributions from research agencies and other individuals interested in the project were gratifying.

Finally, credit is given to those within the MDOT that provided review comments on the draft guide and those individuals representing county road commissions in Michigan and transportation departments from other states.

REFERENCES

(1) Andrew J. Zeigler, Guide To Management of Roadside Trees, (Lansing: Michigan Department of Transportation and the Federal Highway Administration, 1986).

(2) Andrew J. Zeigler and others, Study to Develop a Guide To Management of Roadside Trees, (Lansing: Michigan Department of Transportation and the Federal Highway Administration, 1986).

(3) Asplundh Environmental Services, Roadside Obstacle/Tree Removal Management Program and Preparation of Environmental Assessment, Phase I Report, (Lansing: Michigan Department of Transportation, 1978).

(4) Asplundh Environmental Services and the University of Michigan Highway Safety Research Institute, Roadside Obstacle/Tree Removal Management

Program and Preparation of Environmental Assessment, Phase II Report, (Lansing: Michigan Department of Transportation, 1979).

(5) Asplundh Environmental Services, Guidelines For Removing Hazardous Trees From Highway Rights-of-Way: A Management Manual, (Lansing: Michigan Department of Transportation and the Federal Highway Administration, 1979).

(6) James O'Day, Identification of Sites with a High Risk of Run-Off-Road Accident, Interim Report UM-HSRI-79-39, (Ann Arbor: University of Michigan Highway Safety Research Institute, 1979).

(7) Michigan Department of State Police, "Michigan Accident Location Index" (MALI) system, (Lansing: Michigan Department of State Police, 1978 through 1985).

(8) Asplundh Environmental Services, Assessment of Guidelines for Removing Hazardous Trees from Highway Rights-of-Way, (Lansing: Michigan Department of Transportation, 1979).

(9) Michigan Department of Transportation, Environmental Assessment for Removal of Hazardous Roadside Trees from Highway Rights-of-Way, (Lansing: Michigan Department of Transportation, 1980).

Figure 1. Fatal vehicle accidents in Michigan, total and tree related, from 1978 to 1985.

Figure 2. Distance of struck trees from road.

Figure 3. Vehicle/tree accidents per miles traveled by road type, curved or straight sections in Michigan, 1981 to 1985.

Figure 4. Method for evaluating higher risk roadside environments.

