MN NWAC Risk Assessment Worksheet (04-2011)	Common Name	*Latin Name*
	introduced forms of common reed	**introduced forms of *Phragmites australis***
Reviewer	**Affiliation/Organization**	**Date (mm/dd/yyyy)**
Anthony Cortilet **Ken Graeve**	**Minnesota Department of Agriculture** **Minnesota Department of Transportation**	**09/12/2012** **August 2016**

Common reed, *Phragmites australis*, is represented in MN by a native subspecies (*Phragmites australis* subsp *americanus*, hereafter native *Phragmites*) and a non-native form (P. *australis* haplotype M, hereafter introduced *Phragmites*). This risk assessment focuses introduced *Phragmites.* Introduced *Phragmites* is highly invasive in many parts of North America, including adjacent and nearby states on the great lakes and has been shown to cause significant ecological disruption. It is present in Minnesota in widely scattered but small infestations. The abundance of introduced *Phragmites* in MN is far lower than in other affected states, but conditions are such that rapid spread is likely in the near future. There is some beneficial use of introduced *Phragmites* in the form of reed beds used for wastewater treatment, but this benefit is outweighed by the threats to wetland ecosystems in Minnesota. This risk assessment recommends that introduced *Phragmites* be regulated on the noxious weed list as a "Prohibited: Control "species in order to motivate control and containment within the state.

The following chart shows the steps in the risk assessment protocol that have led to this conclusion. However, because of the complexities of this species, more detail is provided in a narrative after the protocol.

Box	Question	Answer	Outcome
1	Is the plant species or genotype non-native?	*Phragmites australis* is a wetland grass with a cosmopolitan distribution. Four distinct lineages have been identified in North America (Saltonstall 2007, Meyerson and Cronin 2013). One is a collection of several endemic haplotypes that has been formally described as P. *australis* subsp *americanus* (Saltonstall 2004). Another lineage, often referred to as Haplotype M, is the most common lineage worldwide. Genetic comparisons and historical distribution data have shown that haplotype M was likely introduced to North America, possibly from sources in the United Kingdom, sometime before 1910 (Saltonstall 2002, Plut et. Al. 2011). Both native *Phragmites* and introduced *Phragmites* have been documented in Minnesota (Saltonstall 2002, Melchior & Weaver 2016).	Yes Go to 3

Box	Question	Answer	Outcome
3	The plant, or a related species, is documented as being a problem elsewhere?	Introduced *Phragmites* is considered a highly invasive plant in north American marshes, is considered problematic in at least 18 states, and is especially invasive along the east coast, great lakes states, and Nebraska (Galatowitsch 2012, Falck & Olson 2015, Saltonstall 2002, Swearingen & Saltonstall 2010, Gucker 2008, Hodredge & Bertness 2010, Farnsworth et al 2003).	Yes Go to Step 6
6	The Plant has the capacity to establish and survive in MN?		
A.	Is the plant, or a close relative established in MN?	Yes. Both native *Phragmites* and introduced *Phragmites* have been documented morphologically and molecularly in MN (Saltonstall 2002, Melchior & Weaver 2016).	Yes Go to Step 7
7	The plant has the potential to reproduce and spread in MN?		
A.	Does the plant reproduce by asexual/vegetative means?	Yes. Introduced *Phragmites* reproduces vigorously by rhizomes, stolons, and roots. Fragments of these structures can be carried by water and re-root. Abundant viable seed is also produced making seed an important invasion vector (Albert et al 2015, Gucker 2008, Meyerson et al 2009).	Go to 7B
B.	Are the asexual propagules – vegetative parts having the capacity to develop into new plants – effectively dispersed to new areas?	Yes. Water action along lakes, ponds, wetlands, or streams can break root fragments off of the plant and transport downstream to new areas. Rhizome or stolon fragments can also be transported by humans and equipment (Gucker 2008, Marks et al 1994). Roadsides have been shown to be especially conducive to spreading this species due to their hydrologic characteristics and maintenance practices (Brisson et al 2010).	Go to 7I

Box	Question	Answer	Outcome
C.	Does the plant produce large amounts of viable, cold hardy seeds?	**Sexual reproduction does occur. In Minnesota it is thought to be restricted to growing seasons that extend late into the year, allowing time for seed maturation. While this is thought to be limited, such growing seasons will likely become increasingly common as the climate changes (Galatowitsch, pers. comm, EPA 2016, Zandlo 2008). On the other hand, seed production may already be prevalent. Melchior and Weaver found evidence of sexual reproduction in Minnesota (2016) and a recent study in Quebec found that 84% of new plants grew from seed rather than fragments (Albert et al 2015).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**
D.	For species that produce low numbers of viable seeds, do they have a high level of seed/seedling vigor or remain viable for an extended period (seed bank)?	**Seedlings are thought to be susceptible to winter freezing, and thus their survival limited to mild winters (Albert et al 2015, Brisson et al 2010). However, there is concern that seed will contribute more to spread as mild winters increase with climate change (Brisson et al 2010). Evidence already exists for sexual reproduction in MN (Melchior & Weaver 2016).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**
F.	Are sexual propagules – viable seeds – effectively dispersed to new areas?	***Phragmites* seed is dispersed by wind (Gucker 2009).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**

Box	Question	Answer	Outcome
G.	Can the species hybridize with native species (or other introduced species) and produce viable seed and fertile offspring in the absence of human intervention?	**Yes, hybridization is thought to be rare (Fant et al, in press) but both intra- and interspecific hybridization have been documented (Chu et al 2011, Lambertini et al 2012, Blossey et al 2014, Paul et al 2010).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**
I.	Do natural controls exist, species native to Minnesota that are documented to effectively prevent the spread of the species in question?	No. Biological control research is being conducted. Two stem-mining noctuid moth species are under consideration and have shown some promise. All host specificity testing has been done and turned out to the researcher's satisfaction and they are preparing a petition to TAG proposing the release of *Archanara geminipuncta* and *A. neurica*, two stem mining moths from Europe. The anticipated submission of the release petition is late fall 2016 (Bernd Blossey, personal communication). There is concern that biological control for introduced *Phragmites* will be harmful to native *Phragmites* (Cronin et al 2016).	Go to Step 8
8	Does the plant species pose significant human or livestock concerns or have the potential to significantly harm agricultural production, native ecosystems, or managed landscapes?		

