NCHRP

SYNTHESIS 341

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Integrated Roadside Vegetation Management

A Synthesis of Highway Practice

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OF THE NATIONAL ACADEMIES

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 341

Integrated Roadside Vegetation Management

A Synthesis of Highway Practice

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FOREWORD

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Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis report will be of interest to state department of transportation (DOT) management and personnel, as well as to other professionals in both the public and private sectors. Its primary purpose is to report on the incorporation of integrated roadside vegetation management decision-making processes into highway project planning, design, construction, and maintenance, as well as to document existing research and practice.

This synthesis report of the Transportation Research Board contains information culled from survey responses received from transportation agencies in 21 states and 5 Canadian provinces. Survey results offer up a broadly varied picture of the state of the practice. An overall increase in environmental knowledge and regulation has triggered implementation of individual vegetation management methods that are environmentally responsive, but often very costly. This has greatly challenged DOTs. Although there is little documentation, some example documents are presented to supplement text references. This information is combined with reviews of applicable literature to yield a compendium of successful practice and that which might have potential for success and implementation in other state DOTs.

A panel of experts in the subject area guided the work of organizing and evaluating the collected data and reviewed the final synthesis report. A consultant was engaged to collect and synthesize the information and to write the report. Both the consultant and the members of the oversight panel are acknowledged on the title page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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INTEGRATED ROADSIDE VEGETATION MANAGEMENT

SUMMARY

Since humankind developed systems of travel, nature has challenged the integrity and function of those systems with vegetation growth. Such challenges for a modern highway system range from risks to the safety of facility users to premature deterioration of the road system infrastructure to negative impacts on the environment where the highway facility is located. Limitations on resources available for designing, building, and maintaining highways need to be considered by roadside managers during decision-making processes. New methods and technologies need to be embraced throughout the country to enhance the effectiveness, safety, and efficiency of roadside vegetation management activities. Doing so will allow programs to benefit from innovation and to expand vegetation management methods, materials, and techniques.

For the past 50 years or more, mowing and herbicides have been the predominant methods used to control roadside vegetation. New environmental laws, reduced budgets, and increased public interests necessitate finding more environmentally sensitive methods, incorporating new technologies, incurring lower maintenance costs, and finding cost-effective alternatives to today's methods toward management of roadside vegetation.

In the last few decades, roadside managers have developed a concept of a decision-making process called Integrated Roadside Vegetation Management (IRVM), which has been defined by the Iowa Living Roadway Trust Fund as "a response to poor roadside management."

Poor roadside vegetation management practices have ranged from blatant neglect to routine blanket applications of herbicides. Roadside vegetation managers for public road systems have recognized the need to better manage the plant communities that will meet identified goals. Just as the highway system serves as a transportation link for movement of people and materials, roadsides serve as a transportation link for the spread of invasive weeds. National and regional organizations have been established to address the educational challenges associated with IRVM.

This synthesis attempts to review, collect, and document the information available on IRVM and define parameters for the future. A survey of transportation agencies in the United States and Canada showed that many agencies are still in the process of implementing a science-based integrated approach to making decisions on roadside vegetation management.

The development of best management practices (BMPs) is under way for roadside management; however, few written documents are available to roadside managers nationally. Some states have provided BMPs and other resource documents, through institutions of higher education, to county and state government agencies that manage roadsides. BMPs cover a wide spectrum: some address programmatic methodology of IRVM plans and administrative organizations, whereas others are developed to be site specific or species specific to address the control of a single species of plant and a specific plant community.

The extensive survey completed by representatives of state road agencies in the United States and Canada provided information on many aspects of IRVM programs. The questionnaire covered the following categories:

- Agency policies and procedures and state laws and regulations,
- Costs and benefits,
- Environmental impacts,
- Public opinion,
- Methods of vegetation management,
- Implementation,
- Revegetation,
- Effectiveness,
- Best management practices, and
- Additional items.

Although nearly all responding states reported that they have a policy on roadside vegetation management, only about half have authority and/or direction from their legislative bodies to pursue an IRVM decision-making process in managing roadsides. Some county governments have likewise endorsed the IRVM process and given direction for its implementation to local roadside managers.

Mechanical control of roadside vegetation is the most common method employed by nearly all responding state departments of transportation (DOTs) on 90% to 100% of their roadsides. Chemical control methods are used nearly as often and as extensively. Biological controls were reported as the least used method.

There was varied reporting about the economic aspects of managing roadside vegetation through data on actual life-cycle costs of various vegetation management activities. An overall increase in environmental knowledge and regulation has prompted implementation of vegetation management methods that are environmentally responsive but often very costly. Such high-cost vegetation management activities have in some cases exhausted the limited available resources (labor, equipment, and materials) that could have been devoted to implementing or enhancing an IRVM program. That is, there could have been a holistic approach to addressing the problems in regard to vegetation management.

Desirable vegetation on highway roadsides controls erosion and stabilizes slopes. Three of four survey respondents identified aesthetics as a major consideration in decision making for roadside vegetation management programs.

In addition, roadside fires are a concern of several highway agencies, including those in Florida, Illinois, Indiana, Maryland, Ohio, Texas, and Washington, and in British Columbia, Canada. In Texas, between 1988 and 1991, an average of 3,586 roadside fires was reported each year.

Investigations into how roadside vegetation affects the integrity and life of the highway infrastructure, specifically pavements, are needed. The creation of a task force for developing a national database on costs for various types of vegetation management activities could improve the projections of economic impacts among methods of control.

Also, the creation of a task force for developing a database on assigned dollar values for the benefits of environmentally sensitive methods of managing vegetation would be helpful. Roadside managers could be assisted in justifying the use of the more costly methods of vegetation management in environmentally sensitive areas.

Nationally, professional interest appears to be high in regard to implementing IRVM programs. The survey identified eight states that have, by official policy, implemented IRVM programs.

Written BMPs are needed to make IRVM programs happen with continuity and result in more sustainable roadside vegetation patterns that would meet identified goals. The National

Roadside Vegetation Management Association offers a key, well-recognized national forum for such information during an annual conference-style meeting. Meetings of the TRB Roadside Maintenance Committee at the association's conference serve as a vital link to other transportation community and vegetation management decision makers.

In addition, roadside vegetation managers need to communicate with the rest of the transportation community to integrate BMPs into roadway management systems. Many regional and local organizations provide resources to roadside managers. The major regional differences in how vegetation is managed are usually identified as "cool season grasses" in the northern states and Canada, and "warm season grasses" in the southern states. The regional differences often are so dramatic that there are many action-specific aspects of an IRVM program that cannot be transferred to other regions. Such differences in some aspects are better served through coordination at the regional level.

CHAPTER ONE

INTRODUCTION

BACKGROUND

A need for greater knowledge about managing vegetation, concerns about the potentially off-target effects of herbicides, and an understanding of the long-term economic benefits of stabilizing desirable roadside plant communities, have prompted examination of activity nationally in regard to Integrated Roadside Vegetation Management (IRVM) programs. The Iowa Living Roadway Trust Fund defines IRVM as "a response to poor roadside management" (*1*). Figures 1 and 2 depict positive and negative situations, respectively.

SCOPE AND OBJECTIVES

The primary purpose of this synthesis is to survey state departments of transportation (DOTs) about incorporating IRVM decision-making processes into highway project planning, design, construction, and maintenance. It also seeks to document existing roadside vegetation research and practices. The expected benefits from incorporating IRVM are more economical and sustainable roadsides along America's highways. The secondary purpose of this synthesis is to identify cost data on a broad array of current vegetation management activities for comparison and informational purposes.

METHODOLOGY

The synthesis was developed based on a survey of U.S. state and Canadian provincial agencies, a review of the literature on IRVM, and follow-up interviews with selected respondents. Subsets of survey questions covered the following specific topics: agency policies and procedures and state laws and regulations, costs and benefits, environmental impacts, public opinion, methods of vegetation management, implementation, revegetation, effectiveness, best management practices (BMPs), and additional items. The survey is included as Appendix A.

Twenty-one states (42%) and five provinces (50%) provided at least some information within a subset of the questionnaire. Respondents are identified in Appendix B. Only a few states provided examples of documents that they had mentioned in the survey. The survey responses are summarized in Appendix C.

ORGANIZATION OF SYNTHESIS

This synthesis consists of six chapters. Chapter one presents the background of the problem, scope and objectives, and synthesis organization. Chapter two covers the history of the approaches and techniques of roadside vegetation management. Also included are definitions and a discussion of the importance of incorporating the process of IRVM in project development. Chapter three reviews findings from the literature review. Chapter four reports on survey responses about state and federal guidelines; current state practices; practices by other organizations; BMPs; involvement of IRVM in plan-

FIGURE 1 Stabilized desirable roadside plant community in the Pacific Northwest (*courtesy:* Washington State DOT).

FIGURE 2 Uncontrolled encroachment of vegetation on a rural highway (*courtesy:* John Cantlon, E. I. DuPont Co.).

ning, designing, and construction of highway projects; and current maintenance practices and costs. Chapter five discusses information systems, biocontrol methods, cultural control materials, equipment, and other materials that reflect current technologies. Chapter six provides a summary of findings, conclusions, and suggestions for further research.

CHAPTER TWO

HISTORY

VEGETATION MANAGEMENT APPROACHES AND TECHNIQUES

Vegetation management has been a part of road maintenance since the first trails were upgraded to roads. As these trails became roads and ultimately highways, the need for more effective vegetation management became evident. Literature dealing with some aspects of pavement life identifies the presence of water in the subgrade of a roadway as strongly affecting a reduced pavement life and serviceability (*2*).

The early efforts at managing roadside vegetation integrated manual methods of cutting and pulling with biological methods of allowing goats, sheep, and other grazing animals to keep grasses, forbs, and palatable brush species in check. Historically, estates in Europe and along the eastern seaboard of the United States used grazing and browsing animals as a primary means of controlling grasses, brush, and lower tree limbs. That is, the animals groomed the landscapes and roadways. Cultural methods of controlling unwanted types of vegetation usually involved the establishment and maintenance of dense desirable vegetation patterns that would resist invasion by undesirable plants. An example of cultural control would be meadows of grasses and forbs that are managed at optimum plant densities, keeping weeds and brush as well as tree seedlings from establishing and maturing. Figure 3 shows one such method.

As modes of transportation changed from horses and carts to faster-moving, motor-powered vehicles, the need to control and manage vegetation along the roadside changed as well. When speeds increased, safety became a more important motivator in managing vegetation that blocked sight distances, contributed to winter skidding risks by shading pavements, or presented an impact risk. The safety of road users and others within the right-of-way of the facility dictated the need to improve roadside visibility, especially at intersections and where pedestrians could interact with the motor vehicles (see Figure 4*a* and *b*).

The presence or absence of vegetation can have a detrimental effect on the highway system infrastructure. Environmental quality issues surrounding erosion control, stormwater management, protection of wildlife habitat, control of noxious and invasive weeds, and needs of special plant communities combine with highway aesthetics to dictate vegetation management programs. In addition, roadside fire starts have become a problem in some regions (see Figure 5*a* and *b*). Hauser and McCully co-authored a research report, *Presuppression of Roadside Fires* (*3*), which addresses possible methods for stopping grass fires originating on highway roadsides, before they begin.

With the advent of herbicides came an additional method of vegetation management. Naturally occurring herbicides, such as salt (NaCl), were the first chemical control methods used on roadsides. In the 1940s, many synthetic herbicides were added to the available "tools" that the roadside manager had for managing vegetation.

Since the early 1960s, there has been increasing concern about the use of synthetic herbicides (*4*). Early synthetic herbicides varied widely in their degree of controlling of the many species of vegetation occurring along America's roadsides. Some herbicides are quite selective control measures, whereas others offer broad-spectrum control of many varieties and species of plants. Some of the new herbicides, such as those in the sulfonylurea family, brought into use in the past decade, are applied at rates as low as 0.5 oz of product per acre, compared with the level of the substituted urea family of herbicides, which can be applied at rates of up to 15 lb of product per acre—a difference of 48,000% or 480-fold. Many new herbicides have characteristics that make them very selective for the environments in which they are applied, ensuring little off-target damage potential. In addition, their half-life is brief enough that persistence in the environment can be reduced to hours or a few days. In the 1950s, borate herbicide (polybor-chlorate) was applied at rates of up to 3,200 lb of product per acre in an attempt to keep areas vegetation free for 1 year (*5*).

Various approaches to data collection toward better management of roadside vegetation have been explored for many years. One of the longtime coordinated and continuous efforts to exchange such information between states was an annual meeting and workshop held in Ohio. The Ohio Short Course on Roadside Development began before World War II and continued into the late 1960s, facilitating more than 40 years of information exchange by states nationwide. The issues of 40 years ago and more continue to be raised at today's conferences and symposiums that are concerned with managing vegetation on the 12 million acres of highway rights-of-way in the United State (*6*).

FIGURE 3 Mechanical control using a roadside mower in Idaho (*courtesy:* John Cantlon, E. I. DuPont Co.).

(a)

(b)

FIGURE 4 Before (*a*) and after (*b*) photographs illustrating the need to manage roadside vegetation for road user safety (*courtesy:* John Cantlon, E. I. DuPont Co.).

(a)

(b)

FIGURE 5 (*a*) Accidental fire in the median of I-5 in Washington State; (*b*) Fires originating on the highway right-of-way can pose a serious threat to adjacent crops, buildings, and other improvements (photographs by Robert L. Berger).

The first Western Canadian Roadside Development Conference was held in Banff, Alberta, Canada, in 1964. In a presentation during the 1964 session on maintenance and conservation, V.C. Brink stated, "There are not many places on the roadside where, with confidence, one can recommend natural revegetation and the natural succession" (*7*). He attributed the problem to how maintenance practices damaged the nurse crops that had the potential to "make possible a stable native perennial cover within a decade." Another conference presenter, W.E. Bottomley, said that "it is very difficult to get to maintenance and the equipment used on maintenance, without touching on design and construction" (*7*). Both speakers acknowledged the need to meld all the individual issues into a total package if success were to be realized. Such efforts to involve design, construction, and maintenance professionals in decision making continues today in the development of IRVM plans and policies.

Early stages of project planning and design provide an opportunity to accommodate the operational and aesthetic needs of the roadside. In the early 1970s, a team of landscape architects from the FHWA, U.S. Forest Service, and Washington State DOT worked on a vegetation management plan for a new highway traversing the North Cascade Mountains in Washington State. That team developed the "zone" concept for categorizing the aesthetic, operational, and functional needs of the roadside. The resulting three-zone concept is a prescription approach to the design and management of vegetation patterns within each zone, to meet the identified objectives of the zone (see Appendix D). The zone concept has been adopted by several highway agencies for use in planning and maintaining roadsides.

In 1984, an organization was formed to reestablish a national forum for information exchange on the science of roadside vegetation management, equipment availability, and access to other tools that are part of an integrated program. The National Roadside Vegetation Management Association (NRVMA) held its first meeting in Kansas City, Missouri, in October of that year. Since that meeting, which attracted 150 representatives of highway agencies and support industries, NRVMA has seen attendance rise to nearly 400 at its annual meeting and conference. NRVMA continues to provide the only national forum for addressing the holistic issues of roadside vegetation management for state, county, and city roadside managers. Communicating the needs and developments of roadside vegetation management to transportation decision makers is a key element for improvement and change in how the work is planned and accomplished.

As discovered in the literature review for this synthesis, the earliest statutory use of the term "integrated roadside vegetation management" (IRVM) occurred when the Iowa legislature adopted its IRVM program in 1988. The Iowa legislature also created the Iowa Living Roadway Trust Fund (*1*), directing that the money be used for the development and implementation of integrated roadside vegetation plans for areas on or adjacent to road, street, and highway rights-of-way. The Iowa DOT administers the program.

Many regional and state organizations have been formed to provide localized information and forums on integrated vegetation management programs as they pertain to roadsides and similar public rights-of-ways. Among these organizations are the Western Forestry and Conservation Association (*8*) and the Washington State Weed Association (*9*). The NRVMA website has links to several other state and regional IRVM associations and conferences (*10*).

County IRVM programs are established at many locations. Several counties in Kansas have programs coordinated through the Kansas DOT and Audubon of Kansas (*11*). The Roadside Office of the University of Northern Iowa (UNI) was established to encourage county participation in the state IRVM program (*12*).

KEY DEFINITIONS

Several definitions were established for use in this study and are described here.

Integrated roadside vegetation management (IRVM) is an outgrowth of a science-based pest management decision-making process developed by scientists working on control of insects that were resistant to insecticides during the middle of the 20th century. The parent process was called integrated pest management (IPM). IRVM focuses on the control of only vegetation as the pest and the application of the principals to roadside rights-of-way.

Integrated pest management (IPM) definitions vary widely, from statutory definitions to those used by a group concerned with the use of herbicides by their local road maintenance agency. Oregon State University's Integrated Plant Protection Center has a compendium of more than 60 definitions of IPM on its website, the root from which IRVM was developed (*13*).

Several states and other entities have varying definitions for IRVM and IPM. States with policy definitions of IPM or IRVM include Arkansas, Florida, Maryland, Minnesota, New York, Ohio, Pennsylvania, Texas, and Washington, as well as Alberta, Canada (see Appendix C). Most state DOT definitions of IPM and IRVM recognize that they represent a dynamic and not a static decision-making process. Through an IRVM program task force report in 1997, NRVMA defined IRVM this way:

> A decision-making and quality management process for maintaining roadside vegetation that integrates the following:
>
> Needs of local communities and highway users
> Knowledge of plant ecology (and natural process)
> Design, construction, and maintenance considerations
> Monitoring and evaluation procedures
> Government statutes and regulations
> Technology
>
> [w]ith cultural, biological, mechanical, and chemical pest control methods to economically manage roadsides for safety plus environmental and visual quality (*14*).

Olkowski et al. (*15*) in *Common Sense Pest Control* defined IPM as "a decision-making process for determining: IF you need pest suppression treatment, WHEN you need them, WHERE you need them, and WHAT strategy and mix of tactics to use to provide cost-effective, environmentally sound control."

