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How Engineers and Roadside Vegetation Managers Maintain Roadside Vegetation in Iowa, USA

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Abstract

Recently the value of roadside vegetation as habitat for pollinators has gained increased attention, particularly in areas dominated by agriculture where there is little native vegetation available. However, many factors, including safety, cost, public perception, erosion control, and weedy plants must be considered when managing roadside vegetation. Although their decisions influence thousands of hectares of public rights-of-way, how engineers and roadside managers maintain roadside vegetation has been the subject of little research. In this study, we surveyed county engineers and roadside managers who manage vegetation along secondary roads in Iowa, USA to assess how they maintain roadside vegetation. Some counties employ roadside managers, who often have an environmental sciences background, to implement the on-the-ground management of roadside vegetation, while some counties use other staff. Compared to engineers, roadside managers more strongly agreed that using the ecological principles of integrated roadside vegetation management (IRVM) provided environmental benefits. Engineers in counties with a roadside manager more strongly agreed that IRVM practices reduce the spread of invasive species and provide attractive roadsides. Both engineers and roadside managers mentioned challenges to managing roadside vegetation, including interference with some native plantings by adjacent landowners, and ranked safety and soil erosion concerns as the highest priorities when making decisions. Four in ten roadside managers said their counties had protected native plant community remnants on secondary roadsides. Our findings can inform conservation outreach efforts to those responsible for managing roadside vegetation, and emphasize the importance of addressing safety and soil erosion concerns in roadside research and communications.

Keywords Roadsides · Roadside revegetation · Integrated roadside vegetation management · Roadside managers · Engineers · Pollinators

Introduction

Roads department personnel often manage roadside vegetation mainly for safety and weedy plant removal. Safety is understandably a main priority. For visibility, shorter vegetation is more suitable for the level clear zone (the portion of the roadside closest to the road), or near intersections, driveways, and structures in the roadside (Eck and McGee 2008; Federal Highway Administration 2017). Agencies are also legally obligated to remove weeds that spread along roadsides and are designated as noxious by government agencies.

However, comprehensive roadside management focuses on more than reducing undesirable plants. It encourages the growth of desirable plants that provide safety, erosion control, and environmental benefits. Taller native vegetation can be appropriate on the foreslope, bottom, and backslope of the ditch (Brandt et al. 2015). These plants can provide safety benefits in the winter by reducing snow glare and controlling snow drifts (Forman et al. 2003).

Because drivers are drowsier when roadside scenery is monotonous (Thiffault and Bergeron 2003), different types of roadside plants may also increase driver alertness,

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reducing crash rates (Mok et al. 2006). Moreover, herbaceous grassland roadside vegetation provides a softer landing to slow down vehicles that leave the road compared to grass that is mowed short (Harper-Lore et al. 2008).

Native plants with deep roots can reduce erosion by increasing slope stability on steep slopes (Forman and Alexander 1998; Stokes et al. 2009; Rahardjo et al. 2014). In the Midwestern United States, the dense, fine root systems typical of tallgrass prairie grasses are more effective at binding soil compared to coarse root systems (Loades et al. 2010). The dense root systems also increase organic matter in the soil (Li et al. 2021); calculations of the universal soil loss equation indicate that increasing soil organic matter from 1 to 3 percent can reduce erosion by 20 to 33 percent (Funderburg 2001).

The most appropriate plants for a given site depends on site conditions such as soil type, climate, and erosion hazard (Gray and Sotir 1996; Brandt et al. 2015). The type of roadside vegetation also plays an important role in water infiltration. More than 30% of a watershed may directly drain into the roadside ditch system (Buchanan et al. 2013; Schilling et al. 2018). Roadside vegetation may improve water quality. One Iowa study found northeastern Iowa roadside ditches reduced NO3-N concentration in similar amounts as wetlands (0.2 to 0.4 g/m^2/day) (Schilling et al. 2018). Initial research indicates the type of vegetation, e.g., warm-season or cool-season grasses, do not appear to significantly differ in their effect on water quality, although further research is recommended (Schilling et al. 2018; Boger and Ahiablame 2019).

While the cost of native prairie plant seed is more than that of non-native Eurasian grasses, over the long term, investment in native prairie plants can save roads departments money on establishment because they do not require nitrogen and phosphorous fertilizer to become established (Hillhouse et al. 2018). While they may require regular mowing during the first year to reduce weed competition, once established, native plants require less mowing and are effective at outcompeting weeds (Smith 2004; Hillhouse et al. 2018). Reduced mowing can save operational costs (Barton et al. 2005; Guyton et al. 2014) without leading to a proliferation of invasive plant species (Guyton et al. 2014; Wigginton and Meyerson 2018) or safety complaints (Norcini 2014).

The over four million hectares of roadside vegetation managed by state departments of transportation in the United States (Forman et al. 2003) represent a large area that can potentially be managed for habitat. In regions dominated by farmland, roadsides can provide one of the few areas of habitat for bees, birds, and butterflies (New et al. 2021; Depalma et al. 2022). Roadsides can also have considerable conservation value and serve as wildlife corridors that connect larger patches of habitat (Spooner 2015; Gardiner et al. 2018). In recent years, conservationists have become increasingly interested in creating or enhancing pollinator habitat within roadsides (Hopwood et al. 2015; Underwood et al. 2017; Rights-of-Way as Habitat Working Group 2022). Roadsides are in sunny locations conducive to pollinator foraging. Roadsides can also be one of the few public areas available for restoring diverse, native nectar and host plants, especially in areas dominated by row-crop agriculture. Some plants such as common milkweed (*Asclepias syriaca*), critically important for Monarch butterfly reproduction, readily establish in rural roadsides within the American Midwest (Kaul and Wilsey 2019). There are some concerns about pollinator mortality from vehicle collisions (McKenna et al. 2001; Keilsohn et al. 2018). Hopwood et al. (2015) suggest that pollinator mortality rates from collisions are a small proportion (0.6–10%) of the population, depending on the species. Providing habitat in landscapes where little exists may provide a net benefit to pollinators (Phillips et al. 2020; New et al. 2021).

