Invasive Species Program 2018

by

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EXECUTIVE SUMMARY

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is an agency exercising delegated authority from 11 federally recognized Ojibwe tribes in Minnesota, Wisconsin, and Michigan (Figure 1). These tribes retain hunting, fishing, and gathering rights in the territories ceded to the United States through various treaties. The degradation of native ecosystems by invasive species poses a serious threat to the continued exercise of these rights and the traditional lifeways they sustain.

This report summarizes the activities undertaken by GLIFWC staff during 2018 to address the spread of invasive species in the Ceded Territories. GLIFWC's invasive species program consists of 1) prevention, 2) early detection rapid response, 3) control and management, 4) research, and 5) coordination of these activities with cooperating tribes, government agencies and groups to maximize the efficient use of limited resources.

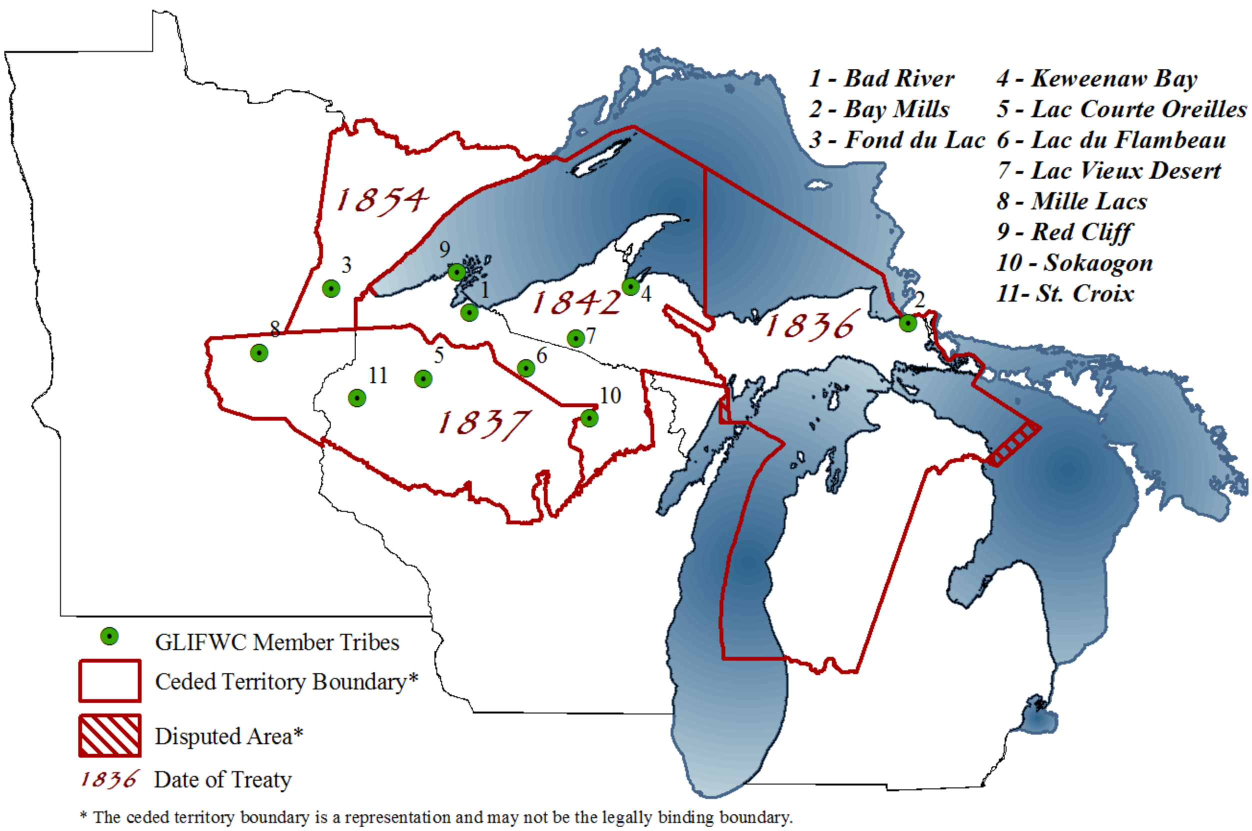

Figure 1. Location of GLIFWC member tribes and Ceded Territories.

ACKNOWLEDGMENTS

The Great Lakes Indian Fish and Wildlife Commission acknowledges the following for their financial support of GLIFWC's invasive species program. The BIA continues to provide the foundation for developing new partnerships and leveraging additional resources for invasive species management (Figure 2). The activities summarized in this report were funded by:

- Bureau of Indian Affairs (BIA)
  - GLIFWC's base funding
  - Noxious Weed Program
  - Invasive Species Program
  - Great Lakes Restoration Initiative (GLRI) Invasive Spp.

- U.S. Environmental Protection Agency (EPA)
  - GLRI Coastal Wetlands Planning, Protection and Restoration

- U.S. Fish and Wildlife Service (USFWS)
  - Great Lakes Restoration Initiative (GLRI) Tribal AIS
  - Wisconsin State ANS Plan

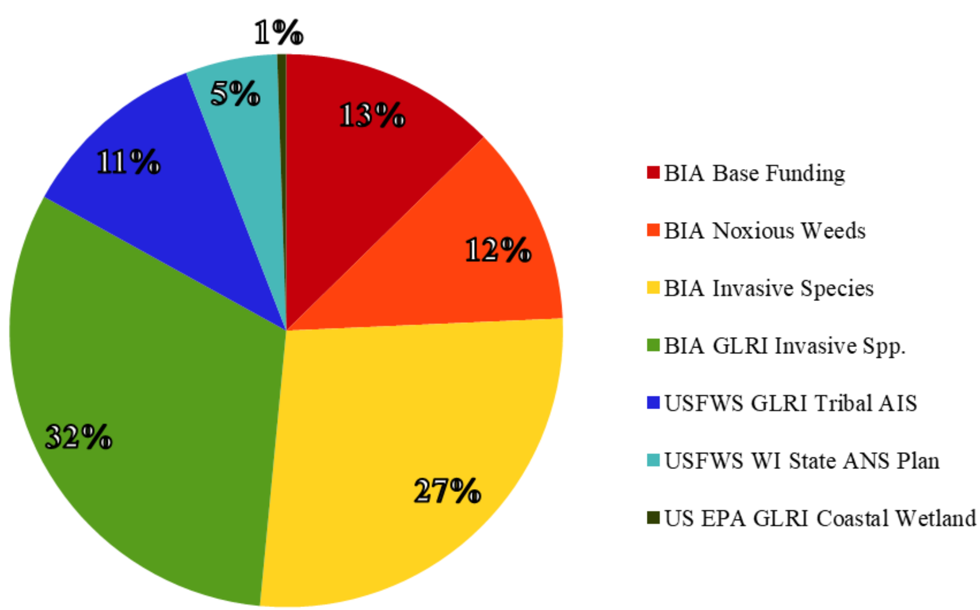

Figure 2: Funding sources for GLIFWC's Invasive Species Program in 2018.

PREVENTION

Introduction

The most effective approach to combat the spread of invasive species is to prevent their initial establishment. Because the vast majority of invasive species introductions can be attributed to human activities, effective prevention efforts depend on an informed public. A variety of education, outreach, and training materials are needed to alert a diverse public to the threats posed by invasive species and the actions required to prevent their spread.

Program Overview

A suite of educational materials have been compiled and/or developed to reach a broad range of audiences. These materials include ID cards, brochures, stickers, presentations, and videos. GLIFWC distributes educational material with the help of cooperating state and federal agencies throughout the Ceded Territories. Additional outreach is provided via GLIFWC's invasive species web site and quarterly newsletter - *Mazina'igan*.

Accomplishments

Mazina'igan Articles
GLIFWC's newsletter (circulation = 18,500) features articles on invasive species. Topics covered in 2018 included:

- News Brief: "European shrimp is latest invasive species found in Gichigami" by GLIFWC staff. Spring 2018. http://www.glifwc.org/Mazinaigan/Spring2018/inc/pdf/flipbook.pdf.
- "Shockingly high levels of mercury found in Lake Superior lamprey" by Sara Moses. Spring 2018. http://www.glifwc.org/Mazinaigan/Spring2018/inc/pdf/flipbook.pdf.
- News Brief: "Forest pests continue to challenge natural resource managers" by Steven Garske. Summer 2018. http://www.glifwc.org/Mazinaigan/Summer2018/index.html?page=2 .
- "Red Cliff spearheads non-native phragmites removal" by Todd Norwood for Mazina'igan. Summer 2018. http://www.glifwc.org/Mazinaigan/Summer2018/index.html?page=8 .
- "New aquatic invasive species discovery underscores ballast water issues" by Ben Michaels. Summer 2018. http://www.glifwc.org/Mazinaigan/Summer2018/index.html?page=8 .
- "Sea lampreys pose challenges to healthy Gichigami fishery" by GLIFWC staff. Summer 2018. http://www.glifwc.org/Mazinaigan/Summer2018/index.html?page=14 .
- "Big changes to emerald ash borer regulation take hold in 2018" by Steven Garske.

Summer 2018. http://www.glifwc.org/Mazinaigan/Summer2018/index.html?page=20 .
- "High lamprey numbers challenge fishery, resource managers" by Bill Mattes. Fall 2018. http://www.glifwc.org/Mazinaigan/Fall2018/index.html?page=14 .
- "Red Cliff, partners remove non-native phragmites beds from Chequamegon Bay region" by Gabrielle VanBergen for Mazina'igan. Winter 2018-2019. http://www.glifwc.org/Mazinaigan/Winter2018/index.html?page=6 .