Antipesticide-oriented groups often call for IRVM definitions to allow for the use of herbicides only as a last resort—when all other methods have failed.

UNI's Roadside Office defines IRVM in their mission statement as

> a decision-making and quality management process for maintaining roadside vegetation that integrates the following: needs of local communities and highway users; knowledge of plant ecology (and natural processes); design, construction, and maintenance considerations; government statutes and regulations; technology, and with cultural, biological, mechanical, and chemical pest control methods to economically manage roadsides for safety plus environmental and visual quality (*12*).

Official or statutory definitions of IPM or IRVM were reported by Florida, Maine, Maryland, Minnesota, Montana, and Washington (see Appendix C). The NRVMA or UNI's Roadside Office definitions of IRVM represent those that would be supported by a majority of the roadside vegetation management practitioners working within public entities.

Another definition needed is that for cultural controls, which represent those vegetation management activities that address plant needs for food, water, and light. The competition between different plants, desirable and undesirable, for these essential needs will influence the relative population densities of the desirable plant. An example of cultural control in grass management is meeting the grass plants needs by supplying adequate levels of nutrients (with the correct nitrogen–phosphorus–potassium ratio), water (irrigation), and reducing shade by thinning or removing overstory plants. The control of existing undesirable broadleaf weeds by applying a selective herbicide would occur as part of the chemical control methods that are integrated with the cultural control method. Cultural control methods employed when the grass stand is free of weeds make the grasses vigorous and dense, supporting the concept of weed prevention. This prevention approach to weed control is more effective than waiting until weeds are present before applying the cultural control practices in concert with other management methods.

Finally, there is the definition of danger trees. These are trees that pose a risk to life or property should they structurally fail and fall within the road right-of-way or on adjacent property. Generally, they do not necessarily include the trees that are considered roadside obstructions, located within the errant vehicle recovery zone of the road right-of-way. They are sometimes referred to as "hazard trees." In Washington State, they are legally identified as "danger trees."

INCORPORATION OF INTEGRATED VEGETATION MANAGEMENT INTO PROJECT DEVELOPMENT PROCESS

The early design and planning activities of a highway project afford a golden opportunity for vegetation managers to influence the sustainability of the resulting project. Configuration of soil surfaces, moisture regimes, and introduction of native or exotic plant species will have a long-term effect on the existing or future plant community. Appropriate decisions in the early planning and design process that direct construction of a project will bring the intent to fruition. The lack of such decisions will burden the maintenance efforts for years to come.

Management of vegetation is critical for maintaining a safe, traversable clear zone on the roadside that is available for an errant vehicle. Designing the roadside to be free of fixed objects, such as trees, is the responsibility of the highway designers (personal communication, N. Artimovich, Apr. 7, 2003). Figure 6*a* and *b* exemplify a poorly managed roadside.

To promote continuity and coordination of the IRVM decision-making process, states implement policies, guidelines, and regulations. Approximately half of the survey

(a)

(b)

FIGURE 6 (*a*) A poorly managed roadside allows invasive plant species to encroach within the functioning roadside; (*b*) Vegetation can obscure roadside hardware and accelerate deterioration of the wood and metal components (*courtesy:* Washington State DOT).

respondents indicated that they had a policy that requires use of a defined integrated approach to vegetation management and that it goes beyond maintenance efforts. Planning, design, and construction activities are part of such policies. The Washington State DOT "Roadside Classification Plan" has a policy statement that incorporates the integrated vegetation management decision-making process into "regional and route-specific planning, design, construction, and maintenance programs" (*16*).

Furthermore, eight states and one province (Alaska, Arkansas, Florida, Illinois, Maryland, Minnesota, Texas, Washington, and Alberta) have roadside vegetation policies that address the long-term sustainability of roadside plantings.

CHAPTER THREE

LITERATURE REVIEW

INTERNET SOURCES

A review of the literature and an Internet search undertaken for this synthesis project yielded information relating to IRVM. Many of the documents have links to related Internet sites, as well as references and bibliographies that are worth reviewing.

Many Internet sites referenced the term IRVM in descriptions of a vegetation management program, but very few referred to it as a decision-making process. A common reference to IRVM was in the context of explaining that an entity used "more than one method of controlling roadside vegetation." Nevertheless, some Internet sites provided detailed information on what an IRVM program is, how it is organized, and how such a program can be implemented.

GUIDES FROM ORGANIZATIONS

NRVMA has produced a guide for developing and implementing an IRVM program (*17*). NRVMA also offers a national certification program for individuals to become either a Certified Professional Roadside Manager or a Certified Professional Roadside Technician at the time of satisfactory completion of a written examination and evaluation of education and work experience. Also, certification for one to become a Certified Manager of Invasive Plants is offered by the North American Weed Management Association (*18*).

Furthermore, several groups at the state, county, and regional levels have embraced the IRVM philosophy in their mission statements or reflected it in their organization's names.

NCHRP Synthesis of Highway Practice 239 addressed the problem of shortened pavement life as a result of water infiltration into pavement systems (*19*). A subsequent synthesis, *NCHRP Synthesis of Highway Practice 285*, examined highway edgedrain maintenance, providing insight into the problems associated with water in the highway subgrade (*20*). Roadside vegetation at pavement edges accumulates fine debris, creating a dike-like physical barrier that prevents rapid movement of water from the pavement surface, likely allowing it to enter the pavement base materials. A report published in *Transportation Research Record 1326* covered the same subject and suggested future research needs (*21*). H.R. Cedergren, in *Drainage of Highways and Airfield Pavements*, identified the problems of water being trapped in the subgrade materials by a grass sod cover over the face slope (*2*).

GUIDES FROM GOVERNMENT

A 1968 guide for reducing fire hazards along roadsides, prepared by the California Division of Forestry and the U.S. Forest Service, identified several methods to reduce fire starts along roadsides (*22*). In 1993, the Texas Transportation Institute published a research report on roadside fire prevention. That report recommended the use of mowing as a fire control strategy. It is important to recognize that roadside fires can be both a roadside hazard and a roadside vegetation management tool (see Figures 7 and 8). A holistic approach to understanding the use of fire as a management tool and its effect on plant communities and animal habitats is covered in the "Wyoming Guidelines for Managing Sagebrush Communities with Emphasis on Fire Management" (*23*).

Several states and educational institutions have published documents that are valuable to IRVM practitioners. For example, the North Carolina DOT (*24*), Washington State DOT (*25*), and UNI's Roadside Program (*12*) makes use of their websites to assist practitioners in using IRVM.

In addition, *Roadside Use of Native Plants* (*26*), is a compendium of essays written by experts from academia, federal agencies, and state DOTs. Many of the essays, resource lists, and appendixes provide critical information and insights on elements of IRVM. Examples of such essays are "Incorporating Grasses into Clear Zone," by B. Harper-Lore (FHWA) and "Controlling the Spread of Nonnative Invasive Plants," by I. Bickford (Utah DOT), which addresses the need for state noxious weed control laws.

The FHWA quarterly newsletter, *Greener Roadsides*, reports on issues and state case studies being addressed by roadside decision makers, including invasive plant and vegetation management methods.

FIGURE 7 Roadside fire in median of I-5 near Olympia, Washington (*courtesy:* John Cantlon, E. I. DuPont Co.).

FIGURE 8 Use of fire to eliminate weed debris from roadside in eastern Washington State (*courtesy:* John Cantlon, E. I. DuPont Co.).

CHAPTER FOUR

GUIDELINES AND PRACTICES

A review of the literature, an Internet search, personal communications, personal knowledge, and the review of the completed questionnaires distributed to all states and Canadian provinces are the basis for summarizing the current status of the IRVM guidelines and practices.

A widely accepted definition of IRVM identifies the decision-making process that integrates the six major components of IRVM. These components were included within the grouping of questions that made up the survey questionnaire.

The survey questionnaire (as given in Appendix A) was divided into the following parts:

- Agency policies and procedures and state laws and regulations,
- Costs and benefits,
- Environmental impacts,
- Public opinion,
- Methods of vegetation management,
- Implementation,
- Revegetation,
- Effectiveness,
- Best management practices (BMPs), and
- Additional items.

Appendix B lists the states and provinces that responded to the questionnaire and provided information that is included in this synthesis. Appendix C presents the responses to the survey questionnaire.

FEDERAL AND STATE GUIDELINES

Proposed federal guidelines in the 2003 transportation bill included new funding for different aspects of IRVM programs (*6*). Many publications and newsletters from federal offices refer to the concepts of IRVM, and many address the principles that become part of the decision-making process. Sustainability is frequently identified as the desired end product of an effort associated with IRVM. Long-term economic benefits are often identified as an objective of sustainable plant communities. Executive Order 13112—Invasive Species was identified as having an impact on roadside vegetation management programs by 12 (60%) of the responding state DOTs. Some of the states indicated that Executive Order 13112 did not affect their vegetation management programs, because their programs were in compliance at the time the order was issued. An article in the fall 1999 issue of *Greener Roadsides* gave guidance on invasive species for federal-aid highways (*27*). Figure 9 shows the adverse effects of the invasive European blackberry plant.

Also, the federal Endangered Species Act was identified in the survey as having an impact on the roadside vegetation management programs of 15 of the 19 responding states.

The states of Florida, Maine, Maryland, Minnesota, Montana, and Washington and the Canadian provinces of Alberta and Saskatchewan have statutes mandating an IPM approach to roadside vegetation management. Legal mandates for control of designated noxious weeds are in place in 18 states and 3 provinces. Policy in 19 of the responding states and provinces indicated why vegetation is managed on roadsides, giving clear objectives for the IRVM efforts.

Specific legislation has been proposed in Maine and New Mexico and passed in Florida, Illinois, Maryland, Montana, Ohio, Pennsylvania, South Carolina, Texas, and Washington that directs the methods or level of effort concerning roadside vegetation management programs. Such methods include the use of convict labor, welfare recipient labor, IPM approaches, and adopt-a-road projects.

STATE DEPARTMENT OF TRANSPORTATION PRACTICES

Eighteen of the responding states and three Canadian provinces indicated that they have a written policy on vegetation management for their roadsides. Ten states, Arkansas, Florida, Illinois, Maryland, Minnesota, New York, Ohio, Pennsylvania, Texas, and Washington, reported that their policies require a defined integrated approach to vegetation management. British Columbia and Saskatchewan gave similar reports. Only about half of the responding agencies indicated that current policy requires addressing vegetation management in the planning, design, and construction aspects of highway development. Long-term sustainability of roadside plantings was addressed in policies for Alberta and Alaska, Arkansas, Florida, Illinois, Maryland, Minnesota, Texas, and Washington. Also, eight states (Alaska, Arkansas, Connecticut, Florida, Illinois, New York, Texas, and Washington) indicated policies that require consideration of maintenance impacts in the design and construction of roadsides. Only Florida and Washington noted that their policies require annual maintenance

FIGURE 9 European blackberry escapes cultivation and outgrows native plant communities in the Pacific Northwest (*courtesy:* Washington State DOT).

cost projections for vegetation management on newly constructed roadsides.

The aesthetics of roadsides is a strong driver of decisions concerning and assignment of resources for vegetation management activities. Three of four DOTs responding to the synthesis survey identified aesthetics as a major consideration in decisions about roadside vegetation management programs (see Figure 10 for an example).

Furthermore, water management within the highway right-of-way may strongly influence decisions on vegetation management practices. The single most significant water management policy influence was erosion control, identified by all 20 of the responding states and the province of Alberta. Drainage from the pavement surface was identified by 17 of the 20 states and one of the four provinces as a concern of their vegetation management programs. However, subsurface drainage was a concern for only Connecticut, Florida, Maryland, Utah, West Virginia, and British Columbia. Stormwater regulations or laws have an impact, by specific direction, on roadside vegetation management programs in slightly more than half of the states that responded to the questionnaire.

One-third of the states (Florida, Illinois, Indiana, Maryland, Ohio, Texas, and Washington) reported control of roadside fire starts as a concern addressed by their vegetation management practices. This provided a representative sampling of states from across the nation.

The use of native plants in construction or restoration of roadside vegetation patterns was mandated by policy or state laws in slightly more than 40% of the reporting states, and in some areas in Saskatchewan. Figure 11 shows an example of the planting of native species in Washington State.

Several survey respondents indicated that significant changes in agency policy and state statutory mandates in regard to vegetation management practices were made in the past 10 years, thus increasing efforts or emphasis in several areas. The most frequently reported policy change was the implementation of Executive Order 13112, which was reported by approximately 25% of the responding states. That result was expected, given that the order was signed on February 3, 1999. Ohio, West Virginia, and the province of Alberta reported that agency policy on vegetation management had expanded. Adding the term "integrated" to the vegetation policy or state statutory mandates was identified by Maryland and Ohio. Washington was the only state indicating a change in policy that resulted in a reduction of a vegetation management activity that was previously directed at improving subsurface drainage. Indiana, Minnesota, Texas, and Washington reported that their vegetation management activities were affected by stormwater management objectives.

The dollar value assigned to benefits of "environmentally sensitive" maintenance methods (e.g., mowing of brush versus spraying of brush) has been established by four states: Florida, Illinois, South Carolina, and Texas. The same value in regard to construction methods was identified by only Florida and Illinois. Florida was the only state to assign dollar values

FIGURE 10 A native roadside can be an aesthetic amenity for a highway system (*courtesy:* Washington State DOT).

FIGURE 11 Citizen volunteers plant native species within a suburban interchange (*courtesy:* Washington State DOT).

for the benefits of environmentally sensitive design approaches (e.g., bridges) of vegetation management compared with the benefits of conventional design approaches (e.g., cut and fill). Only two states, Florida and South Carolina, assigned dollar values to environmentally sensitive materials or native plants versus the values of introduced species used in vegetation management activities (e.g., organic rather than synthetic fertilizers).

Fourteen of the 19 states and 2 of the 4 Canadian provinces recognized the social values of environmentally sensitive approaches to roadside vegetation management, even though no dollar value is assigned to the benefit. Approximately 70% of the responding states indicated that environmental impacts from long-term sustainability are given consideration in the design of new roadside projects, whereas two-thirds reported that the same consideration was given to roadside maintenance activities. Connecticut, Illinois, Maine, Minnesota, Nebraska, Ohio, Pennsylvania, Texas, Utah, Washington, and West Virginia noted that environmental impacts from long-term sustainability were given consideration in the construction of new roadside projects.

A section of the questionnaire dealt with items grouped as "public opinion." States were asked whether public opinion was measured and whether it influenced roadside vegetation management decisions. Florida, Illinois, Minnesota, Ohio, Pennsylvania, Texas, Utah and Washington indicated that they had surveyed public opinion about roadside vegetation management. When asked how they rated the influence of public opinion regarding their practices, 45% identified it as "moderate," 30% said "weak," and 25% said "strong." One state, Washington, noted that its "strong" identifier applied just to the use of herbicides, with a "moderate" rating assigned to aesthetics.

More than 85% of the respondents reported on at least some categories of roadside acreage. The average state right-of-way reported was 502,976 acres, with a high of 4.6 million (Florida) and a low of 22,108 (Maryland) acres. In slightly more than 50% of the reporting states, the total right-of-way acreage ranged from 100,000 to 300,000 acres.

Implementation of IRVM programs by official policy has occurred in Florida, Maine, Maryland, Minnesota, New York, Pennsylvania, Texas, and West Virginia. Washington indicated that IRVM had been implemented in the design process, but not in the maintenance program. An organized training program has been used to implement an IRVM program by 12 of the 17 responding states. However, 30% of those states (Maine, Nebraska, South Carolina, Utah, and West Virginia) were doing so without a policy requirement. Only one state, Washington, used a consultant to implement about 5% of the IRVM program.

IRVM programs were reported to be tied to geographic information system (GIS) and the Global Positioning System (GPS) in Maryland and Utah. Actual roadside management plans were part of the implementation program in Florida, Illinois, Maine, Maryland, Minnesota, Montana, New Mexico, Ohio, Pennsylvania, South Carolina, Texas, and Utah, and in the provinces of Alberta and Quebec.

Revegetation of the roadside was the main focus of another section of the survey. The percentage of native plants used, other than grasses, for right-of-way revegetation averaged 75% for the responding states, with a high use (80% to 100%) being reported by Alaska, Arkansas, Connecticut, Indiana, Montana, Nebraska, New Mexico, Ohio, Texas, Utah, Washington, and West Virginia, and in British Columbia. Two states, Maine and Maryland, used native plants less than 20% of the time for revegetation of the roadside. Native grasses were used for roadside revegetation less often than were non-native plants. The average percentage of use of native grasses for revegetation was reported as only 45%. High rates (90% to 100%) were noted by Alaska, Arkansas, Montana, Nebraska, and New Mexico, whereas 40% of the states indicated a use rate of less than 20%.

Irrigation was used to establish 90% to 100% of the newly planted acreage by Arkansas and Connecticut. Four states (Montana, New Mexico, South Carolina, and Utah) indicated that 20% or less of the acreage required irrigation for establishment. Six states (Arkansas, Montana, New Mexico, South Carolina, Utah, and Washington) indicated that between 25% and 0.1% of the newly planted acreage requires irrigation on a perpetual basis. On average, 58% of the newly planted acreage requires no significant maintenance work on a perpetual basis, as reported by the responding states. Also, 23% of the responding states indicted that less than 20% of the newly planted acreage requires no significant maintenance work on a perpetual basis. Arkansas, Connecticut, Montana, Nebraska, Texas, and British Columbia indicated that between 90% and 100% of the acreage requires no significant maintenance work on a perpetual basis.

The average acreage annually planted with bulbs, seeds, and other plants for special effects amounted to approximately 120 acres for each state that reported some annual planting. The greatest area planted for a special effect by a responding state (Arkansas) was 1,000 acres. Seven of the 19 responding states (Alaska, Connecticut, Maine, Montana, New York, Texas, and Utah) indicated that no acreage was planted annually for special effects.