An approach to roadside vegetation management called integrated roadside vegetation management (IRVM) can benefit pollinators and provide other environmental, economic, and logistical benefits. Iowa is among the few areas in the world to provide financial support for widely applying the principles of IRVM along county or secondary roads. Under IRVM, roadside vegetation is primarily managed for safety, among other purposes, using an integrated, ecological approach. Management techniques include seeding native plant species, judiciously spraying herbicides, strategic mowing, conducting prescribed burns, and removing brush.

In 1988, the Iowa state legislature passed legislation stating that counties "may" adopt an IRVM plan (Iowa Code 314.22). During the same year, the Iowa legislature also created the Living Roadway Trust Fund (LRTF) (Iowa Code 314.21), which is administered by the Iowa Department of Transportation. The fund includes an annual competitive grant program that provides funding for eligible equipment and activities for cities, counties, and applicants with a statewide impact.

About half (47) of Iowa's counties have chosen to both create an IRVM plan and employ a roadside vegetation manager who is responsible for managing the right-of-way. In the remaining counties, the engineer is the county official responsible for managing the right-of-way; nine of these counties have an IRVM plan. Collectively, they are responsible for a large share of the public land in Iowa. Approximately 60% of public land, or 420,733 hectares, consists of roadsides, and of that, 308,370 hectares consists of county roadsides (personal communication, Mark Masteller, Iowa Department of Transportation).

The goal of this study was to understand how county engineers and roadside vegetation managers manage county, or secondary, roads in Iowa, USA. Approaches to

roadside vegetation management have large safety and conservation implications, yet to our knowledge, there is little information about county officials' management approaches to roadside vegetation. One study surveyed attitudes towards roadside revegetation with native plants by New England state departments of transportation (Campanelli et al. 2019). Our results apply to entities who want to have a better understanding of how county roadside vegetation is managed, which shares some similarities to roadside vegetation management along state and federal roadsides.

Materials, Methods, and Participants

First, we identified five roadside management behaviors that we were interested in: (1) planting native plants in roadsides, (2) managing plantings, (3) spot-spraying of herbicides to control weeds, (4) preserving roadside prairie remnants, and (5) evaluating the success of plantings. Then, we assessed the knowledge and attitudes of Iowa county engineers and roadside vegetation managers to identify perceived barriers and benefits to implementing IRVM practices in their counties.

We sent questionnaires to the county engineer in each of Iowa's 99 counties and the county roadside vegetation manager in the 37 counties that had one at the time of the survey (Stephenson and Losch 2016). Nearly 2/3 of county roadside managers are housed within the secondary roads department, reporting to the county engineer. In counties without a roadside manager, the engineer is the main person responsible for how the county's roadside vegetation is managed. The engineers and roadside managers were surveyed separately because each represents a different type of community with different roles, priorities, beliefs, and values. While roadside managers often have a degree in a biology- or environmental studies-related discipline and largely focus on managing vegetation as part of their job, engineers have an engineering degree and have broader job duties. Engineers are responsible for the overall administration, planning, and supervising of the secondary roads department and the secondary road system. In counties without a roadside manager, engineers may contract out roadside management responsibilities since they do not have the time and energy to address roadside vegetation. According to Iowa Code, counties are required to employ a licensed civil engineer while counties "may" employ a roadside manager and practice the principles of IRVM to manage their roadsides.

Approximately 1/3 of Iowa county roadside vegetation managers are housed within the county conservation department, reporting to the county conservation board director. County conservation boards are appointed citizen volunteers who guide conservation program establishment (Iowa Association of County Conservation Boards 2008). The county conservation boards are similar to other states' county parks and recreation departments (Meyer 2010). At any given time in the last 30 years, fewer than six county roadside managers have been independent, reporting directly to the county board of supervisors. The conservation board directors and the chairs of the county boards of supervisors were the subjects of a different survey (Nemec et al. 2021).

Survey Administration

We collected data using a web-mail sequential mixed-mode design (de Leeuw and Berzelak 2016), a survey method that reduces costs, improves response rates, and reduces coverage and nonresponse errors (de Leeuw 2018). Unlike single-mode approaches, mixed-mode surveys allow sampled members to answer the questionnaire using different modes, in this case, mail and web surveys. We emailed all Iowa county engineers ($n = 99$) and county roadside managers ($n = 37$) on March 2, 2016. Eight county engineers had responsibilities for two counties and were asked to complete one survey for each county. We sent email reminders to non-respondents on March 10, March 17, and March 28 and mailed a paper survey to those individuals who had not responded after the initial email invitation and these successive reminders. We sent a final email reminder on April 20 to those who received mail surveys and completed data collection by April 30. We received 98 completed questionnaires (64 from engineers and 34 from roadside managers), resulting in response rates of 65% and 92%, respectively.