Events, Presentations and Other Outreach Activities
Activities in 2018 included:

- Pocket size cards were distributed with permits during spring spearing and netting season to educate tribal harvesters on steps to prevent the spread of AIS, including how to clean equipment and specific tribal AIS regulations (Spring 2018).
- Fish measuring stickers with AIS prevention and tribal regulation information were distributed at tribal registration stations and GLIFWC events.
- Handed out 94 AIS prevention bobbers at 3 events held by three member tribes.
- Updated Boat Disinfection Protocol and spiny water flea lake list and map for tribal wardens and harvesters.
- GLIFWC's portable boat washer was used during tribal spring spearing and netting season:
  - Used by at least 41 tribal harvesters, who washed a total of 21 boats to remove potential AIS.
  - Stationed at landings of 2 tribal-harvested waters with high priority AIS, particularly spiny water fleas (May 2018).
  - Having a boat washer available provided educational as well as preventive value.
- Assisted with invasive species education and garlic mustard (*Alliaria petiolata*) hand pulling event with Bad River Youth and Northland College students (14) along the Bad River in Mellen, WI (May 17, 2018).
- GLIFWC's invasive species website features species abstracts for many of the regions' invasive plants, photos that can be downloaded for educational purposes, GLIFWC reports, and links to interactive maps and other internet resources on invasive species.

EARLY DETECTION RAPID RESPONSE (EDRR)

Eradicating or containing invasive species is more feasible and cost effective when populations are at an early stage of infestation. GLIFWC staff have conducted annual invasive species surveys since 1995 and have documented over 10,000 occurrences for several hundred species of invasive organisms throughout the Ceded Territories. This information provides a baseline to determine if newly detected occurrences are nascent populations, and whether rapid response efforts are warranted. Early detections by GLIFWC staff have led to successful rapid response control efforts for curly-leaf pondweed (*Potamogeton crispus*), Eurasian water-milfoil (*Myriophyllum spicatum*), garlic mustard (*Alliaria petiolata*), knotweed (*Fallopia* spp.), non-native phragmites (*Phragmites australis* subsp. *australis)*, purple loosestrife (*Lythrum salicaria*), teasel (*Dipsacus* spp.), and yellow iris (*Iris pseudacorus*), with Dalmatian toadflax (*Linaria dalmatica*) added for 2018.

Throughout this report, “population” refers to a biological population of living beings or species, whereas “site” has been used to designate the location of a more or less discrete patch or colony of that species (usually designated by a GPS point or coordinate). Unless otherwise noted, plant scientific nomenclature follows Voss and Reznicek (2019).

AQUATIC AND WETLAND INVASIVE SPECIES

Introduction

Since the early 1800s, at least 190 species of fish, plants, invertebrates, algae and pathogens have been introduced from other continents and become established in the riparian and aquatic habitats of the Great Lakes basin (GLANSIS 2018). Several dozen additional species native to North America but not the Great Lakes basin have been introduced to the basin as well. Many of these organisms have subsequently invaded inland lakes and rivers in the Ceded Territory, and others are poised to do so. The most destructive of these invasives have caused major environmental and economic impacts (Pimentel et al. 2005).

GLIFWC staff continued to survey selected Ceded Territory waters in 2018, to 1) assess and document the scope of the problem, 2) detect small populations of the most ecologically disruptive invasive species before they become large, environmentally damaging populations, and 3) prioritize education and management efforts.

Methods

GLIFWC staff surveyed 18 lakes for multiple aquatic invasive species (AIS) in northern Wisconsin and Michigan in 2018 (Figure 3, Table 1). Seventeen lakes were surveyed for a suite of invasive plants and animals. Lac Vieux Desert was visited twice – in June, to delineate Eurasian water-milfoil, and in August, to delineate *manoomin* (wild rice) beds. Lakes surveyed for AIS were chosen in coordination with tribal, state, county and other local management partners. Surveys mostly targeted lakes important for tribal *ogaa* (walleye) and *manoomin* harvest. Most lakes chosen had high visitation rates or were in close proximity to infested waters.

For the 17 comprehensively surveyed lakes, qualitative surveys for invasive species were conducted by observing the littoral zone from the water's surface. The boat was driven roughly parallel to shore, in a meandering pattern between shallow water and the outer edge of the littoral zone. Surveys focused on submergent, emergent and shoreline plants. These areas were also inspected for invasive animals or evidence of their presence. Surveys attempted to cover as much of the shoreline (including island shorelines) as possible, with shorelines of all of these lakes completely surveyed.

All public and some private boat landings were surveyed. Shorelines, shallow water areas, pier supports, floating fragments, rocks and beach debris in the vicinity of the landings were inspected for invasive plants and animals. Rake tosses and D-net pulls were conducted at the main boat landing for five minutes. The material retrieved by each rake throw was placed in a bin and inspected for invasive plants and animals. For two lakes that had multiple boat landings (Beaver Dam with five, and Otter Lake with four), rake throws were only done on one and three landings, respectively. Rake throws were also not done at the one Duroy Lake landing.

Ecologically disruptive aquatic invasive species with limited abundance and distribution in the Ceded Territories were classified as "priority species" (Table 2). Aquatic invasive species that could not be easily quantified such as invertebrates or crustaceans, species that were abundant and widespread within the waterbody, and terrestrial invasive plants were classified as "present" and only their initial occurrence within a waterbody was documented.

If a "priority" invasive plant species was found on a lake where it was previously undocumented, a specimen was generally collected, along with notes on location and habitat. Michigan collections were sent to the University of Michigan Herbarium (MICH) in Ann Arbor, Michigan, while Wisconsin collections were sent to the Wisconsin State Herbarium (WIS) at UW Madison, with any duplicates mounted and accessioned into the GLIFWC herbarium cabinet. Because of the difficulty in identifying them accurately in the field, non-native cattails (*Typha angustifolia* and *T.* x *glauca*) were also collected, for careful inspection at a later date. *Manoomin* or wild rice (*Zizania palustris*) and native phragmites (*Phragmites australis* subsp. *americanus*) populations

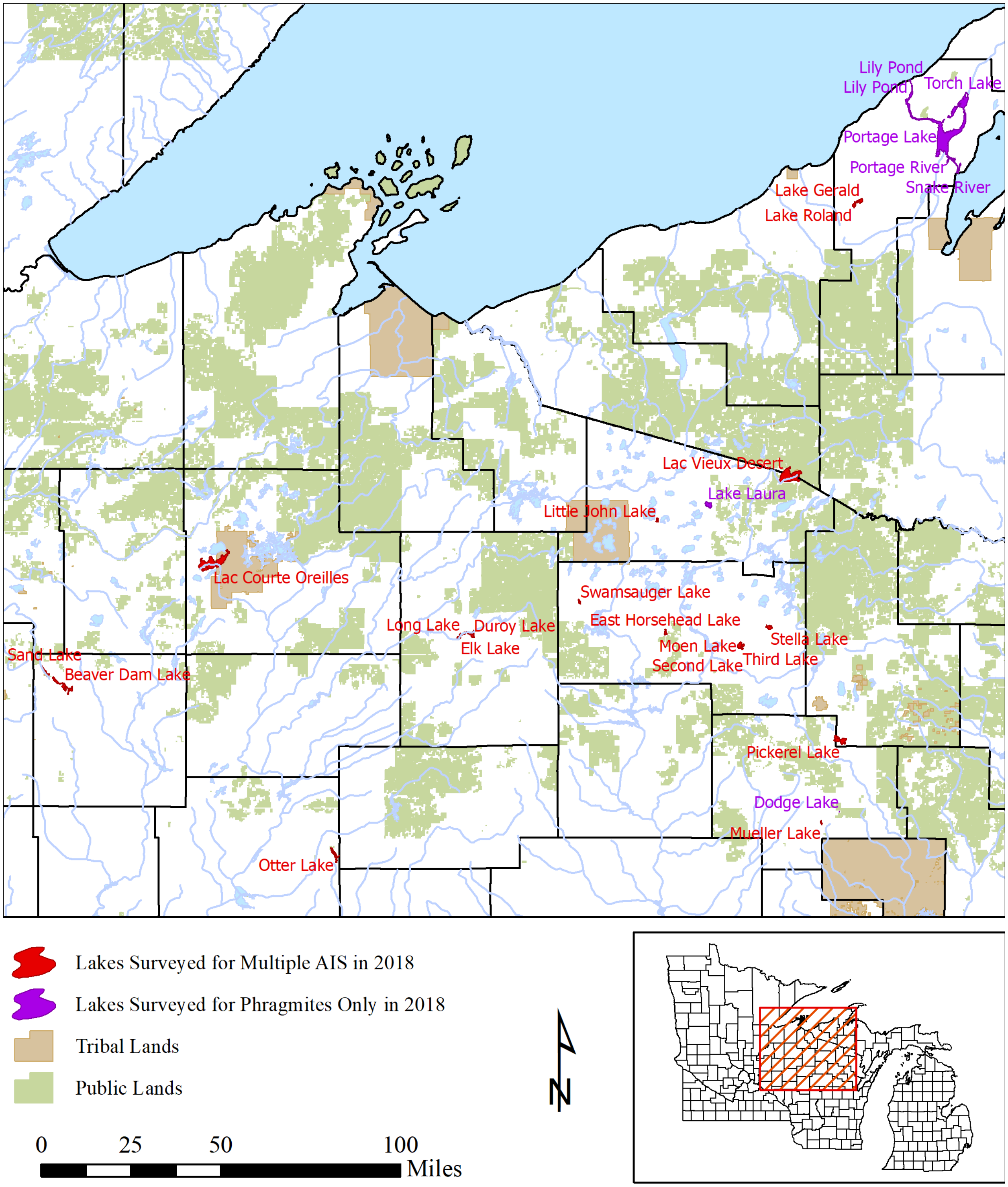

Figure 3: Lakes surveyed for aquatic invasive species in 2018.