When asked if they had performance measurements for the design of roadsides, Florida, Indiana, Maryland, Ohio, and Pennsylvania answered "yes." The same states gave a positive response to the performance measurement for the construction of roadsides. Performance measurements for the maintenance of roadsides are done by 11 of the 19 responding states. Three states (Florida, Ohio, and Pennsylvania) reported that they have performance measurements for the public relations aspects of roadsides.

An Internet search for county roadside vegetation management programs in the United States resulted in few that identified an integrated approach. However, 87 counties in Iowa have worked with the UNI's Roadside Office at the Center for Energy and Environmental Education located at Cedar Falls, Iowa, in implementing IRVM programs for their roadsides.

CANADIAN AND AUSTRALIAN PRACTICES

Five Canadian transportation agencies responded to the survey. Responses closely paralleled the U.S. responses in many categories. Erosion control concerns significantly influenced roadside vegetation management programs in Alberta. Pavement surface drainage was a concern of vegetation management programs, according to British Columbia's response. No dollar values have been assigned for the benefits of environmentally sensitive materials or methods of design, construction, or maintenance. Environmental impacts from long-term sustainability are given consideration in design, maintenance, and construction of roadsides by Alberta and Quebec. Public opinion on roadside vegetation management practices was considered "moderate" in responses from British Columbia, Quebec, and Saskatchewan, and "weak" in Alberta. No legislation has been proposed or passed that would direct methods or "levels of effort" about vegetation management programs (e.g., convict labor, welfare recipient labor, IPM approaches, and adopt-a-road projects) by any of the reporting provinces. Performance measurements are not used in the design, construction, and public relations aspects of roadsides in any of the Canadian responses. British Columbia and Saskatchewan reported performance measurements for the maintenance of roadsides. In British Columbia, the roadsides are maintained by contract, not by provincial employees. Written BMPs were reported for most roadside activities by Quebec.

Australian roadside vegetation management practices are addressed in an article published in the journal *Public Roads* (*28*). The observations offer an insight as to why Australian roadsides have an appearance that is different from roadsides in the United States.

BEST MANAGEMENT PRACTICES

The review of information available on BMPs resulted in a broad range of definitions for the term. BMPs are considered by most entities to be organized information pieces, providing direction for decision making about program management activities and processes, and for operational activities at the field level.

From the program management aspect, BMPs address how decision-making and policy processes are to be carried out. For operational activities, BMPs constitute detailed information on how to accomplish a specific task, and they can be detailed to specify the labor, equipment, materials, and estimated costs for the activity for a particular time of the year (see Appendix E for examples of BMPs).

Written BMPs are often used to ensure continuity of effort toward accomplishing an identified policy, objective, or goal. Of the responding states, Arkansas, Connecticut, Illinois, Maryland, Nebraska, Ohio, and Utah indicated that they have BMPs for all types of vegetation management activities on roadsides. BMPs for maintenance of vegetation within stormwater facilities are in place for five states—Maryland, Texas, Utah, Washington, and West Virginia. One-third of the responding states have written BMPs for controlling dangerous trees on roadsides. BMPs for controlling noxious weeds within the right-of-way were reported by Arkansas, Illinois, Maryland, Nebraska, Ohio, Pennsylvania, Texas, and Utah. States indicating that they had BMPs for controlling trees that are or may be roadside obstructions were Alaska, Connecticut, Illinois, Maryland, Nebraska, New York, Pennsylvania, Texas, and Utah. BMPs for mowing grasses on roadsides were identified by more than half of the respondents (Arkansas, Connecticut, Illinois, Maryland, Nebraska, New York, Ohio, Pennsylvania, Texas, Utah, and West Virginia), whereas more than 35% (Arkansas, Connecticut, Illinois, Maryland, Pennsylvania, Texas, and West Virginia) identified BMPs for mowing brush and small trees on their roadsides. Other horticultural activities (e.g., tree trimming by contract) performed on vegetation within the roadsides involved BMPs as identified by Illinois, Nebraska, and Texas.

PROJECT PLANNING AND DESIGN

To ensure maximum effectiveness, an IRVM program is best incorporated in project planning as early as possible. Nearly 55% of the responding states (Alaska, Arkansas, Connecticut, Florida, Illinois, Indiana, Maryland, Pennsylvania, South Carolina, Texas, and Washington) indicated that they have a policy that includes vegetation management considerations in project planning and design phases.

The National Environmental Policy Act of 1969 provides that consideration of sustainable plant communities be a part of project planning. At the time a highway is being constructed or reconstructed, the designer can incorporate IPM principles that will result in long-term sustainability of the vegetation (see Figure 12).

Examples of these IPM principles are as follows:

- Selection of grass seed species and inclusion of forbs in the erosion control seeding will inoculate the site with a plant community having the potential to develop into a somewhat stable plant community that will be self-sustaining.
- A stable plant community minimizes the continuing demands on available resources.

FIGURE 12 Well-planned roadsides, at time of construction or reconstruction, can accommodate integrated vegetation management practices (*courtesy:* Washington State DOT).

- Specifying the timing and methods of mowing new plants will influence the long-term plant populations and plant diversity that may be part of a habitat for other species.
- Prescription use of fertilizers and herbicides contributes to the integration of the methods of managing the vegetation.
- As the plant community matures under a plan developed and initiated in the project planning process, the introduction of biological control organisms may be needed to control target species of plants that may jeopardize the long-term sustainability of the plant community.

PROJECT CONSTRUCTION

Alaska, Arkansas, Florida, Illinois, Indiana, Maryland, Pennsylvania, South Carolina, Texas, and Washington indicated that they have policies that include vegetation management considerations in project construction. British Columbia and Alberta have similar policies.

The role of IRVM in projects at the time of construction is different from that of other project development activities. Unanticipated conditions and change orders can make earlier plans for revegetation inappropriate for the final configuration of the land masses and moisture regimens discovered during construction activities. Opportunities to adjust revegetation plans to the new site conditions by changes during the contract period will contribute to the ultimate success of the project.

Incorporation of a plant establishment period in the highway construction contracts that involve new plantings will protect against a delay in critical activities, such as nutrient management, water, weed control, plant replacement, and others. These activities must have continuity from the initial planting time into the long-term continuing maintenance program, so that there is successful plant growth and development.

CURRENT MAINTENANCE PRACTICES

Questions were asked in the survey about the methods of vegetation management. Florida, Maine, Minnesota, Pennsylvania, South Carolina, and Utah indicated that they use a *documented* integrated vegetation management program. When asked to identify the percentage of roadside acreage on which each of the methods of vegetation management (mechanical, cultural, biological, and chemical, and documented IRVM) is practiced, a great diversity of responses was reported.

Mechanical control methods were reported by all of the responding states, with Alaska, Arkansas, Connecticut, Illinois, Indiana, Maryland, Montana, New York, and West Virginia identifying 90% to 100% of their rights-of-way being cut. Kentucky, Maine, New Mexico, Ohio, Pennsylvania, South Carolina, and Utah indicated that 50% to 89% of their roadside acreage is being cut. Florida and Washington State reported that less than 50% was managed using mechanical methods. Alberta, British Columbia, and Saskatchewan reported the use of mechanical controls on more than 69% of their roadside rights-of-way. Figure 13 shows specialized mowing equipment used on steep slopes.

Cultural control methods were reported by Florida, Kentucky, Maine, Maryland, New York, Ohio, Pennsylvania, South Carolina, Utah, Washington, and West Virginia. Slightly more than 60% indicated that 0% to 5% of their rights-of-way were involved with cultural control methods; 18% indicated that 6% to 10% of the acreage was involved; and another 18% indicated that more than 10% of their acreage was involved with cultural methods, with the highest, New York, reporting 90%.

Biological control practices using predator organisms such as beetles and seed flies were identified by Florida, Illinois, Kentucky, Maryland, Utah, and Washington, with 0.5% to 2% of their rights-of-ways being involved.

FIGURE 13 Specialized mowing equipment cuts brush and trees on steep slopes (*courtesy:* John Cantlon, E. I. DuPont Co.).

Arkansas, Connecticut, Florida, Illinois, Indiana, Kentucky, Maine, Maryland, Montana, New York, Ohio, Pennsylvania, South Carolina, Utah, Washington, and West Virginia, as well as the provinces of Alberta and Saskatchewan, practiced chemical vegetation control methods. Maryland indicated that 100% of its right-of-way acreage involved chemical control methods, whereas Indiana and Washington reported that 50% to 89% of their acreage was affected. Slightly more than 40% of the responding states indicated that 25% to 49% of the acreage was involved; another 40% stated that 5% to 24% of their rights-of-way was involved with chemical control methods. Only Alaska and British Columbia reported no chemical control work. Just four states, New York, Pennsylvania, Utah, and Washington, indicated that they had documented integrated control methods of vegetation management used on their roadsides. The range was from a low of 2% to a high of 100% of their rights-of-way. Figure 14 shows the application of herbicides.

CURRENT MAINTENANCE COSTS

Incomplete responses to questions about average unit costs for specific vegetation management activities made it impossible to report representative figures. The limited number of responses to that part of the questionnaire showed extreme variation in unit costs, which included labor, equipment, and materials. Following are some examples of the extreme range of responses. Mowing high-quality (fine) turf by state employees varied from $187.26 (Florida) to $20.62 (West Virginia) per acre per cut, whereas the same unit of work performed by contractors cost a high of $125.00 (Kentucky) and a low of $37.50 (South Carolina). Mowing roadside grass (not fine turf) by state employees varied from $60.00 (Maryland) to $2.38 (Washington) per acre per cut, whereas contractors were paid from $130.00 (Maryland) to $5.75 (Montana) per acre per cut.

FIGURE 14 Roadside applications of herbicides are applied by equipment specially designed for such use (*courtesy:* John Cantlon, E. I. DuPont Co.).

The frequency of mowing the same acre of roadside grass (not fine turf) per year, by contract or noncontract employees, ranged from once (Maine, Montana, Utah, Washington, West Virginia, Saskatchewan, and Alberta) to 10 times (Florida). Mowing brush and small trees by state employees ranged from $500.00 (Maryland) to $14.00 (Washington) per acre per cut, with contract costs ranging from $305.00 (Maryland) to $22.91 (Texas) per unit. Few states indicated that they mowed brush and small trees on the same site more frequently than once each year. The costs to hand cut brush and small trees likely reflected the variation in stand density, as shown by $2,000.00 (Kentucky) to $30.00 (South Carolina) per acre cut. Figure 15 shows typical mowing activity.

The application of selective herbicides (including labor, equipment, and materials) to the general highway roadside by agency employees ranged from a high of $167.00 (Saskatchewan) to a low of $2.45 (Florida) per acre per application. Contractors charged from $2.37 (Florida) to $455.16 (Connecticut) per acre per application for the same type of work.

Additional items dealing with costs are provided in Appendix C, in the tabulation of all responses from states and provinces.

ADDITIONAL SURVEY RESULTS

Five states that responded to the survey included additional items. New Mexico identified an experimental project involving the successful use of grazing goats to control noxious weeds. The Pennsylvania DOT identified several departmental publications offering information on design, construction, and maintenance of roadsides in Pennsylvania, as well as its *Roadside Vegetation Management Research Report* (*29*). South Carolina identified its engineering directive dealing with *Vegetation Management on State Highways* (*30*) and their *Herbicide Operations Manual* (*31*). The Washington State DOT referenced its "Integrated Vegetation Management for Roadsides" document (*25*). Finally, the West Virginia DOT identified its *WVDOT Landscape Manual (32).*

FIGURE 15 Mowing roadside brush occurs at infrequent intervals in most states (*courtesy:* Washington State DOT).

CHAPTER FIVE

TECHNOLOGY

Today's technologies pertaining to systems, biocontrol methods, cultural control materials, equipment, and other materials will enable roadside managers to benefit from the efficacy of contemporary IRVM programs. Acquisition of the new technologies and training for those employees who implement or use the new IRVM technologies will be the next challenges for highway roadside managers and decision makers.

INFORMATION SOURCES

The advent of the Internet has opened a world of information to anyone with a computer linked to it. Virtually all suppliers of equipment and materials maintain websites. Internet inquiries can provide sources for a particular herbicide, fertilizer, biological control agent, or other material used in today's roadside vegetation management programs. Also, issues concerning the safe use of pesticides and other materials can be addressed with technical data from a product's material safety data sheets and product labels that are accessible by means of the Internet.

Research findings are available on the Internet through the use of general information search engines, or as in the case of highway information, through a specialty database such as the Transportation Research Information Services (TRIS) (http://trisonline.bts.gov/search.cfm).

Most transportation, natural resource, and agricultural agencies (state, federal, county, and city) have websites that are accessible to those looking for information on policies and programs associated with roadside vegetation management. Universities, colleges, and other educational institutions provide information through their websites and databases. Even so, access is sometimes restricted on websites and there may be a cost to use some websites and databases.

BIOCONTROL METHODS

Some of the oldest methods of vegetation management have become the "new" alternative methods. The use of livestock that forage on the target species to be controlled is being tried in some areas. As mentioned earlier, goats appear to be the animal of choice for brush control, while goats or sheep are often used for control of herbaceous weed species. The New Mexico State Highway and Transportation Department developed an experimental project for noxious weed control along a 6-mi section of state highway in Taos County, using goats.

Research continues toward finding new, more effective biocontrol agents or natural competitors for controlling invasive species of vegetation that occur along roadsides (see Figure 16). Plant diseases have been commercially produced and sold in an effort to suppress populations of knapweeds, leafy spurge, skeleton weed, and Scotch broom. Multiple control organism releases often work in concert to control populations of weeds such as musk thistle and Canada thistle. For Canada thistle there are also beetle, weevil, and gall fly release services available from commercial sources (*33*).

CULTURAL CONTROL METHODS

Plant species that are strong competitors are often introduced into a site that has been invaded, or is subject to invasion, by noxious weed species. Selections of native grasses previously not available in commercial quantities are now available for seeding on roadsides. The same holds true for woody species and nongrass herbaceous species that would provide strong competition and/or shade against some invasive species. Both plant seeds and specially grown plants in deep-root containers make it feasible to reintroduce native species to roadsides.

Water retention gels and other soil amendments can ensure moisture availability for newly introduced plants on plant hostile sites. Controlled release synthetic or organic fertilizers make it possible to provide plant nutrients, but they also keep establishment costs within economic constraints of the project.

Mulches, erosion control blankets and mats, and native seed that are certified "weed free" are now available in many parts of the United States. Their use helps avoid the introduction of weed species in newly seeded or planted roadsides.

EQUIPMENT

Today's roadside manager has an opportunity to consider the use of GPS and GIS to assist in many areas of roadside vegetation management. Commercial GPS and GIS products are on the market and in development. The systems can provide or record information, such as environmentally sensitive site

FIGURE 16 Crisolina beetle, a biocontrol agent, feeds exclusively on St. Johnswort, an introduced weed (*courtesy:* John Cantlon, E. I. DuPont Co.).

locations, for use in planning or implementing IRVM programs. Tracking and record-keeping systems that are linked to today's compatible high-tech injection sprayers or roadside mowers are being marketed. Only Maryland and Utah indicated that they tie their IRVM programs to a GIS or GPS program.

Furthermore, computer-controlled spray equipment is currently available on the market. Injection-type sprayers that measure and inject multiple ingredients used in herbicide applications make it possible for equipment operators to use computers to change materials and/or rates of materials as they move along the right-of-way. The total volume of mixed spray is also controlled, allowing the equipment operators to vary their travel speed and area of coverage while moving. The onboard computer can generate the required pesticide application record information for downloading or storage in databases. Today's injection systems can be coupled with the use of packaged pesticide concentrates that are totally "closed," minimizing the potential for spills or operator exposure associated with the traditional transfer of packaged materials to spray tanks.

Nozzles and materials that reduce the potential for off-target drift of sprayed materials are available. Nozzles that reduce or eliminate the generation of spray particles that are under 200 microns in size reduce the potential for significant off-target movement of liquid applied herbicides. Nozzles have been developed that enable applications to be made to targets at the outside edge of many rights-of-way, thus improving the efficiency of roadside vegetation management applications without increasing the risk of off-target placement.

Spray mix additives and/or special mixing equipment have led to roadside invert-emulsion spray equipment that can deliver large droplet, oil-rich, herbicide applications to target plants with minimal risks of drift, and with improved herbicide absorption by the target plant (see Figure 17). This

FIGURE 17 Field demonstration of invert-emulsion carriers shows good "targeting" several feet from the specialized nozzle manifold (*courtesy:* Washington State DOT).

invert-emulsion technology and equipment has existed for several decades, but has recently been reintroduced for roadside vegetation management programs. A roadside vegetation management research report by the commonwealth of Pennsylvania and Pennsylvania State University (*29*) contains information about invert-emulsion sprays and other roadside vegetation management items.

Recent research and development work by Purdue University has led to commercial production of an equipment system, which can electronically identify individual weeds within its path and deliver a prescribed targeted application of herbicide in a single pass over the roadside. This innovation has the potential to reduce the amount of herbicide needed to treat an acre of roadside, reduce costs, and minimize the amount of herbicide introduced into the roadside environment.

Mowing equipment with herbicide application nozzles incorporated within the cutting head cowling is available for use in roadside vegetation programs. The application of a selective herbicide to the cut stubble of small trees and brush during the mowing operation has given effective control of

target plants. Little or no "brownout" beyond that associated with the mowing operation is evident following the use of this combination type of mower and sprayer.

Hand cutting may be used, as shown in Figure 18. However, pulling of invasive weed species sometimes is the method of choice, resulting from environmental constraints. Woody plants often cannot be pulled by hand. High-leverage, tightly gripping tools are often used to handle these tough pulling jobs.

Some types of equipment that have been in use for many years have undergone recent changes that make them more desirable in today's roadside vegetation control programs. The farm disk has been redesigned to be used to eliminate vegetation at the pavement edge by shallow cultivation. Rotary brush and tree mowers have been redeveloped to be effective at low-cutting head revolutions per minute, greatly reducing the potential for throwing debris.

In addition, the use of nonpetroleum oils in hydraulic equipment minimizes the risk of damage from broken hoses and lines on sensitive environments, where this type of equipment is often preferred.

