An assessment to support strategic, coordinated response to invasive *Phragmites australis* in Minnesota

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Assessment summary

Invasive *Phragmites* (*Phragmites australis* subsp. *australis*) has spread across the wetlands of many regions of North America, and is well-documented to have detrimental effects on wildlife, fish, native plants, water supply, and recreational uses. This tall, fast-growing, non-native wetland grass spreads to lakeshores, wetlands, roadside ditches, and other wet habitats, sometimes after intentional introduction, as occurred in Minnesota. Numerous reports over the past ten years had suggested that the invasion of this species was progressing in Minnesota and that the window of time might be closing to efficiently respond and prevent widespread damage to the state's wetlands. Over the last two years, our research has verified 389 invasive *Phragmites* populations in Minnesota. Many populations are producing viable seed and so have high capacity for further spread. However, these numerous populations currently add up to an area of approximately 50 acres. In light of these findings, a coordinated, statewide control effort with the aim of eliminating all established populations is still feasible, if pursued without delay. Invasive *Phragmites* has the capacity to quickly spread and overtake areas; partial or uncoordinated responses are unlikely to be beneficial or cost-effective. This assessment suggests strategies for collaboration, coordination, and implementation of control efforts; provides control cost estimations; details core competencies for participating entities; identifies potential funding sources; and addresses possible challenges associated with such a response.

We present invasive *Phragmites* status information and possible response strategies tailored to 12 regions of the state. This regionalized approach is intended to highlight differences in distribution and the social and environmental contexts in which invasive *Phragmites* occurs across Minnesota, and to empower regional and local organizations to quickly mobilize and initiate response efforts. Some regions include many populations with various sizes, habitats, and property ownerships, while others include only a few populations under similar invasion contexts. Each regional section contains a description of the regional status of invasive *Phragmites*, potential partner organizations and funding options, estimated control costs, and training and capacity needs.

Review of the scientific literature shows the most effective approach for controlling invasive *Phragmites* to be end-of-summer herbicide treatment, supplemented by winter or late summer mowing to remove dead stems. It is likely that this management schedule will need to be repeated for three years to eliminate the plant from most sites. While burning, cutting, and water-level management have also been employed in invasive *Phragmites* management, these approaches have either been shown to be ineffective or come with important caveats. The type of equipment required to conduct control (e.g., backpack sprayer, boat, etc.) will need to be varied depending on characteristics of the targeted site. Only equipment that can be sufficiently decontaminated of plant propagules should be used in conducting control to avoid contributing to invasive *Phragmites* spread.

In addition to wild invasive *Phragmites* populations, there are 16 wastewater treatment facilities in Minnesota that use invasive *Phragmites* in their operations. While the invasive *Phragmites* at these facilities are potential sources of spread, they also support wastewater treatment operations by dewatering biosolids following sewage treatment. Ultimately, a plan for transitioning

these facilities to effective, alternative dewatering methods would be needed for a truly comprehensive response to invasive *Phragmites* in Minnesota. While potential alternatives are being evaluated, best management practices to minimize spread risk should be developed for facilities' dewatering operations and materials disposal.

An effective statewide response to invasive *Phragmites* is only possible with local to state level partners and partnerships. To varying degrees, invasive *Phragmites* falls under the jurisdiction of multiple state agencies, including the Minnesota Department of Natural Resources, Minnesota Department of Transportation, Minnesota Department of Agriculture, and Minnesota Pollution Control Agency. Response efforts could be coordinated by state agency staff – either by managing control contracts directly or by administering funds to regional and local entities – or by regional and local organizations implementing private or grant-funded projects from non-agency sources. Cooperation with private and commercial landowners will be essential. Regardless of the level at which control efforts are organized, a truly statewide response will require significant coordination, which could potentially be centralized and designed to work across jurisdictions. We do not identify "priority" populations for control in this assessment because a partial approach is inconsistent with the well-understood biology of this species—that all seed-producing populations have high capacity to trigger broader spread.

Participants in invasive *Phragmites* response should be trained in several core competencies to ensure effective and responsible management. Individuals conducting surveillance for new populations must know how to report their findings and distinguish invasive *Phragmites* from the native subspecies (*Phragmites australis* subsp. *americanus*) or how to collect and submit specimens to an expert for identification. Those implementing control will need to acquire the appropriate permits, follow applicable herbicide-use regulations, and determine the control approaches and equipment needs specific to each site. Adequate reporting and evaluation of control efforts will be needed to support comprehensive response and to facilitate adaptive management.

Responding to invasive *Phragmites* statewide will require substantial financial investment at the outset. Several potential sources of funding to support invasive *Phragmites* response are identified in this assessment. We have estimated costs for three years of herbicide treatment and mowing of all verified wild populations at $818,500-2,019,000. These costs are comparable to costs of invasive *Phragmites* control efforts conducted in other states, though Minnesota is unique in that this level of investment can be deployed at a time when reversal of spread remains feasible. Should potential partners choose to wait to implement response efforts, control costs will increase as invasive *Phragmites* becomes more widespread and difficult to manage, requiring more complicated equipment and more labor. It is critically important to recognize that choosing not to respond is choosing to allow invasive *Phragmites* spread to escalate, and this choice will severely limit the feasibility of control within the not-too-distant future.

Mobilizing a strategic, coordinated response to invasive *Phragmites* statewide is clearly an ambitious undertaking that will come with many challenges. Lack of support from state, regional, and local entities; private landowners; or grant programs would hinder efforts. Depending on the rate of invasive *Phragmites*' spread, the potentially short window of opportunity for effective response requires

mounting efforts both quickly and responsibly. Coordinators will need to ensure that control efforts are of sufficient quality and include adequate follow-up and equipment decontamination. Potential pathways for reinvasion will need to be addressed and ongoing monitoring will be needed to support early response to newly detected populations. While the challenges are real, they are not insurmountable, and overcoming them will yield significant benefits for the state.

Acronyms and abbreviations

Abbreviation	Meaning
AIS	Aquatic invasive species
AISPA	Aquatic Invasive Species Prevention Aid
BNSF	BNSF Railway Company
BWSR	Minnesota Board of Soil and Water Resources
CPL	Conservation Partners Legacy Grant Program
CWMA	Cooperative Weed Management Area
DNR	Department of Natural Resources
EDDMapS	Early Detection and Distribution Mapping System
GLRI	Great Lakes Restoration Initiative
LCCMR	Legislative-Citizen Commission on Minnesota Resources
LSOHC	Lessard-Sams Outdoor Heritage Council
MAISRC	Minnesota Aquatic Invasive Species Research Center
MDA	Minnesota Department of Agriculture
MNDNR	Minnesota Department of Natural Resources
MNDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
NFWF	National Fish and Wildlife Foundation
SWCD	Soil and Water Conservation District
UMN	University of Minnesota
USFWS	United States Fish and Wildlife Service
UTV	Utility vehicle

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Introduction

A highly invasive European lineage of common reed (*Phragmites australis* subsp. *australis*), a wetland grass, has been introduced to multiple locations in Minnesota and appears to be spreading. While native *Phragmites* (*P. australis* subsp. *americanus*) is an important component of Minnesota's wetland flora, invasive *Phragmites* can have strong negative impacts on biological diversity, wildlife, habitat quality, and recreation (Meyerson et al. 2016). Invasive *Phragmites* tends to grow very tall and dense, creating unsuitable shelter and food for wildlife and fish, and displacing native flora that would otherwise provide those benefits (Able and Hagan 2000, Minchinton et al. 2006, Meyer et al. 2010). The native subspecies has been largely displaced by the invasive along the New England to mid-Atlantic coast (Saltonstall 2002, 2011). Invasive *Phragmites* has also been shown to invade shoreline areas and can block views of and access to water, thereby impeding recreation (see also About invasive *Phragmites*). Several U.S. states have exceedingly large invasive *Phragmites* populations, and some are forced to fund expensive annual control projects just to prevent further spread and provide localized relief of negative ecological and recreational effects (Figure 1).

Recent research at the University of Minnesota has documented the distribution of invasive *Phragmites* and assessed its ability to reproduce and spread by seed within Minnesota (hereafter, referred to as the "MNPhrag" project). The following points summarize key findings:

- Over the past 2 years, 389 individual invasive *Phragmites* populations have been verified throughout Minnesota using a combination of crowdsourcing and targeted surveillance.

- Reporters are able to accurately identify invasive *Phragmites* 95% of the time, based on comparison of reporters' morphological identifications to genetic tests.

- A map of the statewide distribution of invasive *Phragmites* shows it to be most common in the Twin Cities metropolitan region, Chisago and Wright counties, and in and around the city of Duluth (Figure 2).

- In addition to the 389 verified wild invasive *Phragmites* populations, there are 16 wastewater treatment facilities in Minnesota that use invasive *Phragmites* in their operations.

- While invasive *Phragmites* has long been known to be capable of spreading through accidental transport of vegetative structures (e.g., rhizomes and stolons), it was previously thought that invasive *Phragmites* had little capacity for sexual reproduction and spread by seed. However, invasive *Phragmites* is now broadly understood to produce viable seed (Kettenring and Whigham 2009), and MNPhrag research has confirmed that, even under Minnesota's climate, invasive *Phragmites* populations in the state are producing viable seed.

Figure 1.

A) European common reed (*Phragmites australis* subsp. *australis*) is an invasive wetland grass.

B) Secretive marshbirds like the least bittern nest more frequently in marsh meadow habitats than invasive *Phragmites* stands. Invasive *Phragmites* can also negatively affect fish populations, as has been shown in mummichogs on the East Coast (Able and Hagan 2000).

C) It is capable of invading a wide variety of wetland habitats, including lakeshores, marshes, and roadside ditches.

D) An extensive invasive *Phragmites* monoculture (light green) in Wisconsin along Lake Michigan; similar conditions are found in New England, Michigan, and Nebraska, necessitating control efforts to reduce abundance.

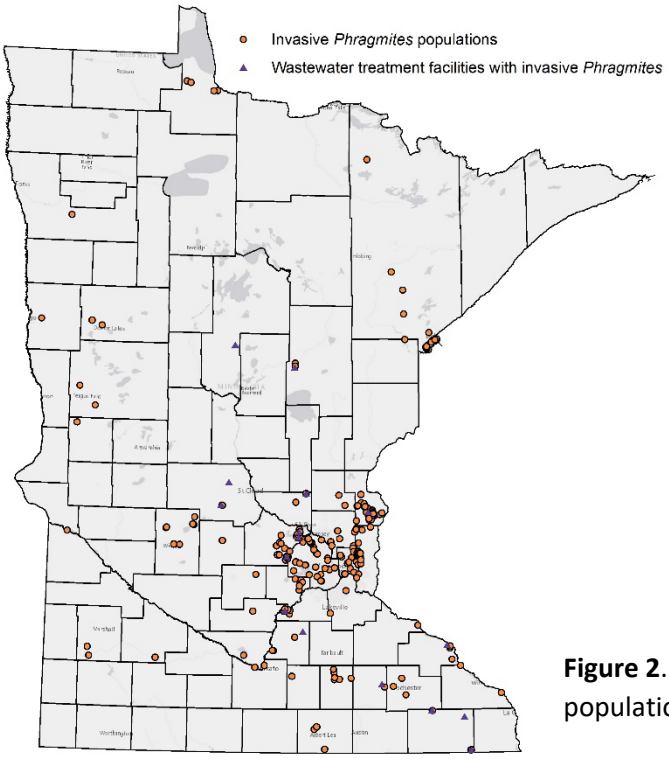


Figure 2. Verified invasive *Phragmites* populations throughout Minnesota.

The window of opportunity to limit invasive *Phragmites* invasion in Minnesota is now. With less than 400 verified populations, the state has relatively low invasive *Phragmites* abundance. Neighboring states and provinces are not large sources of invasive *Phragmites*. Wisconsin regulates invasive *Phragmites* as a prohibited species in its western half and is systematically controlling invasive *Phragmites* populations there, reducing potential for further introductions from across Minnesota's eastern border. There have been few reports of invasive *Phragmites* in North Dakota, South Dakota, and Iowa. However, invasive *Phragmites* populations have been spreading through southern Ontario and into Manitoba (ISCM 2019, Ontario 2019). Proactive, coordinated control and monitoring could minimize negative impacts of invasive *Phragmites* and reverse its spread. Delaying response to invasive *Phragmites* invasion will increase the costs of control activities and reduce their effectiveness, as controlling large populations is difficult (Quirion et al. 2018, Rohal et al. 2019). Based on the distribution of invasive *Phragmites* populations in Minnesota, likelihood of further spread, and resources in place for management of non-crop invasive plants, the capacity for coordinated control of invasive *Phragmites* varies regionally across Minnesota.

Invasive *Phragmites* is a shared problem, as it inhabits roadsides, lakeshores, wetlands, and other habitats on both publicly and privately owned lands, and is used in some municipal wastewater treatment facilities. Successful response will hinge upon commitments by regional and local organizations, the support and collaboration of state agencies, and cooperation by individual landowners (Epanchin-Niell et al. 2010). In addition, ongoing surveillance will require "eyes on the ground" at the local level. The intention of this document is to support a comprehensive statewide response to invasive *Phragmites*. For each of 12 regions of Minnesota, we characterize the various environmental and social contexts in which

invasive *Phragmites* has been found, identify potential partner organizations, and propose strategies that could be implemented to control invasive *Phragmites* populations. We also address regional and statewide coordination and training needs, current and future actions to prevent spread from wastewater treatment facilities, potential funding sources, and likely challenges, and estimate control costs to support effective response.

A proposed goal for invasive *Phragmites* response

With the limited distribution of invasive *Phragmites* in Minnesota, a well-designed and coordinated landscape-scale response, along with continuing surveillance, could effectively eliminate it from the state. Invasive species practitioners know that management is most effective in the early stages of invasion, when the invasive is not yet widely abundant and distributed across the landscape (Simberloff et al. 2013). Despite 389 populations of invasive *Phragmites* having been verified across Minnesota, these populations comprise an area of approximately 50 acres, as opposed to hundreds or thousands of acres in other states across the country. Invasive species control efforts often aim to meet site-specific goals, which can be challenging to meet since species' dispersal is not bound by political or property boundaries. Effective control approaches are well understood and documented for invasive *Phragmites*. A coordinated, landscape-scale effort aimed at eliminating it from Minnesota would at least delay and could realistically reverse its spread in the state. Additional pioneer populations would continue to arise from various sources, but ongoing surveillance and rapid response would allow maintenance of very low abundance statewide. The costs of the initial control effort, followed by management of intermittent new invasions, would likely be far lower than the costs of allowing invasive *Phragmites* to continue to spread—i.e., the costs associated with perpetual nuisance control and asset preservation, and the costs resulting from degradation of wetlands, lakeshores, and other habitats and the ecosystem services they provide.

Because functionally eliminating invasive *Phragmites* from the state appears to be attainable, we did not attempt to prioritize populations for control. At this stage, all populations must be given priority, as this is fundamental to a successful response at the landscape-scale given the biology of the species. Depending on management outcomes, prioritization could later be considered following an initial, concerted response effort.

How to use this document

The intended audience for this document is federal to local agencies and organizations who may be involved in invasive *Phragmites* response efforts. Part I of this assessment provides stakeholders with an overview of regional complexity, capacity, and potential strategies. Regional and local partners may not need to read the regional sections outside their area, while we encourage those coordinating at the statewide level to read the document fully. It is recommended that partners read Parts II-IV as well as the regional section that applies to them, as Parts II-IV expand on the information provided in Part I, with critical considerations for effective and appropriate response efforts. Those reading the document fully will find some redundancies in the information presented across the regional sections, which are intended for regional and local partners interested in a particular region. The appendices describe important caveats regarding how information was compiled. We urge entities participating in

invasive *Phragmites* response efforts to read Parts II-IV and the appendices, particularly for important considerations regarding recommended use of regional control cost estimates, property ownership determinations, and recommendations and requirements for control implementation.

This assessment is intended to support landscape-scale invasive *Phragmites* response efforts by characterizing capacity, identifying needs, and posing potential strategies for implementation. We hope that the information presented in this document will aid development of plans, identification of partners and resources, and carrying out organized and thoughtful control and monitoring.

Part 1:
Regional assessments of invasive *Phragmites* response needs

Invasive *Phragmites* response regions

This assessment takes a regional approach to account for the various invasion scenarios (i.e., characteristics of invasive *Phragmites* populations and the environmental and social context in which they occur) and organizational capacities specific to different parts of the state. It assumes coordination and support at the statewide level is integral to a successful, comprehensive response.

The 12 regions in this assessment were defined largely based on the distribution of verified invasive *Phragmites* populations, county boundaries, active invasive *Phragmites* control efforts, tribal boundaries, and the presence of cooperative weed management areas (CWMAs) and other entities with an interest in invasive plant management. Environmental characteristics and boundaries, watershed boundaries, land use, and the operating units of state agencies were also considered. With the configuration defined here, each region has at least one CWMA and at least one verified invasive *Phragmites* population (with the exception of the Northeast Region; Figure 3). Partner organizations involved in invasive *Phragmites* response may find adjustments to this regional configuration necessary to more efficiently plan for implementation.

The region-specific sections that follow describe invasive *Phragmites* abundance, population characteristics, response capacity and strategies, and estimated control costs. These sections, as well as the reference sections, can be used by participating organizations in communications and coordination of invasive *Phragmites* response efforts. The regions are ordered from highest-to-lowest number of verified invasive *Phragmites* populations. Please see the Methods appendix for a description of how costs were estimated, land ownership was determined, strategies and restoration sites were identified, and capacity was evaluated, along with associated caveats.

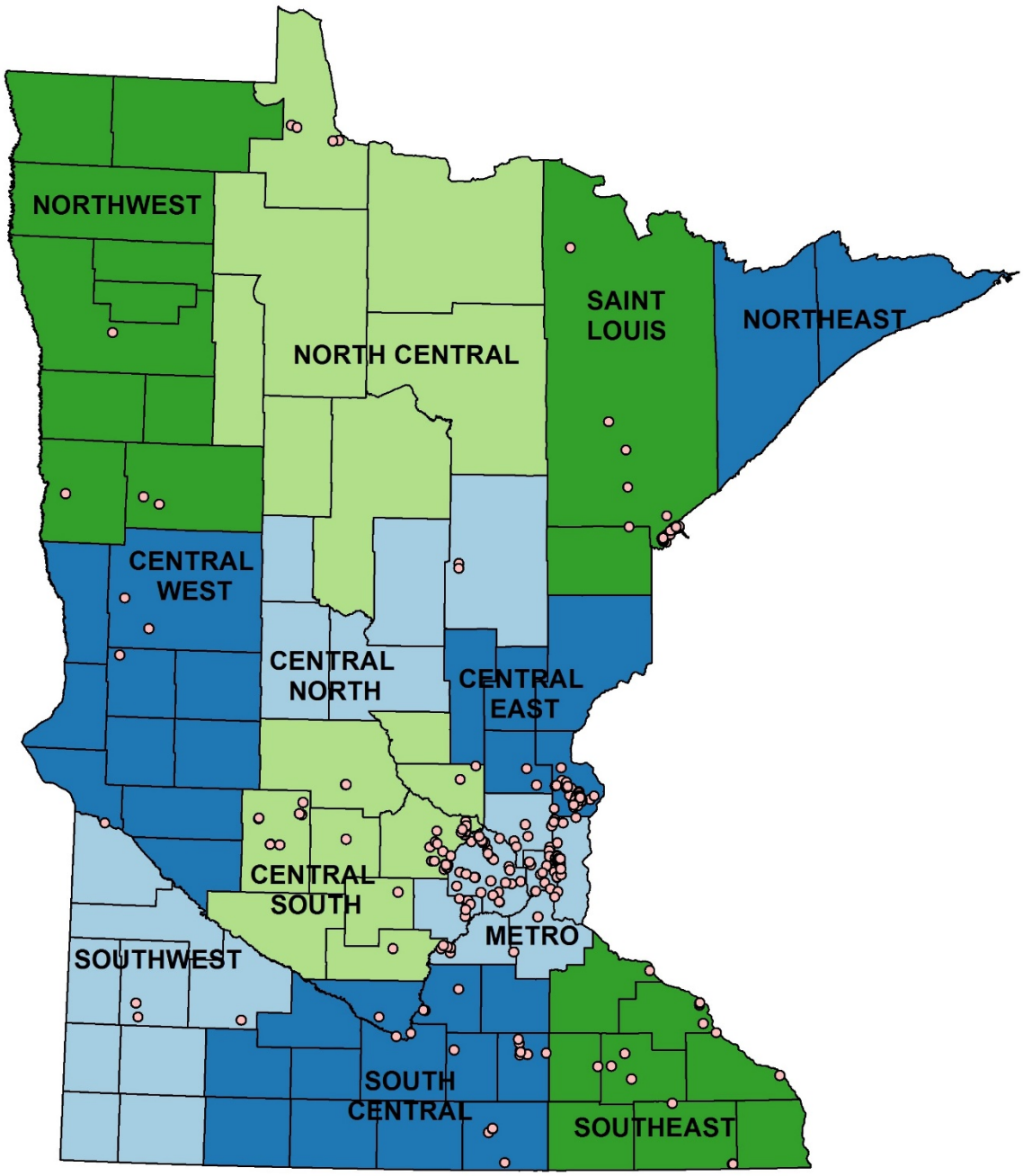


Figure 3. The 12 response regions under which invasive *Phragmites* status, response capacity, and strategies are described in this assessment.

Metro region

Counties

- Anoka
- Carver
- Dakota
- Hennepin
- Ramsey
- Scott
- Washington

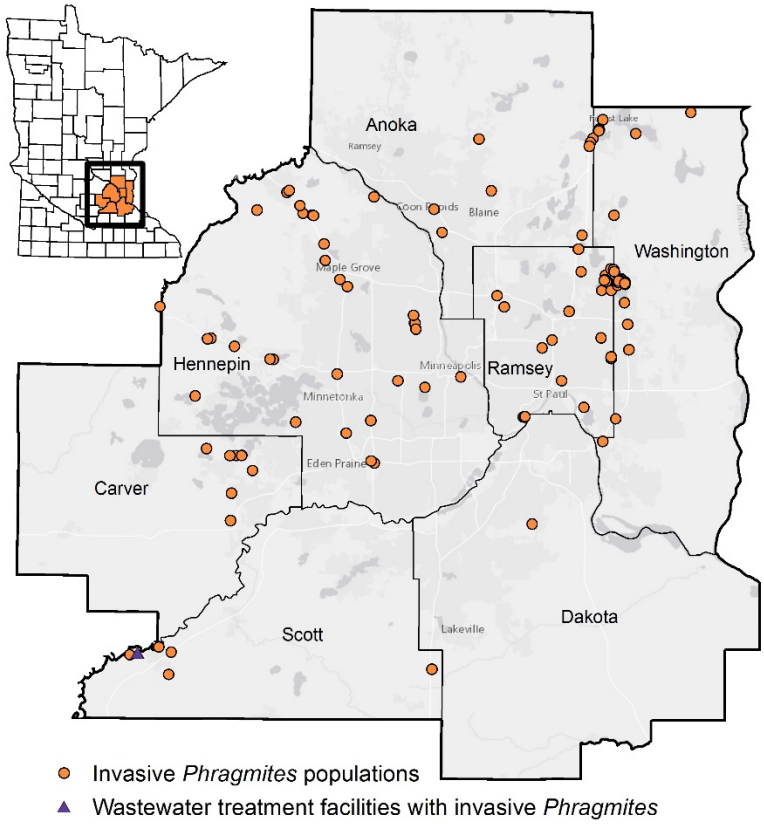
Invasive *Phragmites* status

The seven-county Metro Region has 108 verified invasive *Phragmites* populations to date. Thirty-seven of these are along rights-of-way managed by the Minnesota Department of Transportation (MNDOT). There are another 22 lake and shoreline populations in White Bear Lake. Most populations (68%) are 1,000 sq. ft. or less in size. The largest population is approximately 1 acre and is located in a wetland extending across properties owned by the Minnesota Vikings and other commercial entities. Other relatively large populations (0.7-0.85 acres) have been verified in Maplewood's Priory Neighborhood Preserve and in the city of Saint Louis Park along a railway right-of-way and the Cedar Lakes Trail. Populations estimated at less than ½ acre occupy a variety of habitats, with many along roadsides, in White Bear Lake, in county and municipal parks, and on commercially owned property. There is also a wastewater treatment facility in Scott County using invasive *Phragmites* as part of their operations.

Invasive species response capacity

While a large proportion of invasive *Phragmites* populations in Minnesota occur in the Metro Region, this region has significant invasive species response capacity. The region is within a single MNDOT district (the Metro District), through which state and federal roadside maintenance is coordinated. White Bear Lake has an active conservation district and active restoration and homeowners' associations. Additionally, there are CWMAs in Anoka, Washington, Ramsey, Dakota, and Scott counties. Minnesota Department of Natural Resources (MNDNR) has aquatic invasive species specialists and wildlife managers operating in this area out of their Central Region. Some of the populations are on land owned by the BNSF and Soo Line railroad companies, which may have their own rail maintenance personnel or be willing to allow access to their property for control activities. Other private entities may be willing to contribute funds toward invasive *Phragmites* control on their properties.

Invasive *Phragmites* has been verified within the boundaries of 18 of the 34 watershed districts and management organizations in the Metro Region. The Shakopee Mdewakanton Sioux Community is also located in this region. There are County Agricultural Inspectors and Soil and Water Conservation Districts (SWCDs) in every county; these oversee noxious weed law and implement natural resources programs, respectively.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 108*

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	57		Roadside	38		Private	17
>500 sq. ft. – .25 acre	41		Lakeshore	30		Municipal	13
>.25 – 1 acre	9		Wetland	21		County	7
>1 – 2 acres			Mixed	8		Lake	22
>2 acres			Stormwater pond	6		State	3
Unknown	1		Industrial			MNDOT	37
			Riverine	5		Federal	
			Other			Mixed	9

*This total does not include an invasive *Phragmites* population in use in the operations of a wastewater treatment facility in Scott County.

Invasive *Phragmites* response options

Because of the high density of populations, elimination of invasive *Phragmites* from the Twin Cities Metro Region will be challenging. It should be possible, however, with substantial funding, control coordination, and collaboration among participating organizations. Cooperation with MNDOT will be particularly important for controlling the large number of roadside populations. While most populations are relatively small, controlling the largest populations will require collaboration with city parks departments and commercial entities. In some cases, coordinators will need cooperation from landowners to access private properties. Coordinated monitoring and reporting from partner organizations will support early detection and comprehensive response. Collaboration with the Scott County wastewater treatment facility using invasive *Phragmites* will also be needed for efforts to be comprehensive.

A truck, utility vehicle (UTV), or other vehicle with a mounted herbicide tank and hose could be used to treat many of the roadside, wetland, and lakeshore populations in this region. Some of the populations in White Bear Lake will only be accessible by boat, while shoreline populations may be treatable from shore using an ATV or backpack sprayer. Five to 10 populations may warrant the use of a wetland-adapted vehicle.

Mowing dead invasive *Phragmites* stems (while not recommended as a control strategy alone) increases the effectiveness of subsequent herbicide treatments. Most populations in the Metro Region could be knocked down or cut using a flail mower, forestry mower, or similar equipment, though larger wetland-adapted vehicles may be needed in some cases. A few populations are small enough that they could be cut by hand using a brush saw.

Estimated control cost for region: $175,000-$301,500 over three years

Cost estimation notes

Values presented include three-year costs of control (herbicide application and mowing) only; costs of restoration, project administration by contractees, surveillance, purchasing equipment, and other expenses are not included. The largest populations, near the Minnesota Vikings property, White Bear Lake, Priory Neighborhood Preserve, and the Cedar Lakes Trail may likely require more than three years of control. These values also do not include costs of transitioning to alternative methods for the wastewater treatment facility (see the Invasive *Phragmites* at wastewater treatment facilities section). Only minimal coordination across partner organizations and with ongoing plant management efforts (e.g., state or county highway maintenance) was assumed; further collaboration among coordinators could reduce control costs. For more information about how costs were estimated, see the Methods appendix.