Box	Question	Answer	Outcome
A.	Does the plant have toxic qualities, or other detrimental qualities, that pose a significant risk to livestock, wildlife, or people?	There have been no reported toxic qualities associated with *Phragmites*.	No, Go to 8B
B.	Does, or could, the plant cause significant financial losses associated with decreased yields, reduced crop quality, or increased production costs?	No known impacts to production in the literature. There is a concern that introduced *Phragmites* could threaten wild rice production, not based on direct evidence but based on overlapping habitat requirements (Falck, pers comm).	Possibly, Go to 8C
C.	Can the plant aggressively displace native species through competition (including allelopathic effects)?	Introduced *Phragmites* has been shown to reduce native plant diversity through rapid growth, litter accumulation, hydrological alterations, and allelopathy (Ailstock et al 2001, Chambers et al 1999, Farnsworth and Meyerson 1999, Galatowitsch 2012, Holdredge & Bertness 2010, Price et al 2014, Rudrappa et al 2007).	Go to Step 9

Box	Question	Answer	Outcome
D.	**Can the plant hybridize with native species resulting in a modified gene pool and potentially negative impacts on native populations?**	**Hybridization has recently been confirmed to occur between wild populations of introduced and native *Phragmites* (Paul et al 2010, Blossey et al 2014).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**
E.	**Does the plant have the potential to change native ecosystems (adds a vegetative layer, affects ground or surface water levels, etc.)?**	**Introduced *Phragmites* can grow in such dense stands that it alters ecosystem structure and function. Considered to be an ecosystem engineer, introduced *Phragmites* growth and rapid litter accumulation alter hydrology, and cause changes in nutrient cycling, soil properties, surface temperatures, and light levels within marsh communities (Gucker 2009, Meyerson et al 2009). These changes have been associated with reduced plant and animal diversity and with significant alterations at the base of the food web (Able & Hagan 2000, Able & Hagan 2003, Benoit & Askins 1999, Gratton & Denno 2006, Meyer et al 2010, Meyerson et al 2009, Gucker 2008). Introduced *Phragmites* also hampers wetland restoration by crowding out target plant communities (Meyerson et al 2009).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**
9	The plant has clearly defined benefits that outweigh associated negative impacts?		

Box	Question	Answer	Outcome
A.	Is the plant currently being used or produced and/or sold in MN or native to MN?	Yes Non-native *Phragmites* is used in reed beds for wastewater treatment at 17 facilities in MN (Sherry Bock, pers comm). *Phragmites* subsp. *americanus* is native and may be sold in certain wetland mixes/restoration mixes. However, no known sales in the nursery trade at this time have been established (Power pers comm, Shimek pers comm, Malone pers comm).	Go to 9B

Box	Question	Answer	Outcome
B.	Is the plant an introduced species and can its spread be effectively and easily prevented or controlled, or its negative impacts minimized through carefully designed and executed management practices?	Introduced *Phragmites* is a non-native form of *Phragmites australis* and is distinct from the native subspecies, *P.a.* subsp *americanus* (Saltonstall 2002). The risk of spread from wastewater treatment facilities has been downplayed by that industry, with claims that rhizomes are effectively contained by the liner used in the reed bed structure and that disposal requirements for biosolids ensure that it gets applied to unsuitable (upland) sites Bock, pers comm, Davis, pers comm). Even so, there are naturalized populations adjacent to at least two treatment facilities in MN and three in Wisconsin (Bock pers comm, Falck 2015, Wright County) although genetic analysis to determine the source of these infestations has not been done. Even if rhizome containment is 100% effective, it does not address sexual reproduction. Given the strong evidence for spread by seed in MN (Galatowitsch pers comm, Melchior & Weaver 2016), it would be irresponsible to assume that containment of rhizomes is sufficient. Seed production in reed beds could be prevented by mowing during August. Currently the logistics of accomplishing such a mowing are difficult but solutions are being investigated (Davis pers comm, Hegeman pers comm).	Go to 9C

Box	Question	Answer	Outcome
	C. Is the plant native to Minnesota?	No	Go to Question D
	D. Is a non-invasive, alternative plant material commercially available that could serve the same purpose as the plant of concern?	Yes While there are no rigorous studies comparing the performance of native with introduced *Phragmites* in reed beds, the designer of the majority of reed bed systems in North America, Scott Davis of the Constructed Wetland s Group, is increasingly using native *Phragmites* in new installations. Davis has observed the native *Phragmites* to be a little more difficult to propagate but its overall performance is similar to that of introduced *Phragmites*. Native *Phragmites* has already been installed in one reed bed in MN (Bock) and possibly three others (Evanocheck pers comm). Nebraska prohibits the use of *P. australis* subsp. *australis* in reed beds (29) and Indiana has also banned the practice (Hegeman).	Go to Step 10
	E. Does the plant benefit Minnesota to a greater extent than the negative impacts identified at Box #8?	**No.** **The various ecological and infrastructure impacts described above are extensive but difficult to quantify. The cost of controlling introduced *Phragmites*, although undoubtedly a vast underestimate of impacts, represents a more accessible quantitative measure of its impacts. Regional control projects for which expenditures are readily available include efforts in the central Platte river valley of Nebraska, which has spent $4.5million over six years (Walters, unpublished data); and work in the great lakes totaling over $16million since 2010 (Braun, pers. comm.). An economic survey of management efforts by Martin and Blossey found that organizations across the U.S. spent over $4.6million per year from 2005-2009, but that few organizations had accomplished their management objectives (2013).** **The benefits of non-native *P. australis* in wastewater treatment reed beds are substantial in that they reduce the operating costs and environmental impact of wastewater treatment. However, it would be difficult to argue that these benefits outweigh the vast ecological impact of many thousands of acres of infestation. Also, native *P. australis* is increasingly being used as a replacement (Davis pers comm).**	**Text is provided as additional information not directed through the decision tree process for this particular risk assessment.**