MATERIALS

Materials used in today's IRVM programs have changed dramatically from those used a few years ago. Plant pallets have changed from predominately ornamental, as used from the 1940s to the 1970s, to today's often exclusively native plantings. The availability of native wetland plants has improved to the point where some plant nurseries now specialize in the production of large quantities of only wetland and aquatic species. Native trees, shrubs, and ground covers are now available in large quantities and larger sizes, compared with the situation of only a few decades ago, when the supply of these materials required lengthy lead times to propagate and grow. Continued plant explorations and plant breeding are leading to new and improved species and varieties of plants that will perform better in the field than did the previous standards.

FIGURE 18 Hand cutting of brambles is still practiced in many areas (*courtesy:* John Cantlon, E. I. DuPont Co.).

Furthermore, the supply of seed for planting on roadsides has experienced a change similar to that for plants. Many types of seed of native grasses, forbs, and woody plants were not available from any source, commercial or government. Today, this type of seed is available not only in the native genus, but can often be commercially collected as a regional ecotype to match the area in which it will be used.

Mulches used to control weed growth or improve survival of introduced plants has not only improved in the type of material (e.g., recycled or waste stream products, native grasses, clean cereal straws, pine needles, screened bark, and agricultural crop waste products), but many are also certified to be weed free.

Herbicides have changed from the broadly nonselective, high-use rate materials of the 1940s to the very selective, low-use rate materials available on today's market. Special formulations of active ingredients allow placement to be targeted and efficient.

Fertilizers and soil amendments are now available to meet nearly any site restrictions that may be applied to a project site. Certified organics, coated synthetics, pelletized homogonous formulations, and seed coatings containing beneficial mycorrhizae, are a few of the specialized materials available on today's plant nutrient marketplace. Fertilizer regulations by many states ensure the quality of products and prevent toxic contaminates. Soil amendments, which improve soil aeration or moisture-holding capacity, are available as synthetic materials or natural weed-free organic materials.

Finally, a model certification training manual for right-of-way pesticide applicators (*33*) is available for agencies that use herbicides as a tool in their IRVM programs. The Internet provides almost instantaneous access to information about sources for new products, services, and equipment.

CHAPTER SIX

CONCLUSIONS

The literature review conducted for this synthesis identified the lack of a uniform definition of integrated roadside vegetation management (IRVM), or the more inclusive term, integrated pest management. However, most IRVM definitions identified a decision-making process that integrates

- Needs of local communities and highway users;
- Knowledge of plant ecology and natural processes;
- Design, construction, and maintenance considerations;
- Monitoring and evaluation procedures;
- Government statutes and regulations; and
- Technologies.

Alongside these elements are cultural, biological, mechanical, and chemical control methods to economically manage roadsides for safety plus environmental as well as visual quality.

An extensive survey was completed by representatives of state road agencies in the United States and Canada to provide information on many aspects of IRVM programs. The questionnaire covered several categories. They include

Agency policies and procedures and state laws and regulations,
Costs and benefits,
Environmental impacts,
Public opinion,
Methods of vegetation management,
Implementation,
Revegetation,
Effectiveness,
Best management practices (BMPs), and
Additional items.

Nearly all states reported having a policy on roadside vegetation management, and approximately half of the state road agencies have authority and direction from their legislative bodies to pursue an IRVM decision-making process in managing roadsides. Some county governments have given similar direction to their local roadside managers.

The survey identified that mechanical and chemical control methods are the most frequently employed techniques for roadside vegetation management. Mechanical control of roadside vegetation is employed by nearly all state departments of transportation (DOTs) on 90% to 100% of their roadsides. Chemical control methods are used nearly as often and as extensively as are mechanical methods on roadside areas. However, mechanical methods are often repeated on the same areas several times a year. According to the respondents, cultural and biological controls are the least used methods of managing vegetation on roadsides.

An overall increase in environmental knowledge and regulation has prompted implementation of high-cost vegetation management methods, such as hand weeding of new plantings. These high-cost efforts have exhausted the limited resources (labor, equipment, and materials) that could have been used to implement an IRVM program that would affect more roadside areas.

Nationally, interest is high in implementing IRVM programs. Written BMPs are needed to make IRVM programs happen with continuity, resulting in more sustainable roadside vegetation patterns meeting identified goals. The study concludes that IRVM as a decision-making process is a popular concept and has enthusiastic support from most state highway agencies. All states responding to the questionnaire have implemented some aspects of an IRVM program.

This section provides suggestions for further research. The economic aspects of managing roadside vegetation need to be improved with sufficient and accurate data on actual life-cycle costs of various vegetation management activities. Creation of a task force for developing a national database on costs of various types of vegetation management activities would improve the projections of economic impacts of one method of control over another.

It is also suggested that research be considered to

- Develop a model that would be used by states to report the actual costs of major items of work associated with IRVM.
- Investigate how roadside vegetation affects the integrity and life of the highway infrastructure—specifically pavements. Literature dealing with some aspects of pavement life identifies the presence of water in the subgrade of a roadway as strongly leading to a reduced pavement life and serviceability.
- Identify potential control of accidental fire starts along roadsides as affected by vegetation management programs.

- Investigate the potential liability for damage to properties affected by roadside fires, if possible.
- Develop a fire hazard reduction guide for roadsides to replace a 1963 guide.
- Develop a reporting system and database to gather assigned dollar values for the benefits of environmentally sensitive methods of managing vegetation to justify the use of the more costly methods of some sensitive management activities. That research could establish the content of such a reporting system and identify the repository for such a database.

Also, given the high level of professional interest in implementing IRVM programs, written BMPs are needed to offer continuity. The result may be more sustainable roadside vegetation patterns meeting identified goals. It is suggested that an entity be created and funded as a repository for retention and distribution of IRVM BMPs.

REFERENCES

1. "Living Roadway Trust Fund of Iowa," Cedar Falls, Iowa [Online]. Available: http://www.iowalivingroadway.com/irvm.asp.
2. Cedergren, H.R., *Drainage of Highways and Airfield Pavements*, John Wiley & Sons, Inc., New York, N.Y., 1974, updated 1987, 302 pp.
3. Hauser, D.S. and W.D. McCully, *Presuppression of Roadside Fires*, Final Report, TX-93/902-7, Research Report No. 902-7, Texas Transportation Institute, College Station, Oct. 1993, 30 pp.
4. Carson, R., *Silent Spring*, Houghton Mifflin, Riverside Press, Boston, Mass., 1962.
5. Pacific Coast Borax Co., Weed Control Report, to State of Washington, Department of Highways, Olympia, Apr. 27, 1954.
6. Harper-Lore, B., FHWA, Presentation at the National Roadside Vegetation Management Association 2003 Conference, Spokane, Wash., Oct. 6–8, 2003.
7. *Proceedings 1st Western Canadian Roadside Development Conference*, Banff School of Fine Arts, Edmonton, AB, Canada, June 22–26, 1964.
8. Western Forestry and Conservation Association, Portland, Ore. [Online]. Available: http://westernforestry.org.
9. Washington State Weed Association, Annual Conference, Pasco, Wash. [Online]. Available: http://www.weedconference.org.
10. National Roadside Vegetation Management Association [Online]. Available: www.nrvma.org.
11. Audubon of Kansas–Conservation, Manhattan, Kans., 2003 [Online]. Available: www.kansasaudubon.org/pages/irvm_locations.html.
12. UNI, Roadside Office [Online]. Available: http://www.uni.edu/irvm/web/index.html.
13. Integrated Plant Protection Center, Oregon State University, Corvallis, Ore. [Online]. Available: http://www.ippc.orst.edu/ipmdefinitions/defineIII.html.
14. National Roadside Vegetation Management Association, Integrated Roadside Vegetation Management Program Task Force, Mar. 1997.
15. Olkowski, W., S. Daar, and H. Olkowski, *Common Sense Pest Control*, The Taunton Press, Newtown, Conn., July 1991, 715 pp.
16. "Roadside Classification Plan," Washington State Department of Transportation, Olympia, 1996.
17. "How to Develop and Implement an Integrated Roadside Vegetation Management Program," National Roadside Vegetation Management Association, Mar. 1997.
18. North American Weed Management Association, Granby, Colo. [Online]. Available: http://www.nawma.org.
19. Christopher, B.R. and V.C. McGuffey, *NCHRP Synthesis of Highway Practice 239: Pavement Subsurface Drainage Systems*, Transportation Research Board, National Research Council, Washington, D.C., 1997, 44 pp.
20. Christopher, B.R., *NCHRP Synthesis of Highway Practice 285: Maintenance of Highway Edgedrains*, Transportation Research Board, National Research Council, Washington, D.C., 2000, 62 pp.
21. "Safety Rest Areas, Roadway Vegetation, and Utility and Highway Issues," *Transportation Research Record 1326*, Transportation Research Board, National Research Council, Washington, D.C., 1991, 40 pp.
22. "Fire Hazard Reduction Guide for Roadsides," California Division of Forestry and U.S. Forest Service, Region 5, Vallejo, Calif., Jan. 1968.
23. Wyoming Interagency Vegetation Committee, "Wyoming Guidelines for Managing Sagebrush Communities with Emphasis on Fire Management," Wyoming Game and Fish Department and Wyoming Bureau of Land Management, Wyoming, Nov. 15, 2002 [Online]. Available: www.wy.blm.gov/wildlife/docs/fsbfiremgmtguidelines.pdf.
24. "Vegetation Management Program," North Carolina Department of Transportation, Raleigh [Online]. Available: http://www.doh.state.nc.us/operations/dp_chief_eng/roadside/vegetation/maintenance/vegmgmt.html.
25. "Integrated Vegetation Management for Roadsides," Washington State Department of Transportation, Olympia [Online]. Available: http://www.wsdot.wa.gov/biz/maintenance/htm/roadside-maint.html.
26. *Roadside Use of Native Plants*, B. Harper-Lore and M. Wilson, Eds., Island Press, Washington, D.C., 2000, 665 pp.
27. "Roadside Use of Native Plants," *Greener Roadsides*, Fall 1999 [Online]. Available: http://www.fhwa.dot.gov/environment/greenroadsides.htm.
28. Harper-Lore, B., "An Australian Road Review," *Public Roads*, May/June 2000, Vol. 63, No. 6, pp. 35–37.
29. Cole, H.C., Jr., N.L. Hartwig, L.J. Kuhns, and T.L. Watschke, *Roadside Vegetation Management Research Report*, Report No. PA-4620+85-08, Commonwealth of Pennsylvania, Department of Transportation, Harrisburg, 1987, 124 pp.
30. *Vegetation Management on State Highways*, South Carolina Department of Transportation, Columbia.
31. *Herbicide Operations Manual*, South Carolina Department of Transportation, Columbia.
32. *WVDOT Landscape Manual*, West Virginia Department of Transportation, Charleston.
33. "Model Certification Training Manual for Right-of-Way Pesticide Applicators," Pesticide Environmental Stewardship Program, U.S. Environmental Protection Agency, Washington, D.C. [Online]. Available: http://www2.agriculture.purdue.edu/pesp/rowmanual, 100 pp.

APPENDIX A

Survey Questionnaire

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Project 20-5, Topic 33-04

QUESTIONNAIRE

Integrated Roadside Vegetation Management

There is a wide variation among transportation agencies in terms of how they manage vegetation on all types of roadsides. This includes variation in terms of

- Policies and regulations,
- Costs and benefits,
- Environmental impacts,
- Methods of vegetation management,
- Implementation of new information and techniques,
- Re-vegetation selections, and
- Perceived effectiveness of the efforts.

This questionnaire seeks to shed light on these issues by documenting the state of practice among state and federal transportation agencies.

Persons who are familiar with your agency's statewide vegetation management program for roadsides should complete the questionnaire. *Your answers to this questionnaire are relevant and important regardless of whether your agency is actively engaged in some of the specific aspects of an integrated roadside vegetation management program.*

Please return the completed questionnaire and any supporting documents by July 15, 2002 to:

Robert L. Berger
Consulting Landscape Architect
2634 19th Way NW
Olympia, WA 98502-4181
USA

If you wish, you may fax your response to him at 360-357-6075.

If you have questions, you may contact him by telephone at 360-357-6075, or by e-mail at randdberger@attbi.com.

State of the Practice: Integrated Roadside Vegetation Management

BACKGROUND INFORMATION

Agency/Organization Responding: _____

Address: _____

_____

Name of Respondent: _____

Title: _____ Phone Number: _____

Date_____ E-mail: _____

It is intended that your responses include data for all different types of roadsides (formal landscaped areas, native areas, safety rest areas, viewpoints, wildflower plantings, endangered species habitat, stormwater facilities, etc.).

PART 1—Agency Policies & Procedures and State Laws & Regulations

1. Do you have a written policy on vegetation management on roadsides? Yes___ No___
2. Does policy require use of a defined *integrated* approach to vegetation management? Yes___ No___
3. Does policy address vegetation management in project planning and design? Yes___ No___
4. Does policy address vegetation management in project construction aspects? Yes___ No___
5. Does policy address long-term sustainability of roadside plantings? Yes___ No___
6. Does policy require consideration of maintenance impacts in design and construction of roadsides? Yes___ No___
7. Does policy require annual maintenance cost projections for vegetation management on newly constructed roadsides? Yes___ No___
8. Does state law address use of a defined *integrated* approach to pest (vegetation) management practices by state agencies? Yes___ No___
9. Does policy address *why* vegetation is managed on roadsides? Yes___ No___
10. Do state laws require your agency to control designated noxious weeds on roadside? Yes___ No___
11. Does the federal Endangered Species Act (ESA) impact your roadside vegetation management program? Yes___ No___
12. Does Executive Order 13112—Invasive Species impact your roadside vegetation management program? Yes___ No___
13. Is aesthetics a major consideration in decisions regarding roadside vegetation management programs? Yes___ No___
14. Do soil erosion concerns significantly impact your roadside vegetation management program? Yes___ No___
15. Do your state's stormwater management regulations or laws impact by specific direction your roadside vegetation management program? Yes___ No___
16. Is pavement *subsurface* (permeable base) drainage a concern in vegetation management programs? Yes___ No___

17. Is pavement *surface* drainage a concern in vegetation management programs? Yes___ No___

18. Are *accidental roadside fire starts* addressed as a concern of roadside vegetation management? Yes___ No___

19. Does policy or state law require use of *native plant species* when constructing or restoring roadside vegetation? Yes___ No___

20. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4 +).
#_____
_____

Please provide highlighted copies of supporting documents identified in the above question, if possible.

PART 2—Costs and Benefits

1. Please provide your actual average unit costs or *estimated average unit costs* (identify *estimated costs* as "est."). Please include labor, equipment, and materials costs for each of the following items:

   a. Mowing *quality turf (fine lawn)* by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   b. Mowing *roadside grass (not fine lawn)* by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   c. Mowing *quality turf (fine lawn)* by contract per acre/per cut _____; average number of cuts/year_____.

   d. Mowing *roadside grass (not fine lawn)* by contract per acre/per cut _____; average number of cuts/year_____.

   e. Mowing *designated noxious weeds* by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   f. Mowing *designated noxious weeds* by contract per acre/per cut _____; average number of cuts/year_____.

   g. Mowing Executive Order 13112—Invasive Species by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   h. Mowing Executive Order 13112—Invasive Species by contract employees per acre/per cut _____; average number of cuts/year_____.

   i. Mowing *brush/small trees* by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   j. Mowing *brush/small trees* by contract per acre/per cut _____; average number of cuts/year_____.

   k. Hand cutting *brush/small trees* by non-contract employees per acre/per cut _____; average number of cuts/year_____.

   l. Hand cutting *brush/small trees* by contract per acre/per cut _____; average number of cuts/year_____.

   m. Application of *selective herbicides* by non-contract employees to *landscape plantings* per acre/per application_____; average number of applications/year_____.

   n. Application of *selective herbicides* by contract to *landscape plantings* per acre/per application_____; average number of applications/year ____.

o. Application of *selective herbicides* by non-contract employees to *general roadsides (no landscape improvements)* per acre/per application_____; average number of applications/year_____.

p. Application of *selective herbicides* by contract to *general roadsides (no landscape improvements)* per acre/per application_____; average number of applications/year_____.

q. Application of *selective herbicides* by non-contract employees to *landscape plantings* per acre/per application_____; average number of applications/year_____.

r. Application of *selective herbicides* by contract to *landscape plantings* per acre/per application_____; average number of applications/year_____.

s. All costs (mow, spray, etc.) to meet requirements of Executive Order 13112—Invasive Species per year_____.

t. Hand weeding of *landscape plantings* by non-contract employees per acre/per event (cycle) _____; events (cycles)/year_____.

u. Release of biological control agents per site/per event_____; events/year_____.

v. Application of fertilizer to *quality turf (fine lawn)* by non-contract employees per acre/per application_____; applications/year_____.

w. Application of fertilizer to *quality turf (fine lawn)* by contract per acre/per application_____; applications/year_____.

x. Application of fertilizer to *erosion control grass (not fine lawn)* by non-contract employees per acre/per application_____; applications/year_____.

y. Application of fertilizer to *roadside grass (not fine lawn)* by contract per acre/per application_____; applications/year_____.

z. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each item (e.g., item "a +").
items_____
_____
_____

2. Benefits

a. Do you have assigned dollar values for the benefits of environmentally sensitive *maintenance methods* (e.g., mowing brush) of vegetation management over conventional maintenance methods (e.g., herbicide applications)? Yes___ No___

b. Do you have assigned dollar values for the benefits of environmentally sensitive *construction methods* (e.g., no burning of debris) of highway building over conventional construction methods (e.g., burning of debris)? Yes___ No___

c. Do you have assigned dollar values for the benefits of environmentally sensitive *design approaches* (e.g., bridges) of vegetation management over conventional design approaches (e.g., cut and fill)? Yes___ No___

d. Do you have assigned dollar values for the benefits of environmentally sensitive *materials* (e.g., organic fertilizer) for vegetation management over conventional materials (e.g., synthetic fertilizers)? Yes___ No___

e. Do you have assigned dollar values for re-vegetation with native plants over re-vegetation with introductions of plant species? Yes___ No___

f. Does your agency recognize the "social value" of environmentally sensitive approaches to roadside vegetation management, even though no dollar value is assigned to the benefit? Yes ___ No___

g. Have you used the *Community Tree Guide* from the Center for Urban Forest Research (Davis, CA) to identify costs/benefits of urban trees? Yes___ No___

h. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each item (e.g., item "a +").
items_____
_____
_____

Please provide highlighted copies of examples of issues mentioned above.