Variables and Analysis

The survey consisted of 41 questions. Four sets of questions were used, including background information (gender, role, and time in position), approaches to managing roadside vegetation in general, approaches to managing native roadside plantings, and barriers to implementation of these practices. The specific wording of the questions and response options (except for background information) is provided in the Supplementary Material and in Stephenson and Losch (2016); also see Stephenson and Losch for detailed results for each question posed.

For the analysis, descriptive statistics were computed. These included percentages, means, and standard deviations for each group (engineers and roadside managers). Differences between the two groups were assessed using independent samples t tests. We also used independent samples t tests to analyze the data based on the presence or absence of a roadside manager and reported significant differences in

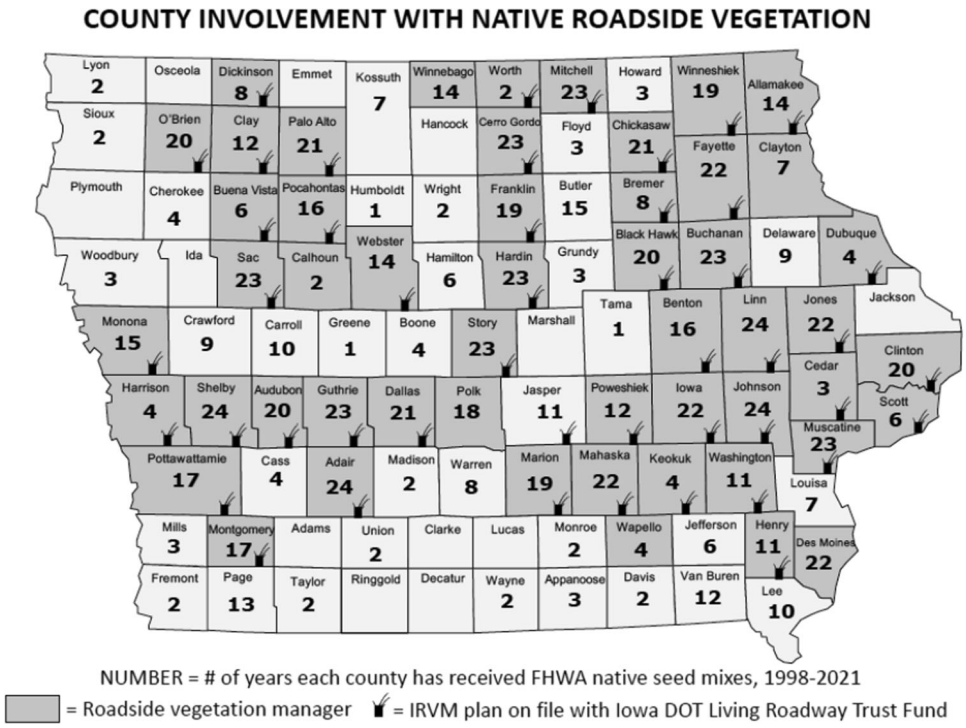

Fig. 1 Counties in Iowa that have a county roadside vegetation manager, an integrated roadside vegetation management (IRVM) plan on file with the Iowa Department of Transportation, and/or plant native seed mixes in their roadsides with seed received through a Federal Highway Administration (FHWA) grant, as of 2021

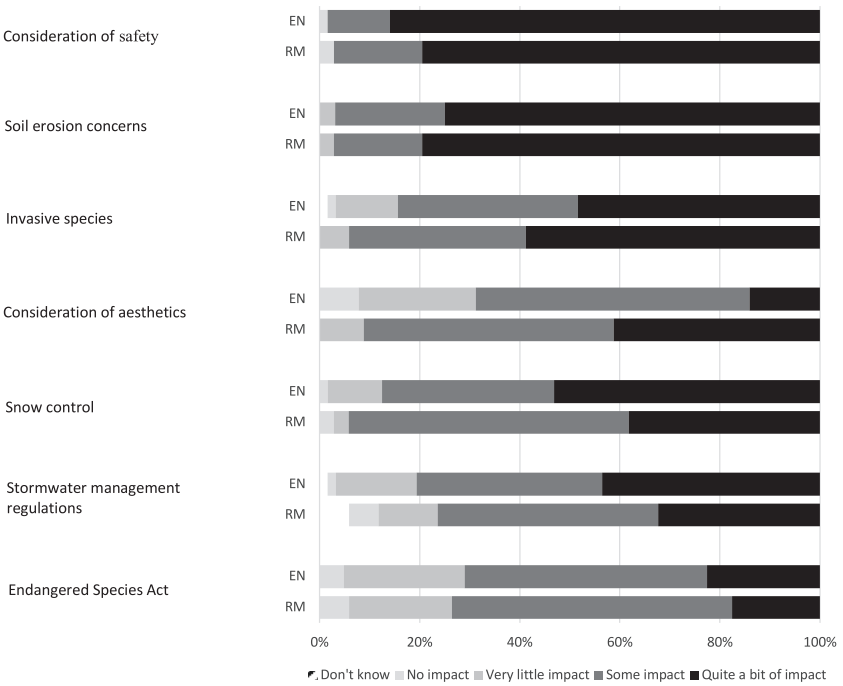

Fig. 2 Responses of engineers (EN) and roadside vegetation managers (RM) to the question "How much impact does each of the following items have on decisions about roadside vegetation management in your county?"

the results. The counties with a roadside manager (Fig. 1) are considered to have the most active roadside programs since they have a dedicated person to implement the principles of IRVM along roadsides. We rounded percentages in figures to the nearest whole number; therefore, percentage totals range from 99 to 101%.

Results

Respondent Characteristics

The vast majority of both county engineers (98%) and roadside managers (94%) were male. Engineers had served

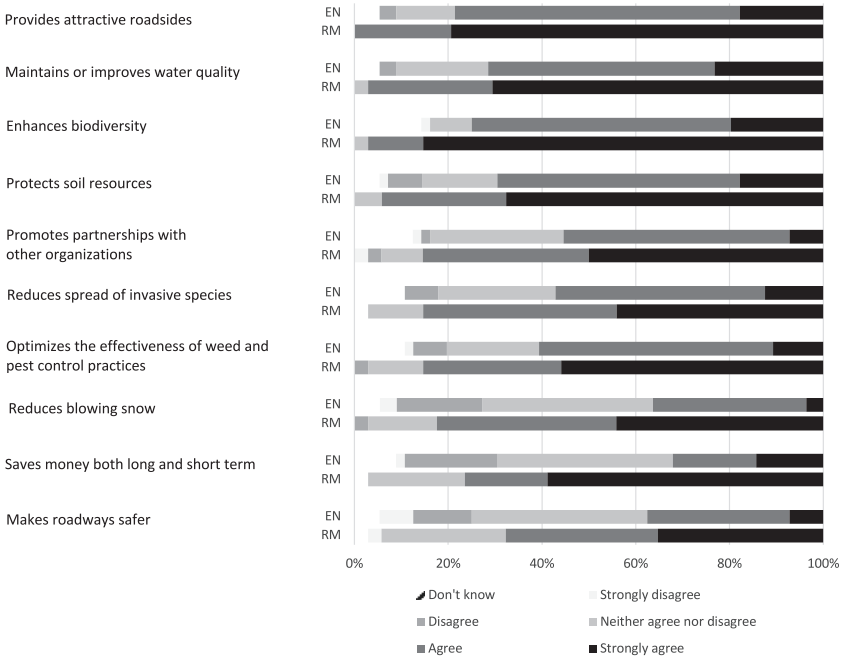

Fig. 3 Responses of engineers (EN) and roadside vegetation managers (RM) to the question "To what extent do you agree or disagree with the following statements regarding benefits of IRVM in your county"

in their roles for an average of 10 years, and roadside managers had served in their roles for an average of 11 years. Around nine in ten roadside managers (91%) described their current position in roadside vegetation management as full-time, while the majority of engineers (56%) described their role in roadside vegetation management as part-time. Engineers who identified their positions as part-time estimated spending on average less than 5% of their time on roadside vegetation management. Roadside managers in part-time positions estimated, on average, 18% of their time was devoted to roadside vegetation management.

Influences on Roadside Vegetation Management Decisions

Respondents identified the relative impact of different influences on their roadside vegetation management decision-making. The two influences that were identified most often by both groups as having quite a bit of impact were "consideration of safety" and "soil erosion concerns" (Fig. 2). Eighty-six percent of engineers and 79% of roadside managers identified "consideration of safety" as having quite a bit of impact on roadside vegetation management decision-making in their county. At least 3/4 of respondents in each group indicated the same for "soil erosion concerns".

The next greatest influence differed by group although only one difference reached statistical significance. Over half (53%) of engineers said snow control had quite a bit of impact, while 59% of roadside vegetation managers said invasive species had quite a bit of impact. Aesthetics was the only factor that significantly differed between the two groups. Roadside vegetation managers had a higher mean score ($n = 34$, $M = 3.32$ (SD = 0.638)) than engineers ($n = 64$, $M = 2.75$ (SD = 0.797)) for how much aesthetics impacted their decision making ($t = -3.62$ (df = 96), $p < 0.001$). For engineers, whether or not their county had a roadside program did not play a significant role in influencing their decision-making priorities.

Benefits of Integrated Roadside Vegetation Management

Respondents were asked to identify the impact that IRVM practices have on improving secondary roads. All roadside managers and a majority of engineers (79%) agreed or strongly agreed that IRVM provides attractive roadsides in their county (Fig. 3). The majority of both engineers and roadside managers agreed that IRVM provides a suite of ecosystem service benefits to counties as well. Three quarters (75%) of engineers agreed that IRVM enhances biodiversity. Seven in ten agreed that it maintains or improves water quality (71%) and protects soil resources (70%). Over ninety percent of roadside managers agreed that IRVM provides each of these ecosystem service benefits. For each benefit except for promotion of partnerships with other organizations, roadside managers had a significantly higher mean score than engineers did for the degree to which they agreed the benefit resulted from IRVM (Fig. 3).

Whether their county employed roadside vegetation managers or not, engineers generally showed little difference in their perceptions of the benefits of IRVM. However, there were two exceptions. Engineers with

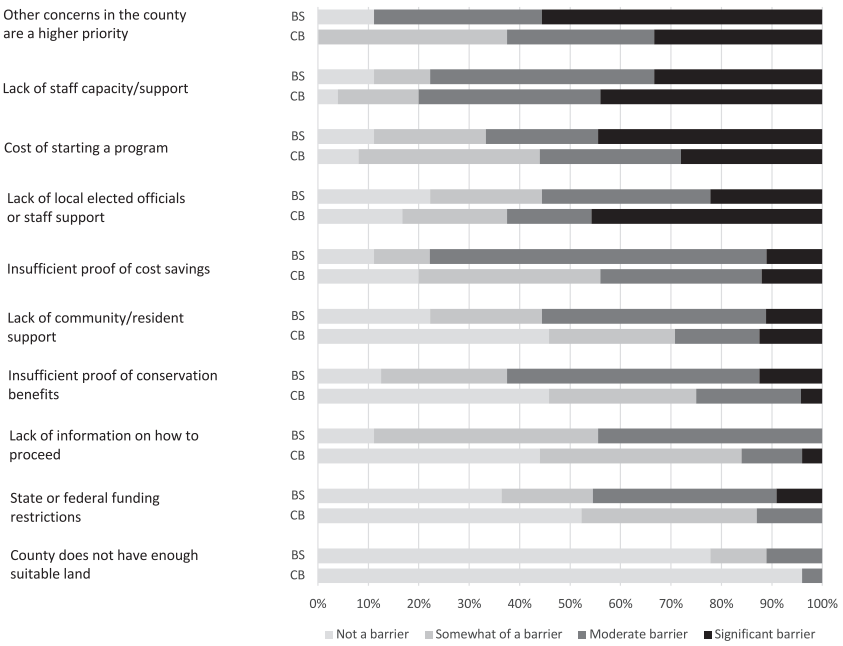

Fig. 4 Responses of chairs of the county board of supervisors (BS) and conservation board directors (CB) to the question "Which of the following have been or currently are barriers to your county's implementation of IRVM practices?"

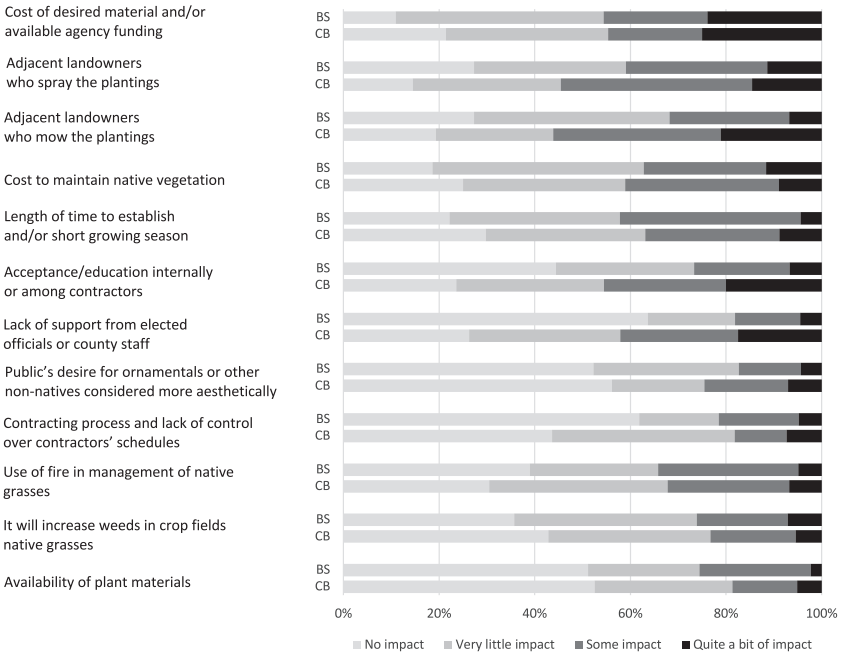

Fig. 5 Responses of chairs of the county board of supervisors (BS) and conservation board directors (CB) to the question "Which of the following have been or currently are barriers to your county using more native species in any land management projects?"

roadside managers had significantly higher mean scores ($n = 22$, $M = 4.32$ (SD = 1.04)) than engineers without roadside managers ($n = 34$, $M = 3.32$ (SD = 1.00)) for agreeing that IRVM practices reduce the spread of invasive species ($t = 2.20$ (df = 54), $p = 0.032$). Engineers in counties with roadside managers also had significantly higher mean scores ($n = 22$, $M = 4.50$ (SD = 0.673)) than did engineers in counties without roadside managers ($n = 34$, $M = 3.82$ (SD = 0.797)) for agreeing that IRVM provides attractive roadsides ($t = 3.29$ (df = 54), $p = 0.002$). It is possible engineers in counties with roadside managers perceive benefits from these IRVM practices either because the roadside managers influenced the engineers' values or because the engineer and/or other county officials already held these values, leading them to hire a roadside manager. Constituents may also influence county officials to manage in accordance with environmental values.

Challenges to Planting and Managing Native Plant Species

Seven in ten engineers (71%) rated their agency's experience using native plantings as somewhat, moderately, or extremely challenging while only four in ten roadside managers (41%) rated their experience the same. Respondents who indicated that their agency's experience using native plantings has been somewhat to extremely challenging were asked to identify their primary challenges in greater use of native species.

There were no significant differences in challenges identified by engineers and roadside managers. The most common challenge identified by both engineers (66%) and roadside managers (62%) was the length of time to establish and/or short growing season (Fig. 4). Six in ten roadside managers (62%) and one-third of engineers (34%) identified interference with native plantings by adjacent landowners mowing or spraying herbicides as challenges in their county (Fig. 5).

