

Project No. 14-40

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

FINAL REPORT

Prepared for
National Cooperative Highway Research Program
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

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ABSTRACT

The NCHRP 14-40 project provides guidance for roadside vegetation management to identify the cost, safety, and environmental impacts of routine mowing compared with managed succession of vegetation for areas outside the safety clear zone. Departments of Transportation (DOTs) are re-evaluating their roadside management practices regarding costs and environmental concerns versus benefits. The ecosystem services provided by minimizing roadside vegetation maintenance practices can include ecosystem diversity, stormwater quantity and quality management, carbon sequestration, conservation and/or restoration of pollinator and/or wildlife habitat, and aesthetics. A key safety benefit comes from reducing maintenance personnel exposure to traffic hazards, equipment, and chemical treatments. This provides both short-term and long-term cost savings and benefits. Overall, managing the roadside as a valued transportation asset consists of taking advantage of the natural ecosystem services that modified mowing regimes and/or managed succession can provide to see the return in cost/benefit.

EXECUTIVE SUMMARY

The NCHRP 14-40 project provides guidance for roadside vegetation management to identify the cost, safety, and environmental impacts of routine mowing compared with managed succession of vegetation for areas outside the safety clear zone. Departments of Transportation (DOTs) are re-evaluating their roadside management practices regarding costs and environmental concerns versus benefits. The project goals were accomplished through two objectives. The first objective was to conduct a thorough assessment of roadside vegetation management practices in the United States. This assessment included relevant research regarding environmental sustainability and benefits, ecosystem services (ES), wildlife habitat, driver and maintenance worker safety, and the cost differentials of reduced mowing/managed succession compared to routine mowing. The second objective was to develop guidance tools. The guidance tools include guidelines and an interactive web-based tool that enables user input to consider the specific site conditions and evaluate feasibility of implementing a managed succession approach to roadside vegetation management. The development of the tool was based on the information collected from the literature review, a survey of practice, and follow-up interviews with select DOTs.

The managed succession method of roadside maintenance is a strategic approach of selective control measures using a combination of zero maintenance, targeted mowing, mechanical trimming and removal, and chemical and/or biological treatments to allow desirable plant species to colonize roadside areas outside the safety clear zone. Often these plant species are larger, taller and woodier. As such, these plant materials may create habitat for pollinators and/or other wildlife, and provide other important environmental functions. This approach is typically part of a long-term plan to minimize right of way (ROW) maintenance requirements over time.

The focus of this report is on the management of Zone 3. This is the area that extends beyond the safety clear zone to the ROW boundary. Zone 3 typically contains more naturally occurring vegetation than Zones 1 and 2 and may have different management strategies that allow for more naturalization. Roadside maintenance and operations for Zone 3 accommodate different types of adjacent property development and users such as urban, industrial, and agricultural. The ecosystem services provided by minimizing Zone 3 roadside vegetation maintenance practices can include ecosystem diversity, roadside aesthetics, stormwater quantity and quality management, carbon sequestration, conservation and/or restoration of pollinator and/or wildlife habitat, and improvements to local microclimate such as changes in solar radiation, wind speed, air temperature, relative humidity, and re-radiation from paved areas. A key safety benefit comes from reducing maintenance personnel exposure to traffic hazards, equipment, and chemical treatments. Modifications to vegetation management practices can provide both short-term and long-term cost savings and benefits. Overall, managing the roadside as a valued transportation asset consists of taking advantage of the natural ecosystem services that modified mowing regimes and/or managed succession can provide to see the return in cost/benefit.

One of the costs associated with mowing is repairing the damages incurred from mowing on slopes. Steep slopes of 3:1 or greater are good candidates for implementing some version of managed succession. Mowing when soil is too wet can also cause damage. Mowing damage left

unattended can lead to costly repairs from severe erosion problems that can undermine the pavement edge and other infrastructure. Removing such areas from mowing is a viable solution.

There are noted concerns with establishing larger/taller vegetation on the roadside. One concern found in the literature is the attraction of wildlife to vegetation. In Arizona, planners avoid species known as “ice cream species” that may pull in elk on the roads. Animal-vehicle collisions are more likely to occur at road crossing locations such as creeks, rivers and drainage ways regardless of the roadside vegetation management practices. The other issue lies in the potential fire risk in semi-arid, arid and drought-prone areas. More vegetation means more fuel for areas susceptible to wildfires.

The development of naturalized type roadside requires time for the desired vegetation to become established. For many states, this is between 2 to 5 years depending on regional climate conditions. During the establishment period, there is typically more maintenance required to control undesirable species and enable the target species to establish. After establishment, DOTs can see long-term savings when the managed succession area becomes self-sustaining and requires minimal management that generally consists of maintaining the safety clear zone, and removal of undesirable vegetation and/or larger vegetation that creates interference with sight distance or other safety related issues

Management of the roadside needs to reflect its value as a transportation and environmental/community asset, its unique management issues, and its integration into the larger transportation system. Adopting an asset management systems for roadside vegetation management can further enable DOTs’ ability to document management practices over time and allow DOTs to better utilize their limited resources, maximize worker safety, and get the most out of the ecosystem services that a sustainable roadside environment provides.

There are remaining knowledge gaps identified over the course of the project that further research could address. The following suggested topic would benefit state DOTs in managing roadside vegetation as part of a greater transportation system:

- A synthesis of DOT asset tracking systems for roadside vegetation management and others that may be adapted to roadside vegetation management.

CHAPTER 1. BACKGROUND

Many factors are at the forefront of comparing the cost, safety, and environmental benefits of routine mowing and managed succession of roadside vegetation outside the safety clear zone. Some of these benefits may include the reduced costs associated with modification of roadside vegetation management practices. However, many of the benefits fall under ecosystem services (ES). These ES benefits include ecosystem diversity, stormwater quantity and quality management, carbon sequestration, erosion control, pollinator corridor development, wildlife habitat, and aesthetics. The importance of planted and naturally occurring vegetation on the roadside and the associated ES lies in the environmental, social, and economic benefits provided by trees and forests (Wolf 2013) and is discussed further in the Ecosystem Services section of this report.

Most departments of transportation (DOT) have adopted some form of roadside zones for their vegetation management regimes characterized by three zones as shown in Figure 1. Some DOTs have additional zones for their management protocols. Zone 1 is considered the operational zone and its management includes pavement preservation, erosion control, sight distance assurance, placement and maintenance of roadside appurtenances and other safety related issues. Zone 2 is the safety clear zone designated for errant vehicle recovery. Zone 2 is routinely mowed and vegetation is controlled for sight distance, fire hazard and fixed object control. Other uses include stormwater infiltration, detention, conveyance, and treatment, vegetative buffer, scenic enhancements, and above and below ground utilities and signage. However, the focus of this report is on the management of Zone 3. This is the area that extends beyond the safety clear zone to the right of way (ROW) boundary. Zone 3 typically contains more naturally occurring vegetation than Zones 1 and 2 and may have different management strategies that allow for more naturalization.

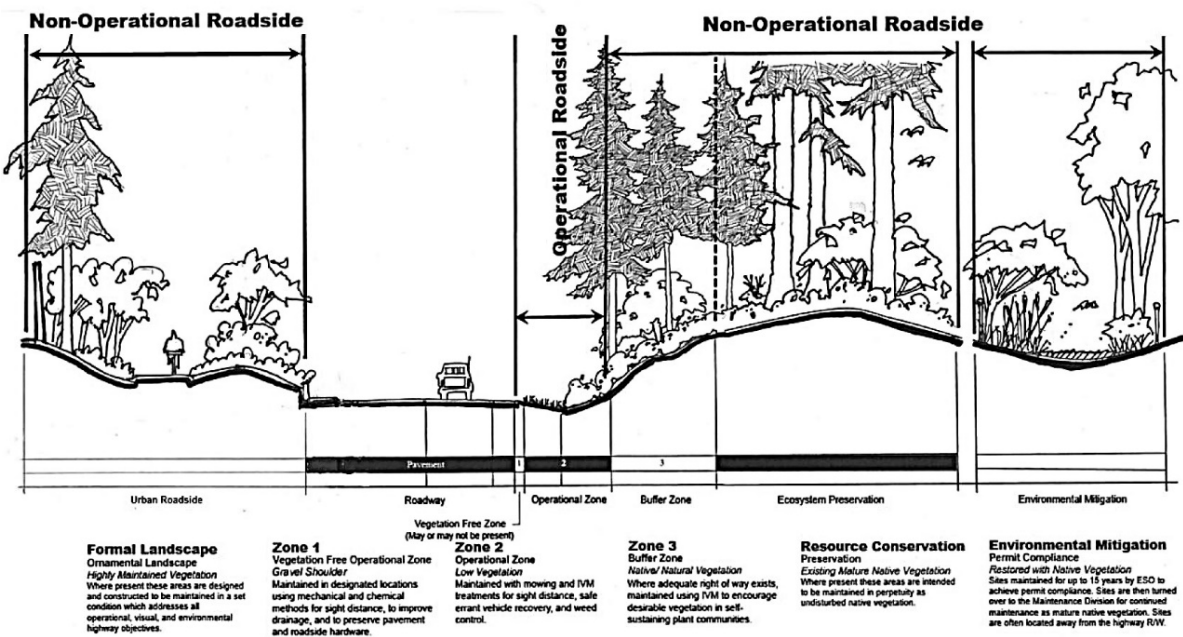


Figure 1. Roadside management zones (WSDOT 2015).

Roadside maintenance and operations accommodate different types of adjacent property development and users such as urban, industrial, and agricultural. The managed succession method of roadside maintenance is a strategic approach of selective control measures using a combination of zero maintenance, targeted mowing, mechanical trimming and removal, and chemical and/or biological treatments to allow desirable plant species to colonize roadside areas outside the safety clear zone. Often these plant species are larger, taller and woodier. As such, these plant materials may create habitat for pollinators and/or other wildlife, and provide other important environmental functions. This approach is typically part of a long-term plan to minimize ROW maintenance requirements over time.

However, a managed succession approach may differ slightly from naturalization. Managed succession may be more controlled in the species allowed to propagate on the roadside. Larger/taller plant species may not be appropriate in locations that create conflicts with sight distance, adjacent properties, and roadway geometry. Naturalization may use a more hands-off approach to roadside management typically treating only for noxious weeds and safety related concerns.

DOTs have historically incorporated roadside vegetation management operations that consist of mowing and herbicide treatments, not only for the safety clear zones, but also the remainder of ROW from boundary to boundary. DOTs are re-evaluating their roadside management practices regarding costs and environmental concerns versus benefits. Transportation agencies seek methods to minimizing ROW maintenance without compromising safety.

Roadside vegetation management practices can have a direct impact on the ES provided. An example is the Minnesota DOT and Department of Natural Resources joining efforts to adjust roadside mowing schedules to accommodate wildlife such as pheasants, gray partridge, rabbits, waterfowl, and songbirds that nest on the ground or in low vegetation (MNDOT 2019). A federal policy that supports the concept of ES in natural areas of the roadside is the 2014 Presidential Memorandum *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* prompting many state and local DOTs to recognize that changing mowing practices may be a pollinator-friendly practice (White 2014). 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.

STUDY OBJECTIVE

The goals of this research were to identify and quantify the cost, safety, and environmental impacts of routine mowing compared with managed succession of vegetation for areas outside the clear zone and develop guidelines for recommended roadside vegetation management practices.

The project goals were accomplished through two objectives. The first objective was to conduct a thorough assessment of roadside vegetation management practices in the United

States. This assessment included relevant research regarding environmental sustainability and benefits, ES, wildlife habitat, driver and maintenance worker safety, and the cost differentials of reduced mowing/managed succession compared to routine mowing. The second objective was to develop guidance tools to assist agencies in determining whether a managed succession program is appropriate for a specific location. The guidance tools include guidelines and an interactive web-based tool that enables user input to consider the specific site conditions and evaluate feasibility of implementing a managed succession approach to roadside vegetation management.

Researchers focused 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,
- Wildfire considerations,
- Roadway context,
- Public perception/outreach/stakeholder involvement,
- DOT performance metrics, and
- Snow/ice/wind concerns.

CHAPTER 2. RESEARCH APPROACH

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 questionnaire.

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

The interim report reflects the work conducted on the project including the literature review of available research and existing state DOT practices, and the results of the survey. 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 reflect a system perspective where the anticipated users such as DOTs, landscape architects, vegetation managers, engineers and other personnel tasked with managing roadside vegetation for the corridor are considered. The user-friendly and application oriented guidelines focus on roadside maintenance scenarios and address the subject areas listed in the project objectives.

Task 5: Develop Interactive Tool

This practical and user-friendly tool provides recommendations to transportation agencies regarding their roadside maintenance operations. A web-based interactive tool will assist the user in application of the guidelines developed in Task 4. The interactive tool is configured to allow user input for various site considerations.

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 and can assist in a more consistent and efficient manner of selecting treatments. The results are practical and immediately usable for implementation by planning, design, and operations staff in state and city DOTs and metropolitan planning organizations.

CHAPTER 3. LIERATURE REVIEW

OVERVIEW

Roadside vegetation management requires a high level of expertise and resources to plan, design, construct, and maintain the roadside environment. The management of roadside vegetation involves driver and worker safety, environmental and ecological benefits and impacts, stormwater management, public relations, aesthetics, and budget constraints. 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 covers research and DOT practices regarding the major focus areas for routine mowing and managed succession designated by the project.

ROADSIDE ECOLOGY

Roadways are great for moving people and goods from point A to point B and all places in between. However, their construction can be detrimental to the surrounding roadside ecosystems. The effects of roadways on ecology can include:

- Loss of habitat due to new pavement construction,
- Direct mortality of wildlife by collisions with vehicles,
- Habitat fragmentation due to barriers that affect animal movements,
- Low habitat quality adjacent to roads,
- Isolated populations and reduced genetic diversity,
- Less animal communication and foraging due to traffic noise pollution,
- Reconfiguration of local landforms,
- Spread of noxious/invasive species adjacent to roadsides,
- Changes to hydrology and water quality, and
- Air pollution and particulate deposition through vehicle emissions (Kociolek et al. 2016, Coffin 2007, Proppe et al. 2017).

Although many roadsides may have a naturalized appearance, they are not undisturbed. Their soil structure and site hydrology are thoroughly altered from predevelopment conditions to meet strict vehicular roadway design. Periodic automotive-based maintenance controls the roadside vegetation composition as well (Li et al. 2008). An ecological approach to roadside vegetation management can save resources as part of a long-term plan. 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, regional climate), its functions, and different limiting factors (Harper-Lore et al. 2013).

Efficient use of the roadside area for vegetation establishment can mitigate the negative influence of roadways on the environment. Establishing native and non-native plant species on available roadside areas reinforces sustainability and improves roadside ecology. The following are identified by Li et al. as factors that contribute to the character of roadside ecology.

- 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 (Li et al. 2008).

Ecosystem Services

The concept of ecosystem services gained its popularity in the 1990s. ES considers the roadside environment as a valued transportation facility asset that should be managed as such. 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. Green infrastructure developed for stormwater management can provide co-benefit of health and livability (Wolf 2013, Säumel et al. 2016). Transportation agencies manage vast quantities of roadside environment that are valued as a transportation, environmental, and community asset with unique management issues within the larger transportation system.

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 (Kahn 2016). 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. Table 1 shows the results using models developed by the U.S. Forest Service and the U.S. Environmental Protection Agency (EPA) to approximate the ES benefits and estimate monetary values for each research location in terms of pounds of carbon sequestered and gallons of rainfall intercepted. This study depicts the contributions of the street trees to the community through quantitative analysis using a time frame of 2015 to 2065. Previous literature characterized multiple ES provided by roadside vegetation and proposed management approaches (Maes et al. 2014).

Table 1. 50-Year ecosystem services projection using I-Tree Design (Kahn 2016).

Study Location	Carbon Sequestered (pounds)	Rainfall Intercepted (gallons)	Savings Air Quality Improvements
State Street	217,845	1,576,716	\$1,622.00
Union Street	229,857	1,724,691	\$1,845.00

Pine Street	232,860	5,252,454	\$4,801.00
Cedar Street	255,436	1,360,042	\$1,393.00

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) (Säumel et al. 2016). Table 2 lists several of ES and associated management approaches. Although the noise reduction using vegetation is listed in Table 2, achieving a reduction in decibel levels from traffic noise requires vegetation with adequate height, depth and density and may not be a viable method due to limited ROW areas. The additional vegetation may be viewed as providing a more psychological effect.

Washington State DOT (WSDOT)'s *State Roadside Manual* lists some contributions of roadside vegetation to the environment (WSDOT 2017). These ES contributions 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.

Table 2. Ecosystem Services provided by roadside vegetation (Kahn 2016).