PART 3—Environmental Impacts

1. Are environmental impacts from long-term sustainability given consideration in design of new roadside projects? Yes___ No___

2. Are environmental impacts from long-term sustainability given consideration in maintenance of roadsides? Yes___ No___

3. Are environmental impacts from long-term sustainability given consideration in construction of new roadside projects? Yes___ No___

4. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4 +).
#_____
_____

Please provide highlighted copies of examples of issues mentioned above.

PART 4—Public Opinion

1. Has your agency surveyed public opinion about roadside vegetation management? Yes___ No___

2. Are you aware of any public opinion surveys regarding roadside vegetation management? Yes___ No___

3. Do you consider public opinion on roadside vegetation management practices in your state to be
Strong ____
Moderate____
Weak____

4. Has legislation been proposed or passed in your state to direct methods, or level of effort, concerning roadside vegetation management programs (i.e., convict labor, welfare recipient labor, integrated pest management approaches, adopt-a-road, etc.)?

5. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4 +).
#_____
_____

Please provide highlighted copies of examples of issues mentioned above.

PART 5—Methods of Vegetation Management

1. Is a documented integrated vegetation management program used in your agency? Yes___ No___

2. Identify the following roadside vegetation management methods that are used by your agency by indicating the percentage of the roadside acreage that it is practiced on:

   a. Mechanical ___%
   b. Cultural ___%
   c. Biological ___%
   d. Chemical ___%
   e. Integrated (documented) ___%

3. Identify the approximate acreage of your roadsides by the following categories:

   a. Formal landscape plantings _____acres
   b. Informal landscape planting _____acres
   c. Erosion control grasses _____acres
   d. Reforestation _____acres
   e. Leased for agricultural use _____acres
   f. Leased for non-agricultural use _____acres
   g. Dedicated habitat for endangered species _____acres
   h. Other _____ acres
   i. Maintained by others _____acres
   j. Total roadside right-of-way _____acres

4. Which answers to the above items represent a significant <u>change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4 +).
   #_____
   _____

Please provide highlighted copies of examples of issues mentioned above.

PART 6—Implementation

1. Has your integrated roadside vegetation management (IRVM) program been implemented by official policy? Yes___ No___

2. Has implementation of your IRVM program been accomplished by an organized training program? Yes___ No___

3. If "yes" to #2 above, has implementation of your IRVM program been accomplished by use of a consultant? Yes___ No___

4. Is your IRVM program "tied" to a GIS/GPS program? Yes___ No___

5. Are actual roadside management plans a part of your implementation program? Yes___ No___

6. Which answers to the above items represent a significant <u>change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4 +).
   #_____
   _____

Please provide highlighted copies of examples of issues mentioned above.

PART 7—Re-vegetation

1. What percentage of the *non-grass plants* used for re-vegetation is native to the state or region? _____%

2. What percentage of the *grass plants* used for re-vegetation is native to the state or region? _____%

3. What percentage of newly planted acreage requires *irrigation for establishment only*? _____%

4. What percentage of newly planted acreage requires *irrigation on a perpetual basis*? _____%

5. What percentage of newly planted acreage requires no significant maintenance work on a perpetual basis? _____%

6. How many acres are replanted annually with bulbs, seeds, or other plants for special effects? _____ acres.

7. Which answers to the above items represent a significant <u>change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4 +).
   #_____
   _____

Please provide highlighted copies of examples of issues mentioned above.

PART 8—Effectiveness

1. Do you have a performance measurement for *design of roadsides*? Yes___ No___

2. Do you have a performance measurement for *construction of roadsides*? Yes___ No___

3. Do you have a performance measurement for *maintenance of roadsides*? Yes___ No___

4. Do you have a performance measurement for the *public relations aspects of roadsides*? Yes___ No___

5. Which answers to the above items represent a significant <u>change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4 +).
   #_____
   _____

Please provide highlighted copies of examples of issues mentioned above.

PART 9—Best Management Practices (BMPs)

1. Do you have written BMPs for *all types of vegetation management activities* on roadsides? Yes___ No___

2. Do you have written BMPs for *maintenance of stormwater facilities* located within the roadsides? Yes___ No___

3. Do you have written BMPs for *controlling danger trees* on roadsides? Yes___ No___

4. Do you have written BMPs for *controlling noxious weeds* within the roadsides? Yes___ No___

5. Do you have written BMPs for *controlling trees that are or may be roadside obstructions?* Yes___ No___

6. Do you have written BMPs for *mowing grasses* on roadsides? Yes___ No___

7. Do you have written BMPs for *mowing brush/small trees* on roadsides? Yes___ No___

8. Do you have written BMPs for *other types of horticultural activities performed on vegetation* within the roadside? Yes___ No___

9. Which answers to the above items represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4 +).
   #_____
   _____

Please provide highlighted copies of examples of issues mentioned above.

PART 10—Additional Items

1. If there are studies or documents done by you or others you consider to be useful guides or best management practices (BMPs) for integrated roadside vegetation management programs, please identify them.
   _____
   _____
   _____
   _____
   _____

2. If there are research studies that cover aspects of integrated roadside vegetation management that you consider to be useful, please identify them.
   _____
   _____
   _____
   _____
   _____
   _____
   _____

END OF QUESTIONNAIRE

Please return the completed questionnaire and any supporting documents by July 15, 2002, to

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USA

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APPENDIX B

Respondents

States Responding

Alaska
Arkansas
Connecticut
Florida
Illinois
Indiana
Kentucky
Maine
Maryland
Minnesota
Montana
Nebraska
New Mexico
New York
Ohio
Pennsylvania
South Carolina
Texas
Utah
Washington
West Virginia

Canadian Provinces Responding

Alberta
British Columbia
Manitoba
Quebec
Saskatchewan

APPENDIX C

Survey Responses

PART 1—Agency Polices & Procedures and State Laws & Regulations

1. Do you have written policy on vegetation management on roadsides?

Yes	AK, AR, CT, FL, IL, IN, KY, ME, MD, MN, NE, NY, OH, PA, SC, TX, WA, WV, AB, BC, SK

2. Does policy require use of a defined *integrated* approach to vegetation management?

Yes	AR, FL, IL, MD, MN, NY, OH, PA, TX, WA, AB

3. Does policy address vegetation management in project planning and design?

Yes	AK, AR, CT, FL, IL, IN, MD, PA, SC, TX, WA

4. Does policy address vegetation management in project construction aspects?

Yes	AK, AR, FL, IL, IN, MD, PA, SC, TX, WA, AB, BC

5. Does policy address long-term sustainability of roadside plantings?

Yes	AK, AR, FL, IL, MD, MN, TX, WA, AB

6. Does policy require consideration of maintenance impacts in design and construction of roadsides?

Yes	AK, AR, CT, FL, IL, NY (mowing limits manual), TX, WA

7. Does policy require annual maintenance cost projections for vegetation management on newly constructed roadsides?

Yes	FL, WA

8. Does state law address use of a defined *integrated* approach to pest (vegetation) management practices by state agencies?

Yes	FL, ME, MD, MN, MT, WA, AB, SK

9. Does policy address *why* vegetation is managed on roadsides?

Yes	AK, AR, FL, IL, KY, ME, MD, MN, NE, NY, OH, PA, SC, TX, WA, WV, AB, BC, SK

10. Do state laws require your agency to control designated noxious weeds on roadside?

Yes	FL, IL, IN, KY, MD, MN, MT, NE, NM, OH, PA, UT, WA, AB, BC, SK

11. Does the federal Endangered Species Act (ESA) impact your roadside vegetation management program?

Yes	AR, CT, IL, IN, KY, ME, MD, MN, NM, OH, PA, SC, TX, UT, WA

12. Does Executive Order 13112—Invasive Species impact your roadside vegetation management program?

Yes	AR (when implemented), CT, IL, KY, MD, NM, NY, OH, PA, SC, TX, UT

13. Is aesthetics a major consideration in decisions regarding roadside vegetation management programs?

Yes	AK, AR, CT, FL, IN, KY, MD, MN, NE, OH, SC, TX, UT, WA (sometimes), WV, BC

14. Do soil erosion concerns significantly impact your roadside vegetation management program?

Yes	AK, AR, CT, FL, IL, IN, KY, ME, MD, MN, MT, NE NM, OH, PA, SC, TX, UT, WA, WV, AB

15. Do your state's stormwater management regulations or laws impact by specific direction your roadside vegetation management program?

Yes	AR, CT, FL, IL, IN, MD, MN, NM, TX, UT, WA

16. Is pavement *subsurface* (permeable base) drainage a concern in vegetation management programs?

Yes	CT, FL, MD, UT, WV, BC

17. Is pavement *surface* drainage a concern in vegetation management programs?

Yes	CT, FL, IL, IN, ME, MD, MN, MT, NE NM, OH, PA, SC, TX, UT, WA, WV, BC

18. Are *accidental roadside fire starts* addressed as a concern of roadside vegetation management?

Yes	FL, IL, IN, MD, OH, TX, WA, BC

19. Does policy or state law require use of *native plant species* when constructing or restoring roadside vegetation?

Yes	FL, IL, MD, MN (policy; no state law), MT, NE (but not limited to natives), OH, WA (but not exclusively), SK (guidelines on use of native species in some areas)

20. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4 +).

CT	12+
FL	See note (decentralized into eight districts, each with turf management plan)
IL	All of the above
IN	15
KY	12+
ME	11
MD	2+, 5+, 8+, 11+, 12+, 19+
MN	15, 19, 11
MT	19, 16
NE	None—we have been doing this since 1964
NM	No significant changes in the past 10 years
OH	1+, 2+, 13+
PA	12+
TX	12+, 15+
UT	None
WA	1–6+, 8+, 9+, 15+, 16+, 19+
WV	1+
AB	1+, 3+, 4+, 5+, 9+
QC	11+

PART 2—Costs and Benefits

1. Please provide your actual average unit costs or estimated average unit costs (identify *estimated costs* as "est."). Please include labor, equipment, and materials cost for each of the following items:

a. Mowing *quality turf (fine lawns)* by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	$187.26; 15
IL	No response; 3
IN	0; 0
KY	$75 est.; 15
ME	No response; 4
MD	$70; 7
MN	$35; 4
MT	N/A
NM	Unknown
OH	(See note that all cost info is held at districts)
PA	N/A; N/A
SC	N/A; N/A
TX	N/A; No response
WA	$31, 22
WV	$20.62; 3
AB	Do not do
SK	N/A

b. Mowing *roadside grass (not fine lawn)* by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
AR	No response; 3
CT	$57 per swath mile; 3
FL	$15.73; 10
IL	No response; 3
IN	$5,761,801 total; 3
KY	$40 est.; 3
ME	$35 est.; 2
MD	$60; 5
MN	$40; 2
MT	$2.38; 1 to 2
NM	Unknown
NY	$34; 3
PA	$56; 3
SC	$26 est.; 5
TX	$33.43; 2
UT	$36; 1
WA	$3.20; 1
WV	$36.83; 1
AB	Do not do
SK	$15 est.; 1

c. Mowing *quality turf (fine lawn)* by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	$73.97; 15
IL	N/A
IN	0; 0
KY	$125; 14
ME	N/A
MD	$110; 7
MT	N/A
NM	Unknown
PA	N/A; N/A
SC	$37.50; 40
TX	N/A
WA	N/A
WV	0; 0
AB	Do not do
SK	N/A

d. Mowing *roadside grass (not fine lawn)* by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
AR	$40; 3
CT	0; 0
FL	$13.92; 10
IL	N/A
IN	$2,563,102 total; 3
KY	$37; 3
ME	No response; 1
MD	$130; 5
MT	$5.75; No response
NM	Unknown
PA	$79; 4
SC	$78; 5
TX	$22.91; 2
WA	N/A
WV	0; 0
AB	$15; 1–2
BC	$80; 3 (variable)
SK	$13; 1

e. Mowing *designated noxious weeds* by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	Included in “b” above, no cost breakdown
FL	N/A
IL	$300; 1
IN	N/A
KY	N/A
ME	N/A
MD	$40; 2
MN	$50 est.; ±2
MT	N/A
NM	Unknown
PA	$56; 3
SC	N/A; N/A
TX	$33.43; 2
WA	N/A
WV	None; 0
AB	Do not do
SK	N/A

f. Mowing *designated noxious weeds* by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	N/A
IL	N/A
IN	N/A
KY	N/A
ME	N/A
MD	$50; 2
MT	N/A
NM	Unknown
PA	$79; 4
SC	N/A; N/A
TX	$22.91; 2
WA	N/A
WV	None; 0
AB	$15; 1-2

g. Mowing Executive Order 13112—Invasive Species by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	N/A

IL	$125; 1
IN	N/A
KY	N/A
ME	N/A
MD	0
MT	N/A
NE	0; 0
NM	Unknown
PA	$56; 3
SC	N/A; N/A
TX	$33.43; 2
UT	No response
WA	N/A
WV	None; 0
AB	Do not do
SK	N/A

h. Mowing Executive Order 13112—Invasive Species by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0 “conn sprays”
FL	N/A
IL	N/A
IN	N/A
KY	N/A
ME	N/A
MD	0
MT	N/A
NE	0; 0
NM	Unknown
PA	$79; 4
SC	N/A; N/A
TX	$22.91; 2
WA	N/A
WV	None; 0
AB	Do not do
SK	N/A

i. Mowing *brush/small trees* by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	Included with “b” above, there is no cost breakdown
FL	N/A

IL	$125; 1
IN	N/A
KY	$150 est.; 1
ME	N/A
MD	$500; 1
MN	$75; 2
MT	N/A
NM	Unknown
PA	$39; 1
SC	$26 est.; 1
TX	$33.43; 2
WA	$14; 0.33
WV	$94.03; 1
AB	Do not do
SK	$15; 1

j. Mowing *brush/small trees* by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	N/A
IL	N/A
IN	N/A
KY	N/A
ME	N/A
MD	$305; 1
MT	N/A
NM	Unknown
PA	$114; 1
SC	N/A; N/A
TX	$22.91; 2
WA	N/A
WV	0; 0
AB	Do not do
BC	$500 per shoulder kilometer; variable
SK	$13; 1

k. Hand cutting *brush/small trees* by non-contract employees per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	$250 per swath mile; 1
FL	$439.11; 2
IL	$225; 1
IN	$554,407 total; 1
KY	$2,000 est.; 1

ME	No response; 1
MD	$1,000; 1
MN	?; ?
MT	N/A
NM	Unknown
NY	$253; 1/3 (every 3 yr) 0.33
PA	$31; 1
SC	$30 est.; 1
TX	N/A; N/A ($5,552,184.79/yr)
WA	$60; 0.33
WV	$254.55; 1
AB	Do not do
SK	N/A

l. Hand cutting *brush/small trees* by contract per acre/per cut _____; average number of cuts/year _____.

AK	N/A
CT	0; 0
FL	$130.45; no response
IL	0; 0
IN	0: 0
KY	$2,000 est.; 1
ME	$1,500 est.; 1
MD	$900; 1
MT	N/A
NM	Unknown
PA	N/A; N/A
SC	N/A; N/A
TX	N/A; N/A
WA	N/A
WV	0; 0
AB	$100; less than 1
SK	N/A

m. Application of *selective herbicides* by non-contract employees to *landscape plantings* per acre/per application _____; average number of applications/year _____.

AK	N/A
CT	0; 0
FL	$59.35; no response
IL	$150; 1
IN	0; 0
KY	N/A
ME	No response; 1
NM	Unknown
PA	N/A; N/A

SC	$35; 2
TX	N/A; N/A (Part of $4,306,754.55/yr)
UT	$20; 4
WA	$140; 1
WV	0; 0
AB	Do not do
SK	N/A

n. Application of *selective herbicides* by contract to *landscape plantings* per acre/per application _____; average number of applications/year _____.

AK	N/A
CT	0; 0
FL	$25.47; no response
IL	$120; 1
IN	0; 0
KY	N/A
NM	Unknown
PA	N/A; N/A
SC	Contract; varies
TX	N/A; N/A (Part of $14,834,392.74/yr)
UT	No response
WA	N/A
WV	0; 0
AB	Do not do
BC	0; 0
SK	N/A

o. Application of *selective herbicides* by non-contract employees to *general roadsides (no landscape improvements)* per acre/per application _____; average number of applications/year _____.

AK	N/A
CT	0; 0
FL	$2.45; no response
IL	0; 0
IN	$1,489,704 total; 1
KY	$16; 2
ME	$40 est.; 1
MD	$50; 1
MN	$40; 1
MT	No response; 1
NM	Unknown
NY	$152; 1
PA	$125; 1
SC	$64; varies
TX	N/A

UT	$50; 1
WA	$13.60; 1
WV	$50; 1
AB	Do not do
SK	$167; 1 (to problem areas only)

p. Application of *selective herbicides* by contract to *general roadsides (no landscape improvements)* per acre/per application _____; average number of applications/year _____.

AK	N/A
CT	$455.16 average; 1
FL	$2.37; no response
IL	0; 0
IN	$364,888.00 total; 1
KY	N/A
ME	$30; 1
MD	$46; 1
MN	$45; 1
MT	$6.87; 1
NM	Unknown
PA	$115; 1
SC	N/A; N/A
TX	N/A
WA	N/A
WV	0; 0
AB	$40; 1–2
BC	0; 0

q. Application of *selective herbicides* by non-contract employees to *landscape plantings* per acre/per application _____; average number of applications/year _____.
(Repeat of "m" above)

r. Application of *selective herbicides* by contract to *landscape plantings* per acre/per application _____; average number of applications/year _____.
(Repeat of "n" above)

s. All costs (mow, spray, etc.) to meet requirements of Executive Order 13112—Invasive Species per year _____.