Over three years, we estimated that roadside populations under MNDOT or other state ownership throughout the region could be controlled for $41,000-112,000. Populations under private, county, and municipal ownership could be controlled in Hennepin County for $60,500-74,500; Ramsey County for $29,000-40,500; Carver County for $6,500-12,500; Anoka County for $5,500-9,000; and Washington County for $2,500-5,000. Some of the populations in Hennepin and Ramsey counties may require employing a Marsh Master® or other appropriate wetland-adapted vehicle, which would significantly increase costs. Populations in and around White Bear Lake and Otter Lake in Ramsey and Washington Counties would best be managed under one contract and could be controlled for $28,000-45,000. The small population at Lebanon Hills Regional Park

could be controlled for $2,000-3,000, with most of these costs being associated with labor and mobilization (e.g., transportation, equipment movement, etc.).

Possible funding structure

Private entities may be interested and able to support invasive *Phragmites* control efforts in this region. Populations on MNDOT and other state-owned properties could be managed along with other roadside maintenance activities. The Costs and funding sources section describes dedicated funding for maintenance of parks and trails. Control of populations under private, municipal, or county ownership could also be supported by many of the programs described in that section. As described in Coordination and networking strategies, funding could be awarded through a state-administered grant program or by regional or local entities directly.

Several populations along highways in the Metro Region are being treated by MNDOT.

Training and capacity needs

Identification, reporting, equipment decontamination, and an understanding of permitting and herbicide use requirements are core competencies for organizations and individuals participating in invasive *Phragmites* response. Participants in surveillance must be capable of distinguishing native and invasive *Phragmites* (or submitting samples to an expert for identification) and know how to report suspected new invasive populations. Management methods should be determined appropriate to a given site and will require access to necessary equipment. If particular equipment cannot be adequately decontaminated, an alternative approach should be used. MNDNR invasive aquatic plant management permits will be needed for control activities in most aquatic environments, and only herbicide formulations approved for aquatic use can be used in those scenarios. Only Commercial Pesticide Applicators licensed through the Minnesota Department of Agriculture (MDA) can be contracted to apply herbicides. Control activities should be reported and evaluated to support effective response across regions and the state.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Central East region

Counties

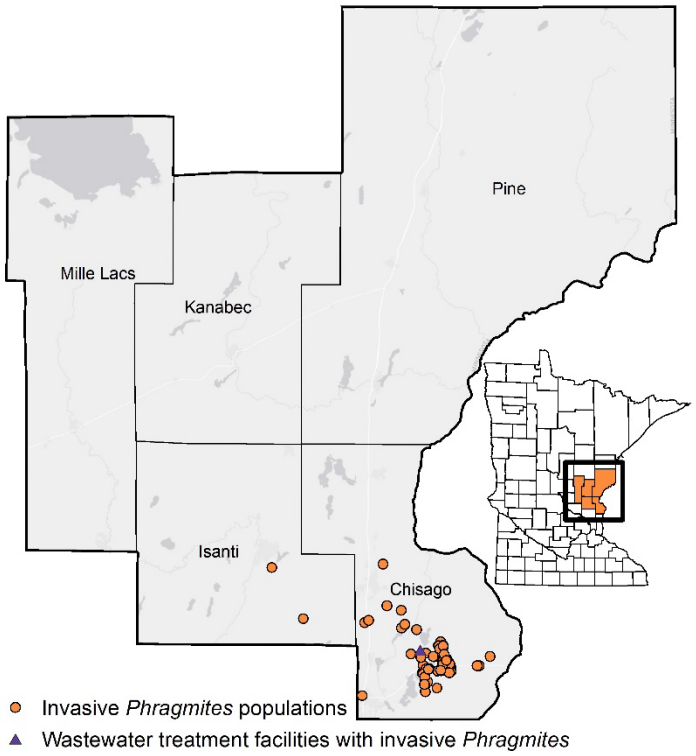
- Chisago
- Isanti
- Kanabec
- Mille Lacs
- Pine

Invasive *Phragmites* status

Nearly 80% of the 92 invasive *Phragmites* populations verified in the Central East Region occur along the shores of North Center, South Center, Chisago, South Lindstrom, and North Lindstrom lakes in Chisago County. All but three lakeshore populations are less than ¼ acre in size, with the largest (estimated at approximately 0.7 acres) occupying private land and the remaining two extending onto county- and state-owned properties. 74% of lakeshore populations cover areas ≤1,000 sq. ft. Most of these extend onto private residential or agricultural properties while some occur along municipal, county, or MNDOT-managed roadsides. The remaining, non-lakeshore populations are along county- and MNDOT-managed roadsides (some of which appear to extend into private properties), in municipal stormwater ponds, and state- and privately owned wetlands. All are ≤¼ acre. There is also a wastewater treatment facility in Chisago County that uses invasive *Phragmites* in their operations.

Invasive species response capacity

The Chisago-Lindstrom Lakes Association and the Center Lakes Association are committed to the management of invasive species and protecting the interests of lakeshore owners. They have already initiated invasive *Phragmites* education and control efforts, in collaboration with the Chisago Lakes Improvement District, Center City Public Works, Comfort Lake-Forest Lake Watershed District, Isanti County, and the Minnesota DNR and DOT. MNDNR aquatic invasive species specialists and wildlife managers operate out of MNDNR's Central and Northeast regions. State and federal highway maintenance in this region is coordinated under three MNDOT districts (Districts 1, 3, and Metro). Kanabec County has the only CWMA. The Mille Lacs Band of Ojibwe is also in this region. There are SWCDs and County Agricultural Inspectors in every county, which implement natural resource programs and oversee noxious weed law, respectively.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 92*

Coverage area	Number of populations	Habitat types invaded	Number of populations	Property ownership	Number of populations
≤500 sq. ft.	57	Roadside	15	Private	6
>500 sq. ft. – .25 acre	33	Lakeshore	70	Municipal	5
>.25 – 1 acre	2	Wetland	3	County	8
>1 – 2 acres		Mixed	2	Lake	
>2 acres		Stormwater pond	2	State	3
Unknown		Industrial		MNDOT	5
		Riverine		Federal	
		Other		Mixed	65

*This total does not include an invasive *Phragmites* population in use in the operations of a wastewater treatment facility in Chisago County.

Invasive *Phragmites* response options

With 92 verified invasive *Phragmites* populations, the Central East Region is fortunate to have lake associations that are already planning response and surveillance efforts. Continued coordination and engagement with partners, and substantial funding, will be needed to eliminate invasive *Phragmites*. Because of shared property ownerships, private landowners, cities, counties, and the state will need to be engaged in lakeshore control activities. Coordination with state and county highway maintenance departments will be needed to control roadside populations. Early detection of populations and comprehensive response would be supported by coordinated surveillance and reporting. Collaboration with the wastewater treatment facility using invasive *Phragmites* in its operations will also be needed to support comprehensive response.

Depending on the habitat invaded, herbicide treatments could be conducted using a boat, truck, UTV, or other vehicle with a mounted tank and hose. The lakeshore populations could be treated using a boat, or in some cases from land via a backpack sprayer or ATV. A truck, tractor, or UTV could be used for the roadside populations. A vehicle adapted for use in wetland environments may be needed for a few populations.

A flail mower or similar equipment could be used to mow or knock down standing dead invasive *Phragmites*, which has been shown to improve the efficacy of herbicide treatments. Knocking down stems may be more feasible for lakeshore and wetland populations, while mowing could be used along roadsides. For some lakeshore populations, mowing or knockdown may be difficult.

Estimated control cost for region: $45,000-$145,500 over three years

Cost estimation notes

Estimates include herbicide application and mowing costs over the course of three years of management; surveillance, restoration, project administration by contractees, equipment, and other related expenses are not included. The largest lakeshore populations may likely require more than three years of control. Implementing an alternative dewatering method at the wastewater treatment facility also is not included (see the Invasive *Phragmites* at wastewater treatment facilities section). Coordination among organizations or with other vegetation management efforts (e.g., state and county highway maintenance activities) could reduce control costs, as we assumed only minimal coordination in developing estimated costs. The Methods appendix further describes how cost estimates were developed.

We estimated that all the lakeshore populations in the Central East Region could be controlled over the course of three years for $26,000-99,000. Populations on Chisago County private and county-owned properties could be controlled for $12,000-36,500. An estimated $2,500-4,000 would cover control activities for the invasive *Phragmites* populations on MNDOT-owned sites. Populations in the other two state-owned sites could be controlled for $2,500-3,000, and the populations in Isanti County could be controlled for $2,000-3,000.

Possible funding structure

The funding programs described in the Costs and funding sources section could support control of many of the invasive *Phragmites* populations in the Central East Region. Funding could be applied for by regional or local entities or awarded through a state-administered grant program, as described in Coordination and networking strategies. Alternatively, private

entities or regional and local organizations could fund control efforts. Control of populations on state and MNDOT-owned lands could also be funded by the programs described in Costs and funding sources or by integrating invasive *Phragmites* control with their previously planned maintenance activities.

Training and capacity needs

Partners involved in invasive *Phragmites* response will need to be able to identify invasive *Phragmites*, report and evaluate actions, decontaminate equipment, and follow permitting and herbicide use requirements. Those involved in surveillance must be able to differentiate between invasive and native *Phragmites* (or submit samples to an expert for identification) and know how to report suspected new populations. Those involved in control activities will need to be able to determine the appropriate management approach. Necessary equipment may need to be acquired and only equipment that can be sufficiently decontaminated should be used. The use of aquatic-approved herbicide formulations and acquisition of invasive aquatic plant management permits from MNDNR will be essential for work in aquatic environments. Only MDA-licensed Commercial Pesticide Applicators can be contracted for these activities. Reporting and evaluation of the results of control activities should be conducted to support effective response.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Some populations found in Chisago County lakes are well established, while other populations are still small with sparse stems.

Saint Louis region

Counties

- Carlton
- Saint Louis

Invasive *Phragmites* status

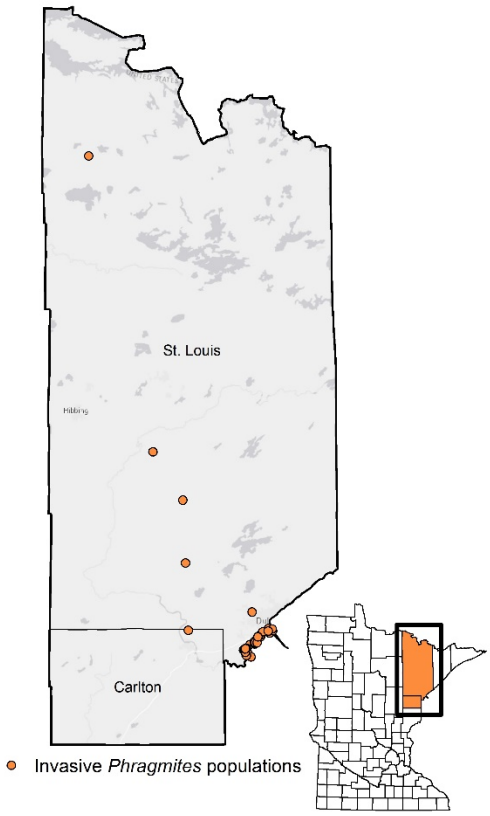
Thirty-three of the 67 invasive *Phragmites* populations verified in the Saint Louis Region are lakeshore (37%) and wetland (12%) populations in and around the port of Duluth. These tend to have mixed ownership, spanning from private, commercial or railway properties to areas owned or managed by the city of Duluth and the Duluth Port Authority. Many have been estimated to be approximately ¼ acre in size. The largest population has been estimated at approximately 2.5 acres. There are several large populations near Grassy Point, Rice's Point, and Spirit Lake Marina, including a 1.5-acre population on state-owned property. There are also several ¼-acre populations in stormwater ponds in Duluth's Oneota neighborhood.

Outside Duluth, two populations have been verified along Highway 53, estimated at ¼ acre and 1 acre. The single population in Carlton County is estimated at ¼ acre and is along Highway 33.

Invasive species response capacity

Significant invasive *Phragmites* control efforts are already being conducted and coordinated by a partnership including the Saint Louis River Alliance, Community Action Duluth, the Great Lakes Indian Fish and Wildlife Commission, and the 1854 Treaty Authority. The Duluth Port Authority and the BNSF and Soo Line railroad companies may be able to provide property access. The railway companies may also be able to use their own maintenance staff for invasive *Phragmites* control. Other private entities may be willing to contribute some of their own funds towards invasive *Phragmites* control on their properties. MNDNR aquatic invasive species specialists and wildlife managers work out of MNDNR's Northeast region. MNDOT-managed roadways are maintained through MNDOT District 1.

There are CWMAs in both Carlton and Saint Louis counties. Lands of the Fond du Lac Band of Lake Superior Chippewa and a small portion of the lands of Bois Forte Band of Chippewa are also within this region. North and South SWCDs in Saint Louis County and SWCD in Carlton County implement natural resource programs. Each county has a County Agricultural Inspector that oversees noxious weed law.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 67

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	4		Roadside	4		Private	31
>500 sq. ft. – .25 acre	48		Lakeshore	25		Municipal	8
>.25 – 1 acre	8		Wetland	8		County	1
>1 – 2 acres	1		Mixed	19		Lake	
>2 acres	1		Stormwater pond	6		State	3
Unknown	5		Industrial	5		MNDOT	3
			Riverine			Federal	
			Other			Mixed	21

Invasive *Phragmites* response options

Of all the regions, the Saint Louis Region has the largest estimated cost for eliminating invasive *Phragmites*. With complex property ownership scenarios and an abundance of relatively large populations, persistent efforts and substantial funding will be needed. Continued collaboration and coordination among public and private entities are essential. Coordinated surveillance and reporting from partners will support early detection and comprehensive response.

Depending on site characteristics, most herbicide treatments in this region could be conducted using a truck, UTV, or boat with a mounted tank and hose reel. Some large wetland populations may require employing a wetland-adapted vehicle.

While mowing alone is not an effective invasive *Phragmites* control method, it can improve the effectiveness of subsequent herbicide treatments. Most sites could probably be mowed using a knockdown via vehicle or other equipment, while a few may warrant a flail mower or similar equipment. A few of the smaller populations could alternatively be cut with a brush saw. Some of the lakeshore and wetland sites may only be accessible for mowing during the winter.

We identified several populations in this region that could benefit from native habitat restoration to prevent reinvasion following elimination of invasive *Phragmites*. These include the large population at Grassy Point, the ¼ acre populations near US Steel Creek, and the small population near Duluth Haines Road and Highway 53. These five were noted in particular for restoration due to their size and close proximity to sites with high ecological value and the St. Louis River Estuary.

Estimated control cost for region: $309,500-$842,000 over three years

Cost estimation notes

Values presented include three-year estimates of invasive *Phragmites* control (herbicide application and mowing) only; costs of restoration, project administration by contractees, surveillance, equipment, and other expenses are not included. The largest populations in this region may likely require more than three years of control. Coordination with planned vegetation management activities (e.g., state or county highway maintenance) or among organizations could reduce control costs, as only minimal coordination was assumed in developing estimates. The Methods appendix describes our process for estimating costs.

Control of populations under private, county, municipal, and mixed ownership in Saint Louis County make up the bulk of the cost, estimated at $259,500-712,000 over three years. Populations on MNDOT-owned properties could be controlled for $25,000-62,000. Invasive *Phragmites* on other state-owned sites could be controlled for $25,000-68,000.

Possible funding structure

The majority of populations in this region could be controlled with the support of one or more funding sources described in the Costs and funding sources section. With many populations within the Great Lakes Basin, the Great Lakes Restoration Initiative may be a particularly useful source. Funding could be awarded through a state-administered grant program or to regional and local entities directly (see Coordination and networking strategies). Those sources could also fund control on state-owned lands, or agencies could integrate invasive *Phragmites* control with previously planned vegetation management efforts. The rail companies may also be able to integrate invasive *Phragmites* control with their existing maintenance activities.

Training and capacity needs

Partners in invasive *Phragmites* response efforts should be capable of identifying and reporting invasive *Phragmites* and decontaminating equipment, and be aware of herbicide-use and permitting requirements. MNDNR invasive aquatic plant management permits are typically needed for control at lake and wetland sites, and herbicides applied at wet sites must be approved for use in aquatic environments. Additional permissions may also be needed for work done in the Saint Louis River Estuary and Duluth-Superior harbor. Additionally, only MDA-licensed Commercial Pesticide Applicators can be hired to conduct treatments. Control and restoration activities should be specific to each site and necessary equipment may need to be acquired. Only equipment that can be sufficiently decontaminated should be used. Evaluation and reporting of control activities will support effective management. Individuals and organizations participating in invasive *Phragmites* response will need to be able to distinguish between native and invasive *Phragmites* and report populations or know where to submit samples for verification.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Treatment of invasive Phragmites populations in the Duluth port area is well underway thanks to coordination by members of the St. Louis River Alliance.

Central South region

Counties

- Benton
- Kandiyohi
- Meeker
- McLeod
- Sherburne
- Sibley
- Stearns
- Renville
- Wright

Invasive *Phragmites* status

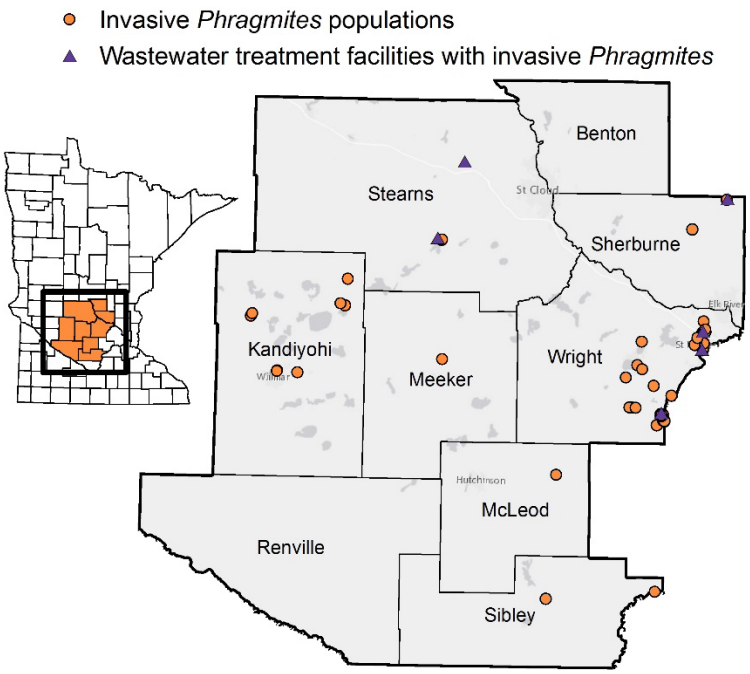
The Central South Region has 64 wild (i.e., non-wastewater treatment) invasive *Phragmites* populations, as well as 6 of Minnesota's 16 wastewater treatment facilities that use or have used invasive *Phragmites* in their operations. Three of these facilities are in Wright County, and many of the wild invasive *Phragmites* populations in the region are situated near them. There are also two invasive *Phragmites*-using wastewater treatment facilities in Stearns County and one in Sherburne County. The majority of populations in this region are along roadsides, in wetlands, and in stormwater ponds with private, state, county, and municipal ownership.

Most populations in this region are <10,000 sq. ft., though the largest population has been estimated to cover approximately 4 acres, making it the largest population in the state; this population is in Kandiyohi County along County Road 40 and extends onto a privately owned wetland. Other relatively large populations in Kandiyohi County include a 1-acre wetland population near Swenson Lake and a ½-acre population along the Glacial Lakes State Trail. Meeker County has a roadside population estimated at approximately 1.5 acres that extends into private land. There are also ½-acre populations in Wright County along Highway 12, including two wetlands under private and municipal ownership and a third wetland near the Princeton wastewater treatment facility in Sherburne County. Kandiyohi County also has a lakeshore population estimated at 10,000 sq. ft. on commercial property near Foot Lake Radio Station.

There are several populations estimated to cover <10,000 sq. ft. There is a single, small population in McLeod County, along Highway 7 near Clouster Lake Wildlife Management Area, extending onto private property. Sherburne County has a 2,400 sq. ft. lakeshore population in Sherburne National Wildlife Refuge. Finally, there are two populations at a cement plant in Stearns County.

Invasive species response capacity

There are CWMAs in Kandiyohi, Meeker, Stearns, and Wright counties. At MNDNR, wildlife managers and aquatic invasive species specialists work out of MNDNR's Central and Southern regions. MNDOT Districts 3, 7, and 8 coordinate state and federal roadside maintenance in this region. Watershed districts also cover much of the Central South Region; including the Buffalo Creek, Clearwater River, High Island Creek, Middle Fork Crow River, North Fork Crow River, and Sauk River Watershed Districts. There are SWCDs and County Agricultural Inspectors in every county, which implement natural resources programs and oversee noxious weed law, respectively. Other, private entities may be willing to contribute some of their own funds towards invasive *Phragmites* control on their properties.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 64*

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	17		Roadside	16		Private	22
>500 sq. ft. – .25 acre	37		Lakeshore	3		Municipal	17
>.25 – 1 acre	5		Wetland	17		County	5
>1 – 2 acres	1		Mixed	13		Lake	
>2 acres	1		Stormwater pond	10		State	3
Unknown	3		Industrial	2		MNDOT	11
			Riverine			Federal	1
			Other	3		Mixed	5

*This total does not include 6 invasive *Phragmites* populations in use in the operations of wastewater treatment facilities in Wright, Stearns, and Sherburne counties.

Invasive *Phragmites* response options

Invasive *Phragmites* populations in the Central South Region encompass the full range of habitats, sizes, and property ownerships. With several large populations and wastewater treatment facilities using invasive *Phragmites*, successful response will hinge upon continuous collaboration, control coordination, and substantial funding and support. Because invasive *Phragmites* has been found on lands varying across public and private ownership, engaging partners in control activities will be important. Partner participation will also be needed to support coordinated surveillance and reporting for early detection and comprehensive response. Collaboration with the wastewater treatment facilities is also needed.

Most populations could be treated using a truck, UTV, or other vehicle with a mounted tank and hose. A few populations could be treated with a backpack sprayer. The large wetland populations are likely to require a wetland-adapted vehicle, such as a Marsh Master® or similar equipment.

For mowing, which can make subsequent herbicide treatments more effective, most populations could be knocked down using a vehicle or other equipment or cut with a Brush Hog®, flail or forestry mower, or similar machine. A few populations may be small and sparse enough to use a brush saw to cut by hand. Some of the larger wetland populations may require larger equipment, such as a Marsh Master® with an amphibious cutter, for mowing.

Due to the high ecological value of the surrounding site, restoration of the population at Sherburne National Wildlife Refuge should be considered following elimination of invasive *Phragmites* to prevent reestablishment.

Estimated control cost for region: $171,000-$454,000 over three years

Cost estimation notes

All estimates include three-year costs of herbicide application and mowing; costs of surveillance, restoration, project administration by contractees, equipment purchase, and other related expenses are not included. The largest wetland and roadside populations may likely require more than three years of control. Also excluded are costs of implementing alternative dewatering methods in the wastewater treatment facilities (see the Invasive *Phragmites* at wastewater treatment facilities section). Further coordination among organizations or with plant management efforts already being conducted by a given public or private entity (e.g., state or county highway maintenance activities) could reduce costs below these estimates, as only minimal coordination was assumed in cost estimation. The Methods appendix further describes how control costs were estimated.

Populations on private, county, and municipally owned lands could be controlled for: $94,000-255,000 in Kandiyohi County; $30,000-80,000 in Wright County; $13,500-35,500 in Meeker County; $4,500-13,500 in Sibley County; $4,000-12,500 in Sherburne County; and $2,500-3,500 in Stearns County. Populations on MNDOT-owned properties could be controlled for $13,500-40,500 over three years and on the other four state-owned properties for $6,500-10,000. The population in Sherburne National Wildlife Refuge could be controlled for $2,500-3,500.

Possible funding structure

One or more of the funding sources described in the Costs and funding sources section could support control of invasive *Phragmites* populations in this region. Funding could be awarded to regional and local organizations or

administered at the state level through grants. Control of populations on federal, MNDOT, or other state-owned lands could be included with populations funded through grants, or by integrating invasive *Phragmites* control with previously planned agency plant management efforts. Some commercial entities in this region may also be willing and able to contribute funds.

Training and capacity needs

Core competencies for invasive *Phragmites* response include the ability to identify the plant, report and evaluate activities, decontaminate equipment, and follow permitting and herbicide use requirements. Entities involved in surveillance must be able to identify invasive *Phragmites* subspecies and report their findings or submit samples for verification. Aquatic approved herbicide formulations will be required for populations in aquatic environments, as will invasive aquatic plant management permits from MNDNR. Contracted herbicide applications can only be conducted by an MDA-licensed Commercial Pesticide Applicator. Partners coordinating and conducting control and restoration activities must be able to determine and implement actions specific to each invasive *Phragmites* site, and support effective response through evaluation and reporting of the results. Specialized equipment may need to be acquired in some cases and only equipment that can be adequately decontaminated should be used.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

The Delano WWTF is one of three WWTFs in Wright County that uses invasive Phragmites.

Southeast region

Counties

- Dodge
- Fillmore
- Goodhue
- Houston
- Mower
- Olmstead
- Wabasha
- Winona

Invasive *Phragmites* status

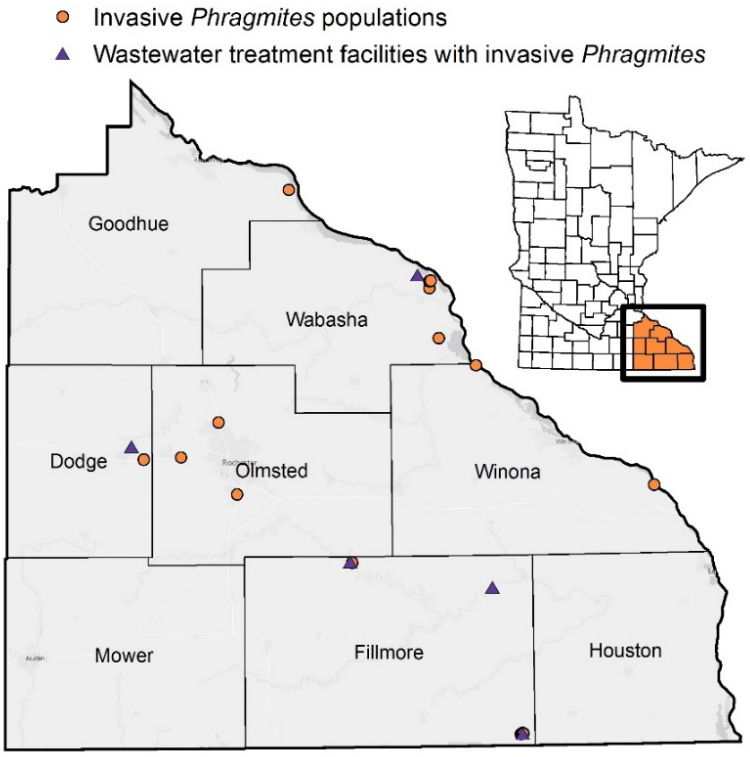
The Southeast Region has 23 verified wild (non-wastewater treatment) invasive *Phragmites* populations and five wastewater treatment facilities using invasive *Phragmites* in their operations: one in Dodge County, one in Wabasha County, and three in Fillmore County. Many of the wild populations are located in wetlands or stormwater ponds or along roadsides near the facilities. While numerous populations in close proximity to wastewater treatment plants are on municipal or county properties, some populations appear to extend onto private properties. The largest population in this region has been estimated at 6,400 sq. ft.; all others are ≤2,500 sq. ft.

Roadside populations identified in this region are along MNDOT-managed highway rights-of-way. There is a small population that extends between MNDOT-managed lands, McCarthy Wildlife Management Area, and lands owned by the Soo Line Railroad Company. Another small population is in a retention pond at the intersection of County Highway 117 and Highway 63. Finally, there is a small population in Frontenac State Park in Goodhue County, which has been treated for the last 2-3 years and will require ongoing monitoring.

Invasive species response capacity

State and federal highway maintenance in this region is coordinated under MNDOT District 6. MNDNR wildlife managers and aquatic invasive species specialists operate out of MNDNR's Southern and Central regions.

There are CWMAs in the Southeast Region in Wabasha, Winona, and Houston counties. This region also contains the following watershed districts: Crooked Creek, Turtle Creek, Bear Valley, Cedar River, Belle Creek, Stockton-Rollingstone-Minnesota City. The Prairie Island Indian Community is also in this region. Every county has a County Agricultural Inspector, who oversees noxious weed laws, and an SWCD, which focuses on natural resources.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 23*

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	12		Roadside	6		Private	7
>500 sq. ft. – .25 acre	11		Lakeshore			Municipal	6
>.25 – 1 acre			Wetland	13		County	2
>1 – 2 acres			Mixed	1		Lake	
>2 acres			Stormwater pond	2		State	1
Unknown			Industrial			MNDOT	6
			Riverine			Federal	
			Other	1**		Mixed	1

*This total does not include five invasive *Phragmites* populations in use in the operations of wastewater treatment facilities in Fillmore, Dodge, and Wabasha counties.
**This is one of the wetland populations on municipal property in Newburg Township near the wastewater treatment facility, though it is on the far side of a ditch outside the dike.

Invasive *Phragmites* response options

Invasive *Phragmites* populations in the Southeast Region span a variety of habitat types and property ownerships. Adequate funding and coordination among partnering organizations will be critical to controlling the 23 small-to-moderately sized wild populations that have been verified. A few of the sites will be challenging to manage because they have steep slopes or will require navigating deep, wet ditches. Participation from MNDNR and MNDOT for populations on their properties, as well as cooperation from private landowners, will be important. Collaboration with wastewater treatment facilities that have invasive *Phragmites* beds will also be essential for supporting comprehensive efforts. Coordinated surveillance and reporting by partners would support comprehensive response and early detection of new populations.

Most populations could be treated using a tank and hose reel extending from a truck, tractor, or UTV. A few of the larger populations may require the use of a wetland-adapted vehicle. A few populations are small enough that hand wicking could be used to avoid non-target plants.

For this region, knockdown using wetland-adapted equipment would be sufficient to prepare most sites for herbicide treatment. A brush saw could be used for small sites. There are a small number of sites where a flail or other mower or a Marsh Master® may be needed. Knockdown or mowing should not be used alone for control, but can increase the effectiveness of subsequent herbicide treatments.

Due to their proximity to sites with high ecological value, the wetland populations south of N County Road 24 could benefit from restoration following elimination of invasive *Phragmites* to prevent reinvasion.

Estimated control cost for region: $21,000-$42,500 over three years

Cost estimation notes

All estimated costs presented include three years of herbicide treatment and mowing; estimates do not include costs of restoration, project administration by contractees, surveillance, equipment, or other expenses. The costs of converting to alternative dewatering technologies at wastewater treatment facilities are also not included (see the Invasive *Phragmites* at wastewater treatment facilities section). Only minimal coordination among organizations was assumed. Further coordination among partners and/or with concurrent plant management efforts (e.g., state and county highway maintenance) could reduce control costs. More information about how cost estimates were developed can be found in the Methods appendix.

Invasive *Phragmites* populations on private and municipal properties in Fillmore County could be controlled for $7,500-16,500. Wabasha County populations in private and county-owned wetlands could be controlled for $7,000-13,000. Controlling invasive *Phragmites* along MNDOT-managed roadsides is estimated to cost $2,500-6,000. The remaining populations, in Frontenac State Park and a retention pond in Olmsted County, could be controlled for approximately $2,000-3,500 each.

Possible funding structure

The programs described in the Costs and funding sources section could fund invasive *Phragmites* control in this region. Funds could be awarded directly to regional and local entities or administered through a state-level grant program (see Coordination and networking strategies). Management of populations on MNDOT and state-owned lands

could be included with others managed through grants, or alternatively controlled in combination with MNDOT's previously planned maintenance efforts. Some private or commercial entities, such as the rail company, may be willing to contribute funds or integrate invasive *Phragmites* control with their own maintenance activities.

Training and capacity needs

There are core competencies for individuals involved in invasive *Phragmites* response, including ability to identify the plant, report and evaluate activities, decontaminate equipment, and follow permitting and herbicide use requirements. Partners will need to be able to distinguish between native and invasive *Phragmites* (or submit samples for confirmation) and report their findings. Control and restoration strategies should be site-specific and specialized equipment may need to be acquired in some cases. Only equipment that can be sufficiently decontaminated should be used. With the majority of populations being located in wetlands, control activities will require permits from MNDNR and managers will need to use herbicide formulations approved for aquatic use. Only an MDA-licensed Commercial Pesticide Applicator can be contracted to conduct herbicide applications. Managers should evaluate and report on control activities to support effective response.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

The Peterson WWTF has four beds containing invasive Phragmites to serve this rural municipality.

South Central region

Counties

- Blue Earth
- Brown
- Cottonwood
- Faribault
- Freeborn
- Jackson
- Le Sueur
- Martin
- Nicollet
- Rice
- Steele
- Watonwan
- Waseca

Invasive *Phragmites* status

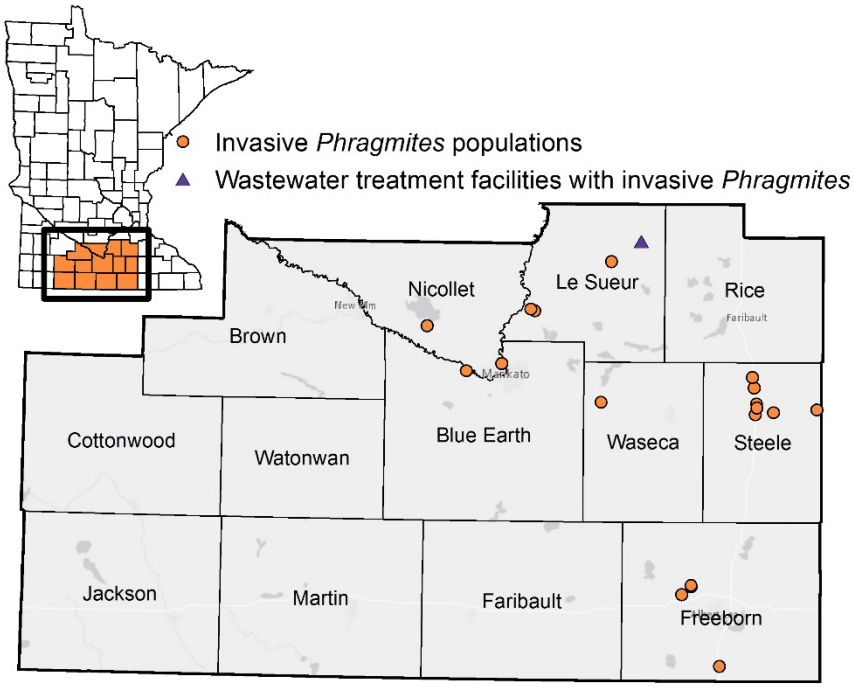
All but a few of the 18 invasive *Phragmites* populations verified in the South Central Region are along roadsides. Most of these roadside populations are on MNDOT-managed highway rights-of-way and a few are along county roads. They range from 120 sq. ft. to 0.4 acres in estimated area. Some populations appear to extend onto private agricultural, residential, and commercial properties. The two largest populations are along Highway 13 and at the Highway 14 and I-169 intersection. One small population borders Swan Lake Wildlife Management Area.

Non-roadside populations are in the wetlands and along the shores of Lake Emily. The larger of the lakeshore populations is estimated to be about one acre and appears to be on private, residential property. The other population is on Ludwig Island in Lake Emily, which is county-owned land. Additionally, a wastewater treatment facility in Le Sueur County uses invasive *Phragmites* in its operations.

Invasive species response capacity

The South Central Region includes MNDOT Districts 6 and 7, through which state and federal highway maintenance is coordinated. Each county also has a roadside maintenance department. MNDNR wildlife managers and aquatic invasive species specialists operate out of MNDNR's Southern region.

This region has several CWMAs, including single-county CWMAs in Rice and Steele counties and a multi-county CWMA encompassing Blue Earth, Brown, Cottonwood, Faribault, Freeborn, Jackson, Le Sueur, Martin, Watonwan, and Waseca counties. There are also several watershed districts, including the Cedar River, Heron Lake, North Cannon River, Shell Rock River, and Turtle Creek watershed districts. Counties also have SWCDs managing natural resources and County Agricultural Inspectors who oversee noxious weed laws.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 18*

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	6		Roadside	13		Private	8
>500 sq. ft. – .25 acre	10		Lakeshore	1		Municipal	
>.25 – 1 acre	2		Wetland			County	1
>1 – 2 acres			Mixed	3		Lake	
>2 acres			Stormwater pond			State	1
Unknown			Industrial			MNDOT	7
			Riverine			Federal	
			Other	1		Mixed	1

* This total does not include an invasive *Phragmites* population in use in the operations of a wastewater treatment facility in Le Sueur County.

Invasive *Phragmites* response options

With more than half of populations covering relatively moderate to large areas, substantial funding and persistent effort from partners will be needed to eliminate invasive *Phragmites* from the South Central Region. Participation from state and county highway departments will be important for coordinating or allowing control activities, as the majority of populations are along roadsides. The multi-county CWMA could be valuable for surveillance and outreach activities, as well as coordination of control efforts for the lakeshore and wetland populations. Cooperation with the wastewater treatment facility will be needed for comprehensive invasive *Phragmites* response. Participation in coordinated surveillance and reporting from partner organizations would support early detection of new populations and effective response. Entities coordinating control will need permission to access areas where invasive *Phragmites* has extended onto private properties.

Most invasive *Phragmites* populations in this region could be treated using a truck or UTV with a mounted herbicide tank and hose reel. A wetland-adapted vehicle may only be needed for the largest population. A boat is necessary to reach the population on Ludwig Island for both herbicide treatment and mowing.

Mowing could be done for the majority of populations using a flail mower or other mower; knockdown may be sufficient for some of these. The largest population may require larger equipment such as a Marsh Master®. Two populations are small enough that they could be cut using a brush saw. Mowing alone is not effective for controlling invasive *Phragmites* in the long-term but has been shown to make subsequent herbicide treatments more effective.

Estimated control cost for region: $31,000-$78,000 over three years

Cost estimation notes

Detailed information about how costs were estimated can be found in the Methods appendix. All values presented are three-year estimates of control (herbicide application and mowing) costs, which do not include restoration, project administration by contractees, equipment, surveillance, or other expenses. The largest lakeshore population may likely require more than three years of control. The cost of installing an alternative method for dewatering at the wastewater treatment facility is also not included (see the Invasive *Phragmites* at wastewater treatment facilities section). We assumed minimal coordination among organizations and with other vegetation management efforts (e.g., state and county highway maintenance). Further coordination could reduce control costs.

We estimate $7,000-22,000 would cover three years of herbicide application and mowing of roadside populations under MNDOT ownership. Remaining populations within the boundaries of the multi-county CWMA could be controlled for $19,000-46,000. Private and county-owned sites in Steele County could be controlled for $3,000-7,000 and the population at Rice Lake State Park could be controlled for $2,000-3,000.

Possible funding structure

Invasive *Phragmites* control in this region could be funded through one or more of the programs described in the Costs and funding sources section, through state-administered grants or to regional and local entities directly (see Coordination and networking strategies). Integration with ongoing agency plant management activities being performed at state-owned sites could cover management of invasive *Phragmites*.

Training and capacity needs

Invasive *Phragmites* identification, reporting and evaluation, equipment decontamination, and compliance with permitting and herbicide-use requirements are core competencies for partners involved in response. Those involved in surveillance must be able to identify *Phragmites* subspecies (or submit samples for verification) and report findings. Control approaches should be tailored to each site and specialized equipment may be needed in some cases. Only equipment that can be sufficiently decontaminated should be employed. For wet sites, such as the lakeshore and wetland locations, aquatic-approved herbicide formulations must be used and invasive aquatic plant management permits from MNDNR may be needed. Contracted herbicide applications can only be conducted by an MDA-licensed Commercial Pesticide Applicator. Management activities should be reported and their results evaluated to monitor progress and effectiveness.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Some large populations are likely to have been established for several years.

Southwest region

Counties

- Lac qui Parle
- Lincoln
- Lyon
- Murray
- Nobles
- Pipestone
- Redwood
- Rock
- Yellow Medicine

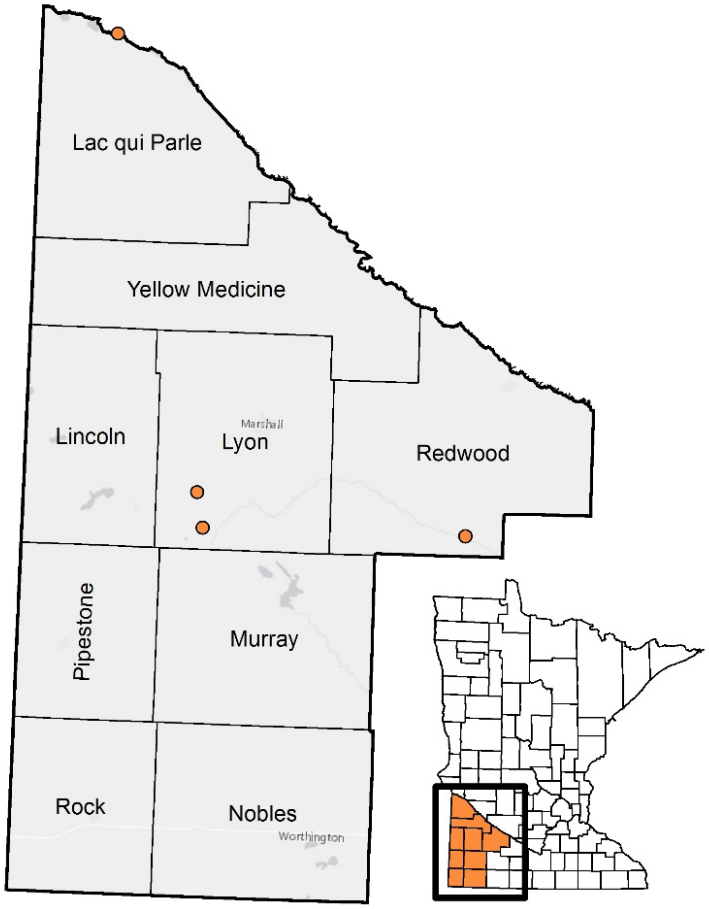
Invasive *Phragmites* status

The Southwest Region has four verified invasive *Phragmites* populations along roadsides and into adjacent wetlands. The largest population is estimated to cover ½ acre in a wetland area in Lac Qui Parle Wildlife Management Area. The second-largest population, estimated at 4,000 sq. ft., is along Highway 23 in Lyon County and may extend between properties owned by BNSF Railway and MNDOT. There is a 3,000 sq. ft. population along Highway 14 in Redwood County, near Lamberton Wildlife Management Area and extending onto private property. This population spans lands with different ownership types (private agricultural land, MNDOT, and MNDNR). The last population, in Lyon County, is estimated to cover 1,600 sq. ft. and is located in a wetland near Highway 14.

Invasive species response capacity

MNDNR wildlife managers and aquatic invasive species specialists operate out of MNDNR's Southern Region. Highway maintenance in the Southwest Region is coordinated under MNDOT Districts 7 and 8. BNSF Railway may have maintenance personnel who manage weeds near their tracks, or who could allow access for such purposes.

There is a single CWMA in this region in Redwood County. In addition, the boundaries of several watershed districts (Heron Lake, Kanaranzi-Little Rock, Lac Qui Parle-Yellow Bank, Okabena-Ocheda, Upper Minnesota River, Yellow Medicine River) cover much of this region. The Upper Sioux Community and Lower Sioux Community are also in this region. County Agricultural Inspectors and SWCDs in each county address noxious weeds and natural resource issues, respectively.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 4

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.			Roadside			Private	
>500 sq. ft. – .25 acre	3		Lakeshore			Municipal	
>.25 – 1 acre	1		Wetland	3		County	
>1 – 2 acres			Mixed	1		Lake	
>2 acres			Stormwater pond			State	1
Unknown			Industrial			MNDOT	2
			Riverine			Federal	
			Other			Mixed	1

Invasive *Phragmites* response options

The four populations in this region will require dedicated control efforts to eliminate invasive *Phragmites*. MNDNR staff could coordinate control of the populations in or near state wildlife management areas. They could collaborate with MNDOT and the private landowner for the population adjacent to Lamberton Wildlife Management Area along Highway 14. Collaboration with or permission to access property from BNSF Railway will also be needed. All of the entities listed above may be able to assist with coordinated surveillance and reporting to support early detection and comprehensive invasive *Phragmites* response.

The variability in size and wetness of the sites will warrant different types of equipment. The ½ acre population in Lac Qui Parle Wildlife Management Area could be treated with herbicide using a wetland-adapted vehicle. The Lamberton Wildlife Management Area population may be accessible using a truck or UTV with a tank and hose. Both populations could also be mowed or knocked down using a wetland-adapted vehicle. The remaining populations, located along state-managed roadsides, could be treated from a truck or other vehicle with a tank and hose for herbicide application. Mowing or knockdown could be done with a flail or other type of mower to increase the effectiveness of subsequent herbicide treatments.

Due to the high ecological value of Lamberton Wildlife Management Area and the adjoining property, it would be beneficial to restore the nearby site following elimination of invasive *Phragmites* to prevent reinvasion.

Estimated control cost for region: $13,000-$28,000 over three years

Cost estimation notes

The populations at Lamberton and Lac Qui Parle Wildlife Management Areas could be controlled for $11,000-21,500 over the course of three years. An estimated $2,500-6,500 would be needed for invasive *Phragmites* control on MNDOT-owned sites in Lyon County. Estimates include three-year costs of herbicide application and mowing only; restoration, project administration by contractees, surveillance, equipment, and other costs are not included. The large population near Lac Qui Parle Wildlife Management Area may likely require more than three years of control. Estimates assume minimal coordination among organizations or with planned vegetation management activities (e.g., state and county highway maintenance); control costs could likely be reduced with further coordination. The Methods appendix further describes how costs were estimated.

Possible funding structure

Control of the invasive *Phragmites* populations on state-owned lands could be funded through integration with planned agency maintenance activities. BNSF Railway may have funding or staff to contribute for the population extending onto their property. Alternatively, organizations could apply for funding through one of the programs described in the Costs and funding sources section. These funds could be awarded through a state-administered grant program or directly to regional and local groups (as described in Coordination and networking strategies. The Minnesota Board of Soil and Water Resources (BWSR) CWMA Grant Program could help increase regional capacity.

Training and capacity needs

Effective response will rely on partners' ability to identify invasive *Phragmites*, evaluate and report response actions, decontaminate equipment, and comply with herbicide use and permitting requirements. Partners involved in surveillance must be able to identify invasive *Phragmites* and report their findings or submit specimens for verification. Wet sites should only be treated with herbicide formulations approved for aquatic use and control activities may require a permit from MNDNR. Contracted herbicide applications may only be conducted by an MDA-licensed Commercial Pesticide Applicator. The use of control approaches and equipment specific to each site (and only equipment that can be sufficiently decontaminated following use), as well as reporting and evaluation of activities, will be needed for effective management.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

The extent of invasive Phragmites appears to be very limited in southwestern Minnesota.

North Central region

Counties

- Beltrami
- Cass
- Clearwater
- Hubbard
- Itasca
- Koochiching
- Lake of the Woods

Invasive *Phragmites* status

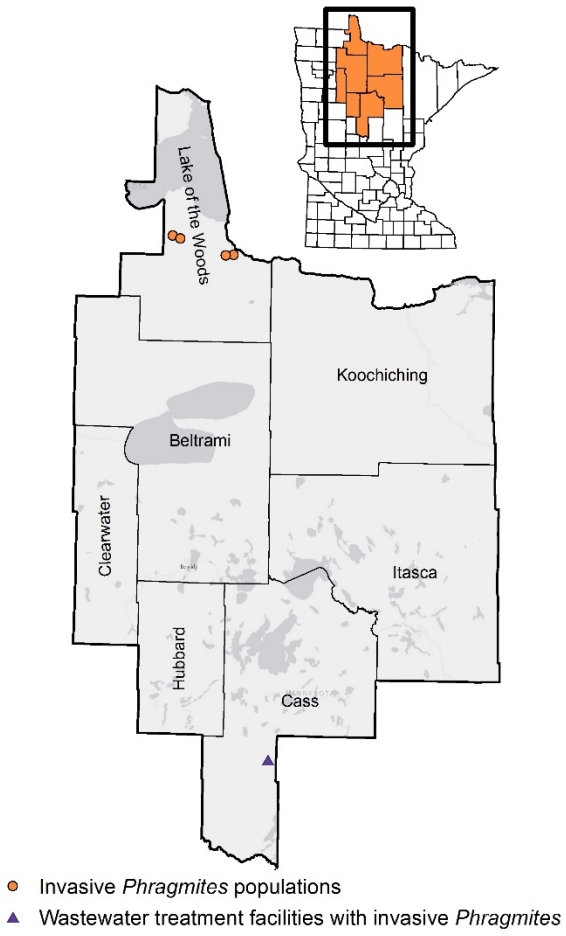
The North Central Region has four verified invasive *Phragmites* populations along Highway 11 and a stretch of railroad in Lake of the Woods County. The largest population is estimated to cover 1,200 sq. ft. There is also a wastewater treatment facility using invasive *Phragmites* in their operations in Cass County.

Railroad corridors appear to facilitate the spread of invasive Phragmites.

Invasive species response capacity

Three MNDOT districts cover this region (Districts 1-3) and the verified invasive *Phragmites* populations are all within District 2. Canadian National Railway may have staff who maintain and remove weeds from the tracks, or could allow access to their property for these purposes.

Itasca County has the only CWMA in this region. There are four watershed districts that work on water-related issues; the boundaries of the Red Lake Watershed District encompass much of Beltrami County and a portion of the Warroad, Wild Rice, and Roseau River watershed districts extend into the western edge of this region. MNDNR aquatic invasive species specialists and wildlife managers operate out of MNDNR's Northwest and Northeast regions. The Bois Forte Band of Chippewa, Leech Lake Band of Ojibwe, and Red Lake Nation have much or all of their lands in this region. The northwestern part of the lands of the White Earth Nation are also in this region. Each county has a County Agricultural Inspector who oversees noxious weed laws and an SWCD that works on natural resources.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 4*

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	2		Roadside			Private	4
>500 sq. ft. – .25 acre	2		Lakeshore			Municipal	
>.25 – 1 acre			Wetland			County	
>1 – 2 acres			Mixed	4		Lake	
>2 acres			Stormwater pond			State	
Unknown			Industrial			MNDOT	
			Riverine			Federal	
			Other			Mixed	

* This total does not include the invasive *Phragmites* population in use at the wastewater treatment facility in Cass County.

Invasive *Phragmites* response options

With collaboration, coordination, and landowner permissions, invasive *Phragmites* could be eliminated from this region with modest effort and funds. The four, relatively small populations identified in Lake of the Woods County could be controlled over the course of a few years. Cooperation with the wastewater treatment facility will be needed as well. Partner organizations could assist with coordinated surveillance and reporting efforts to support early detection and response to new populations. Necessary equipment for control may include a truck or other vehicle mounted with a tank for herbicide and a flail mower or other type of mower to prepare the site for subsequent spraying.

Estimated control cost for region: $2,000-$3,000 over three years

Cost estimation notes

We assumed herbicide application and mowing would be contracted for all four populations together. Because only minimal coordination was assumed in our estimates, combining invasive *Phragmites* control efforts with other plant management activities, either by the railroad company or MNDOT, could reduce control costs. Values include costs associated with herbicide application and mowing only; costs of surveillance, restoration, project administration by contractors, equipment, and other expenses are not included. Costs of transitioning to alternative dewatering strategies at the wastewater treatment facility are also not included (see the Invasive *Phragmites* at wastewater treatment facilities section). For more information about how costs were estimated, see the Methods appendix.

Potential funding sources

Canadian National Railway or MNDOT could integrate control of the invasive *Phragmites* populations in this region with routine maintenance activities. Alternatively, the programs described in Costs and funding sources could be approached for financial support. The BWSR CWMA Grant Program could help bring additional capacity to this region.

Training and capacity needs

Identification, reporting and evaluation, equipment decontamination, and compliance with herbicide use and permitting requirements are core competencies for invasive *Phragmites* response partners. Those participating in surveillance must be able to identify and report invasive *Phragmites* or submit samples for verification. Managers should be able to determine site-specific control approaches. Only equipment that can be sufficiently decontaminated should be used. Those participating in response efforts should be aware of how to report and evaluate control actions to support response effectiveness. They should also know to use aquatic approved herbicides and acquire permits for work in aquatic environments, and that only MDA-licensed Commercial Pesticide Applicators can be contracted to conduct herbicide treatments.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Northwest region

Counties

- Becker
- Clay
- Kittson
- Mahnomen
- Marshall
- Norman
- Pennington
- Polk
- Roseau
- Red Lake

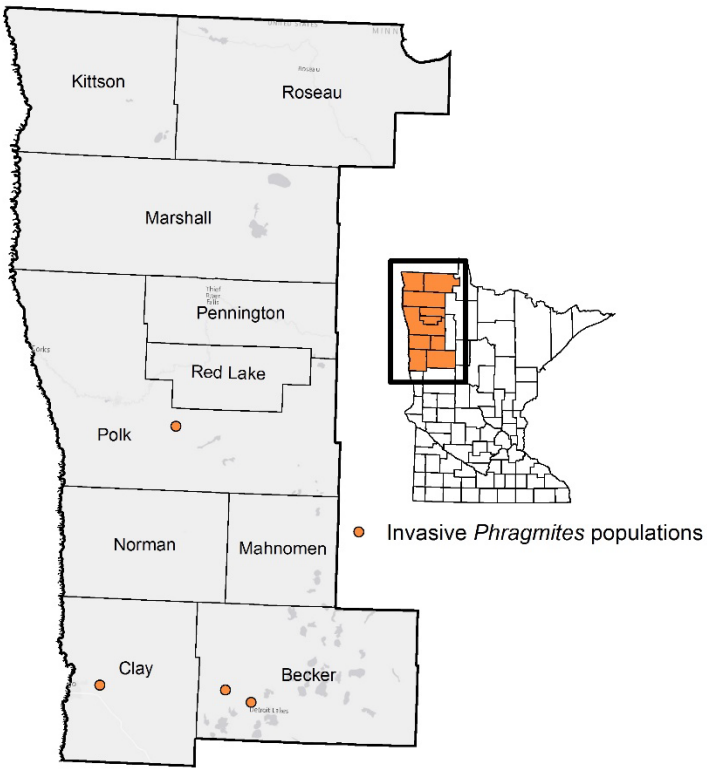
Invasive *Phragmites* status

There are four verified invasive *Phragmites* populations in the Northwest Region. There is a population in Becker County along a MNDOT-owned right-of-way that has been estimated to cover approximately 2 acres—one of the larger populations in the state. A second, small population in Becker County is on private land bordering Highway 10 and Boyer Lake. The third population is also along Highway 10 in Clay County. The last population is within Glacial Ridge National Wildlife Refuge, running linearly along County Road 45 and a BNSF railroad corridor; this is a small population, approximately 200 sq. ft. in size, mixed with native *Phragmites*.

Invasive species response capacity

State and federal highway maintenance is coordinated under MNDOT Districts 2 and 4. The population in Glacial Ridge National Wildlife Refuge involves multiple property ownerships; control will require coordination between the U.S. Fish and Wildlife Service (USFWS), Polk County Maintenance Department, and BNSF Railway. The USFWS has staff dedicated to management of the refuge. The Polk County Maintenance Department conducts vegetation control on their roadside rights-of-way and BNSF Railway may also have staff who work to remove weeds along their railroad corridors, or who would be able to provide property access for control activities.

This region has CWMAs in Becker, Mahnomen, Marshall, Norman, Red Lake, and Roseau counties, as well as the eastern half of Polk County. There are also several watershed districts in the region, including the Buffalo-Red River, Cormorant Lakes, Joe River, Middle-Snake-Tamarac Rivers, Pelican River, Red Lake, Roseau River, Sand Hill River, Two Rivers, Warroad, and Wild Rice watershed districts. MNDNR aquatic invasive species specialists and wildlife managers operate out of MNDNR's Northwest Region. The majority of the White Earth Nation's land is within this region. All counties have an SWCD (Polk County has two, East and West) and County Agricultural Inspector, which work on natural resources and noxious weeds, respectively.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 4

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.	1		Roadside	3		Private	1
>500 sq. ft. – .25 acre	2		Lakeshore			Municipal	
>.25 – 1 acre			Wetland			County	
>1 – 2 acres	1		Mixed	1		Lake	
>2 acres			Stormwater pond			State	
Unknown			Industrial			MNDOT	2
			Riverine			Federal	
			Other			Mixed	1

Invasive *Phragmites* response options

With few populations, elimination of invasive *Phragmites* from the region should be possible with adequate funding, surveillance, and coordination among public and private entities. This region has significant capacity for coordinated surveillance and reporting, through which a broader group of partners than those coordinating control could be involved.

Herbicide treatment of the large population could be conducted using a roadside vehicle with a mounted tank and hose for covering large stands. A flail mower or other equipment could be used to mow or knock down dead stems (mowing can facilitate subsequent herbicide treatments but is not an effective control approached when used alone). Part of this population is located on a steep slope, which could present challenges depending on equipment availability.

The smaller populations are highly manageable and do not yet require sophisticated equipment. Herbicide treatment could be done using a backpack sprayer (or hand wick to avoid native *Phragmites* within the targeted area), and a brush saw could be used in winter to remove dead biomass.

Estimated control cost for region: $33,000-$84,000 over three years

Cost estimation notes

The populations in Becker and Clay Counties are in close proximity along Highway 10 and could be managed under the same contract for approximately $31,000-81,000. The population in Glacial Ridge could be controlled for around $2,000-3,000. Values presented include three-year costs of herbicide treatment and mowing only; costs associated with restoration, surveillance, project administration by contractees, equipment, or other expenses are not included. The largest population may likely require more than three years of control. As only minimal coordination was assumed in developing cost estimates, control costs could be reduced with further coordination among partners or by integrating with concurrent vegetation management efforts, e.g., by BNSF Railway, USFWS, and/or MNDOT staff. More information about how costs were estimated can be found in the Methods appendix.

Possible funding structure

The invasive *Phragmites* populations on federal and state sites could be controlled as part of ongoing plant management activities by agencies, or by BNSF for the population that extends onto their property. Alternatively, control on federal and state sites, as well as privately owned sites, could be funded through one of the programs described in the Costs and funding sources section. Funding could be awarded either through state-administered grants or directly to regional or local organizations (as described in Coordination and networking strategies).

Training and capacity needs

Core competencies for partners involved in response efforts include being capable of identifying invasive *Phragmites*, reporting and evaluation, decontaminating equipment, and awareness of herbicide use and permitting requirements. Individuals capable of distinguishing and reporting native and invasive *Phragmites*, or submitting samples for identification will be needed. Those conducting control should have sufficient expertise to apply site-specific approaches. Specialized equipment may be needed in some cases and only equipment that can be sufficiently decontaminated following use should be employed. Only MDA-licensed Commercial Pesticide Applicators can be contracted to apply herbicides. Partners should also be aware of

permitting and herbicide use requirements for activities at wet sites. Effective response can be supported by reporting and evaluation of management activities.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Most populations of invasive Phragmites are identifiable by their dense inflorescences well into winter.

Central West region

Counties

- Big Stone
- Chippewa
- Douglas
- Grant
- Otter Tail
- Pope
- Stevens
- Swift
- Traverse
- Wilkin

Invasive *Phragmites* status

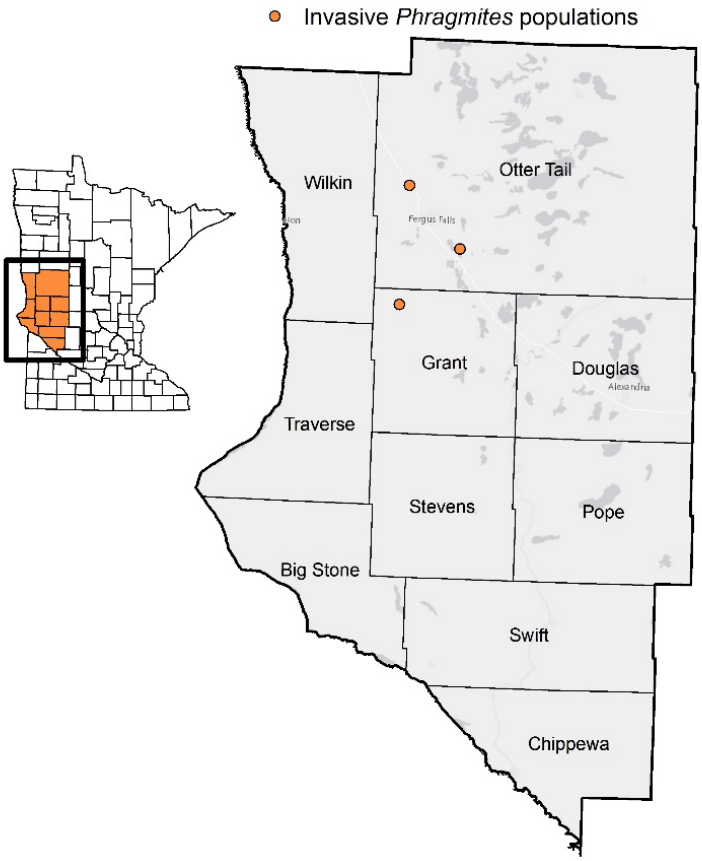
Three invasive *Phragmites* populations have been verified in the Central West Region. Otter Tail County has two populations: a 6,000 sq. ft. population along I-94 and a small roadside population bordering the Central Lakes Trail in the town of Dane Prairie. The last population is in a state-owned wetland in Grant County and is of unknown size.

Invasive species response capacity

State and federal roadside management is coordinated under MNDOT Districts 4 and 8. MNDNR wildlife managers and aquatic invasive species specialists operate out of MNDNR's Northwest and Southern regions.

The Central West Region has several CWMAs, which coordinate with partner organizations to respond to invasive species. There is a single-county CWMA in northeastern Otter Tail County and two multi-county CWMAs in Pope/Swift and Traverse/Big Stone Counties. This region also has a well-developed network of watershed districts, including the Bois De Sioux, Buffalo-Red River, Middle Fork Crow River, North Fork Crow River, Pelican River, Sauk River, and Upper Minnesota River watershed districts. In addition, every county has a County Agricultural Inspector who oversees noxious weed laws, as well as an SWCD, which directs natural resource programs.

The invasive Phragmites population along the Central Lakes State Trail is encroaching on a pocket of remnant prairie which is host to several interesting plant species, including grass of Parnassus.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 3

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.			Roadside	1		Private	
>500 sq. ft. – .25 acre	2		Lakeshore			Municipal	
>.25 – 1 acre			Wetland	1		County	
>1 – 2 acres			Mixed			Lake	
>2 acres			Stormwater pond			State	1
Unknown	1		Industrial			MNDOT	2
			Riverine			Federal	
			Other	1		Mixed	

Invasive *Phragmites* response options

Invasive *Phragmites* could likely be eliminated from this region with relatively modest coordination and funding. Coordinated surveillance and reporting would support early detection and response to prevent further spread.

For all verified populations, herbicide treatment could be conducted using a truck, tractor, or UTV with a mounted tank and hose reel. Mowing or knockdown could be done using a flail mower or other equipment. While mowing alone is not sufficient for control, it can improve the efficacy of subsequent herbicide treatments.

Estimated control cost for region: $6,500-$16,500 over three years

Cost estimation notes

All three populations, which are relatively close to one another and are under shared public ownership (state lands), could be managed for an estimated $6,500-16,500. The largest populations may likely require more than three years of control. The population of unknown size was assumed to be ¼ acre in size for cost estimation purposes. Cost estimates are for three years of herbicide application and mowing activities only and do not account for restoration, project administration by contractees, surveillance, equipment, or other expenses. Increased coordination could reduce control costs, as minimal coordination among organizations and with planned vegetation management activities (e.g., state and county highway maintenance) was assumed in our estimates. The Methods appendix includes further information on how cost estimates were developed.

Possible funding structure

With the three populations being on state-owned lands, control could be integrated into existing state-level plant management activities. Alternatively, the programs described in Costs and funding sources could provide support.

Training and capacity needs

There are some core competencies for response partners, including ability to identify invasive *Phragmites*, report on and evaluate efforts, decontaminate equipment, and comply with herbicide use and permitting requirements. Surveyors must be able to identify and report invasive *Phragmites* or submit samples for verification. Managers must be able to determine control actions appropriate to each site. Only equipment that can be sufficiently decontaminated should be employed. Some of the sites are expected to be wet, requiring the use of herbicide formulations approved for aquatic environments and control permits from MNDNR (though there are exceptions for control activities by MNDNR staff on MNDNR lands). Any herbicide applications for hire may only be conducted by MDA-licensed Commercial Pesticide Applicators. Control actions should be reported and evaluated to support effective response.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Central North region

Counties

- Aitkin
- Crow Wing
- Morrison
- Todd
- Wadena

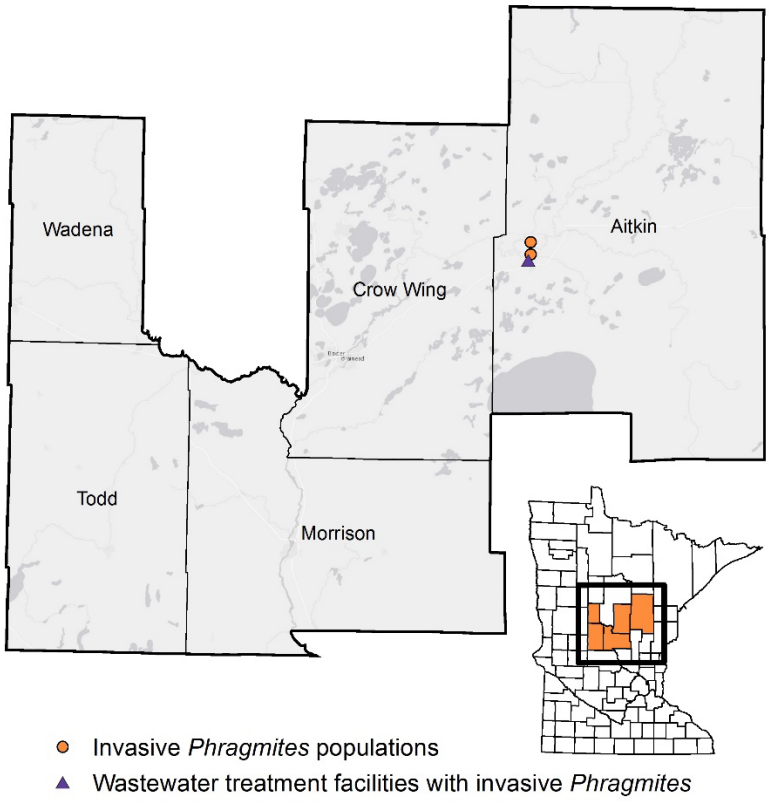
Invasive *Phragmites* status

Two populations have been verified in the Central North Region, both of which are along county roads. The largest of these populations is in Aitkin County, has been estimated to be an acre in size, and appears to extend along County Road 1 onto private agricultural land. Another population in Aitkin County is an estimated 600 sq. ft. in size. There was a wastewater treatment facility using invasive *Phragmites* in their operations in Aitkin County, though the operator at this facility reported that the plant was removed from the operation in 2010.

Invasive species response capacity

County highway departments work to control weeds and conduct other maintenance activities along county-owned roadsides. There is one CWMA in this region in Wadena County that works to control weeds. MNDNR aquatic invasive species specialists and wildlife managers operate out of three regions (Northeast, Northwest, and Central). Highway maintenance in the Central North Region is coordinated under MNDOT Districts 1 and 3. A portion of the Sauk River Watershed District is in the southwest corner of this region. Every county has an SWCD and County Agricultural Inspector, which work on natural resource issues and oversee noxious weed laws, respectively.

Patches of invasive Phragmites occur along nearly 2.5 miles of Cty Rd 1 from the Mississippi River north to 390th St.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 2

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.			Roadside	2		Private	
>500 sq. ft. – .25 acre			Lakeshore			Municipal	
>.25 – 1 acre	1		Wetland			County	1
>1 – 2 acres	1		Mixed			Lake	
>2 acres			Stormwater pond			State	
Unknown			Industrial			MNDOT	
			Riverine			Federal	
			Other			Mixed	1

* This total does not include the invasive *Phragmites* population that was in use in the operation of a wastewater treatment facility in Aitkin County. From conversations with the operator at the Aitkin facility, their invasive *Phragmites* plants were removed in 2010.

Invasive *Phragmites* response options

The two invasive *Phragmites* populations could be eliminated from this region through dedicated control and monitoring efforts, with the larger population expected to require more control effort. Coordinated surveillance and reporting efforts by the entities listed above and others would support early detection and response to new populations.

Suitable equipment for controlling verified populations could include a flail or other mower and a truck or UTV equipped with a tank for herbicide application. Mowing can increase the effectiveness of subsequent herbicide treatments but will not result in long-term control if used alone. Permission to access private property will be needed, at least for the larger of the two populations.

Estimated control cost for region: $11,000-$24,000 over three years

Cost estimation notes

We assumed management of the two populations in Aitkin County would be coordinated under the same contract, estimating a combined cost of $11,000-24,000. As only minimal coordination was assumed, further coordination among partner entities or with county highway maintenance activities could likely reduce control costs. These estimates do not include the cost of implementing alternative dewatering methods at the wastewater treatment facility, should they be needed to remove any residual invasive *Phragmites* propagules (see the Invasive *Phragmites* at wastewater treatment facilities section). Values presented include three-year costs of control only; costs of restoration, project administration by contractees, surveillance, equipment, and other expenses are not included. The largest population may likely require more than three years of control effort. For more information about how costs were estimated, see the Methods appendix.

Possible funding structure

Organizations at the regional or local level could fund control activities or control could be funded through the programs described in Costs and funding sources. The BWSR CWMA Grant Program could help provide additional regional capacity.

Training and capacity needs

Core competencies for invasive *Phragmites* response partners include the ability to identify the plant, report and evaluate activities, decontaminate equipment, and follow permitting and herbicide use requirements. Those participating in surveillance will need to be capable of differentiating and reporting native and invasive *Phragmites*, or know how to submit specimens for identification. Coordinators of control activities must be aware of and follow herbicide use and permitting requirements when applicable. Contracted herbicide treatments can only be conducted by an MDA-licensed Commercial Pesticide Applicator. Determination of control approaches should be site-specific and only equipment that can be decontaminated following use should be employed. Reporting and evaluation of control actions is needed to support effective response.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Northeast region

Counties

- Lake
- Cook

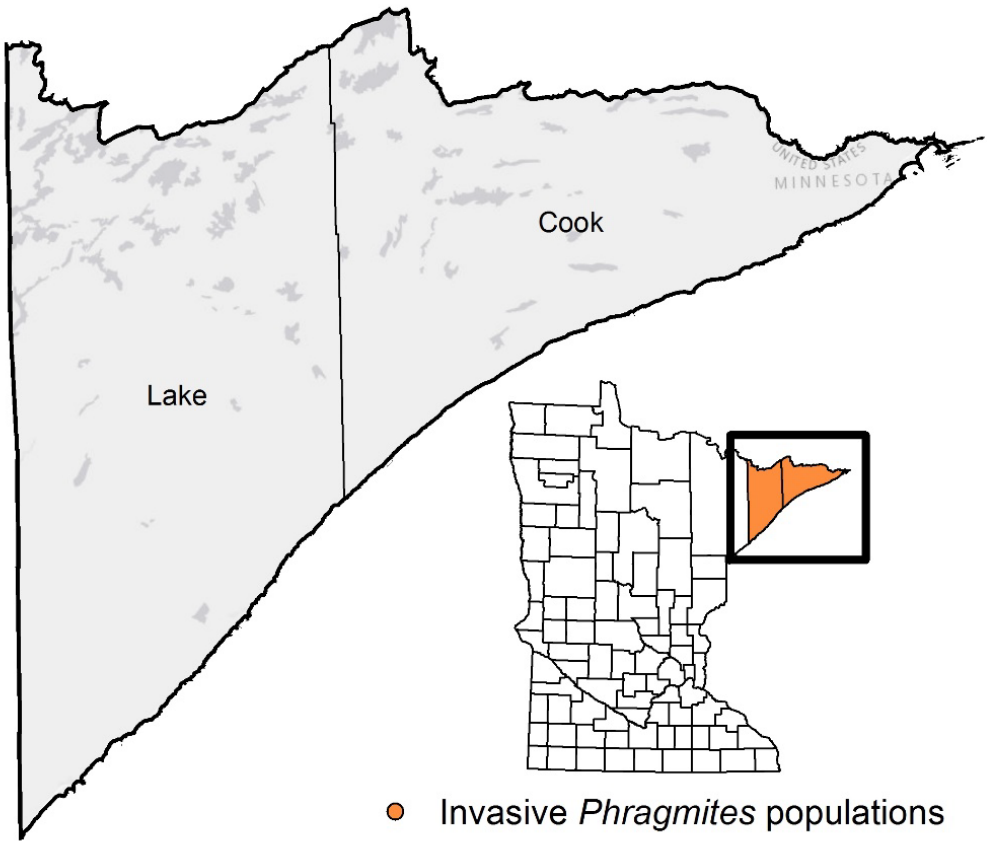
Invasive *Phragmites* status

No invasive *Phragmites* populations have been documented in the Northeast Region to date.

Invasive species response capacity

Both Lake and Cook Counties have CWMAs, which specialize in building partnerships and managing invasive species. This region includes MNDNR's Northeast Region aquatic invasive species specialists and wildlife managers. State and federal highway maintenance is coordinated through MNDOT's District 1. The Grand Portage Band of Lake Superior Chippewa is also in this region. Each county has an SWCD, working on natural resource issues, and a County Agricultural Inspector who oversees noxious weed law.

The vast remote acreages of wetland in the Northeast would be difficult to manage should invasive Phragmites establish in the Northeast Region.



Number of verified invasive *Phragmites* populations of different sizes, habitats, and property ownerships | Total: 0

Coverage area	Number of populations		Habitat types invaded	Number of populations		Property ownership	Number of populations
≤500 sq. ft.			Roadside			Private	
>500 sq. ft. – .25 acre			Lakeshore			Municipal	
>.25 – 1 acre			Wetland			County	
>1 – 2 acres			Mixed			Lake	
>2 acres			Stormwater pond			State	
Unknown			Industrial			MNDOT	
			Riverine			Federal	
			Other			Mixed	

Invasive *Phragmites* response options

While the Northeast Region is fortunate to have no documented invasive *Phragmites* populations, enhanced, coordinated surveillance would support early detection of and response to new reports. Communications with partners in the Saint Louis Region could assist in planning surveillance efforts and preparing response plans for potential populations.

Estimated control cost for region:
None at this time

Cost estimation notes

Some financial support may be needed in the development and implementation of surveillance programs in the Northeast Region. However, we did not estimate surveillance costs in this assessment.

Possible funding structure

While funding is not needed for invasive *Phragmites* control at this time, some of the programs described in the Costs and funding sources section may support surveillance and outreach efforts.

Training and capacity needs

Coordinated surveillance by partners capable of distinguishing and reporting native and invasive *Phragmites* (or ability to submit samples to an expert for verification) will be needed to prevent establishment. Partner organizations should also be aware of invasive *Phragmites* impacts and control approaches and requirements.

Reference sections

- Part II: Potential approaches for invasive *Phragmites* response
- Part III: Planning and networking
- Part IV: Resources for regional response teams

Part 2: Potential approaches for invasive *Phragmites* response

Control approaches for invasive *Phragmites* populations

We conducted a literature review of invasive *Phragmites* management guides and peer-reviewed research. Overall, this synthesis suggests that end-of-summer herbicide treatment (i.e., late August through September) is the most effective and practical approach for controlling invasive *Phragmites* (Kettenring et al. 2015, Peschel 2018). Herbicide treatment will be most effective at this time because invasive *Phragmites* is directing its energy to its roots rather than vegetative growth (MI DEQ 2014). The most effective herbicides are the broad-spectrum herbicides glyphosate or imazapyr, which are also used in combination (Kettenring et al. 2015).

While mowing alone is not effective for controlling invasive *Phragmites*, a winter or summer mow to reduce standing dead stems can facilitate uptake of herbicide. Studies have shown a combination of herbicide treatment with mowing can reduce invasive *Phragmites* cover by 60 to >90% (Back and Holomuzki 2008, Hallinger and Shisler 2009, Moore et al. 2012). These combination control activities (mowing or other site preparation approach plus herbicide treatment) have been shown to be significantly more reliable for controlling invasive *Phragmites* (Figure 4; Peschel 2018).

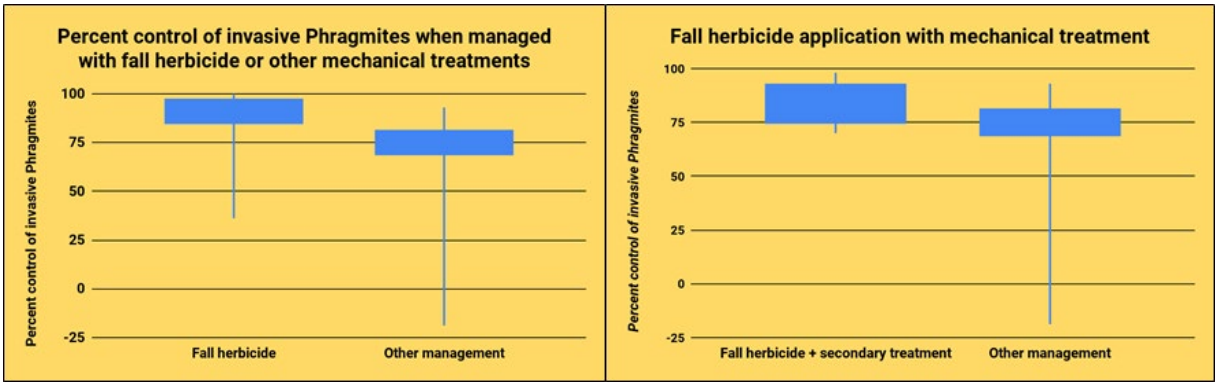


Figure 4. Results of a 2018 MNPhrag literature review conducted by Anna Peschel examining the efficacy of various invasive *Phragmites* control approaches, including fall herbicide treatment (26 studies, median = 94), fall herbicide treatment in combination with site preparation (8 studies, median = 81.5), and management approaches other than herbicide treatment (5 studies, median = 77.6).

It is likely that this control schedule will need to be repeated for three years to eliminate invasive *Phragmites* from most sites, though some sites may require longer-term effort (Farnsworth and Meyerson 1999). Continued monitoring is needed to enable rapid control of regrowth. We recommend five years of post-elimination monitoring at controlled sites, with routine monitoring protocols becoming sufficient after five years. The MNPhrag website further describes how this control approach can be used: www.mnphrag.org. Additional helpful resources include the Kettenring et al. (2015) report to the Utah DNR, the invasive *Phragmites* control guide developed by state agencies in Michigan (MI DEQ 2014), and publications available on the Great Lakes *Phragmites* Collaborative website.

Depending on the characteristics of the targeted site, herbicide treatment and mowing will require various types of equipment. The accessibility and hydrology of the target site, as well as the size and shape of the population, influence the type of equipment needed. For example, a linear roadside population can be readily treated using a hose connected to a tank transported on a truck, tractor, or UTV. A lakeshore population may require treatment from a boat or from shore, depending on the size and accessibility of the population. Large wetland populations may require a wetland-adapted vehicle, or aerial spraying via helicopter in extreme cases. Similarly, for mowing, a small population on a drier site might warrant a brush saw while a large population in a wetland may require employing an amphibious Marsh Master® or other tracked vehicle. Site and population characteristics, and associated equipment needs, determine the effort and costs associated with control. All equipment should be cleaned of plant propagules (including seeds, stems, rhizomes, stolons, and roots) between sites to avoid spreading invasive *Phragmites*. If a particular piece of equipment cannot be sufficiently cleaned, an alternative approach should instead be employed.

Burning, cutting, and water-level management alone have not proven to be effective control methods and can backfire by fueling root growth (van Der Toorn and Mook 1982, Thompson and Shay 1985). However, prescribed burns can be used in combination with herbicide treatment in place of mowing (Moore et al. 2012). Prescribed burning is likely to be more appropriate for populations in rural or undeveloped settings and should only be performed by a trained crew. There are some advantages of burning, including efficient removal of biomass and the potential to stimulate growth of native plants (Ailstock et al. 2001). Mowing or burning should be conducted in the winter or summer, avoiding the period from early March to mid-July when negative impacts to wildlife are more likely (Figure 5). Though flooding is unlikely to effectively control invasive *Phragmites*, it may help prevent reestablishment following reductions through previous years' herbicide treatments (MI DEQ 2014).

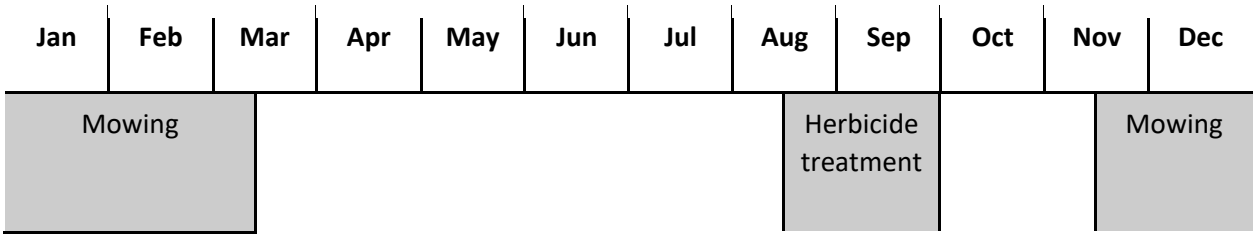


Figure 5. Visual timeline of control and site preparation schedule.

For any invasive plant control activities, key requirements and practices need to be followed to ensure they are effective, responsible, and legal. The "Training" section of this assessment provides further information regarding the best management practices described above. Prior to conducting any control, targeted populations should be verified by an expert as invasive *Phragmites*. For target populations in aquatic environments, a permit is typically needed from MNDNR and any herbicide used must be approved for aquatic use. Contracted herbicide applicators must have the appropriate commercial pesticide applicator license from MDA. Some herbicide formulations, including Habitat® which is a commonly used formulation containing imazapyr, must also be applied by a licensed applicator (either non-commercial or commercial). Organizations opting to conduct their own herbicide treatments should also be trained in appropriate, legal pesticide use. Monitoring and reporting of outcomes of control efforts are needed to verify effectiveness and support adaptive management. Care should be taken to clean seeds and plant fragments from equipment and dispose of plant material so that control activities do not contribute to invasive *Phragmites* spread. Finally, once invasive *Phragmites* appears to have been eliminated from a target site, revegetation or other post-treatment management may be needed to reduce risk of reinvasion.

Invasive *Phragmites* at wastewater treatment facilities

There are 16 wastewater treatment facilities in Minnesota that use or have used invasive *Phragmites* in their operations. Invasive *Phragmites* is used for dewatering biosolids, which are residual organic materials that remain following sewage treatment. The biosolids and invasive *Phragmites* are contained in a "reed bed," where invasive *Phragmites* removes water through evapotranspiration, consolidating the solids and reducing volume. This process is cost-effective for the facilities because it reduces the frequency with which biosolids need to be removed. Volume can be reduced more rapidly in a reed bed than a drying bed lacking water removal via plant transpiration. When early reed beds were constructed, designers assumed that invasive *Phragmites* was incapable of spreading by seed. As invasive *Phragmites* is now understood to produce viable seeds in general (Kettenring and Whigham 2009), including in Minnesota (Bohnen et al., unpublished data), these reed beds are recognized as sources for invasive *Phragmites* spread in Minnesota, and many wild populations are in close proximity to the facilities.

Once a bed is fully consolidated and no further material can be added, the biosolids and plant material must be removed so that operations can continue. MDA issues transport permits so that the solids can be moved to a landfill or applied to agricultural fields. Since the biosolids are nutrient-rich and can aid crop growth, the latter is seen as a beneficial use and is generally less expensive than landfill disposal. However, the biosolids are likely to contain potential propagules when transported. Field applications can only be made at dry sites where agricultural crops will be planted, and there are further restrictions based on proximity to surface waters and groundwater. While conditions at these sites are not optimal habitat for invasive

Phragmites, field-applied sites have not been formally surveyed to ensure that this practice is not contributing to invasive *Phragmites* spread.

Invasive *Phragmites* was recently replaced with the native subspecies at three wastewater treatment facilities in northern Wisconsin. The Treaty Natural Resources Division of the Red Cliff Band of Lake Superior Chippewa conducted a genetic study, which confirmed that nearby wild invasive *Phragmites* populations were related to those in the facilities' reed beds. They then hired a consultant to assess alternative biosolids dewatering strategies. The analysis suggested that removal of invasive *Phragmites* and replacement with the native subspecies would be the most cost-effective and environmentally sound alternative (Table 1). The contracted cost of replacing the beds with native *Phragmites* at all three facilities was ultimately close to $2.8 million, with the bulk of that cost deriving from disposal of the biosolids and plant material (which unexpectedly had to be moved about 80 miles to the nearest operable landfill due to flooding in northern Wisconsin; VanBergen 2019).

Reed beds are used by some smaller municipalities to remove water from sewage sludge, thereby reducing the volume of the biosolids.

Table 1. Summary of findings from Strand Associates, Inc.'s analysis of alternative dewatering strategies for three wastewater treatment facilities in northern Wisconsin. Costs presented are aggregate for all three facilities and were compiled in June 2016. 20-year total present worth includes the transition cost, operations and maintenance costs, replacement, and landfill costs over a 20-year period. The analysis also evaluated and estimated costs associated with transporting the biosolids to another facility for processing; those estimates are not included here as they were highly site-specific. Two of the facilities had four beds with dimensions of 40' x 100' each and the third facility had four beds of 50' x 100' each, for a total of 52,000 sq. ft. of reed beds.

Biosolids Dewatering Alternative	**Advantages**	**Disadvantages**	**Estimated Transition Cost ($)**	**Estimated 20-Year Total Present Worth Costs ($)**
Native Reed Beds: Sludge loaded to native *Phragmites* beds at slightly reduced rates for dewatering, then landfilled	Closely matches existing technology. Staff comfortable with operations. Similar operational costs.	Limited information on effectiveness. Does not eliminate risk of reinvasion.	1,772,000	3,076,000
Sand Drying Beds: Sludge mixed with polymer as needed, loaded into sand drying bed for dewatering, then land applied	Eliminates risk of reinvasion. Requires little mechanical equipment.	Labor intensive. Operations may be undesirable during, or restricted by, winter or wet weather, reducing available drying time.	3,423,000	4,943,000
Biosolids Thickening: Transfer of sludge to a mixed storage tank with mixer for dewatering, then land applied	Eliminates risk of reinvasion. Requires little mechanical equipment.	Increased waste generation. Increased carbon footprint and costs associated with hauling liquid sludge.	2,243,000	3,940,000
Biosolids Dewatering: Sludge mixed with polymer and a phosphorus-binding chemical, pumped into geotextile tubes for dewatering and eventually moved to a landfill	Eliminates risk of reinvasion. Requires little mechanical equipment.	Requires chemical use. Constraints on winter operations unless design allows operations during freezing conditions.	2,393,000	3,758,000

Transitioning to the use of different plant species would likely be the most cost-effective alternative for facilities in Minnesota as well. Another option for biosolids dewatering is storage in drying beds, which lack plants for enhanced water removal. While drying beds are designed and operated differently than reed beds, reed beds may be able to be operated as drying beds. The specific needs of each facility would determine if this is a feasible option. This approach may require facilities to remove biosolids more often, posing unanticipated costs. Other engineering methods for managing biosolids would entail high construction costs. While the estimated costs in Table 1 above are site-specific, they may provide a sense of the relative costs of different biosolids management strategies.

MNPhrag researchers are currently reviewing scientific literature related to the use and efficacy of various plant species for dewatering biosolids at wastewater treatment facilities, as well as physiological characteristics that could influence their effectiveness. Further research should evaluate the potential species' *in situ* effectiveness and identify short-term strategies to reduce the potential for invasive *Phragmites* spread from the facilities. Alternatives for biosolids dewatering must achieve similar performance to support sound wastewater treatment. Pilot projects testing the efficacy of alternative plant species in reed beds are needed. There may also be variability in practices such that optimal solutions may differ among facilities. An understanding of these practices would allow development of best management practices that could help contain *Phragmites* to the reed beds in the short-term.

Transitioning to an effective alternative for biosolids dewatering at wastewater treatment facilities is an integral part of coordinated, statewide response to invasive *Phragmites*. Reed beds will otherwise serve as sources of further spread and hinder response efforts targeting wild populations. At minimum, thorough, sustained surveillance around the facilities will be needed. Given the relatively limited distribution of invasive *Phragmites* in Minnesota, facilities would ideally shift to an alternative as soon as possible. However, it is critical that wastewater treatment processes are not hampered in the process. Current uncertainties regarding the use of alternatives must be addressed and funding for implementing those alternatives must be identified.

A more practical approach may be to identify funding to support required transition to alternative strategies as existing infrastructure reaches the end of its useful life. While the Minnesota Pollution Control Agency (MPCA) has not stopped construction of new reed beds that would use invasive *Phragmites*, they communicated to facilities' operators in 2013 that invasive *Phragmites* cannot be transported to facilities to be planted according to regulations under the jurisdiction of MDA. Reed bed structures have an expected lifespan of at least 20 years and biosolids and plant material are removed roughly every 4-10 years. Transition to an alternative approach could be required concurrent with updates to the facilities' infrastructure or solids removal (whichever occurs first), pending the identification of reliable alternatives. Possible funding sources to support transitions include the Minnesota Public Facilities Authority's Clean Water Revolving Fund Program (though eligible projects must meet certain criteria and minimum costs), some of the programs described in the Costs and funding sources section of this assessment, or other programs for maintaining and improving infrastructure in the state. Containment, necessary research, and surveillance and control of escapes, should continue in the meantime.

The transportation step of the biosolids management process may require a policy change to prevent invasive *Phragmites* spread as a result of movement and application to land-application sites. If invasive *Phragmites* appears to be spreading from land-applied sites, an MDA policy shift to only allow transport to landfill would be critical to response efforts. However, landfilling material may be more expensive than land application, so additional financial support to facilities may be needed to support this shift. If surveillance near land-applied sites does not suggest this practice contributes to invasive *Phragmites* spread, it may still be considered a viable method for reuse of material.

Solutions supporting coordinated response to invasive *Phragmites* and sound wastewater treatment operations are needed. Efforts to survey land-applied sites, identify effective alternatives, develop interim best practices prior to future transitions, fund transitions, and make appropriate policy changes should be initiated and communicated as soon as possible. For a comprehensive invasive *Phragmites* response, populations of both wild and reed bed invasive *Phragmites* must be addressed.

Part 3: Planning and networking

Coordination and networking strategies

A landscape-scale response to invasive *Phragmites* in Minnesota will require support from individuals and organizations at the local, regional, and statewide levels. Each of these levels is positioned to provide key contributions to response efforts. All levels can engage in education, outreach, and surveillance. For coordinating control and monitoring activities, we describe two possible strategies: 1) a statewide coordination and distribution of funding to regional and local organizations, or 2) organizations and individuals at the regional or local level seeking their own funding from various sources, with support at the statewide level to ensure a comprehensive response.

Under the first strategy, a state agency could administer a grant program to which regional and local entities could apply for funds. Potential sources for the underlying funds for controlling all known invasive *Phragmites* populations in Minnesota could include the Legislative-Citizen Commission on Minnesota Resources (LCCMR), Conservation Partners Legacy Grant Program, the Great Lakes Restoration Initiative (GLRI), or others listed in the Costs and funding sources section of this document or elsewhere. Pending receipt of sufficient funds, the agency could put out its own bids for control. For example, the Wisconsin Department of Natural Resources (DNR) has been coordinating invasive *Phragmites* control using GLRI funds, working with contractors directly. Alternatively, the agency could encourage regional and local entities to apply for the state-administered funding and coordinate control efforts. As identified in the region-specific sections of this report, Minnesota has substantial regional and local organizational capacity which could greatly benefit invasive *Phragmites* response efforts. Partnering with these entities could help ensure effective control and support continued surveillance, which will be critical to reversing invasive *Phragmites* spread. Another consideration is that the entity contracting for control will need to be responsible for the quality of the work completed. That is, the state agency or regional organization coordinating control must be able to supervise projects and monitor and evaluate their results to ensure successful efforts.

The second strategy would rely on regional and local entities providing or applying for funding from various sources to implement control. Locally and regionally, Minnesota is rich with organizations and resources that could lead or serve as partners in invasive *Phragmites* response. These include CWMAs, SWCDs, county programs and staff (such as county agricultural inspectors, natural resource managers, and highway and public works departments), lake associations, watershed districts, municipalities and their natural resource and parks departments, tribal governments, non-governmental and nonprofit organizations, private contractors and businesses, and regional aquatic invasive species (AIS) and wildlife specialists at MNDNR and USFWS. The Costs and funding sources section of this document provides an overview of possible programs that could support invasive species response efforts. Leaders at the regional and local level could develop partnerships to assist with outreach, education, and surveillance; contribute organizational funding or apply for grants; and coordinate, monitor, and evaluate control activities. There are already several organizations at the regional and local levels moving forward with these activities for invasive *Phragmites* response, and there are existing partnerships and networks developed for other natural resources issues

that could be leveraged. At the county level, engaged individuals and organizations can work with their government representatives toward noxious weed or invasive species ordinances that could raise awareness and aid in control activities. In this strategy, statewide support would be needed for invasive *Phragmites* response efforts to be comprehensive. Assessment of control activities statewide, through communications with regional and local entities, will be needed to prevent geographic gaps in response efforts.

Regardless of the chosen strategy, multi-level partnerships will be critical in supporting efficiency and progress toward reversing invasive *Phragmites* spread. There are pros and cons for each strategy. For example, it could take longer to start a statewide grant program specific to invasive *Phragmites* response than to launch regional efforts. A combination of these two strategies is another possibility. This is already happening in Wisconsin, as some regional entities have applied for their own funding from GLRI to control invasive *Phragmites* populations in addition to those targeted by the Wisconsin DNR. Combination approaches may create unnecessary competition for grant funding and make it more difficult to achieve high standards of quality assurance. However, it is imperative that response efforts are rallied now, so the optimal strategy must consider how potential partners can best collaborate. If initiation of statewide efforts is delayed due to capacity or organizational issues, support should be provided to regional and local entities for more immediate planning and implementation.

A central, coordinating entity would greatly increase effectiveness of a statewide response, whether state-level or regional and local entities are administering funds and organizing control efforts. This coordination role may best be served through a staff position operating at a statewide level, fostering communication among partners and filling geographic gaps to support comprehensive control across the landscape. Needs for control evaluation and adaptive management could also be served by this role.

The following paragraphs describe key components of a comprehensive response to invasive *Phragmites* in Minnesota, regardless of the overall strategy employed. Cooperation with private landowners, efficient bidding for control activities, and government agency support are essential.

A significant number (around 25%) of known invasive *Phragmites* populations are located on private, individually or commercially owned properties. Successful coordination of invasive *Phragmites* response efforts will require engaging with private and commercial landowners about the detrimental effects of invasive *Phragmites* and the need to prevent its spread, and requesting property access to enable control activities. Ideally, such engagement can build on previous connections to landowners; in the absence of such connections, new relationships will need to be formed. Special contracting or permitting arrangements may need to be developed to foster agreement and collaboration between organizations. Private entities can also assist in invasive *Phragmites* response efforts by providing funds or other resources, educating neighbors, monitoring known populations and reporting suspected new populations, and, in some cases, attending trainings and conducting control activities.

Grouping target populations for permitting and contracting purposes based on proximity and equipment needs can help to increase invasive species response efficiency and reduce costs. MNDNR could issue bulk permits for multiple sites. This would make the permitting process simpler and less cumbersome for those

coordinating control. Coordinators should also group populations when requesting bids from contractors, as grouping sites based on location, site characteristics, and equipment needs can make implementation more efficient, thereby reducing costs. Different contractors have different types of equipment available to them, which will also influence project costs. Some large equipment, such as a Marsh Master, may need to be rented out for a period of time, suggesting shared specialized equipment needs as another reason for grouping sites.

Several state agencies and organizations address issues related to noxious weeds and invasive species. Some of these already support noxious weed management by providing funding or hosting training workshops. The following paragraphs describe the roles of state agencies related to invasive *Phragmites* response efforts.

- **MNDNR** regulates invasive aquatic plant management activities and will be integral to response efforts. Depending on capacity, resources, and workload, they could coordinate invasive *Phragmites* control at the statewide level and/or apply for grant funding to be directly or regionally allocated (for example, the Wisconsin DNR has utilized funding from the Great Lakes Restoration Initiative to coordinate invasive *Phragmites* control projects for the past five years). At minimum, MNDNR would need to be involved in processing permits and providing technical assistance for invasive *Phragmites* control projects. They could provide bulk permits that would allow control efforts at multiple sites.

- Many documented invasive *Phragmites* populations in Minnesota are on state and federal highway rights-of-way. **MNDOT** coordinates roadside maintenance activities and could assist with invasive *Phragmites* response efforts by supporting control of verified populations by their staff or contractors. Alternatively, if regional or local entities are coordinating invasive *Phragmites* control projects, MNDOT could assist by providing access to rights-of-way.

- **MDA** is responsible for the states' Noxious Weed Law (Minnesota Statutes, sections 18.75-18.91) and coordinates with County Agricultural Inspectors who oversee local implementation. The MDA commissioner consults with and appoints members to the Noxious Weed Advisory Committee, which develops risk assessments to inform regulation. The categorization of a species on the Noxious Weed List defines how that species is regulated. Invasive *Phragmites* is currently regulated as a "restricted" noxious weed, which means the importation, sale, and transportation of propagating parts is prohibited. Species regulated as "prohibited control" means that effort must be made to prevent the spread, maturation and dispersal of propagating parts. "Prohibited eradicate" classification means that all above and below ground plant parts must be destroyed. Both prohibited control and prohibited eradicate do not allow the importation, sale, and transportation except as allowed by Minnesota Statutes, Section 18.82. The Noxious Weed Advisory Committee could potentially recommend regulating invasive *Phragmites* as prohibited eradicate or prohibited control based on new findings regarding its distribution and reproductive potential in the state. If the commissioner agrees to make this regulatory change, the stricter regulation could aid invasive *Phragmites* response efforts. This listing would increase the authority of County Agricultural Inspectors. Under the current restricted

listing, Inspectors cannot require the destruction of existing populations; they can only enforce the prohibition of sale or movement. Under the prohibited listings, Inspectors could require landowners to destroy existing populations, or could have the eradication work done and charged to the landowner if necessary. Communications between MDA and County Agricultural Inspectors could facilitate response efforts. MDA could also possibly host species identification training for Inspectors.

- **MPCA** regulates the operations of wastewater treatment facilities in the state. For the wastewater treatment facilities that use invasive *Phragmites* in their operations, MPCA staff recommendations to facility operators on practices that ensure compliance with Noxious Weed Law and prevent invasive *Phragmites* spread from biosolids dewatering beds are likely to reduce some risks. MPCA staff could assist in identifying and connecting wastewater facilities with potential sources of funding such as Public Facilities Authority funding (a low interest loan program) to transition to another alternative. The MPCA could work with MNDNR and MDA to communicate why it is important these facilities receive funding.

- There are several other statewide organizations that may need to be involved in a landscape-scale invasive *Phragmites* response effort. **BWSR** administers grants to support the development of CWMAs and administers grants and contracts for wetland restoration and reconstruction projects. Several statewide associations that represent the interests of regional and local entities could support response efforts and facilitate communications between the state and regional-local levels, such as the **Association of Minnesota Counties, League of Minnesota Cities, Minnesota Association of Townships, Minnesota Association of Watershed Districts**, and others. State and federal non-governmental and non-profit natural resources organizations could also assist in coordinating and conducting invasive *Phragmites* control projects and providing public outreach.

Training

Knowledgeable participants are needed for successful invasive *Phragmites* response efforts. Managers must be capable of distinguishing between native and invasive *Phragmites*, conducting surveillance for new populations and monitoring known populations, and implementing best management practices for effective control and revegetation. This section describes key competencies for invasive *Phragmites* response related to these areas.

Continuous surveillance for new and undocumented invasive *Phragmites* populations is essential for reducing its spread in Minnesota. Early detection of new populations will make control more effective and less expensive because it can be applied to populations when they cover a smaller area, have a less established seed bank, and contain lower density of belowground structures that can lead to regrowth. Response partners can conduct targeted surveillance based on proximity to known populations. Public outreach can also help expand the network of individuals performing surveillance. There are opportunities to integrate with existing programs for outreach purposes, such as the BWSR Academy, UMN-Extension/MAISRC's AIS Detectors program (several Detectors participants have already been involved in reporting), and others.

It is critical that individuals submitting reports, and especially those planning control activities, be able to differentiate between native and invasive *Phragmites*. There are several publications that support identification, including the MNPhrag Identification Guide. Preliminary data show that observers using this guide achieved 95% accuracy in subspecies identification (relative to genetic testing). Suspected new invasive *Phragmites* populations can be reported online using the Early Detection and Distribution Mapping System (EDDMapS). To prevent destruction of native *Phragmites* populations, it is critical that the identities of all *Phragmites* populations targeted by control activities are verified by an expert as being invasive prior to control implementation. MNPhrag has accepted samples for verification for the past two years.

Determining the appropriate control approach for a given site requires significant expertise. Characteristics of the target population, the type of habitat invaded, the property on which it occurs, and social and cultural concerns all influence decisions related to control. Careful consideration should be dedicated to selecting the most effective control approach within each invasion context. Any removal of emergent vegetation (e.g., invasive *Phragmites* rooted below the ordinary high water line [OHL] in a lake, wetland, or river) using any control approach requires a permit from MNDNR (IAPM or APM) though there are some exemptions for agency staff on their lands). To ensure there are no rare plants or animals at the site that could be harmed by management activities, a data request can be submitted through MNDNR's Natural Heritage Information System. Some of the grant programs described in the section on Costs and funding sources require a Natural Heritage review as part of their application processes.

Practitioners must follow herbicide use regulations designed to ensure treatments are implemented responsibly and minimize non-target impacts. Treatment of populations near water must use herbicide formulations and surfactants that are approved for aquatic use, as some formulations are very harmful to aquatic organisms (Folmar et al. 1979, Relyea 2005, Bringolf et al. 2007). Anyone conducting herbicide applications should be trained in appropriate, legal pesticide use. Any individual hired to conduct herbicide treatments must hold a commercial pesticide applicator license

in the appropriate category from MDA. Some herbicide formulations must also be applied by a licensed applicator (either non-commercial or commercial). This includes Habitat®, which is an herbicide formulation containing imazapyr that is commonly used to control invasive *Phragmites*. MDA's website describes the licensing process and different types of licenses and categories. University of Minnesota Extension has a pesticide applicator program that provides comprehensive training and education for applicators.

Reporting and evaluation of control activities will inform future invasive *Phragmites* control projects and facilitate adaptive management. Complete removal of invasive *Phragmites* from a site is expected to take 3-4 years of sustained effort (Farnsworth and Meyerson 1999). Tracking and assessing control activities will help determine if elimination of the target populations can be achieved by the approaches implemented, or if alternative approaches should be considered. Documentation of control activities should include the control (e.g., herbicide treatment) and site preparation (e.g., none, mowing) approaches implemented, equipment used, herbicide formulation and rates used (if applicable), environmental conditions during implementation, dates of implementation, area managed, and difficulties encountered. Documentation of the resulting effects on targeted invasive *Phragmites* will require assessments of population size and density both before and after control activities are conducted. Partners involved in coordinating invasive *Phragmites* response efforts may be best suited to track control activities and their effects. While it is still in development, the Invasive Species Management Tracking System (ISMTrack) is a web-based software being used by University of Minnesota Extension and state agencies in Minnesota and Wisconsin for tracking invasive species control and monitoring activities. Because it is integrated with EDDMapS, invasive populations reported in EDDMapS will appear in ISMTrack and changes in the status of invasive populations will be reflected in both databases, making it a promising tool for planning and evaluating invasive *Phragmites* response efforts. The Phragmites Adaptive Management Framework (PAMF) is another web-based initiative. PAMF uses statistical modeling to assist managers with site-specific control.

Once invasive *Phragmites* has been eliminated from a location, revegetation and restoration activities should begin where needed. Restoration at sites of high ecological value can assist in the recovery of native plants and wildlife habitat. Planting of desirable species in place of invasive *Phragmites* can also help prevent its reinvasion, or colonization by other undesired plants, and stabilize soil. Revegetation efforts are likely to be unsuccessful if invasive *Phragmites* is still prominent at the site. In such cases, revegetation should be delayed until follow-up control activities have eliminated invasive *Phragmites*. Dead invasive *Phragmites* biomass (standing dead stems and litter) will still be present at sites following control activities, possibly mixed in with remaining live stems. This dead biomass can prevent colonization by other undesired plants until all living invasive *Phragmites* has been eliminated; however, it can also hinder regrowth of beneficial native plants from the seedbank (Kettenring et al. 2015). If invasive *Phragmites* is nearly eliminated and the site is bare, inexpensive plantings may help prevent colonization by undesired plants (though there is risk that invasive *Phragmites* will be able to reinvade if the plantings do not take hold). Sites that have been revegetated or restored should continue to be monitored so that reemerging invasive *Phragmites* can be rapidly controlled.

To prevent invasive *Phragmites* spread, clothing and equipment must be properly decontaminated following control and other activities in invasive *Phragmites*-invaded sites. Vehicles, equipment, boots, and clothing should be cleaned prior to moving to another site. Because invasive *Phragmites*' reproductive potential increases with genetic diversity, there is risk that crews moving among sites could increase invasive *Phragmites*' invasibility by acting as unintentional vectors of genetic diversification. If equipment used in herbicide application or mowing cannot be adequately cleaned, it is recommended to employ an alternative approach rather than risk facilitating further spread. The Great Lakes *Phragmites* collaborative website suggests following the decontamination guidelines provided by the PlayCleanGo initiative and the Ontario Invasive Species Centre's Clean Equipment Protocol for Industry. MNDNR also has a policy outlining decontamination procedures that must be used by their staff (MNDNR Operational Order #113), which could serve as a decontamination guideline for others implementing control activities as well.

Image at right, top: Stem color and the tightness of the leaf sheath are good diagnostic features to distinguish native from invasive Phragmites.

Image at right, bottom: The height of the ligule is another strong diagnostic feature that helps to distinguish native from invasive Phragmites. The ligule in native Phragmites is 1 mm in height. In invasive Phragmites, the ligule is less than 1 mm in height.

Cost and funding sources

A comprehensive approach to invasive *Phragmites* response on a statewide scale will not be attainable without dedicated financial support. Through this assessment, we estimated cost for three years of control of Minnesota's verified invasive *Phragmites* populations to be $818,500-2,019,000 (Table 2). This does not include control and conversion costs associated with the wastewater treatment facilities in Minnesota that currently utilize invasive *Phragmites* in their operations.

Costs of monitoring, restoration and revegetation, equipment, and project administration by coordinators or contractees are additional real costs that we did not attempt to estimate (see Control cost estimations appendix for more information).

Table 2. Summary of verified invasive *Phragmites* populations, acres invaded, and estimated control costs across the 12 regions of Minnesota identified in this assessment.

Region	Number of documented populations	Acres of invasive *Phragmites*	Three year estimated control cost (Low end, $)	Three year estimated control cost (High end, $)
Metro	108	8.4	175,000	301,500
Central East	92	3.7	45,000	145,500
Saint Louis	67	23.0	309,500	842,000
Central South	64	11.1	171,000	454,000
Southeast	23	0.8	21,000	42,500
South Central	18	2.2	31,000	78,000
Southwest	4	0.7	13,500	28,000
North Central	4	0.1	2,000	3,000
Northwest	4	2.3	33,000	84,000
Central West	3	0.4	6,500	16,500
Central North	2	1.0	11,000	24,000
Northeast	0	0	0	0
Total	389	53.7	818,500	2,019,000

While these costs are substantial, it is instructive to compare them to the costs of invasive *Phragmites* control efforts in other states. Over approximately the past seven years, the Wisconsin DNR has spent roughly $700,000 on herbicide treatments to contain invasive *Phragmites* from expanding into western Wisconsin, and an additional $1.6 million for treatments along the Lake Michigan coastline. These figures do not include substantial control grants supporting work by regional partners in eastern Wisconsin, control conducted by GLIFWC in the Lake Superior basin, or treatments supported by the Wisconsin Department of Transportation along state and federal rights-of-way. In Nebraska, the Platte Valley and West Central Weed Management Areas have implemented highly effective invasive *Phragmites* control efforts around the Platte River, with approximately

$5.4 million spent on herbicide application and mechanical control from 2008-2018 (Platte Valley WMA 2019). While these efforts covered a sizeable portion of the state (approximately 43,000 acres around 336 miles along the Platte River), it does not represent all of the invasive *Phragmites* control conducted during that time period. Substantial control efforts have also been conducted along the lower segment of the Platte River, the Republican River, and the upper Missouri River, though cost information was not readily available for those projects (Jeff Runge, *personal communication*). The Maryland DNR has been actively managing invasive *Phragmites* for 25 years. In recent years, typical annual spending on aerial herbicide treatments in critical wetlands has ranged from $75,000-150,000. This is in addition to supplying approximately $20,000 worth of herbicides for licensed state applicators to conduct invasive *Phragmites* control on private lands (Donald Webster and Ned Gerber, *personal communication*).

As with our estimates, these costs from other states do not include staff time and project administration. Due to the extent of invasive *Phragmites* in these states, such efforts will likely need to be continued in some form in perpetuity, depending on management goals and policies. In Minnesota where invasive *Phragmites* is not yet dominant on the landscape, sufficient investment in control now would result in only small expenditures for responding to newly detected populations in the future.

We did not attempt to characterize costs associated with choosing not to respond to invasive *Phragmites* in the state. The costs of invasion are likely to be far beyond current control costs. Estimating the monetary cost of invasion is highly complex, requiring full consideration of the ecosystem services affected (Pimentel et al. 2005, 2006). Such investigation would require a multi-year project. Waiting to implement response until such an investigation were completed would allow invasive *Phragmites* to expand its distribution far beyond the controllable level currently documented and would likely greatly increase overall costs.

Here, several sources of funding are listed that could support invasive *Phragmites* response efforts in Minnesota (Table 3).

The Conservation Partners Legacy Grant Program

The Conservation Partners Legacy (CPL) Grant Program supports restoration projects (up to $575,000 per project in FY2019). Approximately $80 million for the program has been approved annually by the Minnesota legislature since 2009. Eligible applicants include local, regional, state, and national non-profit organizations, including government entities. Most projects are expected to be completed in a 3-4 year period and funded work may only be conducted on public lands or private lands where there is a permanent conservation easement. CPL grants could provide a significant source of funds for control of a few large invasive *Phragmites* populations or many small, distinct populations on public or conservation easement lands within a particular region. Funding for this program comes from the Outdoor Heritage Fund (made up of sales tax revenue which will be available until June 30, 2034 according to the Clean Water, Land, and Legacy amendment). More information about the CPL grant program can be found here.

Minnesota Department of Agriculture Noxious Weed and Invasive Plant Grant Program

MDA has a grant program for control of noxious weeds and invasive plants for which counties, municipalities, and other local government

units are eligible. In FY2019, $300,000 was appropriated by the state legislature for this program. Whether or not the program will continue to be funded is currently being negotiated by the legislature. Should the program continue to operate similarly to previous years, applications would be accepted for all listed noxious weeds and Specially Regulated Plants, though Palmer amaranth or other species on the Prohibited-Eradicate Noxious Weed List assume priority. There is a maximum award of $20,000 per applicant. Depending on funding availability and the nature of competing projects, MDA Noxious Weed and Invasive Plant grants could assist with county-level invasive *Phragmites* control efforts on both private and public properties. More information can be found here.

Minnesota Board of Soil and Water Resources CWMA Grant Program

BWSR administers a grant program to support formation of and increase the capacity of CWMAs that can develop partnerships and coordinate control of invasive species. Since FY2014, $200,000 has been appropriated for this program biennially. Previously, SWCDs were the only eligible applicants for this funding. However, the program is now considering watershed districts, counties, and cities, and may consider others in the future (Dan Shaw, *personal communication*). This program may be particularly beneficial for supporting invasive *Phragmites* response efforts where organizational capacity is currently lacking. More information can be found on BWSR's website here.

Minnesota Aquatic Invasive Species Prevention Aid

Since 2014, $10 million has been allocated annually to Minnesota counties to assist in preventing the spread of AIS through the Aquatic Invasive Species Prevention Aid (AISPA) program. The amount allotted to each county is calculated as a function of the number of watercraft trailer launches and watercraft trailer parking spaces. A county-board designee is charged with developing and implementing county-level AIS prevention programs. The county and designee are able to determine how their funding from AISPA is directed, within broad guidelines dictated by Minnesota Statute 477A.19. Outreach, early detection and response, and managing existing AIS populations are all eligible activities that could benefit landscape-scale invasive *Phragmites* response efforts. One limitation is the variability in the amount of funding counties receive from AISPA. Because of the way allocations are calculated, the amount of funding counties receive varies greatly. Some counties are able to support dedicated AIS staff who could be valuable assets in invasive *Phragmites* response efforts, others receive funds sufficient to implement some control projects or raise awareness of invasive *Phragmites*, and other counties receive no AISPA funding. MNDNR's website on AISPA provides more information.

Greater Minnesota Parks and Trails Commission

The Greater Minnesota Regional Parks and Trails Commission distributes funding to support parks and trails through the Parks and Trails Fund (made up of sales tax revenue that will be available until June 30, 2034, per the Clean Water, Land, and Legacy amendment). The Parks and Trails Legacy Plan prioritizes preventing the spread of invasive species and restoring natural communities that have been degraded by invasive species. A number of documented invasive *Phragmites* populations are found in state and regional parks; the Parks and Trails Fund could be used to assist in controlling those populations. Additional information is available here.

Lessard-Sams Outdoor Heritage Council Funding

Funding for restoration projects with costs exceeding $400,000 can be applied for directly from the Lessard-Sams Outdoor Heritage Council (LSOHC). Approximately $100 million was available in this pool for FY2020 from the Outdoor Heritage Fund. LSOHC funds could possibly support invasive *Phragmites* control and large-scale restoration efforts at high-priority sites. More information can be found on the LSOHC website.

Legislative-Citizen Commission on Minnesota Resources

LCCMR is a 17-member group that makes recommendations to the Minnesota legislature for funding special environmental and natural resource projects. These funds come from the Environment and Natural Resources Trust Fund (ENRTF; which will be supported by income from the Minnesota State Lottery and investment income at least through 2024). LCCMR expects $53 million to be available for FY2020 for projects of all sizes that aim to protect, conserve, and enhance Minnesota's natural resources. While requests for LCCMR funding can be highly competitive, these funds could potentially assist with some of the most challenging invasive *Phragmites* control and restoration projects, or be used to support a coordinated response effort to control and monitor invasive *Phragmites* at a regional or statewide scale. More information can be found here.

National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation (NFWF) has many grant programs, some of which support invasive species response efforts. In particular, the NFWF Pulling Together Initiative, which is a partnership with the Bureau of Land Management, USFWS, and U.S. Forest Service, exists to fund invasive plant management efforts by local communities. Approximately $420,000 was available for projects under this program in 2018. The purpose of the program is to help develop partnerships among landowners and plant management experts within a defined weed management area (such as a watershed, landscape, or county) to implement plant control plans and conduct public outreach and education. This program could assist in conducting landscape-scale invasive *Phragmites* response efforts. Another program which may be applicable is the National Wildlife Refuge Friends grant program, which provides funding to "Friends" organizations for projects supporting National Wildlife Refuges. This website has a full list of NFWF programs.

Great Lakes Restoration Initiative

The GLRI funds projects that protect and restore the Great Lakes, which include invasive species control and prevention efforts. GLRI has been allocated approximately $300 million annually for the past five years. The Wisconsin DNR and several regional and local organizations in Wisconsin have and continue to utilize GLRI funding to conduct invasive *Phragmites* control efforts in the Great Lakes basin. GLRI is another funding source that could potentially support regional invasive *Phragmites* response efforts in Minnesota. More information can be found here.

Great Lakes Fish and Wildlife Restoration Act

The Great Lakes Fish and Wildlife Restoration Act (GLFWRA) seeks to encourage cooperative conservation, restoration, and management activities in the Great Lakes Basin. This includes protecting, maintaining, and restoring fish and wildlife habitat, including wetlands. Partially supported by the GLRI, $1.1 million in GLFWRA

funding is expected for FY2019. For more information, visit this website.

Minnesota State Department Budget Initiative

Most of the avenues for funding previously listed involve the issuance of grant funds to support relatively short-term projects. However, the challenges associated with invasive species response efforts are expected to be ongoing. A state budget allocation towards noxious weed management could support continuous coordination of statewide response efforts.

Table 3. Summary of funding sources which could support invasive *Phragmites* response efforts in Minnesota. Note: This information originated from the funding organizations' websites and notices of funding opportunities and may be subject to change.

Funding Source	Eligible Applicants	Purpose of Funding	Property Type Restrictions	Minimum or Maximum Award	Annual Appropriation
BWSR CWMA Grant Program	SWCDs, and possibly other local and regional entities	Support formation and increase capacity of CWMAs	N/A	None	$200,000
MDA Noxious Weed and Invasive Plant Grant Program	Counties, municipalities, and other local government units	Control of noxious weeds and invasive plants	None	≤$20,000	$300,000, pending negotiations by the state legislature
NFWF Pulling Together Initiative	Federal, state, local, and municipal government entities, Indian tribes, non-profit organizations, educational institutions	Develop partnerships, implement plant control plans and outreach programs	None	None	$420,000
NFWF National Wildlife Refuge Friends Grant Program	National Wildlife Refuge Friends Organizations	Support projects in National Wildlife Refuges	National Wildlife Refuges	None	$50,000
Great Lakes Fish and Wildlife Restoration Act	Federal, state, and local government entities, Indian tribes, non-governmental and conservation organizations, universities	Encourage cooperative conservation, restoration, and management in the Great Lakes Basin	None	None	$1.1 million

Funding Source	Eligible Applicants	Purpose of Funding	Property Type Restrictions	Minimum or Maximum Award	Annual Appropriation
MN AIS Prevention Aid	Counties	Prevent the spread of aquatic invasive species	None	Dependent on number of watercraft trailer launches and parking spaces per county	$10 million
LCCMR	All with demonstrated fiscal capacity	Fund environmental and natural resource projects	None	None	$53 million
CPL Grant Program	National, state, regional, and local non-profit organizations, including government entities	Support restoration projects	Public lands or private lands where there is a permanent conservation easement	≤$575,000	$80 million
LSOHC	Not specified	Support restoration projects	None	>$400,000	$100 million
GLRI	State, local, and Indian tribal governments, non-profit, for profit, and foreign organizations, foreign public entities, educational institutions	Protect and restore the Great Lakes	Lands within the Great Lake Basin, with some exceptions related to invasive species spread	None	$300 million
Greater MN Regional Parks and Trails Commission	Generally county and municipal governments with some additional groups depending on grant category	Support parks and trails	Some grant categories are only for areas outside the Twin Cities Metro	Dependent on grant category	Unknown

Potential challenges

Responding to invasive *Phragmites* at the statewide scale is an ambitious undertaking that will present many challenges. Some challenges are inherent to landscape-scale invasive species response, such as the long-term nature of the endeavor and momentum and organization needed to spur action (Simberloff et al. 2005, Epanchin-Niell et al. 2010). There are additional challenges driven by the availability of funding and how effort is coordinated and regulated. This section identifies likely challenges associated with responding to invasive *Phragmites* throughout Minnesota so they can be anticipated and overcome.

As described previously, there are many potential partners and funding sources that could support this effort and participation from all levels will provide the best chance for success. There are several state agencies with the ability to assist greatly in responding to invasive *Phragmites*, while the absence of their support would hinder efforts. This is also true for key regional and local organizations. Private landowners are potential partners who, if unwilling to allow access to properties occupied by invasive *Phragmites*, could house continuous sources of reinvasion. Capacity could also be reduced if decision-makers do not consider invasive *Phragmites* response efforts to be eligible for various funding sources. Lack of support in any of these forms would necessitate development of alternative strategies that would likely be more difficult to implement.

The short window of opportunity presented at this stage of invasion, as well as gaps in capacity, will require intensive and organized mobilization efforts up-front. The longer we wait to respond, the more difficult and expensive—and less likely to succeed—control efforts will become. State agencies often have to communicate and evaluate recommended actions broadly prior to implementation and may not be able to immediately participate as a result. In the meantime, regional and local momentum will need to be harnessed and nurtured. In some regions, interested partners will need to be identified and outreach and training programs implemented. Many scenarios will warrant applying for grant funding to support efforts. Equipment needs should also be assessed and addressed. Optimally, organizations with access to specialized equipment would share their equipment with partners under specific operating agreements, particularly if the equipment is not consistently used by the owner organization.

Additional scenarios and activities to consider include the presence of rare species at targeted sites and industry and infrastructure practices. Coordinators of control efforts will need to work with experts if there are sites where invasive *Phragmites* coincides with endangered, threatened, or otherwise rare species. Alternative approaches may need to be generated if traditional management is not permitted. The activities of some industries, such as plant nurseries, gravel suppliers, construction, and others, may unintentionally contribute to the spread of invasive *Phragmites* and other invasive species. Because of this, education, outreach, and enforcement to block these potential invasion pathways must accompany on-the-ground control efforts. This includes development and implementation of alternatives for wastewater treatment facilities in Minnesota currently using invasive *Phragmites* for biosolids dewatering.

Perhaps the greatest challenges associated with statewide invasive *Phragmites* response will be ensuring that control efforts are of sufficient quality and sustaining surveillance efforts. Reversing invasive *Phragmites*' spread will hinge upon those conducting the control work being

highly competent and detail-oriented. Individuals conducting invasive *Phragmites* control must employ appropriate and thorough approaches, and understand the severity and opportunity of the issue such that adequate follow-up is provided. Part of employing thorough control includes equipment decontamination and making sure that control efforts do not contribute to spread. Partners coordinating invasive *Phragmites* response efforts can support sound management by holding contractors accountable for their results. Additionally, continued surveillance and early response must be persistent. A strong network of surveyors could best support this. Ongoing monitoring for new populations, and of sites where invasive *Phragmites* has been treated, will help ensure beneficial management outcomes. At the statewide and regional levels, identification and reassessment of 1-, 5-, and 10-year goals could reinforce the need to evaluate progress and maintain long-term surveillance.

Part 4: Resources for regional response teams

About invasive *Phragmites*

Invasive *Phragmites* is a perennial grass that can grow up to 20 feet tall and become dominant in wetlands, lakeshores, roadside ditches, and other wet habitats. In the United States, invasive *Phragmites* and its impacts are widespread throughout New England, the Great Lakes region, the mid-Atlantic, and in western states such as Nebraska and Utah. In Minnesota, fewer than 400 populations have been documented by the MNPhrag project. Most populations have been found in the Twin Cities metropolitan area and around the Lake Superior harbor in Duluth.

The ecological and economic impacts of invasive *Phragmites* are well-documented. It can outcompete and displace beneficial native plant species (Minchinton et al. 2006). It has also been shown to reduce diversity and abundance of fish, waterbirds, and invertebrates (Able and Hagan 2000, Meyer et al. 2010). Because of invasive *Phragmites*' proficiency in taking up water, it can dramatically alter hydrology and transform wetlands into environments resembling drier meadows (Windham and Lathrop 1999). It has also been shown to alter food webs, nitrogen cycling, primary productivity, and greenhouse gas fluxes (Windham and Meyerson 2003, Gratton and Denno 2006, Mozdzer and Megonigal 2013). Economic effects of invasive *Phragmites* involve recreation, commerce, transportation, and agriculture. Invasive *Phragmites* can grow densely along lakeshores, preventing access to lakes and other waterways and reducing property values (as has been shown with other invasive aquatic plants; Horsch and Lewis 2009). It can also obstruct sight lines along transportation corridors (MTO 2015) and compete for wild rice habitat. Invasive *Phragmites* monocultures also burn extremely quickly, presenting a potential public safety concern.

Effective approaches for controlling invasive *Phragmites* must take its basic biology into account. Invasive *Phragmites* can reproduce both sexually (by seed) and asexually (from rhizome, stolon, and stem fragments). While it was previously undocumented, the MNPhrag project has found that invasive *Phragmites* is capable of reproducing sexually in Minnesota's climate, particularly in the southern third of the state. Invasive *Phragmites* is self-incompatible, meaning that sufficient genetic diversity within populations is needed for sexual reproduction; introduction of invasive *Phragmites* from different locations and genetic strains will increase its ability to spread (Kettenring et al. 2010, Kirk et al. 2011). Invasive *Phragmites* flowers in late August and early September. Seeds are developed from September to October. While it will proceed into dormancy following the first frost, seeds can be spread throughout the winter by wind, water, and mechanical means.

Invasive *Phragmites* (*P. australis* subsp. *australis*, as has been referred to throughout this section) should not be confused with the native subspecies (*P. australis* subsp. *americanus*). Distinguishing characteristics include ligule thickness, stem texture and color, density of the flowering head, and others. Consideration of multiple characteristics is needed to reliably distinguish between subspecies. A guide to identifying invasive *Phragmites* can be found on the MNPhrag website. While hybridization between the native and invasive subspecies has been documented in the scientific literature, it is rare and has not been documented in Minnesota.

Invasive *Phragmites* is one of the most studied invasive species in the world (Meyerson et al. 2016). For further information, visit MNPhrag.org.

Appropriate herbicide use

This section provides scientific background for the imperative that anyone applying herbicides is well-trained in appropriate use. We have emphasized throughout this assessment the importance of using aquatic-approved herbicide formulations, as well as the legal requirements for contracting commercially licensed pesticide applicators. These are essential to ensuring that invasive *Phragmites* management activities do not cause unintentional environmental harm.

Terrestrial forms of glyphosate (e.g., Roundup®) contain a surfactant known as polyethoxylated tallowamine (POEA), which is lethal to many forms of aquatic life if applied directly to or near aquatic environments. Surfactants are used to improve herbicide performance. However, low concentrations of POEA have been shown to result in high mortality rates in fish, frogs, and freshwater mussels (Folmar et al. 1979, Relyea 2005, Bringolf et al. 2007). There are aquatic forms of glyphosate available that do not include POEA (e.g., Rodeo®), which are not effective unless mixed with a surfactant that is safe to use in aquatic environments (Annett et al. 2014). There are also special regulatory requirements for some herbicide formulations, including the imazapyr formulation Habitat®, which must be applied by a licensed applicator.

We recommend that anyone applying herbicides for invasive *Phragmites* control possess either a commercial or non-commercial pesticide applicator's license with aquatic certification. Pesticide applicators' licensing is designed to ensure that practitioners are knowledgeable about safe usage practices. Without training, it can be difficult to know which formulations of herbicides to use or the proper amount to apply and, more generally, how to conduct treatments safely and effectively. By law, anyone contracted to conduct herbicide treatments must hold a commercial pesticide applicator license. Comprehensive training and education programs are provided by the University of Minnesota-Extension pesticide applicator program.

Disposal and decontamination

Properly decontaminating equipment and disposing of plant material will be another crucial component of invasive *Phragmites* response efforts. Decontamination and disposal can be time and labor intensive but are needed to prevent management activities from contributing to further spread. After all, regeneration and establishment of new populations is possible from nearly all parts of invasive *Phragmites* (Packer et al. 2017). As described in the Training section of this assessment, there are several resources that provide instruction on how to decontaminate clothing and equipment. The most important thing is to remove all propagules between sites. Disposal of material, if needed, can be more difficult. While large amounts of biomass from well-established populations may need to be managed in some way to facilitate revegetation, material effectively treated with herbicide should no longer be viable and typically should not need to be removed. Some situations that would require disposal are the transitioning of invasive *Phragmites*-using wastewater treatment facilities to alternative dewatering strategies (VanBergen 2019), or where standing invasive *Phragmites* hampers other industrial activities. In some cases, managers or coordinators of control may choose to remove seed heads to prevent dispersal while waiting for the right time of year to conduct treatments. MDA provides recommendations for disposal of noxious weeds. They recommend leaving invasive plant material on site to prevent unintended spread. Burning the material may be the simplest approach for

removing biomass, though this is not always feasible depending on the location of the site, its proximity to developed and natural areas, and regulations and permitting requirements. Alternatively, with a permit, it may be possible to carefully contain and transfer material to one of the approved disposal locations listed on MDA's website.

Further resources

General

- MNPhrag Annotated Bibliography on invasive *Phragmites* invasion biology, impacts, and control
- Great Lakes *Phragmites* Collaborative

Surveillance and reporting

- MNPhrag *Phragmites* Identification Guide
- Early Detection and Distribution Mapping System (EDDMapS)

Control recommendations and response planning

- USFWS and California Invasive Plant Council's "Land Manager's Guide to Developing an Invasive Plant Management Plan"
- MNPhrag Management Recommendations
- Invasive Species Management Tracking System (ISMTrack)
- UMN Pesticide Safety Training
- MDA Pesticide Applicator Licensing

Restoration

- How to Restore *Phragmites*-invaded wetlands (Utah State University, Utah Wildlife Resources and Forestry, Fire & State Lands Divisions):
- Restoring the Marsh: *Phragmites* removal and monitoring (Michigan Sea Grant)

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Photo credits

- **Figure 1b.** Secretive marshbirds Photo by ethan.gosnell2 / CC BY-SA 2.0; Mummichogs Photo by Northeast Coastal & Barrier Network / CC BY-SA 2.0
- **Figure 1d.** Photo by Heidi Springborn, provided by Brock Woods, Wisconsin Department of Natural Resources
- **Herbicide treatment photos:** Brandon Van Tassel
- **All other photos:** Julia Bohnen, University of Minnesota

Links

Part 1: Regional assessments of invasive *Phragmites* response needs

General

- Minnesota DOT districts: http://www.dot.state.mn.us/information/districts.html
- Minnesota DNR aquatic invasive species specialists: https://www.dnr.state.mn.us/invasives/ais/contacts.html
- Minnesota DNR wildlife managers: https://www.dnr.state.mn.us/areas/wildlife/index.html

Central East region

- Chisago-Lindstrom Lakes Association: https://clla-lakes.com/

Part 2: Potential approaches for invasive *Phragmites* response

Control approaches for invasive *Phragmites* populations

- Great Lakes *Phragmites* Collaborative website: https://www.greatlakesphragmites.net/resources/factsheets-guidelines/

Part 3: Planning and networking

Training

- MNPhrag Identification Guide: https://www.maisrc.umn.edu/identifying-phragmites
- EddmapS: https://www.eddmaps.org/
- MNDNR Invasive Aquatic Plant Management permits: https://www.dnr.state.mn.us/invasives/iapm.html
- MNDNR Aquatic Plant Management permits: https://www.dnr.state.mn.us/apm/index.html
- MDA website on licensing process: https://www.mda.state.mn.us/pesticide-fertilizer/pesticide-applicator-licensing
- University of Minnesota Extension's pesticide applicator program: https://extension.umn.edu/pesticide-safety-and-certification/private-pesticide-applicators
- Invasive Species Management Tracking System: http://www.ismtrack.org/index.cfmPhragmites Adaptive Management Framework: https://www.greatlakesphragmites.net/pamf/

- Great Lakes Collaborative decontamination guidelines: http://www.greatlakesphragmites.net/resources/factsheets-guidelines/
- MNDNR Operational Order #113: https://www.dnr.state.mn.us/invasives/dnrlands.html

Cost and funding sources

- The Conservation Partners Legacy Grant Program: https://www.dnr.state.mn.us/grants/habitat/cpl/index.html
- Minnesota Department of Agriculture Noxious Weed and Invasive Plant Grant Program: https://www.mda.state.mn.us/plants-insects/noxious-weed-and-invasive-plant-grant
- Minnesota Board of Soil and Water Resources CWMA Grant Program: http://www.bwsr.state.mn.us/grants/cwma/CWMA.html
- Minnesota Aquatic Invasive Species Prevention Aid: https://www.dnr.state.mn.us/invasives/ais/prevention/index.html
- Greater Minnesota Parks and Trails Commission: https://www.gmrptcommission.org/
- Lessard-Sams Outdoor Heritage Council Funding: https://www.lsohc.leg.mn/index.html
- Legislative-Citizen Commission on Minnesota Resources: https://www.lccmr.leg.mn/
- National Fish and Wildlife Foundation Pulling Together Initiative: https://www.nfwf.org/pti/Pages/home.aspx
- National Wildlife Refuges: https://www.nfwf.org/refugefriends/Pages/home.aspx
- Full list of National Fish and Wildlife Foundation programs: https://www.nfwf.org/whatwedo/programs/Pages/home.aspx
- Great Lakes Restoration Initiative: https://www.glri.us/index.php
- Great Lakes Fish and Wildlife Restoration Act: https://www.fws.gov/midwest/fisheries/glfwra-grants.html

Part 4: Resources for regional response teams

About invasive *Phragmites*

- Guide to identifying invasive *Phragmites*: https://www.maisrc.umn.edu/identifying-phragmites
- University of Minnesota-Extension pesticide applicator program: https://extension.umn.edu/pesticide-safety-and-certification/private-pesticide-applicators
- MDA recommendations for disposal of noxious weeds: https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/disposalnoxweed

Further resources

- MNPhrag Annotated Bibliography on invasive *Phragmites* invasion biology, impacts, and control: https://www.maisrc.umn.edu/phraginvasion-biology
- Great Lakes *Phragmites* Collaborative: https://www.greatlakesphragmites.net/
- MNPhrag *Phragmites* Identification Guide: https://www.maisrc.umn.edu/identifying-phragmites
- Early Detection and Distribution Mapping System (EDDMapS): https://www.eddmaps.org/
- USFWS and California Invasive Plant Council's "Land Manager's Guide to Developing an Invasive Plant Management Plan":

https://bugwoodcloud.org/mura/mipn/assets/File/USFS/2019%20Invasive%20Plant%20Mgmt%20Planning_BMP_USFWS.pdf

- MNPhrag Management Recommendations: https://www.maisrc.umn.edu/phrag-management
- Invasive Species Management Tracking System (ISMTrack): http://www.ismtrack.org/index.cfm
- UMN Pesticide Safety Training: https://extension.umn.edu/safety/pesticide-safety-and-certification
- MDA Pesticide Applicator Licensing: https://www.mda.state.mn.us/pesticide-fertilizer/pesticide-applicator-licensing
- How to Restore *Phragmites*-invaded wetlands (Utah State University, Utah Wildlife Resources and Forestry, Fire & State Lands Divisions): https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1001&context=uaes_pubs
- Restoring the Marsh: *Phragmites* removal and monitoring (Michigan Sea Grant): http://www.miseagrant.umich.edu/files/2012/11/12-720-phragmites-fact-sheet.pdf

Appendices

Methods

MNPhrag surveillance efforts

Due to the ease with which invasive *Phragmites* spreads along road corridors, surveillance of roadsides was determined to be an efficient means to assess distribution of invasive *Phragmites* in Minnesota. MNPhrag staff made nine separate trips covering many major roads throughout the state in an effort to detect invasive *Phragmites* along likely corridors, including state and county highways, secondary roads along railroad corridors, and in the vicinity of each of the 16 wastewater treatment facilities using invasive *Phragmites* in dewatering basins. In addition, routes to and from a subset of sites distributed across the state where invasive *Phragmites* leaf tissue and seed heads were collected (samples were collected three times during the project) were varied to add additional roadsides to the search effort. MNPhrag staff conducted some level of roadside surveillance in 80 of 87 Minnesota counties, driving more than 11,000 miles from September 2017 to May 2019.

MNPhrag staff also engaged 173 citizen volunteers or agency staff as observers to assist in the search for and documentation of populations of invasive *Phragmites* throughout Minnesota. All observers were sent a kit with a MNPhrag identification guide and instructions for submitting samples for expert identification. Plant samples and/or reports were submitted by 55 individuals. MNPhrag staff gave many presentations on invasive *Phragmites* to citizens, contractors, and county, state, and federal natural resource professionals at conferences, workshops, and pesticide recertification trainings. More than 500 individuals were reached through these presentations.

MNPhrag staff and other observers have provided some level of surveillance in 94% of Minnesota Counties over the project period from July 2017 to May 2019. Only 5 counties had no documented surveillance effort by MNPhrag staff or observers during the project period (Figure 6).

The size of each population, as reported in the region-specific sections of this assessment as well as the table in Locations of and basic information about documented invasive *Phragmites* populations, was estimated based on visual assessment upon visiting the site, reports in EDDMapS, or calculation of area from aerial imagery (Table 4). A description of the habitat invaded was also reported as part of our surveillance efforts (Table 5).

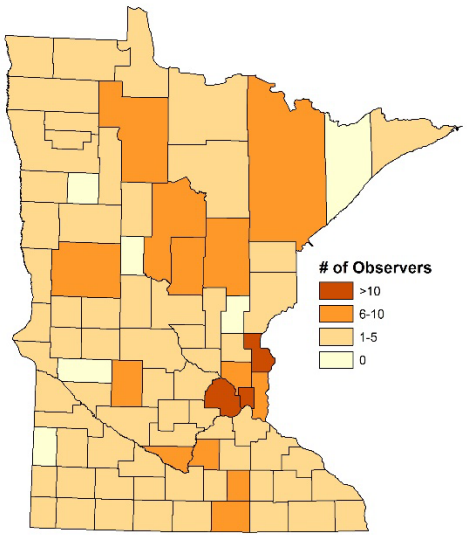

Figure 6. The number of observers contributing to MNPhrag surveillance efforts across Minnesota's 87 counties, including MNPhrag staff surveillance and citizen and agency staff observers.

Table 4. Summary of sizes of verified invasive *Phragmites* populations in Minnesota.

Area Invaded	Number of invasive *Phragmites* populations
≤500 sq. ft.	156
>500 sq. ft. – ¼ acre	189
>¼ – 1 acre	28
>1 – 2 acres	4
>2 acres	2
Unknown	10

Table 5. Summary of habitats invaded by verified invasive *Phragmites* populations in Minnesota.

Habitat Invaded	Number of invasive *Phragmites* populations
Lakeshore	129
Roadside	98
Wetland	66
Mixed	52
Stormwater pond	26
Industrial	7
Riverine	5
Other	6

This assessment includes all invasive *Phragmites* populations documented and verified as of May 5, 2019. While there are undoubtedly invasive *Phragmites* populations in the state that have not yet been verified, surveillance efforts thus far provide an understanding of the plants' distribution in the state sufficient to support an effective landscape-scale response. Capacity for surveillance has increased statewide as a result of MNPhrag's outreach and will continue to improve with a concerted response effort from partner organizations.

Property ownership determination

Ownership of invasive *Phragmites*-occupied sites was determined using county-managed parcel data (either in ArcMap or web-based GIS interfaces or through conversations with county staff) acquired in late 2018, and used to categorize parcels as private, municipal, county, lake, state, MNDOT, federal, or mixed (Table 6). Our *Phragmites* data include coordinates, rather than polygons or areas, so there may be cases where a single population spans multiple ownership categories. We tried to categorize these populations as "mixed," though there may be other populations that span multiple ownerships. There were also some populations where parcel information was not available, primarily along roadsides or in and around lakes. The ownership category for these populations was assumed based on the type of roadway (state, county, or municipally managed) or the ownership category of the nearest adjacent parcel. Participants in invasive *Phragmites* response efforts should be certain of property ownership and acquire all necessary access permissions prior to implementing control.

Table 6. Summary of property ownerships where invasive *Phragmites* populations in Minnesota have been verified.

Property ownership category	Number of invasive *Phragmites* populations
Mixed	105
Private	96
MNDOT	75
Municipal	49
County	25
Lake	22
State	16
Federal	1

Identification of potential partners

The lists of potential partners in the regional "Invasive Species Response Capacity" sections were identified based on web-based investigation and personal communications. We tried to include all Tribes, CWMAs, SWCDs, watershed districts, County Agricultural Inspectors, and MNDOT and MNDNR operating units in each region. Lake organizations, non-individual private entities, federal agencies, and county highway maintenance departments were listed if invasive *Phragmites* has been documented in and around their properties. Other types of organizations that are already coordinating or conducting invasive *Phragmites* response efforts were also recognized if we were aware of them. Given this approach to identifying potential partners, we are likely to have missed other entities with capacity and interest in participating. Regional and local entities may be able to identify these additional partners, expanding capacity and networks beyond the groups described in this assessment; we apologize for any omissions, which were unintended.

Development of regional response options

We developed a list of control and site preparation approaches that could be used to manage invasive *Phragmites* in Minnesota and associated all documented populations with the approaches we anticipated would be most appropriate. Table 7 lists the control and site preparation approaches identified. The regional response options sections summarize the predominant control and site preparation approaches assigned to populations in each region. Managers may, and should when appropriate, choose to depart from the approaches described based on a more thorough knowledge of site conditions. The ability to decontaminate equipment to avoid facilitating invasive *Phragmites* spread should also be considered when determining a control approach.

Table 7. The control and site preparation approaches identified which may be used in controlling invasive *Phragmites* in Minnesota.

Control Approach Number	**Habitat Type and Site Information**	**Control Approach Description**
1	Lakeshores, lake, or riverine	Apply herbicide from boat with tank and hose
2	Lakeshores, lake, or riverine	Apply herbicide from land with backpack
3	Lakeshores, lake, or riverine	Apply herbicide from land with ATV and tank
4	Roadside, reachable with hose, wet	Apply herbicide with hose from tank on truck
5	Roadside, reachable with hose dry	Apply herbicide with hose from tank on truck
6	Roadside or vehicle accessible; square/non-linear shape; wet; too far for hose	Apply herbicide using truck, tractor, or UTV with mounted tank with hose reel; leave roadside to treat stems
7	Roadside or vehicle accessible; square/non-linear shape; dry; too far for hose	Apply herbicide using truck, tractor, or UTV with mounted tank with hose reel; leave roadside to treat stems
8	Wetland	Apply herbicide from tank on dry ground, dragging hose into wetland
9	Wetland	Apply herbicide with backpack sprayer
10	Wetland	Apply herbicide using a wetland-adapted vehicle with a large tank into the wetland
11*	Wetland; large non-linear population	Apply herbicide via helicopter
12*	Not too wet, chemicals undesirable	Physical removal or scrape
13	Dry; small or sparse stand	Apply herbicide with backpack sprayer or hand wick
Site Prep Approach Number	**Site Prep Approach Description**	
1	Winter knock down	
2	Brush saw	
2a*	Underwater brush cutter	
3	DR mower	
4	Forestry mow/brush hog	
5	Tractor with flail or sickle mower	
6	Marsh Master with amphibious cutter	
7	Mowing/knockdown not necessary (e.g., sparse or young populations)	

*These approaches were initially identified as being potentially useful for invasive *Phragmites* control in the state, though they were ultimately not assigned to any populations. There may still be situations where these approaches would be applicable or preferable, based on social and environmental considerations unknown to us.

Control cost estimations

The cost estimates in this assessment were developed based on cost information solicited from contractors and past contracts and available information about invasive *Phragmites* populations documented to date.

For each approach described in Table 7, cost information was solicited from eight entities, including both companies that perform vegetation management (contractors) and organizations that have contracted related work (clients). To be respectful of respondents' time, we accepted cost information in the form that was easiest for them to provide. Some individuals provided information from past projects they had been involved in, from which cost per acre was calculated. Others provided general per-acre cost estimates for the various control and site preparation approaches. From others, we requested costs for controlling multiple invasive *Phragmites* populations at specific locations likely to require similar management approaches. These multi-site costs were requested to account for contractors' administration and mobilization. The cost information received can be found in Figure 7.

We then used the cost information we received to assign control costs to the populations. Generally, populations were grouped together and given an overall cost estimate when there were multiple populations that could be controlled with the same approaches in a region, with similar ownership of sites or likely coordinators of control. Grouping populations in this way assumes some level of coordination as described in Coordination and networking strategies, with further assumptions described below. In some cases, there were populations that were not grouped because of a unique combination of location, equipment needed, and property ownerships. We predominantly used the multi-site cost information to assign cost estimates, assuming that these data better represented the costs associated with implementation. Costs were scaled to the total area of the target populations in each group. For very small sites, mobilization constituted the bulk of the cost. All estimates included a minimum and a maximum to account for the range in cost information provided by different contractors. All minimum and maximum values were above $400-600 for control and $300-400 for site preparation. To develop regional-level costs, the sum of the control and site preparation costs for all regional populations was then multiplied by three (and rounded to the nearest $500), assuming that the average population would need to be managed over the course of a three-year period. That is, regional control cost estimates include the costs of implementing herbicide treatment and site preparation once annually for three years for all documented populations.

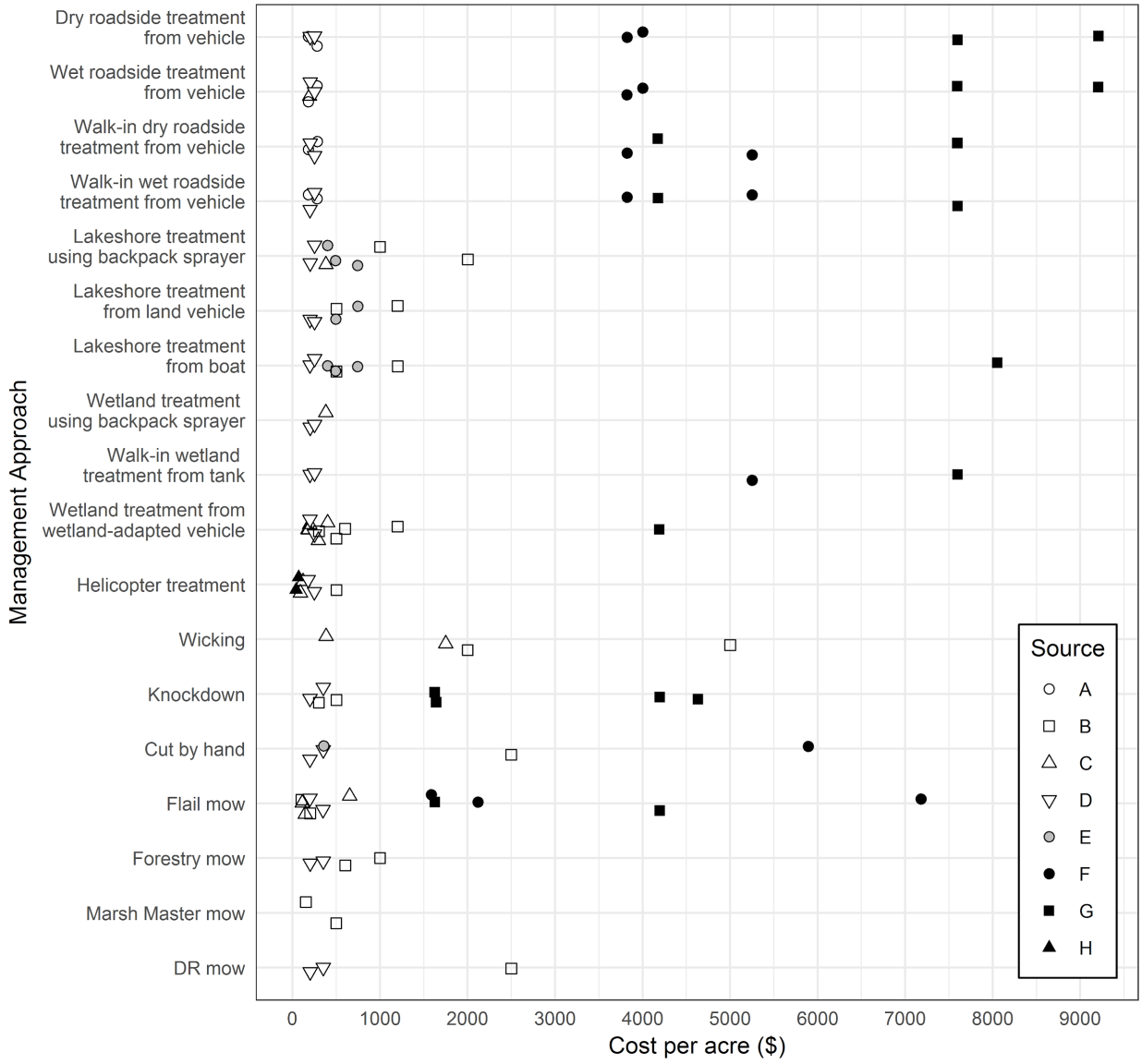

Figure 7. Control cost information provided by contractors and contractees for each control and site preparation approach identified for invasive *Phragmites* management in this assessment. Each source is a different contractor or contractee. White symbols indicate cost data that considered work at only a single site, black symbols indicate cost data that considered multiple sites, and the gray circles include both single and multi-site cost information from a single contractor.

Other assumptions and considerations regarding cost estimates are as follows.

- Cost estimates include the costs of herbicide treatment and site preparation only.

- The costs of restoration, surveillance, project administration by contractees and coordinators, equipment decontamination and purchasing, and other potential expenses are additional real costs that must be considered in planning invasive *Phragmites* response efforts. These costs will depend largely on which organizations participate in invasive *Phragmites* response and their partnerships. Because these details have yet to be determined, we could not estimate costs beyond those of herbicide treatment and site preparation.

- The costs of implementing alternative dewatering strategies at wastewater treatment facilities that currently use invasive *Phragmites* in their operations were also not included in regional estimates.

- It was assumed that control of all populations was contracted. This does not account for the possibility of some governmental, private, or other entities choosing to conduct control using internal staff or including invasive *Phragmites* control under existing plant management efforts, which could reduce costs.

- We assumed what we consider to be a minimal level of coordination among organizations. Generally, populations across county boundaries were not grouped for cost estimation. However, we assumed individual private landowners would not contract for control activities themselves, and would instead allow access to their property to contractors hired by a local, regional, or state entity. State agencies were assumed to contract for control of populations on their properties. The assumption of minimal coordination is not to suggest that that is the level of coordination needed, but is meant to provide a conservative estimate of control costs. Coordination beyond what was assumed in our cost estimation process could further reduce herbicide treatment and site preparation costs (e.g., by grouping populations in close proximity that require similar management approaches). However, additional time spent coordinating efforts could also increase costs in other areas.

- If management is effective, costs should decrease somewhat each year as populations are eliminated or reduced in size, though we did not account for this type of reduction over the three-year period for which costs were estimated.

- In some cases, it is likely that initial control efforts will not achieve elimination of targeted populations, necessitating more than three years of treatment. Several studies have examined efficacy of various control approaches depending on the size of the target population (Quirion et al. 2018, Rohal et al. 2019). In the regional sections of this assessment, we have indicated populations ≥ 0.5 acres as possibly requiring more than three years of control effort. The

management approach employed, quality of management and follow-up, and site conditions are additional factors that could lead to the need for less than or greater than three years of control effort.

There are many factors that contribute to variability in control costs and we stress the importance of engaging contractors for quotes early in the planning process. Contractors and clients described many factors influencing costs, including the type of equipment used, water depth at the site, the density and area of target stands, the distance to and between sites, the number of sites, the quality of surrounding vegetation, and the type of herbicide used (costs are only affected to a small degree by this last point). While the cost estimates in this assessment provide reasonable approximations for regional herbicide treatment and site preparation costs to assist with planning response actions, the estimates also carry assumptions that may not reflect how responses are ultimately implemented. To ensure sufficient funds, we strongly recommend acquiring quotes from contractors in the early planning stages and budgeting for additional expenditures specific to how response efforts are ultimately implemented (e.g., project administration by contractees and coordinators, restoration, surveillance, equipment decontamination and purchasing).

Restoration site identification criteria

Each invasive *Phragmites* population documented as a part of the MNPhrag project was assigned one of three levels of post-control management: restoration of native species, revegetation, or no revegetation (Table 8). Generally, sites requiring some form of revegetation or restoration have large invasive *Phragmites* populations, steep slopes, or are vulnerable to reinvasion. Sites categorized for restoration had high quality plant communities and ecological value prior to invasion; these are the sites described in Part I of this assessment, in the sections specific to the Saint Louis, Southeast, Southwest, and Central South Regions. Sites categorized for revegetation include those having poor ecological quality or strictly functional plant communities (e.g., preventing erosion), and those with potential for erosion or reinvasion by invasive *Phragmites* or other invasive species. The goals of revegetation in these cases are to stabilize soils and provide affordable, robust non-invasive vegetative cover. Sites with small invasive *Phragmites* populations located in areas where the surrounding plant community will fill in openings resulting from control activities may not require revegetation (Rohal et al. 2019). The revegetation categorization assignments provided in Table 8 suggest potential candidate sites where restoration and revegetation could be beneficial. Managers should further assess the need for revegetation following elimination of invasive *Phragmites*, taking into account the risk of not revegetating and the potential benefits of revegetation.

Locations and basic information about verified invasive *Phragmites* populations

The following table includes the locations of all 389 verified invasive *Phragmites* populations as well as their estimated size, property ownership and restoration categorization, and EDDMapS identification numbers when possible. This list includes all populations verified as of May 5, 2019. A periodically updated digital version can be found at MNPhrag.org.

Table 8. Locations of and basic information about all documented invasive *Phragmites* populations in Minnesota as of May 5, 2019.

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
5168439	Central East	Chisago	Wyoming Park and Ride	45.3356	-93.0059	300	Mixed	None
5180875	Central East	Chisago	Chisago Lake, Chisago Blvd	45.3423	-92.8651	1000	Mixed	None
5180871	Central East	Chisago	Cty Rd 23 (Cty Rd 83)	45.3477	-92.8390	5000	Private	Revegetation
7812048	Central East	Chisago	Chisago Lake #7	45.3520	-92.8649	150	Mixed	None
7812049	Central East	Chisago	Chisago Lake #6	45.3533	-92.8668	450	Mixed	None
7812054	Central East	Chisago	Chisago Lake #5	45.3536	-92.8672	30000	Mixed	None
7812053	Central East	Chisago	Chisago Lake #1 Schlimmer's Slough	45.3579	-92.8593	500	Mixed	None
7812052	Central East	Chisago	Chisago Lake #2	45.3586	-92.8655	225	Mixed	None
7812051	Central East	Chisago	Chisago Lake #3	45.3588	-92.8654	10	Mixed	None
7812050	Central East	Chisago	Chisago Lake #4	45.3590	-92.8656	75	Mixed	None
7815888	Central East	Chisago	Chisago Lake #8	45.3598	-92.8649	450	Mixed	None
7815887	Central East	Chisago	Chisago Lake #9	45.3618	-92.8652	12	Mixed	None
7815890	Central East	Chisago	Chisago Lake #10	45.3649	-92.8667	1500	Mixed	None
7815892	Central East	Chisago	Chisago Lake #12	45.3701	-92.8700	500	Mixed	None
7815891	Central East	Chisago	Chisago Lake #13	45.3715	-92.8717	150	Mixed	None
7801883	Central East	Chisago	South Center Lake	45.3716	-92.8119	2500	Mixed	None
7801884	Central East	Chisago	South Center Lake	45.3736	-92.8076	200	Mixed	None
7801880	Central East	Chisago	South Center Lake	45.3741	-92.8378	900	Mixed	None
7801878	Central East	Chisago	South Center Lake	45.3745	-92.8310	300	Mixed	None
7801879	Central East	Chisago	South Center Lake	45.3745	-92.8375	400	Mixed	None
7815893	Central East	Chisago	Chisago Lake #14	45.3749	-92.8690	5	Mixed	None
7801877	Central East	Chisago	South Center Lake	45.3753	-92.8305	9500	Mixed	None

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7801882	Central East	Chisago	South Center Lake	45.3767	-92.8147	400	Mixed	None
7815886	Central East	Chisago	South Lindstrom Lake #3	45.3771	-92.8577	5000	Mixed	None
7801885	Central East	Chisago	South Center Lake	45.3772	-92.8128	100	Mixed	None
7815883	Central East	Chisago	South Lindstrom Lake #2	45.3773	-92.8621	144	Mixed	None
7815884	Central East	Chisago	South Lindstrom Lake #1	45.3777	-92.8631	500	Mixed	None
7815885	Central East	Chisago	South Lindstrom Lake #4	45.3780	-92.8554	3000	Mixed	None
7801886	Central East	Chisago	South Center Lake	45.3796	-92.8134	100	Mixed	None
7801887	Central East	Chisago	South Center Lake	45.3800	-92.8130	300	Mixed	None
7801881	Central East	Chisago	South Center Lake	45.3807	-92.8196	25	Mixed	None
7801889	Central East	Chisago	South Center Lake	45.3808	-92.8077	150	Mixed	None
7801888	Central East	Chisago	South Center Lake	45.3809	-92.8123	400	Mixed	None
7826751	Central East	Chisago	Hwy 8, Shafer	45.3828	-92.7493	100	MNDOT	None
7826750	Central East	Chisago	Hwy 8, Shafer	45.3828	-92.7451	100	MNDOT	None
7801844	Central East	Chisago	Hwy 8 SB, Chisago City	45.3833	-92.8698	400	MNDOT	None
7801876	Central East	Chisago	South Center Lake	45.3843	-92.8261	400	Mixed	None
7801875	Central East	Chisago	South Center Lake	45.3849	-92.8254	4000	Mixed	None
7801890	Central East	Chisago	South Center Lake	45.3856	-92.8100	800	Mixed	None
7801891	Central East	Chisago	South Center Lake	45.3872	-92.8128	100	Mixed	None
7801874	Central East	Chisago	South Center Lake	45.3889	-92.8244	1500	MNDOT	None
7801893	Central East	Chisago	South Center Lake	45.3889	-92.8169	200	Mixed	None
7801873	Central East	Chisago	South Center Lake	45.3893	-92.8199	300	Mixed	Revegetation
5160566	Central East	Chisago	South Center Lake	45.3896	-92.8149	400	Mixed	None
7801843	Central East	Chisago	North Center Lake Boat Launch	45.3899	-92.8252	3000	State	Revegetation
7801892	Central East	Chisago	South Center Lake	45.3899	-92.8156	400	Mixed	None
4425578/5160569	Central East	Chisago	North Center Lake	45.3911	-92.8183	21780	Mixed	Restore
7801894	Central East	Chisago	North Center Lake	45.3923	-92.8258	2400	Mixed	None
7801872	Central East	Chisago	North Center Lake	45.3935	-92.8173	100	Mixed	None
7801846	Central East	Chisago	North Center Lake	45.3937	-92.8296	300	Mixed	None
7801847	Central East	Chisago	North Center Lake	45.3955	-92.8262	200	Mixed	None
7827783	Central East	Chisago	Cty Rd 19, Chisago City	45.3961	-92.8749	1000	Private	Revegetation

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7801851	Central East	Chisago	North Center Lake	45.3964	-92.8314	100	Mixed	None
7801848	Central East	Chisago	North Center Lake	45.3966	-92.8281	300	Mixed	None
5159797	Central East	Chisago	The Ridges - Cty Rd 20 & Magnolia	45.3971	-92.8453	1000	Municipal	Restore
7854381	Central East	Chisago	Cty 37 (310th St)	45.3972	-92.7205	150	County	None
5178331	Central East	Chisago	North Lindstrom Lake	45.3973	-92.8472	2500	Mixed	None
7801852	Central East	Chisago	North Center Lake	45.3975	-92.8328	2400	Mixed	None
7801849	Central East	Chisago	North Center Lake	45.3976	-92.8276	250	Mixed	None
7801850	Central East	Chisago	North Center Lake	45.3984	-92.8293	200	Mixed	None
7801871	Central East	Chisago	North Center Lake	45.3985	-92.8233	400	County	None
7801870	Central East	Chisago	North Center Lake	45.3989	-92.8234	200	County	None
7801853	Central East	Chisago	North Center Lake	45.4001	-92.8333	200	Municipal	None
7801869	Central East	Chisago	North Center Lake	45.4004	-92.8229	6000	Mixed	None
7802967	Central East	Chisago	Cty Rd 19, Chisago City	45.4011	-92.8967	1200	Private	Revegetation
7801854	Central East	Chisago	North Center Lake	45.4012	-92.8321	800	Municipal	None
7801855	Central East	Chisago	North Center Lake	45.4027	-92.8339	300	Municipal	None
5160567	Central East	Chisago	Lincoln Rd (Cty 14) at 316th St	45.4027	-92.8635	600	County	None
7801858	Central East	Chisago	North Center Lake	45.4093	-92.8326	3600	Mixed	None
7801856	Central East	Chisago	North Center Lake	45.4102	-92.8334	200	Mixed	None
7801857	Central East	Chisago	North Center Lake	45.4103	-92.8316	100	Mixed	None
7801868	Central East	Chisago	North Center Lake	45.4117	-92.8259	300	Mixed	None
7801867	Central East	Chisago	North Center Lake	45.4124	-92.8244	1400	Mixed	None
7801866	Central East	Chisago	North Center Lake	45.4134	-92.8248	1000	Mixed	None
7801860	Central East	Chisago	North Center Lake	45.4139	-92.8352	2000	Mixed	None
7801865	Central East	Chisago	North Center Lake	45.4140	-92.8249	3600	Mixed	None
7801859	Central East	Chisago	North Center Lake	45.4143	-92.8357	1600	Mixed	None
7801864	Central East	Chisago	North Center Lake	45.4144	-92.8251	200	Mixed	None
7801862	Central East	Chisago	North Center Lake	45.4144	-92.8275	1000	County	None
7801863	Central East	Chisago	North Center Lake	45.4146	-92.8254	500	Mixed	None
7801861	Central East	Chisago	North Center Lake	45.4203	-92.8303	100	Mixed	None
5160568	Central East	Chisago	Lincoln Rd (Cty 14) at Lindo Trail (340th St)	45.4394	-92.8842	1100	County	None

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
5161673 & 5185238	Central East	Chisago	Cty Rd 18/Lent Rd; Peterson Slough W	45.4421	-92.9179	6000	Private	Restore
5185240	Central East	Chisago	Peterson Slough E shore	45.4470	-92.9102	4000	State	Restore
5164598	Central East	Chisago	Peterson Slough E shore	45.4476	-92.9102	10890	Private	Restore
5161042	Central East	Chisago	Falcon Ave N & Athens Trl (Cty 17)	45.4506	-93.0002	440	County	None
4900160/5161044/7801845	Central East	Chisago	I-35 SB at Athens Trl (Cty 17)	45.4541	-92.9914	2600	MNDOT	Revegetation
5161043	Central East	Chisago	Lincoln Trl at 360th St	45.4699	-92.9190	440	Mixed	None
5180764	Central East	Chisago	Janet Johnson Memorial WMA	45.4769	-92.9508	50	State	None
5184801	Central East	Chisago	410th St EB	45.5427	-92.9588	440	Private	None
7825928	Central East	Isanti	Cty Rd 9 EB	45.4563	-93.1369	500	County	None
7808901	Central East	Isanti	Cambridge Middle School	45.5370	-93.2076	40	Municipal	Revegetation
7801941	Central North	Aitkin	Aitkin, Co Rd 1/410th Ave	46.5523	-93.7077	43560	Mixed	Revegetation
None	Central North	Aitkin	Aitkin, Co Rd 1/410th Ave NB	46.5757	-93.7081	600	County	Revegetation
7801919	Central South	Kandiyohi	Kandiyohi, off Hwy 12	45.1326	-94.9768	3000	Mixed	Revegetation
7979158	Central South	Kandiyohi	Willmar, lakeshore	45.1351	-95.0431	Unknown	Private	Revegetation
5166545	Central South	Kandiyohi	Willmar, wetland	45.1363	-95.0422	10000	Private	Revegetation
5166890	Central South	Kandiyohi	Cty Rd 29, E of Swenson Lk	45.2623	-95.1338	43560	Private	Restore
7801918	Central South	Kandiyohi	Lake Andrew Twp	45.2673	-95.1293	Unknown	Private	Revegetation
None	Central South	Kandiyohi	160th St NE	45.2911	-94.8252	400	Private	None
5167881	Central South	Kandiyohi	Brown Property, 176th Ave NE	45.2952	-94.8394	174240	Private	Restore
4426272/4888810/5166893	Central South	Kandiyohi	Hwy 23, Hawick	45.3530	-94.8180	8000	State	Revegetation
5184208	Central South	McLeod	Hwy 7, Clouster Lake WMA	44.9065	-94.1241	600	State	Restore
5167903	Central South	Meeker	Calhoun Estates, Irving Twnshp	45.1705	-94.5030	65340	Private	Revegetation
7817792	Central South	Sherburne	Sherburne NWR	45.4797	-93.6871	2400	Federal	Restore
7817793	Central South	Sherburne	Princeton WWTP Wetland	45.5484	-93.5740	21780	Municipal	None
None	Central South	Sibley	441st Ave	44.6192	-94.1526	Unknown	County	None
7801917	Central South	Sibley	Hwy 6 - Scenic Byway Rd	44.6378	-93.7981	1000	Private	None
None	Central South	Stearns	Richmond Cement Plant	45.4477	-94.5103	1200	Private	None
7801842	Central South	Stearns	Richmond Cement Plant	45.4483	-94.5139	1000	Private	None
7801965	Central South	Wright	Delano Cty Rd 16 SE	45.0242	-93.7975	400	County	None
7801963	Central South	Wright	Delano Cemstone	45.0340	-93.7724	200	Private	Revegetation

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7801962	Central South	Wright	Delano Cemstone	45.0343	-93.7730	3500	Private	Revegetation
7801964	Central South	Wright	Delano Cemstone	45.0347	-93.7721	1200	Private	Revegetation
7801970	Central South	Wright	Delano Cemstone	45.0348	-93.7734	2500	Private	Revegetation
7801969	Central South	Wright	Delano Cemstone	45.0351	-93.7731	900	Private	Revegetation
4706703	Central South	Wright	Delano-Hwy 12	45.0354	-93.7767	1000	MNDOT	Revegetation
4706696	Central South	Wright	Delano Cemstone	45.0354	-93.7731	401	MNDOT	Revegetation
7813797	Central South	Wright	Delano Stormwater Retention Pond	45.0443	-93.7812	1200	Private	Revegetation
7813784	Central South	Wright	Delano Stormwater Retention Pond	45.0452	-93.7814	1600	Private	None
7813785	Central South	Wright	Delano Wetland	45.0456	-93.7816	21780	Private	Revegetation
7801968	Central South	Wright	Delano Maple Ave & 4th St N	45.0458	-93.7849	600	Mixed	None
None	Central South	Wright	Delano, Wetland complex	45.0464	-93.7825	4000	Private	Revegetation
7813787	Central South	Wright	Delano Stormwater Retention Pond	45.0475	-93.7830	100	Municipal	None
7813786	Central South	Wright	Delano Wetland	45.0486	-93.7822	21780	Municipal	Revegetation
7801967	Central South	Wright	Delano Cty Rd 30 SE/70th St SE	45.0502	-93.7775	700	County	None
7801961	Central South	Wright	Delano WWTP	45.0504	-93.7842	1800	Municipal	Revegetation
7801966	Central South	Wright	Delano WWTP	45.0509	-93.7851	1800	Municipal	Revegetation
7813792	Central South	Wright	Hwy 12	45.0647	-93.8667	21780	MNDOT	Revegetation
7813794	Central South	Wright	Hwy 12 W of Delano	45.0648	-93.8872	1600	MNDOT	Revegetation
7813791	Central South	Wright	Hwy 12 W of Delano	45.0653	-93.8804	1600	MNDOT	None
7813788	Central South	Wright	Hwy 55 W of Rockford	45.0934	-93.7503	5000	MNDOT	Revegetation
7813789	Central South	Wright	Hwy 55 SE of Buffalo	45.1159	-93.8083	20	MNDOT	None
7813793	Central South	Wright	Cty Rd 12 S	45.1347	-93.9002	200	Private	None
None	Central South	Wright	Hwy 55 Buffalo	45.1534	-93.8468	1500	MNDOT	Revegetation
7813790	Central South	Wright	Buffalo, Settlers Pkwy & Wilder Way	45.1634	-93.8624	1200	MNDOT	Revegetation
7801950	Central South	Wright	St Michael Wastewater Trtment Plant	45.1995	-93.6488	100	Municipal	None
7801949	Central South	Wright	St Michael Wastewater Trtment Plant	45.1997	-93.6483	100	Municipal	None
7801948	Central South	Wright	St Michael Wastewater Trtment Plant	45.2000	-93.6481	100	Municipal	None

