A Strategic Overview of Rights-of-Way Pest Management in the United States

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Prepared by the University of Illinois Chicago in collaboration with the North Central Integrated Pest Management Center

North Central IPM Center

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Cover photo: Transmission right-of-way at State Game Lands 33 maintained using integrated vegetation management practices that result in diverse species composition. Source: Caroline Hernandez, University of Illinois Chicago.

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North Central IPM Center

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Introduction

Pest Management Strategic Plans (PMSPs) provide a comprehensive framework for managing pests in an effective, sustainable, and environmentally responsible manner. These plans are typically developed by stakeholders in agriculture, public health, and other sectors affected by pest issues, including farmers, researchers, and policymakers. PMSPs identify key pest management challenges, research needs, and strategies for controlling pests using integrated pest management (IPM). In doing so, PMSPs support pest control practices while minimizing risks to human health, the environment, and non-target species. PMSPs also help guide the allocation of resources and funding to address pest-related problems and support decision-making.

The goal of this PMSP is to:

- provide a broad overview of pest management, namely the management of undesirable vegetation that presents either a safety issue or is otherwise unwanted, on energy and transportation landscapes;
- support the development of policies and regulations that align with sustainable vegetation control practices;
- identify outreach and education needs; and
- inform research to improve the long-term health of ecosystems and society.

The landscapes of concern include roadways, gas pipelines, utility corridors, railways, and similarly managed lands commonly referred to as “rights-of-way.”

Integrated Pest Management and Integrated Vegetation Management

IPM practices on rights-of-way are primarily embodied by a suite of practices known as integrated vegetation management (IVM). To understand the differences between these definitions, consider the following:

- As defined by the USDA, **integrated pest management (IPM)** is “a science-based decision-making process that combines tools and strategies to identify and manage pests. As defined in 7 U.S.C. § 136r, IPM is ‘*a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.*’”
- USEPA defines **integrated vegetation management (IVM)** as “the practice of promoting desirable, stable, low-growing plant communities that will resist invasion by tall growing tree species through the use of appropriate, environmentally sound, and cost-effective control methods.”

While IVM is generally considered a specific application of IPM, they are different in focus. As implied in its name, IVM is centered on *vegetation* and is outcome-focused with a desired objective target or condition. In contrast IPM is more pest-focused and includes vegetation and other potential pests such as bacteria, fungus, insects, or wildlife that may cause specific unwanted or detrimental effects. Most energy and transportation lands focus exclusively on vegetation management for safety, reliability, and other objectives. Thus, this PMSP focuses on the use of herbicides in conjunction with other IVM practices to treat undesirable vegetation.

Energy and Transportation Lands in the U.S.

Energy and transportation rights-of-way span millions of miles across North America and run through a diverse array of landscapes. Rights-of-way are primarily managed for operational compatibility with energy and/or transportation infrastructure by precluding tall growing (or deeply rooted) woody species to ensure the safe and reliable transport of goods, data, energy, and people. Rights-of-way often experience minimal development or disturbance and therefore provide corridors of open space within otherwise developed areas. As a result, these areas may host higher levels of biodiversity compared to surrounding areas and serve as important connectivity corridors for fragmented natural areas and populations.

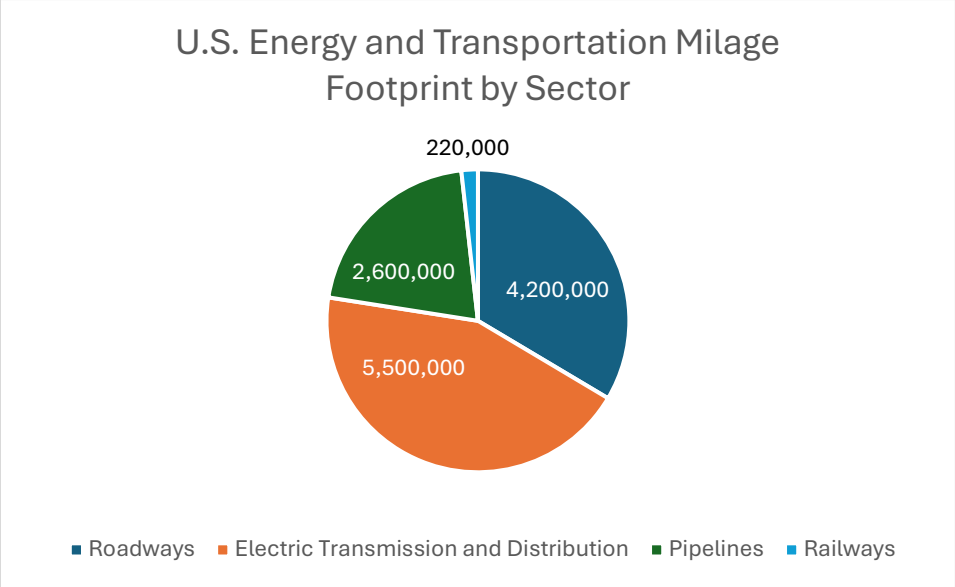

Figure 1. Miles of Rights-of-Way in the U.S. by Sector

As shown in Figure 1, the vast network of rights-of-way in the U.S. includes approximately 4.2 million miles of roadsides (Administration, 2022), 2.6 million miles of natural gas and liquid petroleum pipelines, (Transportation, 2018), 220 thousand miles of railways, (Transportation Statistics Annual Report 2023, 2023), and 5.5 million miles of electric transmission and distribution lines (Marston, 2018).

2003 Rights-of-Way PMSP

The previous rights-of-way PMSP was published in 2003 and covered the 12 states of the North Central region, including Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota, Nebraska, Ohio, South Dakota, and Wisconsin. Most industry representatives that contributed to the development of the PMSP were contractors with expertise in weed control and vegetation management on state, municipal, and commercial rights-of-way. Input provided at that time focused on invasive species and herbicide application challenges in the region.

PMSPs are considered out of date if they are older than five years, which necessitated this update to the rights-of-way PMSP. This update also offers a broader, national focus to capture the state of industry practices across the U.S. and highlight common research, education, and policy needs.

Overview of Right-of-Way Vegetation Management

Right-of-way vegetation management is vital for the maintenance of critical infrastructure systems such as roads, railways, pipelines, data and communications, and electric utilities. Maintaining infrastructure requires buffer areas (i.e., rights-of-way) to provide safe operations, access for maintenance or emergency use, and separation from potentially conflicting adjacent land uses. Rights-of-way are traditionally managed under a property easement or other landowner agreement but, in some cases, are directly owned by the energy or transportation organization. In the former instance, vegetation management activities may be influenced or constrained by property agreements and landowner preferences.

Vegetation Management Objectives

Energy and transportation organizations undertake vegetation management on rights-of-way to address one or more operational objectives:

- Ensure infrastructure functions are safely and reliably maintained;
- Comply with regulations, land use laws, and property agreements;
- Minimize reputational risks resulting from negative community relations or environmental impacts; and/or
- Support conservation practices related to nature-based sustainability reporting and/or other conservation commitments.

Vegetation managers are required to balance these objectives with fiscal responsibilities to provide vegetation management in a timely and cost-effective manner. This necessitates planning, selecting, and executing tools and methods that provide effective pathways to achieve their desired outcomes.

Regulatory Context

Right-of-way vegetation management balances a complex mix of legal, environmental, and operational considerations. Laws, regulations, and ordinances may vary significantly from one state or locality to another, which may directly or indirectly influence the type and frequency of vegetation management practices.

For example, a 2003 blackout in the northeastern U.S. and Canada was caused by inadequate vegetation management (Force, 2004). This blackout affected nearly 50 million people and caused billions of dollars in economic loss. Following this event, the Federal Energy Regulatory Commission (FERC) implemented a new regulatory framework[1] that requires utilities to manage vegetation to avoid similar occurrences. Similarly, vegetation management around other infrastructure types may also be governed by federal law, e.g., the Pipeline and Hazardous Materials Safety Administration (PHMSA) regulates vegetation management along pipelines and the Federal Highway Administration provides standards and guidelines for the management of vegetation along roadsides. Laws and regulations governing rights-of-way management are summarized in Table 1.

[1] FAC-003-4 Vegetation Management Reliability Standard. Online at: https://www.nerc.com/pa/stand/reliability%20standards/fac-003-4.pdf

Table 1. Federal Laws and Regulations Governing Rights-of-Way Management

Law or Regulation	Summary
43 USC 1772	Vegetation management, facility inspection, and operation and maintenance relating to electric transmission and distribution facility rights-of-way on federal lands.
Endangered Species Act (ESA)	The ESA of 1973 protects endangered plants and other species by regulating vegetation management and other activities. Violating the ESA can result in criminal misdemeanor penalties, including up to one year in prison and fines up to $50,000.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	The Federal statute that governs the registration, distribution, sale, and use of pesticides in the United States. FIFRA enforcement is focused on the sale, distribution, and use of pesticides. Before a pesticide may be sold, it must be registered (licensed) with the USEPA. Registration under FIFRA requires the applicant demonstrate that using the pesticide according to specifications "will not generally cause unreasonable adverse effects on the environment." Section 2(ee) of FIFRA also includes certain exceptions to the FIFRA definition of "using a pesticide inconsistent with its labeling", which allows special conditions where it is permissible to use a pesticide in a manner for which it is not specifically labeled (U.S. Environmental Protection Agency).
Interagency Integrated Vegetation Management Practices Memorandum of Understanding	The October 2016 Memorandum of Understanding (MOU) between USEPA and the Edison Electric Institute, U.S. Department of Agriculture (U.S. Forest Service), and U.S. Department of the Interior (Bureau of Land Management, Fish and Wildlife Service, and National Park Service) helped establish IVM practices as the standard for utility rights-of-way management.
Pipeline Inspection, Protection, Enforcement, and Safety (PIPES) Act of 2006	Provides for enhanced safety and environmental protection in pipeline transportation and reauthorized PHMSA, which oversees pipeline rights-of-way standards.
Vegetation Management Reliability Standard, FAC-003	This standard is overseen by FERC and requires that trees and other vegetation growing in or adjacent to the power line right-of-way be trimmed to prevent power outages caused by tree contact with a transmission line.

Pests on Rights-of-Way

Pests commonly identified on rights-of-way include a variety of plants, insects, and other pathogens as summarized in Table 2. Specific pests are unique to geographic locations and other influences, such as introduction timing, land use, and climate. Given the multi-state scope, this PMSP generally refers to categories of pests, rather than focusing on individual species, except for example purposes. This PMSP is focused primarily on plant pests, since this is where energy and transportation organizations invest the majority of their time, personnel, and financial resources.