AK	N/A
CT	There is no cost breakdown.
IL	$700,000
IN	0
KY	N/A
ME	N/A
MN	?
NE	0

NM	Unknown
PA	$5.2 million
SC	$45/acre/application
TX	$53,300,305.99
UT	$10,000
WA	N/A
WV	0
AB	Do not do
SK	N/A

t. Hand weeding of *landscape plantings* by non-contract employees per acre/per event (cycle) _____; events (cycles)/year _____.

AK	N/A
CT	0; 0
IL	0; 0
IN	0; 0
KY	N/A
ME	N/A
MD	0; no response
NM	Unknown
PA	N/A; N/A
SC	$20 est.; 1–2
TX	N/A ($1,966,566.08/yr)
UT	$10; 4
WA	N/A
WV	0; 0
AB	Do not do
SK	N/A

u. Release of biological control agents per site/per event _____; events/year _____.

AK	N/A
CT	0; 0
IL	$2; 4
IN	0; 0
KY	N/A; 2
ME	Varies; mitigation sites only
MD	0; 0
MN	500,000 beetles/yr; 6 locations
NM	None; none
PA	$0
SC	N/A; N/A
TX	N/A
UT	$60; 1
WA	$200; 0.5

WV	0; 0
AB	Do not do
SK	N/A

v. Application of fertilizer to *quality turf (fine lawn)* by non-contract employees per acre/per application _____; applications/year _____.

AK	N/A
CT	0; 0
FL	$25.22; no response
IL	N/A
IN	0; 0
KY	N/A
ME	N/A
MD	$100; 1
NM	None; none
PA	N/A; N/A
SC	N/A; N/A
TX	Included in picnic and rest area maintenance
WV	0; 0
AB	Do not do
SK	N/A

w. Application of fertilizer to *quality turf (fine lawn)* by contract per acre/per application _____; applications/year _____.

AK	N/A
CT	0; 0
FL	$167.45; no response
IL	0
IN	0; 0
KY	N/A
ME	N/A
MD	$90; 1
NM	None; none
PA	N/A; N/A
SC	Contract; 1–2
TX	Included in picnic and rest area maintenance
WV	0; 0
AB	Do not do
BC	Variable; 2
SK	N/A

x. Application of fertilizer to *erosion control grass (not fine lawn)* by non-contract employees per acre/per application _____; applications/year _____.

AK	N/A
CT	0; 0

FL	$25.22; no response
IL	N/A
IN	0; 0
KY	$50; 1
ME	N/A
MD	$45; 1
NE	0; 0
NM	None; none
PA	N/A; N/A
SC	N/A; N/A
TX	N/A; N/A
WV	0; 0
AB	Do not do
SK	N/A

y. Application of fertilizer to *roadside grass (not fine lawn)* by contract per acre/per application _____; applications/year _____.

AK	N/A
CT	0; 0
FL	$167.45; no response
IL	0
IN	0; 0
KY	N/A
ME	N/A
MD	$55; 1
NE	0; 0
NM	None; none
PA	N/A; N/A
SC	N/A; N/A
TX	N/A; N/A
UT	No response
WA	$160; 0.33
WV	0; 0
AB	Do not do
BC	0; 0
SK	N/A

z. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each item (e.g., item a+).

AK	N/A
CT	None
FL	Information from maintenance management system—please use estimate with caution
IL	u
MN	Costs are going up, u—releasing beetles
NM	No significant change in the past 10 years

OH	"I do not have a method of recovering any of the above information. The above information is held by the individual at each district throughout the state."
PA	N/A
TX	Especially e, f, g, h, and s. Generally all of these expenses have increased over the last 10 years.
UT	s+, t+
WV	o+, l+, k+
AB	None
BC	y– (note on reductions due to cost saving measures)

2. Benefits

a. Do you have assigned dollar values for the benefits of environmentally sensitive *maintenance methods* (e.g., mowing brush) of vegetation management over conventional maintenance methods (e.g., herbicide applications)?

Yes	FL, IL, SC, TX

b. Do you have assigned dollar values for the benefits of environmentally sensitive *construction methods* (e.g., no burning of debris) of highway building over conventional construction methods (e.g., burning of debris)?

Yes	FL, IL

c. Do you have assigned dollar values for the benefits of environmentally sensitive *design approaches* (e.g., bridges) of vegetation management over conventional design approaches (e.g., cut and fill)?

Yes	FL

d. Do you have assigned dollar values for the benefits of environmentally sensitive *materials* (e.g., organic fertilizer) for vegetation management over conventional materials (e.g., synthetic fertilizers)?

Yes	FL, SC

e. Do you have assigned dollar values for re-vegetation with native plants over re-vegetation with introductions of plant species?

Yes	FL, SC (in some cases)

f. Does your agency recognize the "social value" of environmentally sensitive approaches to roadside management, even though no dollar value is assigned to the benefit?

Yes	FL, IL, IN, KY, ME, MD, MN, MT, NE, OH, PA, TX, UT, WA, QC, SK

g. Have you used the *Community Tree Guide* from the Center for Urban Forest Research (Davis, CA) to identify costs/benefits of urban trees?

Yes	IL, UT, WA

h. Which answers to the above questions represent a <u>significant change in the past 10 years</u>? Please indicate a + or – for each item (e.g., "a+").

AK	0
AR	0
FL	Info should be obtained from pay item list contract document and the environmental management office.
IL	b–h

MT	f
NE	We have used native seed and wildflowers, limited mowing and similar methods since late 1960s, early 1970s. Now it is environmentally correct or contact sensitive design.
NM	No significant change in the past 10 years
OH	None
PA	N/A
TX	d
UT	f+
WA	a+, c+
AB	None
QC	2+

PART 3—Environmental Impacts

1. Are environmental impacts from long-term sustainability given consideration in design of new roadside projects?

Yes	AK, CT, IL, IN, ME, MN, NE, OH, PA, TX, UT, WA, WV, AB, QC

2. Are environmental impacts from long-term sustainability given consideration in maintenance of roadsides?

Yes	CT, IL, IN, ME, MN, NE, OH, PA, TX, UT, WA, WV, AB, QC

3. Are environmental impacts from long-term sustainability given consideration in construction of new roadside projects?

Yes	CT, IL, ME, MN, NE, OH, PA, TX, UT, WA, WV, AB, QC

4. Which answers to the above questions represent a <u>significant change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4+).

AK	1+, 2–, 3–, 4–
CT	1+
FL	Answers and documents should come from the environ. office
IL	1+, 2+, 3+, 4+
IN	4+ (?)
NM	No significant change in the past 10 years
OH	None
PA	N/A
TX	1, 2, 3
AB	1+, 2+, 3+
QC	2+

PART 4—Public Opinion

1. Has your agency surveyed public opinion about roadside vegetation management?

Yes	FL, IL, MN, OH, PA, TX, UT, WA, BC

2. Are you aware of any public opinion surveys regarding roadside vegetation management?

Yes	FL, IL, MN, PA, TX, UT, WA, AB (not from Canada, technical and trade magazines), BC, QC

3. Do you consider public opinion on roadside vegetation management practices in your state to be strong, moderate, or weak?

Strong	CT, IL, MD, NE (we are a prairie state!), WA (herbicide use)
Moderate	AR, KY, ME, OH, PA, SC, TX (safety, wildflowers, erosion control, aesthetics), UT, WA (aesthetics), BC, QC, SK
Weak	AK, IN, MN, MT, NM, WV, AB

4. Has legislation been proposed or passed in your state to direct methods, or level of effort, concerning roadside vegetation management programs (e.g., convict labor, welfare recipient labor, integrated pest management approaches, adopt-a-road, etc.)?

Yes	FL, IL, ME (proposed, not passed), MD, MT, NM (proposed, not passed), OH, PA, SC, TX, WA (IPM and Adopt-A-Highway)

5. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4+).

AK	None significant
CT	3+
IL	1+, 2+, 3+, 4+, 5+
MT	4+
NM	No significant change in the past 10 years
OH	None
PA	N/A
TX	4+
WA	3+, 4+
AB	None
QC	1+

PART 5—Methods of Vegetation Management

1. Is a documented integrated vegetation management program used in your agency?

Yes	FL, ME, MN, PA, SC, UT, AB

2. Identify the following roadside vegetation management methods that are used by your agency by indicating the percentage of the roadside acreage that it is practiced on:

a. Mechanical ___ %
b. Cultural ___ %
c. Biological ___ %
d. Chemical ___ %
e. Integrated (documented) ___ %

	Mechanical	Cultural	Biological	Chemical	Integrated
AK	100%				
AR	100%			30%	
CT	90%			10%	
FL	18%	65%	2%	15%	
IL	90%		1%	10%	
IN	90%			70%	

	Mechanical	Cultural	Biological	Chemical	Integrated
KY	50%	10%	0.5%	25%	
ME	60%	5%		35%	
MD	98%	5%	1%	15%	
MT	90%			40%	
NM	50%			10%	
NY	95%	90% (?)		5%	100%
OH	50%	10%		40%	
PA	50%	3%		7%	40%
SC	60%	5%		35%	
UT	50%	10%	1%	30%	100%
WA	36%	3%	1%	60%	2%
WV	100%	<1%		100%	
AB	60%			40%	
BC	99%	1%			
SK	90%			10%	

3. Identify the approximate acreage of your roadsides by the following categories:

a. Formal landscape plantings ___ acres.
b. Informal landscape plantings ___ acres.
c. Erosion control grasses ___ acres.
d. Reforestation ___ acres.
e. Leased for agricultural use ___ acres.
f. Leased for non-agricultural use ___ acres.
g. Dedicated habitat for endangered species ___ acres.
h. Other ___ acres.
i. Maintained by others ___ acres.
j. Total roadside right-of-way ___ acres.

	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.
AK	10%		90%						15%	Unknown
AR	<1%	<1%		5,000 est.					31,500	150,000
CT										
FL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,600,000
IL	50	100,000+	10,000	50,000	N/A	N/A	1,000		N/A	155,000
IN	0	60	0	0	0	0	0	0	0	100,000
KY	240	100	130,000	70,000	0	0	10	0	0	200,000
ME	500	500	4,000	2,000	0	0	0	1,000 forest	0	8,000
MD	20	100	18,108	2,348				0	100	22,108
MN					0	0		160,000 mowable		250,000
MT	1,000	1,000	120,000	0	0	0	0			122,000
NM	100	500	None	None	None	None	None	99,400	100	100,000
OH	Unknown	Unknown	Unknown	Unknown	0	0	Unknown	Unknown	Unknown	278,140
PA	250	2,500	120,000	20,000	0	0	100	35,000	1,800	180,000
SC	100+	1,100	305,500	0	0	0	0.5	200	200	305,500+
TX										1,100,000
UT	1,000		200,000	100,000						300,000

	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.
WA										100,000
WV	500	0	25,000	0	0	1,000	0		0	85,000
AL	Don't know									
BC	410									85,000 lane km
SK										1,266,243

4. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4+).

AK	None significant
FL	Info was obtained from maintenance management system—please use caution with these figures and as guidelines only!
IL	a–, b–, c+, d+, g+, j–
NM	No significant change in the past 10 years
OH	None
PA	N/A
TX	3
WV	a+, c+

PART 6—Implementation

1. Has your integrated roadside vegetation management (IRVM) program been implemented by official policy?

Yes	FL, ME, MD, MN, NY, PA, TX, WV, WA (in design, but not in maintenance)

2. Has implementation of your IRVM program been accomplished by an organized training program?

Yes	ME (not required, but used), MD, MN, NE (not required, but used), NY, OH, PA, SC (not required, but used), TX, UT (not required, but used), WA, WV (not required, but used)

3. If "yes" to #2 above, has implementation of your IRVM program been accomplished by use of a consultant?

ME	No
MD	No
MN	No
NE	No
NY	No
OH	No
PA	No
SC	No
TX	No
UT	No
WA	5% by consultant
WV	No

4. Is your IRVM program "tied" to a GIS/GPS program?

Yes	MD, UT

5. Are actual roadside management plans a part of your implementation program?

Yes	FL, IL, ME, MD, MN, MT, NM, OH, PA, SC, TX, UT, AB, QC

6. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4+).

AK	N/A
FL	The roadside vegetation management plans are responsibility of each district office to draft and carry out.
IL	1–, 2–, 3–, 4–, 5–
MD	4+
MT	5
NM	No significant change in the past 10 years
OH	1+, 2+
PA	N/A
UT	2+, 3+, 4+, 5+
WA	1+, 2+, 3+, 4+, 5+
AB	1+
QC	4+, 5+

PART 7—Re-vegetation

1. What percentage of the *non-grass plants* used for re-vegetation is native to the state or region?

AK	99%
AR	100%
CT	80%
IL	75%
IN	90%
KY	75%
ME	>10%
MD	5%
MN	25%
MT	95%
NE	90%
NM	80%
NY	Unknown
OH	80%
PA	70%
SC	50% est.
TX	100%
UT	90%
WA	89%
WV	80%
AB	0%
BC	90%
SK	N/A

2. What percentage of the *grass plants* used for re-vegetation is native to the state or region?

AK	99%
AR	100%
CT	10%
IL	50%
IN	5%
KY	85%
ME	0%
MD	10%
MN	25%
MT	95%
NE	90%
NM	90%
NY	Relatively few, >5% est.
OH	40%
PA	0%
SC	10% est.
TX	46%
UT	80%
WA	15%
WV	50%
AB	>10%
BC	10%

3. What percentage of newly planted acreage requires *irrigation for establishment only*?

AK	90%
AR	50% (watering only during dry weather)
CT	100%
IL	0%
IN	0%
KY	0%
ME	0%
MD	0%
MN	0%
MT	0.1%
NE	0%
NM	20%
NY	0%
OH	0%
PA	0%
SC	10% est.
TX	75%
UT	1%
WA	25%
WV	0%

AB	0%
BC	95%
SK	Irrigation is not used

4. What percentage of newly planted acreage requires *irrigation on a perpetual basis*?

AK	10%
AR	0%
CT	0%
IL	0%
IN	0%
KY	0%
ME	0%
MD	0%
MN	0%
MT	0.1%
NE	0%
NM	1%
NY	0%
OH	0%
PA	0%
SC	25%
TX	0%
UT	2%
WA	2%
WV	0%
AB	0%
BC	5%
SK	N/A

5. What percentage of newly planted acreage requires no significant maintenance work on a perpetual basis?

AK	99%
AR	50%
CT	100%
IL	0%
IN	30%
KY	0%
ME	>10%
MD	65%
MN	80%
MT	99%
NE	100%
NM	20%
OH	50%
PA	70% (mowing is significant)
SC	N/A

TX	100%
WA	75%
WV	20%
AB	80%
BC	90%
SK	0% (all vegetation within the right-of-way requires mowing)

6. How many acres are replanted annually with bulbs, seeds, or other plants for special effects? ____ acres.

AK	0
AR	1,000 est.
CT	0
IL	2
IN	30
KY	50
ME	0
MD	200
MN	20
MT	0
NM	100
NY	0
OH	50
PA	100
SC	550
TX	0
UT	0
WA	2
WV	200
AB	0
BC	Almost none
SK	0

7. Which answers to the above questions represent a <u>significant change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4+).

AK	None significant
IL	1+, 2+, 3–, 4–, 5–, 6+
IN	6+
MD	1+, 2+, 6+
MT	1, 2
NM	No significant change in the past 10 years
OH	6+
PA	N/A
WA	3–, 4–, 5+
BC	6–

PART 8—Effectiveness

1. Do you have a performance measurement for *design of roadsides*?

Yes	FL, IN, MD, OH, PA (design guide manual)

2. Do you have a performance measurement for *construction of roadsides*?

Yes	FL, IN, MD, OH, PA (standard construction planting stats. and construction specs.)

3. Do you have a performance measurement for *maintenance of roadsides*?

Yes	AR (quantity of man-hours worked only), FL, MD, NE, NY, OH, PA, SC, UT, WA, WV, BC, SK

4. Do you have a performance measurement for the *public relations aspects of roadsides*?

Yes	FL, OH, PA

5. Which answers to the above questions represent a <u>significant change in the past 10 years</u>? Please indicate a + or – for each (e.g., #4+).

AK	None significant
IL	1–, 2–, 3–, 4–
MD	3+
NM	No significant change in the past 10 years
OH	4+ (we are in the process of creating a survey to find out our customer satisfaction rate)
PA	4+
UT	3+
WA	3+
WV	3+
QC	3+

PART 9—Best Management Practices (BMPs)

1. Do you have written BMPs for *all types of vegetation management activities* on roadsides?

Yes	AR (manual for vegetation control), CT, IL, MD, NE, OH, UT, AB (covered by contract specs.)

2. Do you have written BMPs for *maintenance of stormwater facilities* located within the roadsides?

Yes	MD, TX, UT, WA, WV, QC

3. Do you have written BMPs for *controlling danger trees* on roadsides?

Yes	AK, CT, IN, MD, PA, TX, QC

4. Do you have written BMPs for *controlling noxious weeds* within the roadsides?

Yes	AR, IL, MD, NE, OH, PA, TX, UT, QC

5. Do you have written BMPs for *controlling trees that are or may be roadside obstructions*?

Yes	AK, CT, IL, MD, NE, PA, TX, UT, QC

6. Do you have written BMPs for *mowing grasses* on roadsides?

Yes	AR, CT, IL, MD, NE, NY, OH, PA, TX, UT, WV, QC, SK

7. Do you have written BMPs for *mowing brush and small trees* on roadsides?

Yes	AR, CT, IL, MD, PA, TX, WV, QC, SK

8. Do you have written BMPs for *other types of horticultural activities performed on vegetation* within the roadsides?

Yes	IL, NE (tree trimming by contract), TX, QC

9. Which answers to the above questions represent a significant change in the past 10 years? Please indicate a + or – for each (e.g., #4+).