Table 1. Lakes surveyed for aquatic invasive species in 2018. Trophic status of lakes located partly or entirely within Wisconsin was obtained from WI DNR 2019. Trophic status of Michigan lakes was based on our observations. Conductivity was measured at a depth of 1 meter, at approximately the deepest point in each lake.

State	Waterbody	WBIC	Watershed	Acres	Date(s)	Survey Type	Trophic Status	Cond. (µS/cm)	# Vel Samples	# Wflea SampleM Is
MI, WI	Lac Vieux Desert	1631900	Mississippi	4403	June 18-21	EWM	Mesotrophic	---		
MI	Lake Roland	31-915	Lake Superior	258	August 6-7	All AIS taxa	Oligotrophic	39.9	0	1
MI	Lake Gerald	31-909	Lake Superior	356	August 6-7	All AIS taxa	Oligotrophic	51.4	0	1
WI	Sand Lake	2661100	Mississippi River	318	June 25	All AIS taxa	Mesotrophic	200.2	3	1
WI	Otter Lake	2157000	Mississippi River	602	June 26	All AIS taxa	Eutrophic	100.7	3	1
WI	Beaver Dam Lake	2081200	Mississippi River	1163	June 27	All AIS taxa	Mesotrophic	174.1	3	1
WI	Lac Courte Oreilles Lake	2390800	Mississippi River	5140	June 28	EWM	Oligotrophic	---	0	0
WI	Elk Lake	2240000	Mississippi River	87	July 2-3	All AIS taxa	Eutrophic	63.7	0	0
WI	Long Lake	2239300	Mississippi River	419	July 2-3	All AIS taxa	Eutrophic	52.4	0	1
WI	Duroy Lake	2240100	Mississippi River	350	July 3	All AIS taxa	Eutrophic	68.5	0	0
WI	Swamsauger Lake	1528700	Mississippi River	136	July 5	All AIS taxa	Eutrophic	42.1	0	1
WI	Little John Lake	2332300	Mississippi River	151	July 9	All AIS taxa	Eutrophic	111.8	1	1
WI	Moen Lake	1573800	Mississippi River	461	July 10	All AIS taxa	Eutrophic	61.2	0	1
WI	Second Lake	1572300	Mississippi River	103	July 10	All AIS taxa	Eutrophic	---	0	0
WI	Third Lake	1572200	Mississippi River	97	July 10	All AIS taxa	Eutrophic	---	0	0
WI	N Branch Pelican River	1570100	Mississippi River	---	July 10	All AIS taxa	---	---	0	0
WI	East Horsehead Lake	1523000	Mississippi River	191	July 11	All AIS taxa	Mesotrophic	94.4	0	1
WI	Pickerel Lake	388100	Lake Michigan	1272	July 16-17	All AIS taxa	Mesotrophic	155.1	1	1
WI	Mueller Lake	194000	Mississippi River	79	July 18	All AIS taxa	Mesotrophic	337.8	1	1
WI	Stella Lake	1575700	Mississippi River	415	August 27	All AIS taxa	Mesotrophic	53.1	0	1

Table 2: "Priority" species for the 2018 aquatic and shoreline invasive species surveys.

Scientific Name	Common Name	Scientific Name	Common Name
Invertebrates			
Bithynia tentaculata	Faucet snail	*Dreissena bugensis*	Quagga mussel
Bythotrephes longimanus	Spiny water flea	*Dreissena polymorpha*	Zebra mussel
Cercopagis pengoi	Fishhook water flea	*Potamopyrgus antipodarum*	New Zealand mudsnail
Corbicula fluminea	Asian clam	*Procambarus clarkii*	Red swamp crayfish
Plants			
Butomus umbellatus	Flowering rush	*Microstegium vimineum*	Japanese stilt grass
Cabomba caroliniana	Fanwort	*Myriophyllum aquaticum*	Parrot feather
Callitriche stagnalis	Pond water-starwort	*Myriophyllum spicatum*	Eurasian water-milfoil
Crassula helmsii	Australian swamp stonecrop	*Najas minor*	Slender-leaved naiad
Egeria densa	Brazillian waterweed	*Nymphoides pelata*	Yellow floating heart
Eichhornia crassipes	Water hyacinth	*Phragmites australis* subsp. *australis*	Non-native phragmites
Glyceria maxima	Tall manna grass	*Pistia stratiotes*	Water lettuce
Heracleum mantegazzianum	Giant hogweed	*Fallopia japonica*	Japanese knotweed
Humulus japonicus	Japanese hop	*Fallopia sachalinensis*	Giant knotweed
Hydrilla verticillata	Hydrilla	*Fallopia* x *bohemica*	Bohemian knotweed
Hydrocharis morsus-ranae	European frog-bit	*Potamogeton crispus*	Curly pondweed
Lysimachia nummularia	Moneywort	*Trapa natans*	Water chestnut

were also documented. Location and other data for native phragmites populations were added to GLIFWC's database and shared with management partners.

Locations were mapped with mobile data collection. KoBo Toolbox, a free open-source data collection tool, was used to create custom data entry forms. Attribute data for each site was recorded using a mobile phone with sliding screens, drop-down menus and built-in constraints in a GIS file-capable format. Data was automatically synced, or uploaded from the mobile phone once network service or a wireless network became available.

Plankton nets (50-cm diameter, 64-micron mesh) were used to sample for zebra and quagga mussel veligers. Vertical plankton tows were used to sample for veligers, following Wisconsin

Department of Natural Resources (WI DNR) protocol (WI DNR 2010). With several exceptions, veliger tows were only conducted on lakes that had high enough dissolved calcium levels (based on specific conductance readings) to sustain a zebra or quagga mussel population (see Papeş et al. 2011). Specific conductance was measured in the deepest basin of each lake at a depth of one meter, using a YSI Model 30 meter to determine the current suitability of each lake. Lakes with a specific conductance reading of equal to or greater than 99 µS/cm were considered suitable and were sampled.

On small or shallow lakes, only one veliger sample was collected. Three veliger samples were collected from each of three larger lakes. The first sample was collected at the deepest point in the lake, with additional samples (if any) collected in other areas of the lake, usually offshore from boat landings. Immediately after collection, samples were condensed, transferred to sample bottles, and labeled and preserved with 190 proof ethyl alcohol, at a ratio of four parts alcohol to one part plankton sample.

An Ekman dredge was used to sample for spiny and fishhook water fleas, following the protocol of Walsh and Vander Zanden (2016). Sediment samples were collected at the deepest location of each lake. At the sampling point, the dredge was lowered to within one meter of the lake bottom. It was then dropped the remaining distance and the "messenger" (a cylindrical metal weight) was sent down the rope to set the dredge. The sample was then condensed, transferred to a plastic bag, labeled and kept cool until it could be frozen.

Veliger samples were sent to the WI DNR Science Operations Center in Madison, Wisconsin for analysis. Water flea samples were examined by GLIFWC staff, by analyzing them under a dissecting microscope to look for spine fragments that would indicate the presence of water fleas.

After finishing each lake, the boat, trailer and equipment were thoroughly disinfected. Plant fragments and other debris were removed by hand or with a brush at the landing, and the drain plug was removed in an area where the water would not run into the lake. A washing location was chosen to ensure that the disinfection solution and rinse water would not run into storm water drains or other areas that might contaminate surface waters. The boat, trailer and all equipment that came into contact with the water (including plankton nets and cups, Ekman dredge, collection nets, ropes, weights, anchor and paddles) were sprayed with a 500 ppm bleach solution. After the appropriate contact time (10 minutes), the boat, trailer and all equipment were rinsed thoroughly. The boat motor was flushed with tap water by using a flushing attachment (flush muffs) for at least two minutes. Veliger sampling equipment was disinfected with the bleach solution, then rinsed and soaked in vinegar for 20 minutes. The vinegar was used to dissolve any veliger remains, ensuring there would be no false positives in subsequent samples. Lakes with known infestations of easily spread invasives were surveyed at the end of each week, to minimize the risk of spreading them to the next waterbody.

Results

A total of 29 new aquatic and wetland invasive species occurrences comprising 7 taxa were found in 2018 (Table 3). Previously unrecorded populations of *Iris pseudacorus* were found on 4 lakes. New water forget-me-not populations were found on 8 lakes, new narrow-leaved and hybrid cattail populations were found on 4 and 3 lakes, respectively, and Eurasian marsh thistle was recorded on 5 new waterbodies. A new Chinese mysterysnail (*Cipangopaludina chinense*) population was recorded from Otter lake.

New purple loosestrife populations were recorded on 3 lakes. Populations on two of the lakes were small: Two flowering plants were found at two locations near each other on the developed northeast shore of Pickerel Lake, and a single flowering plant was found next to the public boat landing at Stella Lake. The Stella Lake plant was treated with Rodeo.

During the 2017 GLIFWC survey of Lac Courte Oreilles Lake, a fragment of Eurasian water-milfoil (EWM) was recorded near the boat landing on the west side of Anchor Bay. This represented the first record of this plant for the lake. In 2018 the lake was revisited, and 20 rooted populations were mapped northeast of the landing in Anchor Bay.

A total of 199 EWM locations were mapped during the spring survey of Lac Vieux Desert.

Twelve veliger and 13 water flea plankton samples were collected during 2018. Except for Lac Courte Oreilles lake, which was sampled for both invasives in 2017, lakes not surveyed for waterfleas were connected to lakes that were sampled. No zebra or quagga mussel veligers, or spiny or fishhook water fleas were detected in any of the samples.