Table 2. Key Pests Identified for Rights-of-Way

Pest Type	Examples	Concern
Plants	Tree-of-heaven, autumn olive, tall-growing native or introduced trees, teasel, cheatgrass, ragweed, invasive *phragmites*	Certain plants may be considered pests due to incompatibility with infrastructure operations and maintenance. Other plants may be considered pests due to their invasive or noxious weed status, fire risk, public or worker safety concerns, or other reasons.
Insects	Emerald ash borer, pine bark beetle, gypsy moth, spotted lanternfly	Insects can cause extensive damage by defoliating leaves, feeding on the bark, and eventually killing trees, thereby creating costly maintenance and safety hazards for rights-of-way.
Pathogens	Dutch elm disease, oak wilt	Fungus or bacteria grow through infected trees' vascular systems, causing trees to wilt and die, thereby creating costly maintenance and safety hazards for rights-of-way.

Methods

This PMSP was developed by the University of Illinois Chicago (UIC) with input from vegetation management industry participants in the Rights-of-Way as Habitat Working Group[2]. The working group was formed by UIC in 2015 to encourage and support the conservation of habitat on energy and transportation lands. The working group is a repository for tools, resources, case studies, and research to support vegetation management on energy and transportation lands. The working group convenes stakeholders interested in integrating habitat conservation into infrastructure management and utilizing industry best practices. The North Central Integrated Pest Management Center (NCIPMC) assisted UIC in gathering input from industry representatives on common plant pests, best management practices, and other aspects of rights-of-way vegetation management.

[2] Rights-of-Way as Habitat Working Group: https://rightofway.erc.uic.edu/

Planning and Preparations

UIC developed an engagement plan and timeline (Appendix 1) for outreach to energy and transportation industry representatives. This included plans for preliminary surveys - one targeting departments of transportation (DOTs) and one targeting energy companies - to collect data prior to sector-specific workshops where the PMSP would be discussed in more detail (Appendix 2,3).

Image: A rights-of-way PMSP Workshop conducted in September 2023.

The purpose of these surveys was to collect data on right-of-way vegetation management practices, current challenges, and research, education, and policy needs for the transportation and energy sectors to guide workshop discussions. The DOT survey was sent to 154 DOT representatives on April 26, 2023, who were given two weeks to respond. UIC received responses from 42 DOT representatives (Appendix 4.1). The energy sector survey was updated to reflect herbicides and vegetation management practices that were discussed in the DOT workshop to facilitate more detailed data collection. The survey was sent to 229 energy company representatives on August 24, 2023, who were similarly given two weeks to respond. UIC received responses from 38 energy company representatives (Appendix 4.2).

Workshops

UIC and NCIPMC designed two interactive workshops based on the National IPM Database Workshop Guidelines[3], the NCIPMC's experience hosting multiple development sessions for other PMSPs, and UIC's experience hosting various roundtable discussions with Rights-of-Was as Habitat Working Group participants. While the two workshops followed a similar structure, UIC found it helpful to convene industry representatives by sector to allow for more specific discussion of the unique practices, challenges, and needs in each sector.

The workshop agendas (Appendix 5) were designed to cover the following topics:

- Weeds of primary concern
- Efficacy of treatments
- Vegetation management practices
- Management timing
- Priorities for research, education, and policy

The DOT workshop was conducted virtually on May 31, 2023, and attended by 21 representatives from the DOT sector (Appendix 4.3). The energy sector workshop was held in-person at the annual Trees & Utilities conference on September 12, 2023, with 15 participants in attendance (Appendix 4.4).

[3] Workshop Guidance in Developing a Pest Management Strategic Plan for the National IPM Database, 2022.

Participants

UIC invited industry representatives from across the U.S. with a variety of backgrounds and years of working experience in vegetation management to participate in the workshops. All participants had knowledge of and experience with IVM and IPM practices. Many of the participants had also been previously involved in the Rights-of-Way as Habitat Working Group, including in habitat conservation and research efforts[4] and/or the development and dissemination of resources[5] related to habitat-friendly vegetation management.

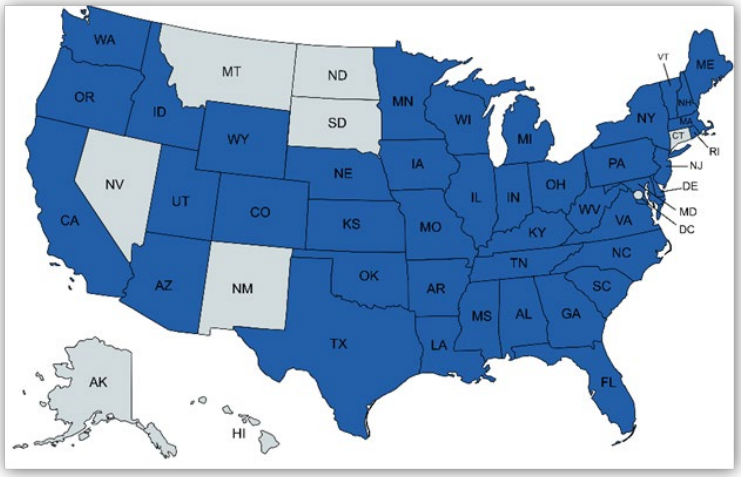

Figure 12. States Represented in Development of this PMSP

Through the surveys and workshops, UIC and NCIPMC gathered detailed information from 84 industry representatives. Participants' level of experience ranged from 1 to 46 years in the industry. Collectively, the participants' organizations manage approximately 53,000 miles of rights-of-way across 42 states (Figure 2).

Analysis

Following the surveys and workshops, UIC compiled all participant responses received. Reponses were analyzed via comment aggregation, keyword organization, and through additional review using the language learning model Notebook LM. UIC examined responses for commonalities across sectors and regions, such as species targeted, management practices utilized, operational challenges experienced, and identified research, education, and policy needs. UIC summarized common responses and themes collected from survey and workshop responses. Specific responses related to herbicide product usage (Appendix 6), weeds of concern (Appendix 7), and other best management techniques that were transcribed from workshop discussions were organized into topic-specific tables for clarity.

Results

Information gathered from the surveys and workshops is described within this report and appendices, including recommendations made regarding research, education, and policy. This report is meant to provide an overview of vegetation management activities on rights-of-way and related concerns based on input from a limited set of participants and their individual observations and experiences. The results should not be considered representative of every energy and transportation organization or right-of-way.

[4] Rights-of-Way as Habitat Working Group Projects
[5] Rights-of-Way as Habitat Working Group Resources

Due to the extensive range of pests, products, and practices described within this PMSP for rights-of-way, UIC and NCIPMC determined it was not possible to include all specific details in the online National Integrated Pest Management Database.

The compiled results from the surveys and workshops, as presented within this PMSP, were shared with industry representatives who previously provided data for this plan. A final PSMP roundtable discussion, which occurred on February 26th, 2025, invited attendees to provide feedback on the content of the drafted PSMP. A questionnaire was also sent to participants following the roundtable to further collect feedback. All feedback and comments provided were compiled and where appropriate, additional data or suggested revisions were incorporated into the finalized version of this PSMP.

Right-of-Way Vegetation Management Practices

The vegetation management practices used on rights-of-way vary depending on the operational objectives, location, target pest (e.g., incompatible plant species), available tools, personnel training and experience, and allocated funding. Based on previous surveys of investor-owned utilities, most vegetation management on rights-of-ways is conducted by contractors (Miller & Hauer, 2021). Based on participant feedback, the use of contractors was frequent across other non-utility rights-of-way sectors as well.

Vegetation management timing, methods, and scale vary significantly by organization across the U.S. Factors including ecoregion, state and federal regulations, local ordinances, staffing, key stakeholders, neighboring or underlying landowners, onsite and adjacent conditions, funding, and personnel and organizational experience can all impact vegetation management decisions on rights-of-way.

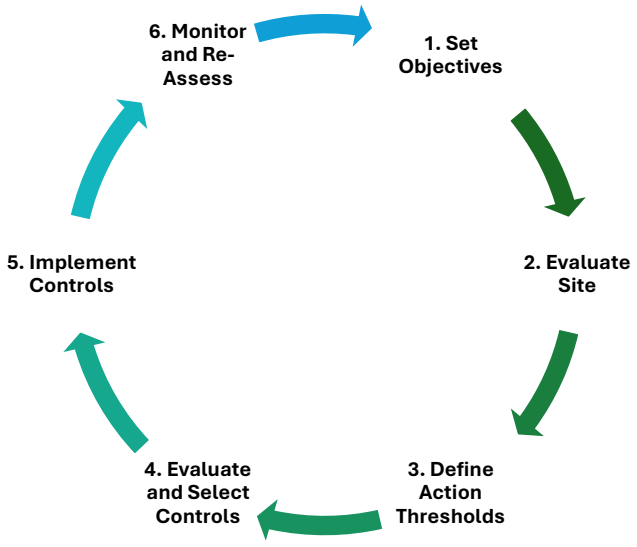

Figure 3. Simplified Integrated Vegetation Management Planning Framework

Vegetation management is often performed in cycles or rotational schedules across the rights-of-way system. With larger rights-of-way networks, vegetation management cycles are often multiple years, i.e., vegetation management is performed in one year and field crews do not return to the same right-of-way until two to five years later. The vegetation management methods used on rights-of-way can impact the growth and composition of vegetation in the intermediate years.

IVM Framework

Rights-of-way IVM focuses on sustainable, multi-method approaches to control vegetation while minimizing ecological impact. Using IVM promotes desirable, stable, low-growing plant communities that will resist invasion by undesirable plant species through the use of appropriate, environmentally sound, and cost-effective control methods. As a management

framework (Figure 3), IVM provides a mechanism for setting objectives and implementing controls to achieve these desired outcomes. When setting objectives, plants that are considered "undesirable" or "pests" are directly or indirectly identified. Use of the IVM framework has been standardized in ANSI A300 Part 7 as a process for managing plant communities.[6]

Energy and transportation organizations are increasingly adopting IVM because it provides significant cost savings, enhances sustainability in vegetation management, and helps meet state and federal regulations. For example, using targeted, long-term treatments like selective herbicides can eliminate the need for frequent, labor-intensive maintenance, which lowers overall operational costs (Goodfellow, 2022). IVM emphasizes maintaining biodiversity, preventing soil erosion, and managing invasive species. By focusing on long-term objectives, IVM minimizes reactive, short-term fixes. This proactive approach ensures that vegetation management efforts are effective and consistent over time, saving both time and money while ensuring operational reliability. IVM resources[7,8] for rights-of-way are becoming more accessible and increasingly included in industry guides and safety and herbicide applicator trainings[9]. The same techniques used in Integrated Vegetation Management are also commonly used by habitat restoration and conservation groups, from addressing invasive species[10], restoring conservation meadows[11], and increasing native plant diversity and at-risk species[12].

Vegetation Management Methods

Energy and transportation organizations use a variety of vegetation control methods for unwanted vegetation such as incompatible, invasive, or other pest species. IVM promotes the use of a combination of physical, chemical, cultural, and biological methods (Table 3). Vegetation control methods are typically given priority based on the cost, time, and ease with which these methods can be used. Survey and workshop participants provided specific examples of common vegetation management methods they use to treat unwanted vegetation (Appendix 3).