Box	Question	Answer	Outcome
10	Enforce control as a noxious weed to prevent introduction &/or dispersal; designate as Prohibited or Restricted	The flow chart directs the analysis into Box 10 based on the analysis that this is a non-native plant with substantial negative impacts that are not outweighed by the benefits that it provides.	
A.	Is the plant currently established in MN?	Yes. Both native *Phragmites* and introduced *Phragmites* have been documented morphologically and molecularly in MN (Saltonstall 2002, Melchior & Weaver 2016).	Go to 10B
B.	Does the plant pose a serious human health threat	No threat to human health has been documented at this time.	Go to 10C

Box	Question	Answer	Outcome
C.	Can the plant be reliably eradicated – entire plant – or controlled (top growth only to prevent pollen dispersal and seed production as appropriate) on a statewide basis using existing practices and available resources?	Control of introduced *Phragmites* infestations is possible. A common concern relating to control of introduced *Phragmites* is that an inability to distinguish it from native *Phragmites* can jeopardize the native subspecies. However, comparison of morphological characteristics with genetic markers by Swearingen and Saltonstall (2010) have revealed several useful field indicators. Although Swearingen and Saltonstall warn that field identification using morphological characteristics without genetic testing may not be 100% reliable, the correlation is strong and Minnesota stands of *Phragmites* have shown 100% correlation between morphological characters and genetic markers (Melchior & Weaver 2016). Also, states like NE have listed it as a noxious weed and have been relatively successful through University of NE Extension in providing enforcement agents in local governments with education on discerning between the native and non-native. Control efforts in other states have shown success with various combinations of treatments such as herbicide, mowing, burning, and restoration (Gucker 2009, Collaborative). Coordinated efforts in Nebraska have reduced infestations and improved flow conveyance in the Platte River (Walters, unpublished data). However, as a word of caution, there are studies that question the landscape-scale and long-term effectiveness of control (Hazelton et al 2014, Martin & Blossey 2013).	Yes – List as a Prohibited Eradicate or Control Noxious Weed.

Final Results of Risk Assessment

	Review Entity	Comments	Outcome
	2012 NWAC LISTING SUBCOMMITTEE	9/13/12 – Control not thought to be possible or feasible - Eradication statewide not thought to be feasible so why expect landowners to attempt eradication? - Potential environmental impacts by forcing either control or eradication - forcing either control or eradication Issues with regulation concerning aquatic (MN DNR) vs. terrestrial (MDA) Group spent a lot of time debating this issue; no real consensus to support regulation at this time	Undecided
	2012 NWAC FULL GROUP	Full membership discussed not listing *Phragmites* at this time. A motion was	

		made and approved to vote for recommending that *Phragmites* be listed as a restricted noxious weed to at least bring attention to this species and restrict its sale and movement in the state.	
	2012 MDA Commissioner	Commissioner Approved as a Restricted Noxious Weed – 1/14/2013	RESTRICTED NOXIOUS WEED
	2017 NWAC LISTING SUBCOMMITTEE	Introduced *Phragmites* has been shown to cause major ecological disruption in other states. This species poses a major threat to Minnesota because of the large number of vulnerable ecosystems and current scattered distribution of infestations in the state. With the risk of rapid expansion increased by continuing climate change, the window of opportunity for containing introduced *Phragmites* and preventing widespread impacts in Minnesota may be closing. Infestations are too numerous for statewide eradication, but prudence dictates that a concerted effort be made to contain this species and eliminate infestations wherever possible. Listing this species as a noxious weed in the "Prohibited: Control" category would be the regulatory approach most likely to facilitate motivate widespread control and containment. Exactly how such a regulation would be applied to the use of introduced *Phragmites* in reed beds needs further discussion, but phase-outs and methods to prevent flowering in existing stands should be considered. Such methods are being implemented or discussed in other states.	Recommend reclassification and listing as a Prohibited: Control Noxious Weed
	2017 NWAC FULL GROUP	Full membership voted 10 – 4 to accept the Listing Subcommittee's recommendation.	Reclassify and list as a Prohibited- Control Species.
	2017 MDA Commissioner	Commissioner reviewed NWAC's request to reclassify from a Restricted Noxious Weed to a Prohibited Noxious Weed on the Control List. Minnesota DNR Commissioner Tom Landwehr sent a letter of appeal within 45 days of the NWAC full membership vote (per NWAC bylaws) to express that the agency does not support reclassification of this species and that the Restricted Noxious Weed Category should remain. ***The appeal letter (attached)*** provides the DNR's reasoning for their opinion. Without support of the MN DNR – an agency with a significant amount of habitat that this risk assessment has concluded would be threatened by future spread of non-native phragmites – and the 10 – 4 vote among NWAC constituent groups, the MDA rejected NWAC's recommendation and non-native Phragmites will remain a Restricted Noxious Weed (02/06/2017).	**RESTRICTED NOXIOUS WEED**
	File #	**MDARA00020COMRED_1_18_2013**	

MN DEPARTMENT OF NATURAL RESOURCES APPEAL OF NWAC RECOMMENDATION

DEPARTMENT OF NATURAL RESOURCES

Office of the Commissioner
500 Lafayette Road North
St. Paul, Minnesota 55155

January 30, 2017

Commissioner Dave Frederickson
Minnesota Department of Agriculture
625 Robert Street N.
St. Paul, Minnesota 55155-2538

Dear Commissioner Frederickson:

The Minnesota Department of Natural Resources (DNR) appreciates the opportunity to participate in the Noxious Weeds Advisory Council. I'm writing regarding the Council's recommendation to reclassify non-native Phragmites from a "restricted noxious weed" to a "prohibited noxious weed" on the control list. DNR recognizes non-native Phragmites is invasive and represents a threat to Minnesota's wetlands. Moreover, we also agree it is better to address invasive species early in the invasion stage rather than when they are widespread and abundant.