Small populations of *manoomin* were found in four survey lakes. Two of these lakes (Moen and Third) had had anecdotal reports of *manoomin* (Peter David, pers. comm. by email, January 14, 2019). Another lake (Beaver Dam Lake) is on the WI DNR date-regulated waters list, but GLIFWC has never received any previous reports of *manoomin* occurrence or harvest there. One lake supported a large population of *manoomin* that was previously not known to GLIFWC staff.

Plant collections for 2018 included two specimens of EWM from Lac Courte Oreilles Lake, to further document the presence of this species there. One specimen was sent to WIS, and the other preserved in the GLIFWC herbarium. A specimen of the non-native peach-leaved willow (*Salix pentandra*) from a bank above Long Lake was sent to WIS. Specimens of non-native phragmites from Mueller Lake and Lake Laura (this time in flower) were sent to WIS, with a duplicate kept in the GLIFWC herbarium.

Specimens of water arum (*Peltandra virginica*) from the Sturgeon River slough in Houghton County were sent to MICH, with a duplicate kept in the GLIFWC herbarium. This species is native to the eastern and east central US, west to Lower Michigan, Illinois and Texas. Its range appears to be expanding though, with the help of waterfowl and/or humans (Thompson 2003).

Discussion

Early detection of invasive species before they become large, environmentally damaging populations makes eradication more likely and reduces the amount of effort required for effective control. A follow-up survey should probably be done for *Salix pentandra*, and control efforts initiated, particularly if the population is still small.

In May of 2018 Wisconsin Lake & Pond Resource LLC (WLPR) began mapping Eurasian water milfoil in Lac Courte Oreilles Lake (Scharl 2018). The largest EWM bed was treated with 2,4-D later that year. Scharl (2018) subsequently recommended treatment with ProcellaCOR (active ingredient florpyrauxifen-benzyl) instead of 2,4-D, due to difficulties maintaining adequate contact time with the relatively small patches of EWM in the open lake. Curly-leaf pondweed has been actively managed in LCO since 2009 (Scharl 2018).

Data for the non-native phragmites sites and control efforts will be shared with the WI DNR, along with the other newly discovered populations of this plant (see below). Follow up treatment will presumably continue in 2019.

Table 3: Aquatic and wetland invasive species found during GLIFWC 2018 survey lakes. Lac Vieux Desert was surveyed for curly-leaf pondweed and Eurasian water-milfoil only. Lac Courte Oreilles Lake was surveyed for Eurasian water-milfoil only.

PHRAGMITES

LOCATION			PLANTS										MOLLUSKS			CRUSTACEANS		OTHER	
STATE	COUNTY	LAKE	Curly-leaf pondweed	Eurasian marsh thistle	Yellow iris	Purple loosestrife	Water forget-me-not	Eurasian water-milfoil	Hybrid water-milfoil	Narrow-leaf cattail	Hybrid cattail	Non-native phragmites	Zebra mussel	Chinese mystery snail	Banded mystery snail	Spiny waterflea	Rusty crayfish	Fresh water jellyfish	Heterosporis sutherlandae
MI, WI	Gogebic/Vilas	Lac Vieux Desert	X					X						X	X		X	X	X_{GLFC}
WI	Barron	Sand Lake				X		X, G						X, G			X		
WI	Barron	Beaver Dam Lake	X, G		G	X, G	G	X		X, G	X, G			X, G			X		
WI	Chippewa	Otter Lake	X				G			G	G			X, G	X				
MI	Houghton	Lake Roland				G	G												
MI	Houghton	Lake Gerald									G								
WI	Langlade	Mueller Lake	X		G					G	G	X, G		X, G	X, G				
WI	Langlade	Pickerel Lake		G		G		X, G	X					X, G	X, G		X		
WI	Oneida	East Horsehead Lake					G				G			X, G					
WI	Oneida	Moen Lake		G						G				X, G	X*		X		
WI	Oneida	N Branch Pelican River		G										X					
WI	Oneida	Second Lake		G			G										X*		
WI	Oneida	Stella Lake			G	G				G				X, G					
WI	Oneida	Swamsauger Lake												X, G					
WI	Oneida	Third Lake												X			X*		
WI	Price	Elk Lake						X							X		X		
WI	Price	Long Lake		G	G		G	X, G											
WI	Price	Duroy Lake	X, G				G	X, G									X		
WI	Sawyer	Lac Courte Oreilles Lake	X				X*^	X^, G						X	X*^		X		
WI	Vilas	Little John Lake					G			X, G	G			X, G	X, G		X, G		

X = Previously verified by WI DNR or others (WI DNR 2019). X^ = Found during 2017 GLIFWC AIS survey. G = observed during 2018 GLIFWC AIS survey.
X* = Previously reported but not verified (WI DNR 2019). X*^ = Verified during 2017 GLIFWC AIS survey. X_{GLFC} = Great Lakes Fisheries Commission fact sheet (GLFC 2017).

Introduction

Phragmites australis is a clonal wetland grass found in marsh ecosystems worldwide. Native (subsp. *americanus*) and non-native (subsp. *australis*) phragmites are both widely distributed in North America. A third subspecies of uncertain origin (subsp. *berlandieri* Saltonstall & Hauber) occurs along the Gulf Coast of the southeastern US and eastern Mexico (Swearingen and Saltonstall 2010).

Local spread of phragmites is primarily vegetative, by underground rhizomes and overland runners. The runners can grow up to 16 feet per year. Long distance dispersal occurs primarily via floating root fragments, and seeds carried by wind or water. Even dislodged shoot sections can re-root from the nodes and grow.

Non-native phragmites is extremely invasive, growing in moist habitats, even colonizing floating vegetation mats in deeper water. It is more tolerant of flooding and salt water than the native subspecies (Meyerson et al. 2009). It can grow to 20 feet tall, and reach densities of over 160 stems per square yard. It can quickly establish dense clonal stands that almost completely exclude all other wetland plants. Large stands of phragmites alter hydrology by increasing evaporation from wetlands and trapping sediments. They can also potentially increase fire frequency and intensity by producing large amounts of durable, flammable stalks which remain standing through the winter, eventually ending up as a thick carpet of thatch.

Until fairly recently it was thought that phragmites spread primarily by floating rhizomes, and that the seeds had low viability. However, recent studies suggest that seed viability and production is directly related to soil nutrients (Saltonstall and Stevenson 2007, Kettenring 2013).

Non-native phragmites poses a serious environmental risk to the freshwater estuaries of Lake Superior and inland *manoomin* waters. Although it is now common along the Lake Michigan shoreline and watershed, it is still uncommon in the Lake Superior watershed. Because of its limited distribution and abundance around Lake Superior, and the serious threat it poses to coastal estuaries and nearshore open waters, non-native phragmites is a high priority for control.

Non-native phragmites was first detected along the shore of Chequamegon Bay by GLIFWC in 2007 (S. Garske, pers. obs.). Several small populations of non-native phragmites were detected and treated in 2013 along the western shoreline of Chequamegon Bay, near the Red Cliff, Bayfield, and Washburn wastewater treatment plants (WWTPs). Until recently, the use of non-native phragmites in WWTPs to dewater sewage sludge (reed bed technology) was permitted by WI DNR, with the EPA permitting its use for tribal applications.

In 2018, after several years of planning, the Red Cliff Natural Resources Department and its partners removed the non-native phragmites populations from all three WWTPs, and replaced them with native phragmites rootstock (VanBergen 2018). GLIFWC continued to conduct phragmites control efforts in and around the Bayfield and Washburn WWTPs in 2018. GLIFWC is planning on continuing close monitoring of the areas around the WWTPs, as well as the travel route from the WWTPs to the landfill that the non-native phragmites debris and sludge is being transported to. GLIFWC will continue to be engaged with all three communities and the permitting agencies to remove remaining non-native phragmites populations from the landscape.

In fall 2014, GLIFWC conducted an initial phragmites survey within the St. Louis River Estuary, which forms the border between Minnesota and Wisconsin. This survey detected 70 occurrences of non-native phragmites within the estuary. Response planning began that fall. Treatment efforts in the estuary were initiated on the Wisconsin side in 2015 and the Minnesota side in 2016. Additional surveillance was conducted in 2017 and 2018, to update the distribution and abundance of phragmites in the estuary, assess treatment effectiveness, and verify early reports that lacked identification to the subspecies level.

In spring of 2017 GLIFWC entered into a subcontract with Community Action Duluth (CAD) to control phragmites populations on the Minnesota side of the estuary. CAD's Stream Corp Program staff continued this work on the Minnesota side in 2018, under a grant from the St. Louis County AIS Prevention Program.

GLIFWC staff continued to monitor and control phragmites sites on the Wisconsin side of the river in 2018. Staff also worked in partnership with the Minnesota DNR, 1854 Treaty Authority, Fond du Lac Band, and the St. Louis River Alliance to plan and conduct phragmites control efforts on the Minnesota side of the estuary. CAD's Stream Corp Program was the lead for monitoring and management of non-native phragmites on the Minnesota side. GLIFWC continued to be an active partner in the St. Louis River area Phragmites Technical Team that assists CAD, by advising on management actions and grant funding to continue these management efforts.

Methods

Surveys: As with the AIS survey, attribute data for each phragmites site was recorded using the mobile phone application. Data collected for each site included location, estimated number of plants (shoots), acreage class, and whether control had been done. All newly discovered native and non-native phragmites locations were recorded wherever they were encountered.

Areas along roadsides were surveyed by driving slowly, watching both sides of the road and adjacent wetlands. Areas away from roads were walked. Lakeshore and riparian areas were surveyed primarily by motorboat.

The Lake Superior coastal shoreline between the Fish Creek Slough and Second Landing was surveyed for native and non-native phragmites in 2018 (Figure 4), a 12.6 mile trip. This segment completed a survey of the Chequamegon Bay coastal wetlands and shoreline.

As for the previous two years the Wisconsin side of the St. Louis River was monitored for phragmites, and any new patches and surviving older patches were treated with herbicide.

The entire Portage Canal shoreline and adjacent wetlands in Houghton County, Michigan were surveyed for phragmites, including the Sturgeon River Slough, Torch Lake and Portage Lake. These 143 survey miles were done by motorboat.

A total of over 667 miles of roadsides, trails, beaches and shorelines were surveyed for phragmites in 2018 (Figure 4). About 507 miles were surveyed by motor vehicle, 149 miles by motorboat, 3 miles by kayak, and 7 miles walking. This does not include phragmites monitoring and control work on the St. Louis River.

Control: Non-native phragmites sites along Chequamegon Bay and the Wisconsin side of the St. Louis River estuary were treated as necessary. GLIFWC crews applied glyphosate (Rodeo®) herbicide with backpack sprayers or by hand swiping the shoots. A number of other sites across northern Wisconsin were also treated with glyphosate.

Control data for each site was recorded using a mobile phone application to document the locations of phragmites sites and control efforts. Data collected for each site included location, estimated number of plants, acreage class, type of herbicide used, and the approximate amount of herbicide applied.

Results

In 2018 GLIFWC staff monitored a total 92 phragmites sites, including 5 in Minnesota, 11 in Michigan and 76 in Wisconsin (Figures 4 and 5). Live phragmites shoots were found at 46 of the Wisconsin sites (Figure 5). Most of these sites had been treated previously with herbicide by GLIFWC, and some had been treated by the WI DNR or other partners before that. In 2018 GLIFWC used glyphosate (Rodeo®) to treat phragmites.

Twenty sites on the Wisconsin side of the St. Louis River estuary were monitored. Fifteen of these still had a fairly small number of live shoots. The water level of Lake Superior continued to be at or near record levels during this year's survey (GLERL 2019), and the St. Louis River was high as well, partly inundating several sandbars and the long barrier island just west of Chase's Point. The phragmites site at the south end of the barrier island had apparently been eroded away by high water, but one new non-native phragmites site was found on a chunk of sod near the north end of the island. (This sod chunk apparently had broken off from a large patch on the Minnesota side, due west of the island.) All 16 extant phragmites sites were treated, mostly by hand-swiping the shoots.

On the Minnesota side of the river, 23 phragmites patches were treated with herbicide by Community Action Duluth.

A total of 41 sites on the west side of Chequamegon Bay were monitored, with 15 sites requiring treatment. This included 2 new satellite patches in Red Cliff. GLIFWC staff also assisted the Bad River Natural Resource Department in treating a fairly large population in the Kakagon Sloughs, east of the bay.

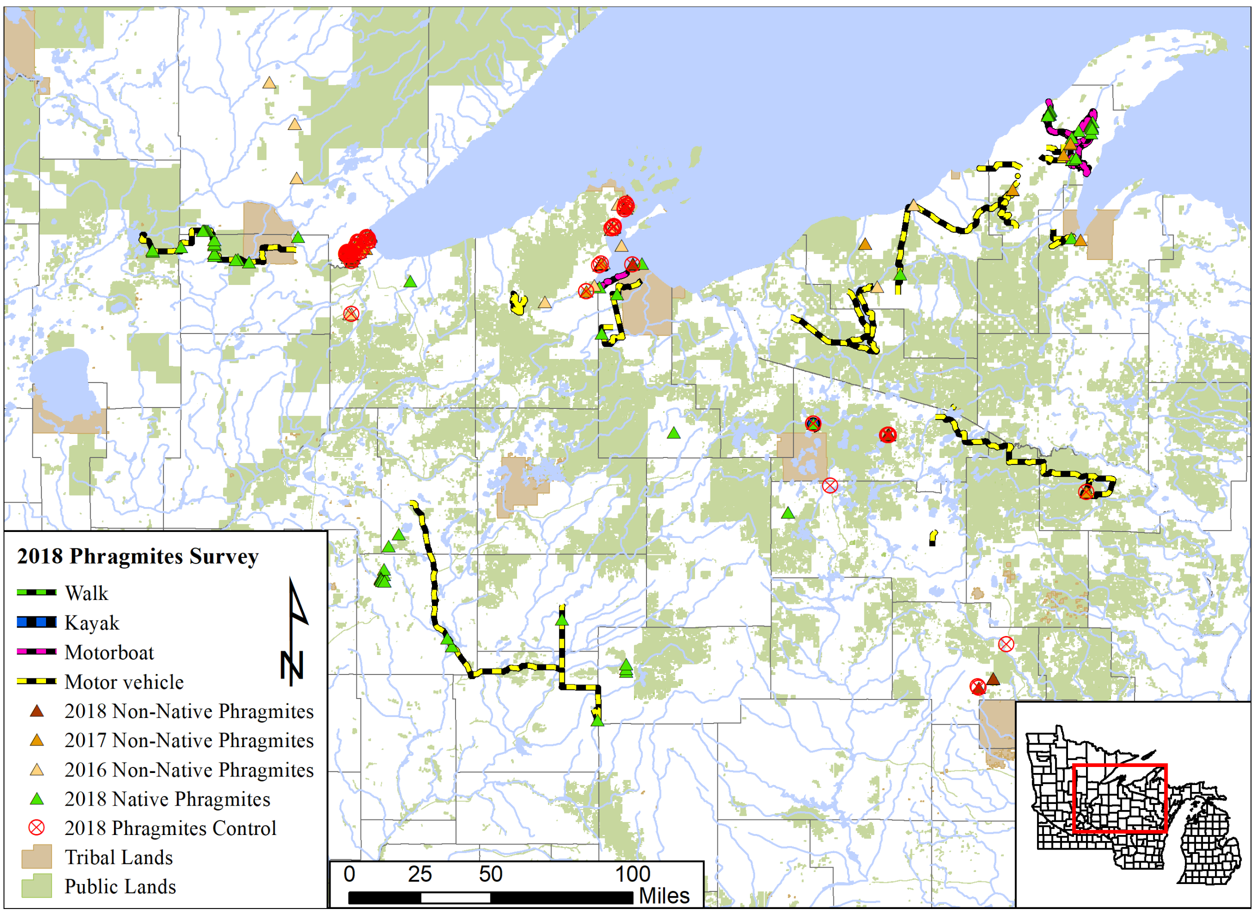

Figure 4: Overview of phragmites 2018 survey routes, occurrences and treatment sites. Native phragmites and 2018 non-native phragmites occurrences are new records.

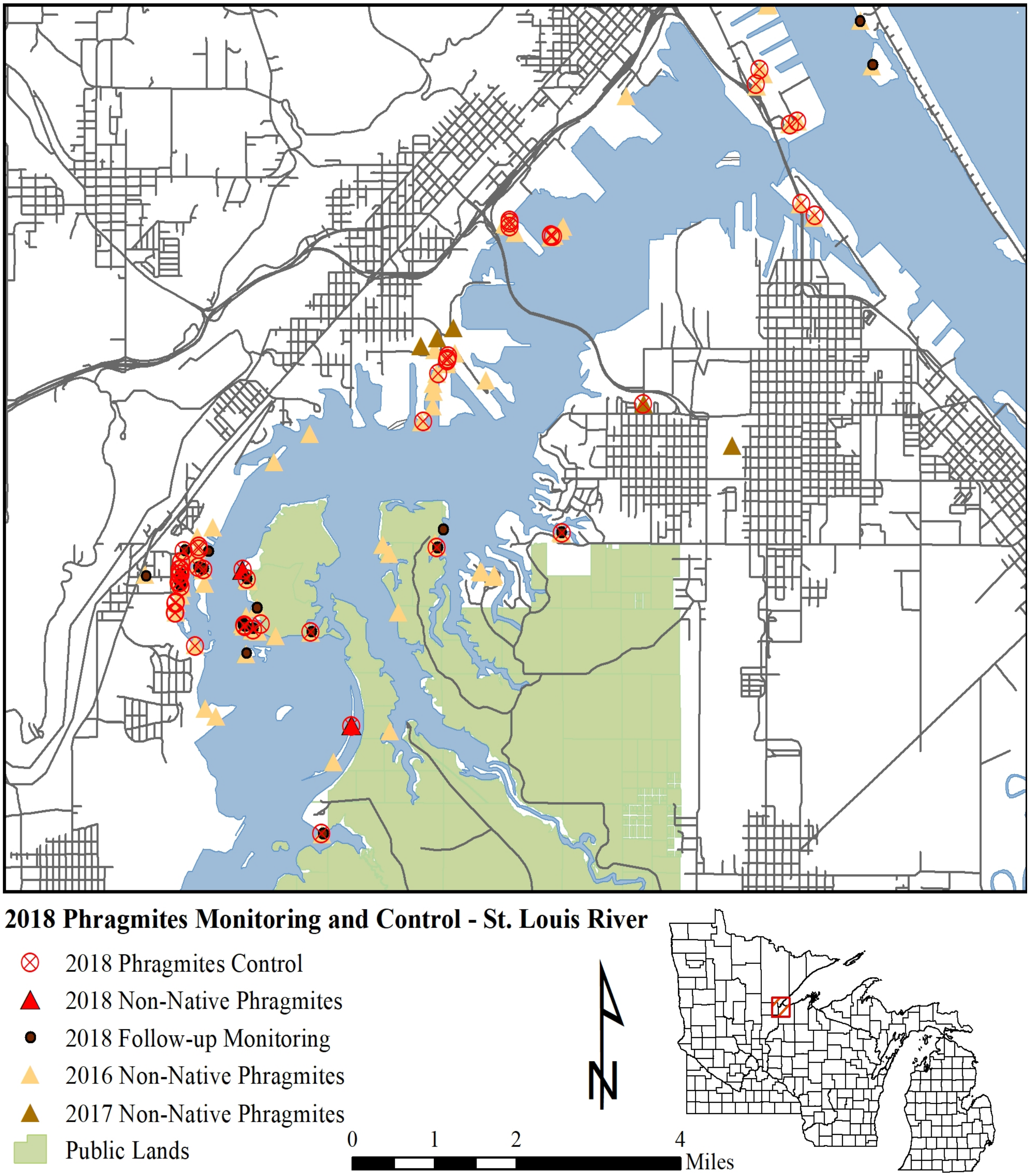

Figure 5: Phragmites 2018 occurrences and treatment sites. No live phragmites was found at untreated follow-up monitoring sites. Minnesota sites were treated by CAD, while Wisconsin sites were treated by GLIFWC.

Elsewhere in northern Wisconsin, 15 sites were monitored and treated by GLIFWC in 2018. This included a small known patch on the northwest side of Mueller Lake (Langlade County) next to the landing, and a small new population in shallow water on the east side of the lake.

The previously treated site on the south side of County BB in northwestern Douglas County, Wisconsin still had about 60 shoots. All of the shoots were hand-swiped, as requested by the landowners. As in 2017 no live phragmites was found on the north side of BB a little west of this site, where a small patch had previously been. There were also no live phragmites shoots at the site of the variegated patch in Price County that was treated in 2017.

Two well-established populations were found on the west side of the City of Superior in 2017. In 2018 GLIFWC treated the Manning Motel population by swiping the shoots with herbicide. The population on Burlington Northern Santa Fe Railway Company (BNSF) land remains untreated, though they have stated that their own crew will treat it. Communication is ongoing with BNSF Senior Environmental Manager, Suzanne Hattenberger.

Two phragmites populations treated by the WI DNR several years ago were monitored by GLIFWC in 2018. One of these populations (two patches) was on private land on the shore of Manitowish Lake in Vilas County, and the other was on private land just west of Minocqua in Oneida County. Suppressed but rebounding populations were found at both sites, and both were treated with glyphosate in 2018.

In 2017 GLIFWC surveys found a large population of non-native phragmites on Lake Laura in Vilas County. In 2018 the entire population was treated by swiping the shoots with glyphosate. The small population along US Highway 2 about three miles west southwest of Ashland and a similar-sized population on the shoulder of a gravel road near Patten Lake in Florence County were also treated in 2018.

The Wabeno site forwarded to us by the WI DNR for verification in 2017 was also revisited. As in 2017 no live phragmites shoots were found there, though two Japanese knotweed patches continue to expand there.

A report of non-native phragmites on Dodge Lake in Langlade County had been forwarded to GLIFWC by the Wisconsin DNR in 2017. GLIFWC staff visited this small, undeveloped seepage lake in August 2018. An extensive population of roughly 4 sparse to fairly dense patches of non-native phragmites was verified in shallow water along the north, west and south sided of the lake. Specimens from Dodge Lake were submitted to WIS and the GLIFWC herbarium.

The Lake Superior coastal shoreline between the Fish Creek Slough and Second Landing was surveyed in 2018. No non-native phragmites was found, but one fairly small native phragmites population was recorded just offshore from Maslowski Park on the west side of Ashland.

No non-native phragmites was found along the Portage Canal shoreline and adjacent wetlands in Houghton County. A fairly large population of native phragmites was recorded on the south end of Portage Lake, and extensive populations of native phragmites were recorded in wetlands bordering the north end of Portage Lake and the south bays of Torch Lake. A specimen of native phragmites was collected from a wetland adjacent to the southernmost bay of Torch Lake, and sent to MICH.

Interestingly two small "arrow-arum" or "tuckahoe" (*Peltandra virginica*) populations were found in remote areas of the Sturgeon River Slough. This species is native from Lower Michigan and Illinois south to the Gulf of Mexico and east to the Atlantic Coast (Thompson 2003). Thompson (2003) mentions that "its range appears to be actively expanding", partly though apparently not entirely with human help. A collection was made from one of these populations and sent to MICH, with a duplicate kept at GLIFWC.

In western Upper Michigan (mostly Houghton County), 11 previously recorded non-native phragmites sites were monitored and the information passed on to Darcy Rutkowski at the Upper Peninsula Resource Conservation & Development (UP RC & D) Council. With the help of the Ottawa National Forest invasive plant control crew, they were able to conduct control work on several of these sites.

Staff collected samples from two native, one questionably native (based on appearance) and two non-native phragmites populations for genetic analysis. Samples from the questionably native population were collected from a population north of Cloquet, Minnesota and sent to Julia Bohnen at the University of Minnesota. Samples were collected from a native patch and from one of the two non-native patches on Manitowish Lake, and sent to Professor Nic Tippery of UW-Whitewater. Samples were collected from one of the two patches in the Kakagon Slough and sent to the Tippery Lab. Because last year's samples had basically senesced by the time they were collected, samples were recollected from the native patch just north of Presque Isle, Wisconsin and sent to the Tippery Lab as well. Unfortunately Julia Bohnen contacted GLIFWC last fall with the news that they would not be able to test the Minnesota samples due to lack of funding. Results from the Tippery Lab are still pending.

Approximately 5.625 acres of non-native phragmites were chemically treated by GLIFWC (assuming sites recorded as < 0.25 acre averaged 0.125 acres). The relative abundance of non-native phragmites shoots at treatment sites in 2018 was down from 2017 (Figure 6). As in previous years, most sites required less than 1 gallon of herbicide mix (Figure 7).

All phragmites occurrences that have been verified as either native or non-native were published online to coordinate appropriate responses among management partners. Sites treated in 2018 were also uploaded. See invasives.glifwc.org/phragmites for more information.

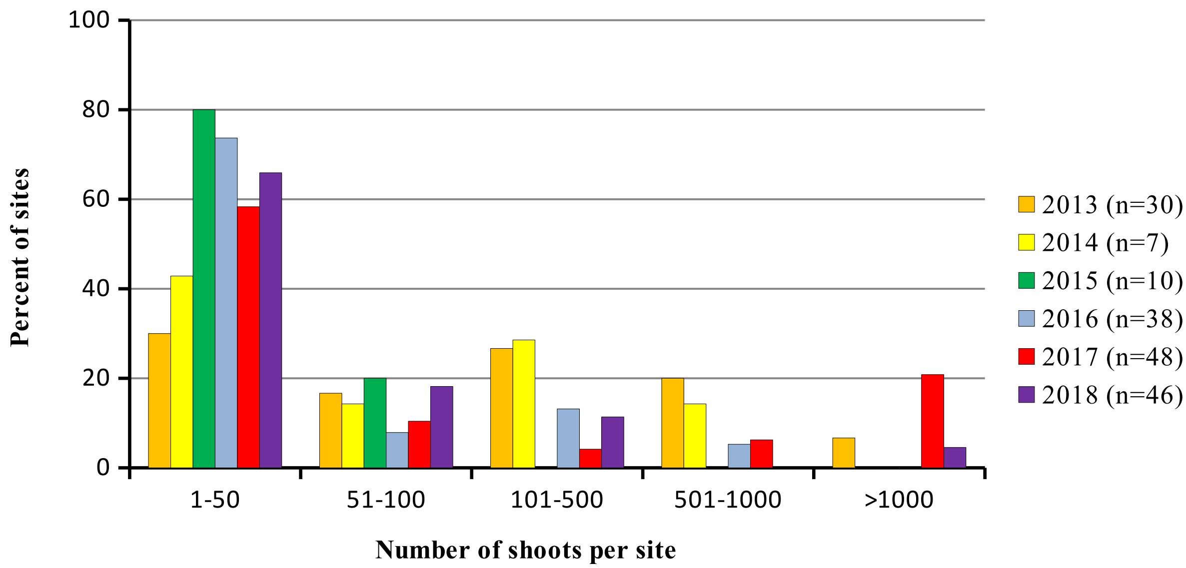

Figure 6. Abundance of non-native phragmites shoots, at sites treated from 2013 through 2018. One 2016 site lacking abundance data was omitted.

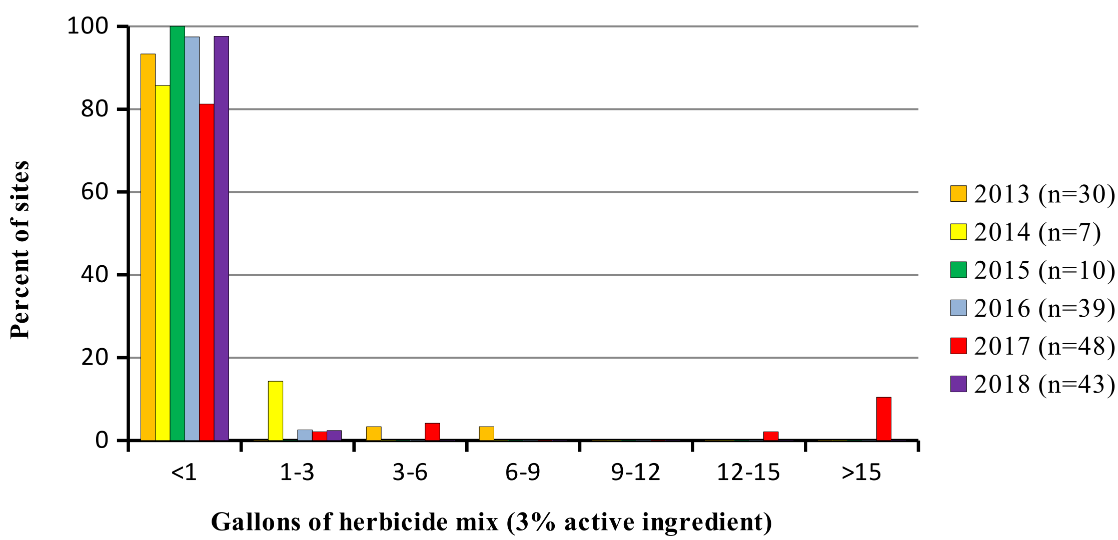

Figure 7. Amount of herbicide mix applied to non-native phragmites, at sites treated from 2013 through 2018. Three sites received some form of manual treatment in 2018.

TEASEL

Introduction

Common and cut-leaved teasel (*Dipsacus laciniatus* and *D. fullonum*) are closely related species, introduced to North America and the Ceded Territory. Common teasel is native to Europe, temperate Asia, and northern Africa, while cut-leaved teasel is native to Europe and temperate Asia (Gucker 2009). Common teasel was introduced to North America as early as the 1700s, while cut-leaved teasel was established in the eastern US before 1900. Common teasel is now widely established across the continental United States. Cut-leaved teasel is primarily established in the northeastern and Midwestern U.S. (sources in Gucker 2009). Although both species are only sparingly established in the Ceded Territory, they are locally common in southern Wisconsin and southern lower Michigan (Wisflora 2019, Voss and Reznicek 2019).

Both common and cut-leaved teasel are herbaceous biennials. Immature teasel plants spend their first year as rosettes. After developing a deep taproot and surviving the winter, they bolt, flower, produce seed, and die. Flowering plants are very spiny and may reach more than 7 ft tall (sources in Gucker 2009). Each plant may produce over 3,000 seeds. The seeds float and are readily spread by water. Teasels produce a fairly short-lived seed bank, with very few seeds surviving beyond 5 years in the soil. Teasel often spreads rapidly along roadsides, presumably aided by mowing equipment and snow plows (Stolp and Cochran 2006, Gucker 2009).

Dry teasel stalks and seedheads persist well into the winter. The seedheads are frequently used in dry-flower arrangements and other decorations. Dispersal from dry seedheads has likely initiated the establishment of numerous new populations (sources in Gucker 2009). Teasel tends to be common in and around cemeteries, presumably originating from floral arrangements left there.

Both teasel species readily invade sunny, disturbed habitats including roadsides, dumps, seeps, ditches, fencelines, power corridors and fields. Both tolerate dry to fairly wet soils. Prairie, savanna and sedge meadows are the natural communities most at risk from teasel invasion (Annen 2007). Prairie and savanna communities are some of the most endangered habitats in North America.

Common and cut-leaved teasel are listed as “prohibited” under Minnesota’s Noxious Weed Law (MN Statutes 18.75-18.91, see http://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/nwlawrevisor.aspx). It is illegal to transport or sell teasel without a permit in Minnesota, and landowners must make a good-faith attempt to control or eradicate it on their property. Both species are also listed as “restricted” invasive species under Wisconsin’s invasive species rule (Wis. Adm. Code chapter NR 40, http://docs.legis.wisconsin.gov/code/admin_code/nr/001/40.pdf). This means they can be possessed and cultivated in Wisconsin, but cannot be knowingly transported, transferred to another party, or introduced to a new site without a permit.

Methods

Surveys: Locations of reported teasel sites were originally acquired from GLIFWC staff and Northwoods Cooperative Weed Management Area (NCWMA) cooperators.

Control: GLIFWC crews controlled populations by manual or chemical treatment, depending on site size and landowner's preference. Manual treatment was conducted by cutting the taproot below the soil surface using a sharp spade, or by digging plants up. Metsulfuron methyl (Escort®) herbicide was used for chemically treating two of the three sites.

Attribute data for each site was recorded using the mobile phone application to document the locations of teasel sites and control efforts. Data collected for each site included location, an estimate of the number of plants, acreage class, type of control used (chemical or manual), and an estimate of the amount of herbicide applied.

Results

In 2018, three common or cut-leaf teasel populations (recorded as 11 sites) were resurveyed and treated. The Ashland population was chemically treated, the Washburn population was partly chemically and partly manually treated, and the Marengo population was manually treated. All were estimated at under 100 plants. Figure 8 illustrates the distribution of detected occurrences and control efforts. Figure 9 shows the abundance of teasel at each treatment site. A fourth population just south of Cornucopia was manually treated by NCWMA staff.

Discussion

With only four known locations still extant in northern Wisconsin, teasel is a high priority for eradication before it becomes more widespread and ecologically damaging. Common and cut-leaved teasel are priority species for the NCWMA as well.

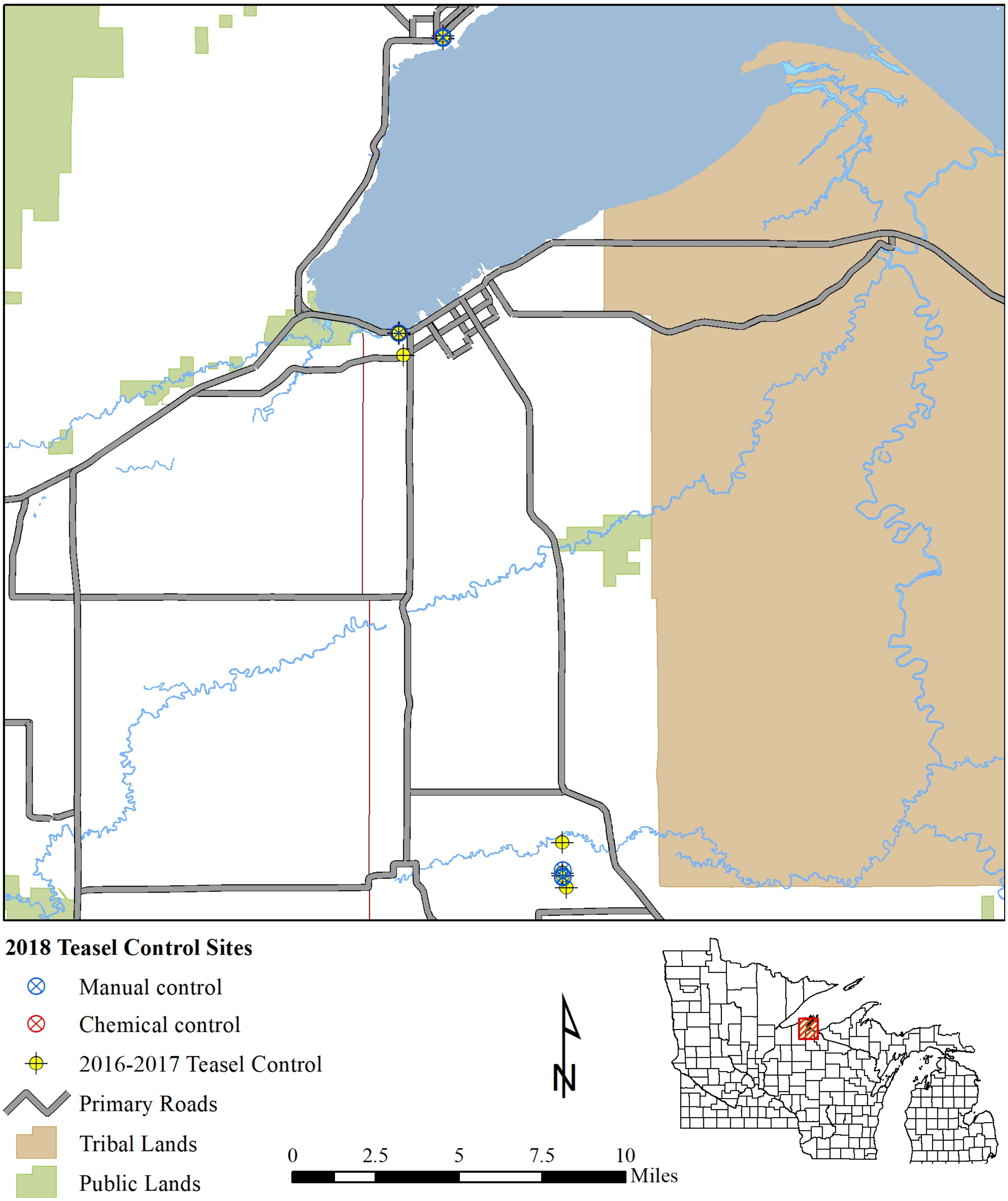

Figure 8: 2018 GLIFWC teasel control efforts. No plants were found at untreated occurrences.

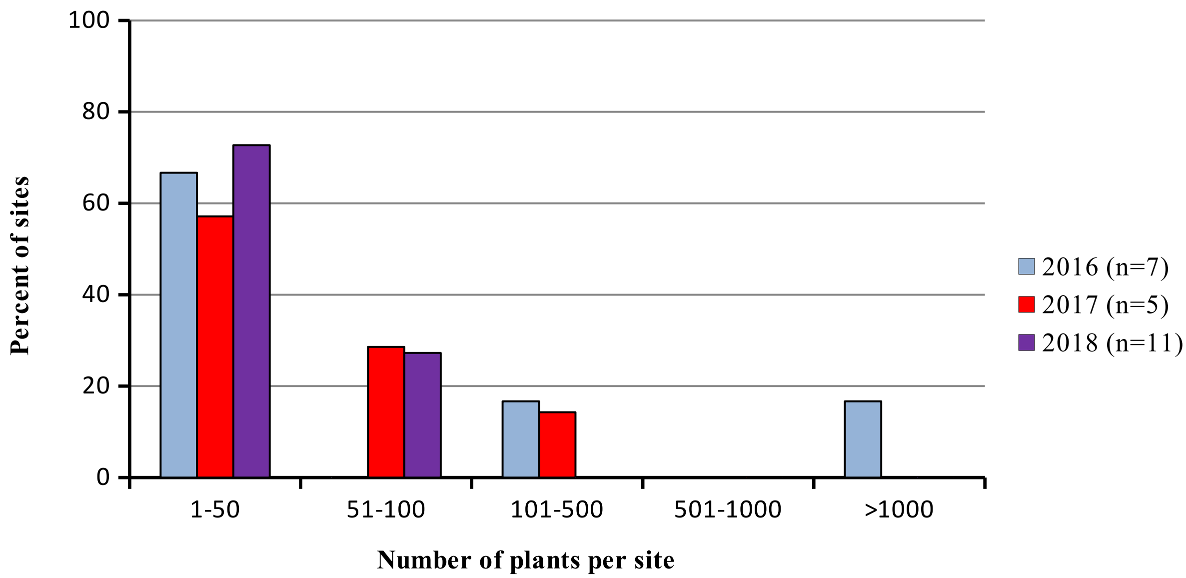

Figure 9. Abundance of common and cut-leaf teasel at sites treated from 2016 through 2018. The 11 sites represent three populations (see text).