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
	- Temperature regulation through shading and evapotranspiration	- Enhance plant biomass in road corridors, from the surface to tree layers. - 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 plant shape characteristics that affect resonant absorption properties	- Enhance vegetation structures at noisy road corridors - Enhance biodiversity (plants, nesting or feeding habitats for birds) in road corridors
	- Stormwater quantity and quality management	- Implement green infrastructure techniques
Provisioning	- Food supply through horticulture along urban roads	- Consider different pollution loads when designing plantings (e.g., distance to roads, barriers, pollutant tolerant species)
	- Allow infiltration of runoff that supports groundwater recharge	- Enhance unpaved regions to foster penetration of water
Habitat	- Encourage attractive native or non-native species or for species of conservation concern	- Link streetscapes with urban habitat networks
	- Ecological corridor or stepping stone for animal and plant species	- Reduce impervious surfaces to foster habitat development

Ecosystem Services (ES)		Management Approaches
		<ul style="list-style-type: none"> - Re-introduce native species (e.g. grassland species at roadsides, wetland species in swales, native tree species) - Work to accept spontaneous vegetation development - Protect habitat structures in old trees (e.g. cavities) - Develop biodiversity-friendly management (e.g. mowing regime; selection of plant species as food source for animals)
Cultural	<ul style="list-style-type: none"> - Attractive streetscapes promote social cohesion and physical outdoor activities and reduce stress 	<ul style="list-style-type: none"> - Develop multifunctional “livable” streetscapes by enhancing green elements - Design green elements according to demands of local people - Protect heritage trees, traditional allées and other historical green elements in road corridors

Native Plants Species

Native plant species naturally grow in a 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 may be difficult to re-establish due to changes in native site conditions after roadway construction (reduced organic matter, compaction, slopes, etc.); however, they are sustainable once established (Harper-Lore et al. 2013). The benefits of native plant establishment are as follows:

- Native plant species 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 can reduce stormwater runoff quantities and act as snow fences when appropriately located.
- Native plantings are aesthetically pleasing and may offer outreach opportunities for DOT environmental initiatives.
- Native plant communities support more native wildlife than non-native plant communities.

State DOTs manage over 17 million acres of ROW land in the U.S. While establishing improved visibility and obstacle-free safety clear zones within 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. In recent years, revegetation of the U.S. roadsides 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 that the IRVM approach encourages stable, independent vegetation with restricted use of mowing and herbicides (Venner and Parsons. 2004). It is achieved through techniques that foster sustainable native plant communities that discourage unwanted plant species. 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 offers advantages that may result in minimal herbicide use and maintenance necessities (Hopwood 2013).

Revegetation efforts differ for each regional ecosystem. Different regions have unique requirements in terms of types of vegetation and associated benefits and challenges. Native woody vegetation outside the safety clear zone provides benefits that differ from prairie grass/forb species (prairie ecosystem) roadsides. Unlike revegetation efforts using woody plants there are some challenges associated prairie ecosystem revegetation. These may include seed availability, the rate of development, and the viability of the seed. One effective approach to improving the success of native revegetation is reusing native topsoil. Existing site topsoil removed during the initial construction process and stockpiled, is then reapplied to the same site to establish vegetative cover from the native seed bed within the topsoil. Appropriate plant species selection for revegetation is the basis for successful roadside revegetation. The Idaho Transportation Department (ITD) recommended some native species for use in revegetation such as *Bluebunch wheatgrass* and *Idaho fescue*, identified as their best performing grasses. ITD also assessed vegetation and soil attributes claiming perennial native vegetation can be a cost-effective approach to reduce surface erosion and weed encroachment (Ament et al. 2017). Revegetation with native species is recommended on a federal level as well. Government offices are coordinated to use 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 (Berger 2005).

The Maine DOT's *Maine Native Plants for Roadside Restoration* (MEDOT 2018) contains guidelines for different plant species as shown in Figure 2. This document outlines the Maine DOT's efforts for revegetating with native plant materials. The document includes a guide for each species used on the roadsides.

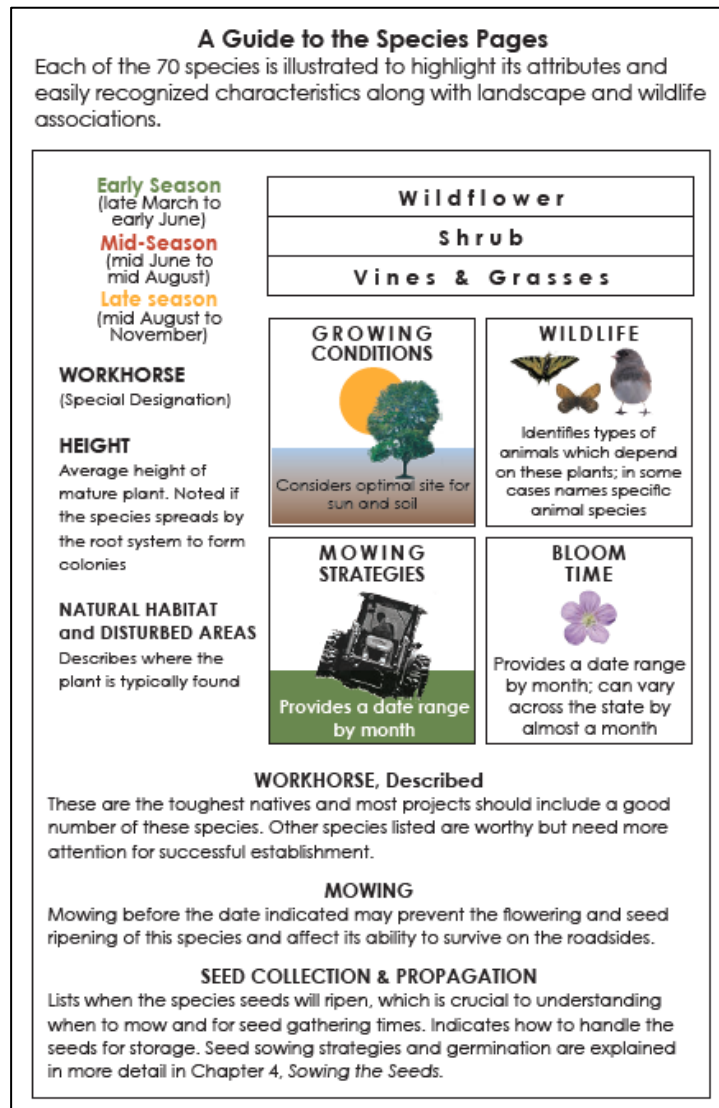


Figure 2. Maine DOT *Native Plant Species Guide* (MEDOT 2018).

Pollinators and Roadside Vegetation

One of the important benefits of roadside vegetation management is providing habitat for the pollinators. FHWA provides a list of best practices to incorporate in state DOT roadside vegetation management plans in order to improve the pollinator population. These practices include protecting the native habitat, adjusting mowing practices, reducing the impact of herbicides, and so on. It is noted that allowing shrubs and trees to proliferate is also important components of pollinator habitat, when compatible with the design of the roadside (Hopwood et al. 2015). Figure 3 shows a WDSOT roadside with Zone 2 covered in the wildflowers and a conifer dominated Zone 3. The incorporation of native plants can help to boost pollinator habitat as well enhance driver experience.



Figure 3. Washington State roadside with wildflower and conifers (Courtesy WSDOT).

Protecting pollinator habitats has been an ever-increasing priority for state and national organizations in roadside vegetation management (Säumel et al. 2016). Highway systems use large areas frequently driving pollinators from the area to find new food sources. Therefore, restoration of their habitat along the roadside is important (Kremen et al. 2007). Roughly 60-80% of world's 250k species of flowering plants depend on insects for pollination.

Pollination of flowering plants is an essential ES (Hopwood 2013). Pollinators such as honey bees, flies, wasps, bugs, moths, and butterflies not only have a distinct role in food webs but are vital to plant biology. Fruits and seeds, the products of pollination, are the primary food for many birds and mammals as well as humans. Roadsides can provide shelter for pollinators, particularly in landscapes substantially altered by urbanization or agriculture. Naturally managed roadsides can furnish pollinators with food and habitat. Pollinator habitat must incorporate a diversity of herbaceous and woody flowering plants which supply pollinators with protein-rich pollen and life-giving nectar. Pollinators additionally require a place 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. Other pollinators create hives in which they leave food for their young, either above or below ground. Native plants are shown to support more butterflies, bees, and other pollinators than non-native grasses and flowers (Harper-Lore et al. 2007).

The diversity of native plant species 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 (Conniff 2013). 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.

One issue for roadside maintenance practices is how managed succession might affect pollinators. Research conducted by Taki et al. investigated the succession influences on wild

bees. The research evaluated successional stages ranging from 1 to 178 years in naturally regenerated and planted temperate forests. “The results suggest that early successional stages of both naturally regenerated and conifer planted forest maintain a high abundance and species richness of solitary bees and their cleptoparasitic bees, although social bees respond differently in the early successional stages. This may imply that, in some cases, active forest stand management policies, such as the clear-cutting of planted forests for timber production, would create early successional habitats, leading to significant positive effects for bees in general” (Taki et al. 2013).

Roadsides can be managed to service pollinators. Florida DOT conducted a project addressing the reduced numbers of pollinators. 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 (Conniff 2013).

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 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.

ROADSIDE MANAGEMENT

Mowing Frequency

Roadside mowing is a disturbance that can impact vegetation's successional process. Mowing changes resource allocation by way of changing the light distribution and exposure, 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).

Roadsides are studied at great length for how they should provide for 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, save money, reduce CO₂ emission, and overcome 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 done in Rhode Island monitored 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 (Wigginton 2015). 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 infiltration 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 (Guyton et al. 2014). 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 increase in the number of deer in infrequently harvested plots extensively seeded with clovers and vetches as well. Public perception review found 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.

Managed Succession and Naturalized Roadsides

The managed succession or naturalized area method of roadside vegetation management has been implemented by several DOTs, either by intent through design and planning, stipulated agency practices, and/or as the result of reduced maintenance activities in Zone 3 of the roadside. For many agencies, a reduced mowing protocol was derived from the need to conserve fuel, labor and equipment costs with limited budgets. Another reason is to establish environmentally sustainable communities of native plant areas for pollinator and wildlife habitat. Zone 1 and Zone 2 (see Figure 1) are routinely mowed for sight distance, structure/pavement integrity, and to maintain the safety clear zone. The area beyond the safety clear zone extending to the outside ROW boundary and/or areas within wide medians can be maintained as a naturalized area using managed succession. Figure 5 shows State Highway 47 in Bryan, TX with the safety clear zone mowed and the remainder of the wide median and Zone 3 of the roadsides colonized with larger, woodier plant species. This strategic approach of roadside management is often part of a long-term plan to minimize ROW maintenance requirements over time.



Figure 5. State Highway 47 in Bryan, TX (Courtesy TTI).

Managed succession and naturalized roadsides are often thought of and implemented in a semi-rural or rural context due to the more available ROW widths these roadways afford. However, it is quite possible to plan and design for managed succession in an urban setting. Two examples in a very urban context are from the Texas Department of Transportation (TxDOT) Houston District and WSDOT. Figure 6 shows TxDOT on the left and WSDOT on the right. Both areas were designed to establish into a naturalized state using under and over story plant materials that require minimal maintenance.



Figure 6. Managed succession in urban context (Courtesy TxDOT and WSDOT).

Several transportation agencies have some mention of managed succession, non-mow zones, or naturalized/minimal maintenance areas within their agency manuals or websites. Although many DOTs do not specifically characterize the naturalized or undisturbed areas in the zones adjacent to the outside ROW boundary as managed succession, the resulting vegetation management protocols achieve similar results. More information regarding DOT documents can be found in Chapter 3 of this report. Excerpts and examples from DOT documents that illustrate managed succession or minimal maintenance strategies are as follows:

- **Alabama** - 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 (ALDOT 2018).
- **Colorado** - 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 (Kohlhepp et al. 1995).
- **Delaware** - 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 (Barton et al. 2009).
- **Florida** - 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 (Ferrell et al. 2012).

- **Illinois** - ILDOT 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 (ILDOT 2017).
- **Indiana** – Mowing is limited to clear zone only. 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 (INDOT 2018).
- **Maryland** - The Maryland Reforestation Law stipulates minimum sizes for Reforestation Areas, minimum species diversity and planting density, but provides limited direction on the design of Reforestation Areas. The State Highway Administration (SHA) Reforestation Areas exceed the minimum requirements of the law to achieve increased survivability, reduce maintenance needs, provide screening and obtain wildlife and aesthetic benefits. Reforestation and Revegetation Areas are designed to recreate and provide the benefits of natural forest with little maintenance. Reforestation and Revegetation Areas are not usually mowed after the Establishment Phase is completed. However, mowing before installation and during the Establishment Phase promotes the growth of trees and shrubs (SHA 2016).
- **Michigan** - 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. Mowing beyond the designated 12-foot limit on any road may only be done to maintain designated clear vision areas, for brush control or to address a specific health and safety problem (MIDOT 2003).
- **Montana** - 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 (MTDOT 2009).
- **Ohio** – The Ohio DOT divides the roadside into four zones. Zone 4 adjacent to the outside ROW boundary is designated as undisturbed. The Zone 4 vegetation management can be dictated by surrounding property, such as farmland or wood lots. Zone 4 is managed to ensure that the vegetation present is not detrimental to neighboring land use (OHDOT 2012).
- **Oregon** - Non-Mow Areas – These are areas not regularly maintained but may need infrequent spot spraying to prevent establishment and spreading of noxious weeds. The intent is to increase the forest canopy by supplemental plantings of trees and/or by managing the environment to allow the natural succession of desirable trees, thereby allowing this landscape to mature as a relatively “wild” landscape (ORDOT 2018).
- **Pennsylvania** - 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 (PADOT 2016).
- **Texas** - 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 (TXDOT 2018).

- **Utah** - Mowing only 10% of the ROW width 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 (UTDOT 2016).
- **Washington** - 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. Retaining and restoring 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. Only the roadway edges are mowed to provide operational functions (WSDOT 2015, WSDOT 2003).
- **Wisconsin** - 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. The "natural roadside" 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 (WIDOT 2019).

As demonstrated in the above section, the practice of leaving the area adjacent to the outside boundary of the ROW in a naturalized state is gaining acceptance. Many other DOTs have practices adapted specifically to pollinators that include reduced mowing protocols but do not specifically leave an area undisturbed for larger plant species.

Roadside Weed Management

Invasive plants are generally non-native or introduced species that can cause economic and/or environmental harm. Ecosystems threatened by invasive plants disrupt the composition and function of natural areas and native plants. These invasive plant species are often introduced unintentionally into an ecosystem. Wind and water can transport invasive plant species' propagule. They are carried by animal fur and feathers, on clothing, or even by the tires of vehicles causing changes to areas set aside for natural wildflower growth (Harper-Lore et al. 2007). Roadside weeds are also spread by various modes of transportation from shipping containers, airplanes, boats, trucks, etc. In fact, in California it is legal to transport hay without being covered. This allows for noxious/invasive species to travel along highway corridors.

Plants native to the U.S. can also become destructive when transported from native locations to another region in the country. Noxious weeds are designated plants that compromise agriculture, harm humans, or degrade natural areas. This definition is typically the 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 can spread into 4,600 acres daily. It is not considered as a natural evolution, but a change due to increased global mobility and speed. Although the spread of invasive species is not specific to the ROW, these changes result from

human decisions and management. Cooperation among affected stakeholders, such as adjacent land owners and transportation decision-makers, will enable informed management choices.

As stated previously, roadsides can be a great contributor to the dissemination of weeds and invasive plants to new areas. According to FHWA, there are some essential considerations for the betterment of the roadside ecosystem and efficient weed management (Harper-Lore et al. 2007). 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 personnel about the methods of weed control. It is essential to know to apply National Environmental Policy Act (NEPA) as a roadside manager.
- Developing a plan of action considering allotted time and resources with agency personnel. Coordination and collaboration among government agencies are essential when tackling issues this spread out across state borders.
- Educating and encouraging adjacent property owners to do their part as government agencies can only go so far off the road before it becomes private property. Identifying species of concern on adjacent properties enables transportation agencies to take a more targeted approach to weed control within the ROW.

Vegetation Management Methods

The method used to manage the roadside vegetation depends on the biology of the roadside plants and weeds. AASHTO's *Guidelines for Vegetation Management* classifies the roadside vegetation into five categories: fern and fern-like species, grasses, sedges, broadleaf forbs, vines, and woody species such as shrubs and trees (AASHTO 2011).

Mechanical Control

Mechanical control can involve large tractor mowing, string trimmers, push mowers, pruning shears, and so on for managing the growth of roadside plants and weeds. In the recent years, some states have developed more innovative practices for the mechanical control purposes and are using more innovative mowing equipment. Minnesota DOT (MnDOT) uses mowers equipped with Automated Vehicle Location (AVL) systems (Porter and Mayer 2017). 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 inlets, and aprons. The operator uses these dots to identify the locations of drainage and other structures while mowing.



Figure 7. MnDOT AVL live map (42).

Cultural and Biological Control

The cultural weed control methods refer to the establishment of competitive desirable species to force out noxious weeds (AASHTO 2011). 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 (e.g., wetlands, retention ponds), insects, bacteria, fungi, viruses, and competing plants to control unwanted vegetation.

Chemical Control

Herbicides are a 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, herbicides can adversely affect 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 area to protect the riparian zones (ORDOT 2016).

However, herbicides have significant effects on pollinators (e.g., monarch butterfly, karner blue butterfly) (Hopwood 2013). Direct contact with herbicides can be deleterious to bees or butterflies. Research demonstrated that butterflies exposed to herbicides had diminished survivorship (ORDOT 2016, Russell et al. 2005). Herbicides indirectly cause harm to pollinators by destroying their source of food. 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 large numbers of larval host plants or adult forage plants are not destroyed. Limited use of herbicides, manual removal of woody plants, avoiding repeated mowing, and targeted use of herbicide use reduce vegetation maintenance costs (Stark et al. 2012).

Effective roadside management requires making informed decisions to integrate different techniques and methods to achieve the greatest benefits. Minnesota DOT conducted a survey of existing best practices in the state to develop *The Best Practices Handbook on Roadside Vegetation Management* (Johnson 2008). The handbook classifies the existing best management practices for roadside vegetation as follows:

- Develop an Integrated Roadside Management Process.
- 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.

Adjacent Properties

One of the considerations for DOTs in implementing a reduced mowing and/or managed succession program are the perceived and actual effects on properties directly adjacent to the outside boundary of the ROW. The Alabama DOT's *Manual for Roadside Vegetation*

Management (ALDOT 2018) supports being a “good neighbor” by considering those who own and use property adjacent to highway ROW. ALDOT personnel are directed to manage the ROW vegetation in a manner that will not hinder the reasonable lawful activity, safety, or aesthetic appearance of adjacent property. Also, the ROW should be blended with the adjacent land uses, e.g., forestlands should extend into the ROW, and ROW adjacent to crop and pasture lands should remain relatively open, etc.

An outreach brochure developed by the Kansas DOT outlines their roadside management practices for the public. The DOT allows adjacent landowners to mow the ROW in front of their property to be consistent with how they maintain the rest of their property. The DOT sees cost savings by allowing permitted farmers and adjacent landowners to harvest hay from the roadsides at no cost. Landscape improvements may be allowed on highway ROW by adjacent landowners by obtaining a permit from any local KSDOT office. KSDOT spends approximately \$6.7 million annually on mowing for safety, vegetation control, improved drainage, and aesthetic reasons. The savings from this roadside management program allows more time and money to be spent on state highways and bridges (KSDOTa 2010).

Several DOTs work with adjacent property owners and allow the ROW to be managed in part by the property owner. This can be accomplished through cooperative agreements, memorandums of understanding (MOU), and/or permits through the respective DOTs. Some agreements allow for more frequent mowing if done through an agreement by persons other than DOT personnel. Sometimes permitted mowing is done to harvest hay. Cooperative agreements can provide a cost savings for DOTs. Examples of cooperative agreements are in Appendix C.

It should be noted that while some of the practices described, such as timber harvest, hay harvesting, and allowing permitted private maintenance, may reduce agency costs, DOTs should determine if these practices are compatible with the agency’s managed succession/natural management methodologies. These non-DOT practices have potential to create inconsistent gaps in highway corridor appearance and/or roadside ecosystems.

COST SAVINGS AND ENVIRONMENTAL BENEFITS

State DOTs struggle with matching maintenance needs with available budgets. Allowing for some sort of managed succession beyond the safety clear zone can reduce the need for mowing and other routine vegetation management practices. Costs for most DOT roadside vegetation management includes items such as the mobilization of personnel, vehicles, equipment, signs (mowing ahead, etc.), and other equipment such as crash attenuator trucks if needed. Some DOTs contract for part or all roadside vegetation management operations and have limited in-house equipment and personnel. Little research has been conducted regarding the cost benefit of managed succession. However, some states have realized monetary savings, and worker safety and environmental benefits of reduced mowing and managed succession

One of the costs associated with mowing is repairing the damages incurred from mowing on slopes (Figure 8). Steep slopes of 3:1 or greater are good candidates for implementing some version of managed succession. Mowing when soil is too wet can also cause damage. Mowing damage left unattended can lead to costly repairs from severe erosion problems that can

undermine the pavement edge and other infrastructure. Removing such areas from mowing is a viable solution.



Figure 8. Mower damage on slopes (Courtesy of WSDOT).

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 (Harrison 2014). This study shows that the cost of the roadside vegetation management is more than the offset 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. The study 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 a half billion dollars with an increase up to \$1.5 billion with the incorporation of pollination and other insect services. 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 (FDOT 2014).

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 (Trevino 2009).

The Maryland State Highway Administration 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 (SHA 2018).

MNDOT 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 reducing its roadside mowing by 50%. However, budget constraints influence projects to create naturalized roadsides. Minnesota, for instance, cut \$50,000 for its roadside seed-acquiring program. The ability to grow native flora and encourage wildlife to pollinate highly depends on the mowing season, seed diversity, and human intervention during ecosystem development. Additionally, the simultaneous

execution of a far-reaching education program helps the public understand the DOT’s efforts to restore natural beauty to the ROW (Johnson 2000).

WSDOT implemented a reduced mowing policy in 2015. The policy consists of the following:

- No more routine mowing beyond one pass.
- Mowing beyond one pass only if part of multi-year IVM treatment plan for weed control.
- Reduced overall Zone 3 mowing by 70%.

The benefits described by WSDOT include:

- Saves approximately \$750K per year in total Zone 3 expenditures over previous costs.
- Benefits native ecosystem and pollinator habitat for native species and honey bees.
- Improves stormwater management.
- Saves 4,000 gallons of diesel fuel per year.
- Requires less equipment in the fleet.
- Reduces carbon emissions by 35 metric tons.
- Un-mowed roadsides are better at storing carbon and stormwater.
- Reduces the amount of employee exposure to traffic hazards.

WSDOT tracked expenditures over a 5-year period for Zone 1 spray, safety mowing, safety trimming and tree removal, noxious weed control, nuisance weed spraying, and landscape. The data compared calendar years 2015 through 2018 to the previous five-year average. The data in Table 3 shows a reduction in overall roadside maintenance costs through reduced maintenance practices. See Appendix D for WSDOT’s *Visualizing Roadsides as Transportation Assets* poster describing the costs associated with the urban roadside, operational roadway, resource conservation and environmental mitigation zones in average cost/acre/year. Zone 1 is \$200, Zone 2 is \$239 and Zone 3 is \$18.

Table 3. WSDOT vegetation maintenance expenditures (WSDOTa 2019).

Expenditure	2018 vs 5-year Average
Total Roadside Vegetation Maintenance	-7%
Zone 1 Spray	20%
Safety Mowing	5%
Safety Trimming and Tree Removal	25%
Noxious Weed Control	-24%
Nuisance Weed Mowing	-63%
Nuisance Weed Spraying	-50%
Landscape	-12%

Roadsides planted with native grasses and forbs reduce erosion, mowing frequency, and use of herbicides, which leads to cost savings (Harper-Lore et al. 2007). Actual cost data is difficult to calculate. There are three basic methods of conducting roadside maintenance that

include using agency personnel for mowing and other roadside maintenance operation, contracting for roadside maintenance, and using cooperative agreements/volunteers which are typically not a cost to the DOT. Mowing and other roadside operations costs are calculated using various methods making a direct comparison challenging. Payment units found include per acre, centerline mile, shoulder mile, mow cycle, and hourly rate. Naturalized and native vegetation areas provide many benefits that may or may not be perceived of as monetary such as stormwater runoff quantity and quality control and reduced blowing snow when used as a snow fence.

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. While most of the issues related to roadside safety occur in the safety clear zone, Zones 1 and 2, there are some considerations for outside the safety clear zone. Effective vegetation management improves sight distance. The other key safety concern for DOTs is for maintenance workers. Modifying roadside maintenance activities reduces maintenance personnel's 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 the driver needs to verify that the road is obstruction free and avoid any conflict by seeing other vehicles, signs, fixtures, animals, and people beside the road. The safety clear zone is kept free of visual and physical obstacles and is typically associated with Zones 1 and 2. However, larger/taller vegetation in Zone 3 located at changes in roadway geometry such as steep slopes, sharp roadway curves and other limited visibility locations can potentially reduce sight distance creating unsafe driving conditions and should be thoroughly evaluated.

Animal Vehicle Conflicts

Roadsides can be favorable habitats for many plants and animals. As such, roadside planning, design and management should consider the possibility of becoming an "attractive nuisance" for animal species known for involvement in animal vehicle conflicts. The vegetation in Zone 2 and Zone 3 can provide a food source, protective cover, and habitat for many insect and animal species. Approximately 2 million animal vehicle conflicts occur in the U.S. each year, with about 135–200 fatalities, 29,000 injuries, and more than \$8 billion loss (Proppe et al. 2017). For example, more than 61,000 deer-vehicle collisions were reported in Virginia in 2016 (Donaldson 2017). As a result, deer-vehicle conflicts are identified as the fourth costliest of the 14 major collision types in Virginia (economic loss of more than \$533 million per year). This financial loss is not only associated with human injuries and fatalities, but also includes crash investigation, carcass removal, and disposal.

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 (Coffin 2007). The author also discusses how the design and management of the roadside can create favorable habitats that may attract animals, insects, small mammals, and carrion-feeders. The author argues that bird, insect, and mammal populations may be affected differently by various mowing regimes or planting designs. Coffin cites the cases in 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.

Hindelang et al. performed a study in Kent County, Michigan aimed to reduce the frequency of deer to vehicle collisions (Hindelang et al. 1999). The researchers performed a GIS spatial analysis to identify clusters of deer collisions 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 concerns. They identify that mowing policies at the time of the study accommodate pheasant populations on the roadside. Additionally, they identified that deer-vehicle collisions tend to occur more frequently on two-lane rural roads.

In their 2008 report to congress, Huijser et al. presented 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 (Huijser et al. 2007). Although 300,000 animal-vehicle collisions per year were documented in 2008, the report estimates that the 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. This study also showed that for the railway setting, this reduction could be around 56%. However, the study cautions that the 56% reduction may not be translate to highways. In the case of deer populations, the report asserts how the density of these populations depend on the quality of the habitat, which requires abundance of food and cover. The Normandeau report summarizes the findings from multiple studies about variables that relate to the frequency of deer-vehicle collisions (Normandeau 2012). This study conducted a survey of 23 different DOTs and quantified deer-vehicle collision impacts of reduced roadside mowing.

Some studies used multivariate logistic regression to define landscape and traffic factors of the increased possibility of deer-vehicle collisions and to determine the correlation with collision frequency (Ng et al. 2008). This model found a positive relationship between deer-vehicle collisions and posted speed limit. Slow speed vehicles are more likely to avoid a deer on road. Furthermore, deer-vehicle collisions are more likely to occur in areas near water sources (Church 1988). Ditches are typically established with non-native grasses which green up faster in the spring. Additionally, the crash rates associated with deer are higher in spring due to earlier green-up of the roadside vegetation. As abundant roadside vegetation is another primary cause of mammal fatality, efficient roadside vegetation management is imperative (Ramp et al. 2006).

The monthly number of moose-vehicle collisions peaked in autumn in Finland whereas similar crashes mostly occurred in winter in Sweden and Norway (Niemi 2016). The number of moose-vehicle collisions has increased in spring due to the early start of growing season. Researchers found ungulate (deer, moose, etc.) vehicle collisions occur least frequently in winter because of worse driving conditions and less passable roads which make passing vehicles move slower (Kušta et al. 2017). 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 (Myczko et al. 2017). Most of the bat species

(based on the sonograms of their calls using call shape, call duration and call end frequency) can be identified in the vicinity of a road; however, its mortality rate is marginal. Higher presence of bats increases nighttime bat vehicle crashes. A study conducted in India showed that foraging bird guilds make their nests by urban roadside trees, which may cause higher number of bird-vehicle crashes (Rao and Koli 2017).

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 (Proppe et al. 2017). Khalilikhah and Heaslip performed a spatial analysis of animal crashes and animal crossing signs for Utah DOT (Khalilikhah and Heaslip 2017). They found that a very small percentage (2%) of animal collisions 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 (Gonçalves et al. 2018). 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

Recommendations from Huijser et al. present the case that timing for cutting roadside vegetation is key, as cutover areas may be attractive as foraging sites by deer (Huijser et al. 2007). 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 wildlife-vehicle collision (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 (Cramer et al. 2016). These researchers investigated animal-vehicle collisions in South Dakota and they recommend the use of mowing/treatment strategies to diminish the 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 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-vehicle collision frequency (Barnum and Alt 2013). The researchers collected before and after data from ten study locations in Maryland and New York and performed a before/after evaluation on collision 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 (Jared et al. 2017). 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 (Huijser et al. 2017).

The effectiveness of the mitigation methods largely depends on the knowledge about landscape connectivity and roadway planning and construction processes (Niemi 2016). The distance between highway and forest edge affects animal crossings on roads (Hooker et al. 2016). According to Niemi and Hooker et al. 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 (Niemi 2016, Hooker et al. 2016). Using fencing combined with wildlife passages such as green bridges and various underpasses have reduced animal vehicle collisions up to 83% (Rytwinski et al. 2016). Bil et al. suggested a comparatively less costly method for animal-vehicle collision reduction (Bil et al. 2018). According to their study conducted in the Czech Republic, use of odor repellents has the potential of reducing animal-vehicle collisions up to 43%.

Although the literature shows the wide acceptance and promotion of mowing and landscape development 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. Animal-vehicle collisions are more likely to occur at road crossing locations such as creeks, rivers and drainage ways. According to the *Roadside Vegetation Management: Final Guidelines Document for Colorado DOT* (Kohlhepp et al. 19957), a greater frequency of animal-vehicle collisions are likely to occur at these locations regardless of the roadside vegetation management practices.

Worker Safety

Gulick et al. conducted a study for the Ohio DOT, *Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation* (Gulick et al. 2017), examining four treatment zones (Figure 9) for current maintenance practices and worker safety implications adding an additional zone to those shown in Figure 1. 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.

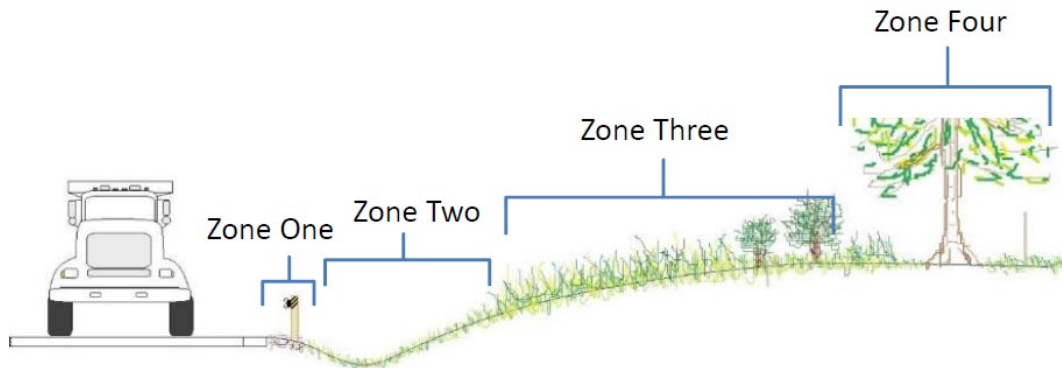


Figure 9. Ohio DOT roadside management zones (Gulick et al. 2017).

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 herbicide application 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 (herbicide applications) 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 (unmown). ROW boundaries can become an issue with vegetation growth. This is controlled by periodic tree trimming and removal. The 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 when doing manual pruning. 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.

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* (AZDOT 2018) 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. 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* (VegCon Plan) (Caltrans 2014). Caltrans vegetation control policy was developed by a statewide committee in 1987.

This policy called 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. The policy strongly emphasized use of pre-emergent chemicals to suppress weed growth in the cleared strips. When considering fire reduction strategies, the key is to assess the risk of fire starts in the right of way and the consequences of that fire escaping to surrounding terrain. Proper fire risk management cannot guarantee elimination of all fires. However, it should recognize the likelihood that a fire may start; the risk to people, property and the environment; and the difficulty of controlling fires. Fire potential varies with the type of roadside vegetation and the configuration of the pavement edge. For example, grasses on a cut slope with a dike at its base are less likely to be ignited by a cigarette or spark than grasses on a flat traversable roadside. Similarly, perennial or low growing annual grasses present fewer fire risks than tall annual grasses. The chance and consequences of a fire escaping vary widely with conditions. The consequences of fire spreading to an adjacent forest may be more serious than fire spreading to desert, chaparral or grasslands. Likewise, the consequences of a roadside fire where there is a containment barrier such as a frontage road or sound wall are less than if the fire can spread unimpeded into adjacent terrain. 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 impacting expected vegetation growth which may increase/decrease fire risk, and urban interface.