Forty-five percent of engineers and three in ten roadside managers (31%) identified the cost of desired material and/or available agency funding as a challenge. Additionally, nearly one-quarter of roadside managers (23%) indicated acceptance or education internally or among contractors as a challenge to greater use of native species. The engineers and roadside managers did not differ significantly in their identification of challenges to using native species. Engineers in counties with a roadside manager were significantly more likely ($n = 14$, $M = 0.64$ (SD = 0.497)) than engineers in counties without a roadside manager ($n = 24$, $M = 0.17$ (SD = 3.81)) to identify interference with native plantings by adjacent landowners who spray the plantings with herbicides as a challenge ($t = 3.09$ (df = 22), $p = 0.005$).

Management Practices

Frequency of planting native plants in roadsides

Respondents were asked to approximate, over the last 3 years, the percentage of road engineering projects in their county that included native plants as a component and those that used non-native plants (e.g., fescue or smooth brome). Roadside managers were significantly more likely to include native vegetation in roadside projects than were county engineers ($t = -3.76$ (df = 89), $p < 0.001$). Over the last 24 years, counties with roadside managers have been more likely to request prairie seed for their roadsides from the University of Northern Iowa roadside office than counties without roadside managers, likely because roadside managers have more time and expertise to plant and manage seed than engineers. One-half of roadside managers (50%) indicated that more than 75% of their projects included native vegetation during the last 3 years and one-fifth (19%) said that 1 to 25% of their projects included native vegetation. One-fifth of county engineers (22%) indicated they did not use native vegetation in any of their projects during the last 3 years. Twenty-four percent of county engineers reported that they used native vegetation in more than half of their roadside management projects over the last 3 years.

Managing plantings

Management of native plantings differed between roadside managers and engineers. A plurality of roadside managers (49%) and engineers (38%) indicated that native plantings are mowed once within 1 year of seeding; however, roadside managers were more likely to indicate native plantings are mowed 2–3 times within 1 year of seeding than were engineers (24% of roadside managers vs. 9% of engineers). Slightly over one-quarter (27%) of both engineers and roadside managers indicated that native plantings were never mowed within 1 year of seeding.

Both groups reported changes in management of native plantings after the plantings are 1-year old, although differences in management by engineers and roadside managers remain. Three in five roadside managers (61%) indicated native plantings are never mowed after they are 1-year old and 39% indicated they are mowed once per year, while roughly one-quarter of engineers (27%) said the plantings are never mowed or mowed once per year (25%).

Nearly half of roadside managers (48%) indicated native plantings are burned every 4–5 years after they are 1-year old; the same percentage of engineers (48%) indicated native plantings are never burned. Engineers were more likely than roadside managers to select "Don't Know" in response to all items about frequency of management actions on native plantings.

Mowing and spraying practices

Engineers and roadside managers were asked about both their mowing and spraying practices for all roadside vegetation regardless of whether or not it had been seeded with native plants. The two most widely used management practices by both groups were "spot-spraying of weeds with herbicides" and "spot mowing of weeds." Nine in ten roadside managers (91%) and engineers (89%) indicated their counties use spot-spraying to manage weeds, while three quarters of county engineers (75%) and roadside managers (74%) use spot mowing. Engineers were significantly more likely than roadside managers to indicate "strip mowing of weeds" as a management practice currently used in their county. One-quarter of engineers and 15% of roadside managers reported using "Full width

mowing." "Blanket spraying of weeds with herbicides" was identified least often by both engineers (16%) and roadside managers (6%) as a management practice they used.

Preserving roadside plant remnants

Awareness of protected native plant community remnants on secondary road rights-of-way (ROW) differed between roadside managers and engineers. Four in ten roadside managers (41%) reported that their counties have protected community remnants on secondary road rights-of-way, 38% reported their counties did not, and one-fifth (21%) were not sure if their county's secondary road rights-of-way contained protected native plant communities. The majority of engineers (58%) were not sure if there were any protected native plant communities on secondary road rights-of-way in their county; about one-quarter (24%) indicated there were not and 18% said their county did have protected native plant communities on secondary road rights-of-way.

Evaluating planting success

Respondents were asked to identify, from a list, the indicators used for defining successful revegetation in their county. Roadside managers were more likely than engineers to select plant coverage and weed control meeting or exceeding success criteria after 1 year as indicators of successful revegetation. Three quarters of roadside managers (74%) identified plant coverage as an indicator of success and six in ten (59%) identified weed control criteria, compared to 37 and 34% of engineers, respectively. Approximately one-third of roadside managers (35%) consider the percentage of native plant coverage when evaluating success of revegetation, a greater proportion than that of engineers (15%). Half of roadside managers (50%) and 58% of engineers assess soil coverage as an indicator of successful revegetation.

Discussion

These findings revealed some similarities and differences in engineers' and roadside vegetation managers' perceptions and priorities when managing roadsides. Both groups were influenced by similar factors when making decisions about roadside vegetation management, with safety and soil erosion concerns being the greatest considerations. This finding is consistent with a survey of managers from New England state departments of transportation that also found safety and soil erosion to be high priorities (Campanelli et al. 2019).