AK	None significant
CT	3+, 5+
IL	1+, 2–, 3–, 4+, 5+, 6+, 7+, 8+
MD	4+, 6+
NM	No significant change in the past 10 years
OH	None
PA	N/A
SC	We have no written/formalized BMPs per se, but have included similar guidance information in our vegetation management directory)
WA	We will be working on all of these as a result of negotiations over ESA issues.
WV	6+, 7+
QC	2+, 4+, 6+

PART 10—Additional Items

1. If there are studies or documents done by you or others you consider to be useful guides or BMPs for integrated roadside vegetation management programs, please identify them.

IL	None
NM	The NM State Highway & Transportation Department developed an experimental project for noxious weed control in Taos County. Goat grazing was used on a 6-mi stretch of state highway to control infestations of noxious weeds. This method may be used in the future, as well.
NY	Alternatives to herbicides are being researched and field tested.
PA	A. PennDOT construction specifications–section 800: Roadside Development; Publication 408; section 804–seeding and soil supplements section 808–plants, planting, and transplanting. B. *Roadside Vegetation Management Manual*—Penn State University/PennDOT (1987 and 1992) C. Publication 408 on PennDOT website.
SC	Engineering Directive No. M-29, "Vegetation Management on State Highways" and *Herbicide Operations Manual*
WA	"Integrated Vegetation Management for Roadsides" WSDOT, July 1997 [Online]. Available: http://www.wsdot.wa.gov/fossc/maint/pdf/IVM.pdf
WV	*VDOT Landscape Manual* and *PennDOT Vegetation Manual*
BC	"Erosion Draw" by John McCullah, and "How to Develop and Implement an Integrated Vegetation Management Program" by NRVMA (1997)

2. If there are research studies that cover aspects of integrated roadside vegetation management that you consider to be useful, please identify them.

AK	Univ. of Alaska–Fairbanks—Cooperative Extension Service; Strategic Plan for Noxious and Invasive Plants Management in Alaska
IL	We are preparing a study on Teasel and how to control this plant.
PA	A. Penn State University—Roadside vegetation management website: [Online]. Available: rvm.cas.psu.edu/intropage.html B. 14 Annual Research Reports—PennDOT/Penn State Roadside Vegetation Management; available at the website cited in “A”
BC	WSDOT publications (2)—“IVM for Roadsides" (July 1997) and “Roadside Classification Plan” (1996)

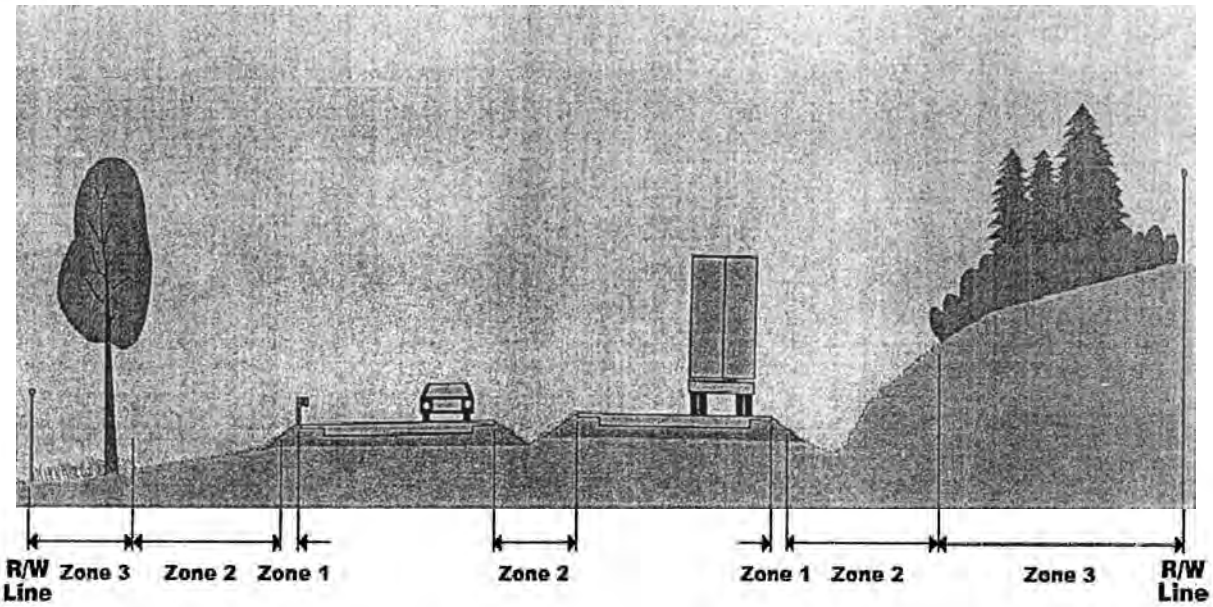
END OF QUESTIONNAIRE

APPENDIX D

Illustration of Roadside Zone

Figure 7.01 shows a cross-section of a typical divided highway, illustrating typical relationships of the Roadside Management Zones within the highway right of way and giving examples of the functional objectives as they apply to the three zones.

Typical Roadside Management Zones



Functional Zone Objectives

Zone 1 – Vegetation Free
(0 to 2 feet from pavement or as necessary)

- Provide for surface drainage
- Reduce fire potential
- Provide for visibility and maintenance of roadside hardware
- Prevent pavement breakup by invasive plants
- Provide sight distance for passing, stopping and at intersections
- Prevent the buildup of wind blown debris and winter sand at the pavement edge

Zone 2 – Operational
(From Zone 1 or pavement edge to meet operational and maintenance needs)

- Maintain design width for vehicle recovery
- Provide sight distance for passing, stopping, at interchanges and at intersections
- Maintain hydraulic capacity of ditches
- Eliminate vegetative obstructions (trees with a trunk diameter of 4" or more
- Control weeds
- Prevent erosion
- Provide wildlife habitat where compatible with roadway traffic
- Accommodate underground utilities
- Enhance visual quality

Zone 3 – Transition/Buffer
(From Zone 2 to Right of Way line)

- Promote self-sustaining plant communities
- Blend and/or screen adjacent surroundings to meet the goals and objectives of the Roadside Classification Plan
- Eliminate hazard trees causing excessive shade (ice and frost potential) on the highway pavement
- Control weeds
- Prevent erosion
- Maintain and enhance visual quality
- Preserve wetlands and wildlife habitat
- Accommodate utilities
- Preserve and conserve native plants and wildflowers

APPENDIX E

Examples of Best Management Practices

Highway Mowing Guidelines—Nebraska Department of Roads, undated

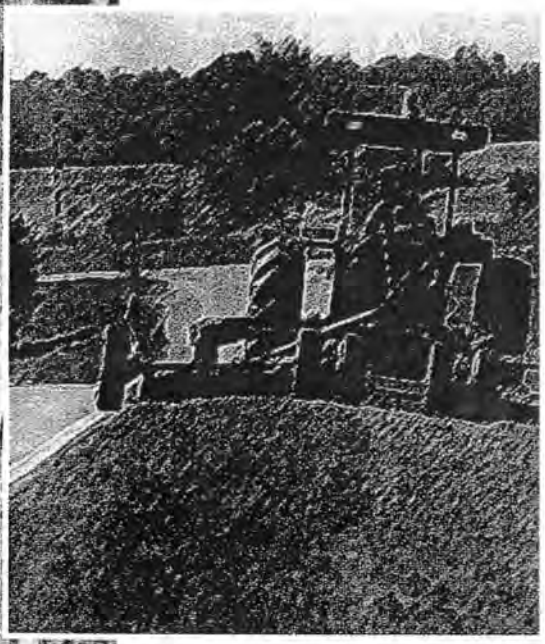
Chapter 7: Integrated Roadside Vegetation Management, North Carolina DOT, Oct. 1998

Chapter 1: Best Management Practice No. 1, Minnesota Department of Transportation, Sep. 2000

Chapter 5, Section 1: Reasons for Pruning, Texas Department of Transportation, Nov. 1993

Best Management Practices—Blackberry Control, Pierce County, Washington, Public Works and Utilities, Environmental Services—Rivers Management Office, Dec. 1995

Highway Mowing Guidelines



Nebraska Department Of Roads

Highway Mowing Guidelines

Section I
General Instructions

1. Slope Mowing

Rural Areas - Slopes 3:1 and steeper shall not be mowed and shall be identified with a marker, or a slope indicator shall be attached to each tractor that is used for mowing.

Urban Areas - Some 3:1 and steeper slopes will be mowed. Use the equipment specifically designed for the operation.

2. Mowing Height

Rotary mowers shall be set no closer than five (5) inches to the ground. The cutting height shall be frequently checked by the supervisor.

3. First Mowing - *(by Memorial Day)*

Interstate and Expressways

Median - Minimum width is 5 feet - if wildflowers are in the median - maximum width is 8 feet. Without flowers - maximum width is 15 feet.

The Outside - Minimum width is 5 feet - if wild flowers are in the first 15 feet then the maximum width is also 8 feet. Without wildflowers - maximum width is 15 feet.

Other Highways

Surfaced Shoulders - Minimum width is 5 feet - maximum width is 15 feet.

Turf Shoulders - Minimum and maximum width is 15 feet *(except where 15 feet would be a hazard to the operator or to the public.)*

4. Second Mowing

The second mowing will be directed at correcting sight distance problems wherever they occur. The mowers may be roaded between sites. Sight distance may have to be corrected more than once - minimum mowing width is 5 feet - maximum mowing width is 15 feet unless sight distance dictates more.

5. Final Mowing - *(after Labor Day)*

As needed for snow control and to finish the total mowing of the right-of-way in areas that are scheduled for a total mow-out this year. Mowing to control volunteer brush is not advised. Use chemicals to do this.

6. Median Mowing

Rural - After the Memorial Day trim - one final full mowing after Labor Day and two trim mowings in between the Memorial Day trim and the Labor Day full mowing. Let the wildflowers go to seed before full width mowing.

7. Community Entrances

Mow these entrances as often as necessary to maintain them in an attractive manner.

8. Private Mowing

Private mowing of the right-of-way is not authorized.

Exceptions: Rural residences
Rural businesses
(They may mow within reason, but no hay harvesting.)

Section II
Specific Instructions

1. Urban Policy

A. **All Urban Areas** - ***keep it neat*** - This means mowed and the trash picked up. Consider contract mowing and more than one group to pick up the trash.

B. **Omaha Areas**

1. **I-80 Platte River to Harrison Street** - Rural - Mow the interiors of Highways 31, 370, 50 and the Harrison Street Interchange.
2. **I-80 - Harrison Street to Missouri River** - Mow as necessary to keep neat. Mow the interiors of the interchanges. Mow one strip next to the fence when possible.
3. **I-680** - Mow one strip next to the fence when possible. Mow the Center Street, Pacific Street, Dodge Street, Maple Street, Fort Street, Irvington Interchange, 72nd Street, Highway 75, and Mormon Bridge Interchanges. Mow as necessary for good sight distance.
4. **I-480 and North Expressway** - Mow as necessary to maintain in a neat and attractive manner.
5. **Kennedy Expressway** - (I-80-to Railroad Avenue) - same as I-480 and North Expressway.
6. **Kennedy Expressway** - Railroad Avenue to Terminus - mow the interior of the interchanges. *Exception:* At Highway 370 Interchange, do not mow wetlands area. Mow one strip next to the fence where houses are present.

2. Rural Interstate and Expressways

A. **Major Rural Interchanges** that serve as city entrances may be mowed on a continuous basis.

B. **Other Rural Interchanges** - Maintain the 5-foot to 15-foot mowing width along the interior of the interchange. These interchanges may be mowed in the fall to emphasize the trees and shrubs and to help protect them from fire. Remember to leave strips of unmowed grass for snow control.

C. **Mainline - Interstate and Expressway**

1. First mowing - 5-foot minimum to 15-foot maximum.
2. Final mowing - as necessary for snow control
3. Total mow-out - one side only. See mowing frequency map. <u>Not before July 15.</u>

D. **Medians - Interstate and Expressways**

1. First mowing - 5-foot minimum to 15-foot maximum.
2. If there are flowers in the median, keep the mowing at the 5-foot to 8-foot width until the blooming has stopped.
3. Final mowing - total mow-out except for medians wider than 58 feet which may be left alone except for the 15-foot mowing.

E. **Rural Primary and Secondary Roadside Areas**

1. Slopes that are 3:1 or steeper shall not be mowed. These slopes shall be identified with a hazard marker or a slope indicator on the tractor.
2. The minimum mowing height is five (5) inches. Where mowing is required, maintain the height of the vegetation between 5 inches and 12 inches. Mow approximately 3 feet beyond the guardrail.
3. Check for sight distance on a frequent basis.

F. **Shoulder Mowing Widths**

1. **Surfaced Shoulder** - The minimum width is 5 feet. The maximum width is 15 feet.
2. **Turf Shoulder** - The minimum and the maximum width is 15 feet *(except where 15 feet would be a hazard to the operator or to the public).*
3. **Flowers** - If the 15-foot width is going to mow flowers, reduce the width to 5 feet or 8 feet until the flowers have stopped blooming.
4. Mowing may be required beyond 15 feet for sight distance at farmsteads, intersections, and rural businesses. When doing this extra mowing, use smooth sweeping curves to blend in with the topography and the other mowing.

3. Sandhills Region Mowing

A **Mowing Operations** - The soil and vegetation characteristics of the Nebraska Sandhills Region differs significantly from other areas of Nebraska whose soils contain a higher level of organic matter.

Because of this difference, shoulder mowing in the Sandhill regions shall be given special consideration. Height of vegetation shall be maintained at a minimum of 5 inches. This height can be obtained with one mowing, on or around July 1st of each year. One additional mowing may be needed in some locations for snowdrift control, this would best be started after October 1st.

Mowing widths on the highway shoulder areas will be limited to a minimum distance of 5 feet and a maximum distance of 15 feet beyond the edge of roadway surfacing on the first mowing. Care should be taken to prevent unnecessary disturbance of the fragile soil and grasses. It shall be at the discretion of the supervisor as to what mowing equipment will be utilized. (15-foot batwing or sickle bar).

B. **Total Mow-out** - not required - optional, but the frequency would be on a five-year basis.

C. **Waterways** - All waterways are to be kept clear and major waterways can be mowed if necessary.

D. **Snow Control Mowing** - The final mowing may extend beyond the 15-foot zone for snow control in those areas that need the extra mowing.

E. **Establishment period mowing** - not required.

4. Establishment Period Mowing for Areas Except Sandhills

The establishment period for the roadside seeding will normally be a two-year period during which fence-to-fence mowing will be done as often as is necessary to control weeds.

Maintain the vegetation stubble at a 5- to 6-inch level. Do not let the weeds get over the 12-inch maximum height before mowing.

The establishment period mowing is critical to the early development of the grass and flowers. The seeding of our roadside is not cheap, but being cheap with the mowing can turn out to be very expensive if we would have to reseed an area!

5. Spraying for Noxious Weeds

The spraying of our rights-of-way is for noxious weeds only. The spraying is limited to spot spraying only. Fence-to-fence spraying is not to be done except in an extremely infested condition, and then only with permission.

The Noxious Weeds at the time of this writing are:

Musk Thistle	• Bindweed
Canada Thistle	• Tall Thistle
Plumeless Thistle	• Wooly Leaf Bursage
Spotted Knapweed	• Flodman Thistle
Difuse Knapweed	• *Noxious in some counties*
Leafy Spurge	

We are under contract with many counties and individuals for weed control work. The maintenance superintendent shall inform the sprayers about our spot spraying policy and remind them to keep the superintendent informed as to their spraying intentions.

Hundreds of dollars worth of goodwill and wildflowers can be destroyed by not sticking to the spot spraying policy.

6. Turf Management

To properly manage the grass stands along the highways, the vegetation will have to be removed by haying or mowing with a rotary mower. These haying or mowing operations will be done on a periodic basis as shown on the mowing frequency map.

The mowing and haying shall be planned so that at least 1/4 or 1/5 of the total mileage is done each year. The vegetation shall not be removed from an entire district in any one year. The mow-out is limited to one side of the road in any given year. The mowing frequency map is your guide.

The haying operations shall not begin until July 15th. Mowing-out operations shall not begin until July 15.

All haying operations shall have the prior approval of the Maintenance Office before proceeding.

When the complete right-of-way is mowed, use extra caution behind the clear zone to save the volunteer trees and shrubs. These volunteer trees and shrubs that are left after mowing must not be a future hazard to our operations or to the public. Trees to avoid leaving are elm and black locust. Cottonwoods that are within 70 feet of the highway must be removed too. Cedars may be left, but they should be thinned to 40 - 50 feet apart. Selective thinning should be used for all the volunteer trees and shrubs left after mowing. The Roadside Development Unit is available for advice for selective thinning.

Chapter 7: Integrated Roadside Vegetation Management

Introduction

In This Chapter ...

- ❑ *Integrated Pest Management*

NCDOT Applications

- ❑ *Plant Selection and Management*
- ❑ *Monitoring Plants and Pests*
- ❑ *Cultural Practices*
- ❑ *Pest Biology and Ecology*
- ❑ *Determining When Pests Need to be Controlled*
- ❑ *Using Pesticides as Needed*
- ❑ *Evaluating an IRVM Program*
- ❑ *Educating the Pest Manager*
- ❑ *Pest Identification*
- ❑ *Pesticide Safety and Training*

Roadside vegetation management can be divided into two categories: 1) *Natural areas* where the vegetation is allowed to grow as nature dictates; and, 2) *managed areas* where the vegetation is designed, planned, and maintained for specific goals and objectives. The highest priority for the vegetation manager is supplying safe transportation corridors with hazard-free safety clear zones, low growing vegetation in the operational zone and open sight distances (Figure 7.1). Actively managing vegetation in these zones contributes greatly to biological diversity in North Carolina, provides attractive roadsides, preserves biological heritage, and reflects local landscape character.

Control of noxious weeds and undesirable plants is also a requirement for managing roadside vegetation. Noxious weeds, as identified by federal and state agencies, threaten thousands of acres of public lands annually. These aggressive plants invade and create masses of unwanted vegetation and greatly reduce biodiversity.