The New Mexico DOT also considers fire hazard reduction as part of their roadside management (NMDOT 2012). 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. The Nevada DOT uses vegetation that does not create a fire hazard or become overly attractive to wildlife. The DOT suggests selecting plants that have been evaluated for drought tolerance, salt and alkali tolerance, seedling vigor, and fire-retardant characteristics that can be established with little or no long-term maintenance by NVDOT (NVDOT 2001).

CONCLUSION ON LITERATURE REVIEW

This review has examined the knowledge and practice of roadside vegetation management. Research and DOT practices regarding the major focus areas for routine mowing and managed succession have been summarized. Several transportation agencies have adopted some manner of managed succession, non-mow zones, or naturalized/minimal maintenance areas within their agency manuals or websites. However, for most DOTs the term managed succession is not used to describe the naturalized, no-mow or undisturbed areas in the zones adjacent to the outside ROW boundary.

There are both short-term and long-term costs and benefits for DOTs. The review of the literature demonstrates that reduction or modification to roadside vegetation management strategies can reduce maintenance personnel exposure to traffic hazards, equipment, and chemical treatments. This provides both short-term and long-term cost savings and benefits. Managing a roadside in a naturalized state requires time for vegetation to become established. For many states, this is between 2 to 5 years depending on regional climate conditions. During the establishment period, there is typically more maintenance required to control undesirable species and enable the target species to establish. After establishment, DOTs can see long-term savings when the managed succession area becomes self-sustaining and requires minimal management that generally consists of maintaining the safety clear zone and removal of large vegetation that creates interference with sight distance or other safety related issues. Little research exists on the long-term cost/benefits of implementing reduced mowing and/or managed succession.

However, the studies conducted showed that managing the roadside as a valued transportation asset can provide economic and societal benefits for the DOTs in terms of reduced actual costs and benefits gained through ecosystem services. Some of the ES benefits demonstrated through implementation of reduced mowing and/or managed succession include carbon storage and sequestration, stormwater interception, and air quality improvement. In the urban context tree canopies are shown to mitigate the urban heat island effect and green infrastructure is instrumental in stormwater management for quantity and quality. Other ES provided include roadside biodiversity and conservation and/or restoration of pollinator and/or wildlife habitat. Overall, managing the roadside as a valued transportation asset consists of taking advantage of the natural ecosystem services that managed succession can provide to see the return in cost/benefit.

CHAPTER 4. 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* (AASHTO 2011) for roadside vegetation management guidance. A search of DOT websites found 45 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. Over 80% of the documents found have some measure of a reduced mowing practice. The decision to reduce mowing came from budget constraints, accommodating wildflowers, pollinators and wildlife, and a desire to enhance environmental sustainability.

SURVEY OF PRACTICE

An online survey of practice was developed and administered to those tasked with managing roadside vegetation in the DOTs to determine their agency's roadside management practices. The survey design tried to optimize responses by balancing the length and 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 A contains the final survey.

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. A list of respondents can be found in Appendix B. The survey comments included were edited, condensed, and/or summarized. As of this Interim Report, 26 states have responded to the survey. These respondents include (see Figure 10):

- Arizona DOT (AZDOT)
- 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)

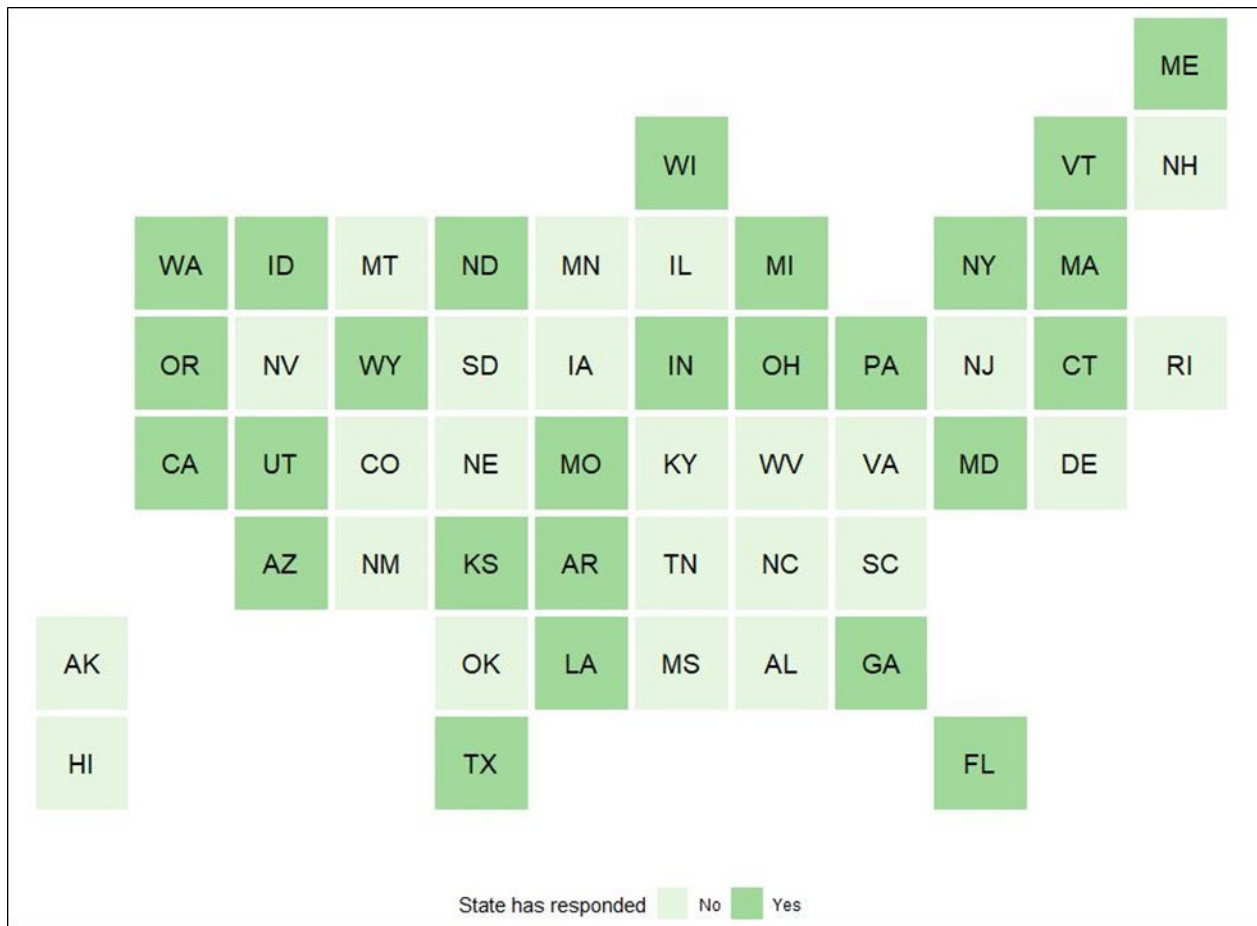


Figure 10. Survey responses by states.

Roadside Ecology

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. Most 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. Table 4 shows the survey responses for ecosystem services.

Table 4. Survey responses for ecosystem services.

Survey Choices	Survey Responses
Erosion control/soil stabilization	FL, NY, TX, WY
Stormwater quantity/quality control	FL, MD, NY, WA
Soil fertility	FL, PA
Pollination	AR, CT, FL, NY, OH, TX, UT, WA
Invasive species control	AR, CT, FL, LA, MD, NY, OH, PA, UT, WA, WY
Carbon sequestration	
Cycling and movement of nutrients	
Aesthetic	AR, FL, NY, TX, WA, WY
Biofuel production	MI
Wind energy collection	
Solar energy collection	
Other alternative uses	

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 (Harrison 2014) 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. Table 5 shows that several states indicated that reduced mowing has been part of their roadside maintenance, some 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.

Table 5. Survey responses for reduced mowing for pollinators and wildlife.

Survey Choices	Survey Responses
YES	CT, FL, GA, ID (district specific), IN, KS, ME, MD, MA, MI, MO, NY, OH, VT, WA, WI, WY
NO	TX

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 are 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.
- OHDOT has a strong program designed to accommodate roadside pollinators and other wildlife. Their research project developed the pollinator program (OHDOT 2016). 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 (PADOT 2016) 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.
- TxDOT did not implement reduced mowing specifically to benefit pollinators and other wildlife, but that is a benefit, along with many other benefits.
- 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 implemented 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. The 20 responses to this question as shown in Table 6.

Table 6. Survey responses for research regarding pollinators and wildlife.

Survey Choices	Survey Responses
YES	AR, CT, FL (limited), LA, ME, MD (ongoing), MI, NY, PA (Penn State Research), WA
NO	AZ, ID, IN, KS, MA, MO, WI
If no, is your agency considering related research?	
YES	CA, GA, OH

The majority of states are very interested in such data to “bolster the argument” for their respective programs. Their 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* (CTDOT 2018).
- 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 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. Table 7 shows the responses.

Table 7. Survey responses for wildlife incident research.

Survey Choices	Survey Responses
Increased road kill	ME, WY
Reduced road kill	ME, WY
Attractive nuisance	WY

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 wildlife incidents.
- 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.

Roadside Management

Survey participants were asked whether their agency/area has some official program that determines the management of their roadside vegetation. Table 8 shows the responses. 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.

Table 8. Survey responses for published vegetation management practices.

Survey Choices	Survey Responses
YES	AR, CA, CT, FL, GA, ID, IN, KS, LA, ME, MD, MA, MI, MO, NY, OR, PA, TX, UT, VT, WA, WI, WY
NO	AZ, MA, UT

If the DOT has a roadside management program, is it statewide or conducted at a regional level? Of those respondents, 62% have some system of statewide vegetation management protocols. Over 42% of the responding states 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. Table 9 shows the survey results.

Table 9. Survey responses for statewide or regional vegetation management.

Survey Choices	Survey Responses
Statewide	CT, IN, KS, LA, MD, MI, NY, OR, TX, VT, WI, WY
Regional	AR, AZ, CA, ID, MA, UT, WA,
Both	FL, ME, MO, PA

The survey and DOT documents review determined how DOTs maintain vegetation outside of the safety clear zone. The survey results are included in Table 10.

Table 10. Survey responses for vegetation management outside safety clear zone.

Survey Choices	Survey Responses
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Scheduled/routine mowing	AR, AZ, CA, CT, FL, ID, IN, KS, LA, MD, MO, ND, OH, OR, PA, UT, VT, WA,
Zero maintenance	CA, IN, MD, NY, OR, TX, VY, WA,
Targeted mowing	AZ, CA, FL, ID, IN, ME, MD, MI, MO, NY, ND, OH, OR, TX, UT, VT, WA, WY
Target chemical application	AR, AZ, CA, CT, FL, GA, ID, IN, LA, ME, MD, MI, MO, NY, OH, OR, PA, TX, UT, VT, WA, WY
Mechanical trimming/removal	AR, AZ, CA, CT, FL, GA, ID, IN, LA, ME, MD, MA, MI, NY, OH, OR, PA, TX, VT, WA,
Biological treatments	CA, FL, ID, MD, MO, NY, OR, PA, WA, WY
Managed succession	IN, ME(interstates), MD, MI, NY (by result not design), OR, PA, TX, VT, WA, WY

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 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 in Table 11.

Table 11. Survey responses for roadside maintenance responsible parties.

Survey Choices	Survey Responses
Agency/area, e.g. direct employees	AR, AZ, CA, CT, FL, ID, IN, KS, LA, ME, MD, MA, MO, NY, ND, OH, OR, PA, TX, UT, VT, WA, WY
Contract maintenance worker	AR, AZ, CA, FL, GA, ID, IN, LA, ME, MD, MA, MI, MO, NY, ND, OH, PA, TX, UT, VT
Public-private partnership	ID, MA, OH, VT, WA, WY
Non-profit group, e.g. friend of monarchs, prairie conservation, etc.	MO, NY, VT, WA

The other methods described include:

- GADOT- Some areas are maintained by the local government, either city or county. Areas with enhancement/landscape plantings are maintained by government sponsor, or by Community Improvement Districts (a county based self-taxing entity made up of local businesses).
- LADOTD – Hay harvesting (1%).
- MDDOT – County Weed Boards apply herbicides for control of noxious weeds.
- MODOT – Adopt-A-Highway has options for mowing, landscaping, etc.
- OHDOT – Agreements with cities and other local municipalities.

- PennDOT – 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-ups.
- WisDOT – Contract with Counties, WisDOT has 72 (each County) contracted with each County to provide maintenance services including mowing and other State roadside vegetation management.
- WYDOT - MOUs with WY Department of Agriculture and County Weed & Pest Districts.

Cost

Only six states (Table 12) 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.

Table 12. Survey responses for cost/benefit research.

Survey Choices	Survey Responses
Worker safety	FL, TX, WA
Direct labor	FL, IN, TX, WA
Equipment	FL, IN, PA, TX, UT, WA
Materials	FL, IN, PA, TX, WA
Management/planning costs	FL, IN, UT, WA
Variances within the context of individual agencies and regional ecosystems	FL, PA, WA
Other	

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 (Harrison 2014) 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 (labor, equipment, materials, operations) 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 where woody plant materials have grown.

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 led their decision-making. Only seven states selected from the choices below. Table 13 shows that roadway context and roadway classification ranked highest. Roadway geometry, adjacent land use, access point and local agreements ranked equally.

Table 13. Survey responses for managed succession roadway criteria.

Survey Choices	Survey Responses
Roadway context, e.g., urban, suburban, rural	FL, IN, MI, OR, WA
Roadway classification	FL, OR, PA, TX, WA, WY
Roadway geometry	IN, MI, TX, WA
Adjacent land use	OR, PA, WA
Number of access points, e.g., driveways, sidewalks	MI, TX, WA
Pedestrian/bicycle usage	FL
Local agency resolution/agreement	OR, WA

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 24 responses shown in the table below, 14 respondents

indicated that their transportation agency does not engage in public outreach regarding vegetation management.

Table 14. Survey responses for outreach/public education/stakeholder involvement.

Survey Choices	Survey Responses
YES	CT, FL, GA, IN, ME, NY, OH, PA, VT, WA,
NO	AZ, AR, CA, ID, KS, LA, MD, MA, MI, MO, OR, TX, UT, WI

Those with some sort of outreach and/or stakeholder participation had the following comments.

- CTDOT has been publicizing the *Vegetation Management Guidelines* (CTDOT 2018) 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 works with local communities.
- NYSDOT stated their outreach is not specifically for managed succession but developed talking points for mowing limits. They 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 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 25 states responding, 60% indicated there are institutional obstacles. Table 15 contains those responses.

Table 15. Survey responses for institutional obstacles.

Survey Choices	Survey Responses
YES	AZ, AR, FL (internal), GA, IN, KS, MD, MA, MO, ND, OH, PA, TX, VT, WA
NO	CA, CT, ID, LA, ME, MI, NY, OR, UT, WI

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 indicated in Table 16 that their respective agency has not faced any

litigation specifically pertaining to changes in roadside mowing protocols outside the safety clear zone.

Table 16. Survey responses for litigation involvement.

Survey Choices	Survey Responses
YES	KS
NO	AZ, AR, CA, CT, FL, ID, IN, LA, ME, MD, MA, MI, MO, NY, ND, OH, OR, TX, UT, VT, WA, WI

The positive response from KDOT indicated that they had other vegetation management practices aside from mowing that may have led to litigation. Another issue expressed by KDOT was visibility of billboards due to tree growth. MDDOT received 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 39% of the respondents as shown in Table 17. Examples of cooperative agreements and permits are in Appendix C.

Table 17. Survey responses for cooperative agreements/permits.

Survey Choices	Survey Responses
YES	GA, LA, MO, ND, OH, PA, TX, VT, WI
NO	AZ, AR, CA, CT, FL, ID, IN, KS, ME, MD, MA, MI, NY, UT

Comments from the survey include the following:

- 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 (see Appendix C).
- 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 increased mowing of 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. Table 18 has these results. Most of the comments were that agencies have not conducted research regarding ice and snow issues related to mowing protocols.

Table 18. Survey responses for winter related issues.

Survey Choices	Survey Responses
Increased need for snow/ice removal-vegetation interferes with snow plowing/storage	
Reduced need for snow/ice removal-vegetation behaves as snow fence	NY, WA
Increased wind issues	WY
Reduced wind issues	
Other winter operations related issues	

- CTDOT performs a late-season, final mowing so no snow/ice issues have arisen.
- INDOT – No but attempting to push the idea of tracking our snow/ice issues in an effort to identify bad/problem areas. If the properly identified, one might be able to assess impacts from vegetation.
- NYSDOT - We've studied living snow fence, which requires a change in mowing protocols (because you don't want to mow the snow fence).
- WSDOT-Area IRVM Plans account for locations where vegetation is managed for snow drift control.

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.

STATE TRANSPORTATION AGENCY DOCUMENTS

This section contains excerpts, key points, and summaries from state DOT documents regarding their protocols, practices and/or policies for roadside vegetation management. The following documents are publicly available through the respective agency's website and other online searches and sources. Although researchers did not find documentation for all DOTs, this does not mean that the respective agency does not have documented vegetation management practices. Some DOT documents are internal to their respective agency and therefore not publicly available.