However, DNR does not support the proposed change in regulatory status of non-native Phragmites at this time. More specifically, we do not believe a change in classification is currently warranted because:

- There is not a clear understanding of distribution and abundance of non-native Phragmites in Minnesota. Without knowing how widespread non-native Phragmites is in Minnesota, we do not know whether we can successfully prevent its spread or manage infestations through required control. We need better information about distribution in the state before we impose control requirements on all landowners.
- Control methods are limited and have not been demonstrated to provide long-term control of Phragmites.
- Non-native Phragmites is difficult to distinguish from native Phragmites. Enforcement would be very difficult. Local units of government would be asked to become experts in identifying non-native and native populations of Phragmites for control purposes, and the potential for incorrect identification is high.
- The current classification of "restricted noxious weed" allows the flexibility to control non-native Phragmites on state and private lands, but does not mandate control. DNR believes this is a better approach at the current time.

Non-native Phragmites does pose a real resource threat. While we do not believe classification as a prohibited noxious weed is currently warranted for the reasons outlined above, DNR does encourage the following actions by the Minnesota Department of Agriculture and its Noxious Weeds Advisory Committee:

- Continue outreach to land managers and the public on non-native Phragmites identification and control.
- Continue working with the wastewater treatment industry to phase out non-native Phragmites in wastewater treatment beds.

- Support research on non-native Phragmites distribution in Minnesota, such as Dr. Dan Larkin's proposals to the University of Minnesota Aquatic Invasive Species Research Center.
- Support funding efforts for a coordinated statewide effort to inventory and control non-native Phragmites.

Thank you for your consideration.

Sincerely,

Tom Landwehr
Commissioner

Introduced *Phragmites* Risk Assessment Narrative

Both native and non-native lineages are present in North America

Phragmites australis is a wetland grass with a cosmopolitan distribution. Four distinct lineages have been identified in North America (Saltonstall 2007, Meyerson and Cronin 2013). One is a collection of several endemic haplotypes that has been formally described as P. *australis* subsp *americanus* (Saltonstall 2004). Another is a haplotype that is found along the Gulf Coast in North America, as well as in South America and on some islands in the southern Pacific. This lineage has been referred to variously as Haplotype I, the Gulf Coast Lineage, and *P. australis* subsp. *berlandieri* (Saltonstall 2002, Saltonstall 2007). The third lineage, often referred to as Haplotype M, is the most common lineage worldwide. Genetic comparisons and historical distribution data have shown that haplotype M was introduced to North America, possibly from sources in the United Kingdom, sometime before 1910 (Saltonstall 2002, Plut et. Al. 2011). Finally, another non-native lineage, referred to as haplotype L, was recently documented in Quebec (Meyerson and Cronin 2013). Both *P. australis* subsp. *americanus* (hereafter native *Phragmites*) and *P. australis* haplotype M (hereafter introduced *Phragmites*) have been documented in Minnesota (Saltonstall 2002, Melchior & Weaver 2016).

Introduced *Phragmites* is invasive and ecological harmful

Introduced *Phragmites* is considered a highly invasive plant in north American marshes, is considered problematic in at least 18 states, and is especially invasive along the east coast, great lakes states, and Nebraska ([14, 8, 9, 17, 23, 24] GLIFWC, Gucker 2008, Hodredge & Bertness 2010, Farnsworth et al 2003).

Ecological differences

There are ecological differences in addition to genetic and morphological differences between native and introduced *Phragmites*. The latter demonstrates earlier emergence, faster growth rates, higher biomass accumulation, higher culm density, greater height, greater tolerance to flooding and greater salt tolerance than native *Phragmites* (Meyerson et al 2009). Introduced *Phragmites* has a faster growth response to elevated CO_2 and nitrogen than the native form (Holdredge et al 2010, Mozdzer & Megonigal 2012). Introduced *Phragmites* also produces more toxic root exudates than native *Phragmites,* as shown in laboratory studies by Rudrappa et al (2007). As with typical introduced species that are released from their native pests upon arrival on a new continent, introduced *Phragmites* suffers less aphid herbivory in North America than native *Phragmites* (Gucker 2009). Introduced *Phragmites* has been shown to be more invasive, with more detrimental impacts on native plant diversity, than native *Phragmites* (Price et al 2014).

Changes in ecosystem structure

Introduced *Phragmites* can grow in such dense stands that it alters ecosystem structure and function. Considered to be an ecosystem engineer, introduced *Phragmites* growth and rapid litter accumulation alter hydrology, and cause changes in nutrient cycling, soil properties, surface temperatures, and light levels within marsh communities (Gucker 2009, Meyerson et al 2009). These changes have been associated with reduced plant and animal diversity and with significant alterations at the base of the food web (Able & Hagan 2000, Able & Hagan 2003, Benoit & Askins 1999, Gratton & Denno 2006, Meyer et al 2010, Meyerson et al 2009, Gucker 2008). Introduced *Phragmites* also hampers wetland restoration by crowding out target plant communities (Meyerson et al 2009).