North Carolina roadside vegetation managers have endorsed and will continue to implement an *Integrated Pest Management (IPM)* program for the roadside acreage in North Carolina. The broad IPM principles have been refined and directed into *Integrated Roadside Vegetation Management (IRVM)*. IRVM guidelines, developed by the National Vegetation Management Association, are used as a process to manage vegetation in the various zones and to control noxious weeds. This chapter will explore integrated pest management philosophies and key elements for managing roadside vegetation in North Carolina.

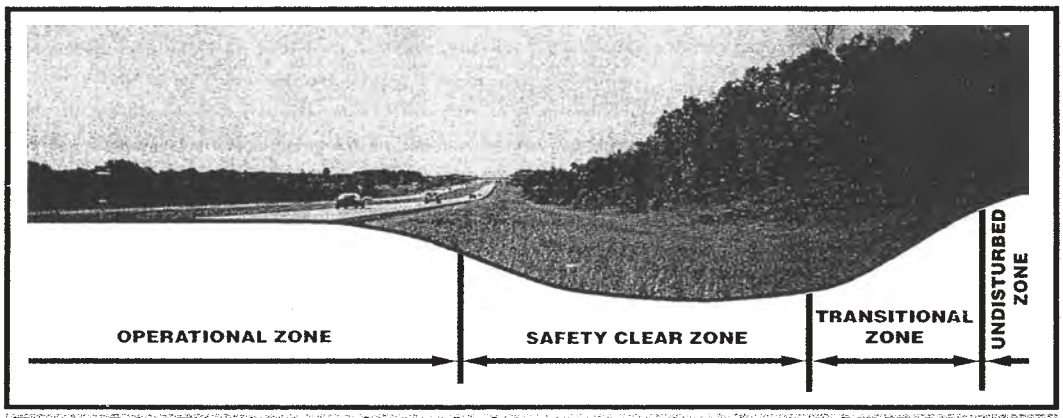


Figure 7.1: Zone concept for roadside vegetation management (NRVMA)

Integrated Pest Management:

Integrated pest management (IPM) is a term used to describe a system of managing pests whereby all possible methods of controlling pests are considered in reducing populations to levels that are economically acceptable. IPM employs proven, practical and least costly methods in a plan designed to exclude pests from the management unit.

The term "pest" is used to describe any unwanted plant or animal species in a landscape. However, this term has no ecological meaning. It is simply a word that broadly characterizes a competitor for resources. Pests are part of a natural system at work. As such they have a role in nature that has been operative for many centuries. Managing unwanted species is most successful when the biological characteristics of organisms are understood and used to advantage.

An IPM program has several major components.

Plant Selection and Management

Landscape designs should incorporate species and cultivars that are well adapted to the landscape sites and exhibit genetic resistance to insects and diseases common to the area. Plants genetically predisposed to pests or known to be high maintenance problems are excluded under an effective IPM program. Physical aspects of landscaping such as the geographical layout should be considered an integral part of the landscape design process. Physical aspects may depend on factors such as slope, accessibility, adjacent structures, waterways, traffic, and microclimatic conditions.

Redtip Photinia is avoided in plant selection due to disease problems.

Pitted pest in the apple

Roadside vegetation is designed to fulfill specific needs. Public safety, cost, and aesthetic appeal all play a role in plant selection, placement and maintenance. Potential pest problems are often low on the priority list. Roadside vegetation areas are artificial habitats that will begin to revert to a natural state as soon as planting is completed unless management is introduced and continued. Pest problems will be lessened to a degree that a roadside landscape is designed and maintained to restrict competition from pests.

Healthy, vigorous plants are good competitors and less likely to have pest problems. Poor variety selection, improper placement for the needs of the plant, and poor maintenance will often be the cause of pest problems. Weeds can be indicators of soil conditions such as compaction, pH imbalance, or low fertility. Before any pest management action is taken, these soil problems must be resolved. In numerous situations, correcting other problems will eliminate pest problems.

Landscape redesign begins with a complete survey that obtains information on species, varieties, location, pest history, past pest control activities, costs, and success of pest control programs. This information should be used to develop a priority list so the most important problems can be addressed first. It is important to ask the question "Why is this pest here?"; or stated another way, "What conditions are allowing this pest to successfully compete in this arena?". The answers to this question will aid the development of permanent pest solutions.

Monitoring Vegetation and Pests

An effective IPM program depends upon regular surveys of managed areas to determine which pests are present and to monitor their population(s). Observations are evaluated in order to make decisions about the necessity for action. Roadside managers can use this information to judge whether the pest population is or will become large enough to cause unacceptable damage or a negative aesthetic impact.

Pesticides must be employed frequently because pest problems occur "overnight" requiring immediate control. Such pest occurrences may take weeks to develop but they seem to appear suddenly because the initial signs were not noticed. This situation can be avoided by utilizing a regular and systematic check for pests.

The complexity of the monitoring program should be proportional to plant value, time available, resources, life cycle of the pest, and skill level of the observer. Monitoring programs may be as simple as doing a visual inspection or as complex as conducting a detailed investigation. For example, a median strip of grass and a cultivated area of flowers will not require the same effort. Monitoring involves both plant and animal pests. The condition of plants will influence the activity of herbivores. Any variance from acceptable norms of appearance or growth should be carefully evaluated for problem causes such as soil fertility and improper soil pH in order to prevent future pest problems.

Record keeping is a part of the monitoring effort. It may appear easy to remember what pests occurred when and where, but daily activities are often distracting and observations are soon forgotten. Making a drawing of the management area to identify locations will help track pests through time.

Record keeping can be as simple as writing general observations or as detailed as tracking counts of specific pests.

Cultural Techniques

Proper cultural methods are an important part of pest management. Vigorous plants and turf are much more pest-tolerant, and even pest-resistant. Emphasis should be placed on maintenance programs for turf and ornamental plantings to insure the correct performance of mowing, fertilization, irrigation, pruning and other cultural practices.

Plant maintenance plans should allow for individual species' needs. Close mowing of some grass species will guarantee weed problems. Infrequent mowing for some grasses will result in unhealthy plants not able to compete. The changing needs of plants should be considered also. Newly planted grass in a well prepared area will face new stresses after 1-2 years. A small landscape plant, after several years of growth, may become crowded leading to stress or shading of other plants. Change must be considered in pest management planning. Keeping plants healthy requires a maintenance plan that changes according to the needs of the plants.

Pest Biology and Ecology

Learning the biology, ecology, and behavior of pests is a critical part of developing an IPM plan. Understanding the life history of pests and their interaction with the environment will yield the keys to management. The objective is to deny the pest part or all of its life support system. This will provide an initial reduction in numbers which, in some cases, may be all that is necessary for adequate control. For example, mulching plants denies weeds both the soil temperatures for germination and sunlight required for growth. Plants in full sun in an exposed area dry quickly denying foliar diseases the moisture required to infect leaves. Acquiring this knowledge will allow an IPM manager to rearrange the landscape to discourage pests.

Even after the landscape has been rearranged, other measures may be needed to further reduce pest populations. Again, the key to success is in the life system of the pest. There may be effective natural enemies that can be employed either by encouraging their establishment in an area or by releasing them directly to an inhabitable site. For native pests, there are many beneficial species that can provide at least partial control. Soil pathogens may be resisted by increasing organic matter or inoculating the roots before planting.

The selection and use of biological control agents is not a casual effort. This is a knowledge-based activity and careful study is required for success. Where products are purchased, where and how they are utilized, the target

species, and other factors must be considered before any release is considered.

Determining When Pests Need to be Controlled

Monitoring of turf and plantings is extremely important to determine when pests reach intolerable levels. IPM does not mean that pesticides are never used. In some situations there are no effective alternatives. Simply sighting a pest is not enough to justify using a pesticide. No action is necessary unless the potential pest damage exceeds acceptable damage levels. The point at which action is necessary is called an *aesthetic threshold*. Using aesthetic thresholds helps in several ways. First, it assures that a pesticide is not used until and unless necessary. Additionally, by waiting until a threshold is reached, natural control agents (which give free control) can increase and possibly control pests without using a pesticide. Waiting also allows plants more time to grow, possibly outgrowing pest problems, or growing into a less susceptible stage.

Setting thresholds is a two step process. First, the level of acceptable damage must be determined. Second, the number of pests required to reach that level of injury must be ascertained. Thresholds can be determined by monitoring, recording pest counts, and comparing the numbers to what is considered to be unacceptable.

Aesthetic thresholds can only be determined on a site-specific basis. Defoliation of landscape plants may not threaten the health of the plant but is unacceptably unsightly. The appearance of specific plantings may not accurately reflect the actual health of the plants. Thus, thresholds vary with the situation. A foundation plant that lines the entrance to an important building will likely have a threshold that differs from a foundation plant that is distant from the road and cannot be easily observed. Some plants do not lend themselves to thresholds. Tea roses, for example, are highly susceptible to several serious pests and are highly valued for their appearance. It would be difficult to set thresholds for these plants. But the majority of plants on a roadside landscape will tolerate some damage.

Vegetative sight-distance obstruction

Vegetative obstruction of sign

Using a threshold to make pest control decisions supports the idea that a healthy roadside ecosystem is occupied by a diversity of species. A diverse species community is more likely to stabilize at a desirable level and less likely to suffer outbreaks.

Using Pesticides As Needed

The agricultural chemicals industry has made great strides in improving the selectivity of pesticides. For more than 40 years it has been possible to remove unwanted broadleaf weeds from grasses without harming the grasses. Pesticide products are now available that remove grasses from broadleaf plants without harming the broadleaf plants. Startling new discoveries in chemistry have even resulted in products that can safely remove one class of broadleaf plants (such as legumes) from others. These advances mean that herbicides can be selected to remove only certain weeds while retaining plants which are desirable or have negligible impact. An effective IPM program utilizes this information to insure that pesticide usage is highly target-specific. Where possible, effective biological controls should be used in lieu of chemical pesticides for added environmental protection.

Any time a pesticide is needed, the pesticide, rate, timing and method of application is "customized" to the specific pest. The old "shotgun" approach is too expensive and is no longer acceptable. By selecting pesticides and rates according to the pest found, using proper application techniques, and applying them at the most susceptible pest stage, effective control can be obtained for less cost.

Selecting a pesticide, rate, and timing of use should be a careful process. Too often the same pesticide is used over and over with little awareness of negative side effects or that more effective materials may be available. When evaluating pesticides consider:

Effect on natural enemies. Certain commonly available pesticides can have a devastating effect on beneficial insects or soil microorganisms. This leads to the need for more pesticides to manage pests that can no longer be controlled naturally.

Hazard to human applicators. Most pesticides cleared for roadside use are among the safest pesticides available. But pesticides should be considered with respect to:

- ❑ risk to non-target organisms (e.g., wildlife).
- ❑ risk to environment (Is it likely to move offsite? If it does, what is the potential impact?).
- ❑ risk of voiding a permanent solution to pest control.

Reevaluating a Pest Management Program

Once implemented, an IPM program must be carefully re-analyzed after an appropriate amount of time has passed (this may be months or years). Initial plans are based on expected outcomes but biological systems sometimes behave in unexpected ways. Thus, the effectiveness of decisions must be evaluated and changes instituted if needed. As landscape plants mature, new situations arise that must be considered (e.g., roots occupy more area and shading increases) with respect to the effectiveness of the IPM program. Questions such as "Is my plan achieving the desired results?" must be asked. If the answer is negative, then steps must be taken to identify what is not working and make corrections. This step may seem self evident but, too often, plans are made and never reviewed.

Educating the Pest Manager

An IPM plan is likely to be hard to implement, slow to show results, and may initially cost more. In many cases pest managers may not have an appreciation for the complex interaction of events occurring on the landscape. It may be critical for them to learn more about biological and ecological processes. IPM managers should continually upgrade their knowledge of pests, pesticides, monitoring systems, plants, and many other subjects. Knowledge of relevant subjects will strengthen the manager's ability to anticipate and correct pest problems.

Chapter 1

Best Management Practice No. 1:

Develop an Integrated Roadside Vegetation Management Plan

WHY HAVE AN INTEGRATED ROADSIDE VEGETATION MANAGEMENT PLAN

An Integrated Roadside Vegetation Management (IRVM) Plan is a decision-making and quality-management process for maintaining roadside vegetation. It integrates many elements with cultural, biological, mechanical, and chemical pest control methods to economically manage roadsides for safety, environmental health, and visual quality.

The challenges government agencies face in managing roadside vegetation drive the need for effective IRVM programs. Those challenges include:

- increasing legal requirements, such as laws regarding water quality, mowing, and noxious weed control
- incentives for quality improvements and cost savings
- the need for the proper use of pesticides and herbicides
- increased public demands and customer expectations
- increased liability concerns
- mandates by governing agencies

An integrated plan will greatly assist in meeting the diverse expectations and requirements listed above as well as the requirements of the Groundwater Act of 1989. This act dictates, under "State Uses of Pesticides and Nutrients," that "The state shall use integrated pest management techniques in its management of public lands, including roadside rights-of-way, parks, and forests; and shall use planting regimes that minimize the need for pesticides and added nutrients" (Chapter 326, Article 5, 18B.063).

In addition to the Groundwater Act of 1989, the 1994 amendment to it (Chapter 558, Section 26)

required the Commissioner of the Department of Natural Resources (DNR) to prepare a plan for the optimum use of sustainable agriculture and integrated pest management techniques on land owned by the state. A report published in March of 1996 provides the framework for the development of local IRVM plans, which are outlined in Chapter 8.

Benefits of implementing an integrated management plan

SAFETY
Creation of adequate sight distances and hazard-free zones
Minimized effects of rain, blowing and drifting snow, and ice formation
Reduced hazardous conditions for maintenance staff

ECONOMIC
Increased productivity from planning work versus reacting to work problems
Economical and environmentally sustainable outcomes
Extended life of pavement
Use of optimum weed and pest control measures
Improved cost-effectiveness of construction activities

FLEXIBILITY
More efficient use of staff, time, and equipment through planning
A variety of management tools and techniques from which to choose at any given time

ENVIRONMENTAL
Improved water quality
Improved overall air quality
Protected soil
Increased biodiversity and desirable native plant communities
Reduced number of invasive plants and weeds
Improved safety for wildlife
Newly created habitat
Reduced impact of roadway projects

AESTHETIC
More healthy vegetation appropriate for the area
Creation of a diverse plant community without noxious weeds and undesirable vegetation
Use of plants for screening
Improved appearance of roadway due to native grasses and wildflowers
Pleasant experience for travelers

PUBLIC RELATIONS
Establishment of partnerships, teamwork
Shared expertise between agencies
Increased public awareness of maintenance activities

DEVELOPING AN IRVM PLAN

When developing an IRVM plan, consider the needs of local communities and users; plant ecology and natural processes; design, construction, and maintenance processes; monitoring and evaluation procedures; government statutes and regulations; and technology. The five steps for developing a plan are:

Section 1
Reasons for Pruning

Safety

Safety is always the first consideration in pruning and takes precedence over all other considerations. Pruning for safety includes:

- maintaining required sight distances
- maintaining adequate clear zones on either side of and above the roadway
- removing low branches that may be hazardous to equipment operated on the right-of-way, such as mowers.

To Accommodate Utilities

Utility companies have special authority to construct and maintain lines on the right-of-way. This authority includes pruning vegetation as necessary. Utility companies are requested to follow the Texas Department of Transportation's pruning guidelines and observe recognized tree surgery practices.

Health of the Vegetation

Dead or diseased branches should be removed to maintain the health of the vegetation.

Aesthetic Considerations

Pruning may be done to enhance the appearance of trees and ornamental plants, if it does not interfere with the health of the vegetation.

Public Works and Utilities
Environmental Services

Problem:

Blackberry bushes have established and produced seed which spreads to adjoining property, which triggers complaints and requests for corrective action by the neighbor.

Location:

Virtually all of the river system is infested, or is subject to Blackberry infestation. Other sundry sites (quarry, equipment storage areas, etc.) are adversely affected by the presence of Blackberry plants.

Target:

Evergreen and Himalayan Blackberry, Rubus species.

Urgency:

For the convenience of fishermen (Tribal and recreational) it would be beneficial to correct the problem on a 'when practical" basis.

Actions:

Short Term:

Mechanical control using a mower (Work Standard Number 006) or hand cutting (Work Standard Number 020) will re establish access immediately. Also removal of all existing runners (canes) will enable treatment with an herbicide when re growth occurs. Treatment with a herbicide (Work Standard Number 015) during the winter dormant period will require that the treated portion (18"-24") be left attached to the root crown until the following April. A soil active/applied herbicide (Work Standard Number 017) should not be used on sites close to water due to the potential for flood water to displace the pesticide into, or along the river. Use of a foliar active herbicide (Work Standard Number 015) would be a good control if applied after June 1st following mechanical removal during the previous winter season. This use during the growing season is only possible on blackberries which were mowed or cut back prior to the growing season, as no fruiting canes will be present, precluding the possibility of fruit contamination. If the plant has fruit set then no herbicide can be applied until after the fruit has fallen (late Fall). Growing season herbicide applications will generally produce aesthetically undesirable "brown-outs".

Long Term:

The best long term strategy is to eliminate the present infestation by use of one of the techniques mentioned in the Short Term action above, and follow with a management program such as seeding with grasses(Work Standard Number 021) or some other desirable specie (Work Standard Number 025 or 027) that will dominate the site, preventing the Blackberries from re establishing as seedlings.

-More-

Fertilization (Work Standard Number 002 7003) of the desirable plant complex will be an effective long term activity for establishing a stable, competitive plant community that will persist. In areas where herbicides can NOT be used due to the site environmental sensitivity, mechanical control(Work Standard Number 006) must be accomplished at least twice (no more than 2 months apart, but no sooner than 1 month following the first cut) during the same growing season. Missing any of the cuttings will enable the Blackberries to re-generate from the root system crown and reestablish on the site, starting the entire control program over.

Monitoring:

Following accomplishment of the selected action schedule a site review in the late Spring (June) of the year following the work to check for any re growth. If re growth is evident review the earlier actions with the Supervisor and develop another program for the control.

Date: December 1995

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation