

NCHRP 14-40

INTERIM REPORT

Comparison of Cost, Safety, and Environmental Benefits of Routine Mowing and Managed Succession of Roadside Vegetation

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CHAPTER 1. INTRODUCTION

BACKGROUND

The Problem

Departments of Transportation (DOT) often struggle with the need to meet the safety design criteria for the specific roadways while being sensitive to the surrounding community's desire for more aesthetic treatments. Public interest generated in "greening" the roadways has caused a number of DOTs to favor alternative designs and maintenance operations while still complying with the minimum criteria recommended by the AASHTO guidelines.

There are many aspects of roadside design relating to the placement of trees and other fixed landscape objects within the right-of-way (ROW). Some of these design approaches seem counter intuitive to traditional roadway safety concepts. Along roadsides bordering the fringe of development or rural, the roadside maintenance and operation parameters may change to accommodate differing types of adjacent development and users such as industrial and agricultural. The managed succession method of roadside maintenance uses a strategic approach of selective control measures such as a combination of zero maintenance, targeted mowing, mechanical trimming and removal, and chemical and/or biological treatments to allow plant species to colonize roadside areas outside the safety clear zone. Often these plant species are larger and woodier. As such, these plant materials may create habitat for pollinators and other wildlife. This approach is often part of a long-term plan to minimize ROW maintenance requirements over time.

Whether rural, suburban, or urban, the roadside and median design that must comply with two basic safety concepts. These are:

- Nominal Safety- based upon compliance with standards, warrants, guidelines and sanctioned design procedures, and
- Substantive Safety – based upon actual crash frequency and severity of highways or roadways.

Within the context of roadway design, substantive safety is very important. Crash data is a critical design and mitigation component. If a tree or other fixed object location has a high crash incidence, even within the nominal safety parameters, then mitigation may be required. Nominal safety parameters include design speed, average daily traffic (ADT), roadway geometry, roadside terrain and functional classification.

Roadside maintenance is key to maintaining the safety clear zone. The AASHTO *Roadside Design Guide (1)* defines a **clear zone** as the total roadside border area, starting at the edge of the traveled way, available for **safe** use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a **clear** run-out area. Figure 1 depicts a typical safety clear zone.

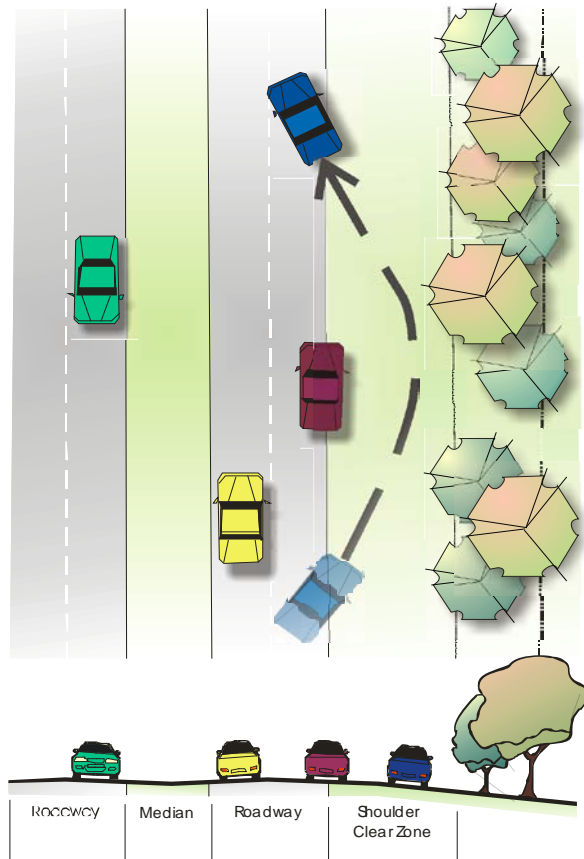


Figure 1. Typical Safety Clear Zone.

environmental agencies are re-evaluating the level at which roadsides should be managed. An example is the Minnesota DOT and Department of Natural Resources. They have combined efforts to adjust mowing schedules to accommodate habitat for pheasant nesting cycles (2).

The 2014 Presidential Memorandum *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* prompted many state and local DOTs to recognize that changing mowing practices may be a pollinator-friendly practice (3). In 2014, six DOTs (Iowa, Kansas, Minnesota, Missouri, Oklahoma and Texas) entered a Memorandum of Understanding (MOU) with the Federal Highways Administration (FHWA). These states are all within the flyway of the migration path of a significant proportion of the U.S. monarch butterfly population (roughly considered a broad tract of land following the I-35 corridor). This memorandum establishes a cooperative and coordinated effort to establish and share vegetation management best practices and the promotion of public awareness initiatives related to pollinators conservation.

OBJECTIVE

The goal of NCHRP 14-40 is to assess the impacts of routine mowing as compared to managed succession of vegetation for areas outside the safety clear zone, the level of success achieved, and the benefits derived. The goal will be accomplished through two objectives.

DOTs have historically incorporated roadside vegetation management operations that consist of mowing and herbicide treatments not only the safety clear zones, but also the remainder of the ROW from boundary to boundary. These practices have come into question as being a reasonable maintenance and operations methodology when considering cost and environmental concerns versus benefit. DOTs are seeking answers to support minimizing ROW maintenance without compromising safety.

Many factors are at the forefront of considering the benefits of managed succession of vegetation outside the safety clear zone. Some of these benefits include the reduced costs associated with modification of roadside vegetation management practices. However, many of the benefits fall under ecosystem services (ES). These include ecosystem diversity, stormwater quantity and quality management, carbon sequestration, pollinator corridor development, wildlife habitat, and aesthetics.

Roadside vegetation management practices can have direct impact on the ES provided. As such, state transportation and

The first objective is to conduct a thorough assessment of roadside vegetation management practices in the United States. This assessment included relevant research regarding environmental sustainability/benefits, ES, wildlife habitat, driver and maintenance worker safety, and reduced costs related to direct labor, equipment, materials, and management/planning.

The second objective is to develop an online guidance tool to assist agencies in implementing reduced mowing and managed succession programs.

Researchers focus on existing/established vegetation, how changes in maintenance and mowing protocols will affect DOTs, and how changes in mowing /maintenance may affect adjacent properties and land uses. The emphasis includes the following areas:

- Safety implications,
- Ecosystem services,
- Wildlife habitat,
- Agency mowing protocols,
- Cost differentials of managed succession as compared to routine mowing practices,
- Institutional obstacles to reduced roadside maintenance,
- Cooperative opportunities,
- Invasive species/noxious weed issues,
- Ongoing maintenance requirements,
- Adjacent land use concerns,
- Roadway context,
- Public perception/outreach/stakeholder involvement,
- DOT performance metrics, and
- Snow/ice/wind concerns.

RESEARCH METHODOLOGY

The research approach for this project included a detailed literature review, review of state transportation agency vegetation management programs, and survey of practice with select follow-up interviews. The identification and development of guidance material involved a project effort with the following six tasks:

- Task 1: Conduct Literature Review.
- Task 2: Conduct Survey of Practice
- Task 3: Prepare Interim Report, Annotated Outline for Guidelines, and Phase II Work Plan.
- Task 4: Develop Guidelines
- Task 5: Develop Interactive Tool
- Task 6: Prepare Final Deliverables.

The tasks for this project divided between two phases. Phase I consists of Tasks 1 through 3. Phase II consists of Task 4 through Task 6.

Phase I

Task 1. Conduct Literature Review

In Task 1, the research team conducted a review of relevant research associated with the effects of reduced mowing and managed succession of vegetation outside the safety clear zone. The research team also gathered state DOT documents pertaining to plans, policies and procedures for roadside vegetation management.

Task 2. Conduct Survey of Practice

The project team developed an online survey instrument for Task 2 to determine state DOT mowing and roadside management practices and to obtain cost /benefit differentials between routine mowing, reduced mowing, and managed succession to the extent available. Identified states implementing managed succession practices on a state and/or local level received follow-up interviews. The research team sent an email invitation to state transportation agency contacts for roadside vegetation management requesting their participation. Appendix A includes the survey instrument.

Task 3: Prepare Interim Report, Annotated Outline for Guidelines, and Phase II Work Plan

The Interim Report reflects the work conducted thus far on the project including the literature review of available research and existing state DOT practices, and the results of the survey thus far. The annotated outline describes the format for the online guidance tool and suggestions for inclusion. The Phase II work Plan outlines the next steps for Tasks 4, 5, and 6. This includes development of the guidelines and online guidance tool.

Phase II

The Phase II Work Plan incorporates feedback from the panel received either via written comments or during the panel meeting.

Task 4: Develop Guidelines

The Guidelines should reflect a system perspective where the anticipated use by various user groups for the corridor is considered. It is a goal of the research team to make the guidelines user friendly and application oriented. Guidelines will include both the reconstruction and new construction situations and will address the subject areas listed in the project objectives.

Task 5: Develop Interactive Tool

This practical and user-friendly document will provide recommendations to transportation and environmental agencies regarding the cost/benefits of reduced roadside maintenance operations. The Project Team will develop an Excel®-based smart interactive tool or web-based interactive tool to assist analysts in application of the Guidelines developed in Task 4. To accommodate various input data needs, this tool will have inputs for required data elements and optional data elements. The Interactive Tool will be configured so the users can use default values for some inputs such as direct labor, equipment, materials, and management/planning costs, or provide values for these inputs if desired. The Interactive Tool will compute several measures of comparative cost-effectiveness, including benefit-cost ratio, and incremental benefit-cost ratio. The Project Team will prepare an instruction manual on the developed Interactive Tool.

Task 6: Prepare Final Deliverables

Preparation of the final project deliverables includes the project report, Guidelines, Interactive Tool and an electronic presentation of the guidelines and interactive tool adaptable for specific audiences. The results from this research will further the state of the practice on managed succession that best serve the goals of sustainable roadsides. The findings from this research can improve and result in a more consistent and efficient manner of selecting treatments. It will produce practical and immediately usable results for implementation by planning, design, and operations staff in state and city DOTs and metropolitan planning organizations.

CHAPTER 2. REVIEW OF LITERATURE

OVERVIEW

The roadside vegetation management requires a high level of expertise and resources to plan, design, construct, and maintain the roadside environment. The benefits of the roadside vegetation management concern the roadside safety, environmental and ecological impacts, economic benefits, erosion control, public relations and aesthetics. A review of the literature and an internet search undertaken for this project yielded information relating to roadside vegetation management. The literature review included examination of conventional research studies and readily available documents from state DOTs. This chapter divides the literature review into four major sections: 1) safety, 2) ecology, 3) management, and 4) economy.

SAFETY

Safety is considered as the top priority in roadside vegetation management. Effective vegetation management reduces the risk of functional or structural failure that may contribute to crash or near crash outcomes. Effective vegetation management will help in improving sight distance and will reduce roadway departure crash and crash induced severities. The other safety concern is for maintenance workers and their exposure to traffic, equipment, chemical treatments and other issues related to roadside vegetation management.

Sight Distance

Sight distance is the length of roadway visible to a traveling driver. A safe sight distance is the distance needed by a traveling driver on a roadway to verify that the road is obstruction free and avoid any conflict by seeing other vehicles, signs, fixtures, animals, and people beside the road. Roadway curves and vegetation can reduce sight distance. When visibility of fixtures due to vegetation growth is obstructed, it results in unsafe driving conditions (4).

Roadway Departure Crashes

According to FHWA, roadway departure crash is a crash in which a vehicle crosses an edge line, a center line, or leaves the traveled way. Roadside fixed objects can pose a major hazard to highway users. Identification and removal or pruning of hazardous trees or brush can reduce roadway departure crashes.

While roadside vegetation provides environmental benefits, higher severity of roadway departure crashes may result from tree associated collisions. Fitzpatrick et al. designed a driver simulation experiment to investigate how the participants respond to the size of clear zones and vegetation density at roadsides, as well as the presence of utility poles (5). The result of this study demonstrated the relationship between clear zone design and driver behavior. Drivers tend to drive their vehicles closer to the edge line as the clear zone size increased for constant dense vegetation. Other studies also showed that adequate clear zones and guardrails help to reduce tree-related fatal crashes (6).

In a Malaysian study, Zainal Abidin et al. investigate single-vehicle crashes involving trees (6). The researchers mined the police national database in Malaysia for years 2006 through 2008 and examined factors associated with tree related crashes including time of day, roadway

geometry, lane numbers, pavement quality, and road shoulders among other factors. The researchers perform various analyses on the crash data, each suggesting multiple combinations of factors associated with changes in the yearly patterns, and proportions of injury levels. This study found that night-time, pavement distress, and narrow shoulder are the key contributing factors for rural two-lane tree involved crashes.

Animal Vehicle Crashes

Approximately 2 million animal vehicle crashes occur in the U.S. each year, with about 135–200 fatalities, 29,000 injuries, and more than \$8 billion loss (7). For example, more than 61,000 deer vehicle crashes were reported in Virginia in 2016 (8). As a result, deer vehicle crash is identified as the fourth costliest of the 14 major collision types in Virginia, (economic loss of more than \$533 million per year). This massive financial loss is not only associated with human injuries and fatalities, but also includes crash investigation, carcass removal and disposal, and the monetary value of the animal to hunters.

Coffin presents an overview of literature regarding ecological effects of roads, including interactions with hydrologic systems, erosion and deposition dynamics, chemistry and noise, roadkill, population fragmentation, and road avoidance behavior (9). The author also discusses the fact that roads are favorable habitats for many plants and animals. In particular, a discussion on how the design and management of the roadside would attract certain animals, like insects, small mammals, and carrion-feeders. The author argues that bird, insect, and mammal populations may be affected differently by different mowing regimes or planting designs. She cites the cases of Austria and the Netherlands where extensive land transformation has left the roadsides as the last areas with native vegetation and thus important attractors of biodiversity in the landscape.

Hinderlang et al. performed a study in Kent County, Michigan aimed to reduce the frequency of deer to vehicle collisions (10). The researchers performed a GIS spatial analysis to identify clusters of deer crashes and to infer characteristics of the areas near those clusters. They assert that most deer-vehicle collisions occur in seasons when mowing and road salt are not issues. They identify that mowing policies at the time of the study accommodate pheasant populations on the roadside. Additionally, they identified that deer-vehicle crashes tend to occur more frequently on two-lane rural roads.

In their 2008 report to congress, Huijser et al. present nation-wide statistics on wildlife vehicle collisions in the United States, their relation to a set of 21 federally listed threatened and endangered species, and an in-depth review of 34 mitigation methods against these types of collisions (11). The report estimates that, although a number of 300,000 collisions with animals per year were documented in 2008, that number was most likely substantially under-reported for various reasons. The researchers used a variety of sources to obtain an estimate of between one and two million collisions with large animals per year in the U.S., with more than 95% of these having no fatal outcomes for the drivers. About 26,000 injuries per year in 2008 were attributable to collisions with animals in the U.S. Huijser et al. cite a study in Sweden that found a 20% reduction in moose-vehicle collision attributed to roadside vegetation clearing, though the study cautions that results may not be transferable to highways. In the particular case of deer populations, the report assert how the density of these populations depend on the quality of the habitat, which requires abundance of food and cover. The Normadeau report summarizes the

findings from multiple studies about variables that relate to the frequency of deer vehicle collisions (12).

Some studies used multivariate logistic regression to define landscape and traffic factors of the increased possibility of deer vehicle crashes and to determine the correlation with collision frequency (13). This model found a positive relationship between deer vehicle crash and posted speed limit. Slow speed vehicles are more likely to avoid a deer on road. Furthermore, deer vehicle crashes are more likely to occur in areas near water because deer require water to aid with metabolism (14). Ditches are typically established with non-native grasses which grow green up faster in the spring. Additionally, the crash rates associated with deer are higher in spring due to earlier green-up of the vegetation along road edges. As abundant roadside vegetation is another primary cause of mammal fatality, efficient roadside vegetation management is imperative (15).

The monthly number of moose-vehicle collisions peaked in autumn in Finland whereas similar crashes mostly occurred in winter in Sweden and Norway (16). The number of moose-vehicle collisions has increased in spring due to the early start of growing season. Researchers found ungulate vehicle collisions occur least frequently in winter because of worse driving conditions and less passable roads which make passing vehicles move slower (17). Additionally, seasonal lack of tall vegetation along roads makes ungulates seen before their crossing that leads to less ungulate vehicle crashes.

Bat species have a strong inclination towards asphalt roads, mainly local roads of low to medium traffic volume at night when they forage (18). Most of the bat species can be identified in the vicinity of a road; however, its mortality rate is marginal. Higher presence of bats increase nighttime bat vehicle crashes. A study conducted in India showed that guilds make their nests by urban roadside trees, which may cause higher number of bird vehicle crashes (19).

The number of small mammals like white-footed mice increase near roadways, because of the increased presence in small patches of edge and open habitats or due to the decline in predator populations (20). Khalilikhah and Heaslip performed a spatial analysis of animal crashes and animal crossing signs for Utah DOT (21). They found that a very small percentage (2%) of animal crashes tend to occur within the recognition distance of animal crossing signs. These findings suggest that well-placed animal crossing signs may help prevent animal collisions. Oliveira Gonçalves et al. investigated reptile road-kill in Brazil and the relationship with traffic and roadside conditions (22). The researchers found an increased risk of reptiles associated with locations in proximity to rice plantations and higher traffic volumes, while they found a decreased risk at locations close to pine plantations. The findings showed that there may be some success associated with animal crossing signs in preventing roadkill, suggesting that deploying this type of sign may supplement the primary strategy of managing the roadside appropriately to prevent animal collisions.

Mitigation Measures

Huijser et al. recommendations present the case that timing for cutting roadside vegetation is key, as cutover areas may be attractive as foraging sites by deer (11). In this regard, the report argues that reducing the quality of available food near roads can be achieved by specific mowing and cutting practices that include reducing the grass-herb and shrub vegetation on the forest floor, or using wild life fencing to make prime feeding habitat unavailable to the deer. However, as of 2008, this report recognizes that “No studies were found that specifically analyze the WVC

safety impacts of roadside management policies or plantings.” Cramer et al. have a similar assessment about the limited evidence supporting a safety benefit from roadside mowing and cutting of the roadside (23). These researchers investigated vehicle-animal collisions in South Dakota and they recommend the use of mowing/treatment strategies to detract roadside value to large wildlife, though they recognized little research support the effectiveness of these strategies. Huijser et al. also conducted technical group meetings with a panel of seven national experts in wildlife-vehicle collisions to qualitatively assess the effectiveness of a set of mitigation strategies. In their assessment of strategies related to roadside and mowing and cutting practices, the panel was unanimous in classifying these strategies as “demonstrated” which was defined as countermeasures that have been implemented in multiple locations, that may be even accepted as de facto standards, but for which valid evaluations have not been found in the literature (as of 2008).

Barnum and Alt investigated the potential safety effects of changing mowing frequency practice and concluded that there appears to be no connection between mowing frequency and deer-car crash frequency (24). The researchers collected before and after data from ten study locations in Maryland and New York and performed a before/after evaluation on crash rates to quantify the change in crash rate potentially attributable to the change in mowing practice. The researchers attempted to control for ADT, and deer abundance as estimated by buck harvest records. They give some rationalization as to why they did not use widely accepted approaches to safety evaluations (such as the EB method). Constructing wildlife passages, for instance, dry paths under road bridges can be a useful mitigation measure for reducing the traffic mortality of small and medium-sized terrestrial animals (25). A Doppler radar system has been implemented along U.S. Hwy 95 near Bonners Ferry, Idaho to detect an approaching animal like deer and elk to warn drivers for potential roadway hazard. The system identified around 70 to 85% of deer to warn the drivers early. This system worked best when road conditions were challenging (e.g., freezing temperatures, snow-covered road surface, and low visibility) and also reduced speed to the range of 0.69-4.43 miles per hour in autumn and winter (26).

The effectiveness of the mitigation methods largely depends on the knowledge about landscape connectivity and roadway planning and construction processes (27). The distance between highway and forest edge affects animal crossings on roads (28). Fences should not be used without a combination of wildlife passages otherwise collisions may increase near fence ends by allowing animals to become "entrapped" within highway right-of-way or animals move to secondary road networks (27, 28). Using fencing combined with wildlife passages such as green bridges and various underpasses have reduced animal vehicle collisions up to 83% (29). Bil et al. suggested a comparatively less costly method for animal vehicle collision reduction (30). According to their study conducted in the Czech Republic, use of odor repellents has the potential of reducing animal vehicle collisions up to 43%.

In addition to human injuries and economic losses, traffic mortality of animals has created a wildlife conservation challenge and an animal welfare issue (27). In brief, following mitigation measures can be implemented to prevent animal mortality rate on roads. These include:

- Modify driving behavior.
- Use warning signs equipped with flashing lights or message signs.
- Establish public awareness campaigns.

- Use fencing.

Although the literature shows the wide acceptance and promotion of mowing and landscaping practices believed to discourage large wildlife from roadsides, it also shows little empirical evidence of a measurable safety effect of such practices. The widely accepted rationale is that animals like deer are discouraged to be on roadside areas where denser vegetation that provides cover has been removed. However, some research has found that if the remaining vegetation is nutritionally attractive, the resulting effect on deer could be the opposite of the intended: an attraction due to access to food. In Arizona, planners avoid species known as “ice cream species” that may pull in elk on the roads. Similar results have been found for reptiles in tropical areas, though there seems to be different types of vegetation that associate with a reduced risk of roadkill of this type.

Worker Safety

Gulick et al. conducted a study for the Ohio DOT, *Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation* (31), examining four treatment zones for current maintenance practices and worker safety implications adding an additional zone to those shown in Figure 10. They compared different management techniques for each zone and evaluated performance, worker safety, cost savings, return on investment (ROI) for equipment requirements. Management for each zone is as follows:

- Zone One—Eliminate or reduce mechanical removal.
- Zone Two—Reduce mowing.
- Zone Three—Remove noxious weed and brush, and prevent regrowth.
- Zone Four—Remove trees and prevent regrowth.

Each of the four zones had specific risks associated with maintenance work. The overall solution for minimizing risk to workers is to decrease the amount of time workers need to spend in each of the zones. Results showed that changes in equipment and maintenance approaches can accomplish this goal.

The safety implications recognized for Zone One includes workers’ proximity to traffic, slip, trip, fall and projectile injuries, and hearing loss from equipment noise. The use of driven power equipment (i.e., tractors or spray trucks) instead of manual mechanical methods (i.e., string trimming crews) will decrease worker risk. The results indicated that the most cost-effective and efficient method of vegetation control in Zone One is the application of an herbicide mixture using a spray truck at all times.

Zone Two management is mowing without plant growth regulators (PGR) or herbicide treatment and for the Ohio DOT is typically performed three to five times per year. The safety implications recognized for Zone Two includes multiple mows annually, proximity to traffic, injury from projectiles, working on or near slopes, equipment rollovers, and exposure to weather, wildlife, and harmful insects. The research showed that using a truck mounted with a skid sprayer with boomless nozzles and a control panel can significantly lower costs compared to the costs of mowing per acre or per mile. The return on investment (ROI) for Zone Two management is realized when frequency of annual mows is reduced and time between mows is lengthened.

Zone Three management includes using mechanical (mower or mulch head) and chemical methods to selectively control vegetation. Annual mechanical maintenance is typical, but may occur more frequently if large, fast growing vegetation creates sight distance issues. This method requires a large amount of labor and equipment and kept staff in a reactive mode. The safety implications for Zone Three include exposure to traffic, difficult access or terrain, working with large, overgrown, or toxic vegetation, and repeated mechanical removal.

The results for the Zone Three tests concluded that using herbicides was more effective at reducing undesirable vegetation coverage when compared to mowing or cutting without using herbicides. In some cases, mowing can be entirely replaced by making properly timed herbicide applications. The judicious use of herbicides can also reduce or eliminate the need for string trimming, mowing, and chain saw thereby reducing maintenance workers' time on the ROW. Work can sometime be performed at a distance to minimize exposure to and contact with poisonous plant toxins.

Zone Four management is to leave the area undisturbed. ROW boundaries can become an issue with vegetation growth. This is controlled by periodic tree trimming and periodic tree removal. Main concerns for this zone are large trees and brush, sight distance, visible signage, road canopy shading the roadway, and hazardous trees within the fall zone of the road. The safety implications for Zone Four include improper tree trimming and removal techniques, working around fast-moving sharp blades, projectiles, and very heavy falling objects, and uneven slopes covered in debris.

Gulick et al. recommended that Zone Four management personnel be properly trained and focus on safety, efficiency, and proper arboricultural techniques. Herbicide applications can also be utilized in Zone Four to reduce the coverage of woody vegetation and lengthen the control period between mechanical maintenance cycles. Tree trimming was found to be most efficient with the chemical side trim if it is permissible to leave dead standing branches (that will eventually fall from self-pruning of the tree). Chemical side trim proved to be the fastest and cheapest option for trimming trees (31).

Fire Hazard

Roadside fires are a grave concern for some states. Adjusting mowing schedules to reduce the amount of available fire fuel is a goal set by several DOTs. The 2018 Arizona DOT *Roadside Vegetation Management Guidelines* addresses vegetation management for fire safety numerous times. The documents states that during drought periods and high fire danger land "managing agencies may require additional fire suppression equipment and tools. Check with the land owner prior to mowing in high fire danger areas." Managing roadsides to reduce fuel sources for wildfires is a key concern for the DOT (32). The California DOT (Caltrans) addresses fire risk in their vegetation control document calling for each district to include fire risk management in their respective Vegetation Control Plans (33). The New Mexico DOT also considers fire hazard reduction as part of their roadside management (34). These are just a few. Many DOTs, particularly in arid and semi-arid areas, have incorporated procedures to manage fire risk next to the roadway.

ECOLOGY

The built environment of roadways is good for human mobility. However, the effects of roadways on ecology include (7, 9, 20):

- Loss of habitat due to new pavement construction,
- Direct mortality by collisions with vehicles,
- Habitat fragmentation due to barriers that affect animal movements,
- Low habitat quality adjacent to roads,
- Isolate populations and reduced genetic diversity,
- Less animal communication and foraging due to traffic noise pollution,
- Reconfiguration of local landforms,
- Changes to hydrology and water quality, and
- Air pollution through vehicle emission.

Roadside vegetation brings some benefits to small mammals and insects by providing habitat and source of food (9). For example, native roadside vegetation is proved to be a vital source of biodiversity in the landscape of Australia and Netherlands (35). The benefits of roadside vegetation to ecosystem depend on the width of verge, design characteristics of roads and management of vegetation. In the wheat belt of Western Australia, the width of the roadway verge increased with the increase in the number of species on the roadside area (36). The design characteristics of the road, including the width, height above grade and surface of the road determines the habitat characteristics for roadside species. Besides, effects of roadways on the bird, insect, and mammal populations largely depend on the efficient roadside vegetation management including differences in mowing regimes or planting designs.

Efficient use of the narrow roadside area for vegetation establishment can mitigate the negative influence of roadways on the environment. In fact, establishing native and non-native plant species on available roadside land reinforces the idea of the sustainable roadway system and improved road ecology. Li et al. identified following determinants to portray the roadside environment characteristics (37). These include:

- Frequency of maintenance,
- Roadway type and traffic frequency,
- Longitudinal and cross-sectional slope of the right-of-way,
- Adjacent land use characteristics (land cover, slopes, maintenance),
- Storm water management methods and structures,
- Mowing height,
- Soil compaction,
- Existing plant mix, and
- Exposure to roadway-based pollutants.

A roadside environment is a distorted natural environment regardless of the physical appearance (37). Soil structure and the hydrology of the roadside are thoroughly altered from its predevelopment state to meet strict vehicular roadway design, and periodic automotive-based maintenance controls the roadside vegetation composition as well. An ecological approach to roadside vegetation management is essential as it saves the resources in the long run. To properly manage roadside habitat and minimize the damage of roadside ecology, it is imperative to understand the components of the ecosystem (plant and animal species, soils, water, weather), its functions and different limiting factors (38).

Native Plants, Non-Native Plants and Noxious Weeds

Native plant species naturally grow in a particular region, state, ecosystem, and habitat without direct or indirect human activities. Native plants are well acclimated to the given area and develop in a delicate ecological balance without posing a threat as an invasive weed. These species are difficult to establish; however, they are sustainable once planted (9). Figure 2 shows an example of common native plant in Florida. The benefits of native plant establishment are as follows:

- Requires little mowing and irrigation,
- Requires fewer herbicide applications,
- Reduces roadside maintenance costs,
- Provides erosion control in their native soils, and
- Mitigates roadside fire hazards by producing less biomass and fire fuel.

Invasive plants are non-native species that can cause economic or environmental harm to human health. *Kudzu* is an example of an invasive plant from Asia purposely introduced to solve land use problems in the 1920's (38). Plants native to the U.S. can also become destructive when moved to another region in the country. Invasive plants are often called weeds. Noxious weeds are designated plants that compromise agriculture, harm humans or degrade natural areas. This definition is typically same for each state. Noxious weeds are usually invasive plants, except they have legal standing and are subject to penalties. Each state has unique weed laws to meet their needs. Invasive plants degrade the environment at the cost of \$23B annually and spread into 4600 acres daily. It is not considered as a natural evolution, but change is ramped up by increased global mobility and speed. These changes result from human decisions; hence transportation decision-makers have a responsibility to make better choices.



Figure 2. Wildflowers *Gaillardia* along the highways in Florida

State DOTs manage over 17 million acres of ROW land in the U.S. While establishing improved visibility and obstacle-free roadsides, vegetation managers also focus on preserving the rare ecosystems and endangered species, controlling the soil erosion and sedimentation, and preventing the spread of noxious weeds as well. In recent years, revegetation of the U.S. highways with native plants has shown a resurgence. States including California, Illinois, Iowa, Wisconsin, Minnesota, Texas and many others have adopted the concept of Integrated Roadside Vegetation Management (IRVM) for the revegetation. AASTHO states IRVM approach encourages stable, independent vegetation with restricted use of mowing and herbicides (39). It is achieved through techniques that help self-sufficing native plant communities to discourage the plantation of unwanted plant species naturally. IRVM starts with proper soils management, planting method, revegetation, then

acknowledges correct mowing or restrictions, weeding, pruning, and thinning. Thus, mature roadside plant environment through IRVM results in minimal herbicide use and maintenance necessities. IRVM offers following advantages for roadside management (40).

- Native grasses and flowers are best adapted to local conditions.
- An established diverse plant community provides the most stable cover for erosion and weed reduction.
- Improved weed and erosion control can reduce herbicide usage, mowing, and associated costs.
- Native plants are less likely to encroach on land bordering rights-of-way.
- Native plant communities will reduce runoff in the spring and act as snow fences in the winter.
- Native plantings are aesthetically pleasing and may offer educational opportunities.
- Native plant communities support more native wildlife than non-native plant communities.

Importance of Roadside Vegetation

Washington State DOT (WSDOT)'s *State Roadside Manual* lists some contributions of roadside vegetation to the environment (41). These include traffic calming, stress reduction, shading for pedestrians, streambank stabilization, wetland mitigation, water quality improvement, water retention and smoother flow, air pollution mitigation, noise reduction, wildlife habitat, visual quality, quality of life, and corridor continuity. Ecosystem services are the procedures by which natural ecosystems nurture and satisfy human life (42). This concept gained its popularity in the 1990s. There are four main ES types (further divided into 30 sub-categories): 1) regulating (e.g., climate, water, soil retention, flood retention), 2) provisioning (e.g., food, raw materials, medicine, water supplies), 3) habitat (e.g., ecological corridor, nutrient cycling, decomposition), and 4) cultural (e.g., science and education, artistic, spiritual) (43).



Figure 3. Green infrastructure for storm water management (Source: 33)

Flooding, carbon emissions, degraded air quality, and urban heat island effects are critical issues that the built environment is currently facing. Trees and nature address basic human needs by improving livability and enhance the quality of life. They modify local microclimate to improve living conditions, for example, changes in solar radiation, wind speed, air temperature, relative humidity, and re-radiation from paved areas. Urban vegetation positively influences stormwater runoff quantity and quality, as the pervious soils of planted territories permit infiltration of precipitation, lessening overflow and expanding groundwater recharge. Regions of considerable tree canopy over a city can deliver an oasis impact in hot atmospheres, adding to the relief of the urban heat island impact. Figure 3 shows a green infrastructure installation for stormwater management that can provide co-benefit of health and livability. Additionally, sidewalks with a wide buffer with trees are considered as the safest as well (42).

To quantify the ES an experiment was conducted on four roadside types (e.g., major arterial roadways, minor arterial roads with no tree setback, collector streets, and a local residential street setting) in Springfield, Massachusetts (44). In this research, over 50 years of data were used regarding structure of the street sides, including the underground and overhead utilities, drainage systems, greenspace components, shade tree canopy, and tree structure. Online software tool *i-Tree Design* was used to approximate quantitative amounts of the ES provided by street trees, such as carbon storage and sequestration, stormwater interception, and air quality improvement. Models developed by the U.S. Forest Service and the U.S. Environmental Protection Agency (EPA) were used to get an approximate saving as well. This study depicts the contributions of the street trees to the community through quantitative analysis. Previous literature characterized multiple ES provided by roadside vegetation and proposed management approaches (45). Table 1 lists several of ES and associated management approaches.

Table 1: ES provided by roadside vegetation (Source: 43)

Ecosystem Services (ES)		Management Approaches
Regulating	- Improving air quality through immobilization of pollutants	- Develop structurally diverse species along roads, with a variety of plant species and morphologies. - Increase the total plant surface area, e.g., by transforming lawns into meadows or by allowing spontaneous vegetation at road verges.
	- Temperature regulation through shading and evapotranspiration	- Enhance plant biomass in road corridors, from the surface to tree layers. - Implement water-sensitive urban design to enhance evapotranspiration. - Design greening measures to shade and maintain cooling by allowing air exchange
	- Carbon sequestration	- Optimize plant choices and consider holistic approaches to maximize urban carbon pool
	- Noise reduction via diffusion depending on the shape of vegetation barriers; leaf size and branching characteristics affect resonant absorption properties	- Enhance vegetation structures at noisy road corridors - Enhance biodiversity (plants, nesting or feeding habitats for birds) in road corridors
	- Regulation of water cycling	- Implement water-sensitive urban design and green streetscape principles (e.g., swales, planters, vegetated curb extensions, rain gardens, pervious paving for storm water management)
Provisioning	- Food supply through horticulture along urban roads	- Consider different pollution loads when designing plantings (e.g., distance to roads, barriers) - Adapt choice of crops regarding pollution loads (e.g., berries instead of vegetables)
	- Allow infiltration of runoff that supports groundwater recharge	- Enhance unpaved regions to foster penetration of water
Habitat	- Dispersal corridor for species supporting ES or for species of conservation concern	- Link streetscapes with urban habitat networks
Cultural	- Attractive streetscapes promote social cohesion and physical outdoor activities and reduce stress	- Develop multifunctional “livable” streetscapes by enhancing green elements

The condition of urban ecosystems and ES require a broad general knowledge base that many citizens and members of government do not have. In the EU–MAES final report, European Commission compared their findings on urban green infrastructure, state of urban ecosystems and ES to reflect the needs of cities to establish a safer and more sustainable eco-footprint (45). This report evaluates urban ecosystem condition and local ES covering Europe.

Roadside Weed Management

Since ecosystems threatened by invasive plants disrupt the composition and function of natural areas and native plants, more prevention measures, as well as strict regulations and policies at federal and state levels, should be implemented. The wind transports invasive plant species' propagules, or sometimes they are circulated through the water. Sometimes they are carried by animals and people in fur or feathers and clothing, or even by the tires of vehicles. It can destroy area set aside for natural wildflower growth (46).

Roadsides are the genesis of where weeds and invasive plants get expanded to new areas, creating the obligation to cultivate good native plants and discard the unwanted weeds (35). According to FHWA, there are some essential considerations for the betterment of the roadside ecosystem and efficient weed management (46). These include:

- Identification of weeds or other invasive grasses/wildflowers in the region to focus on classes of plants causing the most issues for the given area.
- Training field personnel well enough about the method of weed control. It is essential to know where should apply National Environmental Policy Act (NEPA) as a roadside manager.
- Developing a plan of action considering allotted time and resources and discuss with government personnel. Coordination and collaboration among government agencies are essential when tackling issues this spread out across state borders.
- Encouraging property owners to do their part as government agencies can only go so far off the road before it becomes someone's land. It is always better to identify the plaguing factor of the specific property so that the agencies can take a more targeted approach to the situation.

Revegetation of Native Species

Despite being beneficial, native plants were the first to be eliminated for the sake of saving money or saving time on roadside projects. For example, the smooth coneflower which once occurred in over eight states in more than 65 colonies now appear in four states with only 24 colonies documented in 2000 (47). Appropriate plant species selection for revegetation is the basis for successful roadside revegetation. Idaho Transportation Department recommended some native species for use in revegetation. For example, *Bluebunch wheatgrass* and *Idaho fescue* were identified as the best performing grasses. They also assessed vegetation and soil attributes claiming perennial native vegetation can be a cost-effective approach to reduce surface erosion and weed encroachment (48).

Many DOTs are currently intrigued by local revegetation projects and plan to decrease harmful weeds and to create alluring and sustainable roadside condition. Revegetation with native species is recommended federally as well. Government offices are coordinated to utilize local species by different Executive and Administrative Orders. However, according to NCHRP 20-5, 33-04 report, DOTs use only 45% of native grasses on average for revegetation, yet this ranges to a high of 90-100% in few states (45). Revegetation with native species provides the following advantages:

- Better adapted more natural species,
- Improved slope stabilization ,
- Soil conservation,
- Ensure roadway safety while reducing erosion,
- Optimize roadside maintenance costs, and
- Reduce noxious weeds in right-of-ways.

Native revegetation is often a problematic process filled with issues including seed availability, the rate of development, and the viability of the seed. One approach is improving the effectiveness of native revegetation by reusing native topsoil. To this end, soil removed in the construction process is held amid the procedure and afterward reapplied to the same site to establish the prior vegetation cover from the current soil seed bank (30). Rights-of-way present challenges for any planting. Often the slopes are too steep for planting equipment, the soils are highly manipulated and compacted, and the full-sun exposure and poor soils make for a harsh planting environment. The FHWA manual demonstrated the establishment of native plant design consideration (eight step guideline) (38).

Pollinators in Roadside Vegetation

Protecting butterfly habitats has been an ever-decreasing priority for state and national organizations in roadside vegetation management (41). The environment can be a better place by protecting existing pollinator habitat, growing more to bring color and life to the sides of the roads, and improving public perception of the quality use of funds as well. Bees are nationally known as the essential pollinators in the ecosystem; however, often ignored when making new highways, planting grasses and other fauna on the roadside lands. It takes up lots of acreages, driving bees out from the area to find new food sources. The rich diversity of native plants results in more pollinators and hence more wildflowers in the area. Roughly 60-80% of world's 250k species of flowering plants depend on insects for pollination. Therefore, restoration of their habitat along the roadside is essential (49).

Pollination of flowering plants is an essential ES (40). Pollinators, for example, honey bees, flies, wasps, bugs, moths, and butterflies play distinct parts in food webs encouraging the generation of flowering plants. Fruits and seeds, the product of pollination, are the primary food for many birds and mammals. The primary habitat needs—flowers for nectar, pollen, and place to nest that can be easily provided in the roadsides. However, research indicates that wild pollinator habitats are in decline, which impacts pollinators themselves as well as the durability of roadside ecology and agricultural productivity.

Roadsides can likewise be a shelter for pollinators, particularly in landscapes substantially altered by urbanization or agriculture. Minimal natural surroundings like roadsides can furnish pollinators with place to search for food and to settle. Pollinator habitat must incorporate blooming flowers, which supply pollinators with protein-rich pollen and life-giving nectar. Pollinators additionally require a place to settle or to lay their eggs. Butterflies and moths, for the most part, lay their eggs on or by the host plant upon which their vegetation-eating caterpillars will feed. Conversely, honey bees create nests in which they leave food for their young. Numerous honey bee species create underground homes in their preferred soil type, while

other species settle above ground in plant stems or pits in dead wood. Honey bees settle inside protected cavities, under clusters of grass or in old rodent tunnels. Native plants support more butterflies and bees than non-native grasses and flowers (46).

The diversity of native wildflowers with overlapping bloom times should be introduced while establishing new roadside vegetation thus helps to bring pollinators throughout the growing seasons. For instance, monarch butterflies, are known for their unusual long-distance seasonal movement, depend on milkweed species as host plants (50). Monarch butterflies have been declining over the last fifteen years. Decreased quantities of milkweeds over the butterfly's breeding range, especially inside agricultural fields, are likely adding to their decline. Planting milkweeds along roadsides can reestablish monarch breeding habitat, including along migration courses.

Roadsides can be of favorable to pollinators. Florida DOT conducted a project addressing the problem of reduction in number of pollinators (50). Pathogens, pesticides, and habitat loss ruin native pollinators. However, agriculture is the second greatest contributor to the state economy after tourism and approximately 100 essential crops rely upon pollinators. The goal of the project is promoting highway wildflower tourism and saving pollinators concurrently. Roadside administrators can build up an efficient procedure for vegetation management addressing safe roadway and habitat for pollinators (50).

A review of DOT websites and documents shows that 82% have some form of wildflower and/or pollinator-friendly program within their agency. These programs often include reduced mowing to accommodate wildflower season and minimal or no chemical treatments. Many DOTs have teamed with other state agencies such as Department of Agriculture, U.S. Fish and Wildlife, etc. and volunteer groups in an effort to promote, establish and maintain the roadsides for pollinators and other wildlife. A growing trend is the placement of signage in pollinator and/or wildlife habitat restoration areas. These signs are used as outreach for the DOTs programs and as reminders to maintenance personnel for mowing practices. Figure 4 shows examples of these signs for Connecticut, Indiana, Minnesota, and North Carolina.



Figure 4. Roadside Signage for Connecticut, Indiana, Minnesota and North Carolina.

Effect of Mowing Frequency

Roadside mowing is one of the disturbances and has an impressive impact on vegetation's successional procedure. Mowing changes resource allocation by way of changing the light regime, increasing carbon allocation, removing nutrients, and disturbing soils. However, it is difficult to make speculations regarding the results of mowing since the ecological attributes are not uniform over the roadside. The effect of mowing on roadside vegetation largely depends on the temperature, amount of precipitation, the rate of human disturbance, various species characteristics, tolerance, the speed of growth, and the mowing regime (i.e., when, how often, at what height). A frequent mowing regime can generate an environmental benefit to a particular grass species which cannot endure shade; however, has a remarkable resistance to unsettling influence. This particular feature can result in either the enhancement of the existing dominant species or their elimination. This outcome can prompt more differing natural surroundings and trigger the predominance of another species.

Roadside ecosystems are studied at great length for how they should provide motorist safety, but rarely funded to study some essential ecological functions, i.e., water filtration, carbon storage, and wildlife habitat. Reduced roadside mowing can enhance native habitat, saves money, reduces CO₂ emission, and overcomes habitat fragmentation; however, transitioning to a reduced mowing regimen raises concerns about the potential proliferation of invasive plants. Areas where mowing has been limited or waived are often assumed to lead to an increase in invasive plant colonization. A study was done in Rhode Island to monitor storm water filtration and invasive plant colonization in reduced or eliminated mowing areas to see if the ecosystem services were affected by this change in management (51). Researchers studied types of roadside ecosystems—forested, early successional, and frequently mowed grasslands—under three types of vegetation management—never harvested, reduce mowed and entirely mowed. The result shows never mowed roadside areas have the highest native plant biodiversity and roadsides that fostered higher natural richness tended to have lower introduced (non-native) species diversity. Additionally, change in mowing frequency has the potential to slow the flow of runoff, increasing absorption in roadsides and resulting in less runoff entering surrounding wetlands and croplands.

Mississippi Department of Transportation (MSDOT) assessed the changes in native and non-native plant communities, the presence of wildlife (e.g., deer) on roadways, and public perception due to changes in mowing frequencies on roadside vegetation (52). No critical contrast could be identified in the height of plant three weeks after each mowing between control plots that were harvested four times per year and plots mowed only once in respective uplands or lowlands near bridges. However, the result shows an increase in native plants in annually mowed plots and an uptick in the number of deer infrequently harvested plots extensively seeded with clovers and vetches as well. Public perception review discovered fanatical support for wildflowers on roadsides yet distaste for litter. The public would agree to less mowing of the ROW if it saves money, makes the roads safer and hides the litter.

Reducing the Impacts of Herbicides

Herbicides have significant effects on pollinators (40). Direct contact with herbicides can be deleterious to bees or butterflies. Experiments proved butterflies exposed to herbicides had diminished survivorship (53, 54). Herbicides indirectly cause harm to pollinators by destroying their source of food. The sudden elimination of host plants will make caterpillars starve, and the reduction of plants that give pollen and nectar will drive bees and butterflies to find new natural surroundings somewhere else. Use of herbicides is a useful tool for roadside vegetation management. However, it is vital to utilize herbicides cautiously to prevent the decline in species that use roadsides (e.g., monarch butterfly, karner blue butterfly) (40). Typically, a sprayer, weed wiper, or similar type of procedure is used to control the growth of the invasive plant. Broadcast spraying or pellet dispersal should be avoided so that large numbers of larval host plants or adult forage plants are not destroyed.

Harvesting seeds in the fall season can be a way to reduce the cost. Limited use of herbicides, manual removal of woody plants, avoiding repeated mowing and blanket herbicide use reduce vegetation maintenance costs (54). Roadsides planted with native grasses and forbs reduce erosion, mowing frequency and use of herbicides, which leads to cost savings (46). Reduced storm water flow and reduced blowing snow due to native plantings are more difficult to calculate but also may likely produce savings.

MANAGEMENT

Well-maintained roadside vegetation provides a clear area for the errant vehicles to return safely to the roadway. Clear zones also help the drivers see other vehicles, traffic control devices, people and animals along the roadside. Safety-related practices of roadside vegetation management process involve removing the hazardous trees and branches, reduce standing water on roadways, reduce driver fatigue with variety of changing aesthetics, and reduce fire potential at pavement edge. Well-managed roadside vegetation can help to increase the property values, and reduce the liability from visibility accidents (Figure 5).



Figure 5. Examples of roadside vegetation obstructing traffic signs (Source: 55).

The study funded by Florida DOT (FDOT) estimates the benefits of the roadside management in terms of aesthetics, air quality, carbon sequestration, invasive species resistance, pollination and other insect services, and reductions in run-off-road crashes (56). This study shows that the cost of the roadside vegetation management is more than the offset just by the value of carbon sequestration, and implementing the sustainable vegetation management could become an asset to the state DOT's rather than a liability.

One of the important benefits of roadside vegetation management is providing habitat for the pollinators. FHWA project lists the best practices to incorporate in state DOTs' roadside vegetation management plans in order to improve the pollinator population (57). These practices include protecting the native habitat, adjusting mowing practices, reducing the impact of herbicides, and so on. Figure 6 shows the roadside covered in the Texas native Bluebonnet flowers. The native plants can help to boost the pollinators habitat as well enhance driver experience.

The method used to control the roadside vegetation greatly depends on the biology of the roadside plants and weeds. AASHTO's *Guidelines for Vegetation Management* classifies the roadside vegetation into the ancestral plants, fern and fern-like species, grasses, sedges, broadleaf forbs, vines and woody species such as shrubs and trees (58).



Figure 6. Texas roadside covered with Bluebonnet, the official state flower (Source: 57).

Mechanical Control

Mechanical control can involve large tractor mowing, string trimmers, push mowers, pruning shears and so on for controlling the growth of roadside plants and weeds. The goals of mowing include creating attractive roadsides, clear vision at intersections, provide safe pull-off areas, clear recovery zones, lower the maintenance costs, preserve the native vegetation, and improve the wildlife habitat. In the recent years, some states have developed more innovative practices for the mechanical control purposes and are using more innovative equipment for the mowing purposes. Minnesota DOT (MnDOT) is using mowers equipped with Automated Vehicle Location (AVL) systems (59). The AVL live maps show the locations of known noxious weeds using pink and red polygons as shown in Figure 7. The dots show the locations of infiltration basins, drop



Figure 7. AVL live map (Source: 59).

inlets and aprons. The operator can use these dots to identify the locations of drainage and other structures while mowing.

Permanent Vegetation Control

Permanent vegetation control consists of using the permanent barriers around the roadside fixed objects where the mowing and spraying are difficult. Although the initial cost of the permanent barriers is high, this application can be cost-effective in the long term because of limited mowing and herbicide spraying. This treatment should be considered for the new constructions, but is not recommended for the existing guardrails due to the high costs.

AASHTO guidelines has identified the following permanent vegetation control methods (58):

- Minor Concrete Pavement (Figure 8).
- Asphalt Composite
- Stamped Asphalt Paving
- Patterned Concrete Pavement
- Rock Blanket
- Gravel Mulch
- Aggregate Base
- Rock Slope Protection
- Weed Control Mat
- Herbicide Geofabric
- Rubber Weed Mat
- Irrigated Ornamental Vegetation
- Native and non-irrigated Vegetation
- Organic Mulch.



Figure 8. Minor concrete vegetation control (Source: 58).

Cultural and Biological Control

The cultural weed control methods refer to the establishment of competitive desirable species to force out noxious weeds (58). The methods include burning, mulching, flooding, soil modification and organic treatments such as hot water, soap, vinegar and so on. Biological control uses the animals (e.g. grazing), fish, insects, bacteria, fungi, viruses, and competing plants to control unwanted vegetation.

Chemical Control

Herbicides are the major component of vegetation management programs. Herbicides typically provide a selective control for certain species of targeted noxious and invasive weeds. Some of the advantages of using the herbicides are their safety and time-effectiveness benefits. The workers and mowers spend less time on the ROW when using the chemical control methods.

However, the herbicides can have adverse effect on the environment by endangering the crops, livestock, fish and wildlife. Some states such as Oregon DOT include the fish and wildlife protection strategies in their roadside vegetation plans by reducing the spraying time and width to protect the riparian areas (60).

The EPA administers Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for regulating the sale, distribution and use of herbicides. Roadside application herbicides fall into two main categories: soil-active and foliar-applied (61). The soil active herbicides are applied to the soil where residuals move into the plant root by water and rainfall. The foliar-applied herbicides are typically sprayed directly onto targeted plant foliage or bare soil (Figure 9).



Figure 9. Model 85 herbicide spraying unit (Source: 61).

Other Methods

In addition to the aforementioned methods, some states have been practicing with other more-innovative and less labor-intensive methods (62).

Roadside Zone Management Practices

It is essential to incorporate the vegetation management into the transportation planning and design phases to achieve the highest benefit and cost effectiveness. Most state DOT's have adapted the zoning practice developed by National Roadside Vegetation Management Association (NRVMA) to incorporate the vegetation management in transportation planning phase. States use either three or four zones to define the roadside zones. Figure 10 depicts the roadside zones described in WSDOT's *Roadside Policy Manual* (63). The figure also incorporates the activities and the functionalities of each zone.

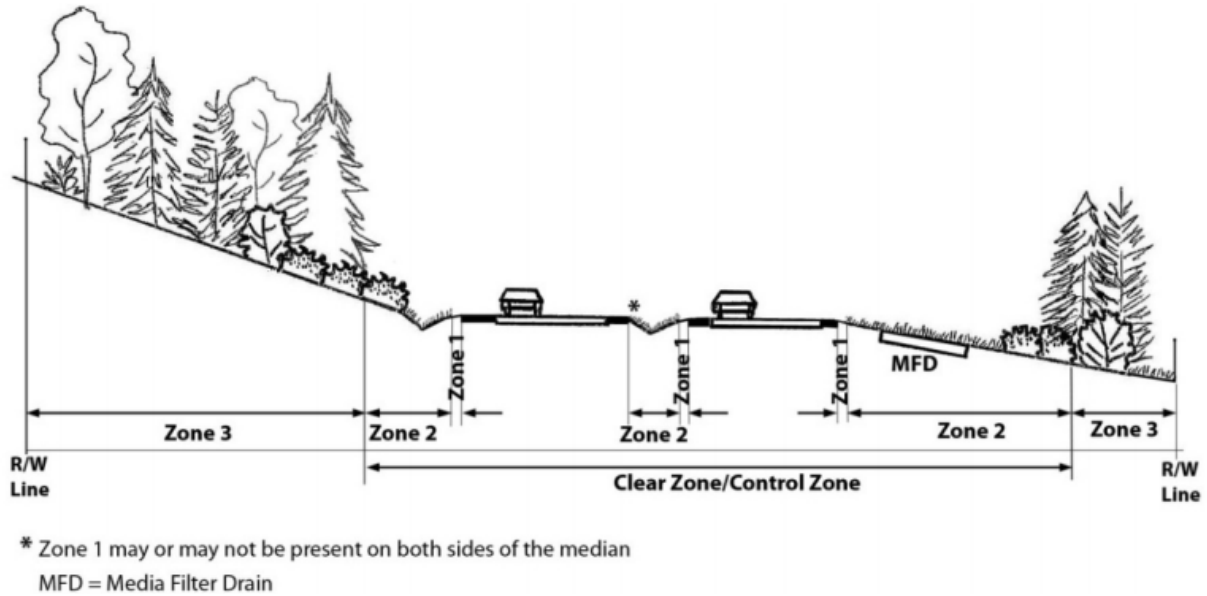


Exhibit 1-1 Roadside Zones

	Zone 1	Zone 2 ²	Zone 3
Definition	The vegetation-free or routinely mowed zone adjacent to the pavement	Clear Zone as defined in the <i>Design Manual</i> ; also includes Zone 1 Control zone as defined in the <i>Utilities Manual</i> ; also includes Zone 1	Area beyond the clear zone up to the right of way line Typically contains native or naturally occurring vegetation
Activities and Features		Errant vehicle recovery	
	Guideposts and buried utilities	Signs and buried utilities	
	Sight distance	Sight distance, sign visibility	
	Erosion control	Erosion control	Erosion control
	Noxious weed control	Noxious weed control	Noxious weed control
	Pavement preservation	Slope stabilization	Slope stabilization; provides carbon sequestration
	Level spreader and filter for stormwater leaving the pavement	Stormwater conveyance and treatment, such as filter strips and swales	Stormwater conveyance, treatment, and storage, such as natural dispersion areas and ponds
		Corridor continuity	Corridor continuity
		Scenic enhancement, screening, and blending	Screening and blending; scenic enhancement
	Guardrail	Signs	Walls and other structures
	Mechanical or chemical control of vegetation	IVM techniques to preserve sign visibility/sight distance, and provide weed control	Minimal intervention using IVM techniques to encourage desirable self-sustaining plant communities
	Zone 1 has no stream and wetland buffer functions	Zone 2 has limited stream and wetland buffer functions	

Figure 10. Roadside management zone definitions and activities (Source: 63)

- Zone 1 is the vegetation-free or routinely mowed zone adjacent to the pavement. The main features of Zone 1 are to support the guideposts, guardrails and buried utilities,

provide for sight distance, control erosion, preserve pavement, filter stormwater leaving the pavement, and help provide a mechanical and chemical control of vegetation.

- Zone 2 contains the Clear Zone that provides the recovery area for the errant vehicles as well as supports the traffic control signs. Other features of Zone 2 include providing sight distance and sign visibility, erosion control, stormwater conveyance and treatment (filter strips and swales), corridor continuity, scenic enhancement, noxious weed control and slope stabilization.
- Zone 3 is the area beyond the Clear Zone up to the ROW line. This zone typically contains native and naturally occurring vegetation. Zone 3 activities consist of erosion control, noxious weed control, slope stabilization, stormwater conveyance, screening and blending, and constructing permanent vegetation barriers.

The effective roadside management process requires making informed decision to integrate different techniques and methods to achieve the greatest benefits. Minnesota DOT has conducted the survey of the existing best practices in the states to develop *The Best Practices Handbook on Roadside Vegetation Management* (64). The handbook classifies the existing best management practices for roadside vegetation as follows:

- Develop an Integrated Roadside Management Process (IRVM).
- Develop a Public Relations Plan
- Develop a Mowing Policy and Improved Procedures
- Establish Sustainable Vegetation
- Control Noxious Weeds and Prevent the Establishment of New Invaders
- Manage Living Snow Fences
- Use Integrated Construction and Maintenance Practices.

ECONOMY

State DOTs struggle with meeting maintenance need with available budgets. Roadside vegetation management practices seem to provide flexibility within budgets. Allowing for some sort of managed succession within select areas reduces the need for mowing and other vegetation management. Little research has been conducted regarding the cost benefit of managed succession. However, some states have realized saving with reduced mowing.

The Florida DOT (FDOT) stated a potential cost savings of 30% by implementing sustainable management practices such as reduced mowing. A conservative estimate for enhanced ecosystems services provided by sustainable practice is about \$1 billion with an increase up to \$15 with the incorporation of wildflowers (56). It is estimated that a 10% reduction in mowing along rural roads (excluding asset maintenance) can reduce the department's annual expenditures for mowing by \$1,265,597 (65),

The Georgia DOT (GDOT) implemented reduced mowing in 2009. The decision was based on budgetary constraints. The cost saving to GDOT of limited mowing was estimated to be \$10.95 million for the year following implementation (66).

The Maryland State Highway Administration (SHA) initiated a reduced mowing program designed to return select areas of grassed roadsides to meadows and forests. SHA not only

decreased the number of mowed acres, they also reduced the number of seasonal mowing cycles. In fiscal year 2010, 33,000 less acres were mowed, freeing up \$3.5 million for use in other maintenance programs. The SHA realized the ecosystem services of reduced mowing such as benefits to wildlife, and improvements to stormwater quality and quantity (67).

MSDOT assessed that more than 10M of savings is conceivable if mowing is reduced to once every year in late fall after seed set. Virginia spared \$20M in 2009 by cutting its roadside mowing in half. However, budget constraints influence projects to create naturalized roadsides — Minnesota, for instance, cut \$50,000 for its roadside seed-acquiring program. Ability to grow native fauna and encourage wildlife to pollinate highly depend on the mowing season, seed diversity, and human intervention during ecosystem development. Therefore, a right balance of mowing frequency can increase passengers' safety on the roadways while offering a sustainable approach to preserve the roadside vegetation. Additionally, the simultaneous execution of a far-reaching education program would be necessary for the public to understand the restorations of natural beauty adjacent to the ROW thrive (50).

CONCLUSIONS

There is a growing body of research and project implementation regarding the management of roadside vegetation. DOTs are realizing that less is more when it comes to roadside vegetation management. The ecosystem services provided by minimizing roadside vegetation maintenance practices not only benefits the environment but also saves DOTs money in the long term. Workers are exposed to less traffic hazards that can occur during vegetation management activities and fewer chemicals due to minimizing treatments. Although reduced roadside vegetation management may not be applicable to all roadside scenarios such as many urban roadways, there are thousands of miles of ROW where reduced mowing activities are applicable. Public outreach and volunteer programs have benefited DOTs in educating the public on the benefits of using the roadsides to provide more than something aesthetically pleasing.

From a transportation agency perspective, roadsides could be categorized within an asset management plan in terms of an operational zone and environmental zone. Each is managed with different goals and personnel. The operational zone contains those components related to safety, drainage, utilities and roadside appurtenances. The environmental zone is managed as an environmental asset containing all of the ecosystem services that a healthy roadside provides.

CHAPTER 3. STATE TRANSPORTATION AGENCY PRACTICES

This chapter contains the detailed information collected from the various state agencies through a survey of practice, follow-up interviews and review of the available manuals and documents. The state DOT documents categories include performance standards, technical standards and guidance documents. However, some of the vegetation management guidance found was not a formal document, but rather as DOT website information. Many DOTs defer to AASHTO's *Guidelines for Vegetation Management* (58) for roadside vegetation management guidance. A search of DOT websites found 42 states with some documentation regarding their roadside vegetation management practices. This documentation was not always an official document. Some states have website pages that outline their wildflower programs, etc. These are included as a roadside management practice. Of those documents found, 27 states have a reduced mowing practice. The decision to reduce mowing came from budget constraints, accommodating wildflowers, pollinators and wildlife, and other environmental concerns. Appendix A summarizes the state DOT documents reviewed and the relevant information contained.

SURVEY OF PRACTICE

An online survey of practice was developed and administered to those tasked with managing roadside vegetation in the DOTs to determine the following:

- Does your agency/area have a published/established roadside mowing/vegetation management protocol?
- Does agency/area in which you work follow a statewide vegetation management plan or is it specific to your area of responsibility?
- How does your agency/area maintain vegetation outside of the safety clear zone?
- Who is responsible for your conducting roadside vegetation maintenance, e.g. mowing, herbicide, etc.?
- Has your agency/area conducted research/performance measurement regarding the cost/benefit of reduced mowing, managed succession or other adjustments to routine mowing protocols outside the safety clear zone?
- Has your agency/area conducted research or assigned values to ecosystem services or to increased natural function associated with reduced mowing, managed succession or other adjustments to routine mowing protocols outside the clear zone and roadside ecosystem services?
- Has your agency/area implemented reduced mowing protocols specifically as part of a program to accommodate roadside pollinators and other wildlife habitat conservation and/or habitat establishment?
- Has your agency/area conducted any research/performance measurement regarding your program to accommodate roadside pollinators and other wildlife habitat conservation and/or habitat establishment?
- Has your agency/area conducted research/performance measurement regarding the association between changes in mowing protocols and wildlife incidents?
- If your agency has implemented a program of managed succession, does your agency have protocols for determining implementation of managed succession?

- Does your agency/area provide outreach/public education/stakeholder involvement regarding changes to roadside vegetation management, specifically managed succession?
- Has your agency/area faced any institutional obstacles in the implementation of a reduced mowing protocol and/or managed succession outside the safety clear zone?
- Has your agency/area been involved in any litigation regarding changes in roadside mowing protocols outside the safety clear zone (adjacent property owners, wildlife issues, etc.)?
- Does your agency/area have any cooperative agreements for roadside mowing/maintenance with other agencies, local entities or private landowners that do not want reduced mowing and/or managed succession adjacent to their property?
- Has your agency/area conducted research/performance measurement regarding the association between changes in mowing protocols and snow/ice/wind conditions on the roadway
- What information would your agency/area consider important for inclusion in an online guidance tool for determining vegetation management best practices outside the safety clear zone?

The survey design tried to optimize responses by balancing the length and the level of detail of the survey with the respondent willingness to complete the survey with useful information. The on-line survey instrument used a web-based survey administration facilitator. The project panel reviewed a draft survey, and a final survey instrument reflected the panel member comments. Appendix B contains the final survey.

RESULTS

The survey respondents included a broad range of technical expertise in roadside vegetation management such as vegetation managers, landscape architects, maintenance engineers, environmental coordinators and others. The survey comments included were edited, condensed, and/or summarized. As of this Interim Report, 26 states have responded to the survey. Those states include:

- Arizona DOT (ADOT)
- Arkansas DOT (ArDOT)
- California DOT (Caltrans)
- Connecticut DOT (CTDOT)
- Florida DOT (FDOT)
- Georgia DOT (GDOT)
- Idaho Transportation Department (ITD)
- Indiana Dot (INDOT)
- Kansas DOT (KDOT)
- Louisiana Department of Transportation & Development (LADOTD)
- Maine Dot (MaineDOT)
- Maryland DOT (MDDOT)
- Massachusetts DOT (MassDOT)
- Michigan DOT (MIDOT)
- Missouri DOT (MoDOT)

- New York State DOT (NYSDOT)
- North Dakota DOT (NDDOT)
- Ohio DOT (OHDOT)
- Oregon DOT (ORDOT)
- Pennsylvania DOT (PennDOT)
- Texas DOT (TxDOT)
- Utah DOT (UDOT)
- Vermont DOT (VTrans)
- Washington DOT (WSDOT)
- Wisconsin DOT (WisDOT)
- Wyoming DOT (WYDOT)

A consensus found throughout the DOT literature, websites, and survey results was roadside vegetation maintenance activities focuses on:

- Maintaining the safety clear zone,
- Encouraging and/or preserving native or adaptive low maintenance vegetation to inhibit the spread of noxious or invasive plant species,
- Managing for wildlife and pollinators,
- Managing the quantity roadside fuel available to reduce fire hazard risk,
- Managing soil erosion and invasive plants to preserve infrastructure integrity,
- Utilizing vegetation for stormwater quality and quantity control,
- Compatibility with adjacent land uses,
- Environmental compliance, and
- Aesthetics.

Survey participants were asked whether their agency/area has some official program that determines the management of their roadside vegetation. Of those respondents, 89% have published roadside vegetation management documents that determine vegetation management and/or mowing practices. The Arizona DOT is currently drafting their vegetation management guidelines and Maryland is updating their manual.

If the DOT has a roadside management program, is this statewide or conducted at a regional level? Of those respondents, 76% have some system of statewide vegetation management protocols. The states with statewide plans, 30% also allow regional level management and priority decision-making regarding roadside management to fit the local conditions such as terrain, precipitation, native plants and adjacent land uses. Regional or district level plan implantation is conducted by 23% of the states responding.

The survey and DOT documents review determined how DOTs maintain vegetation outside of the safety clear zone. The survey results include the following:

- Scheduled/routine mowing—81%
- Zero maintenance—74%
- Targeted mowing—67%

- Target chemical application—81%
- Mechanical trimming and removal—74%
- Biological treatments—37%
- Managed succession—3%
- Other maintenance activity—26%

The other maintenance activity used include prescribed burns, timber sales, and private use and maintenance of the ROW for hay collection and other uses. The surveyed state agencies that indicated they have implemented or are in the process of implementing a managed succession program are INDOT, MaineDOT, MDDOT, MIDOT, ORDOT, PennDOT, TxDOT, VTrans, WSDOT, and WYDOT.

The majority of agencies use either direct employees or contract labor to the roadside maintenance. However, there seems to be an increased interest by various volunteer type groups for maintaining areas associated with pollinators, wildflowers and wildlife habitat. The results are as follows:

- Agency/area, e.g., direct employees—89%.
- Contract maintenance worker—78%
- Public-private partnership—22%
- Non-profit group, e.g., Friends of Monarchs, Prairie Conservation, etc.—15%
- Other method—33%

The other methods described include:

- Permitted vegetation management by adjacent landowners and billboard/sign owners respectively,
- Adopt-A-Highway and other beautification volunteer programs,
- Memorandums of Understanding with Department of Agriculture and County Weed and Pest Districts,
- County Weed Boards for herbicide and noxious weed control,
- Agreements with cities, counties, and other local municipalities,
- Permitted hay harvesting, and
- Contracts with counties.

Only six states indicated they have conducted research/performance measurement regarding cost/benefit of reduced mowing, managed succession or other adjustments to routine mowing protocols outside the safety clear zone and selected from the response choices to this question. The remaining responses indicated no or did not answer. However, there were several comments. The response choices for cost/benefit were:

- Equipment—100%.
- Materials—83%.
- Direct labor—67%.
- Management/planning costs—67%
- Worker safety—50%.

- Variances within the context of individual agencies and regional ecosystems—50%.
- Other—33%.

The comments received are as follows:

- CTDOT has not conducted research as of this date. Reduced mowing has been implemented for several years at this point so research data is available for a near-future study.
- MaineDOT relied on the Florida study (56) to support the position that managed succession would result in lower cost.
- NYSDOT has no plans presently for research, but knows that reduced mowing has benefits in many of these areas.
- ODOT has not completed research, but has plans to do so soon.
- PennDOT referenced a project conducted by Penn State, Roadside Vegetative Management Project, <http://plantscience.psu.edu/research/projects/vegetative-management>.
- VTrans has some limited cost-benefit information.
- WSDOT is gathering data on LEMO costs and environmental consequences of mowing vs. managed succession and defining how roadside is categorized and valued as part of the agency's Asset Management Plan that is currently being drafted. WSDOT is defining roadsides in terms of operational right of way vs. areas that are wide enough to accommodate managed succession.
- WisDOT has not conducted research. However, over the years WisDOT has reduced its mowing from mowing the entire roadsides three times a year in the 50's, to today mowing only the clear zone once a season and allow mowing the entire roadside once every three years were woody plant materials has grown.

DOTs research regarding the connection between ecosystem services and reduced mowing, managed succession or other adjustments to routine mowing protocols is limited. Only 50% of the respondents answered this question with the remaining answering no or skipped the question. However, there were several comments. The majority of the responses, 85%, were regarding adjusted mowing schedules for invasive species control. Pollinator studies ranked second among the answers. Aesthetics were the third greatest answer. The responses are as follows:

- Erosion control/soil stabilization—31%.
- Stormwater quantity and quality control—31%.
- Soil fertility—15%.
- Pollination—62%.
- Invasive species control—85%.
- Carbon sequestration—0%.
- Cycling and movement of nutrients, e.g., nutrient leaching—0%.
- Aesthetics—46%.
- Biofuel production—8%.
- Wind energy collection—0%.
- Solar energy collection—0%.

- Other alternative uses—0%.

The comments on the area of research included:

- GDOT is looking into this.
- ITD would like to conduct research in this area but no funding available.
- INDOT—having this information would be useful to communicate additional benefits for reduced maintenance and the implementation of IVM.
- MaineDOT relied on the Florida study (56) to support position that managed succession would result in lower cost.
- MassDOT—Not currently, but very interested in what other agencies are finding on this subject.
- NYSDOT is in the planning stages for a new pollinator project.
- WSDOT is collecting data on pollinator presence in mowed vs. "native restoration" roadside areas, but current data just reflects the before condition. Complete data on the restored condition will not be available for several years from now when native vegetation is established. Data on the other areas of environmental impact is needed.
- WYDOT— Yes, within context of Regional Ecosystems (i.e., Eco-Regions) per construction projects reclamation.

There was a broad range of answers to the question regarding implementation of reduced mowing protocols specifically as part of a program to accommodate roadside pollinators and other wildlife habitat conservation and/or habitat establishment. Four states responded that they have not implemented any sort of reduced mowing program. Several states indicated that reduced mowing has been part of their roadside maintenance for many years. Although 48% of the states did not respond to the survey, many states have implemented reduced mowing, managed succession and programs that accommodate wildlife and pollinators. Comments from the survey participants are as follows:

- ARDOT is in the process of creating wildflower areas outside the clear zone for aesthetics and for pollinators.
- ADOT encourages minimal mowing in areas seeded with native vegetation. Construction projects all use native seeding with seed mixes of 10-15 species selected by the biozone - 9 zones across the state. Mowing is minimal in some districts and more common in less than half.
- Caltrans is looking at reducing mowing acreage and its impact on reduction of greenhouse gas emissions.
- CTDOT seeded/planted eight pollinator corridors throughout CT in 2017. These sites will be monitored this coming season and with possible future expansion.
- FDOT reduced mowing in certain areas change from a 15-foot strip to an 8-10 foot safety strip depending on time of the year and what pollinators and or flowers present.
- GDOT reduces mowing on a short-term basis to accommodate wildflower program.
- ITD has a reduced mowing practice, but it is implemented at the discretion of the district Operations Engineer.

- INDOT indicated that reduced mowing immediately and positively impacts pollinators. Further comments stated that the opinions of internal and external sources forces mowing.
- KDOT mowing practices are to mow out only 1/4 of the ROW each year and delay mow out until after October 1. KDOT uses a seed mix of forbes and native grasses for newly disturbed ground from construction activities.
- LADOTD has not implemented reduced mowing yet, but has native wildflowers and prairie in test plots.
- MaineDOT reduced mowing in 2008, but not specifically to benefit pollinators.
- MDDOT reduced mowing prior to pollinators becoming an issue. This was done to save money. Reduced mowing has resulted in increases of pollinators on roadsides.
- MassDOT has a pilot effort by some of the district offices to identify locations for reduced mowing. These are typically marked with a No Mow or Limited Mow sign.
- MIDOT reduced mowing per state legislation to reduce cost and create habitat for ground nesting birds.
- MoDOT reduced their mowing the late 1980s. Generally, urban areas are mowed more than rural areas. Majority of mowing is one or two passes from the shoulder.
- NYSDOT conducted a pollinator pilot project with modified mowing protocols on a 6-mile segment of RT 390. The current mowing guidelines also stress adjusting mowing frequencies to accommodate ground nesting birds.
- ODOT has a strong program designed to accommodate roadside pollinators and other wildlife. Their research project developed the pollinator program (68). The DOT also has partnership with Pheasants Forever to provide guidance on pollinator habitat establishment.
- PennDOT incorporated a reduced mowing policy into their Maintenance Manual (69) years ago due to budget shortages and found that it provides pollinator benefits if incorporated. There is only a voluntary effort if district/county managers want it.
- UDOT is currently discussing pollinator habitat mowing reductions as long as the safety aspects are maintained.
- VTrans considered many competing interests in drafting their Mowing BMP. This includes increasing and improving pollinator habitat on VTrans-managed ROW.
- WSDOT WA-Ref. the attached Proposed Agency Policy for Reduced Mowing and 11/25/15 briefing paper. TES guidance specifies mowing timing windows in key locations.
- WisDOT has a small 20-mile pollinator pilot project on STH 26 in Dodge, Jefferson, and Rock Counties. WisDOT is working in partnership with the county highway partners. The first year, 2017, was developing the partnership and program. In the field, the once-a-season roadside mowing was delayed to late fall (after the majority of the pollinators were no longer in the area). Plans are currently in development for 2018.
- WYDOT uses targeted mowing to reduce large game/ vehicle collisions in the clear zone.

Of the states that have implements various programs for pollinators and wildlife accommodation, the researchers want to know if the DOT has conducted some sort of research or have performance measurements for this activity. There were 23 responses to this question. Eight states said they have not conducted any research. The majority of states are

very interested in such data to “bolster the argument” for their respective programs. Other comments include:

- ARDOT—Yes.
- Caltrans has an internal effort to encourage pollinators is in progress, but development is not yet complete.
- CTDOT referenced the Pollinator Corridors chapter in *Connecticut Department of Transportation Vegetation Management Guidelines* (70).
- FDOT has very limited research.
- GDOT is considering this research.
- LADOTD— Pollinator habitat is becoming more of a topic in recent discussions.
- MaineDOT conducted research on pollinators in roadside environments last year. The report should be completed very soon. The surveys were conducted by entomologists from the University of Maine, Orono.
- MDDOT has ongoing 3-year research project looking into improving pollinator habitat by either annual dormant mowing or selective herbicide spraying. The report expected in 2020.
- MassDOT is interested in efforts by other agencies.
- MIDOT—Yes, Michigan State University is researching the effects of mowing, reduced mowing, and not mowing on milkweed.
- NYSDOT has an overview of the pilot project located at: <https://www.dot.ny.gov/regional-offices/region4/other-topics/pollinator-project>.
- ODOT has ongoing performance measures on their projects.
- PennDOT—Penn State research has provided information on common milkweed and impacts of various herbicides.
- UDOT is looking into this.
- WSDOT has conducted a series of baseline transects for pollinator presence in a various roadside locations throughout the state, including areas where native restoration is being created through new construction or by maintenance operations. These transects will be monitored over a number of years. We also have "before" costs and levels of maintenance in formerly mowed areas.
- WisDOT stated that no research has been conducted, but performance measures are being considered.

One of the critical issues for some states is the attraction of wildlife to roadside vegetation. Researchers wanted to know if the DOT has conducted research/performance measurement regarding the association between changes in mowing protocols and wildlife incidents. There were 19 responses to this question and 16 of these were some form of no. the concerns seen throughout the literature and other DOT documents is the large wildlife collision issue. The responses include the following:

- MaineDOT studied trends since beginning tree clearing along the interstate system in areas of high moose crashes. We have watched trends for the past 10 years in crash data. Moose crashes are on a continual down trend, but deer crashes are rising over the same period. Difficult to say it is due in either case to increasing the distance to the tree line.
- TxDOT has seen no difference in the number of roadkills.

- WSDOT stated that adjustments to mowing patterns for increase wildlife visibility in known high accident locations are documented in the Area IRVM Plans. WSDOT is tracking roadkill data, but has not compared with areas being treated with reduced mowing.
- WYDOT gets their collision data from the Highway Safety Segment Reports derived from Accident Reports (WYDOT) Planning Division.

Determining if and where managed succession should occur requires consideration of many criteria. The states that implemented a level of managed succession were asked what lead their decision-making. Only seven states selected from the choices below. Of these, roadway context and roadway classification ranked highest. Roadway geometry, adjacent land use, access point and local agreements ranked equally.

- Roadway context, e.g., urban, suburban, rural—86%.
- Roadway classification—71%.
- Roadway geometry—43%.
- Adjacent land use—43%.
- Number of access points, e.g., driveways, sidewalks—43%.
- Pedestrian/bicycle usage—14%
- Local agency resolution/agreement—43%.

These are the comments received.

- ADOT's seed mixes for construction projects are tailored to a near road mix (lower stature), a mix for beyond the clear zone, and a mix for wetter areas such as drainage basins and adjacent to washes/riparian areas. Other mixes may be created as needed for some of the situations above but no formal protocol. Development is on a project-by-project basis.
- MDDOT indicated that all appropriate areas outside the clear zone are planted or managed as forest so the Agency can meet TMDL goals.
- Pennsylvania Department of Conservation and Natural Resources has administered timber sales on PennDOT limited access right of ways when they have a timber sale on nearby state forestland.
- VTrans stated that safety dictates their actions
- WSDOT stated that local arrangements and multi-year plans are documented in the Area IRVM Plans.

Reduced mowing and managed succession are relatively new concepts for the public. Change usually requires some public outreach to educate the public regarding why DOT procedures are occurring. Of the 26 responses, 16 indicated that their transportation agency does not engage in public outreach regarding vegetation management. Those with some sort of outreach and/or stakeholder participation had the following comments.

- CTDOT has been publicizing the *Vegetation Management Guidelines (70)* and various aspects of it via the website (ct.gov/dot), meetings with Audubon Societies, plant /

pollinator working groups, and recently, testimony to the Environment Committee in a legislative meeting.

- FDOT has district POCs that are available to the public and go speak on behalf of the department.
- GDOT releases information through the GDOT Communications Office.
- INDOT does outreach upon invitation to interested groups. They would like to see more open and highlighted efforts demonstrating the effectiveness of the changes.
- MaineDOT uses news media reports, and working with local communities.
- NYSDOT stated their outreach is not specifically for managed succession, but developed talking points for mowing limits, and also placed signs for the pollinator pilot project.
- PennDOT participates in developing the State Pollinator Management Plan and the State Invasive Species Management Plan.
- TxDOT—We have set these areas up many years ago.
- VTrans involves many external stakeholders primarily from sister state agencies, but have collaborated with general public and monarch interest groups on our mowing BMP.
- WSDOT invites outside input on the contents of Area IRVM Plans and adjusts plans based on local interest where possible. In the coming years there will be a need to do additional public education and engagement in supporting native restoration over mowing.

Changes within an institution can be challenging. The purpose of this question was to see the level of difficulty agencies face when implementing changes in roadside vegetation management practices. Of those 26 states responding, 63% indicated there are institutional obstacles. The most common comment is negative public opinion regarding the aesthetics of a less frequently mowed roadside. The NYSDOT summarized it concisely stating that it is a complex issue.

- ADOT—Business and property owners sometimes mow or spray areas on our ROW in order to create a "neater" appearance or maintain visibility of business signs located off the ROW.
- ARDOT—The current three mowing cycle program is constantly criticized by the public with the bulk of the complaints being that we do not mow enough.
- FDOT—Internal department issues.
- GDOT—The biggest challenge to reduced mowing protocols is public perception.
- INDOT—Internal and external opinions strongly opposed to change- no real data other than opinions of aesthetics. "Looks like xyz".
- KDOT—Public outcry that we are not mowing our ROW. Uncontrolled growth of cedar trees is a problem for our agency and adjacent landowners.
- LADOTD—Public outcry tends to be negative when vegetation reaches certain heights.
- MDDOT—If there are complaints by the public about lack of mowing, Districts tend to respond by mowing areas in question no matter the location.
- MassDOT—There are conflicting expectations of how the roadside should look. Limited mowing occasionally results in call-in complaints that roadways do not look cared for. Some maintenance personnel have reported difficulties with trash or dumped materials embedded in or hidden by grasses allowed to grow.

- MoDOT—Almost always. Some prefer a manicured look, similar to a golf course fairway or lawn.
- NYSDOT—It's a complex issue. Employees want to have a right of way that looks "well maintained" and is safe, so the tendency is to mow more. The public has mixed expectations. Some people favor less mowing for pollinators and other wildlife, while others desire the more manicured look.
- NDDOT—Based on differences in geography, climate and farming practices in the areas.
- ODOT—Number of our managers have complained stating that it will cause the public to complain and feel we are not providing the services we need to provide.
- PennDOT—Urban roadsides are influenced by public opinion and their related legislative representation. Hard to change the paradigm of urban roadsides to reduce mowing cycles.
- TxDOT—There are always complaints when it comes to mowing. It is either too much or not enough.
- VTrans—Mainly public pressure regarding roadside aesthetics.
- WSDOT—Field maintenance workers almost always prefer a simpler "just mow it" approach. Also, it is difficult to prioritize and implement multi-year native restoration projects within normal maintenance operations and emergency response.
- WisDOT—Managed succession outside the safety clear zone has not been addressed.
- WYDOT—Typical within urban segments, especially interstate routes.

Another concern for agencies is regarding the potential impacts of change. Did the agency face any litigation that arose from these changes in roadside vegetation management practices? The majority, 96% indicated that their respective agency has not faced any litigation specifically pertaining to changes in roadside mowing protocols outside the safety clear zone. One agency indicated that they had other vegetation management practices aside from mowing that may have led to litigation. Another issue expressed was visibility of billboards due to tree growth. Also stated were complaints by abutting property owners regarding reduced mowing and planting of trees, but none have resulted in litigation.

Because of reduce roadside maintenance programs, many DOTs are allowing cooperative agreements for roadside mowing /maintenance with other agencies, local entities or private landowners that do not want reduced mowing and/or managed succession adjacent to their property. Some sort of cooperative agreement exists for 41% of the respondents. These are shown below. Examples of cooperative agreements and permits are in Appendix C.

- GDOT has a standard Mowing and Maintenance Agreement used for enhancement planting projects found in their GDOT Traffic Operations document.
- INDOT stated that it is not uncommon for adjacent landowners to mow areas on state roads and US roads. Interstate system is not impacted by adjacent landowners, though some have taken woody vegetation management into their own hands.
- LADOTD has agreements mostly with municipalities. In general, they want increased mowing which is the main reason they enter into the agreements.
- MDDOT has informal arrangements made by Districts that allow abutting landowners to mow or farm within Agency ROW.
- NYSDOT may have some local agreements where villages, airports, etc., want a more manicured look in certain locations.

- NDDOT State law allows adjacent landowners to mow ditches.
- ODOT has a number of permits for businesses and municipalities to mow the ROW. The agreements and permits are mainly in urban areas.
- PennDOT issues M-688 and M-700 permits for vegetation management by adjacent landowners and billboard/sign owners respectively. Adopt and Beauty agreements are for volunteers to plant and do litter pick-up.
- TxDOT has agreements, but they are mostly just a verbal agreement with the local supervisor.
- VTrans has agreements with municipalities to have them manage landscape features in roundabouts. They also have adjacent landowner agreements allowing more frequent mowing by the landowner. Many restrictions and conditions apply.
- WSDOT has Adopt-a-Highway agreements and a Vegetation Alteration Permit.
- WisDOT has contracted with Wisconsin's 72 counties for State roadside mowing. Counties are interested in increases the number of times each season they mow the clear zone. WisDOT has also allowed increases mowing of it roadsides near selected urban areas.

One concern associated with allowing larger, woodier vegetation grow along the roadside is how this practice affects winter road conditions. Larger vegetation can create shadowing and ice hazards. However, the larger vegetation may also act as a living snow fence. Only 13 agencies responded to this question. Of those, 15% stated changes in mowing reduced the need for snow and ice removal because the vegetation behaves as a snow fence. The majority of the comments were that agencies have not conducted research regarding ice and snow issues and mowing protocols.

In an effort to include relevant data in the interactive online tool respondents were asked what be of value to their respective agencies. The complied results are as follows.

- Showing the benefits of reduced mowing would go a long way in gaining support and implementation by district and county managers.
- A definition of safety clear zone.
- Noxious and invasive weed identification and control measures.
- Special/sensitive management areas (pollinator habitat, endangered species, etc.)
- Site assessment, to take into consideration of neighbors, etc.
- Hazardous tree management.
- Erosion concerns as larger species dominate and shade/destroy grasses.
- Importance of including wildflowers and other pollinator plantings in open / cleared / disturbed areas to minimize the recurrence or new establishment of invasive plants.
- Examples of public-private management for habitat benefit
- Examples of outreach strategies
- Succession management strategies
- Wildlife/impacts of limited/reduced mow.
- Best management for safety and cost reduction.
- Creation of an Integrated Vegetation Management plan that controlled the growth of noxious and invasive plants using herbicides as well as mowing.

- Discussion of design considerations.
- Specific maintenance strategies that have worked, particularly for steeper slopes.
- Monetary and nonmonetary value of native habitat management.
- Frequency of brush/small tree cutting on the edge of the clear zone to keep small trees from becoming large trees and potentially falling in the roadway.
- Address utilities, both underground and above ground and existing and permits for new utilities.
- How to maintain fences with shrubs growing around and into the fence.
- Fire hazard controls.

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APPENDIX A State Transportation Agency Documents

The Appendix contains excerpts, key points and summaries from state DOT documents reviewed for NCHRP 14-40. This does not include research conducted for DOTs related to the project objectives.

Alabama Department of Transportation (ALDOT)

- The Alabama Department of Transportation will encourage the growth and preservation of naturally occurring wildflower areas.
- Wildflowers that have naturalized within the rights-of-way should be allowed to remain. Every effort should be made to mow around them and avoid spraying herbicides with the exception of spot treatments to eliminate certain weed species.
- Blend the highway right-of-way with the adjacent land uses. For example, forestlands should extend into the right-of-way, and right-of-way adjacent to crop and pasture lands should remain relatively open, etc.

Vegetation management standards address activities that concern ALDOT objectives and the needs of the traveling public. Of equal importance, however, are our neighbors who own and utilize property adjacent to highway right-of-way. Therefore, in the spirit of a "Good Neighbor", ALDOT personnel will endeavor to manage the right-of-way vegetation in a manner that will not hinder the reasonable lawful activity, safety, or aesthetic appearance of adjacent property. Activities included in this policy are mowing and spraying operations, drainage considerations, wildflower preservation and vegetation pruning.

The proper management of plant succession can be one of the most enduring assets of land use, whether it is for roadside development, forest, parkland or wildlife refuge. Plant succession as a continuing natural process is an important part of ALDOT's vegetation management program. Selective spraying to encourage natural regeneration and succession outside designated mowing limits creates climax shrubs and groundcover communities.

A Manual for Roadside Vegetation Management (April 2018).

<https://www.dot.state.al.us/maweb/pdf/VegetationManagementManual.pdf>

In so far as possible, roadsides on any given segment of highway right-of-way should be managed/mowed in a manner compatible with the level of development of the adjacent property.

Alabama Department of Transportation. *Maintenance Manual*. 1995.

<https://www.dot.state.al.us/maweb/pdf/Maintenance%20Manual.pdf>.

Alabama DOT's mowing requirements are twice annually or when vegetation reaches a height of 16 inches unless directed or permitted by the Engineer. Areas designated for frequent mowing are roadway shoulders, medians and front slopes flatter than 3:1 extending 60 feet beyond the edge of pavement or to the toe of the front slope whichever is less. All other areas are designated as not subject to frequent mowing.

Alabama Department of Transportation. *Standard Specifications for Highway Construction* 2018 Edition Draft Sept. 1, 2017.

<https://www.dot.state.al.us/conweb/pdf/Specifications/2018StandardSpecificationsCompleteBook.pdf>.

Alaska Department of Transportation and Public Facilities (DOT&PF)

The Alaska DOT&PF has an IVMP. Two key points from the documents reviewed are the control of noxious and invasive plant species and vegetation control to prevent attracting large wildlife (such as moose) to the roadway. The DOT&PF works with other agencies in its implementation of the IVMP. There is a 10-step process for collaborating with the DOT&PF. These partnering agencies include the following as well as others not listed in the documents reviewed:

- National Forest Service
- National Park Service
- Bureau of Land Management
- Alaska Department of Agriculture
- Alaska Department of Natural Resource

Alaska Department of Transportation and Public Facilities Integrated Vegetation Management Plan. Revised September 2018.

http://www.dot.alaska.gov/stwdmno/ivmp/documents/ADOTPF_IVMP.pdf.

Arizona Department of Transportation (ADOT)

Each ADOT District will be developing individual vegetation management plans for each route within their district with an overall goal of establishing self-sustaining, low growing, weed-free vegetation on the roadsides over as much of the state highway system as possible. This system will require a process of removing undesirable species, such as noxious and invasive weeds and replacing them with desirable native species using seasonally-timed control measures.

Reducing the number of annual mowing cycles can have several short and long-term benefits, including:

- Fewer staff hours spent mowing, allowing staff to perform other maintenance activities
- Reduced fuel usage
- Reduced vehicle emissions and dust creation, contributing to improved air quality
- Reduced equipment maintenance
- Habitat conservation for pollinators and other wildlife.

ADOT Roadside Vegetation Management Guidelines. March 2018.

<https://apps.azdot.gov/files/Sitefinity-Files/Vegetation-Management-Guidelines.pdf>

ADOT's goal is to reduce the use of herbicides and mowing on roadway shoulders by the establishment of low-maintenance native grasses and wildflowers for highway visibility, soil stabilization, and weed control. Although ADOT uses an integrated approach to vegetation management, herbicide application is currently the most efficient means of controlling hazardous and invasive plant species. Proper herbicide treatment provides the greatest degree of control for the least amount of cost and labor. Mowing activity includes swath mowing to improve sight distances, control weeds, eliminate snowdrifts, and reduce available roadside fuels to minimize fire hazard. The mow swath is between 5 and 14 feet wide and conducted when vegetation reaches 17 inches.

AzDOT Maintenance and Facilities Best Management Practices Manual. 2010.

[https://www.azdot.gov/docs/default-source/planning/maintenance-and-facilities-best-management-practices-\(bmp\)-manual.pdf?sfvrsn=6](https://www.azdot.gov/docs/default-source/planning/maintenance-and-facilities-best-management-practices-(bmp)-manual.pdf?sfvrsn=6).

Arkansas State Highway and Department of Transportation (ArDOT)

Vegetation management consists of both mechanical and chemical means. Mechanical methods of vegetation control include hand pulling, cultivation, trimming, and mowing. Chemical methods include the application of approved herbicides to control or suppress problem vegetation. Herbicide use is a key element to be used in combination with mechanical methods for roadside vegetation management.

Facilities Management

https://www.arkansashighways.com/maintenance_division/facilities_management.aspx

ARDOT allows adjacent property owners to mow ROW vegetation unless the DOT has restricted that activity. Adjacent property owners can obtain a permit to install irrigation systems on the ROW as permitted.

Arkansas Motor Vehicle and Traffic Laws and State Highway Commission Regulations. 2017.

<http://www.arkansashighways.com/act300/AR%20Motor%20Vehicle%202017%20Edition.pdf#search=%22mowing%22> Arkansas State Highway and Transportation Department and the Department of Finance and Administration

California Department of Transportation (Caltrans)

Caltrans has a very detailed document for roadside vegetation management with safety of the traveling public, aesthetics, environmental laws, and compatibility with adjacent land use the prime considerations. Reduction of available fuel as a fire risk is a key issue. Mowing practices call for a narrow clear strip (4 to 8 feet) next to pavement edges to control risk of fire, to provide for visibility, to provide space for emergency use, and to preserve the pavement. Although deemed safe, some public opinion expressed the desirability of reducing or eliminating the need to do chemical vegetation control on highway roadsides. This lower level of vegetation control would reduce herbicides in roadside environments.

The 12 Caltrans districts develop respective District Vegetation Management Plan (VegCon Plan) relative to regional conditions. VegCon Plans are necessary due to the state's diversity of climate, terrain and native species of vegetation. The VegCon Plan must consider fire risk in sufficient detail to reflect changing vegetation types along highway edges, differing adjacent land uses, highway configurations, and annual rainfall affecting expected vegetation growth, which may increase/decrease fire risk, and urban interface.

Maintenance Manual Volume 1, Chapter C2 Vegetation Control. July 2014.

http://www.dot.ca.gov/hq/maint/manual/2014/17_Chpt_C2_May_2015_rev_1-01.pdf

Don't forget the concept of ecological succession when selecting seed species. The most successful plant species for a project site will change over time in response to competition from other species, changes in soil structure, and other factors. Many disturbed sites are initially "colonized" by annuals and grasses and later support a more diverse cover of perennials, woody

shrubs and large trees. Because of the uncertainty of exactly which plants will thrive on a project site, many designers select a plant palette that provides both immediate cover (annuals and grasses) as well as long-term cover (perennials, woody shrubs and trees).

Specifying Seed and Plant Species. http://www.dot.ca.gov/design/lap/landscape-design/erosion-control/plants/plant_select.html Updated April 13, 2018

Colorado Department of Transportation (CDOT)

CDOT can reduce maintenance costs along a right-of-way by utilizing Integrated Roadside Vegetation Management and limiting roadside disturbance, which tools allow CDOT better management and coordination opportunities with landowners and local governments and provide regional planning and coordination.

The goal of the Mow Wisely program promotes the establishment of non-mow areas and adjusted mowing schedules to accommodate wildlife whenever possible. In intensive agricultural areas, the only suitable nesting habitat for upland birds is within highway rights-of-way. The timing and frequency of mowing schedules in these areas dramatically affects nesting success.

Roadsides are especially important to wildlife in rangeland areas subjected to continuous livestock grazing. Since boundary fences normally keep domestic livestock off the right-of-way, the roadsides in these areas usually provide a higher diversity of grasses and forbs than the heavily grazed adjacent lands.

Eliminating roadside vegetation treatments could result in improved wildlife habitat on some sites. Lack of periodic disturbance to soils and vegetation would allow native plant communities to remain or become established, favoring animals associated with these habitats.

The *Roadside Vegetation Management Guidelines* for CDOT uses a categorization of state and county highways based on traffic volume and adjacent property use and describes management practices for each category.

P. Kohlhepp, T. Sanders, C. Tackett, R. Walters. *Roadside Vegetation Management: Final Guidelines Document for Colorado DOT*. 1995. Colorado Department of Transportation & Colorado Transportation Institute

<https://www.codot.gov/programs/research/pdfs/1996/roadsidevegetation.pdf>

Do not place plants that may attract large mammals (e.g. deer or elk) adjacent to the roadway.

Design Workshop. *CDOT Landscape Architecture Manual* 2014 file:///C:/Users/b-storey/Downloads/Landscape%20Architecture%20Manual_8-18-14_final.pdf

The Colorado resolution 17-1029 renamed Interstate Highway 76 from Mile Marker 1 to Mile Marker 183 as the "Colorado Pollinator Highway".

House Joint Resolution 17-1029

https://leg.colorado.gov/sites/default/files/documents/2017A/bills/2017a_hjr1029_enr.pdf

Connecticut Department of Transportation (CTDOT)

CTDOT implemented a pilot program in 2017 in accordance with CT Public Act 16-17, establishing several highway median and bowl areas throughout the state as pollinator corridors. Planned vegetation management will permit regeneration of naturalized flowering grasses and create cultivated replacement plots with the goal of reestablishing habitats for pollinators, such as insects, meadow birds and other species. CTDOT currently is coordinating with DEEP, UCONN, and CAES to implement best management practices in the establishment and monitoring of these locations for potential future expansion of the program.

Naturalized Pollinator Corridors will be established in selected highway medians and along roadsides. Limited mowing is necessary for the success of a pollinator corridor. A 12-15 foot area will be mowed around the perimeter of the site in the interest of safety and sightline issues. Additionally, annual mowing at the end of the growing season (after October 1) may be used to limit the growth of weeds and invasive plants. Pollinator plugs may be planted to establish the pollinator corridor. Cultivated Pollinator Corridors will be reserved for bowl / gore areas and construction projects.

Roadside mowing is conducted for approximately 24 weeks beginning around May 1 or when the grass reaches an average height of 8 inches.

Connecticut Department of Transportation Vegetation Management Guidelines. Bureau of Highway Operations – Office of Maintenance February 2018.

http://www.ct.gov/dot/lib/dot/documents/dmaintenance/veg_man_guidelines_final_02-15-18.pdf

Delaware Department of Transportation (DelDOT)

Enhancing Delaware Highways (EDH) is a direct response to a need to develop an integrated and sustainable roadside vegetation management program. DelDOT is committed to reducing pesticide use, increasing biodiversity and reducing negative environmental impacts of roadside vegetation management by adopting an IRVM approach.

One of the key points is the release of turf areas from routine mowing whenever possible in the ROW. Spot spray or mow periodically to control invasive woody plants. Mow an edge routinely. Another point is the integration of vegetation management in the planning, design and construction phases of highway development.

Routine mowing of all roadside rights-of-way is an unnecessary management practice. Improper mowing can increase some weeds' ability to compete and degrade the plant community making the roadside more susceptible to weeds and erosion. Mow only the immediate road shoulder and where dictated by safety considerations (such as intersections, bridges, sharp curves, and farm and field entrances). A reduced mowing plan requires the ability to identify desirable and undesirable plant species, and to provide spot treatment at the proper growth cycle for undesirable species. Maps or detailed instructions may be required to show operators where to mow, depending on the specific roadside conditions.

Roadside Vegetation Establishment and Management Manual Enhancing Delaware Highways. Delaware DOT. 2009. S. Barton, R. Darke, G. Schwetz, A. Lucey, and C. Finnie.

http://www.deldot.gov/Publications/manuals/edh/pdfs/edh_establishment_management.pdf

Florida Department of Transportation (FDOT)

Within wildflower areas, the mowing frequency and schedule should allow time for wildflowers to grow, flower, and set seed. Within any wildflower area, mowing should commence only with documented authorization from FDOT. Wildflower areas can be delineated with roadside signs or maps.

Guide for Roadside Wildflower Management: A Supplement to the Guide for Roadside Vegetation Management. March 15, 2017

<http://www.fdot.gov/maintenance/RDW/WildflowerGuide.pdf>

- Each District develop and implement a plan to reduce mowing area and frequency (or combination) by 10%
- Monitor roadside conditions for one year and revise plan as needed
- Monitor for a second year and revise plan as needed
- Using lesson learned, amend the Turf Management Guide

The FDOT report, *A Guide for Roadside Vegetation Management*, defines roadside maintenance areas, T-1 and T-2. The T-2 area lies at the outside boundary of the ROW. Except under unique field conditions, T-2 maintenance areas are normally not mowed. This encourages the regeneration of natural growth and allows the areas outside the established mowing limits to return to their native state.

Encouraging natural growth or the planting of native trees, shrubs, and ground cover appropriate to the local environment is desirable. Such growth reduces the area the FDOT must maintain through mowing and thus the overall cost for maintenance operations. In addition, regenerated areas improve the appearance of Florida's roadways and serve as valuable habitats for native wildlife.

Wildflower sites may be established and maintained within existing mowing limits if their locations are compatible with routine maintenance operations. Sites may occasionally be located outside the normal mowing limits, including areas of natural regeneration. Locations selected for wildflower sites should be highly visible from the roadway and relatively free from competitive or noxious plants.

J. Ferrell, B. Unruh, and J. Kruse. *A Guide for Roadside Vegetation Management*. 2012.
[http://www.fdot.gov/maintenance/RDW/DOC%20Final%20\(3\)Turf%20Management%20Guide%20UF.pdf](http://www.fdot.gov/maintenance/RDW/DOC%20Final%20(3)Turf%20Management%20Guide%20UF.pdf)

The decline in honeybees and monarch butterflies has brought the issue of pollinators to the forefront over the past few years. Their importance of pollinators to Florida agriculture and ecosystems is recognized by FDOT and is now included in the Purpose Statement of the most recent version of the Wildflower Procedure.

"To develop and implement integrated vegetation management practices on roadsides and other transportation right of way, including reduced mowing, for the benefit of pollinators, while developing and maintaining safe, cost effective and efficient transportation corridors and systems..."

And as noted in the Purpose Statement, reduced mowing is being encouraged as a means of increasing roadside wildflowers and native grasses that benefit pollinators and other desirable insects. FDOT also sponsors pollinator and related research:

- Evaluating the Importance of Roadside Habitat for Native Insect Pollinators
- Survey of Key Monarch Habitat Areas Along Roadways in Central and North Florida
- Economic Impact of Ecosystem Services Provided by Ecologically Sustainable Roadside Right of Way Vegetation Management Practices
- Creating Economically and Ecologically Sustainable Pollinator Habitat: A District 2 Demonstration Research Project (Updated October 2017)

Production Support, Production Support / Wildflower / Pollinators.

<http://www.fdot.gov/designsupport/wildflowers/Pollinators.shtm>

Georgia Department of Transportation (GDOT)

Integrated Roadside Vegetation Management establishes these standards:

The use of these standards will aid in the accomplishment of five (5) major goals:

1. Increased efficiency of operations and productivity.
2. Increase sight distances at interchanges, intersections, driveways, etc.
3. More safety awareness by the Department's employees and the traveling public.
4. Reduction in overall cost of mowing.
5. More attractive roadsides through uniformity of mowing techniques

Wildflower plots/areas that are germinating and/or are established will not be mowed until after wildflowers have bloomed and the seeds have matured. Contact the District Roadside Enhancement Coordinator for wildflower plot locations and timing for mowing.

IRVM straight Line Mowing Standards Manual. GADOT. 2011.

<http://ssl.doas.state.ga.us/PRSapp/bid-documents/164840148400-410-0000032393193885.pdf>

Hawaii Department of Transportation (HDOT)

All maintenance personnel are required to meet the mowing standards. All turf grasses grown in Hawaii are warm season grasses. They can tolerate high temperatures in the summer, but may stop growing and go dormant in the winter if temperatures are consistently below 50°F. In most areas of Hawaii the winter temperatures are not cold enough for complete dormancy. At cooler higher elevations the grass may not grow much in mid-winter.

Mowing Standards for Hawaii

Vegetation management scenarios	Mowing Standards	Minimum (inches)	Maximum (inches)
High visibility areas where higher levels of maintenance will enhance the natural beauty of the location (scenic lookouts)	A	1.5 inches	3 inches
Medians, level road sides and interchanges (unless in urban areas)	B	2 inches	4 inches
Erosion control	C	2 inches	8 inches
Behind guard rails	D	2 inches	24 inches
Rural areas where the mature height of the existing vegetation can go up to 36 inches	E	No mow (May be mowed when directed by the Engineer)	No mow (May be mowed when directed by the Engineer)
Fire season : Rural areas prone to annual dry season fires	F	5-6 inches (mow 30 ft. width to edge of pavement)	Mow once in July/August as directed by the Engineer
Steep slopes	G	No mow (May be mowed when directed by the Engineer)	No mow (May be mowed when directed by the Engineer)

Road and street maintenance workers do several general types of mowing. In order of importance, these are:

- Aesthetic Mowing - Primarily done in high visibility areas, such as urban main streets for beautification; generally, the entire right-of-way.
- Safety Mowing - Ensures signs and other traffic control devices, guard rails and other safety features can be seen. Provides good sight distance for drivers approaching intersections and driving around curves.
- Transition Mowing - Makes a smooth change from a narrow mowed width to a wide mowed width when different widths of right-of-way are mowed using different mowing equipment. There should be no visible difference in grass mowed with riding mower versus weed eater.
- Contour or Selective Mowing - Naturally blends the grass with other vegetation planted in the Landscape Maintenance Zone. Shows off special architecturally designed landscaping areas or dresses up an interchange entrance or median in an urban area.
- Fire Season Mowing - Rural areas prone to summer fires require occasional mowing from the roadside edge to inside of 30 ft.

Highway Manual for Sustainable Landscape Maintenance. 2011. Hawaii Department of Transportation Highways Division

http://hidot.hawaii.gov/highways/files/2013/02/Landscape-ch5_MOWING.pdf

Hawaii Landscape Architecture Program

<http://hidot.hawaii.gov/highways/landscape-architecture-program/>

Idaho Transportation Department (ITD)

Strategic reduced mowing and consideration of the timing of mowing can improve roadside habitat quality for pollinators. Mowing should not be scheduled until after mid-July or later unless the height of the vegetation exceeds 24 inches and/or vegetation becomes a safety hazard. Mowing during late fall may be considered when grass height exceeds 18 inches to prevent snow drifting. Mowing in the fall can also benefit a variety of pollinators by allowing flowering plants to bloom uninterrupted throughout the growing season. Mowing after seed maturity of desirable and native vegetation is recommended and should be considered when scheduling mowing. Every attempt should be made to protect native and other desirable vegetation. If an area to be mowed is treated with herbicides prior to mowing, delay the mowing two (2) weeks after spraying. Coordinate mowing with other phases of roadside vegetation management.

General roadside mowing should be confined to 6 – 10 feet on narrow or steeper foreslope roads extending outward from the edge of the pavement to the toe of the foreslope. Mowing widths of 10-15 feet on wide foreslope roads is appropriate. For interstates, mowing width will be determined by District Operations taking into account the time of year, plant germination, pollinator species present, and other environmental factors. Mowing beyond the clear zone should be reduced as much as possible to avoid impact to pollinator species. Urban and other special needs areas (e.g., snow drifting and sight distance) may require solid mowing. Mowing in these areas should be scheduled and timed to meet required objectives.

The mower height shall be adjusted so that 10 inches of vegetation remains after mowing unless height of vegetation needs to be reduced to prevent snow drifting, for fire prevention or safety hazards.

Idaho Operations Manual Section 200. October 2017.

<http://apps.itd.idaho.gov/apps/manuals/OperationsManual/OperationsManual.html>

Illinois Department of Transportation (IDOT)

IDOT will only mow 15 feet of right of way beyond the edge of the roadway. Exceptions will be made in certain areas to preserve sightlines for motorists and to prevent the spread of invasive plant species.

New IDOT Mowing Approach to Help Protect Monarch Butterfly, Pollinator Populations in Illinois. May 15, 2017. https://www2.illinois.gov/IISNews/14413-IDOT_Monarch_Butterfly_Release_.pdf

Indiana Department of Transportation (INDOT)

INDOT employs a three-pronged approach to vegetation management:

- Targeted Timing of Mowing Cycles
- Selective Herbicide Application
- Vegetation Management Zones

INDOT crews closely monitor the growth of grass and vegetation and schedule mowing cycles based on geographic location and weather. Correctly timed mowing cycles slow the regrowth of grass and vegetation and reduce the need for additional mowing.

INDOT schedules mowing cycles in order to maximize the effectiveness of each cycle and to minimize the number of cycles needed. Except in areas where mowing is performed to address driver sight distance and safety issues, the first mowing cycle takes place after seed heads develop – which is approximately mid-May in the southern part of the state and early June in the north. While this does result in tall grass in the late spring/early summer, it also requires only two mowing cycles. The alternative to allowing tall grass to develop would require additional mowing cycles at approximately \$4 million per cycle.

By limiting mowing to only the clear zone areas, native vegetation and wildflowers can thrive, providing food source and habitat for bees, butterflies, and other pollinators.

<https://www.in.gov/indot/3262.htm> Mowing & Vegetation Management
https://www.in.gov/indot/files/Maintenance_MowingPolicy.pdf

INDOT's Vegetation Management program has increased native habitat while reducing the cost of maintaining roadway rights-of-way.

Over the past three decades, INDOT, recognizing the need to promote native habitat and control invasive species, has studied ways to control weeds and increase native species along roadsides. In addition to these decade-long studies, INDOT recently conducted more intensive studies, leading to new vegetation management practices that have demonstrated habitat improvement benefits and cost savings.

As a result, INDOT last year adopted a vegetation management policy that includes reduced mowing and selective herbicide use to control invasive and noxious weeds that suppress native plants. Native plants are essential to ecosystem health and habitat for wildlife, including many species of pollinators. Noxious weeds include invasive plants that injure agricultural crops, natural habitats or ecosystems.

For example, black swallowwort is a threat to milkweed species, which monarch butterflies need to reproduce. Invasive species, such as Canada thistle, also out-compete many native plants that support pollinators, including monarch butterflies and honeybees.

INDOT's Vegetation Management Program Recognized as Bee Friendly. Inside INDOT – June 2015. https://www.in.gov/indot/files/INDOT_and_POLLINATOR-F1.pdf

Iowa Department of Transportation (IowaDOT)

In 1988, the Iowa Legislature established the Living Roadway Trust Fund (LRTF). The IowaDOT administers this fund, including an annual, competitive grant program that provides funding for IRVM activities to eligible cities, counties, and applicants with statewide impact. In doing so, the Iowa DOT and its partners promote and educate the public about the need for an integrated approach to managing the vegetation along Iowa's roadsides. This approach ensures

that roadside vegetation is preserved, planted, and maintained to be safe; visually interesting; ecologically integrated; and useful for many purposes.

Iowa Living Roadway Trust Fund. IRVM Plan Outline for Counties and Cities. 2016.
<https://iowadot.gov/lrtf/docs/2016PlanRequirements.pdf>

The DOT is in the process of replanting all the roadsides on state primary highways to native grasses and wildflowers. The DOT believes the native vegetation, once established, will provide sufficient benefits and reduced maintenance costs to warrant replacing the existing vegetation. IowaDOT promotes the use of native vegetation to:

- Improve habitat for birds, butterflies, skippers and other wildlife.
- Enhance motorist safety by reduced blowing snow because many native species remain standing in the winter, breaking up the snow's reflective surface
- Create greater visual stimulation for drivers from variation in colors, sizes and textures, which helps reduce sleepiness from "highway hypnosis."
- Reduce long-term maintenance costs due to less need for fertilizing, mowing and spraying.

On each revegetation project, the DOT is using anywhere from three to 10 grass species, mixed with a variety of forb species. Each project will have seed mixes designed specifically for the conditions of that project. For the first two years these roadsides will be mowed periodically to reduce weed competition, promote germination and develop deeper root systems for healthier vegetation. After the third year of planting, minimal maintenance should be required.

Iowa DOT. *Roadside Vegetation Q&A*.
https://www.iowadot.gov/pdf_files/roadside_vegetation_q_and_a.pdf

Kansas Department of Transportation (KDOT)

The KDOT Roadside Management Program has some of the major benefits that include:

- Fewer accidents by KDOT mowers on dangerous slopes.
- Reduced mowing saves money for tax payers and KDOT.
- Pleasing roadside appearance.
- Less erosion of roadsides.
- Restricts growth of unwanted vegetation.
- Provides cover for small wildlife.

KDOT spends approximately 6.7 million dollars annually on mowing for safety, vegetation control, improved drainage, and aesthetic reasons. These areas left unmown for wildflower growth and wildlife cover may concern adjacent landowners. KDOT makes an effort to keep these areas free of unwanted vegetation. Landowners are allowed to mow the right-of-way in front of their property to be consistent with how they maintain the rest of their front yard. They are asked to use caution when mowing close to the edge of the highway and keep the safety of them-selves and the traveling public in mind at all times. Landscape improvements may be allowed on highway right-of-way by adjacent landowners by obtaining a permit from any local KDOT office.

The savings from this roadside management program allow more time and money to be spent on state highways and bridges. Farmers and adjacent landowners are able to harvest hay from the roadsides at no cost. Any person, firm or corporation wanting to mow or bale hay will need to submit a permit application to the KDOT office in their area. Permits are good for one year, or a specific haying season. Permit forms are available from any KDOT office. Adjacent landowners will be given first priority if they apply for a permit by March 31 of a given year.

Roadside Management Program.

<https://www.ksdot.org/bureaus/burmaint/connections/roadside/Roadside.asp>

KDOT has implemented a new, environmentally sensitive mowing policy as part of its roadway maintenance program. The policy encourages planting of native grasses and wildflowers along roadsides, and designates mowing heights and times to ensure vegetation is mowed on a schedule to enhance plant growth and protect wildlife habitat. KDOT also has agreed to abstain from mowing on high-ozone alert days. KDOT coordinates its roadside management program with the Department of Wildlife and Parks, the Natural Resource Conservation Service, and conservation groups.

Appendix C — Kansas Long Range Transportation Plan New SAFETEA-LU Planning Provisions

https://www.ksdot.org/Assets/wwwksdotorg/LRTP2008/pdf/Appendix_C%20_FINAL.pdf

- Spot spraying of herbicides rather than broadly applying chemicals.
- Reduced mowing, driven in part by earlier agency decisions to cut fuel costs.
- Fence-to-fence mow-outs are done only once every four years and timed so the mowing does not interfere with late fall wildflower seed propagation.
- Mowers will make only one pass on shoulders and will let the grass grow to 12 inches before cutting.

Kansas DOT. 2010 Decade Report.

https://www.ksdot.org/PDF_Files/FINALKDOTREPORT.PDF.

Kentucky Transportation Cabinet (KYTC)

The Kentucky Transportation Cabinet has approximately 200,000 acres of right-of-way. Of that, it maintains about 100,000 acres with mowing, spraying, re-seeding, etc.

- Overall, for its Pollinator Protection Zones, the Kentucky Transportation Cabinet has 35 sites in 10 of 12 districts across the state for a total of 71 acres.
- The cabinet has converted former rest areas to monarch way-stations and provided pollinator plantings in Area 2 (Hardin County)
- Kentucky passed a Highway Rights of Way law in 2010 allowing local Transportation officials to consider using pollinator habitat at interstate interchanges:
lrc.ky.gov/record/10RS/SJ177.htm
- As a matter of policy, the Kentucky Transportation Cabinet does not spray fence rows.

- Ongoing: The Kentucky Transportation Cabinet is considering delaying some mowing schedules to reduce impact to the late-summer generation of monarchs.

http://www.kyagr.com/statevet/documents/OSV_Bee_KY-Pollinator-Pro-Plan.pdf

Louisiana Department of Transportation and Development (LADOTD)

It shall be the policy of the Department to encourage the growth, planting and preservation of wildflowers in order to provide a natural setting for the traveling public. Mowing and spraying operations shall be coordinated and timed to enhance the wildflower population and provide a naturally appealing roadside appearance.

Exceptions to the mowing policy includes areas where individuals or businesses mow right-of-way along their property, appropriate herbicide treatment can keep vegetation within the standards, that are not applicable, i.e., wildflower areas, and where seedlings are planted and/or permitted to grow.

Policy for Roadside Vegetation Management. Louisiana Department of Transportation and Development. 2000.

http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Misc%20Documents/Policy%20For%20Roadside%20Vegetation%20Management.pdf

Maine Department of Transportation (MaineDOT)

Vegetation management practices are relative to the roadway's level of service. These include interstate and other multi-lane, control of access corridors, priority one and two corridors and all other roads.

Maine Department of Transportation Roadside Vegetation Management Policy

Updated 10/11/2017 https://file.ac/OvRV51uU_io/

This document outlines the MaineDOT's efforts for revegetating with native plant materials. The document includes a guide for each species used on the roadsides.

To promote native plants, mowing should be reduced to once a year and occur after the growing season (between November and late April). While areas along the immediate edge of the paving may need to be mowed regularly for visibility, most of the roadside landscape should be left unmowed during the growing season.

This shift away from summer mowing can free up roadside managers to spend the summer and early fall focusing on controlling invasive species, which are spreading across the state. For native plants to thrive, invasive species must be managed. All the money and human time that has been spent mowing during the growing season could now be spent on invasive species control!

Maine Native Plants for Roadside Restoration.
2018. Maine Department of Transportation.

<http://www.maine.gov/mdot/publications/docs/guides/MaineNativePlantsForRoadsideRestoration.pdf>





Maryland Department of Transportation (MddOT) Maryland State Highway Administration (SHA)

In 2011, SHA intensified this cost savings and enhanced environmental stewardship with its new Turfgrass Management Guidelines. The guidelines call for a maximum of three “one-pass” mowing cycles that are confined to ten feet from the edge of highways. The mowing does not occur until grass has reached a height of 18 inches. Median mowing is addressed in similar manner. Restricted visibility areas, such as interchanges, intersections, and acceleration or deceleration lanes are mowed more frequently and the grass is maintained at a lower height for the safety of motorists. In late fall, a “full width” mowing is performed along roadsides and in medians to assure that noxious vegetation is managed and trees do not establish in areas where they could pose a danger to motorists.

Mowing Reduction

<http://www.roads.maryland.gov/Index.aspx?pageid=353>

A Guide to the Species Pages
Each of the 70 species is illustrated to highlight its attributes and easily recognized characteristics along with landscape and wildlife associations.

Early Season (late March to early June) Mid-Season (mid June to mid August) Late season (mid August to November)	Wildflower	
	Shrub	
	Vines & Grasses	
WORKHORSE (Special Designation)	GROWING CONDITIONS  Considers optimal site for sun and soil	WILDLIFE  Identifies types of animals which depend on these plants; in some cases names specific animal species
HEIGHT Average height of mature plant. Noted if the species spreads by the root system to form colonies	MOWING STRATEGIES  Provides a date range by month	BLOOM TIME  Provides a date range by month; can vary across the state by almost a month
NATURAL HABITAT and DISTURBED AREAS Describes where the plant is typically found	WORKHORSE, Described These are the toughest natives and most projects should include a good number of these species. Other species listed are worthy but need more attention for successful establishment.	
MOWING Mowing before the date indicated may prevent the flowering and seed ripening of this species and affect its ability to survive on the roadsides.		
SEED COLLECTION & PROPAGATION Lists when the species seeds will ripen, which is crucial to understanding when to mow and for seed gathering times. Indicates how to handle the seeds for storage. Seed sowing strategies and germination are explained in more detail in Chapter 4, Sowing the Seeds.		

HB 830 (Public Act: 755) requires that pollinator habitat plans established by the Maryland Department of Natural Resources, the Maryland Environmental Service, and the State Highway Administration be as protective of pollinators as the Maryland Department of Agriculture's managed pollinator protection plan. The bill also: (1) requires contents of the plans to be modified to focus on pollinator habitat areas, rather than pollinator habitats; (2) specifies that pollinator habitat plans must include best management practices for the designation, maintenance, creation, enhancement, and restoration of pollinator habitat areas; and (3) prohibits the use of certain pesticides, seeds, or plants in the pollinator habitat plan. The bill was signed by the governor on 25 MAY 17 and it becomes effective on 1 JUL 17.

HB 830 (SB 386) Pollinator Habitat Plan Requirements.

http://www.mdot.maryland.gov/newMDOT/Planning/Environmental/Documents/072517/NaturalResources_July_2017.pdf

Massachusetts Department of Transportation (MassDOT)

District 1 Vegetation Management Plan. 2012.

http://www.massdot.state.ma.us/Portals/8/docs/vmp/D1_VMP_0112_1216.pdf

MassDOT District 1 yearly Operational Plan. 2016.

http://www.massdot.state.ma.us/Portals/8/docs/yop/YOP_2016_D1.pdf

Michigan Department of Transportation (MDOT)

Per the mowing regulations, effective November 2002, medians less than 50 feet wide can be mowed entirely. Medians more than 50 feet in width, and located outside of the Federal Aid Urban Boundaries, will have one, twelve (12) foot swath mowed adjacent to the inside shoulder. The entire median can no longer be entirely mowed, on a routine basis, if it is greater than 50 feet in width. Twenty-five percent of all medians greater than 50 feet within a region shall be mowed annually for brush control (once every four years). Mowing beyond the designated 12-foot limit on any road (except medians less than 50 feet wide and any mowing performed within the Federal Aid Urban Boundaries), may only be done to maintain designated clear vision areas, for brush control or to address a specific health and safety problem. Brush mowing may only be performed between July 16 and the following March 1, and shall not exceed 50% of all roads annually. Brush mowing may only be done on roads where brush is a problem.

https://www.michigan.gov/documents/mdot/MM_2003-03_Roadside_Mowing_212503_7.pdf

https://www.michigan.gov/documents/mdot/MA_2012-04_Roadside_Vegetation_Management_404444_7.pdf

https://www.michigan.gov/mdot/0,4616,7-151-9623_26662_26679_27267_48606-330996--,00.html

Fast facts:

- MDOT expanded a successful 2016 pilot project to plant sunflowers in additional locations in Bay and Isabella counties this year.
- The plantings are designed to support pollinators, as well as to test the potential to grow flowers in MDOT right of way.
- Despite adverse weather conditions this summer, the flowers bloomed in September.

MDOT expands sunflower planting, increases late season food source for pollinators.

<https://www.michigan.gov/mdot/0,4616,7-151-9620-449779--,00.html>

Minnesota Department of Transportation (MnDOT)

MnDOT and other state agencies are looking specifically at insect pollinators. Two insects, the honeybee and the Monarch butterfly, are serving as flagship species for the entire insect pollinator group.

We currently plant native grasses and forbs on 30% of construction projects where soil beyond the in-slope is disturbed. The native seed mixes can be found in MnDOT's Seeding Manual. Once established, these planted native prairies provide many benefits such as

- Increased soil fertility
- Increased water infiltration
- Pollinator and small mammal habitat
- Control of blowing and drifting snow
- Aesthetics

Pollinators and MnDOT, I-35 Monarch Highway.

<http://www.dot.state.mn.us/pollinators/index.html>

<http://www.dot.state.mn.us/maintenance/pdf/manual/ch5.pdf>

<https://www.dnr.state.mn.us/roadsidesforwildlife/index.html>

Mississippi Department of Transportation (MSDOT)

No documents found.

Missouri Department of Transportation (MoDOT)

Slopes steeper than 3 to 1 and areas not required to be mowed should be planted to wildflowers and native grasses, encouraged to naturalize or landscaped.

Pollinator-beneficial vegetation should be promoted in these areas. The number of mowing cycles may be adjusted and coordinated statewide if growing conditions require it. Native vegetation should be left standing and encouraged in areas that are prone to drifting snow.



Roadside Vegetation Management. 2017. Missouri DOT. http://epg.modot.mo.gov/files/9/97/822_2017.pdf

Montana Department of Transportation (MDT)

The roadside is comprised of an active zone, which is typically the area from the paved shoulder out 15 feet, and a passive zone, which is the remainder of the right-of-way width. The passive zone should not be mowed unless it is a component of a predetermined management issue, such

as snow drifting areas, sight distance, aesthetic issues in urban areas, or a component of weed control plans.

Maintenance Manual. 2009.

<https://www.mdt.mt.gov/publications/docs/manuals/mmanual/chapt5c.pdf>

The focus of the MDT IRVM plan is the control of noxious and invasive plants. The plan outlines six major components.

- Public awareness and education.
- Prevention and early detection.
- Rapid response and management.
- Restoration and rehabilitation.
- Research and new technology.
- Assessment (monitoring and evaluation).

DOT Statewide Integrated Roadside Vegetation Management Plan: 2012-2018. 2012.

https://www.mdt.mt.gov/publications/docs/manuals/weed_mgmt_plan.pdf

Nebraska Department of Transportation (NEDOT)

Most roadways receive three mow cycles with a minimum width of 5 feet and maximum of 15 feet. If wildflowers are present within the first 15 feet then the maximum mow width is 8 feet.

Highway Mowing Guidelines. Department of Roads. 2008. 14p. OCLC #281432347.

R6000H034-2008. <http://www.nlc.state.ne.us/epubs/R6000/H034-2008.pdf>

The Nebraska Department of Transportation is focused on being good stewards of the environment as well as our roadways. We work each year to balance the needs of the public while maintaining valuable habitat for native Nebraska wildlife. We do this through strategic mowing as well as noxious weed maintenance. The website below contains a video explaining the NEDOT weed management program, *Nebraska's Roadsides-Noxious Weeds*.

Managing Nebraska's Roadsides - Noxious Weeds & Mowing. August 18, 2017

<https://dot.nebraska.gov/news-media/transportation-tidbits/managing-nebraskas-roadsides-noxious-weeds-mowing/>

Roadside seed mixtures are planted during highway construction projects. Mixtures that are planted away from highway shoulders are comprised of approximately 10-20% native wildflower seed, by weight. Species planted are suited to the region of Nebraska in which the construction project occurs, and may serve as food and habitat for pollinators.

- NDOT programmatic documents have been revised to recommend mowing dates and frequencies that minimize interference with pollinator life cycles and foraging needs.
- NDOT staff participate in efforts led by Nebraska pollinator interest groups, to develop action plans and policies to support pollinator life cycles and develop habitat.

- NDOT is a cooperator with the Nebraska Game and Parks Commission on a pollinator habitat establishment project on Nebraska's Cowboy Trail:
<http://outdoornebraska.gov/cowboytrail/>

NDOT Activities to Support Pollinators.

<https://dot.nebraska.gov/projects/environment/pollinators/>

A total mow-out of the right-of-way will be completed periodically. This shall be planned so that at least ¼ or 1/5 of the total mileage in the maintenance area 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. Mow-out operations are not recommended until after October 1.

- Mow-outs shall comply with the dates allowed by the Memorandum of Understanding between NDOR and the Nebraska Game and Parks Commission (See Appendix C). However, mowing foreslopes, ditches, and backslopes only after October 1 is beneficial for seed dispersal of wildflowers AND for supporting pollinating organisms' life cycle completion.
- Landscape program trees and shrubs – When the complete right-of-way is mowed, use extra caution beyond the clear zone to preserve established woody plantings. Newer plantings usually have mulch spread around the trunks, or may be guywired with a stake.
- Volunteer trees and shrubs – saplings of red cedar, cottonwood, Siberian elm, and other weedy species should be mowed out. Mowing is not recommended for trees greater than 3 feet tall. Volunteer shrubs may be left to grow, unless they cause a snow drifting hazard or interfere with sight distance requirements. Trees and shrubs that remain after mowing must not be a future hazard to NDOT operations or to the public.

NDOT Roadside Vegetation Establishment and Management. 2018.

<https://dot.nebraska.gov/media/4016/veg-manual.pdf>

Nevada Department of Transportation (NVDOT)

No documents found.

New Hampshire Department of Transportation (NHDOT)

No documents found.

New Jersey Department of Transportation (NJDOT)

- It is in the public interest of the State of New Jersey to ensure that the roadsides in New Jersey are safe, ecologically integrated, and useful for many purposes;
- Roadsides serve as physical barriers, sound barriers, and highway beautifiers and provide refuge for many animals, insects, and plants native to New Jersey;
- A coordinated effort by the State and public and private entities to include native plants and wildflowers in the management of the roadsides will create biodiversity, improve scenic value, preserve wildlife habitats, prevent soil erosion, and provide other environmental benefits to the State; and
- It is altogether fitting and proper for the Legislature to establish an "Integrated Roadside Vegetation Management Program" within the Department of Transportation, to

encourage the preservation and repopulation of native plants and wildflowers along the roadsides of New Jersey.

Integrated Roadside Vegetation Management Program. Approved May 1, 2017.

ftp://www.njleg.state.nj.us/20162017/PL17/44_.PDF

New Mexico Department of Transportation (NMDOT)

NMDOT's emphasis is on providing vegetation management to maintain a safe ROW by providing clear sight distances, to clear signs and fixtures of vegetation for visibility and functionality, to provide adequate drainage in roadway ditches, to reduce fire hazard, provide snowdrift control, and to slow and/or prevent the spread of noxious weeds.

http://dot.state.nm.us/content/nmdot/en/Vegetation_Management.html

New York State Department of Transportation (NYSDOT)

NYSDOT manages vegetation on State highway rights-of-way (ROW) for the following safety, environmental, and infrastructure management objectives:

- Provide motorists with adequate sight distances.
- Control visibility of signs and guiderails.
- Prevent the presence of deadly fixed objects (usually trees that may impact cars that leave the roadway).
- Control the introduction and spread of invasive plant species and noxious plants.
- Maintain pavement by controlling drainage problems.
- Prevent pavement breakage by plants.

NYSDOT and its contractors use an IVM Program. IVM process components include: prevention; monitoring; establishing action thresholds for when control is needed; selecting and undertaking control methods; and evaluation.

Conservation Alternative Mowing Plans (CAMPs) is NYSDOT's statewide program of mowing its 1 million roadside acres in an environmentally sensitive manner. It is directed towards Interstate, Expressway, and Parkway systems outside urbanized or gateway areas. CAMPs includes recommendations for mowing frequencies in Roadside Management Zone 2, where the majority of mowing work is required. Mowing in Zone 2 should be managed by section, as follows:

- Frequently Mowed Section- includes an area adjacent to the road (typically 8-10 feet wide) and drainage ditches-- mowed several times a year.
- Annually Mowed Section- a transition between areas of frequent mowing and natural regeneration-- mowed once a year or less. Such a reduction in mowing frequency may result in denser grasses, perennials and brush. This vegetation may require acquisition or rental of heavier or special mowing equipment.

CAMPs protects grassland habitat for ground nesting migratory songbirds, such as the Eastern Meadowlark and the Bobolink, by delaying mowing in Roadside Zone 2 until after August 1st to avoid disturbance during nesting season. This is in compliance with the Migratory

Bird Treaty Act, by which it is unlawful to intentionally or unintentionally take, capture or kill any migratory bird or disturb their nests or eggs without a permit. CAMPs encourages changes in mowing practices that may conserve funds for staff hours and fuel usage, improve air quality through reduced fuel emissions, reduce required equipment maintenance, and reduce habitat fragmentation without impacting the safety or functionality of the roadsides

Environmental Handbook for Transportation Operations A Summary of the Environmental Requirements and Best Practices for Maintaining and Constructing Highways and Transportation Systems. June 2011.

<https://www.dot.ny.gov/divisions/engineering/environmental-analysis/repository/oprhbook.pdf>.

Pollinator Project. Highways as part of the Butterfly Beltway- NYSDOT has piloted a strategy to adjust mowing limits and delay mowing from mid-summer to late September, along a six mile section of I-390 in Livingston County to provide:

- Habitat for caterpillar development
- Habitat for migrating butterflies
- Late season forage for pollinators

<https://www.dot.ny.gov/regional-offices/region4/other-topics/pollinator-project>

North Carolina Department of Transportation (NCDOT)

In early 1986, NCDOT developed a Contract Mowing Program and took bids for mowing of highway rights-of-way in 40 of the state's 100 counties. Thirty of the contracts were awarded and 29 operated during that mowing season. The value of these contracts was \$3,164,000.

Today, NCDOT prepares proposals, bid sheets and lettings in addition to collecting data and advertising mowing contracts for each contract year. In 2003 the program included 66 mowing contracts in 98 counties with a total value of \$16,474,632 and an estimated 638,346 shoulder miles.

https://www.ncdot.gov/doh/operations/dp_chief_eng/roadside/

The pollinator habitat effort is an extension of the popular NCDOT Wildflower Program focusing on sustaining the state's strong agribusiness community. The NCDOT Roadside Environmental Unit is establishing pollinator habitats across the state. By utilizing land along the right-of-way to plant specific species of flowers, NCDOT is able to provide habits for the dwindling pollinator population and enhance the traveling experience.

Starting in April, crews will seed for beds of pollinator friendly and visually appealing plants. The roadside effort will utilize the same planting techniques, equipment and agronomic protocols associated with the Wildflower Program.

NCDOT will plant hybrid sunflowers and canola with the objective to work in partnership with industry leaders to make the pollinator habitat project self-sustaining. These are extremely pollinator friendly species and popular with the traveling public

NCDOT Pollinator Habitats.

https://www.ncdot.gov/doh/operations/dp_chief_eng/roadside/wildflowerbook/pollinator/

North Dakota Department of Transportation (NDDOT)

Roadside mowing should be done in the spring and fall to control vegetation growth. Districts should work with adjacent local landowners prior to mowing. The Office of Operations will issue a press release each year informing the public about the start of the spring mowing operation. The right-of-way should be spot mowed, as necessary, to control the growth of trees and noxious weeds. Districts should coordinate with the respective County Weed Control officer for control of noxious weeds. Where this cannot be accomplished, the Department should contract with weed control companies. Districts need to maintain a mowing fleet that can accomplish the minimums and maximums laid out in the mowing plan. It is recommended during spring cut the 8 foot buffer on 2-Lane Rural and outside shoulder on 4-Lane Rural that a 9.5 foot disc or 10 foot rotary mower be used.

NDDOT will change its mowing practices along state highways this summer due to drought conditions across the state. Instead of completing regular mowing practices in July, the NDDOT will conduct only limited mowing along highways and ditches from June to early August. Limited mowing will focus on urbanized areas, intersections, ramp areas, medians of four-lane highways and other areas as needed. Adjacent landowners (farmers and ranchers) are encouraged to harvest grass in the state highway (non-Interstate) ditches as a way to help combat this summer's drought. Private mowing is not allowed in medians of four-lane highways.

NDDOT changes mowing practices on state highways due to drought conditions. 2017.

<http://www.dot.nd.gov/dotnet/news/Public/View/6730>.

The NDDOT has taken the initiative in 2016 to collaborate with agency partners to determine and prioritize projects that can have pollinator species incorporated or managed. These areas include ROW within widely separated divided highways as well as ROW adjacent to Wildlife Management Areas, Federal lands, state school lands, and native prairie. Limitations to pollinator establishment and management within NDDOT ROW include allowing for the continuation of haying the ROW for agriculture purposes

Future Goals

- Plant pollinator species at rest area locations to provide benefits to pollinators as well as increase the attractiveness of rest areas for the traveling public.
- Collaborate with NDDOT Districts and Maintenance staff on the mowing policy to facilitate pollinator establishment/management.
- Identify remnant habitats in ROW and prioritize roadside vegetation management practices in those areas to maintain and expand natural vegetation including site reclamation activities for both roadway projects and borrow area locations.
- Promote pollinator establishment with counties and municipalities in rural and urban plantings.
- As threat of listing several pollinator species under the Endangered Species Act continues; develop a more formal, long term pollinator plan for the NDDOT.

North Dakota Monarch Butterfly and Native Pollinator Strategy. First version December 2016. Second version April 2018.

<https://gf.nd.gov/gnf/conservation/docs/nd-monarch-butterfly-native-pollinator-strategy.pdf>

Ohio Department of Transportation (ODOT)

Roadways are divided into four vegetation management zones, with each zone having specific maintenance requirements:

- Zone 1—Vegetation Free.
- Zone 2—Operational.
- Zone 3—Transition.
- Zone 4—Undisturbed.

The Zone 4 vegetation management can be dictated by surrounding property, such as farmland or wood lots. Manage Zone 4 to ensure that the vegetation present is not detrimental to neighboring land use.

Maintenance Administration Manual Section 400 Vegetation Management.

Ohio Maintenance Operations Manual 2012 Ohio DOT

<https://www.dot.state.oh.us/Divisions/Operations/Maintenance/Documents/Ohio%20Maintenance%20Operations%20Manual.pdf>.

Ohio Department of Transportation. *Statewide Roadside Pollinator Habitat Program Restoration Guidelines and Best Management Practices*. June 2016.

http://www.davey.com/media/1619374/1_odot_statewide_roadside_pollinator_habitat_restoration_guide.pdf

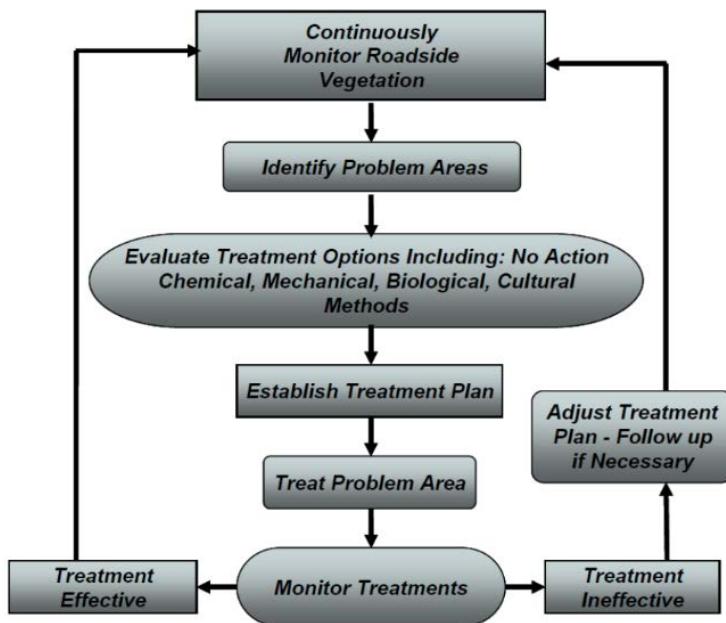
Oklahoma Department of Transportation (OKDOT)

The department planted the pollinator garden and updated its mowing practices in anticipation of the memorandum of agreement that was signed in partnership with six other states. This collaboration with the Federal Highway Administration and the Missouri, Texas, Iowa, Kansas and Minnesota DOTs designates Interstate 35 as the Monarch Highway.

Press Releases Thursday, May 26, 2016 ODOT sweetens Monarch Highway with new garden.

https://ok.gov/triton/modules/newsroom/newsroom_article.php?id=277&article_id=22039

Oregon Department of Transportation (ORDOT)



ODOT Integrated Vegetation Management Statewide Plan. August 2017.

https://www.oregon.gov/ODOT/Maintenance/Documents/statewide_IVM_plan.pdf.

A best practice for the development of pollinator habitat with minimal conflicts with Maintenance would be to include a diverse suite of wildflowers in the seeding for embankment or cut slopes where mowing or maintenance would be infrequent or not occur at all.

Areas with perennials, forbs, and grasses do not need for frequent mowing (annually or every 2-3 years). Spot spraying with herbicide to manage noxious weeds should be done in early fall and/or early spring as needed. Typically, mowing should occur no more than once a year. Mow between August 1st and September 30th (after risk of starting grass fires has subsided) to allow for grasses and forbs to set seed; the mower will then disperse the seed.

Guidelines for Planning, Design, Construction and Maintenance for Landscape, Hardscape and Visual Resources. VERSION 2.0 APRIL 1, 2018.

https://www.oregon.gov/ODOT/GeoEnvironmental/Docs_Environmental/Roadside_Development.pdf

Pennsylvania Department of Transportation (PennDOT)

PennDOT has annual mowing schedules and cycles determined by the District Roadside Specialist and County Maintenance Manager guided by Standard Limits of Mowing and conducted based on financial, climatic, environmental or emergency conditions that exist.

The objective is to manage roadside vegetation successional development to provide safety, utility, economy and beauty to the roadside area. Utility includes stabilizing roadside soils, preventing erosion and growing and encouraging desirable vegetation in place of undesirable vegetation. PennDOT uses an IVMP approach that includes biological/cultural, chemical and mechanical/ manual methods of control.

The vegetative succession is complicated by the individual or collective desires of our twelve million residents and by highway construction and reconstruction programs which keep roadside vegetation in a near perpetual state of pioneer plant development. Most pioneer species such as brambles, locust, sumac, etc. are undesirable "Front Yard" vegetation.

Chapter 13: Roadside Management PUB 23 - Maintenance Manual. 2016.

<http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%2023/Pub%2023-Chapter%2013%20.pdf>

Rhode Island Department of Transportation (RIDOT)

No documents found.

South Carolina Department of Transportation (SCDOT)

SCDOT may be approached by non-SCDOT entities including, but not limited to utility providers, government entities, adjacent property owners, business owners, private citizens, and groups or organizations to manage roadside vegetation. This section is designed to provide guidance to these entities. Also, this section addresses the occasional unauthorized vegetation management that may occur within SCDOT right-of-way.

Vegetation Management Guidelines. 2016

<http://www.dot.state.sc.us/business/pdf/oda/VegMgmtGuide.pdf#search=Vegetation%20Management%20Guidelines>

See 4.2 Maintenance Partnership Agreement in Appendix C.

South Dakota Department of Transportation (SDDOT)

No documents found.

Tennessee Department of Transportation (TNDOT)

The approach of the TDOT Pollinator Habitat Program includes:

- Best maintenance practices and sound ecological principles, through Integrated Roadside Vegetation Management (IRVM methods are currently utilized along guardrails.)
- Modify mowing schedules to be compatible with pollinator cycles
- Utilize swath mowing practices to reduce costs and increase habitat (currently implemented)
- Include pollinator plants in roadside landscaping during new construction and rehabilitation projects where possible
- Establish pollinator meadows and gardens at Welcome Centers and Rest Stops across the state
- Develop pilot projects in each region (Research is currently underway. More information TBA.)
- Create information signage to educate the public about the many benefits of pollinators

Pollinator Habitat Program

<https://www.tn.gov/tdot/environmental-home/environmental-highway-beautification-office/beautification-pollinator-habitat-program.html>

Texas Department of Transportation (TxDOT)

Modified full-width mowing includes all unpaved right of way, except for delineated non-mow or natural areas. To promote cost savings, on rural roadways with very wide rights-of-way or medians, mowing shall be limited to a maximum of 30 foot width. Generally, non-mow or natural areas would begin at the toe of the slope in fill areas or the back of the ditch for cut sections, as long as clear zone requirements are met.

The frequency of modified full-width mowing for a given roadway will depend on the level of vegetation management assigned to that segment of roadway. There are two levels of vegetation management along Texas highways:

- Developed Urban Highways
 - Highly maintained areas which are predominantly residential, commercial, or services development within major metropolitan areas; includes rights of way within smaller cities, towns and villages.
- Rural Highways
 - Surrounding land use is rural only.

The District Engineer may consider exceptions to the policy based on the following criteria:

- Distance to right-of-way.
- Brush control.
- Adjacent land use.
- Wildlife incident history/potential.
- Wildlife history/potential.
- Drainage issues.
- Other factors.

Roadside Vegetation Management Manual 2018

http://onlinemanuals.txdot.gov/txdotmanuals/veg/manual_notice.htm

TxDOT's wildflower program not only helps our highways look good but also reduces the cost of maintenance and labor by encouraging the growth of native species that need less mowing and care. As with grasses, Wildflower Program initiatives strive to establish roadsides that blend into their surroundings. The grasses and wildflowers also help to conserve water, control erosion and provide a habitat for wildlife in all the natural regions of Texas. Maintenance techniques used to encourage wildflower growth include safety, or strip mowing which allows the wildflowers to bloom and native grasses to emerge.

Wildflower Program. <https://www.txdot.gov/inside-txdot/division/maintenance/wildflower-program.html>

Utah Department of Transportation (UDOT)

The Utah Division of Wildlife Resources (DWR) initiated the Utah Rural Roadsides for Wildlife Program (URRWP) to promote roadside habitat enhancement. The DWR and UDOT are

developing and testing roadside seed mixes that will optimize nesting and winter cover. Roadside management techniques and mowing schedules that are responsive to wildlife needs are being tested. Specifically, Utah's Rural Roadsides for Wildlife Program encourages:

- Public involvement in developing roadside vegetation management policy.
- Interdepartmental cooperation in roadside vegetation management.
- Proper management of existing patches of high quality roadside vegetation as habitat for wildlife.
- Mowing only 10% of the ROW width ROW off the shoulder annually.
- Mowing the entire ROW once every 3-5 years to stimulate plant vigor. No more than 1/4 mile per 1-mile section would be mowed in any one year.
- Scheduling renovation mowing after the nesting season - generally after August 1.
- Spot spraying noxious weeds to minimize damage to adjacent cover.
- Eliminating unplanned roadside burning, a common practice throughout the state.
- Discourage snowmobiling and ATV riding on roadsides.
- Educating the public about the value of Utah's Rural Roadsides for Wildlife Program.

Roadside Habitat. <https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:271,34531>. 2016.

Vermont Department of Transportation (VTrans)

VTrans mows non-limited access and limited access highways annually, referred to as the Clear Zone Cut, to meet safety standards. One mow is conducted every 3rd year during the growing season as a substitute for the annual Clear Zone Cut in that area the ROW width and for that year is allowed.

Increased mowing coverage and frequency in medians, islands, and intersection areas of non-limited access highways is permissible in order to maintain a more manicured lawn appearance throughout the growing season. Increased mowing activity must be authorized by the DTA. Narrow medians on non-limited access highways, may be fully mowed (across the entire median width) beyond the clear zone for safe visibility purposes and to avoid narrow strips of grass being left in the middle of these medians.

VTrans State Highway System Mowing Best Management Practices (BMPs). 2016.

http://vtrans.vermont.gov/sites/aot/files/operations/documents/OpsMowingBMP_10-1-2016.pdf

Virginia Department of Transportation (VDOT)

Mowing is based upon a level of service for the designated roadway. Maintenance of intersection sight distances shall take precedence over any service level. Additional mowings may be required to maintain sight distances. Field conditions and right-of-way limitations shall dictate the site distance maintenance requirements.

Mowing & Litter Removal Service Level Matrix															
Average Daily Traffic (ADT)	Interstate and Other Limited Access Roads				Primaries				Secondaries				Unpaved Roads		
	Roadway Category	Mowing Service Level	Litter Removal		Roadway Category	Mowing Service Level	Litter Removal		Roadway Category	Mowing Service Level	Litter Removal		Roadway Category	Mowing Service Level	Litter Removal
200,000+	1	B	YES												
100,000-199,999	1	B	YES		1	B	YES								
50,000-99,999	1	B	YES		1	B	YES		1	B	YES				
25,000-49,999	1	B	YES		1	B	YES		1	B	YES				
10,000-24,999	1	B	YES		1	B	YES		1	B	YES				
5,000-9,999	1	B	YES		2	B	YES		2	B	YES				
2,500-4,999	2	B	YES		3	C	*		3	C	*				
1,000-2,499	2	B	YES		3	C	*		3	C	*		4	C	*
750-999	2	B	YES		3	C	*		4	C	*		5	D	*
450-649									4	C	*		5	D	*
100-449									4	C	*		5	D	*
50-99									4	C	*		5	D	*
<50									4	C	*		5	D	*

Level B roads with more than two lanes receives three annual cuts no wider than 18 feet from edge of pavement. Two-lane roads limit cut width to 9 feet. Level C roads get two mow cycles with a maximum width of 9 feet. Level D has one annual mow to a maximum width of 9 feet.

VDOT Vegetation Management Policy. 2010

http://www.virginiadot.org/projects/resources/VDOT_VegetationMgmtPolicyFinal_VDOTwebsite.pdf

In 2014, VDOT developed and implemented a pollinator habitat program to create naturalized areas planted with nectar and pollinator species. One goal of this program is to reduce maintenance costs by reducing the number of mowings/year and other vegetation maintenance costs such as invasive species control and herbicide applications,

Pollinator Habitat Program

http://www.virginiadot.org/programs/pollinator_habitat_program.asp

Washington Department of Transportation (WSDOT)

The WSDOT Roadside Manual is one the most comprehensive discussions regarding managed succession and other vegetation restoration as part of their program. This manual discusses the concepts roadside management in detail and provides guidance.

Two basic restoration approaches are used: managed succession and accelerated climax community development. They are based on the principles of plant succession in natural ecosystems. The decision on which approach to use depends on permitting requirements, project goals, and roadside functional objectives.

WSDOT Roadside Manual Chapter 810 – Vegetation. July 2003.

<https://www.wsdot.wa.gov/publications/manuals/fulltext/M25-30/810.pdf>

Retaining large masses of native trees is desirable to intercept rainfall, provide canopy cover to compete against weeds, and minimize mowing and the need for herbicides. The following is an example of a maintainable interchange, with trees that have been preserved. Only the edges are mowed to provide operational functions.

WSDOT Roadside Policy Manual M 3110.03 August 2015

<https://www.wsdot.wa.gov/publications/manuals/fulltext/M3110/RPM.pdf>

WSDOT is doing for pollinators:

- Preserving native habitat, whenever feasible.
- Managing roadsides for natural succession.
- Restoring project disturbances using native plants, including woody native flowering species, and providing other habitat features such as logs and snags for native bees and birds.
- WSDOT will continue managing the roadside with mowing along the pavement edge as needed for driver safety. But in other areas beyond the pavement edge, mowing will only be done if it's planned as part of a multiyear treatment strategy using a variety of vegetation management tools.
- Collaborating with others to seek opportunities for partnerships to promote the health of pollinators.
- Our reduced mowing and selective herbicide use policy will help protect pollinators. By leaving roadsides in a more natural state, we can provide pollinators with sources of nectar, pollen, larval host plants and nesting locations needed for them to grow and thrive.

Promoting the Health of Pollinators along WSDOT's Roadsides.

<http://www.wsdot.wa.gov/publications/fulltext/Roadside/PollinatorsFactSheet.pdf>

West Virginia Department of Transportation (WVDOT)

Operation Wildflowers is sponsored by the West Virginia Garden Club, Inc. in cooperation with the West Virginia Division of Highways and the Department of Environmental Protection, REAP Program. Started in 1990 to bring beauty and diversity to roadside landscapes by planting native and naturalized wildflowers in areas which normally supported weeds and dense brush. Their objective was also to encourage the preservation of natural stands of native wildflowers that traditionally had been mowed down and the planting of wildflowers on private property. In the last few years highway landscapes have been greatly improved as a result of this cooperative effort.

Operation Wildflowers.

<https://transportation.wv.gov/highways/maintenance/wildflowers/Pages/default.aspx>

Wisconsin Department of Transportation (WisDOT)

In 2009, routine maintenance work priorities were further redefined in response to budgetary constraints. Consistent with the natural roadsides philosophy, the mowing policy was curtailed to safety locations such as vision corners when needed and roadside shoulder cuts to once a season.

In the same year, 2009, Invasive Species Rule (NR 40) was passed. This rule lists and regulates a number of non-native invasive species and requires control of these invasive species. To accomplish this control, mowing completion dates were included as part of the philosophy.

In 2014 the mowing policy was revised to add an urban mowing component. The urban mowing policy is used in combination with the natural roadsides philosophy and allows for increased mowing frequency in specified urban areas to produce a closer match in vegetation management to adjacent land uses.

The actual mowing is done by county highway crews.

Mowing Wisconsin's roadsides. 5/1/2018.

<http://wisconsindot.gov/Pages/doing-bus/real-estate/roadsides/mowing/default.aspx>

- The "clear zone" - zone one
 - An area of grass, small trees and shrubs off the shoulder to facilitate highway operations.
 - Allows visibility of signs and traffic at interchanges and curves.
 - Large trees and encroachments are removed for safety and herbicides are used selectively for vegetation control around beam guard and sometimes for invasive species.
- The "natural roadside" - zone two
 - This is any area outside the "clear zone."
 - The natural roadside allows for vegetation to establish based on natural selection, typically this includes native or low maintenance vegetation.

Roadsides. <http://wisconsindot.gov/Pages/doing-bus/real-estate/roadsides/default.aspx>. 5/1/2018.

Wyoming Department of Transportation (WYDOT)

<http://employees.dot.state.wy.us/cms/maintenance>

APPENDIX B SURVEY OF PRACTICE

The Texas A&M Transportation Institute (TTI) is currently conducting research for the National Cooperative Highway Research Program (NCHRP) Comparison of Cost, Safety, and Environmental Benefits of Routine Mowing and Managed Succession of Roadside Vegetation to develop guidelines for managed succession of roadside vegetation outside the safety clear zone. Managed succession is a strategic approach of selective control measures that utilize a combination of zero maintenance, targeted mowing, mechanical trimming and removal, and chemical and/or biological treatments to allow plant species to colonize roadside areas outside the safety clear zone. Often these plant species are larger and woodier. As such, these plant materials may create habitat for pollinators and other wildlife. This approach is often part of a long-term plan to minimize right of way maintenance requirements over time.

The objective of this research is to evaluate managed succession beyond the safety clear zone as compared to routine mowing to determine the potential impacts for driver and maintenance worker safety, environmental sustainability and benefits, and reduced costs related to direct labor, equipment, materials, and management/planning. This will be accomplished, in part, by gathering information from state transportation agencies to determine their policies, procedures and experience with variations in roadside mowing protocols regarding safety, cost, and environmental impacts. The data collected for this project will be used to develop an interactive, online guidance tool for DOTs that effectively evaluates potential costs and benefits of a managed succession approach to roadside vegetation management compared with routine mowing.

Please complete and submit this survey by March 2, 2018. We estimate that it should take no more than 20 minutes to complete. It is designed so you can exit and return to the survey if you need to allocate your time over several days. If you have any questions or problems related to this questionnaire, please contact our principal investigator Ms. Beverly Storey at (979) 845-7217 or b-storey@tti.tamu.edu.

1. Contact Information

Name	<input type="text"/>
Agency	<input type="text"/>
Location	<input type="text"/>
Area of Responsibility (statewide, district, region, etc.)	<input type="text"/>
State/Province	<input type="text"/>
Email Address	<input type="text"/>
Phone Number	<input type="text"/>

2. May we contact you for a follow-up email and/or telephone interview?

☐ Yes

☐ No

3. What is your role in implementing your agency's roadside mowing/vegetation management program (e.g. maintenance engineer, vegetation manager, landscape architect, etc.)?