[6] *ANSI A300 Pt 7: Tree, Shrub, and Other Woody Plant Management Standard Practices (Integrated Vegetation Management a. Utility Rights-of-way)*
[7] IVM Best Management Practices, 3rd Edition
[8] Managing Compatible Vegetation for Targeted Species and Biodiversity
[9] Nebraska Right-of-Way Pest Control manual
[10] Titanich, H. (2024, September 25). *Using herbicide: An important tool in establishing streamside forests*. Using Herbicide: An Important Tool in Establishing Streamside Forests. https://stroudcenter.org/news/herbicide-an-important-tool-establishing-streamside-forests/
[11] Phillips-Mao, L. (2017). Restoring Your Woody Invaded Meadow to Conservation Meadow. The Nature Conservancy https://www.nature.org/content/dam/tnc/nature/en/documents/Restoration-Guide-Woody-Invaded-to-Conservation-Meadow.pdf.
[12] Phillips-Mao, L. (2017). *Your Woody Invaded Meadow to Conservation Meadow*. The Nature Conservancy. Retrieved from https://www.nature.org/content/dam/tnc/nature/en/documents/Restoration-Guide-Woody-Invaded-to-Conservation-Meadow.pdf.

Table 3. Common Rights-of-Way Vegetation Management Methods

Method	Frequency of Industry Use	Description*
Physical	Frequent	Mechanical or manual controls involve physical cutting or removing vegetation through the use of equipment or hand tools.
Chemical	Frequent	Use of herbicides for either targeted or broadcast treatments. May include use of broad spectrum (i.e., non-specific) or selective (i.e., targeted to a specific growth form) herbicide formulations, or in combination. Tree growth regulators may also be used to reduce growth rates.
Biological	Somewhat Frequent	Use of natural competition, allelopathy, animals, insects, or pathogens to favor desirable plants and discourage unwanted vegetation.
Cultural	Occasional	Modifying site conditions or adopting compatible land uses that either promote desirable plants or discourage unwanted vegetation.
Prescribed Fire	Occasional	Utilizing planned and controlled application of fire to control invasive plant species and promote native grasses and forbs.

*Descriptions developed in accordance with IVM Best Management Practices, 3rd Edition, and Managing Compatible Vegetation for Targeted Species and Biodiversity.

Physical Methods

Physical methods of vegetation management directly control unwanted plant growth to maintain safe, accessible corridors. Techniques such as mowing and tree cutting are commonly used to reduce vegetation height, prevent encroachment, and minimize hazards. Physical controls are sometimes completed in conjunction with other control methods such as chemical or cultural controls. Physical control methods are separated into two categories: manual and mechanical methods.

Manual Controls

Manual methods involve individuals using hand-operated tools, such as chainsaws, string-trimmers, or brush cutters, to selectively prune or remove undesirable herbaceous weeds, brush, or trees. These methods are highly targeted and typically have minimal environmental impact, though they can be among the more costly and time-consuming methods for right-of-way maintenance. Manual methods are typically only used on rights-of-way that are hard to access, have a specific vegetation management requirement, or other limitations on the management activities done at a particular location. Manual control methods can also result in more exposure and risk to workers especially near roads.

Mechanical Controls

Mechanical methods involve the use of equipment-mounted saws, mowers, masticators, forestry mowers, or other devices. Mechanical methods are suitable for controlling undesirable vegetation over large areas, since they are faster and less expensive than applying manual methods alone.

Mowing is one of the most common tools for managing vegetation on rights-of-way. Many participants use mowing as their primary control method. DOTs and pipeline operators, in particular, typically mow rights-of-way several times per year to prevent the growth of undesirable vegetation and meet compliance standards for their operations. Mowing is sometimes paired with another form of treatment, such as herbicide application, to further prevent growth and prepare areas for habitat restoration.

Mowing may consist of either grassland or forestry mowing. Grassland mowing can help control vegetation height, prevent the establishment of woody plants, and reduce fire hazards. It can also support cultural controls and ecological management by promoting the growth of low-growing, native plants, which can suppress woody plant growth, outcompete invasive species, and provide habitat for pollinators and other wildlife.

Downsides of grassland mowing include the potential for spreading invasive species, the need for accessible conditions for equipment, inadvertently removing native or desirable species if improperly timed, and environmental disturbance. Mowing can also be expensive and requires repeated treatments. Participants emphasized the need for mowing at the appropriate time to control target species and avoid inadvertently spreading invasive while at seed.

To reduce negative impacts to at-risk wildlife species, vegetation managers should aim to mow outside of peak blooming, migratory, and nesting periods. Some priority species may have guidelines available, such as the mowing best management practice resource created for the monarch butterfly by the Monarch Joint Venture and Xerces Society[13]. Vegetation managers can also reduce habitat damage by raising the height of the mower deck and blade to prevent excessive soil disturbance and protect low-growing plants, pollinator habitat, and ground-nesting species. Leaving buffer zones around wetlands, streams, and other sensitive areas helps to preserve critical habitat and reduces erosion risks. Strip or staggered mowing also supports habitat diversity by leaving undisturbed sections of the right-of-way for wildlife refugia.

By contrast, forestry mowing targets woody vegetation, using equipment like a skid steer with a brush hog-mounted mower and masticating blades. This method is commonly used on woody vegetation that is growing in moderate to heavy densities. Like grassland mowing, forestry mowing may require additional considerations for the time of year and extent to which it is conducted depending on localized conditions and environmental considerations.

[13] Mowing and Management: Best Practices for Monarchs

Chemical Methods

Chemical methods are extensively used for brush control to maintain clear and safe rights-of-way, treating noxious and invasive species, and creating or enhancing wildlife habitat by selectively removing undesirable species that threaten biodiversity. Herbicide controls can be classified into several categories, including:

- Selective/non-selective herbicides(e.g., affects certain species or growth forms),
- Pre-emergent/post-emergent (e.g., modes of action working before or after plant emergence),
- Foliar-applied/soil-applied (e.g., applied directly to live foliage or soils), and
- Growth regulators and inhibitors (e.g., slow plant growth, reducing the frequency of maintenance activities and minimizing disturbance to the surrounding environment).

Image: Herbicide application on pipeline right-of-way. Source: Marathon Petroleum

Other pesticides such as insecticides, fungicides, and rodenticides, were noted as being minimal and infrequently used on rights-of-way by industry participants. Thus, this document focuses on herbicide use and its application.

Application Types

Herbicides must be applied according to label requirements. Some application types vary by state to ensure compliance, effectiveness, and alignment with manufacturer's recommendations. Common herbicide application types on rights-of-way include the following (listed from most targeted to least):

- Cut-stem treatments apply herbicide directly to cut plant stems to prevent regrowth,
- Cut-stump treatments apply herbicide directly to the cut base of a plant to prevent regrowth,
- Basal bark treatments apply herbicide to the lower bark of trees,
- Hack-and-squirt uses manual cuts in tree bark to apply herbicide,
- Low-volume (or targeted) foliar sprays target the leaves of individual plants,
- Broadcast applications treat large areas that may contain both targeted and non-targeted species; this approach may be modified using strip treatments to target narrow bands of vegetation, and
- Aerial applications use aircraft such as drones, helicopters, or airplanes to spray large areas.

Participants utilize an array of application types and herbicide products to address targeted species and differing site conditions. There is no one-size-fits-all product or treatment method. Some application types are better than others at minimizing off-target impacts (e.g., adverse effects on desirable vegetation and habitat); however, the range of application types offers

flexibility in managing vegetation across various environments. Finding the best product and method for a targeted species can incur a period of trial and error. Vegetation managers should research any herbicide product and method before utilizing it within their operations.

Survey participants from both the energy and transportation sectors most frequently noted using low-volume foliar, cut-stump, and basal bark treatments. A summary of participant responses on herbicide products and application approaches from both sector-specific workshops is given in Table 4. Although workshop participants operate from locations across the country and address a broad range of species, this commentary reflects a limited number of participants' experiences with these products and may not represent wider industry trends.

Table 4. Herbicides Used (in alphabetical order) and Common Application Approaches*

Herbicide (Product Name)	Examples of Targeted Species	Comments on Application	Comments on Mixtures and Formulation
2,4-D Amine	Broadleaf, thistle, foliar brush	Use extra course nozzle to reduce drift Used by Midwest participants in active growing season; an Idaho-based participant uses it in late winter/early spring	Concerns with runoff Add drift reduction or deposition products May be restricted in some state agencies
Aminocyclopyr achlor (Method)	Trees, shrubs, herbaceous weeds	Spot treatment/low-volume foliar application Annual or less frequent treatment	Mix with aminopyralid, imazapyr, and metsulfuron, plus surfactant added Triclopyr and glyphosate are common tank mix partners
Aminopyralid (Milestone)	Forbs (thistle, legume, rose); trees and brush	Used in active growing season. Cut-stump method on woody species. Escort used for low-volume foliar treatments	Mainly mixed with other products
Clethodim	Grasses	An Ohio-based participants uses for post-emergence for control of grasses.	
Clopyralid (Transline)	Forbs (thistle, knapweed, legume species), woody vines	Used in active growing season. Low-volume foliar application	Used by itself. Transline beneficial for tree plantings
Dithiopyr (Dimension)	Grasses and broadleaf	A California-based participant uses as a pre-emergent herbicide.	
Diuron (Karmex)	Grasses, broadleaf	Bare ground treatment, pavement edge treatments	Respirator requirement; thus, not commonly used

Herbicide (Product Name)	Examples of Targeted Species	Comments on Application	Comments on Mixtures and Formulation
		A Louisiana-based participants uses for Itch Grass control	
Dicamba	Trees and shrubs	Basal bark treatment Too volatile for foliar treatments, off-target concerns	Tank mix with Triclopyr used on basal spraying
Fluazifop (Fusillade DX)	Johnsongrass	A Louisiana-based participant uses it over wildflowers to suppress grass	
Floridone (Sonar)	Aquatic or wetland plants	Participant stated that it is very effective when concentration is correct	Paired with Komeen or Reward
Florpyrauxifen-benzyl (Terravue)	Forbs	A Minnesota-based participant uses it for wild parsnip/carrot family, poison hemlock	Mixed with aminopyralid
Fosamine (Krenite)	Trees and shrubs	Chemical pruning	Used with imazapyr
Glyphosate (Roundup, Buccaneer, Ranger Pro, Aquaneat, AquaMaster)	Trees, shrubs, and grasses	Broadcast application for new site preparation to remove all previous vegetation Backpack, cut-stump, low-volume foliar	Not typically used alone. Used with imazapyr and triclopyr or Escort for total vegetation control
	Grasses (Johnsongrass)	Broadcast spray, backpack spray for rugged terrain	
	Bamboo	Foliar application, spot treatment (after cutting)	Use with imazapyr
	Aquatic species, forbs	Selective treatment	
	General usage	Does not last as long as some bare ground products but works immediately and well for restoration or revegetation. No residual activity	
Imazapic (Plateau)	Grasses	It is used to suppress grass growth to reduce mowing. A Minnesota-based participant uses in May for cool season grass, June for forbs An Idaho-based participant uses it in late fall for grasses	Tank mix with indaziflam or used separately. May add Escort to mix
Imazapyr (Polaris, Arsenal, Stalker)	Trees and shrubs	Non-selective Cut stump method, low-volume foliar treatment.	Used at low end of rate (quarter of a percent)

Herbicide (Product Name)	Examples of Targeted Species	Comments on Application	Comments on Mixtures and Formulation
		If used at low label rate, it can be used as seed head suppression	
	Grasses (cogon grass, phragmites); purple loosestrife	Spot or broadcast spraying	Sometimes used as tank mix for perennial control
Indaziflam (Rejuvra, Esplanade)	Grasses (cheatgrass, toadflax, medusa head, buffel grass), thistle	Broadcast spraying, (industrial) bare ground. Low-volume foliar treatment	Most of the time it is used by itself, sometimes used with glyphosate
Isoxaben	Grasses and broadleaf	A California-based participant uses as a pre-emergent	
Metsulfuron-methyl (Escort)	Trees and shrubs	Used in active growing season	Tank mix
	Broadleaf, forbs, cool season grasses	Seed head suppression	
MSMA	Grasses (Johnsongrass)	Used in South and Central parts of country Used in Louisiana for Bermuda grass release Commonly a restricted use product, some don't use because of the restricted label	
Picloram (Tordon, Graslan)	Broadleaf, woody species	Mechanical/backpack sprayer, stealth sprayer, basal bark application, hack and squirt Cautious of root uptake from beneficial trees and groundwater leaching Utilizing only in the middle of treatment area can reduce off-target impact Use it where you want to encourage grasses and knockout broadleaf	Often mixed with triclopyr, and sometimes with Arsenal and imazapyr

Herbicide (Product Name)	Examples of Targeted Species	Comments on Application	Comments on Mixtures and Formulation
		Largely restricted use AI, deterring some participants from use	
Sulfosulfuron	Grasses, biennial weeds/forbs	For Johnsongrass – spot or broadcast, foliar applied from the ground	
Tebuthiuron	Trees and shrubs, forbs	Used for pasture management. It can be used in many regions except tropical areas. Backpack spraying/selective use, bare ground treatment Less favored typically due to soil mobility concerns	Available in pellet or liquid forms
Triclopyr (Pathfinder, Garlon 3a, Garlon 4)	Trees and shrubs, aquatic species, broadleaf	Commonly used in low-volume foliar and cut-stump applications (woody species) Basal bark treatment Following label guidelines, can be used for treatment near aquatic areas	Standalone or mixed with imazapyr for low-volume use. Standalone for basal bark Garlon is a concentrate and has to be mixed
Triclopyr choline (Vastlan)	Trees, shrubs, broadleaf	Basal bark herbicide or cut-stump, chemical pruning, low-volume foliar applications A Minnesota-based participant uses it in winter, dormant type application	
Formulation of 2,4-D, dicamba, and MCPP-P (TRIPLET SF)	Broadleaf	Low-volume foliar	
Formulation of 2,4-D, dicamba, and triclopyr (TZone SE)	Broadleaf	Broadcast application	

*Chemicals listed may be used in conjunction with other chemicals, and not all chemicals in this table are permitted in some states.

More information on how survey participants rated the efficacy of specific chemicals and formulations can be found in Appendix 6.

Reducing Off-Target Effects

Herbicide applicators must take steps to minimize off-target damage when treating vegetation on rights-of-way. The most common way herbicides move off-target is through "drift". Spray drift occurs when herbicide droplets are carried by wind or air currents away from the intended target area, potentially harming non-target vegetation, water sources, or surrounding ecosystems. Other herbicides (such as imazapyr) may be residual in soil and have the potential to translocate underground. To reduce these risks, targeted application treatments should be used when possible to minimize drift through localized applications.

Cut-stem, basal bark, and hack-and-squirt methods are precise (limiting exposure to surrounding vegetation) but labor intensive. Backpack or handheld sprayers also allow for targeted application with minimal overspray. Low-pressure sprayers that produce larger droplets also minimize the likelihood of drift, since larger droplets are less susceptible to wind. Many vegetation managers use advanced nozzle technologies, such as extra coarse nozzles, to deliver herbicides more precisely.

Weather conditions must also be carefully monitored. Herbicide applications should be scheduled on calm days with low wind speeds to further reduce the risk of drift.

Product labels and state and federal regulations may also set requirements, such as the use of buffer zones around sensitive areas (e.g., water bodies, wetlands, and residential properties), to prevent accidental herbicide exposure. Buffer zones help contain any potential drift and protect surrounding environments. These practices not only minimize the impact of herbicide use on non-target areas but also help ensure that vegetation management efforts are both efficient and environmentally responsible.

Application Timing

The timing of herbicide applications is crucial for effective vegetation management on rights-of-way. Optimal seasonal timing can vary based on the herbicide product, application method, targeted plant species, ecoregion, and surrounding environmental conditions. Many herbicides are only effective during the growing season, while other formulations allow for year-round application. Effective management of many invasive species often requires applications at specific life stages (such as before going to seed) or may require multiple treatment cycles. Vegetation managers should also consider timing herbicide applications to avoid blooming periods, migratory, or nesting seasons of at-risk or beneficial wildlife species. Additionally, weather conditions and other temporal factors can sometimes play a role in herbicide effectiveness (e.g., most products should not be applied immediately before a precipitation event).

Biological Methods

Biological methods involve creating, enhancing, and conserving compatible plant communities through natural competition and/or allelopathy, a process by which plants and microorganisms

release chemicals that impact the growth of other plants or microorganisms. Maintaining robust plant communities that are beneficial and compatible with operations helps reduce the opportunity for non-compatible vegetation to become established. Through this suppression effect, vegetation managers can reduce their long-term costs and management inputs on the rights-of-way. A New York-based participant noted their organization focuses on encouraging low-growth vegetation that requires minimal maintenance.

Biological methods can also include managing targeted plant species through the introduction of a "natural enemy," such as a parasite, pathogen, or another organism that will feed off it. A Minnesota-based participant noted their organization's use of biological control to manage invasive species such as purple loosestrife, leafy spurge, and spotted knapweed. They have introduced insects that naturally feed on these species to decrease large-scale invasions. Overall, they found that utilizing herbicides on the perimeter of targeted populations and then applying biological control methods within the interior has been an effective strategy for larger-scale restoration sites. When effectively implemented and in combination with other methods, biological controls can serve as a long-term and less labor-intensive strategy to manage undesirable vegetation.

Cultural Methods

Cultural methods involve changing site conditions or integrating land use practices to reduce the establishment and growth of invasive or other non-compatible species. Examples of compatible land practices can include agricultural crops, parks, pastures, and other managed areas (Miller R. H., Integrated Vegetation Management, 2007)

Image: Goats grazing on transmission right-of-way. Source: ComEd

Cultural controls include:

- Seeding native plants and other desirable vegetation to re-establish or restore beneficial plant communities that can outcompete non-compatible species.
- Managed grazing can act as a vegetation control by using livestock (typically sheep or goats) to selectively graze non-compatible plants, reducing the need for mechanical or chemical interventions.
- Using inert materials such as crushed granite, gravel, stone, and boulders and decomposed materials like bark mulch can prevent new growth of unwanted species.
- Institutionalizing weed prevention practices that educate, encourage, and in some cases, mandate worker responsibilities for reducing the spread of unwanted weeds and pests. In practice, weed prevention may include plant identification training, identifying, and avoiding weed populations to minimize disturbance, cleaning equipment before mobilization, and utilizing tracking and reporting mechanisms.

Information on the timing and implementation of these methods can be found in various ecoregional planting guides and conservation resources[14]. Using diverse, pollinator-friendly seed mixes is an increasingly common way that energy and transportation organizations incorporate this practice as a cultural component of their management. Grazing is becoming more widely accepted as a vegetation management practice on photovoltaic systems and is occasionally seen on utility and pipeline rights-of-way but is rarely used for roadsides due to logistical challenges and safety concerns.

Grazing

Grazing is typically limited to locations that are too remote or inaccessible for worker safety, or where property rights do not allow for other methods such as herbicide. The costs associated with setting up and maintaining a grazing program can be high compared to other control methods and the results may be inconsistent depending on timing, herd size, and animal management factors. Workshop participants used a variety of cultural controls within their management regimens. An Idaho-based participant emphasized the practice of revegetating areas that were cleared during invasive species removal with competitive native species. Participants reiterated the value of combining cultural controls with other methods to improve overall management effectiveness.

Prescribed Fire

Prescribed fire, also known as controlled burning, involves the use of planned, controlled fires to manage vegetation and achieve specific management goals. It is an effective tool for controlling invasive weeds and woody vegetation and plays a crucial role in many habitats by returning nutrients to the soil and maintaining the health of native plant communities. Prescribed fire can be a costly management tool that requires careful planning and specialized training to mitigate potential hazards from fire, smoke, and equipment. The presence of high voltage wires, pipelines containing flammable products, and highways with traveling public makes this method less frequently used as compared to other control methods. Due to the risks and resources needed to conduct prescribed fires safely, prescribed fire is typically reserved for low-risk settings where ecological objectives encourage the use of prescribed fire to maintain specific conditions.

Image: Prescribed fire is a less frequently used tool for vegetation management on rights-of-way. Source: Evergy.

Roundtable participants emphasized the importance of proper timing and location to balance specific management needs most effectively with considerations for sensitive wildlife populations. One workshop participant described using prescribed fire in conjunction with herbicide applications to manage weed populations.

[14] Rights-of-Way as Habitat Working Group online resources library

Key Pest Management Concerns

Vegetation management on rights-of-way is an evolving practice that responds to changing regulations, research, and operational priorities. Workshop discussions with participants identified pest management concerns that can be broadly classified into the following themes: the environmental impact of vegetation management, vegetation control efficacy, regulatory inconsistencies, and worker safety. In addition, a list of specific weeds of concern identified by survey and workshop participants is provided in Appendix 3.

Environmental Impacts of Vegetation Management

An inherent outcome to vegetation management is the modification of the natural environment to achieve certain objectives. The ability to manipulate the environment through various control methods is recognized by practitioners as having the potential for either positive or negative impacts to the surroundings. Workshop participants noted the importance of management practices being effective over the long term to minimize future interventions. This indicates a desire for sustainable solutions that reduce the need for repeated treatments. Reducing the frequency of treatments also minimizes the potential for negative impacts resulting from equipment use, vehicle access, or other disturbance.