However, one of the areas with the largest differences in the study was the two groups' perceived benefits of roadsides. Roadside managers expressed significantly higher agreement than engineers did that IRVM provides benefits like making roadways safer, enhancing biodiversity, saving money both long and short term, optimizing the effectiveness of weed and pest control practices, protecting soil resources, maintaining or improving water quality, reducing the spread of invasive species, providing attractive roadsides, and reducing blowing snow. When comparing engineers' responses based on whether their county has a roadside program or not, engineers in counties with a roadside program expressed significantly larger agreement with the statements that IRVM practices reduce the spread of invasive species and provide attractive roadsides. The presence of a roadside manager vouching for these benefits may encourage engineers to have a more positive view, or engineers that have a favorable view of these benefits are more likely to hire a roadside manager. County officials who hold these values may also be more likely hire engineers with aligned values and more likely to hire roadside managers. Conversely, county officials may be responding to residents who encourage the county to hire a roadside manager. From 2017 to 2021, two counties with urban centers hired roadside managers in response to public pressure to manage roadside vegetation in a more ecological manner that benefits pollinators.

Interestingly, both engineers and roadside managers agreed the least with the statement that IRVM "makes roadways safer." However, "consideration of safety" was noted as having the largest impact when both groups decide how to manage roadside vegetation. Other key county decision makers, the conservation board directors and chairs of the county boards of supervisors, also ranked safety as the highest consideration in a separate survey (Nemec et al. 2021). Roadside safety considerations often involve wildlife-vehicle collisions (WVCs). The majority of WVCs involve white-tailed deer (*Odocoileus virginianus*) (Huijser et al. 2008). To reduce the risk of attracting deer to the roadside, roadside managers can consider planting seed mixes that are unpalatable (Huijser et al. 2008). Because deer prefer to eat easily-digestible plants like tree seedlings and legumes (Prusnenski and Hernández 2020), they are less likely to be attracted to grazing on roadsides that are dominated by cool-season and warm-season grasses, which form a large component of Iowa roadsides. Snow et al. (2018) found that in Midwest eco-zones dominated by agriculture, traffic volume and deer abundance were better predictors of deer-vehicle collisions than landscape composition.

In contrast to perceptions of benefits, there were no significant differences in the challenges to roadside vegetation management identified by county engineers and roadside managers. Of respondents who said using native species was somewhat, moderately, or extremely challenging, members of both groups selected length of time to establish and/or short growing season as the greatest challenge. The second and third largest challenges, adjacent

landowners spraying and mowing the plantings, were also among the top three challenges ranked by chairs of the county boards of supervisors and county conservation board directors (Nemec et al. 2021). According to our interactions with roadside managers and county officials outside of the context of this survey, some landowners view native vegetation as undesirable because they view it as weedy and are concerned about it encroaching into their land. Other landowners simply enjoy mowing. However, in the years since we conducted our survey, some county officials have observed some landowners continuing to mow, but mowing around milkweed plants growing in the roadside by their property. Their modified mowing behavior could be a response to growing public awareness about declining Monarch butterfly populations. It is unclear if roadside managers have altered their management practices, for example by changing the timing of mowing to avoid negatively impacting pollinators; this would need to be the subject of a new survey.

The presence of a roadside manager on staff clearly resulted in greater use of native plants on secondary roads projects. Roadside managers usually have more training in conservation and plant management than engineers and are more likely to be the county employee responsible for planting native plants. Mowing and burning are two management practices that can influence the establishment of native seed mixes. While little research has been conducted on roadside prairie vegetation management techniques, results from other types of restoration research may help inform roadside mowing and burning practices. Mowing tallgrass prairie plantings established on former cropland during the first year can reduce prairie seedling competition with weeds, increasing the number of seeded species and native grass and forb stem density while decreasing annual weeds compared to plantings that are not mowed (Meissen et al. 2020). While over half of roadside managers indicated native plantings are never mowed after they are 1-year old, one-quarter of engineers said plantings are never mowed after 1 year. Engineers were more likely than roadside managers to select "Don't Know" when asked how often management actions were implemented, indicating they had fully delegated responsibility for management to the roadside managers and were unaware of the nuances of how the plantings were managed. Different approaches to mowing between roadside managers and engineers who were familiar with mowing frequency could reflect differences in training, with roadside managers being more likely to be trained in conducting prescribed burns for managing native vegetation as opposed to mowing for long-term maintenance of plantings.

Prescribed burns once prairie vegetation is established can help reduce weeds and woody plants and stimulate the growth of prairie plants (Rowe 2010). Although some state DOTs do not allow prescribed burns in state roadsides because of liability issues (personal communication, Joy Williams, Iowa DOT), many Iowa counties do allow prescribed burns in county roadsides. About half of roadside managers replied that native plantings are burned every 4–5 years after they are 1-year old, which is within the commonly recommended burn regime of 3–5 years for roadside vegetation (Minnesota DOT 2008; Federal Highway Administration 2017). In our survey, we did not ask when roadsides were burned, which may have implications for forb diversity. Research suggests prairie vegetation burned in the summer and fall has higher flowering forb diversity in the year following a burn (Roberton and Rebar 2022).

Both engineers and roadside managers used similar mowing and spraying practices when managing all roadside vegetation, not just areas of the roadside that had been seeded with native plants. We did not ask how mowing and sprayed were used for native plantings specifically. Like state DOTs, spot mowing and spot-spraying weeds were widely used management practices (Minnesota DOT 2008; Van Dyke et al. 2021). Blanket spraying was used the least often; in blanket spraying the herbicide covers an entire area rather than targeted weeds (Minnesota DOT 2008). Blanket spraying herbicides can have the unintended effect of creating disturbed areas that allow invasive plants to colonize (Marsh et al. 2021).