Alabama Department of Transportation (ALDOT)

The ALDOT *A Manual for Roadside Vegetation Management* (ALDOT 2018) includes the general guidelines for roadside management.

- 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.

The ALDOT *Maintenance Manual* (ALDOT 1995) states that, 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. According to ALDOT's *Standard Specifications for Highway Construction* (ALDOT 2017) 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.

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

The Alaska DOT&PF has an IVMP (AKDOT 2018). Two key points from the documents reviewed include 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

Arizona Department of Transportation (AZDOT)

The 2018 *Roadside Vegetation Management Guidelines* (AZDOT 2018) states that each AZDOT 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.

AZDOT's goal is to reduce the use of herbicides and mowing on roadway shoulders through the establishment of low-maintenance native grasses and wildflowers for highway visibility, soil stabilization, and weed control. Although AZDOT 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 2010).

Arkansas State Highway and Department of Transportation (ARDOT)

Roadside vegetation management is found in the ARDOT's *Facilities Management* document (ARDOT 2018) and it 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.

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 (ARDOT 2017).

California Department of Transportation (Caltrans)

Caltrans has a very detailed document for roadside vegetation management that considers the safety of the traveling public, aesthetics, environmental laws, and compatibility with adjacent land uses. Furthermore, reduction of available fuel (i.e., roadside vegetation) due to a fire risk potential is another 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 (Caltrans 2014).

The Caltrans website *Specifying Seed Selection and Plant Species* (Caltrans 2018) states to consider 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).

Colorado Department of Transportation (CODOT)

CODOT can reduce maintenance costs along a right-of-way by utilizing Integrated Roadside Vegetation Management and limiting roadside disturbance. These tools allow CODOT 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 agricultural-intensive 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 can 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* (Kohlhepp et al. 1995) for CODOT uses a categorization of state and county highways based on traffic volume and adjacent property use and describes management practices for each category.

- Level One – developed urban (varies)
- Level Two – partially developed urban or rural (ADT >10,000)
 - Mowing will be confined to Zones 1 and 2 shoulders and slopes on all highways and the narrow medians on four lane highways until after the first of July to protect nesting along fence rights-of-way and barrow pits for game birds. Perform swath mowing only where necessary during wildflower season. Perform subsequent swath mowings as necessary (a minimum of two swaths is recommended). Perform one full-width mowing in late fall.
- Level Three – rural (ADT 3,000 to 10,000)
 - Normally perform strip mowing only as needed for safety during wildflower season and throughout the April 15 through August 1 wildlife nesting and rearing season (a minimum of one swath is recommended). Perform spot mowings as necessary.

- Establish non-mow areas where appropriate (slopes, wide rights-of-way, large interchanges, etc.) to allow for maximum reseeding and vigor of native grasses, forbs, legumes, and wildflowers and to provide for almost continuous nesting use from spring until late summer.
- Level Four – rural (ADT 0 to 3,000)
 - Perform spot and swath mowing as needed for safety (a minimum of one swath is recommended).
 - Establish non-mow areas where appropriate (slopes, wide rights-of-way, large interchanges, etc.). A slope with a 3:1 ratio is considered the maximum angle of safety for mowers, therefore, any slope with a 3:1 ratio or greater should not be mowed.

The *CDOT Landscape Architecture Manual* recommends not placing plants that may attract large mammals (e.g. deer or elk) adjacent to the roadway (Design 2014).

The Colorado House Joint Resolution 17-1029 renamed Interstate Highway 76 from Mile Marker 1 to Mile Marker 183 as the "Colorado Pollinator Highway" (STCO 2017).

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 Department of Energy and Environmental Protection, University of Connecticut, and Connecticut Experimental Station 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 to 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 (CTDOT 2018).

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 EDH key points is the release of turf areas from routine mowing whenever possible in the ROW, spot spraying or mowing periodically to control invasive woody plants and

mowing an edge routinely. Another point is the integration of vegetation management in the planning, design and construction phases of highway development.

According to EDH, 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 (Barton et al. 2009).

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 (FDOTa 2017).

- Each District will 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* (Ferrell et al. 2012), defines roadside maintenance areas, T-1 and T-2. The T-2 area lies at the outside boundary of the ROW. T-2 maintenance areas are normally not mowed, except under unique field conditions. 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.

The decline in honeybees and monarch butterflies has brought the issue of pollinators to the forefront over the past few years. The 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. The Purpose Statement includes the development and implementation of 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 (FDOTb 2017):

- 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).

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 (GADOT 2011).

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 winter temperatures are not cold enough for complete dormancy. At cooler higher elevations the grass may not grow much in mid-winter. See Figure 11 for the Hawaii mowing standards.

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)

Figure 11. Mowing standards for Hawaii (HIDOT 2011).

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. (HIDOT 2011, HIDOT 2019).

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 (ITD 2017).

Illinois Department of Transportation (ILDOT)

ILDOT 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 (ILDOT 2017).

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 (INDOT 2017).

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 2015).

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 (IADOT 2016).

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 (IADOT 2004).

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 (KSDOTb 2010).

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 (KSDOT 2008).

- 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 (KSDOT 2010b).

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 (KYTC 2017).

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 include areas where individuals or businesses mow right-of-way along their property, where appropriate herbicide treatment can keep vegetation within the standards, or where they are not applicable, i.e., wildflower areas, and where seedlings are planted and/or permitted to grow (LADOTD 2000).

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 (MEDOT 2017).

Maine Native Plants for Roadside Restoration (MEDOT 2018) outlines the MaineDOT's efforts for revegetating with native plant materials. The document includes a guide for each species used on the roadsides as shown in Figure 12.

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.

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.





<p>Early Season (late March to early June)</p> <p>Mid-Season (mid June to mid August)</p> <p>Late season (mid August to November)</p> <p>WORKHORSE (Special Designation)</p> <p>HEIGHT Average height of mature plant. Noted if the species spreads by the root system to form colonies</p> <p>NATURAL HABITAT and DISTURBED AREAS Describes where the plant is typically found</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center;">Wildflower</td></tr> <tr><td style="text-align: center;">Shrub</td></tr> <tr><td style="text-align: center;">Vines & Grasses</td></tr> </table>	Wildflower	Shrub	Vines & Grasses
	Wildflower			
	Shrub			
	Vines & Grasses			
<p style="text-align: center;">GROWING CONDITIONS</p>  <p style="text-align: center; font-size: small;">Considers optimal site for sun and soil</p>	<p style="text-align: center;">WILDLIFE</p>  <p style="text-align: center; font-size: small;">Identifies types of animals which depend on these plants; in some cases names specific animal species</p>			
<p style="text-align: center;">MOWING STRATEGIES</p>  <p style="text-align: center; font-size: small;">Provides a date range by month</p>	<p style="text-align: center;">BLOOM TIME</p>  <p style="text-align: center; font-size: small;">Provides a date range by month; can vary across the state by almost a month</p>			
<p style="text-align: center;">WORKHORSE, Described</p> <p style="font-size: x-small;">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.</p> <p style="text-align: center;">MOWING</p> <p style="font-size: x-small;">Mowing before the date indicated may prevent the flowering and seed ripening of this species and affect its ability to survive on the roadsides.</p> <p style="text-align: center;">SEED COLLECTION & PROPAGATION</p> <p style="font-size: x-small;">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, <i>Sowing the Seeds</i>.</p>				

Figure 12. Maine DOT Native Plants for Roadside Restoration (MEDOT 2018).

**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* (SHA 2018). 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.

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 May 25, 2017 and it becomes effective on July 1, 2017 (STMD 2017).

The SHA *Landscape Design Guide* (SHA 2016) contains a section on reforestation design. The Maryland Reforestation Law of COMAR 5-103 regulates linear highway projects utilizing State funds that impact one acre (43,560 SF) or more of forest within the project limits. It also includes individual tree impacts within project limits. The Law is a 'no net loss law' that requires a 1:1 replacement for the loss of forest cover. Forest cleared for highway construction is replaced on an acre-for-acre basis, on public lands, within one year of project completion.

Massachusetts Department of Transportation (MassDOT)

MassDOT is amenable to exploring alternative land uses or management agreements that would minimize the need for herbicides (Figure 13). As part of this, MassDOT may allow private abutters to maintain roadside vegetation. However, any alternative use or management program must be consistent with federal guidance, as well as MassDOT policies and operational needs. Any options must control the undesirable vegetation in a manner that is environmentally sound and consistent with the requirements of this VMP (MADOT 2012, MADOT 2016).

TARGET	CONDITIONS	CONTROL METHODS
Grasses and Herbaceous Vegetation	- Where terrain and traffic conditions allow	Mechanical (mowing)
	- Shoulders - Medians - Under and along all guardrail - Pavement cracks and curb - Joints in pavement or structures	Herbicide application (foliar)
Low Growth Vegetation (shrubs and larger herbaceous vegetation)	- Terrain allows, and - Species are not persistent or invasive	Mechanical (mowing)
	- Terrain prevents mowing, and - Species are not persistent or invasive	Mechanical (hand cutting)
	- Locations where terrain prevents mowing - Invasive or persistent species	Herbicide application (foliar and stem injection)
	- Nuisance vegetation (e.g. poison ivy) that is within ROW	Herbicide application (foliar)
Tall Growth Vegetation (Tall shrubs and trees)	- Individual trees or branches	Mechanical (selective trimming)
	- Vegetation >12 feet high ; or - Terrain too steep; and - Species are not persistent or invasive	Mechanical (hand cutting)
	- Vegetation >12 feet high	Herbicide application (cut surface, frill/girdling, basal treatment, stem injection)

Figure 13. MassDOT vegetation management plan (MADOT 2012).

Michigan Department of Transportation (MIDOT)

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 (MIDOT 2003).

MIDOT 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 MIDOT right of way. Despite adverse weather conditions this summer, the flowers bloomed in September. MIDOT expands sunflower planting, increases late season food source for pollinators (MIDOT 2017).

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 (Johnson 2000, MNDOT 2018).

Mississippi Department of Transportation (MSDOT)

No publicly available documents found.

Missouri Department of Transportation (MoDOT)

Slopes steeper than 3:1 and areas not required to be mowed should be planted to wildflowers and native grasses and encouraged to naturalize. 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 as shown in Figure 14 (MODOT 2017).



Figure 14. MODOT native vegetation used to control snow drift (MODOT 2017).

Montana Department of Transportation (MTDOT)

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 (MTDOT 2009).

The focus of the MTDOT 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) (MTDOT 2012).

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 (NEDOT 2008).

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* (NEDOT 2017).

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/> (NEDOT 2019).

A total mow-out of the right-of-way will be completed periodically. This shall be planned so that at least 1/4 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 (NEDOT 2018).

Nevada Department of Transportation (NVDOT)

The Nevada Department of Transportation established landscape and aesthetic corridor plans for their major highway systems. This documents their efforts using native vegetation enhance wildlife and pollinator habitat (NVDOT 2006).

New Hampshire Department of Transportation (NHDOT)

No publicly available 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 (NJDOT 2017).

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 (NMDOT 2019).

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 site 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.

The NYSDOT's *Environmental Handbook for Transportation Operations A Summary of the Environmental Requirements and Best Practices for Maintaining and Constructing Highways and Transportation Systems* (NYSDOT 2011) outlines some specific environmental considerations related to roadside mowing:

- Do not mow wetland mitigation areas; the MEC can help identify these areas before mowing season. If mowing markers were not installed during construction, consider installing permanent markers;
- Try to avoid mowing when turf is saturated or significantly wet. When soil is rutted, weeds and invasive species are more likely overtake preferred grasses and native species;
- Environmental agencies prefer that the NYSDOT control ditch vegetation with mowing, rather than cleaning ditches with heavy equipment. Mowing causes less erosion of exposed soil and can result in improved water quality;
- Whenever possible, vary the mowing limit lines for a more natural appearance;
- Do not mow areas managed for wildflowers more than once a year, after the first hard frost or in the late fall;
- A suggested BMP is to leave an unmowed buffer strip at least 10 feet (3 meters) at the edge of all streams and wetlands. Such strips should be monitored to ensure brush does not become a fixed object or limit sight distances;
- On Air Quality Action Days, NYSDOT's has a policy to curtail roadside mowing and similar activities by NYSDOT employees or contractors, consistent with safety, operational needs or contractual requirements;
- Special mowing restrictions apply in the Capital District: In portions of Albany, Saratoga, and Warren Counties, some areas of the ROW provide habitat for Karner blue butterflies, a federally and state protected Endangered Species. Karner blue butterflies lay their eggs on, and their caterpillars feed exclusively on, the blue lupine plant. Mowing blue lupine plants before September 1st violates state and federal law. Consult the MEC to identify areas with blue lupine to properly schedule mowing activities; and
- NYSDOT is gaining experience with grasses that require little or no mowing. For example, Little Bluestem grass is a native species that grows 20-40 inches high. It is suitable for planting in Roadside Zones 2 and 3.

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

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 (NYSDOT 2019).

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 (NCDOTa 2019).

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 (NCDOTb 2016)

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 (NDDOTa 2019).

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 (NDDOTb 2019).

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 (OHDOT 2012).

The OHDOT *Statewide Roadside Pollinator Habitat Program Restoration Guidelines and Best Management Practices* (OHDOT 2016) lays out the main goals of this program. These include:

- Reducing roadside management costs through the use of Integrated Roadside Vegetation Management (IRVM) practices, such as reduced mowing regimes and reduced pesticide use.
- Increasing the available pollinator resources in Ohio by installing diverse mixes of native grasses and wildflowers along roadsides in lieu of traditional, less diverse cool-season grass plantings.
- Improving the public perception and understanding of pollinator health issues and disseminating information on ways these declines can be mitigated.

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 (OKDOT 2016).

Oregon Department of Transportation (ORDOT)

ORDOT's *Integrated Vegetation Management Statewide Plan* contains the following elements:

- Preventing unwanted vegetation problems
- Monitoring for the presence of unwanted vegetation
- Establishing thresholds that trigger treatments
- Establishing a treatment plan
- Applying treatments
- Evaluating the effects of treatments following up with additional treatments if necessary.

Figure 15 shows the flowchart developed for roadside management (ORDOT 2017).

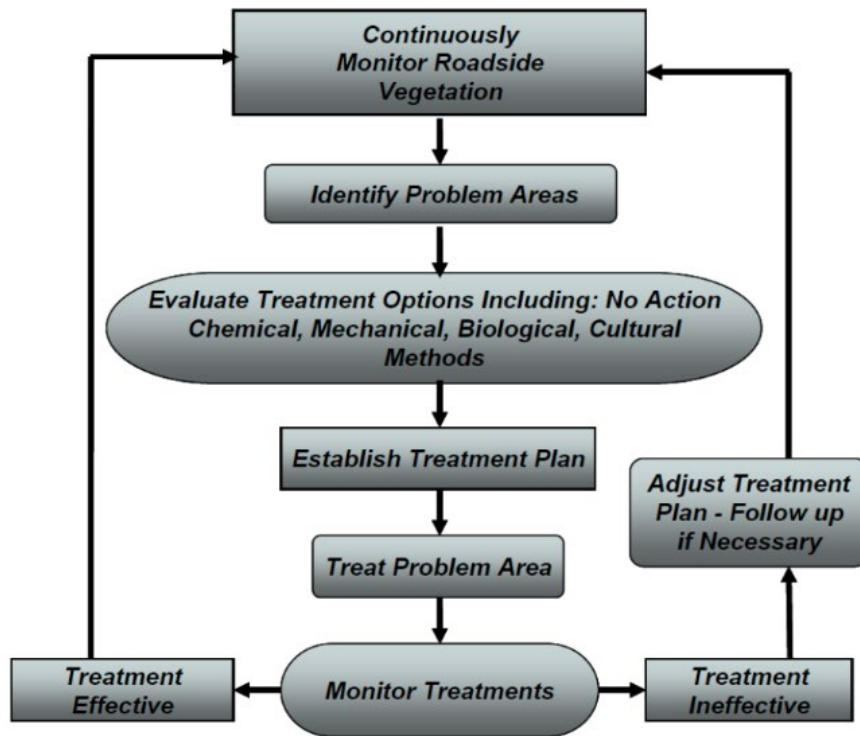


Figure 15. ORDOT integrated vegetation management process (ORDOT 2017).

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 (ORDOT 2018).

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 (PADOT 2016).

Rhode Island Department of Transportation (RIDOT)

No publicly available 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 (SCDOT 2016).

South Dakota Department of Transportation (SDDOT)

No publicly available documents found.

Tennessee Department of Transportation (TNDOT)

The approach of the TDOT Pollinator Habitat Program (INDOT 2019) 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.

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 (TXDOT 2018).

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 (TXDOT 2019).

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 (UTDOT 2016).