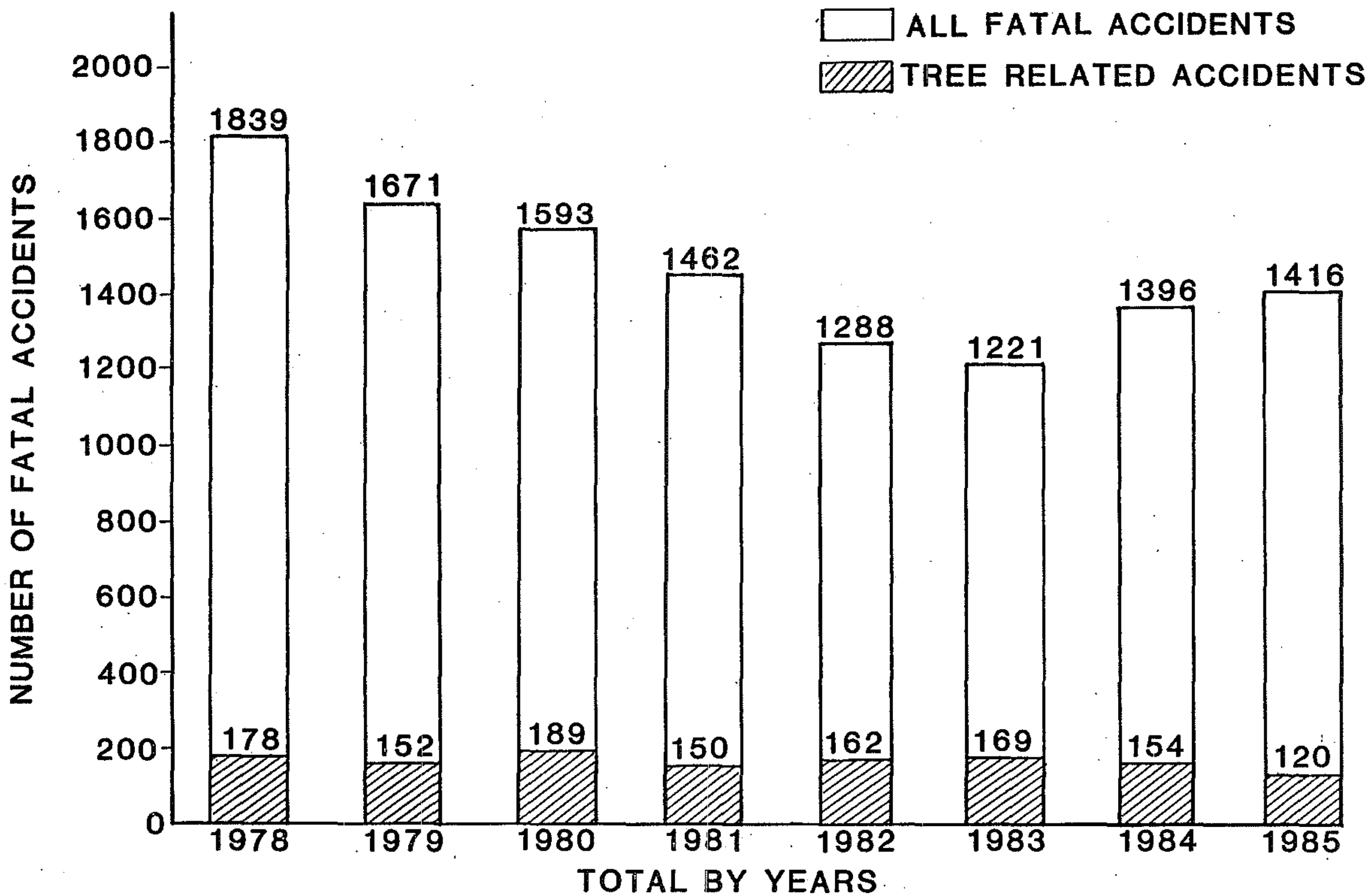

Figure 1. Fatal vehicle accidents in Michigan, total and tree related, from 1978 to 1985.