Threats to native plant species

Introduced *Phragmites* has been shown to reduce native plant diversity through rapid growth, litter accumulation, hydrological alterations, and allelopathy (Ailstock et al 2001, Chambers et al 1999, Farnsworth and Meyerson 1999, Galatowitsch 2012, Price et al 2013, Rudrappa et al 2007, Holdredge et al 2010). Native plant biodiversity increases following control of introduced *Phragmites* (Ailstock et al 2001, Farnsworth and Meyerson 1999). One native plant species of both ecological and economic importance in Minnesota is wild rice (*Zizania* sp.). Because the habitat requirements of introduced *Phragmites* overlaps those of *Zizania* sp., there is concern that introduced *Phragmites* could cause significant harm to *Zizania* sp. populations and the wild rice industry (Falck, pers comm.).

Threats to native *Phragmites*

Introduced *Phragmites* crowds out native *Phragmites* (Meyerson et al 2009) and the spread of introduced *Phragmites* has been associated with simultaneous declines of native *Phragmites* on the east coast, in the great lakes, and in Nebraska (Saltonstall 2002, Larson et al 2011, Meyerson et al 2009). Hybridization is another potential threat to populations of native *Phragmites*, and hybridization has recently been confirmed to occur between wild populations of Introduced and native *Phragmites* (Paul et al 2010, Blossey et al 2014). There is some concern that control of introduced *Phragmites* will lead to inadvertent harm to native *Phragmites*, but the risks to native *Phragmites* of allowing the continued spread of introduced *Phragmites* shed doubt on this concern.

Impacts to wildlife

Impacts on animals are less clear than impacts on native plants, with effects varying by species and sometimes more strongly influenced by landscape scale conditions than by dominant plant species (Gucker 2009, Collaborative). Several studies demonstrate impacts on marsh fauna and food webs (Able & Hagan 2000, Able & Hagan 2003, Benoit & Askins 1999, Gratton & Denno 2006, Meyer et al 2010). Other studies show little difference in animal species diversity between monotype stands of introduced *Phragmites* and native plant communities, but in some of these same studies the species composition in introduced *Phragmites* stands has been shown to consist of fewer rare and specialist species and more generalist species (Gucker 2009, Collaborative, Robichauld and Rooney, 2016). One possible mechanism for this shift is that introduced *Phragmites* reduces overall structural diversity by replacing both wet meadow and cattail habitats with a single and novel habitat type (Robichauld and Rooney, 2016, Ailstock et al 2001, Weis and Weis, 2003, Hanson et al 2002). Among the rare and specialist species whose habitats are impacted by introduced *Phragmites* are the sandhill crane, least tern, piping plover, and least bittern, some of which are listed as threatened or endangered at the state or federal level (Larson et al 2011, Robichauld and Rooney 2016,). Hydrological alterations caused by monotypic stands of introduced *Phragmites* are associated with detrimental effects on fish and in general alter the ability of the marsh to support biodiversity (Meyerson et al 2009, Weinstein & Balletto 1999). Some studies that found little difference in introduced *Phragmites* stands were comparing with marshes dominated by another highly invasive species, *Typha angustifolia* (Gucker 2009).

Threats to infrastructure

Introduced *Phragmites* is a threat to highway infrastructure. Its relatively high tolerance for salinity and variable hydrology suit it to roadside ditch conditions. In this setting it can restrict visibility, which is a safety concern, and interfere with proper drainage, which both reduces safety and accelerates degradation of pavement and structures.

Control costs

The various ecological and infrastructure impacts described above are extensive but difficult to quantify. The cost of controlling introduced *Phragmites*, although undoubtedly a vast underestimate of impacts, represents a more accessible quantitative measure of its impacts. Regional control projects for which expenditures are readily available include efforts in the central Platte river valley of Nebraska, which has spent $4.5million over six years (Walters, unpublished data); and work in the great lakes totaling over $16million since 2010 (Braun, pers. comm.). An economic survey of management efforts by Martin and Blossey found that organizations across the U.S. spent over $4.6million per year from 2005-2009, but that few organizations had accomplished their management objectives (2013).

Benefits

Despite all of the negative impacts described above, there are possible benefits from introduced *Phragmites*. As an ecosystem engineer and a dominant climax community plant species, introduced *Phragmites* stands are likely to serve as carbon sinks and possibly as nitrogen sinks (Meyerson 2009). Also, its ability to increase elevation of marshes may be able to keep pace with climate-change-induced sea-level rise, thus providing significant ecosystem service of coastal protection (Meyerson et al 2009). This latter effect is not likely to offer much benefit in Minnesota.

Introduced *Phragmites* is also used in reed beds for wastewater treatment in many places, including at 17 municipal facilities in Minnesota (Bock, pers comm, Davis, pers comm), where it provides environmental benefits in the form of effective, low-input dewatering of biosolids (Davis, pers comm). These facilities have what seem to be ample protocols for containing the rhizomes, thus making vegetative spread a minor issue. However, containment methods seem to have overlooked the possibility of spread by seed or genetic outcrossing via pollen. There are no methods currently in place to prevent this, and several facilities exist in Minnesota and Wisconsin with nearby naturalized stands of introduced *Phragmites* (Wright County, Bock, pers comm, Falck 2015). It is possible that a mid-summer mowing of the reed beds could prevent the production of viable seed (Galatowitsch, pers comm) and this option is being explored in Wisconsin, but no easily accessible methods to accomplish it are known. The non-native strain has been the default for these systems because of its faster growth rates and greater resistance to aphids. Some have said that native *Phragmites* will not work in these systems (Bock, pers comm) but it is currently being used at one site in MN and Scott Davis, the foremost designer of these systems in North America, has conceded that native *Phragmites* will probably work nearly as well. Despite these benefits of introduced *Phragmites*, it would be nearly impossible to argue that they outweigh the impacts to native wetland plant communities and biodiversity.

Imminent threat to MN

Minnesota is a state that could be particularly vulnerable to ecological impacts of introduced *Phragmites* because of its high number of lakes and wetlands, substantial population of native *Phragmites*, and reliance on fishing and other lake-related recreation industries. While introduced *Phragmites* has become very abundant and impactful in many regions, it is still relatively uncommon in Minnesota. This suggests that there is still an opportunity to prevent widespread ecological impacts in this state.

Distribution

Despite being relatively uncommon in Minnesota, there are numerous small but widely scattered infestations of introduced *Phragmites* (see attached maps from Falck & Olson 2015, Melchior & Weaver 2016). Many of these infestations have been confirmed to be introduced *Phragmites* by genetic testing (Melchior & Weaver 2016). Numerous other infestations have been confirmed based on expert assessment of morphological characteristics that have been suggested as reliable indicators by Saltonstall and confirmed in Minnesota to correlate with genetic markers (Melchior & Weaver 2016). Introduced *Phragmites* is known to spread along road ditches (Brisson et al 2010) and subsequently invade adjacent wetlands and streams. The survey by Melchior & Weaver found that most introduced

Phragmites infestations are currently located in roadsides and have not yet reached the Mississippi or Minnesota Rivers but are very close in some cases (2016). Invasion of a major river has already occurred in the St. Louis Estuary (Falck 2015). There are also up to 17 introduced *Phragmites* stands at wastewater treatment facilities scattered around the state (Bock, pers com). This current distribution in Minnesota pre-positions it for rapid expansion in the state.

Spread

The rapid expansion of introduced *Phragmites* in Minnesota could be imminent. Vegetative reproduction is clearly an important means of spread but vegetative spread alone is relatively slow without human intervention and reduces possibilities for genetic variability(Albert et al 2015, Gucker 2009). Sexual reproduction would allow more rapid spread and increased genetic variability, both of which can accelerate invasion. While sexual reproduction has been assumed to be limited in cold climates, with growing seasons being too short for seed maturation and many winters being too cold for seedling survival (Galatowitsch, pers comm), increasing evidence shows that sexual reproduction is possible and happening in cold climates such as Quebec (Albert et al 2012, Albert et al 2015) and Minnesota (Galatowitsch, pers comm., Melchior & Weaver 2016). Sexual reproduction is likely still limited in the state by short growing seasons and cold winters but climate data show that winters are becoming progressively milder and growing seasons longer (EPA 2016, Zandlo 2008). Data suggests that it is only a matter of time before Minnesota experiences a series of longer growing seasons and milder winters that, when coupled with the scattered distribution of introduced *Phragmites*, can lead to explosive spread. Once that happens it is likely that any possibility of containing the invasion of introduced *Phragmites* will have been lost.

Control is possible

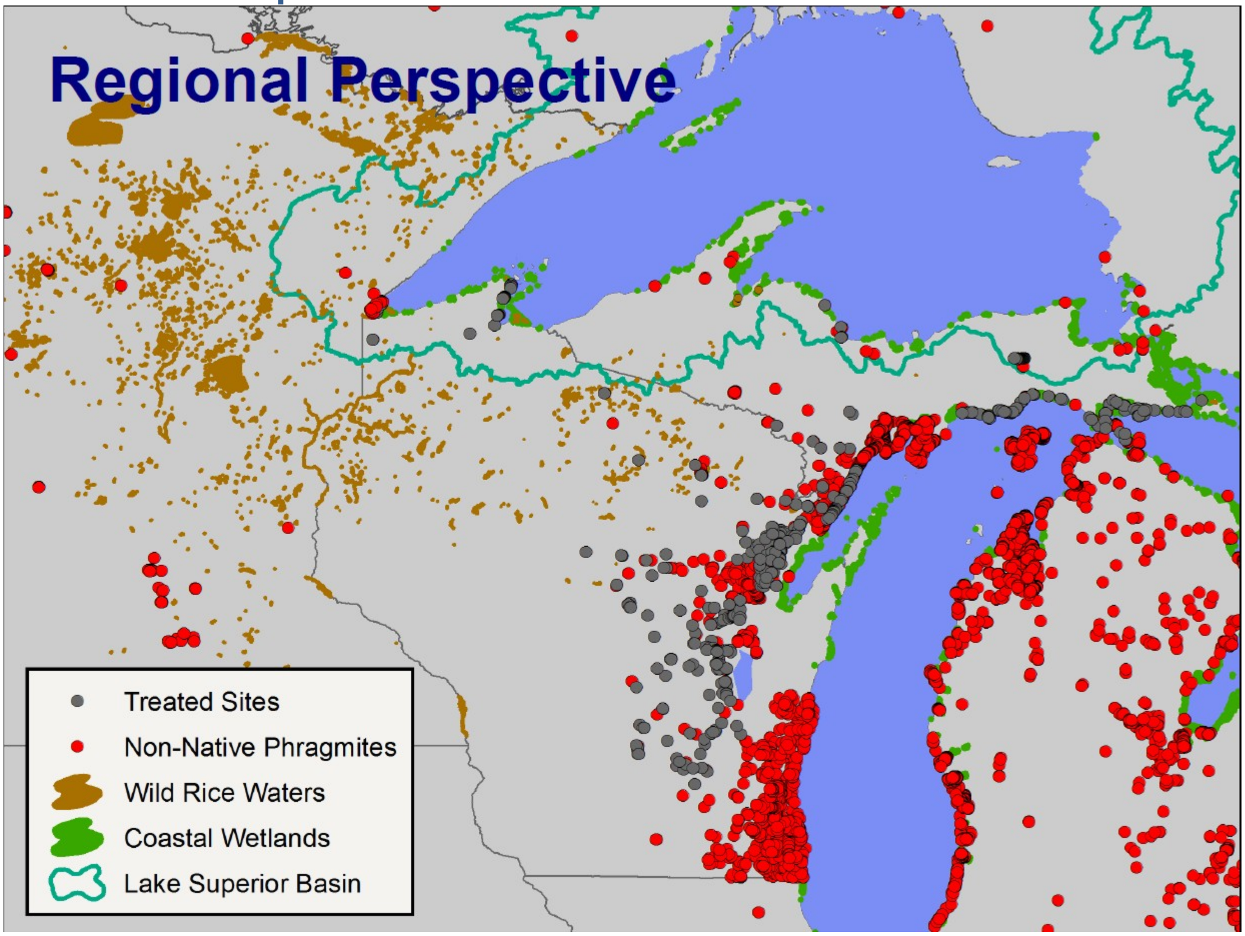
Control of introduced *Phragmites* infestations is possible. A common concern relating to control of introduced *Phragmites* is that an inability to distinguish it from native *Phragmites* can jeopardize the native subspecies. However, comparison of morphological characteristics with genetic markers by Swearingen and Saltonstall (2010) have revealed several useful field indicators. Although Swearingen and Saltonstall warn that field identification using morphological characteristics without genetic testing may not be 100% reliable, the correlation is strong and Minnesota stands of *Phragmites* have shown 100% correlation between morphological characters and genetic markers (Melchior & Weaver 2016). Also, states like NE have listed it as a noxious weed and have been relatively successful through University of NE Extension in providing enforcement agents in local governments with education on discerning between the native and non-native.