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7801947	Central South	Wright	St Michael Wastewater Trtment Plant	45.2001	-93.6482	100	Municipal	None
7801946	Central South	Wright	St Michael Wastewater Trtment Plant	45.2007	-93.6487	400	Municipal	None
7801953	Central South	Wright	St Michael Wastewater Trtment Plant	45.2014	-93.6501	750	Municipal	Revegetation
7801952	Central South	Wright	St Michael CtyRd 119/45th St	45.2113	-93.6742	100	Municipal	None
7801960	Central South	Wright	St Michael Cty Rd 119/45th St	45.2117	-93.6743	600	Municipal	None
7801959	Central South	Wright	St Michael CtyRd 119/45th St	45.2121	-93.6756	1000	State	None
7801957	Central South	Wright	St Michael 3rd St NW	45.2123	-93.6697	900	Municipal	None
7801951	Central South	Wright	St Michael Cty Rd 119/Birch Ave	45.2123	-93.6744	100	County	None
7801958	Central South	Wright	St Michael 3rd St NW	45.2124	-93.6698	600	Municipal	None
7801954	Central South	Wright	St Michael Maciver Ave NE	45.2153	-93.6441	900	Mixed	None
7813796	Central South	Wright	Buffalo, Hwy 25	45.2176	-93.8498	1800	MNDOT	Revegetation
7801956	Central South	Wright	St Michael/Albertville	45.2218	-93.6648	700	County	None
7801955	Central South	Wright	St Michael/Albertville	45.2227	-93.6647	600	Mixed	None
7801978	Central South	Wright	Albertville, Kyler Ave	45.2278	-93.6662	3200	Municipal	Revegetation
7801977	Central South	Wright	Albertville I-94	45.2370	-93.6465	150	MNDOT	None
7801971	Central South	Wright	Albertville Memorial Park	45.2400	-93.6502	50	Municipal	None
7854374	Central South	Wright	Albertville, 63rd St NE & Marlowe Ave NE	45.2417	-93.6398	2500	Private	Revegetation
7854375	Central South	Wright	Albertville, Mackenzie Ave NE	45.2472	-93.6408	3000	Mixed	Revegetation
7854378	Central South	Wright	Albertville, 80th St NE	45.2664	-93.6462	200	Private	None
7801930	Central West	Grant	Wetland	46.0712	-96.1757	Unknown	State	Restore
7801939	Central West	Otter Tail	Central Lakes Trail	46.2104	-95.9734	800	MNDOT	Restore
3956003	Central West	Otter Tail	I-94	46.3593	-96.1574	6000	MNDOT	Revegetation
5184238	Metro	Anoka	I-35E	45.1381	-93.0392	440	MNDOT	None
7824018	Metro	Anoka	Coon Rapids Blvd ramp to Hwy 610	45.1412	-93.2810	17424	Mixed	Revegetation
5251712	Metro	Anoka	Coon Creek and Hwy 10	45.1698	-93.2948	5000	Mixed	Revegetation
7814494	Metro	Anoka	Blaine, Sunrise Lake Channel	45.1927	-93.1961	7500	Private	Revegetation
5160578	Metro	Anoka	W Freeway Drive	45.2474	-93.0268	18537	MNDOT	Revegetation
5184240	Metro	Anoka	I-35W just N of Lake Dr NE	45.2518	-93.0245	6000	MNDOT	Revegetation

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7628228	Metro	Anoka	Ham Lake Baptist Camp	45.2558	-93.2176	150	Private	Restore
5183924/5185257/7801920	Metro	Anoka	I-35W, Columbus	45.2568	-93.0205	2500	MNDOT	Revegetation
7826165	Metro	Carver	Jonathan Carver Pkwy	44.7879	-93.6424	100	Mixed	None
5178722	Metro	Carver	Clover Ridge Dr/RR ROW	44.8211	-93.6411	2000	Private	None
5162229	Metro	Carver	Big Woods Lake Chaska	44.8488	-93.6052	200	Municipal	Revegetation
7801915	Metro	Carver	Hwy 5	44.8669	-93.6331	100	MNDOT	None
7801916	Metro	Carver	Hwy 5	44.8669	-93.6447	100	Municipal	None
None	Metro	Carver	Hwy 5	44.8671	-93.6242	100	MNDOT	None
7801914	Metro	Carver	Hwy 5	44.8674	-93.6236	100	MNDOT	None
7801913	Metro	Carver	Carver Park Reserve Mitigation Pond	44.8754	-93.6849	6800	County	Restore
7801945	Metro	Dakota	Lebanon Hills Reg Park Visitor Ctr Entr Rd	44.7853	-93.1245	50	County	None
7801987	Metro	Hennepin	I-169/I-94 Interchange Bloomington/Eden Prairie	44.8589	-93.3959	600	MNDOT	None
7801986	Metro	Hennepin	Winter Park Bloomingon	44.8618	-93.4016	43560	Private	Revegetation
7801993	Metro	Hennepin	I-494 Roadside	44.8955	-93.4449	450	Private	None
7801988	Metro	Hennepin	Excelsior Covenant Church	44.9089	-93.5317	4000	Private	Revegetation
7801991	Metro	Hennepin	I-169 S of 7th St/2nd Ave S	44.9112	-93.4026	250	State	None
None	Metro	Hennepin	Little Long Lake	44.9399	-93.7051	400	Private	Revegetation
5184341/7637430/7801995	Metro	Hennepin	Lake of the Isles	44.9519	-93.3097	1000	Municipal	Restore
4425694/4998527	Metro	Hennepin	Cedar Lake Trail, St Louis Park	44.9597	-93.3560	36419	Private	Revegetation
5185251	Metro	Hennepin	Franklin Ave & Cedar Ave, S Mpls	44.9649	-93.2479	3300	County	Revegetation
7801994	Metro	Hennepin	I-494 overpass of Oakland Rd	44.9678	-93.4610	100	MNDOT	None
7801981	Metro	Hennepin	Hwy 12 Orono	44.9851	-93.5711	200	MNDOT	None
7801982	Metro	Hennepin	Hwy 12 Orono	44.9855	-93.5765	200	MNDOT	None
7801989	Metro	Hennepin	Hwy 12 Maple Plain	45.0010	-93.6382	1400	MNDOT	None
7801990	Metro	Hennepin	Hwy 12 Independence	45.0095	-93.6848	200	MNDOT	None
None	Metro	Hennepin	Hwy 12 Maple Plain	45.0105	-93.6783	100	MNDOT	None
7813795	Metro	Hennepin	Crystal Lake, Robbinsdale	45.0231	-93.3255	1400	Municipal	None
7818000	Metro	Hennepin	Hollingsworth Park	45.0302	-93.3280	18	Mixed	Revegetation
7817999	Metro	Hennepin	Hollingsworth Park	45.0303	-93.3274	36	Private	Revegetation

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
7801983	Metro	Hennepin	3905 Nature View Circle at 46th 1/2 Ave N	45.0398	-93.3301	400	Private	Revegetation
7813798	Metro	Hennepin	Delano, County Line Rd SE/Hwy 139	45.0485	-93.7667	200	MNDOT	None
7801992	Metro	Hennepin	Wetland S of Usher Smith	45.0744	-93.4443	5000	Private	None
7814501	Metro	Hennepin	Timber Crest Drive	45.0833	-93.4571	4356	County	Revegetation
7820767	Metro	Hennepin	3Rivers Reg Trl S of Weaver Lake Rd	45.1062	-93.4828	5700	County	Revegetation
7801984	Metro	Hennepin	I-94, Maple Grove	45.1266	-93.4846	500	MNDOT	None
5183925	Metro	Hennepin	Hwy 81 SB	45.1610	-93.5037	800	MNDOT	None
5183926	Metro	Hennepin	Hwy 81 SB	45.1620	-93.5054	200	MNDOT	None
7801985	Metro	Hennepin	I-94 at Brockton Ln N (Cty 101)	45.1636	-93.5210	900	MNDOT	None
5229628	Metro	Hennepin	Tucker Rd adj to Henry Lake	45.1676	-93.6010	200	County	None
5183922	Metro	Hennepin	I-94 at Cty Rd 81	45.1731	-93.5266	1000	MNDOT	None
7801980	Metro	Hennepin	Champlin Mill Pond	45.1842	-93.3992	10	Private	Revegetation
7817791	Metro	Hennepin	Hwy 81 SB	45.1895	-93.5497	800	MNDOT	None
4712842/5183927	Metro	Hennepin	I-94 at 101, Rogers	45.1917	-93.5459	15000	MNDOT	Revegetation
7801911	Metro	Ramsey	Victoria Park	44.9156	-93.1377	900	Municipal	None
7801912	Metro	Ramsey	Victoria Park	44.9157	-93.1379	400	Municipal	None
7979211	Metro	Ramsey	Victoria Park	44.9158	-93.1405	200	Municipal	None
7801910	Metro	Ramsey	Victoria Park	44.9160	-93.1380	100	Private	None
4707458	Metro	Ramsey	Victoria Park	44.9164	-93.1371	2500	Municipal	None
5182174	Metro	Ramsey	Pig's Eye Regional Park	44.9280	-93.0356	7875	Municipal	Revegetation
5178489	Metro	Ramsey	Swede Hollow Park-St Paul	44.9602	-93.0744	325	Municipal	Revegetation
5159642/5178491	Metro	Ramsey	Swede Hollow Park-St Paul	44.9603	-93.0742	325	Municipal	Revegetation
4202699	Metro	Ramsey	Maplewood, Adj to Priory Neighborhood Preserve	44.9877	-92.9891	2800	State	Revegetation
4202700	Metro	Ramsey	Maplewood, Adj to Priory Neighborhood Preserve	44.9878	-92.9888	130	State	None
4202698	Metro	Ramsey	Maplewood, Adj to Priory Neighborhood Preserve	44.9895	-92.9888	30492	Municipal	Revegetation
5788216	Metro	Ramsey	McCarrons Pond Apartment Raingarden	45.0008	-93.1076	4000	Private	Revegetation
7638249	Metro	Ramsey	I-35E SB to Hwy 36 E	45.0103	-93.0906	5600	MNDOT	Revegetation

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
5184343	Metro	Ramsey	Hwy 36 at McKnight	45.0129	-93.0062	1600	Mixed	Revegetation
5168437	Metro	Ramsey	I-35E/I-694E ramp	45.0452	-93.0614	4356	MNDOT	Revegetation
5285313	Metro	Ramsey	Tony Schmidt Reg Pk	45.0507	-93.1735	1000	County	Revegetation
5252262	Metro	Ramsey	I-35W NB	45.0641	-93.1860	Unknown	MNDOT	Revegetation
7814380	Metro	Ramsey	White Bear Lake	45.0707	-92.9890	21780	Lake	None
7814378	Metro	Ramsey	White Bear Lake	45.0708	-93.0053	400	Lake	None
7814386	Metro	Ramsey	White Bear Lake	45.0809	-92.9941	10	Lake	None
7814388	Metro	Ramsey	White Bear Lake	45.0810	-92.9947	400	Lake	None
7814382	Metro	Ramsey	White Bear Lake	45.0814	-92.9971	4356	Lake	None
4792397	Metro	Ramsey	White Bear Lake	45.0830	-93.0009	16770	Mixed	None
4792398	Metro	Ramsey	White Bear Lake	45.0842	-92.9992	400	Mixed	None
7814391	Metro	Ramsey	White Bear Lake	45.0895	-92.9988	400	Lake	None
7817790	Metro	Ramsey	Hammond Rd, White Bear Lake	45.0935	-93.0405	3600	Private	None
7814392	Metro	Ramsey	White Bear Lake	45.0965	-92.9847	21780	Lake	None
7814394	Metro	Ramsey	White Bear Lake	45.0972	-92.9896	900	Lake	None
3108803	Metro	Ramsey	Otter Lake, Tamarack NC	45.1217	-93.0455	220	Mixed	None
7801836	Metro	Scott	Hwy 5 - Hickory Blvd	44.5988	-93.7461	200	MNDOT	None
4494058	Metro	Scott	I-35 Median	44.6073	-93.2961	1000	MNDOT	Revegetation
7801838	Metro	Scott	Hwy 6 Belle Plaine	44.6224	-93.8132	200	MNDOT	None
7801837	Metro	Scott	I-169 Belle Plaine	44.6264	-93.7420	300	MNDOT	None
7801839	Metro	Scott	Hwy 25	44.6324	-93.7636	1500	MNDOT	None
7801929	Metro	Washington	I-494	44.8865	-93.0034	900	Private	Revegetation
7801925	Metro	Washington	I-494 at Exit 60 Lake Rd	44.9139	-92.9812	700	MNDOT	None
7801926	Metro	Washington	I-694 & Cty Rd 14 (34th St N)	44.9983	-92.9585	400	MNDOT	None
None	Metro	Washington	I-694 & Hwy 36 Interchange	45.0294	-92.9606	400	MNDOT	None
7814376	Metro	Washington	White Bear Lake	45.0560	-92.9659	100	Lake	None
7814390	Metro	Washington	White Bear Lake	45.0774	-92.9779	200	Lake	None
None	Metro	Washington	White Bear Lake	45.0786	-92.9650	400	Lake	None
7814393	Metro	Washington	White Bear Lake	45.0795	-92.9652	10890	Lake	None
7814385	Metro	Washington	White Bear Lake	45.0805	-92.9769	250	Lake	None

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7814395	Metro	Washington	White Bear Lake	45.0806	-92.9653	400	Lake	None
7814389	Metro	Washington	White Bear Lake	45.0815	-92.9651	20	Lake	None
None	Metro	Washington	White Bear Lake	45.0822	-92.9762	400	Lake	None
7814387	Metro	Washington	White Bear Lake	45.0824	-92.9754	400	Lake	None
7814381	Metro	Washington	White Bear Lake	45.0829	-92.9730	400	Lake	None
7814383	Metro	Washington	White Bear Lake	45.0834	-92.9719	10	Lake	None
7814377	Metro	Washington	White Bear Lake	45.0846	-92.9712	100	Lake	None
7814379	Metro	Washington	White Bear Lake	45.0851	-92.9716	20	Lake	None
7814396	Metro	Washington	White Bear Lake	45.0938	-92.9836	250	Lake	None
7801928	Metro	Washington	Geneva Ave, Hugo	45.1626	-92.9841	3500	Municipal	Revegetation
3215821	Metro	Washington	Scandia Trl & Hoekstra Ave N	45.2623	-92.9462	50	Private	None
5183923	Metro	Washington	I-35W NB, Forest Lake	45.2660	-93.0099	1000	MNDOT	Revegetation
5177908/5183929	Metro	Washington	1-35W NB, Forest Lake	45.2671	-93.0091	800	MNDOT	Revegetation
5177909/5184237	Metro	Washington	I-35 SB, Forest Lake	45.2683	-93.0095	600	MNDOT	Revegetation
5168438/5183917	Metro	Washington	I-35W Exit 131 to W Broadway Ave	45.2796	-93.0037	400	MNDOT	None
7801927	Metro	Washington	Meadowbrook Ave, Forest Lake	45.2883	-92.8508	900	Mixed	None
7826749	North Central	Lake of the Woods	Hwy 11 WB	48.7107	-94.7053	1200	Private	Revegetation
7826753	North Central	Lake of the Woods	Hwy 11 WB	48.7129	-94.6603	800	Private	Revegetation
7826748	North Central	Lake of the Woods	Hwy 11 WB	48.7734	-94.9804	500	Private	Revegetation
7819637	North Central	Lake of the Woods	Hwy 11 WB	48.7842	-95.0268	20	Private	Revegetation
5168434	Northwest	Becker	Hwy 10/RR ROW	46.8418	-95.9288	87120	MNDOT	Revegetation
None	Northwest	Becker	Hwy 10	46.8778	-96.0492	600	Private	None
None	Northwest	Clay	Hwy 10	TBD	TBD	2400	MNDOT	None
7801934	Northwest	Polk	Glacial Ridge NWR Cty Rd 45	47.7023	-96.3278	200	Mixed	None
None	Saint Louis	Carlton	Hwy 33 ROW	46.7633	-92.4533	10890	MNDOT	Revegetation
None	Saint Louis	St. Louis	S of Kilchlis Meadow	46.6820	-92.1804	10890	Mixed	Revegetation
None	Saint Louis	St. Louis	S of Mouth of US Steel Creek	46.6871	-92.2011	10890	Mixed	Restore
None	Saint Louis	St. Louis	Mouth of US Steel Creek	46.6880	-92.2030	10890	Mixed	Restore

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
None	Saint Louis	St. Louis	Island	46.6941	-92.1959	10890	Mixed	Restore
7823447	Saint Louis	St. Louis	No description	46.6951	-92.2048	10890	Private	None
None	Saint Louis	St. Louis	S of Munger Landing	46.6987	-92.2082	10890	Private	None
7823445	Saint Louis	St. Louis	S of Munger Landing	46.6997	-92.2081	10890	Private	None
None	Saint Louis	St. Louis	S of Munger Landing	46.7006	-92.2073	10890	Mixed	None
None	Saint Louis	St. Louis	N of Munger Landing	46.7015	-92.2072	10890	Mixed	None
7823454	Saint Louis	St. Louis	N of Munger Landing	46.7017	-92.2073	10890	Mixed	None
None	Saint Louis	St. Louis	N of Munger Landing	46.7020	-92.2075	10890	Mixed	None
None	Saint Louis	St. Louis	N of Munger Landing	46.7024	-92.2076	10890	Private	None
None	Saint Louis	St. Louis	Swenson Ave	46.7028	-92.2136	10890	Mixed	Revegetation
7823439	Saint Louis	St. Louis	N of Munger Landing	46.7030	-92.2073	10890	Private	None
7823440	Saint Louis	St. Louis	N of Munger Landing	46.7037	-92.2073	10890	Private	None
7823438	Saint Louis	St. Louis	N of Munger Landing	46.7042	-92.2071	10890	Private	None
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7051	-92.2048	10890	Mixed	None
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7053	-92.2046	10890	Mixed	None
None	Saint Louis	St. Louis	No description	46.7056	-92.2067	10890	Private	Revegetation
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7059	-92.2042	10890	Private	None
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7066	-92.2046	Unknown	Private	Revegetation
None	Saint Louis	St. Louis	Spring Street	46.7070	-92.2055	10890	Private	Revegetation
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7071	-92.2044	50	Private	None
None	Saint Louis	St. Louis	Spirit Lake Marina	46.7081	-92.2017	43560	Private	Revegetation
None	Saint Louis	St. Louis	Celeste's Island	46.7185	-92.1847	10890	Mixed	None
None	Saint Louis	St. Louis	No description	46.7198	-92.1649	10890	Private	Revegetation
None	Saint Louis	St. Louis	No description	46.7216	-92.1629	10890	Private	None
None	Saint Louis	St. Louis	No description	46.7232	-92.1627	10890	Private	None
None	Saint Louis	St. Louis	No description	46.7241	-92.1629	7500	Private	None
4202302	Saint Louis	St. Louis	Grassy Point, Duluth	46.7245	-92.1535	63772	State	Restore
None	Saint Louis	St. Louis	No description	46.7252	-92.1622	43560	Private	None
None	Saint Louis	St. Louis	No description	46.7263	-92.1604	10890	Private	None
None	Saint Louis	St. Louis	No description	46.7266	-92.1604	21780	Private	None

EDDMapS Number	Response Region	County	Description	Latitude	Longitude	Area Invaded (sq. ft.)	Property Ownership	Restoration Category
5159381	Saint Louis	St. Louis	Grassy Point	46.7272	-92.1604	43560	Private	Revegetation
None	Saint Louis	St. Louis	Grassy Point	46.7274	-92.1590	43560	Municipal	Revegetation
None	Saint Louis	St. Louis	Waseca Industrial Rd Overpass	46.7278	-92.1626	10890	Private	Revegetation
None	Saint Louis	St. Louis	No description	46.7283	-92.1650	10890	Private	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7403	-92.1420	10890	Municipal	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7404	-92.1421	10890	Municipal	Revegetation
7823449	Saint Louis	St. Louis	Oneota	46.7406	-92.1415	10890	Municipal	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7406	-92.1417	10890	Municipal	Revegetation
7823444	Saint Louis	St. Louis	Oneota	46.7408	-92.1484	10890	Mixed	Revegetation
7823457	Saint Louis	St. Louis	Oneota	46.7411	-92.1404	10890	Municipal	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7415	-92.1399	10890	Municipal	Revegetation
7823444	Saint Louis	St. Louis	Oneota	46.7416	-92.1495	10890	Mixed	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7417	-92.1493	Unknown	Private	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7418	-92.1498	10890	Mixed	Revegetation
7823458	Saint Louis	St. Louis	Oneota	46.7419	-92.1503	10890	Mixed	Revegetation
None	Saint Louis	St. Louis	Oneota	46.7422	-92.1492	Unknown	Municipal	Revegetation
5159381	Saint Louis	St. Louis	Duluth Hallett Dock Area	46.7479	-92.1377	107593	Private	None
None	Saint Louis	St. Louis	Rice's Point	46.7529	-92.0999	10890	Private	None
None	Saint Louis	St. Louis	Rice's Point	46.7532	-92.0985	100	Mixed	None
None	Saint Louis	St. Louis	Courtland St	46.7561	-92.1288	Unknown	Mixed	Revegetation
7801932	Saint Louis	St. Louis	Rice's Point - Duluth Seaway Port Authority	46.7570	-92.1060	21780	Private	Revegetation
None	Saint Louis	St. Louis	Rice's Point	46.7585	-92.1045	750	Private	None
None	Saint Louis	St. Louis	Rice's Point	46.7589	-92.1056	Unknown	Private	None
None	Saint Louis	St. Louis	Rice's Point	46.7590	-92.1051	100	Private	None
None	Saint Louis	St. Louis	Hearding Island	46.7594	-92.0854	10890	State	Revegetation
None	Saint Louis	St. Louis	Harbor Point Circle	46.7644	-92.0875	21780	Private	Revegetation
7823453	Saint Louis	St. Louis	Rice's Point	46.7661	-92.1039	10890	Mixed	None
7823453	Saint Louis	St. Louis	No description	46.7662	-92.1036	10890	Mixed	None
7801933 & 8067311	Saint Louis	St. Louis	Duluth Haines Road	46.8161	-92.1746	800	County	Restore
None	Saint Louis	St. Louis	Hwy 53	46.9644	-92.4638	43560	MNDOT	Revegetation

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5162173	Saint Louis	St. Louis	Hwy 53, Cotton	47.1523	-92.4726	10890	MNDOT	None
None	Saint Louis	St. Louis	Hwy 7	47.2966	-92.6032	2100	Mixed	Revegetation
7801931	Saint Louis	St. Louis	Hwy 53/RR ROW	48.1818	-92.8839	500	State	Revegetation
4792145	South Central	Blue Earth	Fernwood Rd N of RR tracks	44.1743	-94.1242	150	Private	None
4494028	South Central	Freeborn	I-35 N of Exit 42	43.5361	-93.3547	3000	MNDOT	Revegetation
4498339	South Central	Freeborn	Cty Rd 14 to 700th Ave	43.6914	-93.4685	120	Private	None
5181870 & 4498342	South Central	Freeborn	Hwy 13/RR ROW, S of Manchester	43.7086	-93.4396	2200	Private	Revegetation
4498342 & 7801979	South Central	Freeborn	Hwy 13/RR ROW, S of Manchester	43.7112	-93.4410	17424	Private	Revegetation
7801921	South Central	Le Sueur	Ludwig Island, Lake Emily	44.3067	-93.9190	2000	County	Restore
5178885 & 5182768	South Central	Le Sueur	110/107 (Lake Emily Rd) & 21 (Golf Course Rd)	44.3101	-93.9319	43560	Private	Revegetation
5181867	South Central	Le Sueur	Le Center, Cty Rd 5	44.4156	-93.6871	2200	Private	Revegetation
5182572	South Central	Nicollet	Hwy 14 and I-169 Ramp	44.1913	-94.0180	400	MNDOT	None
5183181	South Central	Nicollet	Swan Lake WMA	44.2710	-94.2447	600	MNDOT	Revegetation
5181869	South Central	Steele	Owatonna, Bridge St	44.0842	-93.2500	870	MNDOT	None
4795628	South Central	Steele	Owatonna - off intersection Partridge Ave SE & Rose St, S of Rose St	44.0878	-93.1953	3000	Mixed	Revegetation
7847066	South Central	Steele	Rice Lake State Park	44.0942	-93.0641	300	State	None
4711241	South Central	Steele	I-35 NB, Owatonna	44.0989	-93.2450	10000	MNDOT	Revegetation
5159796	South Central	Steele	I35W N-bound, Under Exit 43 sign, ramp to NW 26th St	44.1067	-93.2456	130	MNDOT	None
None	South Central	Steele	380th Ave Janesville	44.1089	-93.7153	400	Private	None
5184803	South Central	Steele	Owatonna, I-35 at Exit 45	44.1424	-93.2534	3000	Private	Revegetation
5159674	South Central	Steele	I-35 NB Medford	44.1648	-93.2585	4356	MNDOT	Revegetation
7801896	Southeast	Dodge	Hwy 14 E of Kasson	44.0254	-92.6994	2000	MNDOT	Revegetation
7801900	Southeast	Fillmore	Mabel Hwy 44	43.5236	-91.7659	400	MNDOT	None
7801902	Southeast	Fillmore	Mabel WWTP	43.5242	-91.7603	900	Municipal	None
7801903	Southeast	Fillmore	Mabel WWTP	43.5244	-91.7603	100	Municipal	None
7801899	Southeast	Fillmore	Mabel WWTP	43.5247	-91.7627	400	Private	None
7801904	Southeast	Fillmore	Mabel WWTP	43.5247	-91.7590	6400	Municipal	None
7801907	Southeast	Fillmore	Mabel WWTP	43.5249	-91.7631	100	Private	None

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7801901	Southeast	Fillmore	Mabel WWTP	43.5252	-91.7624	400	Private	None
7801906	Southeast	Fillmore	Mabel WWTP	43.5253	-91.7607	1600	Municipal	None
7801905	Southeast	Fillmore	Mabel WWTP	43.5254	-91.7596	2400	Municipal	None
7801898	Southeast	Fillmore	Mabel WWTP	43.5258	-91.7606	200	Municipal	Revegetation
7801908	Southeast	Fillmore	Chatfield	43.8368	-92.1800	2500	Private	None
7801895	Southeast	Goodhue	Frontenac State Park	44.5106	-92.3304	50	State	None
5209042	Southeast	Olmsted	SW corner of Cty 117 & US Hwy 63	43.9621	-92.4659	200	Mixed	None
7801923	Southeast	Olmsted	Hwy 14	44.0289	-92.6058	150	MNDOT	Revegetation
7801922	Southeast	Olmsted	Hwy 52	44.0923	-92.5118	2100	MNDOT	Revegetation
5160840	Southeast	Wabasha	McCarthy WMA Hwy 61	44.2401	-91.9569	108	Private	None
7801937	Southeast	Wabasha	N of Cty Rd 24	44.3306	-91.9793	3000	County	Restore
7801938	Southeast	Wabasha	N Cty Rd 24	44.3433	-91.9779	4000	Private	Restore
7801935	Southeast	Wabasha	N Cty Rd 24	44.3437	-91.9788	4000	Private	Restore
7801936	Southeast	Wabasha	N Cty Rd 24	44.3449	-91.9758	5000	County	Restore
None	Southeast	Winona	Hwy 61 Frontage Rd	43.9702	-91.4228	300	MNDOT	Revegetation
7801944	Southeast	Winona	Hwy 61, Minneiska	44.1907	-91.8649	200	MNDOT	Revegetation
None	Southwest	Lac Qui Parle	Lac Qui Parle WMA	45.2167	-96.2364	21780	State	Restore
7826752	Southwest	Lyon	Hwy 14	44.2396	-95.9467	1600	MNDOT	None
5157823	Southwest	Lyon	Hwy 23	44.3100	-95.9648	4000	MNDOT	Revegetation
7801940	Southwest	Redwood	Hwy 14 Lamberton WMA	44.2396	-95.2174	3000	Mixed	Restore