Vermont Department of Transportation (VTrans)

VTrans State Highway System Mowing BMP has several guiding principles:

- Create consistent mowing requirements throughout the state;
- Form the basis for contractor specifications;
- Limit activities only to those areas where mowing is necessary for the safety of the traveling public and long-term infrastructure protection;
- Schedule mowing during the growing season to maximize benefit and minimize cost;
- Create mechanisms and standards for addressing environmentally sensitive areas, riparian areas, steep slopes, wetlands, rare & endangered species and their habitats, unique natural areas, and wildlife habitats;
- Create provisions for areas of special landscape treatment;
- Foster long term sustainable landscape vegetation management, minimizing excessive mowing and herbicide use;
- Increase and improve Pollinator habitat on VTrans-managed rights-of-way;
- Preserve the scenic qualities of the corridor to the extent practicable, while maintaining environmental stewardship and conserving resources.

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 2016).

Virginia Department of Transportation (VADOT)

Mowing is based upon a level of service for the designated roadway (see Figure 16). 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 (VADOT 2010).

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	*

Figure 16. VDOT level of service matrix (VADOT 2010).

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.

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 (VADOT 2019).

Washington State Department of Transportation (WSDOT)

The *WSDOT Roadside Policy Manual* (WSDOT 2015) is one the most comprehensive discussions regarding managed succession and other vegetation restoration as part of their program. This manual is intended for use in all phases of transportation asset management: Planning, Program Management, Project Development, Construction, and Maintenance. The manual states that roadsides are the green infrastructure that contributes to the highway system and discusses the concepts roadside management in detail and provides guidance. The two roadside roles consist of the operational function and environmental functions.

- Operational Functions
 - Access control, guidance and navigation, glare and distraction screening, providing recovery areas and sight distances with accommodations for signs and utilities, and snow storage.

- Environmental Functions
 - Water quality preservation, protection, and improvement; stormwater treatment, infiltration, and conveyance; environmentally sensitive areas protection; noxious weed control; noise control; habitat protection; habitat connectivity; air quality improvement; carbon sequestration; reduction in urban heat island effect; erosion control; corridor continuity; roadway and adjacent property screening and buffering; and scenic view preservation (WSDOT 2015).

Sustainable roadsides fulfill roadside design intent and roadside functions over the long term, within present and future available funding, personnel, and equipment allocations and methodologies. To achieve sustainable roadsides, roadside partners must strive to utilize, protect, and support the physical and ecological resources necessary for a fully functioning roadside.

The primary management considerations for sustainable roadsides are:

- **Design intent:** Roadside functions (operational, environmental, visual, and auxiliary) and maintenance standards, criteria, and actions are coordinated and balanced to the greatest degree possible to achieve the design intent on all levels. Design to achieve the long-term goals of Integrated Vegetation Management (IVM).
- **20-year planning horizon:** All roadside management decisions are weighed in their long-term context, including projected land use and public health, safety, and welfare considerations. Address future adjacent land uses and roadside functions when designing present-day projects.
- **Projected life cycle costs:** All roadside management decisions are in keeping with present and future available funding, personnel, equipment, and methodologies. What are the costs of the project over its “lifetime?”
- **Utilize, protect, and support the roadway and roadside infrastructure:** All roadside management decisions are balanced with the need to sustain, and to preserve, restore, and enhance the roadside character and natural environment. The emphasis is on careful management of existing and volunteer native vegetation.
- **Continued cooperative involvement:** Roadside management decisions are based on continued active involvement between all roadside partners within WSDOT. This begins at the earliest planning stages with communication between all affected parties through an open, collaborative management process and designated lines of communication between roadside partners.

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 (WSDOT 2017, WSDOTb 2019).

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 (WSDOTc 2019).

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 (WVDOT 2019).

Wisconsin Department of Transportation (WisDOT)

General mowing policy goals

- Support public safety, especially at intersections and curves
- Provide safe areas for vehicles to pull off roads in emergencies, and clear recovery zones for errant vehicles that leave the roadway
- Balance the need to manage invasive species with overall aesthetics and budgetary limitations
- Protect wildlife, preserve and encourage native wildflowers and grasses
- Preserve Wisconsin's natural beauty.

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 (WIDOT 2019).

- 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.

The WisDOT *Facilities Development Manual* (WIDOT 2006) has guidelines for woody and herbaceous plant materials. For herbaceous plant materials the goals are as follows:

- Preserve native forbs (wild flowers) and grasses on roadsides and encourage their regeneration.
- Preserve rare and endangered species and encourage their regeneration.
- Promote ecological integrity and Wisconsin's natural heritage by planting native grasses and forbs in appropriate places on state transportation facilities.
- Provide roadside vegetation of an intermediate height to effect a smooth transition from the roadway to taller vegetation at the edge of the highway right-of-way.
- Provide wildlife habitat.
- Plant desirable species that will out-compete invasive weedy species.
- Plant desirable species for erosion control.
- Meet the requirements 23 CFR Part 752.11(b) that at least 0.25 percent of federal funds expended for landscape planting projects be used to plant native wildflower seeds or plants. This may be accomplished through the wildflower banking system agreement with FHWA initiated by the department in 1998.

Woody plant materials guidance follows the Natural Roadsides Policy stating that species that can be used in a project are partly dictated by the Department's Natural Roadsides Policy as defined in Policy 74.05 of the Highway Maintenance Manual. This policy mandates that species planted along state highways be native to the area. In this context 'native' means the species existed in the area prior to settlement in 1848. The native species requirement may be relaxed somewhat in urban and transitional areas if non-native species or cultivars (improved varieties) will better tolerate certain site-specific conditions (WIDOT 2019, WIDOT).

Wyoming Department of Transportation (WYDOT)

No publicly available documents found.

SUMMARY

This chapter has examined project implementation strategies by the DOTs regarding the management of roadside vegetation. The findings demonstrate that 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. Public outreach and volunteer programs have benefited DOTs not only in educating the public on the safety issues regarding roadside vegetation management, but also by fostering cooperative relationships that provide maintenance services within the ROW.

CHAPTER 5. CASE EXAMPLES

The purpose of this chapter is to further investigate and highlight specific examples of state DOT practices relating to modified mowing regimes that have been developed and found to be effective. The states identified for follow interviews were Indiana, Texas, Washington and Wisconsin. Information obtained through the review of pertinent literature, state DOT documents and survey results identified these states as having experience relevant to managed succession of the ROW. The case example states provided additional information, documents and photographs for use in this section. The following summarizes each state's effective practices.

INDIANA DEPARTMENT OF TRANSPORTATION

The Indiana Department of Transportation (INDOT) Roadside Vegetation Management Program outlines how INDOT manages the state's ROW for medians and roadsides. As with most other DOTs, limited budgets and environmental directives steer how vegetation management is conducted to attain sustainable roadsides and accommodate pollinators and other wildlife. The zonal approach in Figure 17 shows that:

- 0-15 feet is mowed
- 0-30 feet broadleaf weed control
- 30-80 feet reduce trees as ROW exists and promote this area as early successional habitat
- Wider than 80 feet are allowed to move into native vegetation.

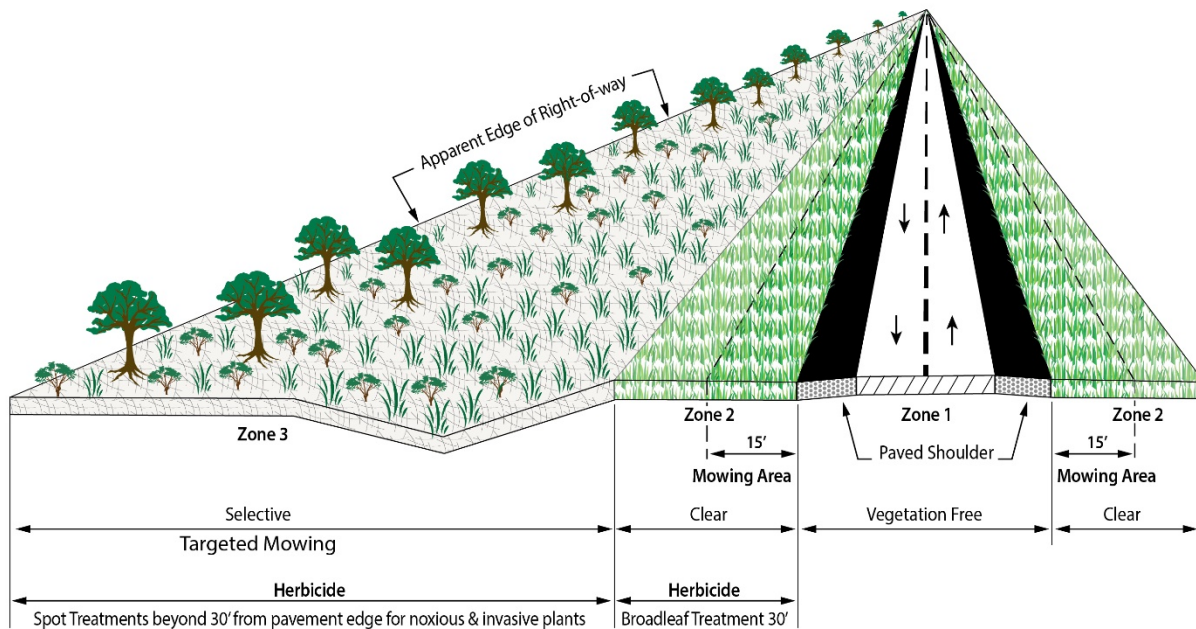


Figure 17. INDOT vegetation management zones (INDOT 2018).

The INDOT approached a modified mowing program in two stages. The first stage was implemented in 2014 with a statewide vegetation management policy which transitioned from mowing the full ROW width to a 30' width. The results of this policy has shown both observed and anecdotal increase in species diversity. However, the increased diversity also showed an

increase of invasive and other undesirable species. While the program is intended to reduce the spread/increase control efforts of these species, it has proven challenging to work towards species/spot specific management techniques given the limited work force and diverse responsibilities, i.e. few, if any, maintenance crews are dedicated to vegetation management. As an example, the same team who patches roads was also the same crew responsible for mowing and herbicide application. It is hard to be a “master of many tasks”. INDOT’s herbicide program went from spraying approximately 32,000 acres to nearly 60,000 acres in 2019. This implies that control efforts of invasive and other undesirable species has increased. INDOT has also increased woody vegetation biomass reduction through the purchase, rental and use of forestry mulchers, which has significantly increased the output of acres being mechanically treated for woody plants.

One outcome of the policy is that mowing “fence to fence” has largely become a thing of the past- though some areas are still holding tight to the idea that it is essential. Five years after implementation, managers’ grasp of the importance the timing of mowing cycles to match the seed head maturation of the cool-season grasses and the warm-season grasses. There has been an increase in the abundance of woody vegetation in the previously mowed, but now unmown areas that concerns many folks. However, the majority of Indiana has a forested climax community consisting of woody plants. The woody plants present in the now, unmown areas fall into a few categories:

- Long established plants that consist of multiple stems from years of infrequent mowing/mechanical reduction.
- Invasive woody plants, such as the bush honeysuckles (*Lonicera spp.*) and callery pear (*Pyrus calleryana*).
- Newly established plants from seed.

The next major change in the vegetation management program began in 2019. Mowing widths transitioned from a combination of 30 feet and 15 feet that had been in practice for the past five growing seasons to 15 feet from the edge of pavement policy. Mowing was now executed entirely by contractors, rather than the mix of in-house and contracted work, as it was in years prior. Herbicide applications were nearly entirely completed by contracted forces. The focus of the program remained true to the policy instated in 2014, with only minor modifications to the mowing regime. However, the frequency of broadcast herbicide applications over the 30’ clear zone, as right-of-way allows, increased to an annual operation over the

These three above changes enabled a much more consistent approach to vegetation management. The 2019 growing season didn’t go exactly to plan. As with most roadside activities, unexpectedly wet weather resulted in scheduling/timing issues. With the 15-foot mowing widths in 2019, INDOT saw some dissatisfaction with median mowing widths, which has resulted in a change for the 2020 growing season to mow the full width of any median less than 60 feet. Due to this recent change and limited data from the newly implemented practices, outcomes are difficult to quantify. Customer service calls and a recent customer service survey showed there was little change in satisfaction/dissatisfaction with roadside vegetation management policy. Most issues to date have been worked through on a case by case basis. A permit process is in the development stages that might enable interested parties to be involved in

vegetation management along the right-of-way. The goal of the permit would be to enable folks to manage invasive and noxious weeds and/or plant/promote native/desirable vegetation. INDOT is stepping up efforts in internal and external communications surrounding its vegetation management program but realizes there is still room for improvement.

INDOT established two separate mapping projects:

- An geographic information systems based “Land Management Map” has been developed to aid in quantifying the number of acres, categorizing land use/cover type, and identifying right-of-way boundaries- out of necessity for the potential enrollment in the Nationwide Candidate Conservation Agreement for Monarch Butterfly on Energy and Transportation Lands
- Field collected invasive species and tree risk assessment mapping

The goal of executing the invasive species and tree risk assessment mapping contract year over year is an effort to track changes in species presence, species spread and to monitor efficacy of control efforts. Data is intended to guide species specific spot treatments and development of budgets surrounding herbicide control options. For example, the DOT knows the treatment cost for an acre of Canada thistle, but can’t create a holistic budget for an unknown number of acres of Canada thistle. As with most invasive species, one can treat thousands of acres every year and never make a dent in the overall population if treatments aren’t occurring on the majority of the infested acres.

There are few collection options for vegetative mapping that present some challenges that include:

- Remote sensing
 - The breadth of area makes high quality data collection and analysis a challenge (11,000 centerline miles covering about 200,000 acres of land) from a logistics and financial aspect.
 - The dynamic nature/diversity of the vegetation within the right-of-way may require different timings of data collection on the same acreage to make it useful to map undesirable species populations due to emergence times, species similarities and other factors.
- Photogrammetry
 - A number of deep learning tools are beginning to come online that would enable users to capture high resolution imagery at various times through the year and use computer programs that can differentiate between species. These tools are being developed in the agricultural industry where monocultures of crop and known likely species occurrence lend to the development of these tools.
 - i. The diversity and densities of vegetation in the right-of-way pose some additional challenges to these methods, but they are coming to the rights-of-way industry.
- Mobile visual observation by users using GPS enabled devices
 - The breadth of area makes high quality data collection and consistency in collection a challenge (11,000 centerline miles covering about 200,000 acres of land) from a personnel aspect. For example, Dame’s Rocket (*Hesperis*

matronalis) and garlic mustard (*Alliara petiolata*) bolt and bloom from spring through early summer, thereby enabling rapid identification, while other species of interest may not be in bloom, or otherwise easily distinguishable until late summer, requiring separate data collection passes.

- Observers' botanical identification qualifications at various stages of vegetative development across and within data collection crews.

INDOT has a work management system that is used to capture all costs associated with every maintenance activity. Some challenges exist with comparing in-house operations and contracted operations in years past due to inconsistent reporting and execution of or adherence to policies. Approximately 50,000 acres fall within the 30' clear zone. With nearly 200,000 acres in ROW, by reducing mowing of areas outside of the clear zone and being more strategic in the application of vegetation management methods, a reduction in overall operating cost is expected as compatible vegetation becomes more common within the ROW. However, inflation, equipment and labor costs all continue to rise, so normalizing this data/values would be a very difficult to accurately capture without some numerous assumptions and variables being included in the analysis.

Although INDOT does not have any definite data regarding worker safety, it has contracted the majority of the roadside vegetation management program so in-house worker exposure is reduced. Again, based on the sheer idea that fewer passes and less time spent on the side of the road, there should be a reduced exposure, even for the contracted workers and equally as important, the motoring public.

INDOT uses a combination of road classification based largely on average annual daily traffic to determine mowing frequency, as well as the road's proximity to major urban centers. The goal of the vegetation management program is to treat all portions of the ROW consistently with the same set of standards, regardless of proximity to urbanization. The primary functions of a ROW, beyond providing for the safe travel of the motoring public, is to enable maintenance operations, and, in the event the need arises, to serve as additional space for additional traveled lanes/future construction. Distance from road surface, i.e. the "clear zone concept," remains as the major deciding factor as it relates to what vegetation is considered compatible, thereby directing management techniques within the ROW.

The results of the implementation of a consistent vegetation management policy has seen a general satisfaction with the actions of the DOT regarding roadside maintenance. Public outreach regarding INDOT's efforts surrounding a pollinator friendly vegetation management program has been a component of the explanations as to why such actions were undertaken and the expected benefits to be derived from environmental sustainability and overall reduced DOT costs. Given a few years, the DOT expects to see reduced populations of invasive plants, a continued increase in native compatible species diversity and abundance and ultimately, a greater public acceptance of this management regime.

TEXAS DEPARTMENT OF TRANSPORTATION

The Texas Department of Transportation modified the mowing width requirements for a variety of reasons that include:

- Encouraging
 - Biodiversity
 - Native species that require less maintenance
 - Grasses and wildflowers that conserve water, control erosion and provide a habitat for wildlife across Texas
- Reducing worker exposure to traffic and use of chemical treatments such as herbicides
- Providing cost savings by reducing the number of acres mowed.
- Reducing erosion caused by mower damage on slopes.