Use of herbicides on rights-of-way is increasing. At the same time, this practice is scrutinized by the public. With more targeted and selective use of herbicides, the management of habitat at a landscape scale is now feasible where it once may have been expensive or beyond the scope of most vegetation management programs. Participants acknowledged that appropriate herbicide use can help enhance and create beneficial habitat, while also noting the importance of understanding the effects of herbicides on pollinators and other sensitive species.

Specific concerns expressed included:

- Use of persistent (i.e., soil residual) herbicides can be problematic when they hinder desirable plant growth, such as when reseeding or relying on existing native plant communities. Participants noted the potential for herbicides to negatively impact plant diversity and restoration efforts if applied without consideration of effects and follow-up.
- Participants recognized the potential for active and inert ingredients in herbicides to negatively impact pollinators, potentially contaminate surface or groundwater, or cause off-target damage. However, participants also noted that herbicides can be an effective tool to support much-needed habitat for pollinators and endangered species.
- Wildfire risks can increase with the spread of invasive species, which can increase fuel loads and create dangerous fire conditions. Participants noted the increasing need to consider wildfire risk when performing vegetation management.
- To maintain internal goals and stakeholder interests related to sustainability, there is increasing pressure for organizations to adopt practices that promote biodiversity, such as using native plants, seed banks, and vegetation management for ecosystem benefits. However, vegetation managers and environmental specialists may not always have the resources or support to effectively implement these goals.

Control Efficacy

Some participants expressed concerns that the control methods being used today may not be sustainable or offer effective long-term management. Vegetation management decisions often must be site-specific, making it difficult to implement standardized, one-size-fits-all practices. Factors such as the type of vegetation, terrain, climate, and proximity to sensitive areas can all impact the effectiveness of control methods.

Some techniques are inherently limited in their ability to provide effective long-term control on their own. For example, mowing is often seen as a temporary solution that only makes vegetation manageable, rather than being effective as long-term control. Similarly, contact herbicides may only provide temporary suppression of perennial weeds, which can resprout from root systems. This suggests that a single treatment or application type may not be sufficient to control all undesirable vegetation.

Treatment efficacy is also heavily determined by the personnel conducting the treatments. Failure to meet management objectives may reflect a lack of training or familiarity with the treatment methods, products or equipment used, or uncertainty about their efficacy. Participants recognized that the results of herbicide applications often depend on the applicator, suggesting that proper training and technique are essential for achieving consistent and effective results.

Participants also noted that herbicide resistance is an increasing concern, as repeated use of the same herbicides can lead to resistant weed populations. This can make future control efforts potentially more difficult and costly. To combat resistance, vegetation managers can use a variety of herbicide mixtures, as well as combine herbicides with mechanical or biological control methods. This adaptive approach helps reduce reliance on a single chemical treatment, slows the development of resistance, and improves long-term management outcomes for right-of-way vegetation.

Regulatory Inconsistencies

Workshop participants identified several layers of regulatory inconsistencies that may cause confusion or complications when conducting vegetation management on rights-of-way. Federal, state, local, and private lands all have site-specific requirements, which can be difficult for practitioners to navigate. For example, a workshop participant described having faced restrictions in applying targeted herbicide treatments for invasive species management on easements on federally owned lands, despite state-level regulations requiring management of said invasive species. Multiple industry partners mentioned difficulties in meeting the specific management requirements for multiple protected species occurring, which can sometimes conflict with one another or present limited windows for vegetation management activities. And one industry partner mentioned wanting to use lower rates of certain chemicals, but unable to due to the need to seek exceptions for diverging from label instructions.

Worker Safety

Participants identified specific safety concerns, including accidents due to equipment usage on steep slopes or unlevel surfaces, long-term exposure to herbicide chemicals, and exposure to noxious plant species. DOT survey respondents most frequently cited worker proximity to traffic as a primary safety concern.

Herbicide treatments can pose health risks to applicators, so it is essential that all personnel are professionally trained and follow specified safety measures. Product labels and safety data sheets (SDS) contain explicit instructions on the correct and safe use of the chemical, including the use of personal protective equipment (PPE), proper application techniques, and other safety protocols. Workshop participants indicated a move away from chemicals that require applicators to wear respirators, both for safety and worker comfort. For example, the use of diuron powder, which necessitates respirator protection, has been limited.

Rights-of-way vegetation managers may prioritize products or application methods with reduced environmental impact, which oftentimes goes hand-in-hand with reducing exposure risks for workers. Herbicides designed for targeted applications can limit the area of exposure and reduce the need for extensive protective gear. Low-toxicity, low-volatility herbicides support worker safety, streamline safety protocols, and enhance overall operational efficiency.

Key Priorities and Needs

Workshop and survey participants were asked to identify their greatest research, education, and policy needs to improve the effectiveness of vegetation management on rights-of-way. Operational priorities often vary by organization and can change over time. The Rights-of-Way as Habitat Working Group supported by NCIPMC has tracked the relevance and importance of habitat conservation to energy and transportation organizations since 2019 through its annual buy-in survey[15]. Results have demonstrated a slight but positive upward trend in organizations adopting habitat conservation practices. Participants' recommendations provided below reflect many of the same priorities indicated by the Rights-of-Way as Habitat Working Group's wider industry survey.

Research

Research needs and priorities identified by participants for energy and transportation sectors included:

- **Industry standard best management practices**, including effective strategies for management of specific species. There is an increasing interest in early detection of emergent populations using technologies.
- **More research on the effectiveness and safety of individual herbicides and application techniques**. This demonstrates overall uncertainty about which herbicides work best and how to apply them for optimal results.
- **Understanding the long-term effectiveness of herbicides** in

Image: Research on Florida Department of Transportation rights-of-way by the University of Florida.

[15] https://rightofway.erc.uic.edu/habitat-buy-in/

managing invasive and other unwanted species, including their success in habitat restoration applications. Several participants highlighted a need to better address herbicide resistance as well as a need for methods that limit off-target effects of herbicide on beneficial vegetation.

- **Long-term studies on the effectiveness of vegetation management practices** are crucial for informing future rights-of-way management strategies. A prime example is Pennsylvania's State Game Lands 33, where over 50 years of research focuses on the long-term impacts of different vegetation management approaches, including herbicide use, grazing, and the restoration of native plant species. Similar studies in other geographic regions would be valuable.
- **Understanding the biodiversity conservation value of energy and transportation lands**, including studies on habitat fragmentation, species migration corridors, and ecosystem services provided by energy and transportation lands, can inform future vegetation management practices.
- **Identifying the potential effects of global weather changes on plant growth and pest dynamics** will help managers prepare for risk management concerns and inform adaptive management strategies.
- **Understand the impacts of a product's potential to negatively impact a protected or sensitive resource,** such as critical habitat, soil biota, or threatened or endangered species.

Education

Education needs and priorities identified by participants for energy and transportation sectors included:

- **Pesticide applicator safety** to ensure that applicators understand the risks and proper handling techniques for herbicides to minimize health and environmental risks. Ongoing training programs cover topics such as personal protective equipment use, safe application methods, and first aid in case of exposure. These topics should continue to be emphasized throughout regular training sessions and within organizational policy and procedures.
- **Application practices and techniques** for new workforce personnel as well as on new or emerging concerns for more experienced workers. This may include practical techniques like "scan before you spray" and worker safety considerations as well as other topics like merging science with traditional ecological knowledge, facilitating landowner engagement, managing for drift, and advanced IVM approaches that blend multiple control methods. Continuing education on technological advances, such as the use of artificial intelligence, light detection and ranging (LiDAR), drones, and geographic information systems (GIS), as well as improved equipment to conduct work more effectively on the ground, can also benefit the industry.
- **Ecological effects of vegetation management practices**, including the long-term consequences of herbicide resistance and the benefits or negative impacts of vegetation management on wildlife. Training related to native plant identification and their ecological importance may help to limit off-target impacts to beneficial species as well as improve management strategies for habitat.

- **Policy implications for vegetation managers** and how they impact organizations and vegetation management practices. Vegetation managers must navigate changing laws, regulations, and policies to ensure compliance while also achieving effective vegetation control. For example, recent changes in USEPA regulations on pesticide application, such as restrictions on certain chemicals through the registration processes, may necessitate adjustments to management plans. Staying up-to-date with regulatory changes is essential to minimizing legal and environmental risks and maintaining the safety and functionality of rights-of-way.

Participants from both sectors also highlighted the need for public and policymaker education to address concerns and misinformation:

- **Understanding herbicides for ecological applications** has been a significant educational hurdle. Participants highlighted that many people believe all uses of herbicides are harmful to the environment and human health without understanding the value of chemical control methods for certain ecological applications. Participants emphasized the need for more public education on the beneficial uses of herbicides and their role in vegetation management.
- **The importance of native plants** in supporting pollinator and other wildlife habitat, while also challenging the perspective that native plantings or habitats are unsightly. Other benefits provided by native plantings, such stormwater management, erosion control, and mitigating risks associated with invasive species, might also be highlighted. Utilization of aesthetic native plants in locations of high public visibility can be a valuable education tool when paired with effective signage.
- **Educational resources for policymakers, regulators, and procurement departments**, who have influence over how vegetation management is implemented. This may include providing introductory courses and other educational materials on best management practices that support habitat. This can help ensure that sufficient resources, effective tools, application techniques, and qualified contractors are prioritized for habitat-focused management projects.
- **Educating private landowners** on vegetation management methods, noxious and invasive species, conservation efforts, and regulatory requirements could support more cooperative relationships between vegetation managers and underlying and adjacent landowners on rights-of-way.

Participants noted that education can take many forms, including formal training curricula, webinars and publications, fact sheets, and other informational formats.

Policy

Policy needs and priorities identified by participants for energy and transportation sectors included:

- **Creating incentives to prioritize IVM methods, habitat conservation, and invasive species control** could improve vegetation managers' ability to address environmental and social objectives. This need was embodied in several recommendations:
    - Formal government agency support or mandates for IVM methods to streamline coordination with federal land managers at the local level. Participants also

suggested better coordination between federal agencies on vegetation management on federal lands would ease implementation challenges for rights-of-way vegetation managers.
    - Federal and state agency recognition of voluntary commitments, such as the Right-of-Way Stewardship Council accreditation or participation in the nationwide monarch butterfly conservation agreement (i.e., Monarch CCAA), by streamlining regulatory requirements and/or approval timelines.
    - Policies that promote the use of native plants and seed mixes. Existing post-construction standards for stormwater erosion and sedimentation control incentivize fast-establishing (often non-native) vegetation that is in conflict with other land management objectives (e.g., establishing long-term biological control).
    - Availability of a range of chemical products on the market to manage invasive species and other unwanted vegetation on rights-of-way. Participants expressed concern about the limited number of available herbicides for effective vegetation control and addressing aggressive invasive plants. If any are removed from use via registration restrictions, it could have a sizeable impact on the efficacy of rights-of-way vegetation management.
- **Expand restrictions prohibiting the sale of invasive plant species.** The use of invasive plant species for ornamental or other vegetation purposes contributes to the spread of these species, some of which are incompatible with rights-of-way operations or negatively impact the surrounding environment and ecosystem.
- **Continue to work within existing regulations to balance herbicide use with other regulatory priorities.** The regulatory landscape for rights-of-way vegetation management is shaped by several important policy frameworks, including the Endangered Species Act (ESA). The ESA requires careful consideration of the potential impacts of herbicide applications and other vegetation management practices on threatened or endangered species and their habitats. However, participants noted that at times they have found herbicide policies to unnecessarily restrict the use of herbicides for habitat restoration activities that would benefit at-risk species. Recently the EPA published updated regulations on pesticide and herbicide use and are considering pest management on rights-of-way in 2025.
- **Develop policies related to the use of new technologies,** such as autonomous vehicles, drones, and new herbicide formulations. As new technologies are developed, the industry will continue to navigate their use on private property and federal lands. Delays in policies regarding new technologies can stifle innovation and lead to incongruent policies across land management authorities.