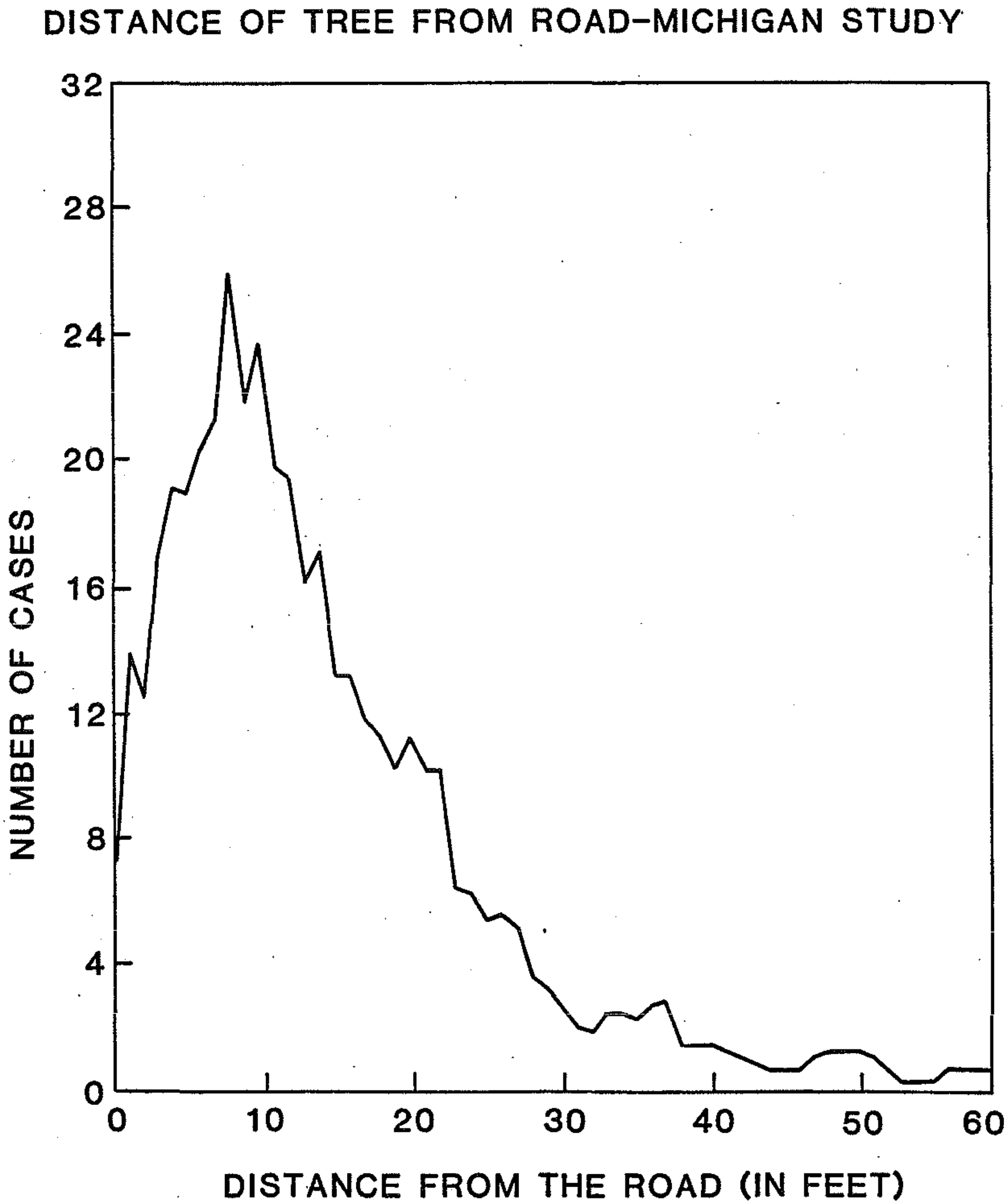

Figure 2. Distance of struck trees from road.

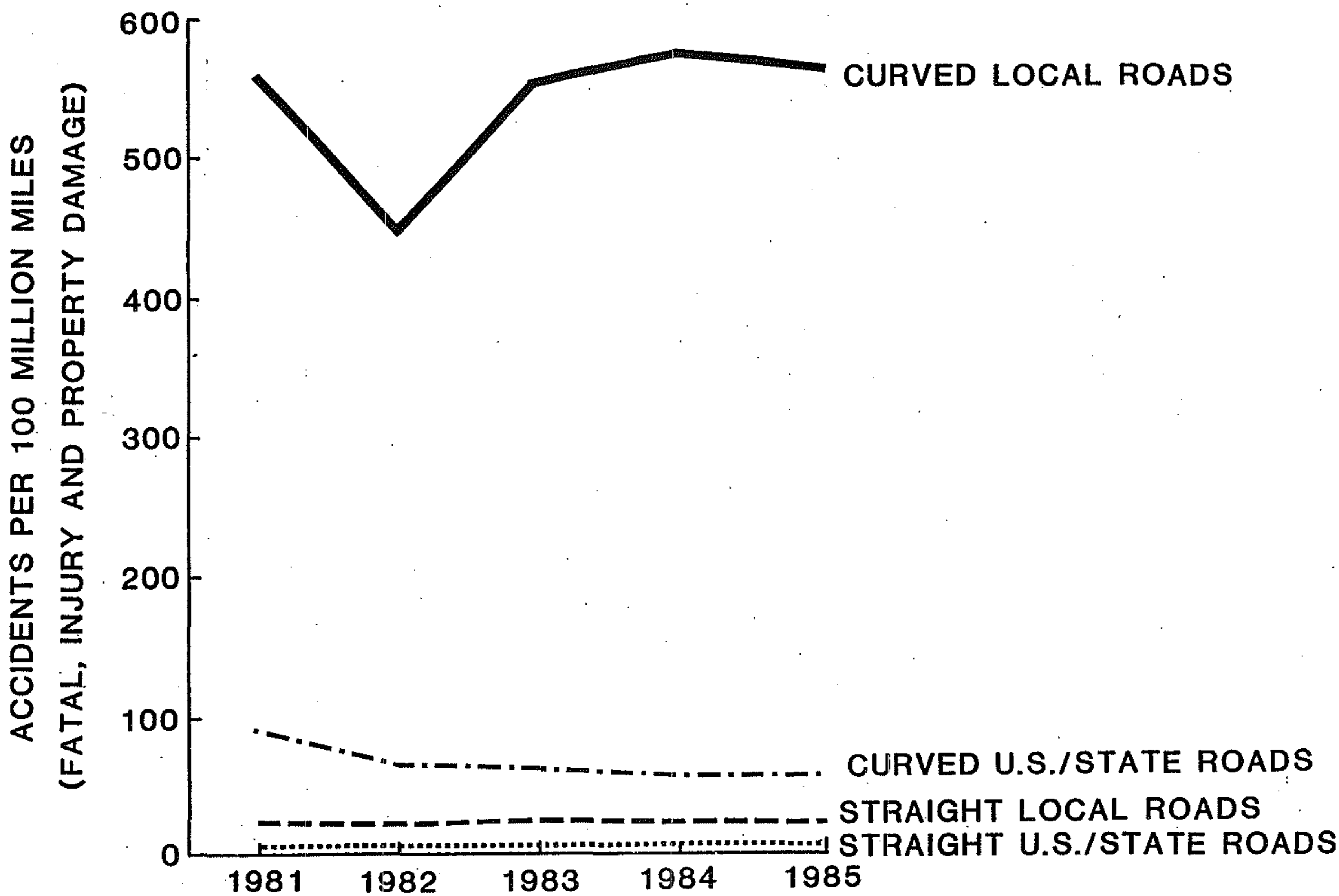

Figure 3. Vehicle/tree accidents per miles traveled by road type, curved or straight sections in Michigan, 1981 to 1985.