TxDOT currently has approximately 800,000 acres of mowable ROW. The current directive is to mow a 30-foot swath adjacent to the travel lane as a safety clear zone. However, it is left to the discretion of the District to implement the mown width based on site specific conditions. The remainder of the ROW is encouraged to grow to a naturalized state that requires minimal maintenance. TxDOT contracts for all mowing.

According to TxDOT's 2018 *Roadside Vegetation Management Manual* (TXDOT 2018), 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.

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.

For some areas the mowing frequency remains constant, but the width of the mow area can change. For example, TxDOT's costs are reduced by eliminating at least one full mower width of 15 feet. Because mowing is paid for at a per acre cost this practice reduces the total number of acres. The reduced mow area must be at least a full mower width to see the cost

savings. Cost considerations include the mobilization of personnel and equipment. Reducing the mow width by less than a full width still incurs the mobilization costs. Other cost savings seen through reduced mowing is the use of herbicides. The majority of herbicide treatments are located in the mowed areas. Mobilization for herbicide treatments include specially trained personnel, equipment, chemicals, and work zone safety such as crash attenuator vehicles.

TxDOT stated that there are a few factors that predicate where larger vegetation can be allowed to grow. These are the presence of overhead utilities, adjacent land use issues and enough ROW width to eliminate at least one full 15-foot mower width. Eliminating a full mower width has demonstrated cost savings for the DOT and provides an area wide enough for larger vegetation establishment.

There is a general “grow-out” period of 3 years based on regional conditions for managed succession to reach a self-sustaining state. TxDOT conducts routine brush control on a 4 to 5 year cycle and tree trimming has a 10-year cycle. Each type of vegetation control cycle is based upon site specific conditions such as clear zone encroachment, fire potential or other safety related issues.

TxDOT works with adjacent land owners to provide a reasonable mowing regime that meets DOT safety, maintenance and cost savings goals while addressing the land owner concerns. The advantage to allowing a more naturalized ROW is the ability to blend with the adjacent properties. However, one of the main concerns of some adjacent land owner is aesthetics. A common complaint when TxDOT implemented a reduced mowing regime was the larger vegetation that was allowed to proliferate which was a change in appearance from the routinely mown vegetation.

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

WSDOT’s *Roadside Policy Manual* (WSDOT 2015) is very comprehensive in its discussions regarding managed succession and other vegetation restoration as part of their program. IVM has been a part of WSDOT for many years. The DOT has specialized crews trained to manage areas for IVM. The *Roadside Policy Manual* develops vision and instructional policy as follows (from the Foreword):

The Washington State Department of Transportation (WSDOT) is responsible for the stewardship of approximately 100,000 acres of roadside along over 7,000 miles of state roadway. This includes hundreds of ancillary facilities such as rest areas, viewpoints, environmental mitigation sites, beautification areas, quarries, and pit sites.

The *Roadside Policy Manual* works to achieve low maintenance costs and sustainability by promoting conservation and protection of resources. It requires retention and replacement of vegetation to provide ongoing environmental stewardship. Restoration of the roadside supports economic vitality and vibrant communities by preserving the essential character and nature of the Evergreen State for future generations.

This manual is intended for use in all phases of transportation asset management: Planning, Program Management, Project Development, Construction, and Maintenance. In conformance with current WSDOT policies, the roadside policy team developed a

comprehensive roadside policy that promotes our state's healthy economy, environment, and communities. The *Roadside Policy Manual* develops vision and instructional policy for:

- Complying with legal obligations and commitments and obtaining environmental permits and approvals.
- Roadside preservation, design, construction, and maintenance.
- The level of restoration required as a result of roadside impacts.
- Achieving roadside sustainability through the use of native plants, Integrated Vegetation Management, and a long-term management approach.
- Developing the roadside to provide functions such as stormwater, erosion control, weed control, and slope stabilization in a way that supports the visual character of Washington State.
- Providing the highest benefit at the lowest feasible cost.

Figure 18 shows WSDOT's Roadside Restoration Worksheet used to assist with the design decisions for roadside development.

WSDOT's *Roadside Land Use Executive Summary Asset Management Document* (WSDOTd 2019) states the following:

Roadside assets include all non-paved lands and environmental protection sites that WSDOT owns and manages. These assets include:

- 40,000 acres of operational right of way adjacent to pavement edges.
- 2,000 acres of environmental mitigation sites still under permit.
- 580 acres of formally landscaped areas.
- 55,000 acres of land outside the operational right of way along major freeways and interchanges.

The WSDOT owned non-paved lands are managed to serve two important transportation functions:

1. Operational – Safe highway operation and stormwater drainage.
2. Non-Operational – Environmental mitigation and buffering for water, air, and habitat, as well as a visual/spatial buffer between the highway and surrounding land use.

The agency has also instituted a geographic tracking system (GIS) for referencing system inventory and maintenance activities. This new system is referred to as the Highway Activity Tracking System (HATS) and it is designed to record the detailed data needed to fully document the asset condition and ongoing maintenance performance. Current measurements of maintenance performance in terms of service level delivery and permit compliance for have been in place for over 20 years, and data from these systems provides a reasonable assessment of historic asset management performance.

Project Level Estimate (check one)*: Scoping Level Estimate Updated Estimate
 (*Estimate must be updated if roadside impacts or assumptions change through project development)

State Route **Mile Posts** From To **Program Type** P1,P2,P3,II,D,B,H

Project Name **WIN** **Ad Date** **Region**

Roadside Character Classification

Forest	Open	Built	Scenic & Rec. Hwy.*
MP <input type="text"/>	MP <input type="text"/>	MP <input type="text"/>	MP <input type="text"/>

Circle or highlight Roadside Classification(s) per [Roadside Policy Manual 2015](#) and Scenic & Rec Hwy per [Scenic and Recreational Highways](#)
 List mileposts below each designation that occur in project (example MP 13.43 - 14.68).
 If one classification occurs in multiple locations, list mileage only.
 *Includes Forest Service and Parks land, Scenic Byways, state scenic highways, Wild and Scenic Rivers.

List assumptions:

Roadside Character Classification and/or Treatment Level Exception Requested

No *Yes Circle or highlight *a requested deviation (yes) requires State Design Engineer approval.

Brief description:

Description of disturbance expected to roadside, locations (cuts, fills, slope flattening, clearing and grubbing, utility installation) and area of impacts.

List assumptions:

Roadside Restoration Treatment Elements and Strategies (see, Chapter 4, Roadside Restoration Toolkit, of the Roadside Policy Manual)
 Describe how roadside restoration activities (modification of structures, landform, and vegetation) will support the roadside character for the project area:

Estimated Construction Cost of Restoration (not to include seeding)

Stream Buffer	Wetland Buffer	Wetland Mitigation	Roadside Restoration	Other	Total Estimate
Acres: <input type="text"/>	Acres: <input type="text"/>	Acres: <input type="text"/>	Acres: <input type="text"/>	Acres: <input type="text"/>	not include mobilization, engineering, contingencies or tax
\$ per acre*: <input type="text"/>	\$ per acre*: <input type="text"/>	\$ per acre*: <input type="text"/>	\$ per acre*: <input type="text"/>	\$ per acre*: <input type="text"/>	
Estimate: <input type="text"/>	Estimate: <input type="text"/>	Estimate: <input type="text"/>	Estimate: <input type="text"/>	Estimate: <input type="text"/>	

* Dollars per acre costing provided by Region Landscape Architect, does not include real estate costs, traffic control, excavation, or temporary erosion control.

State assumptions for restoration specifications such as soil amendments, vegetation, and spacing:

Prepared by: Name Telephone number date PE Office

Reviewed by:** Name Telephone number date

**Requires Region LA concurrence or HQ Roadside & Site Development Section for regions without a landscape architect

Copy to Design Documentation Date Sent to Program Management

Roadside and Site Development Design Documentation

Project Name	WIN	Ad Date	Region
0 <input type="text"/>	<input type="text"/>	<input type="text"/>	0 <input type="text"/>

The purpose of this section is to document design decisions on the project and how they have responded to the roadside and statewide policies as spelled out in the Roadside Policy Manual, i.e.:

1

Figure 18. WSDOT Roadside Restoration Worksheet.

WISCONSIN DEPARTMENT OF TRANSPORTATION

The Wisconsin Department of Transportation (WisDOT) implemented a minimal roadside mowing policy in the 1950's as a measure to find a balance between limited budgets and providing a safe driving experience for travelers, protecting the highway facility itself, and providing sustainable roadsides. WisDOT's maintenance budget is driven by, and overwhelmingly is dedicated to winter maintenance leaving limited budget for summer activities that includes mowing. WisDOT's maintenance of state highways is performed by the state's 72 county highway departments under annual calendar year contracts known as the Routine Maintenance Agreement (RMA). They also use Discretionary Maintenance Agreements (DMAs) (WIDOT).

The statewide mowing policy for WisDOT's 11,800 miles of highway system generally outlines once a year mowing allowing for a 15-foot cut, or to the bottom of the ditch whichever comes first (outside main line gravel shoulder out 15 feet). On a multi-lane road with grass median, a 5-foot mow once a year in the median. Ramps are mowed 5 feet wide on both sides again once a year. Mowing for safety (sight distance) is allowed as needed.

“Although the cultural benefits of natural roadsides can be substantiated and the benefits of limited mowing and regenerating native vegetation outweigh those of a turf grass monoculture the aesthetics of natural roadsides are not universally accepted” (WIDOT 2019). WisDOT implemented an urban mowing policy in 2014 which allows for additional mowing (wider and more often) for aesthetic purposes to further coordinate with the vegetation management of adjacent land uses. This policy was prompted by public requests for a more options for roadside aesthetics specific for their area. Mowing to control woody vegetation should only be done every three years, typically in conjunction with the annual long-line mowing. This mowing policy has shown the WisDOT cost savings for summer maintenance operations and has increased worker safety by limiting exposure.

- Mowing is not permitted in wet areas to prevent rutting and erosion.
- Mowing equipment is not permitted on steep slopes (3:1 or greater) due to scalping, rutting and operator safety concerns.
- Prior to mowing, remove all litter.
- Do not mow fence line to fence line.
- Mowing is allowed in newly seeded areas the first few years to keep weed competition down.
- Variations to the policy may occur in urban areas for consistency with mowing practices.
- An agreement can be developed between WisDOT and a local municipality allowing additional mowing at the municipality's expense (WIDOT 2019).

WisDOT tracked its RMA and DMA costs for mowing, woody vegetation, control of unwanted vegetation and urban mowing from 2000 through 2019. The 2008 RMA mowing cost was \$5,992,700.08 and 2009 RMA mowing cost was \$3,538,719.37. The cost reduction represents going from two long-line mowings in 2008 to one in 2009. Table 19 shows the comparison of costs for RMA and RMA/DMA combined for 2000 and 2019.

Table 19. WisDOT cost comparisons.

RMA Costs			
Description	2000	2014	2019
Mowing	\$ 6,054,792.78	\$ 4,166,762.81	\$ 4,222,376.32
Woody Vegetation	\$ 3,286,297.01	\$ 3,314,641.93	\$ 3,354,190.70
Control of Unwanted Vegetation	\$ 785,576.31	\$ 484,556.11	\$ 624,807.82
Urban Mowing	\$ 400,404.07	\$ 608,783.39	\$ 745,793.05
Total Spent	\$ 10,527,070.17	\$ 8,574,744.24	\$ 8,947,167.89
RMA and DMA Combined Costs			
Mowing	\$ 6,079,717.35	\$ 4,166,762.81	\$ 4,222,376.32
Woody Vegetation	\$ 3,304,863.20	\$ 3,331,618.51	\$ 3,628,185.29
Control of Unwanted Vegetation	\$ 785,576.31	\$ 484,556.11	\$ 624,807.82
Urban Mowing	\$ 405,900.04	\$ 608,783.39	\$ 745,793.05
Total Spent	\$ 10,576,056.90	\$ 8,591,720.82	\$ 9,221,162.48

As shown in Table 19 the urban mowing costs increased. This is due to implementation of the urban mowing policy in 2014 which allows for additional mowing (wider and more often). However, overall mowing costs to the WisDOT were without compromising safety. This effort also increased the WisDOT's natural roadsides.

CHAPTER 6. CONCLUSIONS, RECOMMENDATIONS, AND SUGGESTED RESEARCH

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 benefit the environment but they also save DOTs money in the long term. Although reduced roadside vegetation management may not be applicable to all roadside scenarios, such as some urban roadways, there are thousands of miles of ROW where reduced activities are appropriate. Table 20 shows some of the challenges and benefits for Zone 3 routine mowing and managed succession regarding safety, management, ES and costs.

Table 20. Challenges and benefits comparing routine mowing and managed succession.

	Routine Mowing	Managed Succession
Safety Challenges	<ul style="list-style-type: none"> • Worker proximity to traffic • Exposure to routine chemical treatments • Injury from equipment, litter, projectiles, etc. • Hearing loss from equipment noise • Hazards of working on or near slopes $\geq 3:1$, i.e., equipment rollovers, slope damage, etc. 	<ul style="list-style-type: none"> • Increased fuel for fire prone areas • May lure wildlife to roadside • Depending on roadway geometry larger/taller vegetation may create site distance issues at steep slopes, sharp roadway curves and other limited visibility locations • Possibility of hazardous trees and debris • Possible winter snow shadow affect • Ensure that the presence of larger/taller vegetation, particularly in the urban/suburban context, does not create an environment for the prevalence of illegal/unauthorized use of the ROW and present safety issues and/or maintenance concerns
Safety Benefits	<ul style="list-style-type: none"> • Maintains clear sight lines for entire ROW width • Less available fuel for wildfires 	<ul style="list-style-type: none"> • Minimizes or eliminates mowing on steep slopes • Reduces worker proximity to traffic • Reduces worker exposure to routine chemical treatments • Minimal maintenance after establishment period - typically 2-5 years depending on regional climate conditions • May be used to reduce headlight glare in wide medians • May be used as snow fence to reduce blowing snow

	Routine Mowing	Managed Succession
Management Challenges	<ul style="list-style-type: none"> • Requires mowing and other activities to maintain roadside aesthetic • Subject to invasive weed species • May requires more frequent chemical treatments to maintain • Timing and frequency of mowing schedules to accommodate pollinators (wildflowers) and/or wildlife • Establishing native grass/forb species (prairie ecosystem) in highly disturbed soils • Mowing around drainage structures, utilities, and roadside appurtenances • Public perception regarding modified mowing schedules 	<ul style="list-style-type: none"> • May be difficult to access with equipment • May require maintenance of large, overgrown, or toxic vegetation • Establishment period may require removal of undesirable vegetation and control of noxious and invasive plant species • Ensure that cooperative agreements for maintenance do not create inconsistent gaps in highway corridor appearance and/or roadside ecosystems • Ensure that cooperative agreement groups are able to maintain a site with larger/taller vegetation using their personnel, training, equipment
Management Benefits	<ul style="list-style-type: none"> • Cooperative agreements and/or volunteer groups for routine mowing 	<ul style="list-style-type: none"> • Generally requires minimal chemical treatments for target species after establishment • Greatly reduced maintenance after establishment
ES Challenges	<ul style="list-style-type: none"> • Coordination of maintenance activities with targeted pollinator and/or wildlife needs • Establishment/conservation of target plant species for pollinators and/or wildlife • Pollutants from equipment to maintain 	<ul style="list-style-type: none"> • Establishment/conservation of target plant species for pollinators and/or wildlife
ES Benefits	<ul style="list-style-type: none"> • Establishment/conservation of habitat for pollinators and/or wildlife • Stormwater management for quantity and quality • Corridor continuity • Visual quality • Stormwater management for quantity and quality 	<ul style="list-style-type: none"> • Improved air quality from reduced vehicle emissions and generated dust • Improves carbon storage • Improves stormwater management for quantity and quality • Cooperative agreements with conservation groups to maintain site for pollinators and/or wildlife • Mechanism for addressing environmentally sensitive areas, riparian areas, steep slopes, wetlands, rare/endangered species, habitats, and other natural areas • Restoration/conservation with native plants, including woody native flowering species • Provide/protect habitat structures such as old trees, logs and snags • Corridor continuity

	Routine Mowing	Managed Succession
		<ul style="list-style-type: none"> • Visual quality • Rainfall interception • Enhanced biodiversity • Urban/suburban areas – mitigation for solar radiation, wind speed, air temperature, relative humidity, and re-radiation from paved areas
Cost Challenges	<ul style="list-style-type: none"> • Mobilization of personnel, vehicles, equipment, signs (mowing ahead, etc.), and other equipment such as crash attenuator trucks • Limited budgets for vegetation management 	<ul style="list-style-type: none"> • Assurance that cooperative agreements are compatible with the agency’s managed succession/natural management methodologies • Maintenance of larger/taller vegetation over time
Cost Benefits	<ul style="list-style-type: none"> • Cooperative agreements and/or volunteer groups for routine mowing • Agreements with adjacent landowner for hay harvesting 	<ul style="list-style-type: none"> • Conservation of fuel, labor and equipment costs with limited budgets • Minimizes or eliminates need for continual slope repair from mowing damage • Fewer staff hours spent mowing allows DOT staff to perform other maintenance activities • Agreements with adjacent land owners for timber harvesting

The review of the literature demonstrates that reduction or modification to roadside vegetation management strategies can reduce maintenance personnel exposure to traffic hazards, equipment, and chemical treatments. This provides both short-term and long-term cost savings and benefits. Managing a roadside in a more naturalized state requires time for vegetation to become established. For many states this is between 2 to 5 years depending on regional climate conditions. During the establishment period, there is typically more maintenance required to control undesirable species and enable the target species to establish. DOTs see long-term savings when the managed succession area becomes self-sustaining and requires minimal management generally consisting of maintaining the safety clear zone, targeting invasive species and removal of large vegetation that creates interference with sight distance or other safety related issues. Little research exists on the cost/benefits of implementing reduced mowing and/or managed succession. However, the studies conducted showed an economic benefit for the DOTs in terms of reduced actual costs and benefits gained through ecosystem services.