Although most roadside plant communities in Iowa are highly disturbed, according to vegetation studies, some remnants of never-plowed native prairie vegetation exist in county roads, comprising less than five percent of the roadside vegetation (Searles 2017). Slightly over a third of county roadside managers said their county had protected plant community remnants along the county roadside. Johnson County has one of the more extensive native plant community policies, with sections on identifying native plant communities, addressing engineering and construction considerations, assessing quality through a remnant scoring guide, and maps of roadside remnants (Johnson County 2006). Some states also include procedures for protecting roadside native plant communities. For example, according to the Florida DOT's Wildflower Management Program Procedure, no herbicide or fertilizer is allowed within protected areas, which include some native plant communities (Harrison 2014). Some scientists argue that more roadside remnant vegetation should be protected in Australia because of its high conservation value to imperiled insects (New et al. 2021).

Monitoring roadside revegetation projects and having clear success criteria are key to determining if project goals are being met. Plant coverage, weed control, and soil coverage meeting or exceeding success criteria after 1 year post-planting were the success criteria most often used by roadside managers and engineers. In a survey of prairie

restoration managers across seven states in the Upper Midwest/Great Lakes region, including Iowa, different aspects of biodiversity such as number of plant species (species richness), diversity in plant functional types, range of bloom times, and support for a variety of non-plant taxa were the most important goals (Barak et al. 2021). We did not list these factors as options in our survey, instead listing plant coverage since adequate erosion control is a high priority for roadside revegetation.

Roadside managers may inherently value using an integrated, ecological approach to roadside management, particularly if they have a conservation or biology background, more than engineers. Because engineers ranked perceived benefits significantly less than roadside managers, better communication with engineers may still help narrow this difference. In recent years the largest increase in counties choosing to have a roadside vegetation program occurred the year after the program manager responsible for coordinating with and supporting county roadside programs spoke at the annual Iowa County Engineers' conference. Conveying information about roadside programs through a quarterly e-newsletter, virtual meetings, or regional engineering meetings may help further narrow the gap. Because people may be more influenced by testimonials from their peers (Liu et al. 2018), video or written testimonials from county engineers supportive of roadside programs may also be effective communication mechanisms.

Conclusion

This study provides insights into how county officials responsible for managing roadside vegetation along county (secondary) roads in Iowa, USA perceive and implement their management practices. While every county has an engineer, less than half of Iowa counties have a roadside manager on staff whose responsibilities focus mainly on managing roadside vegetation. Compared to engineers, roadside managers more strongly agreed that there are a range of environmental benefits from managing roadsides using the ecological principles of IRVM. Engineers in counties with a roadside manager more strongly agreed that IRVM practices reduce the spread of invasive species and provide attractive roadsides. Both groups had similar perceptions of the challenges to using native vegetation and used similar techniques when managing all roadside vegetation. Because roadside managers are more directly involved in on-the-ground management of native vegetation, they were more familiar with practices for protecting native remnants and managing recently established plantings.

The perspectives of county officials implementing roadside vegetation management have not been discussed in published studies to date. Some statistical limitations of our study include: (1) multiple testing and the increased risk of achieving significant results by chance (Type I error), (2) the small group sample sizes, especially for some subgroup analyses, which reduce the statistical power of our analysis, and (3) the use of bivariate analyses to compare the groups, not controlling for potential confounders. One confounder may be differences in land use across the state, which may affect attitudes towards the relative importance of roadside vegetation in providing environmental benefits. For example, counties in the northwestern part of the state contain the Loess Hills, which are largely covered by grassland vegetation; most of these counties do not have a roadside program. The majority of land use in the state is either corn and soybean fields or pasture, which is more prevalent in the southern part of the state. Another confounder may be the tax base within the county; counties containing larger cities may be more likely to afford a roadside manager compared to more rural counties. Urban counties may also have a larger population with environmental values that can influence county officials. Differences in county government organizational structure may influence how roadside manager positions are funded and created.

Because the role of roadside vegetation in addressing declining pollinator populations continues to be a major conservation issue, future surveys could examine practices that impact pollinators and other wildlife, such as the type of mowing equipment used and the timing of burns and mowing. A growing body of international research identifies best roadside management practices for minimizing impacts to insects and other wildlife (Jakobsson et al. 2018; Knight et al. 2019; Phillips et al. 2020; Steidle et al. 2022). Because of their low traffic volumes and speeds, rural roads in particular may have conservation value (Spooner 2015; New et al. 2021). However, since local management priorities may focus more on other factors like safety considerations and erosion control, rather than conservation, these conservation practices would likely need to address these concerns to be adopted at the local level. Ultimately, understanding how and why engineers and roadside managers implement management practices can provide avenues for dialogue and research to better serve and balance multiple local societal, environmental, and political goals.

Data Availability

All of our data support our published claims and comply with field standards.

Material Availability

All of our materials support our published claims and comply with field standards.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Consent to Participate Each participant was provided a letter stating that "The purpose of this study is to better understand how to successfully implement IRVM activities. We ask that you please complete the following questionnaire which includes items regarding IRVM and your county's management of rights-of-way. The questionnaire should take 10–15 min to complete and you are free to skip any question you would prefer not to answer by selecting "prefer not to respond." Participation is voluntary and your responses will be kept confidential. In reporting, no identifying information will be stored with your responses. There are no direct benefits for participating; however, your participation in the study is very important to us as your answers will be combined with others to better understand roadside vegetation management in Iowa. Risks are minimal and similar to those typically encountered in day-to-day life."

Ethics Approval The study was approved by the university institutional review board (IRB) and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

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