4. Does your agency/area have a published/established roadside mowing/vegetation management protocol?

☐ Yes

☐ No

5. If your agency/area has a published/established roadside mowing/vegetation management protocol, please provide title of the most current document and a link if the document is not publicly available through your agency's website.

If not, please provide details of the roadside management methods implemented by your agency/office.

6. Does agency/area in which you work follow a statewide vegetation management plan or is it specific to your area of responsibility?

Please provide details.

7. How does your agency/area maintain vegetation outside of the safety clear zone? Please select all that apply.

- ☐ Scheduled/routine mowing
- ☐ Zero maintenance
- ☐ Targeted mowing
- ☐ Target chemical application
- ☐ Mechanical trimming and removal
- ☐ Biological treatments
- ☐ Managed succession
- ☐ If you use another maintenance activity, please provide details.

8. Who is responsible for your conducting roadside vegetation maintenance, e.g. mowing, herbicide, etc.? Please select all that apply.

- ☐ Agency/area, e.g. direct employees
- ☐ Contract maintenance worker
- ☐ Public-private partnership
- ☐ Non-profit group, e.g. friend of monarchs, prairie conservation, etc.
- ☐ If another method of providing roadside maintenance, please provide details.

9. Has your agency/area conducted research/performance measurement regarding the cost/benefit of reduced mowing, managed succession or other adjustments to routine mowing protocols outside the safety clear zone? Please select all that apply.

- ☐ Worker safety
- ☐ Direct labor
- ☐ Equipment
- ☐ Materials
- ☐ Management/planning costs
- ☐ Variances within the context of individual agencies and regional ecosystems
- ☐ Other

If applicable, please provide title of the document and a link, if the document is not publicly available through your agency's website.

If you have cost/benefit information that is NOT compiled in a formal document, please summarize that information below or in a return email.

If no research has been conducted before now, does your agency have plans for conducting future research?

10. Has your agency/area conducted research or assigned values to ecosystem services or to increased natural functions associated with reduced mowing, managed succession or other adjustments to routine mowing protocols outside the safety clear zone and roadside ecosystem services? Please select all that apply.

- ☐ Erosion control/soil stabilization
- ☐ Stormwater quantity and quality control
- ☐ Soil fertility
- ☐ Pollination
- ☐ Invasive species control
- ☐ Carbon sequestration
- ☐ Cycling and movement of nutrients, e.g., nutrient leaching
- ☐ Aesthetics
- ☐ Biofuel production
- ☐ Wind energy collection
- ☐ Solar energy collection
- ☐ Other alternative uses

If applicable, please provide title of the document and a link, if the document is not publicly available through your agency's website.

If no research has been conducted before now, does your agency have plans for conducting future research?

11. Has your agency/area implemented reduced mowing protocols specifically as part of a program to accommodate roadside pollinators and other wildlife habitat conservation and/or habitat establishment?

If yes, please provide details.

If no, is your agency considering a reduced mowing program to enhance pollinator/wildlife habitat?

12. If yes to the previous question, has your agency/area conducted any research/performance measurement regarding your program to accommodate roadside pollinators and other wildlife habitat conservation and/or habitat establishment?

If yes, please provide title of the document and a link if not the document is not publicly available through your agency's website.

If no, is your agency considering related research?

13. Has your agency/area conducted research/performance measurement regarding the association between changes in mowing protocols and wildlife incidents? Select all that apply.

- ☐ Increased road kills
- ☐ Reduced road kills
- ☐ Attractive nuisance

If other observed changes, please provide details.

If applicable, please provide title of the document and a link if the document is not publicly available through your agency's website.

14. If your agency/area has implemented a program of managed succession, does your agency have protocols for any of the following? Select all that apply.

- ☐ Roadway context, e.g., urban, suburban, rural
- ☐ Roadway classification
- ☐ Roadway geometry
- ☐ Adjacent land use
- ☐ Number of access points, e.g., driveways, sidewalks
- ☐ Pedestrian/bicycle usage
- ☐ Local agency resolution/agreement

If another type of successional planning methodology is used, please provide details.

15. Does your agency/area provide outreach/public education/stakeholder involvement regarding changes to roadside vegetation management, specifically managed succession?

- ☐ Yes
- ☐ No

If yes, please provide details of your agency's techniques/strategies for engaging public opinion.

16. Has your agency/area faced any institutional obstacles in the implementation of a reduced mowing protocol and/or managed succession outside the safety clear zone?

- ☐ Yes
- ☐ No

If yes, please provide details.

17. Has your agency/area been involved in any litigation regarding changes in roadside mowing protocols outside the safety clear zone (adjacent property owners, wildlife issues, etc.)?

- ☐ Yes
- ☐ No
- ☐ Other vegetation management practices aside from mowing that may have led to litigation

If "yes" or "other...", please provide details, e.g. motivation behind the litigation (parties do not want reduced mowing, parties want additional pollinator habitat, etc.)

18. Does your agency/area have any cooperative agreements for roadside mowing/maintenance with other agencies, local entities or private landowners that do not want reduced mowing and/or managed succession adjacent to their property?

- ☐ Yes
- ☐ No

If yes, please provide a cooperative agreement example and a link if not the document is not publicly available through your agency's website.

19. Has your agency/area conducted research/performance measurement regarding the association between changes in mowing protocols and snow/ice/wind conditions on the roadway? Please select all that apply.

- ☐ Increased need for snow/ice removal-vegetation interferes with snow plowing/storage
- ☐ Reduced need for snow/ice removal-vegetation behaves as snow fence
- ☐ Increased wind issues
- ☐ Reduced wind issues
- ☐ Other winter operations related issues
- ☐ If application, please provide title of the document and a link if not the document is not publicly available through your agency's website.

20. What information would your agency/area consider important for inclusion in an online guidance tool for determining vegetation management best practices outside the safety clear zone?

A large, empty rectangular box with a thin black border, intended for a user to provide a written response to the question above it.

APPENDIX C COOPERATIVE AGREEMENTS/PERMITS

APPENDIX 1 – MAINTENANCE PARTNERSHIP AGREEMENT

2/17/00

THIS AGREEMENT is entered this _____ day of _____, 20____, by and between _____ (hereinafter "Non-SCDOT Entity") and the South Carolina Department of Transportation (hereinafter "SCDOT").

WHEREAS, in accordance with Sections 57-3-110 (1) and (10), 57-3-650, 57-23-10, 57-23-800(E), 57-25-140, and the SCDOT's Policy of Vegetation Preservation on SC Highways, SCDOT is authorized to allow landscaping and beautification efforts on SCDOT right of ways;

WHEREAS, Non-SCDOT Entity has previously obtained a SCDOT Encroachment Permit for the one-time right to access SCDOT's right of way for landscaping, beautification and/or enhancement. Said encroachment permit is described as follows:

Permit Number: _____ Date Issued: _____

Location _____;

WHEREAS, SCDOT and Non-SCDOT Entity are desirous of entering into this Agreement to grant a continuous license to the Non-SCDOT Entity to enter the SCDOT's right of way to conduct routine maintenance of landscaping, beautification and/or enhancements permitted by the aforesaid encroachment permit;

NOW THEREFORE, in consideration of mutual promises, SCDOT and Non-SCDOT Entity agree to the following:

1) SCDOT grants Non-SCDOT Entity a license to enter onto the SCDOT right of way at the area defined by the encroachment permit. The purpose of the license to enter is limited to routine maintenance of the encroachment permit area. Such entry will be limited to the scope of the work identified in the encroachment permit. No additional encroachment beyond that contemplated by the original encroachment permit is allowed. If additional maintenance, enhancement and/or beautification efforts, different from the original scope of work identified in the encroachment permit, is requested, Non-SCDOT Entity will be required to submit a new encroachment permit identifying the new scope of work. Entry onto SCDOT right of way pursuant to this agreement may be without notice to the SCDOT.

2) Non-SCDOT Entity agrees to post all necessary traffic control devices and take all necessary precautions in conformance with SCDOT traffic control standards and as required by the SCDOT, along the SCDOT right of way prior to and during the performance of any routine maintenance, enhancement and/or beautification efforts.

3) Non-SCDOT Entity agrees that no work shall be accomplished from the mainline side of the highway. Ingress and egress from the work area shall be made from private property as identified on the encroachment permit.

4) Non-SCDOT Entity agrees to indemnify and hold harmless the SCDOT from any and all claims, damages and liability arising or resulting from the Non-SCDOT Entity's presence on and use of the SCDOT right of ways for routine maintenance, enhancement and/or beautification. If Non-SCDOT Entity is a local government, it agrees to be responsible for all claims or damages arising from the work performed within the limits of the SC Tort Claims Act. In addition, Local government shall insert a hold harmless and indemnification clause in its contract with all contractors and subcontractors which requires the contractor and subcontractor to indemnify and hold harmless the local government and the State of South Carolina, specifically the SCDOT, from any liability, claims or damages which may arise from the performance of the work on SCDOT right of way. Further, municipalities agree that they are subject to S. C. Code Section 57-5-140, which provides that SCDOT shall not be liable for damages to property or injuries to persons, as otherwise provided for in the Torts Claims Act, as a consequence of the negligence by a municipality in performing such work within the State highway right of way.

MAINTENANCE PARTNERSHIP AGREEMENT, PAGE 2

5) This Agreement shall not be modified, amended or altered except upon written consent of the parties. Neither party shall assign, sublet, or transfer its interest in this Agreement without the written consent of the other.

6) This Agreement may be terminated upon thirty days' written notice to the other party; however, in cases where the Non-SCDOT Entity is not performing in accordance with this Agreement, SCDOT shall give written notice to Non-SCDOT Entity of the failure in performance and, if the Non-SCDOT Entity does not correct or cure the performance within three days of receipt of the notice, SCDOT shall have the option to terminate this license immediately, and shall, thereafter, give written notice of such termination to the Non-SCDOT Entity.

IN WITNESS WHEREOF, the above parties have hereunto set their hands and seals.

SOUTH CAROLINA DEPARTMENT OF
TRANSPORTATION

Non-SCDOT Entity

By: _____

By: _____

Its: _____

Its: _____

Recommended by: _____

**Memorandum of Understanding
Between the Nebraska Game and Parks Commission
and the Nebraska Department of Roads**

This Memorandum of Understanding is made and entered into by and between the Nebraska Game and Parks Commission, hereinafter referred to as the Commission, and the Nebraska Department of Roads, hereinafter referred to as the Department. The purpose of this agreement shall be the establishment and administration of a program of cooperation in roadside management. Roadside habitat is vitally important to the wildlife species that use it. It is very important to pheasant and quail populations. Pheasant and quail provide the bulk of the upland game hunting in Nebraska and thereby make a substantial annual contribution to the state's economy.

Witnesseth:

Whereas, the Commission under authority of Section 81-805, R.R.S. Statutes of Nebraska, has among other things responsibility for management and enhancement of the wildlife resources of Nebraska, and;

Whereas, such enhancement and management are based on habitat development and improvement, and;

Whereas, as research has shown that 25 percent of the pheasants are hatched in roadsides, and;

Whereas, the right-of-ways along Nebraska's road systems managed by the Department of Roads are of significant importance as wildlife habitat, and;

Whereas, the Department has the responsibility for maintenance, human safety, and vegetation management on roads within its jurisdiction, and;

Whereas, vegetating the right-of-way with adaptive species of grasses and legumes is the most economical method of soil stabilization, reduction of routine maintenance, noxious weed control, enhancement of vehicle safety, and production of wildlife habitat, and;

Whereas, the Department and the Commission have cooperated in the past on developing seeding mixtures for the state and county roads and on a living snowfence program, and;

Whereas, the Department and the Commission are each desirous of performing their aforesaid responsibilities in an efficient and economical manner and in concert with each other;

Now, therefore, in consideration of the execution and adoption of this agreement by the parties hereto, each one agrees with the other as follows:

1. That roadside vegetation management is essential to maintain the vigor and quality of the plant community, and to meet necessary safety and drainage requirements along Nebraska highways, and that mowing or controlled burning are the preferred management options.
2. That total roadside mowing be done on a scheduled rotational basis and that no more than one-third of a district shall be mowed out in any one year. The term "total roadside mowing" is defined as mowing all areas within the right-of-way, including, but not limited to, the median and the road shoulder.
3. That the rotational total roadside mowing be done no more often than every four years east of Highway 14 and no more often than every five years west of Highway 14. The Panhandle and Sandhills regions are excluded from a total roadside mowing requirement.
4. That total roadside mowing be restricted to one side of the road in any given year.
5. That this does not restrict the Department from necessary management of roadside vegetation via shoulder, median, town and farmstead entrance, sight distance, and snow control mowing as may be required on either side of the road on an annual basis.

6. That total roadside mowing will be conducted only between the following dates:
 - A. Rotary mowing at a five-inch or greater height - July 15 to November 1.
 - B. Mowing by haying methods - July 15 to September 10.
7. That the entire roadside may be made available for haying when a drought emergency is declared by the Governor of Nebraska. The areas to be first offered for haying would be those areas that were scheduled for a total roadside mowing in that year. If the demand exceeds these offered areas, other areas may be made available. Haying dates may be extended past the September 10 cutoff date in a drought emergency.
8. That the establishment period for a new seeding is normally a two-year time period during which the seeded area is mowed at a five-inch cutting height as frequently as necessary to insure stand viability.
9. That the Commission will utilize its information and education capabilities to inform the public of the importance of roadsides to the soil, water, and wildlife resources of Nebraska. In addition, they will utilize the same capabilities to educate the public on the need to manage roadside vegetation through rotational mowing and to promote the cooperative programs between the agencies.
10. The Commission will assign a person to serve as a representative to the interagency Statewide Roadside Seeding Committee.
11. The Commission will work with and coordinate activities with the Department in areas where programs or responsibilities overlap, such as county roadside management programs.
12. It is mutually understood and agreed to, by and between said parties, that:
 - A. Nothing herein contained shall be construed as obligating the Department or Commission to expend in any one fiscal year any sum in excess of funds made available for such use.
 - B. This agreement shall be effective on the last date of execution as noted below.
 - C. This agreement shall remain in force until mutually modified or terminated.
 - D. This agreement is executed by the Commission and the Department after due consideration on the dates affixed beside their authorization and adoption thereof.

In witness thereof, the parties hereto have signed this Memorandum of Understanding this

17th day of July 1997.

This agreement is entered into in the spirit of cooperation for the conservation of the roadside habitat that is so vital to our wildlife resources.

State of Nebraska
Game and Parks Commission

Rex Amack
Director

State of Nebraska
Department of Roads

Allan Z. Abbott
Director-State Engineer

M-688 (2-12)



**APPLICATION FOR A RIGHT-OF-WAY
VEGETATION MANAGEMENT PERMIT
(FOR GENERAL USE ONLY)**

Permit No.: _____

County: _____

Under the authority contained in Section 10, Act of June 1, 1945 (P. L. 1242), known as the "State Highway Law," as amended, the Pennsylvania Department of Transportation through the Secretary may authorize the cutting, spraying and/or removal of vegetation growing within the legal right-of-way of any State Highway. Activities authorized under this permit shall be performed in accordance with the requirements.

Instructions: Permittee shall prepare application and forward to the respective Engineering District Office for consideration and approval. List the S.R.L's beneath the appropriate code for the activities to be performed. Upon approval, original permit will be returned to Permittee; one copy to be retained by the District Roadside Specialist and one copy to be forwarded to the respective County Maintenance Manager.

Approved for this work is granted with the understanding that the permittee hereby undertakes to indemnify fully the Department of Transportation from any and all liability, loss or damage which the Department, its officers, agents, and employees may suffer as a result of any and all claims, demands, costs, or judgments of any type arising against it as a result of the granting of the permit to the permittee, including, but not limited to claims, demands, costs or judgments of any type arising as a result of any and all activities of the permittee, its agents, employees, or others at the permit site or any work action taken by any of them pursuant to or in violation of the permit, or as a result of any failure of any of them to conform to all pertinent statutes, ordinances, regulations, or other requirements of any governmental authority in connection with this permit.

PERMITTEE USE:

Permit Requested By: _____ Address: _____

City: _____ State: _____ Zip: _____

Permit Requested For: ☐ 1 Year ☐ 2 Years ☐ 3 Years Anticipated Start Date: _____

Work To Be Performed By: _____ BU No.: _____

Permittee Signature: _____ Title: _____ Date: _____

Contact Person: _____ Title: _____ Telephone: _____

LOCATION(S) AND ACTIVITY DESCRIPTION:

[illegible]

PHONE NUMBERS FOR PennDOT ENGINEERING DISTRICT OFFICES

District 1: (814) 678-7068

District 4: (570) 963-4061

District 8: (717) 787-8853

District 11: (412) 429-5000

District 2: (814) 768-0400

District 6: (810) 871-4100

District 9: (814) 696-7250

District 12: (724) 439-7315

District 3: (570) 388-8888

District 8: (810) 205-8700

District 10: (724) 387-2800

DEPARTMENT USE ONLY:

Proposed Activity Reviewed By: _____ District No.: _____

Permit Approved By: _____ Date: _____

This Permit Automatically Expires In : ☐ 1 Year ☐ 2 Years ☐ 3 Years Expires On: _____

Remarks: _____

(see reverse for requirements)

REQUIREMENTS GOVERNING VEGETATIVE MANAGEMENT BY UTILITY CO'S, OR OTHERS, WITHIN THE HIGHWAY RIGHT-OF-WAY

GENERAL:

Section 410 of the Act of June 1, 1945 (P.L. 1242), as amended, makes it a summary offense punishable by a fine of not less than \$100 or more than \$300, to cut, trim, remove, or otherwise damage any tree, grasses, shrubs, or vines growing within the legal right-of-way of a State highway, with certain exceptions, without obtaining the consent of the Secretary in writing. This permit provides consent only when the activity is conducted in accordance with the following requirements and any violation of these requirements may be grounds for immediate revocation and correction of violation(s) at the permittee's expense.

REQUIREMENTS (Governing all activities):

1. Prior to permit issuance, the proposed work is subject to review by the respective District Roadside Specialist or his designee. An official representative of the permittee and/or his contractor may be required to be present for this review and/or interpretation and instructions. The issuance of this permit in no way relieves the permittee from the responsibilities for damage claims as provided in Section 107.14 of the 408 Specifications. All work is subject to other applicable laws, rules and regulations.
2. An approved, current copy of the permit must be present at the work site whenever work is being performed and must be presented for inspection to any department representative or police officer upon request.
3. Work equipment and personnel shall operate beyond the roadway wherever possible to minimize interference with traffic. Maintenance and protection of traffic shall be carried out in accordance with the requirements of the Department, as set forth in Publication No. 213 "Work Zone Traffic Control Guidelines". Flagmen, sign, and/or flashing lights shall be provided where and as specified by these publications.
4. Except as provided for under the provisions of Act 79 (Highway Vegetation Control Act) the Department strictly prohibits any act of vegetation control which would directly improve visibility of junkyards, billboards, or other roadside enterprises without justifiable benefit to the roadway or the roadside environment.

REQUIREMENTS (Tree Trimming and Removal Activity/Stump Treatment):

1. Tree trimming and removal work shall be performed by skilled workers in accordance with acceptable arboricultural practices.
2. All stubs, abnormal growth, unsightly deformities including sprout clusters, created by previous trimming practices, shall be properly removed under this permit.
3. Vertical and/or horizontal clearance for specific situations may be restricted by the District Roadside Specialist or his designee.
4. Under trimming is permitted if not unreasonably high.
5. Clear cutting, except for ground cover and desirable small growing trees and shrubs may be permitted as sanctioned by the District Roadside Specialist.
6. Large trees shall be removed in sections to prevent damage to the highway or interruption to traffic. Resulting stumps shall not be higher than four inches following the ground contour. Treat all live stumps with a herbicide labeled for this purpose.
7. All logs, cordwood, branchwood, or other forms of wood measuring four inches or more in diameter shall be offered to the abutting property owner for his use or disposal. In all cases, the resulting wood must be removed from the highway right-of-way prior to leaving the site.
8. All resulting brush must be removed from the highway right-of-way either by hauling or chipping. Burning within the right-of-way, or within forty feet of desirable vegetation is prohibited.
9. Tree trimming and removal activities which are not being performed in accordance with the requirements of this permit, or instructions issued by the District Roadside Specialist, shall be suspended until corrective action(s) by the permittee are satisfactory to the Department.

REQUIREMENTS (Pesticide Activity):

1. Pesticide applications, which create brown foliage between June 1st and August 15th are discouraged.
2. Desirable vegetation, as designated by the District Roadside Specialist shall not be treated with herbicides. Desirable vegetation damaged as a result of the permittee's herbicide treatment, as determined by the District Roadside Specialist, shall be replaced or the Department shall be reimbursed by the permittee for the full value of the vegetation.
3. This permit does not supercede any requirements stipulated in Act No. 24 "The Pennsylvania Pesticide Control Act of 1973." and the current rules and regulations adopted thereunder.
4. Each application request for a permit must be accompanied by a description of the material(s) which will be applied under this permit. The permittee shall indicate on this description the proposed application rate, mix ratio and carrier and method of application.
5. Pesticide Business License number (BU No.) of contractor must be shown on the form.

REQUIREMENTS (Mowing Activity):

1. Four inches shall be the minimum criteria for grass after cutting. When directed by the Department, excessive heavy grass or vegetation clippings shall be removed from the right-of-way. Mowing of Crownvetch beyond standard, or designated mowing limits is prohibited.
2. Desirable small trees and shrubs will be designated by the District Roadside Specialist. Any desirable plants damaged or injured by the permittee shall be replaced as directed by the Department. Undesirable plants shall be cut to ground line.
3. No mowing shall commence until litter and debris is removed from the right-of-way areas and disposed of in an acceptable manner.