Public outreach and volunteer programs have successfully educated the public on the benefits of using the roadsides to provide something more than just aesthetically pleasing. There are several approaches to managing the roadsides that include the use of cooperative agreements, permits and volunteer groups. The use of other agencies, local entities and adjacent landowner can ease the DOT’s burden for roadside mowing/maintenance. Allowing maintenance activities by others may enable DOT maintenance budgets to go further.

A consensus throughout the DOT literature, websites, and survey results found that 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 for fire hazard by minimizing the quantity roadside fuel available,
- Managing soil erosion and invasive plants to preserve infrastructure integrity,
- Utilizing vegetation for stormwater quality and quantity control,
- Considering compatibility with adjacent land uses,
- Ensuring environmental compliance, and
- Providing roadside aesthetics.

Wildflower and/or pollinator-friendly programs within DOTs are becoming more prevalent. A review of DOT websites and documents shows that 82% of transportation agencies implemented some form of wildflower/pollinator program. These programs often include reduced mowing to accommodate wildflower season and minimal or no chemical treatments to ensure the safety of pollinators. Other agencies have modified their mowing schedules to address the roadside wildlife such as nesting birds. Whether their plan is to reduce maintenance costs, accommodate wildlife and pollinators, and/or to provide for a more environmentally functional roadside, allowing for more robust vegetation to colonize in Zone 3 of the roadside has shown to provide many benefits to the DOTs, environment, and public.

Roadsides with a naturalized appearance may seem to be left undisturbed. However, their soil structure and site hydrology are thoroughly altered from predevelopment conditions to meet strict vehicular roadway design. Proper roadside management includes understanding the relationships between plant and animal species, soils, water, regional climate and how each functions within the roadside environment with regional specific limiting factors.

RECOMMENDATIONS

Transportation agencies manage vast quantities of right-of-way land. Within these millions of acres lies the roadside environment. Management of the roadside needs to reflect the value of the roadside as a transportation and environmental/community asset, its unique management issues, and its integration into the larger transportation system. An asset management approach to roadside vegetation management can save resources as part of a long-term plan. DOT's are essentially land managers with the need for a management system(s) designed improve vegetation management practices. Roadsides could be categorized within an asset management plan in terms of an operational zone and environmental zone, each 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 with abundant ecosystem services.

Asset management systems routinely track other aspects of transportation facilities, such as pavement, bridges, etc. However, there are very few such asset tracking systems in place for vegetation management. A few examples are:

- Indiana DOT
 - Land Management Map developed to aid in quantifying the number of acres, categorizing land use/cover type, and identifying right-of-way boundaries
 - Field collected invasive species and tree risk assessment mapping.
- Washington State DOT –Roadside Land Use Asset Management
 - Highway Activity Tracking System (HATS) for asset inventory, planned actions, and work accomplishments to be captured, stored, and referenced
 - Maintenance Accountability Process (MAP) for annual performance and system condition data
 - Mitigation Site Database manages and measures their Environmental Mitigation Sites.
- Wisconsin DOT
 - Routine Maintenance Agreement (RMA)
 - Discretionary Maintenance Agreements (DMAs)
 - Tracks RMA and DMA data for mowing, woody vegetation, control of unwanted vegetation and urban mowing

Adopting an asset management plan approach that includes vegetation management and other roadside management issues could help DOTs track actual costs for each type of management zone and assess future needs. Mapping areas can use technologies such as remote sensing, photogrammetry, mobile visual observation by users using GPS enabled devices to not only gather data on roadside vegetation management but other related ecosystem services such as pollinator and/or wildlife habitat. The ability to document management practices over time allows DOTs to better utilize their limited resources, maximize worker safety, and get the most out of the ecosystem services that a sustainable roadside environment provides.

SUGGESTED RESEARCH

There are remaining knowledge gaps identified over the course of the project that further research could address. The following suggested topic would benefit state DOTs in managing roadside vegetation as part of a greater transportation system:

- A synthesis of DOT asset tracking systems for roadside vegetation management and others that may be adapted to roadside vegetation management.

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APPENDIX A

Survey Questionnaire

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
- Agency
- Location
- Area of Responsibility (statewide, district, region, etc.)
- State/Province
- Email Address
- Phone Number

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?

APPENDIX B

Survey Respondents

Table B1 Survey respondents

State	Title/Role/Responsibility	Agency/Organization
AR	Maintenance Engineer	Arkansas Department of Transportation
AZ	Statewide Technical Assistance	Arizona Department of Transportation
CA	Landscape Architect	California Department of Transportation
CT	Vegetation Manager	Connecticut Department of Transportation
FL	Roadside Manager	Florida Department of Transportation
GA	Landscape Architect Manager	Georgia Department of Transportation
ID	Vegetation Manager	Idaho Transportation Department
IN	Roadside Maintenance Specialist	Indiana Department of Transportation
KS	Bureau Chief of Maintenance	Kansas Department of Transportation
LA	Roadside Manager	Louisiana Department of Transportation and Development
ME	Vegetation Manager	Maine Department of Transportation
MD	Technical Lead/Landscape Architect	Maryland Department of Transportation State Highway Administration
MA	Landscape Architect	Massachusetts department of Transportation
MI	Vegetation Manager	Michigan Department of Transportation
MO	Develop and administer policy and guidelines	Missouri Department of Transportation
NY	Director Transportation Maintenance	New York State Department of Transportation
ND	State Maintenance Engineer	North Dakota Department of Transportation
OH	Vegetation Manager	Ohio Department of Transportation
OR	Statewide Vegetation Management Coordinator	Oregon Department of Transportation
PA	Develop and update - maintenance operation policies	Pennsylvania Department of Transportation
TX	Vegetation Manager	Texas Department of Transportation
UT	Statewide Director of Maintenance	Utah Department of Transportation
VT	Working with internal and external stakeholders to develop guidance documents and comply with regulatory drivers	Vermont Agency of Transportation
WA	Statewide Program Manager	Washington State Department of Transportation
WI	State Transportation Landscape Architect	Wisconsin Department of Transportation
WY	Native, roadside vegetation reclamation to meet EPA/WYDEQ Storm water GCP regulation rules.	Wyoming Department of Transportation

APPENDIX C

Cooperative Agreements/Permits

Appendix C contains examples of state DOT documents pertaining to cooperative agreements/permits. Table C1 shows the state agency, source document and the type of document. These documents are on the respective agency's website.

TABLE C1 Examples of state DOT documents for cooperative agreements/permits.

Cooperative Agreements/Permits		
State	Document Title	Document Type
South Carolina DOT	Maintenance Partnership Agreement	Cooperative Agreement Form
Nebraska Department of Roads	Memorandum of Understanding between the Nebraska Game and Parks Commission and the Nebraska Department of Roads	MOU for roadside maintenance
Pennsylvania DOT	Application for a Right of Way Vegetation Management Permit	Permit Form M-688
	Permit Request for Vegetation Control to Restore the Viewing Zone for an Outdoor Advertising Device(s)	Permit Form M-700

South Carolina DOT

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

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.



**PERMIT REQUEST FOR
VEGETATION CONTROL TO RESTORE
THE VIEWING ZONE FOR AN OUTDOOR
ADVERTISING DEVICE(S)**

Vegetation Control
Permit Number: _____

(Instructions, Information and Conditions on Page 2)

Name of Person or Company owning device(s)			
Street Address or P.O. Box			
City	State	Zip Code	Telephone Number ()
Device Permit Numbers	Device Type	And Dimensions	
1 _____	1 _____	1 _____	
2 _____	2 _____	2 _____	
3 _____	3 _____	3 _____	
4 _____	4 _____	4 _____	
Location of Device (County)	Township	Adjacent Highway	
1 _____	1 _____	1 _____	
2 _____	2 _____	2 _____	
3 _____	3 _____	3 _____	
4 _____	4 _____	4 _____	
Distance & Direction to Nearest Crossroads	Name of Nearest Crossroads		
1 _____	1 _____		
2 _____	2 _____		
3 _____	3 _____		
4 _____	4 _____		

Draw here or attach 8 1/2 x 11" sketch(es) showing highway, location(s) of device(s) and the kind, size and type of vegetation to be controlled. If separate sketch(es) are required, the maximum scale shall be one inch equals 200 feet.

Remedial action proposed for viewing zone of each device listed. Vegetation control to include trimming, pruning, relocation or removal. Changes to the device(s) itself to include raising, lowering or adjusting.

Signature of device(s) owner		Date
Date Received by District Office	Time Received by District Office	
Date & Time Approved	Date & Time Disapproved	Date & Time Modified
District Executive Signature		
Reason for disapproval or modification		

INSTRUCTIONS, INFORMATION AND CONDITIONS

1. This application will be limited to four devices within one lineal mile on one side of the road for a \$90 cost. A back to back sign shall be considered as one device.
2. This request is to be delivered in triplicate to the district office having jurisdiction over the location where the proposed work will be performed.
3. A check or money order in the amount of \$90 payable to the Pennsylvania Department of Transportation is to accompany each request.
4. A photograph(s) showing the screening proposed to be remedied for each device is to be attached to this request.
5. Upon issuance of the permit, but in no event more than 10 days before the start of work, the permittee will post a bond covering all work to be done pursuant to all permits issued to an applicant, to insure and protect the Commonwealth against loss or damage to trees or vegetation for which remedial action has not been approved or deemed to be approved and occasioned by pruning, trimming, relocation, or removal of trees or vegetation and to require the applicant to indemnify the department for the replacement costs of any such trees or vegetation so damaged or destroyed. The amount of the bond for each permit shall be at least \$10,000 per screening area or a blanket bond. A larger bond may be required if decided by the department.
6. Requests must be submitted to the district office at least 30 days prior to the anticipated start of work.
7. Approval of this request does not relieve the device owner from securing any applicable Federal or local municipal permits or approvals that may be required.
8. Traffic Control Plan. The applicant shall submit a traffic control plan for all work on freeways and other limited access highways. The department may require an applicant to submit a traffic control plan for department approval under other circumstances where substantial traffic interference or potential hazards may result in the performance of the work. All traffic control plans shall comply with the applicable provisions of Publication 213 and shall clearly indicate how the work area, vehicular and pedestrian traffic will be protected, maintained and controlled.
9. A statement or if necessary a sketch(es) on 8 1/2 x 11" paper is to be included showing how access to each device(s) is to be obtained. Include references and distances to the adjacent highway and prominent nearby landmarks or features.
10. This request is subject to all applicable state laws, statutes, provisions and controls relating to remedial action for outdoor advertising devices screened by vegetation within Interstate and Federal-Aid Primary Highways.
11. Requests will be reviewed by the department for device(s) where the intent of the advertising is not discernible for a total of five seconds. The viewing zone is that distance measured along the center of the lane of traffic of a highway which a vehicle will travel at the posted speed limit.
12. The permittee shall be responsible to remove all tools and materials from the right-of-way at the end of the work and to properly dispose of all excess vegetation outside of the right-of-way in compliance with department policy.
13. Restoration. All disturbed portions of the highway, including slopes and all appurtenances and structures shall be restored by the permittee to a condition at least equal to that which existed before the start of any work authorized by the permit.
14. This permit is valid for a period of 120 days from the date the application is approved.
15. No permit shall be issued for work which is contrary to normal conservation practices including but not limited to the Pruning Standards for Shade Trees of the Tree Care Industry Association (TCIA) (current revision). The treatment procedures for cut stumps must be identified.
16. The department's authorized representatives have the authority to inspect proposed, actual and completed work at any time.
17. This permit shall be located at the work site and shall be available for inspection by any police officer or authorized department representative.
18. Penalty for falsifying application. Information provided in application must be accurate. Section 4904 of the Crimes Code (18 Pa. C.S. §4904), makes it a misdemeanor for any person to mislead a public servant in performing an official function by making any written false statements which a person does not believe to be true.
19. Fine. Violation of a permit shall be a summary offense punishable by a fine of \$100 to \$300 plus the value of any vegetation destroyed or the cost of restoration at the option of the department.

APPENDIX D

Washington State DOT Visualizing Roadsides as Transportation Assets

VISUALIZING ROADSIDES AS TRANSPORTATION ASSETS



WSDOT owns and maintains approximately 100,000 acres of unpaved land. As part of the agency's overall Transportation Asset Management Plan, WSDOT has classified and mapped roadside land use areas as shown on this poster. This geographic inventory of six specific roadside land use types provides the basis for budgeting, planning, tracking, monitoring, and evaluating maintenance actions, and for measuring agency performance.

URBAN ROADSIDE	OPERATIONAL ROADWAY	OPERATIONAL SAFETY AND DRAINAGE	VISUAL/ ENVIRONMENTAL BUFFER	RESOURCE CONSERVATION	ENVIRONMENTAL MITIGATION																																																																																																																																																																																																																																																																																																																																																																																																																								
<p>FORMAL LANDSCAPE Only maintained along major corridors. Plantings are designed and constructed to be routinely maintained in a set condition to provide for safe highway operation.</p> <p>ACRES</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>FORMAL LANDSCAPE</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>ENVIRONMENTAL MITIGATION</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>AVERAGE OVERALL</td><td>\$7,759</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table> <p>COST PER YEAR</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>FORMAL LANDSCAPE</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>ENVIRONMENTAL MITIGATION</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>AVERAGE OVERALL</td><td>\$0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>	ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	FORMAL LANDSCAPE	100	100	100	100	100	100	100	100	100	100	100	ENVIRONMENTAL MITIGATION	0	0	0	0	0	0	0	0	0	0	0	AVERAGE OVERALL	\$7,759											ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	FORMAL LANDSCAPE	100	100	100	100	100	100	100	100	100	100	100	ENVIRONMENTAL MITIGATION	0	0	0	0	0	0	0	0	0	0	0	AVERAGE OVERALL	\$0											<p>ZONE 1 Vegetation-free edge, maintained as required where shoulders are designed for stormwater sheet flow.</p> <p>ZONE 2 Low-growing vegetation, maintained throughout the system, width is determined by highway design and local site constraints.</p> <p>ZONE 3 Present where there is extra right of way beyond the outside edge of Zone 2, between divided highway alignments, and at freeway interchanges.</p> <p>ACRES</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>ZONE 1</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>ZONE 2</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>ZONE 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OVERALL</td><td>\$239</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>	ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	ZONE 1	100	100	100	100	100	100	100	100	100	100	100	ZONE 2	100	100	100	100	100	100	100	100	100	100	100	ZONE 3	100	100	100	100	100	100	100	100	100	100	100	AVERAGE OVERALL	\$200											ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	ZONE 1	100	100	100	100	100	100	100	100	100	100	100	ZONE 2	100	100	100	100	100	100	100	100	100	100	100	ZONE 3	100	100	100	100	100	100	100	100	100	100	100	AVERAGE OVERALL	\$239											<p>ACRES</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>OPERATIONAL SAFETY AND 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These areas require little to no maintenance.</p> <p>ACRES</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>RESOURCE CONSERVATION AREAS</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>ENVIRONMENTAL MITIGATION</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>AVERAGE OVERALL</td><td>\$0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>	ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	RESOURCE CONSERVATION AREAS	100	100	100	100	100	100	100	100	100	100	100	ENVIRONMENTAL MITIGATION	0	0	0	0	0	0	0	0	0	0	0	AVERAGE OVERALL	\$0											<p>ENVIRONMENTAL MITIGATION Sites maintained for 10+ years, in response to highway construction environmental permit requirements (Once permit requirements are fully met, sites are classified and maintained as part of Zone 3).</p> <p>ACRES</p> <table border="1"> <tr><th>ACRES</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr> <tr><td>ENVIRONMENTAL MITIGATION</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr> <tr><td>RESOURCE CONSERVATION AREAS</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>AVERAGE OVERALL</td><td>\$4,600</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>	ACRES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	ENVIRONMENTAL MITIGATION	100	100	100	100	100	100	100	100	100	100	100	RESOURCE CONSERVATION AREAS	0	0	0	0	0	0	0	0	0	0	0	AVERAGE OVERALL	\$4,600										
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