Control efforts in other states have shown success with various combinations of treatments such as herbicide, mowing, burning, and restoration (Gucker 2009, Collaborative). Coordinated efforts in Nebraska have reduced infestations and improved flow conveyance in the Platte River (Walters, unpublished data). Restoration of ecosystem function and biodiversity are also possible upon control (Gratton & Denno 2006, Walters, unpublished data, Ailstock et al 2001). However, other studies have questioned the long-term and landscape scale effectiveness of control, and more research is likely needed into the long-term impacts of control and the integration of restoration activities with control treatments (Hazelton et al 2014, Martin & Blossey 2013). Biological control has been investigated (Tewskbury et al 2002) but may not be an option as due to concerns about threats to native *Phragmites* (Cronin et al 2016). There is also some question as to population-level effectiveness/impact of potential biocontrol agents (Larkin, personal communication).

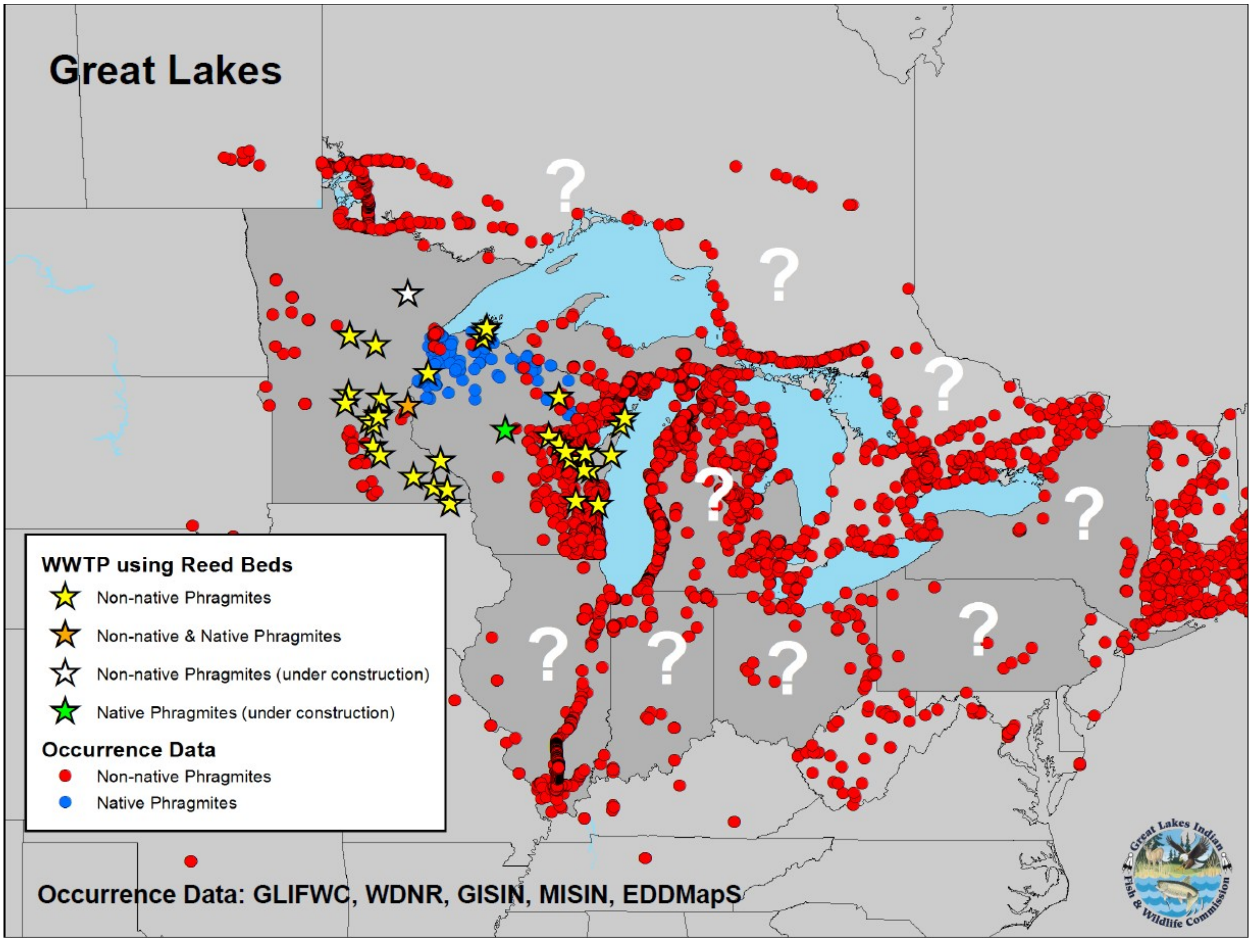
Recommendation

Introduced *Phragmites* has been shown to cause major ecological disruption in other states. This species poses a major threat to Minnesota because of the large number of vulnerable ecosystems and current scattered distribution of infestations in the state. With the risk of rapid expansion increased by continuing climate change, the window of opportunity for containing introduced *Phragmites* and preventing widespread impacts in Minnesota may be closing. Infestations are too numerous for statewide eradication, but prudence dictates that a concerted effort be made to contain this species and eliminate infestations wherever possible. Listing this species as a noxious weed in the “Prohibited: Control” category would be the regulatory approach most likely to facilitate motivate widespread control and containment. Exactly how such a regulation would be applied to the use of introduced *Phragmites* in reed beds needs further discussion, but phase-outs and methods to prevent flowering in existing stands should be considered. Such methods are being implemented or discussed in other states.

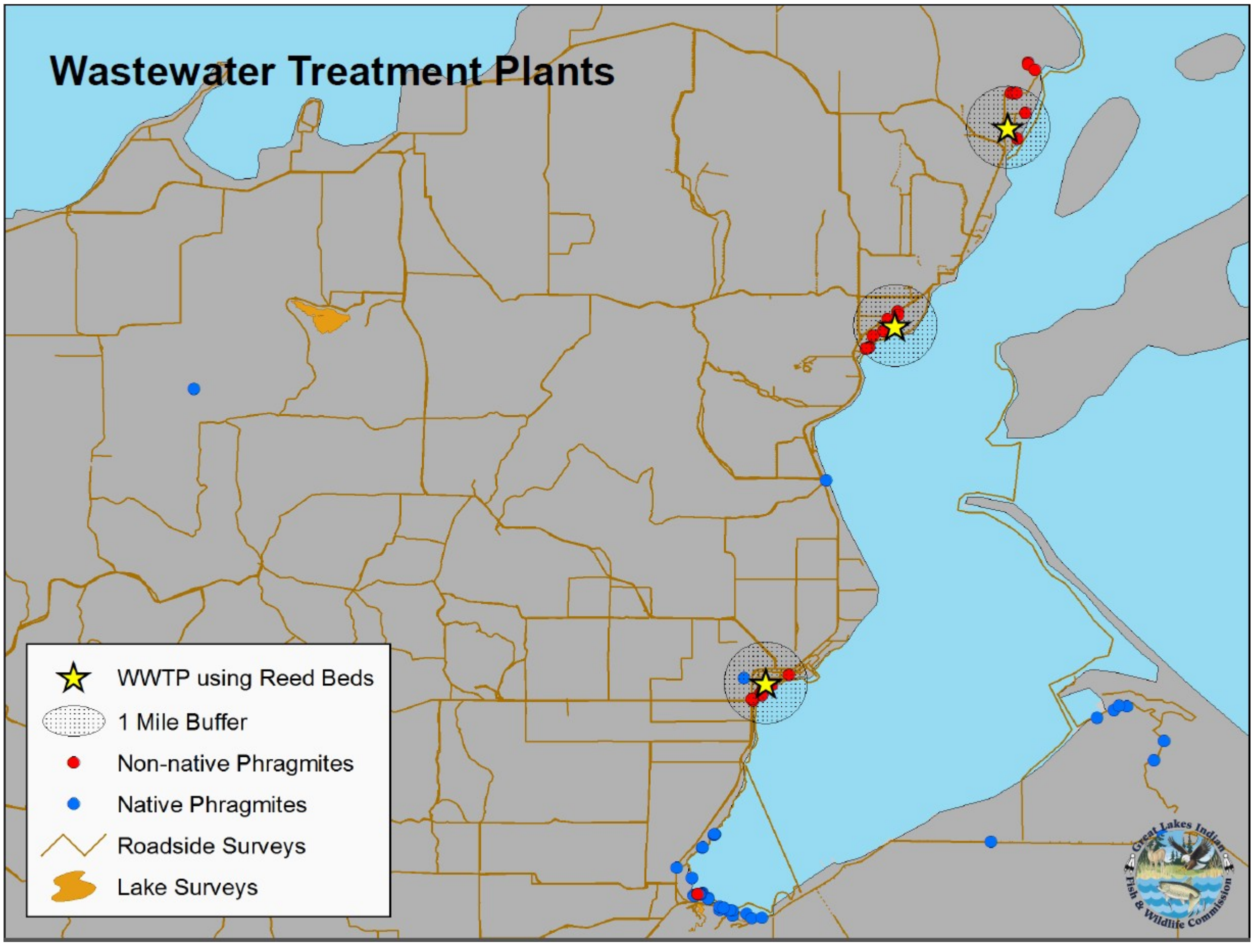
Distribution Maps



Mapped infestations of *P. australis subsp. australis* in the western great lakes region. This map is included to highlight the difference in invasion intensity between Minnesota and other nearby states. Data points are from EDDMapS and Great Lakes Indian Fish and Wildlife Commission. (Falck & Olson 2015)



Relative degree of invasion between Minnesota and other Great Lakes States. Also included are locations of wastewater treatment plant reed beds using *P. australis subsp. australis*. (Falck 2015)



Wastewater treatment plants using *P. australis subsp. Australis* along the Chequamegon Bay of Lake Superior, showing locations of alleged escapes. (Falck 2015).

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