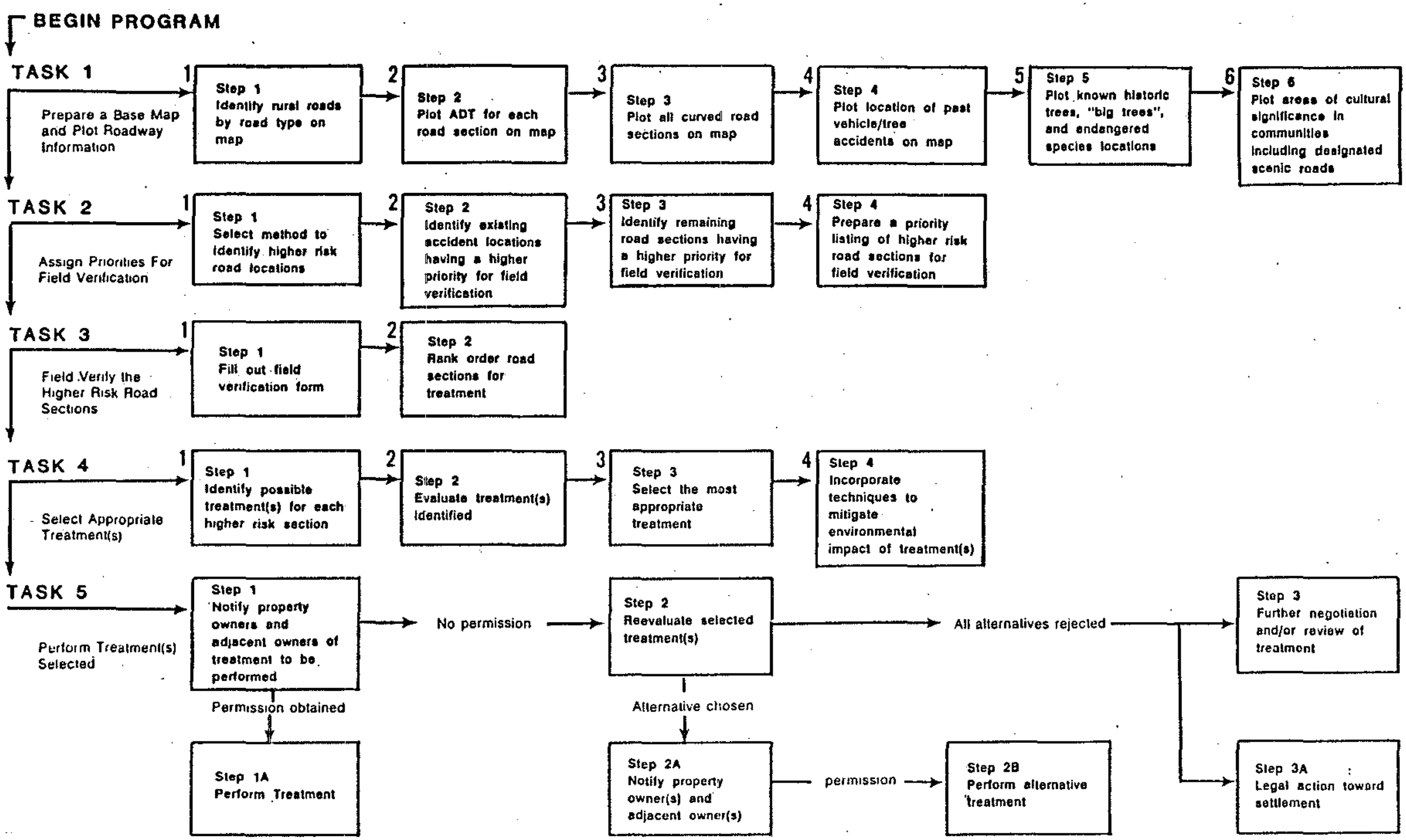

Figure 4. Method for evaluating higher risk roadside environments.