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Appendices

Appendix 1 Engagement Plan – Sent 2023

Summary

Pest Management Strategic Plans (PMSPs) provide a conduit for communicating with regulators, grantors, and others about current pest or vegetation management issues, management practices (both chemical and non-chemical) used in the field and those under development, and related priorities for research, regulation, and education. These plans are typically developed by industry stakeholders, researchers, consultants/contractors, and others and may have a state, region, or national focus. PMSPs for non-agricultural settings address the unique pest (or vegetation) management conditions and challenges of the particular setting, in this case, on energy and transportation rights-of-way.

The U.S. Environmental Protection Agency (USEPA) often references PMSPs when registering pesticides or making related policy, research, or education decisions; however, they typically will not use the information if it is more than 5 years old. The last Rights-of-Way PMSP was completed in 2003. Therefore, we would like to update the Rights-of-Way PMSP with the latest information on vegetation management practices on energy and transportation right-of-way; weeds or other species of concern; critical herbicide uses; alternative, non-chemical management practices; research, education, and regulatory needs; and emerging opportunities like pollinator and biodiversity conservation.

Scope of Review

We will be convening two groups (representatives from the transportation industry and from the energy industry) to meet to discuss weed problems, herbicides, and techniques commonly used to control them. Participants will spend a half day together, reviewing the draft PMSP which will cover weeds of concern, herbicides for residual weed control, short-term control, and non-chemical methods, as well as methods for supporting native pollinator habitat. Department of transportation (DOT) representatives will be convened remotely, and energy sector representatives will meet in-person for half a day at the Trees & Utilities conference. Both sets of feedback and comments will be aggregated and refined into a final PMSP.

List of Potential Participants

Participants invited to join the PMSP review are selected for their knowledge of vegetation management on rights-of-way and expertise in herbicide treatments at their organizations. Participants include vegetation management specialists for energy and transportation organizations, contractors, suppliers, consultants, educators, researchers, and representatives from the Office of Pest Management Strategy (USDA) and the USEPA to ensure a wide variety of experience and expertise.

North Central IPM Center

This work is supported by the USDA National Institute of Food and Agriculture, Crop Protection and Pest Management Program through the North Central IPM Center (2018-70006-28883).

UIC ROW HWG

	DOT Cohort	Energy Cohort
1.	Arizona DOT	Ameren
2.	CalTrans	Arbormetrics
3.	Colorado DOT	ComEd
4.	Florida DOT	Duke Energy
5.	Idaho Transportation Department	East Central Energy
6.	Illinois Tollway	Evergy
7.	Indiana DOT	FirstEnergy
8.	Louisiana DOT	IVM Partners
9.	Minnesota DOT	Liberty Utilities
10.	New York State DOT	National Grid
11.	Ohio DOT	NiSource
12.	Texas DOT	Nutrien Solutions
13.	University of Nebraska	New York Power Authority
14.	Vermont Agency of Transportation	PECO
15.		Penn State University
16.		Sacramento Municipal Utility District
17.		The Ohio State University
18.		Xcel Energy

Timeline

April 25, 2023 – Send out preliminary DOT survey

May 5, 2023 – Receive survey results and analyze feedback

May 8-26, 2023 – Draft PMSP and plan remote DOT meeting

May 31, 2023 - Host remote DOT meeting

July 25, 2023 – Send out preliminary utility survey

August 5, 2023 – Receive utility survey results and analyze feedback

September 11-12, 2023 - Host in-person utility meeting

North Central IPM Center

This work is supported by the USDA National Institute of Food and Agriculture, Crop Protection and Pest Management Program through the North Central IPM Center (2018-70006-28883).

UIC ROW HWG

Appendix 2 DOT Agency Survey Questions

Pest Management Strategy Survey for Departments of Transportation (DOTs)

Start of Block: General Information/Background

The Rights-of-Way as Habitat Working Group is working with the North Central Integrated Pest Management Center to update the Rights-of-Way Pest Management Strategic Plan (PMSP), a document used to communicate with regulators, grantors, and other key stakeholders about current vegetation management issues on energy and transportation rights-of-way, management practices (both chemical and non-chemical) used in the field and under development, and related priorities for research, regulation, and education. We appreciate your input on these topics, in particular, your experience managing problematic, undesirable and or/non-compatible vegetation on rights-of-way. Your responses will be aggregated with others, identifying information will be removed, and the compiled feedback will be used by a small working group to update the previous PMSP that was last updated in 2003. If you have any questions about this survey, please contact Caroline Hernandez at the University of Illinois Chicago at cah272@uic.edu.

1. Name
2. Organization
3. Position Title
4. Email Address
5. How many years of experience do you have in roadside vegetation management?

0 5 9 14 18 23 27 32 36 41 45 50

Use the slider to indicate number of years ()	

6. In which state(s) do you have experience managing roadside vegetation?
7. Approximately how many miles of roadsides does your organization currently manage or maintain?
8. Approximately how many acres does that equate to?

End of Block: General Information/Background

Start of Block: Current Practices

9. What vegetation management practices does your organization currently employ? (select all that apply)
   - Herbicide treatments
   - Mowing, cutting, and/or other mechanical removal
   - Hand removal)
   - Prescribed burning
   - Grazing
   - Seeding/planting of desirable or beneficial species
   - Habitat management practices
   - Other

Display This Question:

If What vegetation management practices does your organization currently employ? (select all that ap... = Other

10. Describe the 'other' vegetation management practices your organization currently employs.

Display This Question:

If What vegetation management practices does your organization currently employ? (select all that ap... = Herbicide treatments

11. What methods of herbicide application does your organization currently employ? (select all that apply)
    - Aerial spray - broadcast
    - Aerial spray - spot treatment
    - Ground broadcast spray - foliar
    - Ground broadcast spray - cut stubble
    - Hydraulic spray - broadcast
    - Hydraulic spray - spot treatment
    - Basal bark individual plant treatment
    - Cut-stump individual plant treatment
    - Cut-surface individual plant treatment
    - Dormant stem treatment
    - Low-volume or ultra-low-volume foliar treatment
    - Other

Display This Question:

If What methods of herbicide application does your organization currently employ? (select all that a... = Other

12. Describe the 'other' herbicide application practices your organization currently employs

Display This Question:

If What vegetation management practices does your organization currently employ? (select all that ap... = Herbicide treatments

13. What herbicide products (if any) do you consider “critical” for effective management of undesirable vegetation on your organization’s rights-of-way?
14. What species present the greatest concerns or challenges on your organization’s rights-of-way (i.e., problematic weeds or other undesirable vegetation)?
15. What specific management practices do you currently employ to treat these species? Q16 Are there other management practices you are considering or that are under development to address these species? If yes, please describe.
16. What are your greatest concerns related to the management of undesirable vegetation on your organization’s rights-of-way? (select all that apply)
    - Employee or contractor safety when performing management practices
    - Environmental impacts of management practices (i.e., to water quality, wildlife, or desirable plant species)
    - Public perception or acceptance of management practices
    - Efficacy of management practices to treat undesirable species (e.g., herbicide resistance)
    - Cost of management practices to treat undesirable species

- Spread of undesirable vegetation to/from adjacent lands
- Regulatory restrictions or limitations on use of certain management practices
- Other

Display This Question:

If What are your greatest concerns related to the management of undesirable vegetation on your organ... = Other

17. Describe the 'other' concerns related to the management of undesirable vegetation.
18. Are there any current concerns with worker safety related to vegetation management activities (e.g., chemical exposure, other risks)? If so, briefly describe.

End of Block: Current Practices

Start of Block: Future Practices

19. What do you think are the greatest **research** needs related to the management of undesirable vegetation on rights-of-way?
20. What do you think are the greatest **education** needs related to the management of undesirable vegetation on rights-of-way? Please specify if the needs relate specifically to roadside managers, contractors, the public, or others.
21. What do you think are the greatest **policy** needs related to the management of undesirable vegetation on rights-of-way? Please specify if the needs relate specifically to roadside managers, contractors, the public, or others.
22. What do you think are the most exciting or promising opportunities related to vegetation management on rights-of-way (either related to the management of undesirable vegetation and/or beneficial vegetation, e.g., pollinator habitat)?
23. Is there anything else you'd like to share?

Appendix 3 Energy Company Survey Questions

Pest Management Strategy Survey for Utilities

Start of Block: General Information/Background

The Rights-of-Way as Habitat Working Group is working with the North Central Integrated Pest Management Center to update the Rights-of-Way Pest Management Strategic Plan (PMSP), a document used to communicate with regulators, grantors, and other key stakeholders about current vegetation management issues on energy and transportation rights-of-way, management practices (both chemical and non-chemical) used in the field and under development, and related priorities for research, regulation, and education. We appreciate your input on these topics, in particular, your experience managing problematic or undesirable vegetation on rights-of-way. Your responses will be aggregated with others, identifying information will be removed, and the compiled feedback will be used by a small working group to update the previous PMSP that was last updated in 2003. If you have any questions about this survey, please contact Caroline Hernandez at the University of Illinois Chicago at cah272@uic.edu.

1. Name
2. Organization
3. Position Title
4. Email Address
5. How many years of experience do you have in right-of-way vegetation management?

0 5 9 14 18 23 27 32 36 41 45 50

Use the slider to indicate number of years ()	

6. In which state(s) do you manage right-of-way vegetation?
7. Approximately how many miles of right-of-way does your organization currently manage or maintain?
8. Approximately how many acres does that equate to?

End of Block: General Information/Background

Start of Block: Current Practices

9. What vegetation management practices does your organization currently employ? (select all that apply)
   - Herbicide treatments
   - Mowing, cutting, and/or other mechanical removal
   - Hand removal
   - Prescribed burning
   - Grazing
   - Seeding/planting of desirable or beneficial species
   - Habitat management practices
   - Other _____

10. What species present the greatest concerns or challenges on the rights-of-way or working lands your organization managers (i.e., problematic weeds or other undesirable vegetation)? Select all that apply
11. What species present the greatest concerns or challenges on the rights-of-way or working lands your organization managers (i.e., problematic weeds or other undesirable vegetation)? Select all that apply
12. What species present the greatest concerns or challenges on the rights-of-way or working lands your organization managers (i.e., problematic weeds or other undesirable vegetation)? Select all that apply

Aquatic weeds Aster, daisy (Leguminosae spp.)	Aster, daisy (Asteraceae) Annual, biennial, or perennial	Autumn olive (Elaeagnus umbellata)
Bermudagrass (Cynodon spp.) Perennial grass	Black locust (Robinia pseudoacacia) Tree	Blue mustard (Chorispora tenella)
Brome (Bromus spp.) Perennial grass	Buckthorn (Frangula) Tall shrub or small tree	Buffelgrass (Cenchrus ciliaris) Perennial grass
California manroot (Marah fabaceus)	Callery pear (Bradford pear) (Pyrus calleryana) Tree	Canada thistle (Cirsium arvense) Perennial
Cattail (Typha spp.) Perennial	Cogongrass (Imperata cylindrica) Perennial grass	Common tansy (Tanacetum vulgare)
Cottonwood & popple (populus deltoides) tree	Crown vetch Cutleaf teasel	Cutleaf teasel (Dipsacus laciniatus) perennial
Dalmatian toadflax (Linaria dalmatica)	Dandelion (Taraxacum spp.) Perennial broadleaf	Dyer's woad (Isatis tinctoria) winter annual, biennial or perennial,
Eastern red cedar (Juniperus virginiana) tree	Foxtail (Alopecurus spp.) Annual grass	Foxtail (Setaria spp.) Annual grass
French broom (Genista monspessulana) perennial shrub	Garlic mustard (Alliaria petiolate) biennial	Giant hogweed (Heracleum mantegazzianum) Perennial broadleaf
Golden bamboo (Phyllostachys aurea)	Grecian foxglove (Digitalis lanata)	Himalayan blackberry (Rubus armeniacus)
Itchgrass (Rottboellia cochinchinensis) Annual grass	Japanese honeysuckle (Lonicera japonica) Perennial vine that is deciduous in northern climates but often evergreen in warmer areas	Japanese knotweed (Fallopia japonica & Polygonum spp., Reynoutria japonica) perennial
Japanese stiltgrass (Microstegium vimineum) annual grass	Johnsongrass (Sorghum halepense) Perennial grass	Jointed goatgrass (Aegilops cylindrica) Winter annual grass
Kochia (Kochia scoparia) Annual	Kudzu (Pueraria montana var. lobata) Perennial vine	Leafy spurge (Euphorbia esula) Perennial
Marestail (Hippuris vulgaris) Annual to biennial	Morning glory & bindweed (Convolvulaceae spp.) perennial	Mulberry (Morus) Tre
Musk thistle (Carduus nutans) Biennial	Mustard (Brassica spp.) Annual broadleaf	Oriental bittersweet (Celastrus orbiculatus) perennial woody vine
Palmer amaranth (Amaranthus palmeri) Annual broadleaf	Paulownia (Paulownia) tree	Phragmites, common reed (Phragmites australis)
Poison hemlock (Conium) Biennial	Prickly lettuce (Lactuca serriola)	Purple loosestrife (Lythrum salicaria)
Ragweed – giant (Ambrosia trifida) Annual broadleaf	Ragweed (Ambrosia spp.) Annual broadleaf	Reed canarygrass (Phalaris arundinacea) Perennial
Rough-leaf dogwood (Cornus drummondii) shrub or small tree	Rush skeletonweed (Chondrilla juncea) perennial (58)	Russian thistle (Salsola tragus) Annual broadleaf (59)

Scotch broom (Cytisus scoparius)	Silvergrass (Miscanthus capensis) Perennial grass	Silverleaf nightshade (Solanum elaeagnifolium) Perennial broadleaf
Spotted knapweed (Centaurea spp) perennial	Sunflower (Helianthus annuus) Annual broadleaf	Thistle (Cirsium spp.) Perennial
Tree-of-heaven (Ailanthus altissima) Woody tree	Wild parsnip (Pastinaca sativa) Biennial/perennial	Wild rose (Rosaceae spp) woody perennial
Wild teasel or fuller's teasel (Dipsacus fullonum) biennial or short-lived perennial	Willow (Salix spp.) Tree	Wisterias (Wisteria) woody vine
Yellow starthistle (Centaurea solstitialis) Annual or biennial	Yellow toadflax (Linaria vulgaris	

13. What herbicide products (if any) do you consider necessary for effective management of undesirable vegetation on the rights-of-way and working lands your organization manages and how effective are they?
    Options: Excellent Good Fair Poor No control Unknown

2,4-D, 2-ethylhexyl ester; 2,4-D LV6; 2,4-D LV4; Lo-Vol 4 2,4-D;	2,4-D choline; Freelexx	2,4-Dichlorophenoxyacetic acid, alkanolamine salt (of the ethanol and isopropanol series); 2,4-D Amine;
3-Pyridinecarboxylic acid, 2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-5-methyl-, monoammonium salt, (. +-.)-; Imazapic (Plateau)	4-Pyrimidinecarboxylic acid, 6-amino-5-chloro-2-cyclopropyl-, monopotassium salt; May be same as acp?	Aminocyclopyrachlor; Method
Aminopyralid; Milestone=aminopyralid; Opensight = Aminopyralid+Escort;	Aminopyralid-tripromine; Gunslinger, NativeKlean, Whetstone	Imazapyr; Arsenal, Habitat, Polaris, Stalker
Clopyralid; Sonora, Transline	Dithiopyr; Dithiopyr, Dimension	Metsulfuron-methyl; Escort
Florpyrauxifen-benzyl; Terravue - mix with aminopyralid (Rinskor is AI)	Fluroxypyr; Comet, Stark Ultra, Vista	Glyphosate; Glyphosate, Buccaneer, Landmaster, Ranger Pro, Razor, Roundup, Makaze, Roundup Custom, Pro COncentrate
Imazapic; Imazapic - combine with plateau	Indaziflam; Esplanade	Isoxaben; Isoxaben
MSMA; MSMA	Oryzalin; Oryzalin, Surflan	Pendimethalin; Stomp, Pendulum Aquicap
Sodium dichloroisocyanurate dihydrate; Chlorox zero splash	Sulfentrazone; Sulfentrazone, Portfolio RF	Sulfometuron methyl; Sulfosulfuron, Outrider, Landmark XP
Sulfosulfuron; Sulfosulfuron, Outrider	Triclopyr amine; Garlon 3A	Triclopyr choline; Vastlan - replacement for 3A
Garlon 4	Triclopyr, butoxyethyl ester; pathfinder 2 (RTU), Garlon 4?	Diuron; sprakil26

Tebuthiuron; Spike	Fusalade DX	E2 - mixed product
Dicamba	Picloram; Tordon, Graslan L, Grazon	Chlorsulfuron; Telar
Other		

Display This Question:

If What vegetation management practices does your organization currently employ? (select all that ap... = Herbicide treatments

14. What methods of herbicide application does your organization currently employ? (select all that apply)
    - Aerial spray - broadcast
    - Aerial spray - spot treatment
    - Ground broadcast spray - foliar.
    - Ground broadcast spray - cut stubble.
    - Hydraulic spray - broadcast
    - Hydraulic spray - spot treatment
    - Basal bark individual plant treatment
    - Cut-stump individual plant treatment.
    - Cut-surface individual plant treatment.
    - Dormant stem treatment
    - Low-volume or ultra-low-volume foliar treatment
    - Other _____

15. What are your greatest concerns related to the management of undesirable vegetation on the rights-of-way your organization manages? (select all that apply)
    - Employee or contractor safety when performing management practices.
    - Environmental impacts of management practices (i.e., to water quality, wildlife, or desirable plant species)
    - Public perception or acceptance of management practices
    - Efficacy of management practices to treat undesirable species (e.g., herbicide resistance)
    - Cost of management practices to treat undesirable species
    - Spread of undesirable vegetation to/from adjacent lands
    - Regulatory restrictions or limitations on use of certain management practices
    - Other _____
16. Are there any current concerns with worker safety related to vegetation management activities (e.g., chemical exposure, other risks)? If so, briefly describe.

End of Block: Current Practices

Start of Block: Future Practices

17. What do you think are the greatest **research** needs related to the management of undesirable vegetation on rights-of-way?

18. What do you think are the greatest **education** needs related to the management of undesirable vegetation on rights-of-way? Please specify if the needs relate specifically to right-of-way managers, contractors, the public, or others.
19. What do you think are the greatest **policy** needs related to the management of undesirable vegetation on rights-of-way? Please specify if the needs relate specifically to right-of-way managers, contractors, the public, or others.
20. What do you think are the most exciting or promising opportunities related to vegetation management on rights-of-way (either related to the management of undesirable vegetation and/or beneficial vegetation, e.g., pollinator habitat)?
21. Is there anything else you would like to share?

End of Block: Future Practices

Appendix 4 Participants and Contributors

Participant names and organizations are included below to acknowledge their contributions. This PMSP would not have been possible without their valuable input.

4.1 DOT survey participants:

Name	Organization
Dustin Hathaway	Arizona Department of Transportation
Conrad	California Transportation Department
Ken Murray	California Transportation Department
Luz Quinnell	California Transportation Department
Stephanie Ponce	California Transportation Department
Benjamin Reynoso	Chicago Department of Transportation
Kenneth Howlett	Colorado Department of Transportation
Pamela Cornelisse	Colorado Department of Transportation
Felicity Davis	Georgia Department of Transportation
Alissa Salmore	Idaho Transportation Department
Cathy Ford	Idaho Transportation Department
Ryan Burgin	Idaho Transportation Department
Brittany Gavin	Illinois Department of Transportation
Kimberly Burkwald	Illinois Department of Transportation
David Zaya	University of Illinois Chicago on behalf of Illinois Department of Transportation
Phil Cassman	Illinois Tollway
Matt Kraushar	Indiana Department of Transportation
Kory Johnson	Itasca County Transportation Department
Chris Henze	Johnson County Secondary Road Department
Ryan Duhon	Louisiana Department of Transportation
Ben Hoskinson	Mahaska County Roadside Management
Austin	McHenry County Department of Transportation
Carla Ahlschwede	Michigan Department of Transportation
Tina Markeson	Minnesota Department of Transportation
Brian Schyvinck	Missouri Department of Transportation
Mark Aufdenberg	Missouri Department of Transportation
Michael McCormick	Missouri Department of Transportation
Joe Demko	Pennsylvania Department of Transportation
Rachel Owens Zerby	Pennsylvania Department of Transportation
Ryan Succheralli	Pennsylvania Department of Transportation
Brian Burkholder	Scott County Secondary Roads Department
Amanda Fowler	Texas Department of Transportation
Gabbie Craft	Texas Department of Transportation
Travis Jez	Texas Department of Transportation
Briana Craven	TRC Companies
Craig DiGiammarino	Vermont Agency of Transportation
Andy Mason	Virginia Department of Transportation
William Lewis	Virginia Department of Transportation
Jennifer Gibson & Christa Schaefer	Wisconsin Department of Transportation

4.2 Energy sector survey participants:

Name	Organization
Jennifer Queen	Ameren
Kevin Patton	American Electric Power
Colby Tisdale	ArborMetrics (Contractor for Columbia Gas)
Tom Hollingsworth	ArborMetrics (Contractor for Columbia Gas)
Trent W Ausherman	ArborMetrics Solutions LLC
Casey Shepard	Arkansas Electric Cooperative Corporation
Kelvin Limbrick	ComEd
Connie Oslica	Energy Transfer
Geoff Vossen	Evergy
Geoffrey Weyburne	FirstEnergy
Michele Dellinger	FirstEnergy
Marie Maiuro	FirstEnergy
Matt Goff	Georgia Power Company
Byron Johnson	Great River energy
Marsha Parlow	Great River Energy
Jared Murphy	Hoosier Energy
Richard Johnstone	IVM Partners, Inc.
Jason Grossman	Liberty Utilities
Scott Sharpe	Marathon Pipeline
Dan Young	National Fuel
Todd Rockwell	National Grid
Lewis Payne	New York Power Authority
Steve Barker	NIPSCO
Travis Rogers	Nutrien Solutions
Mark Beamish	Orange and Rockland Utilities
Stephen Benn	Pepco Holdings, Inc
Eric Brown	Sacramento Municipal Utility District
Ronan Mason	TC Energy
Will Sanders	Tennessee Valley Authority
Dave Clapham	Unitil
Mark Embach	Utility Lines Construction Services
Jeffrey Disorda	Vermont Electric Power Company

4.3 DOT workshop participants:

Name	Organization
Dustin Hathaway	Arizona Department of Transportation
John Orloski	Environmental Protection Agency
James Oliver	Florida Department of Transportation
Cathy Ford	Idaho Transportation Department
Matt Kraushar	Indiana Department of Transportation
Ryan Duhon	Louisiana Department of Transportation
Tina Markson	Minnesota Department of Transportation
Carl Kochersberger	New York State Department of Transportation
Christine Colley	New York State Department of Transportation
Peter Dunleavy	New York State Department of Transportation
Joel Hunt	Ohio Department of Transportation
Joseph Demko	Pennsylvania Department of Transportation
Jennifer Weisbrod	University of Nebraska Lincoln
Claire Paisley- Jones	U.S. Department of Agriculture Office of Pest Management
Clayton Myers	U.S. Department of Agriculture Office of Pest Management
Elyssa Arnold	U.S. Department of Agriculture Office of Pest Management
Julie Val Alstine	U.S. Department of Agriculture Office of Pest Management
Michelle Ranville	U.S. Department of Agriculture Office of Pest Management
Sean Sweeney	U.S. Fish and Wildlife Service
Jennifer Weisbrod	University of Nebraska Lincoln Pesticide Safety Education Program
Bonnie Donahue	Virginia Transportation Department

Meeting Hosts:

Lynnae Jess, North Central Integrated Pest Management Center
Laura Iles, North Central Integrated Pest Management Center
Kelsey Mueller, North Central Integrated Pest Management Center
Caroline Hernandez, University of Illinois Chicago

4.4 Energy sector workshop participants:

Name	Organization
Tom Hollingsworth	ArborMetrics Solutions LLC
Trent W Ausherman	ArborMetrics Solutions LLC
Kelvin Limbrick	ComEd
Stan Vera-Art	Grow with Trees
Rick Johnston	IVM Partners
Jason Grossman	Liberty Utilities
Lewis Payne	New York Power Authority
Susan Murray	NiSource / Columbia Gas
Travis Rogers	Nutrien Solutions
Carolyn Mahan	Penn State University
Eric Brown	Sacramento Utility District
Cameron Douglass	U.S. Department of Agriculture Office of Pest Management
Colby Marshal	Vermont Electric Power Company
Devon Snyder	Vermont Electric Power Company
Jordan Harris	Vermont Electric Power Company

Meeting Hosts:

Lynnae Jess, North Central Integrated Pest Management Center
Laura Iles, North Central Integrated Pest Management Center
Kelsey Mueller, North Central Integrated Pest Management Center

Robin Boudwin, Center for Integrated Pest Management, North Carolina State University
Caroline Hernandez, University of Illinois Chicago

Iris Caldwell, University of Illinois Chicago

Appendix 5 PMSP Workshop Agendas

Pest Management Strategic Plan DOT Workshop Agenda

May 31, 2023

* All times are in CT

Time	Agenda
10:00 AM	Welcome & Introductions
10:15 AM	Weeds
10:30 AM	Controls & efficacy
12:30 PM	Lunch break
12:50 PM	Priorities
1:30 PM	Break
1:35 PM	Worker activities, cultural practices, timelines
2:20 PM	Final priority review
2:40 PM	Final remarks and recap of follow-ups

North Central IPM Center

This work is supported by the USDA National Institute of Food and Agriculture, Crop Protection and Pest Management Program through the North Central IPM Center (2018-70006-28883).

Pest Management Strategic Plan Energy Sector Workshop Agenda

September 12, 2023

* All times are in CT

Time	Agenda
9:00 AM	Welcome & introductions
9:15 AM	Weeds
9:30 AM	Controls & efficacy
10:45 AM	Break
11:00 AM	Worker activities, cultural practices, timelines
11:35 AM	Priorities
12:10 AM	Final priority review
12:30 AM	Final remarks and recap of follow-ups

North Central IPM Center

UIC ROW HWG

This work is supported by the USDA National Institute of Food and Agriculture, Crop Protection and Pest Management Program through the North Central IPM Center (2018-70006-28883).

Appendix 6 Commonly Used Chemicals

Consistent with other PMSPs, workshop participants were asked to rate herbicides and their effectiveness in control using a qualitative scale of Excellent, Good, Fair, Poor, and Unknown. Many herbicides are used for specific control purposes and target species. The table below highlights the percent of industry participants that noted a favorable perception (i.e., either as Excellent or Good) of specific herbicides and their effectiveness based on user experience and context. Because herbicides are selected for specific target species, modes of action, site conditions, and management objectives, these ratings should not be considered a comparison of effectiveness relative to other herbicide formulations.

Based on responses provided, participants named various triclopyr, imazapyr, glyphosate, and aminopyralid as the most favorable herbicides in the energy sector. Chemicals were initially identified by DOT survey and workshop participants as most often used, then energy sector participants were asked to indicate chemical favorability in their survey.

Herbicides by Control Favorability Rating (based on Energy Sector Survey Responses)

Herbicide (Product Name)	Percentage of Respondents Noting a Favorable Rating[16]	Number of Survey Responses
Triclopyr, butoxyethyl ester (Garlon 4)	97%	23
Triclopyr amine (Garlon 3A)	95%	21
Imazapyr (Arsenal, Habitat, Polaris, Stalker)	92%	25
Glyphosate (Buccaneer, Landmaster, Ranger Pro, Razor, Roundup, Makaze, Roundup Custom, Pro Concentrate)	88%	25
Aminopyralid (Milestone=aminopyralid; Opensight = Aminopyralid+Escort)	88%	25
Metsulfuron-methyl (Escort)	79%	19
Triclopyr choline (Vastlan - replacement for 3A)	78%	23
Aminocyclopyrachlor (Method)	68%	22
Indaziflam (Esplanade)	44%	18
Imazapic (Plateau)	33%	15

[16] Favorable is considered a relative rating of either “Excellent” or “Good.”

Appendix 7 Weeds of Concern

Participants identified a variety of invasive plant species as presenting the "greatest concern or management challenge." Energy sector survey participants most frequently identified the tree of heaven (*Ailanthus altissima*) as a problematic species (22 respondents), with the autumn olive (*Elaeagnus umbellate*) and the willow (*Salix* spp.) tied as the second most identified species of concern (17 respondents selecting each). DOT survey participants most frequently identified teasel (*Dipsacus* spp.) (4 respondents) as being of concern, followed by poison hemlock (*Conium maculatum)*, Japanese knotweed (*Reynoutria japonica*), wild parsnip (*Pastinaca sativa*), johnsongrass (*Sorghum halepense*), and invasive phragmites (*Phragmites australis*) (3 respondents each). Overall, energy sector representatives identified tree and shrub species as being a higher management concern/challenge than DOT representatives.

The table below summarizes participant responses on common management methods used for targeted species.

Common Management Methods by Vegetation Type

Vegetation Type	Examples of Targeted Species	Examples of Common Management Methods
Trees, Bushes, and Other Woody Species	Buckthorn, European honeysuckle, bush honeysuckle, autumn olive, tree of heaven, Callery/Bradford pear, black or yellow locust, Norway maple, Japanese barberry, Sassafras albidum,	- Herbicide applications: Basal bark treatment, cut-stump treatment, hack-and-squirt, low-volume foliar spray. - Forestry mowing or manual removal (chainsaws, weedwhackers, etc.), often paired with herbicide application. - Grazing of suitable saplings or brush
Herbaceous Plants/Forbs	Japanese knotweed, purple loosestrife, Canada thistle, spotted knapweed, teasel, garlic mustard, leafy spurge, wild parsnip	- Herbicide applications: Backpack sprayer/spot spraying, broadcast application of widespread invasions - Seasonal mowing to prevent growth/seeding. - Hand-pulling if suitable (particularly in ecologically sensitive areas) - Grazing or biological control with appropriate species/situations
Grasses	Johnsongrass, cogon grass, reed canary grass, invasive phragmites (common or giant reed), cheatgrass, buffelgrass	- Herbicide applications: Backpack sprayer/spot spraying, broadcast application of widespread invasions, hand wicking within smaller populations or ecologically sensitive areas - Seasonal mowing to prevent growth/seeding. - Manual removal of seedheads within ecologically sensitive areas - Grazing where applicable
Woody Vines	Kudzu, trumpet vine, grape vine, mile a minute (carrot thumb), Virginia creeper,	- Herbicide applications: Cut-stump treatment, hack-and-squirt, low-volume foliar spray.

	poison ivy, poison oak, oriental bittersweet, Japanese hopvine	- Similar treatment or management methods as woody species but may require different seasonal timing
Aquatic and Wetland Plants	Invasive phragmites (common or giant reed), purple loosestrife, narrow-leaf or hybrid cattail, water hyacinth, European frogbit	- Herbicide applications: Spot treatments or broadcast spray of large-scale invasions; must ensure herbicides are specified for use within aquatic environments and follow label instructions closely. - Mowing or mechanical removal to prevent seasonal growth of shoreline populations; mechanical boat harvest of floating species. - Flooding of submerged populations - Hand-pulling or manual removal of seedheads within ecologically sensitive areas - Biological control with appropriate species