WILD PARSNIP

Introduction

Wild parsnip (*Pastinaca sativa* L.) is native to Eurasia. It is the wild ancestor of the cultivated garden parsnip, and wild and cultivated forms can freely cross. It was introduced into North America at Jamestown, Virginia in 1609 (Berenbaum et al. 1984). It has probably been established in eastern North America for more than two centuries, reaching Michigan by 1838 (Voss and Reznicek 2019) and Wisconsin by 1894 (Wisflora 2019). Wild parsnip is now found across the US and adjacent Canada, except for the extreme southeastern US. It is locally common across the upper Great Lakes region, and appears to be increasing in abundance and extent.

Wild parsnip is a taprooted biennial or monocarpic perennial, growing for two or more years before it bolts, flowers, and dies (Hendrix and Trapp 1992). Immature plants form a rosette. Flowering plants are typically around 3 ft tall, though may reach 5 ft tall. Like other members of the parsley family, wild parsnip produces flat-topped flower clusters called umbels. The golden-yellow flower clusters may reach 4-8 inches across. Plants typically bolt in June and flower in July. The seeds are about 1/4 inch long, flat, elliptic, and slightly winged. Unless dislodged, the seeds tend to remain attached to the dead stalk well into autumn.

Wild parsnip does well along moist to dry roadsides, old fields, clearings, power line corridors, and other sunny, disturbed areas. It also invades open streambanks and cut-over woods. Mowing and snow-plowing undoubtedly facilitate its spread along roadsides.

Like some other members of the parsley family, wild parsnip produces chemicals that cause photodermatitis, characterized by blistering and discoloration of the skin when exposed to sunlight (Berenbaum et al. 1984). Photodermatitis can be severe, especially in susceptible individuals. On the other hand, wild parsnip is reputed by some to be edible, and at least as tasty as cultivated forms (Thayer 2006). Several related plants, including water hemlock (*Cicuta maculata*), are extremely poisonous.

Wild parsnip is abundant at a number of sites in northern Wisconsin and the western Upper Peninsula (S. Garske, pers. obs.). It has been a high priority for control for GLIFWC and the NCWMA and partners.

Methods

Surveys: In 2016 GLIFWC staff surveyed roadsides, utility corridors and areas near prior wild parsnip reports. Locations of previously reported sites were acquired from prior GLIFWC surveys, along with the Bad River Natural Resources Department, City of Ashland, Iron County Land and Water Conservation Department (LWCD), and other cooperating agencies. Rights-of-way were surveyed by walking or slowly driving along roadsides or paths, surveying both sides of the corridor. Individual sites were flagged with a site number to assist with management efforts. If populations extended for some distance along a road or trail, the two end points were flagged.

After monitoring was completed, occurrence data and site maps were shared with partners including Bad River Natural Resources Department, Ashland, Bayfield, and Iron County Land and Water Conservation Departments and the City of Ashland to coordinate follow-up management efforts.

Control: GLIFWC crews applied metsulfuron methyl (Escort®) herbicide to wild parsnip rosettes at most sites in late spring and early summer, with a minority of sites sprayed in September. Spring treatments targeted all age classes of plants, while fall treatments focused on rosettes that did not bolt earlier in the season.

Attribute data for each site was entered in the field using a mobile phone application to document the locations of wild parsnip sites and control efforts. Data collected for each site included location, an estimate of the number of plants, acreage class, type of control used (chemical or manual), and the approximate amount of herbicide applied.

Results

Wild parsnip was not systematically surveyed for in 2018, though two new sites were recorded incidental to parsnip treatment (Figure 10). Nine additional sites were recorded by GLIFWC partners. GLIFWC worked cooperatively with management partners to treat 195 wild parsnip sites in 2018. All these sites were within Iron, Ashland and Bayfield Counties.

Figure 10 illustrates the distribution of detected occurrences and control efforts in 2018. Figures 11 and 12 show the abundance of wild parsnip at each treated site, and the amount of herbicide used at each site from 2016 through 2018.

Discussion

While GLIFWC lead the survey efforts for wild parsnip in 2017, follow-up treatment since then has been conducted in cooperation with multiple partners.

Of the 195 wild parsnip sites that GLIFWC treated in 2018, 52 were within the boundary of the Bad River reservation. These were treated with the cooperation Bad River Natural Resources staff. GLIFWC crews treated 74 sites in Ashland County near the towns of Marengo and High Bridge. GLIFWC staff also assisted the Iron County LWCD in treating an 0.9 mile long stretch of wild parsnip along State Highway 77 just east of Upson.

Patches treated in 2018 were smaller on average than those treated the previous two years (Figure 11). Wild parsnip was not systematically surveyed for in 2018, but staff recorded 2 new sites in Iron County. Both were part the Hwy 77 population. Cooperators at the NCWMA recorded 9 sites in 2018, 7 of which represented new populations. While control efforts in the established control area are likely to continue in 2019, it is unlikely that sites outside this area can be included in treatment efforts at this time.

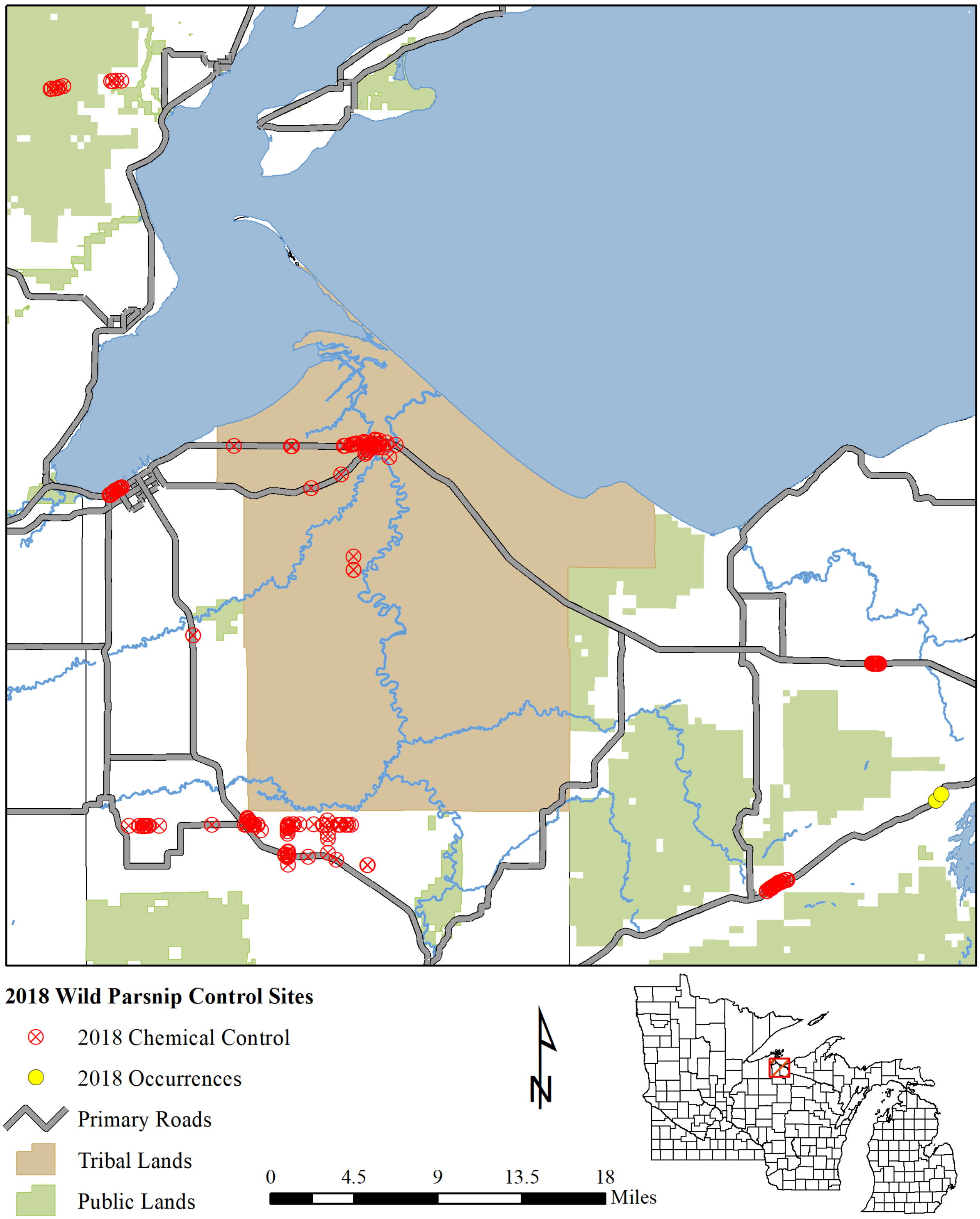

Figure 10: Wild parsnip occurrences and GLIFWC control sites in 2018.

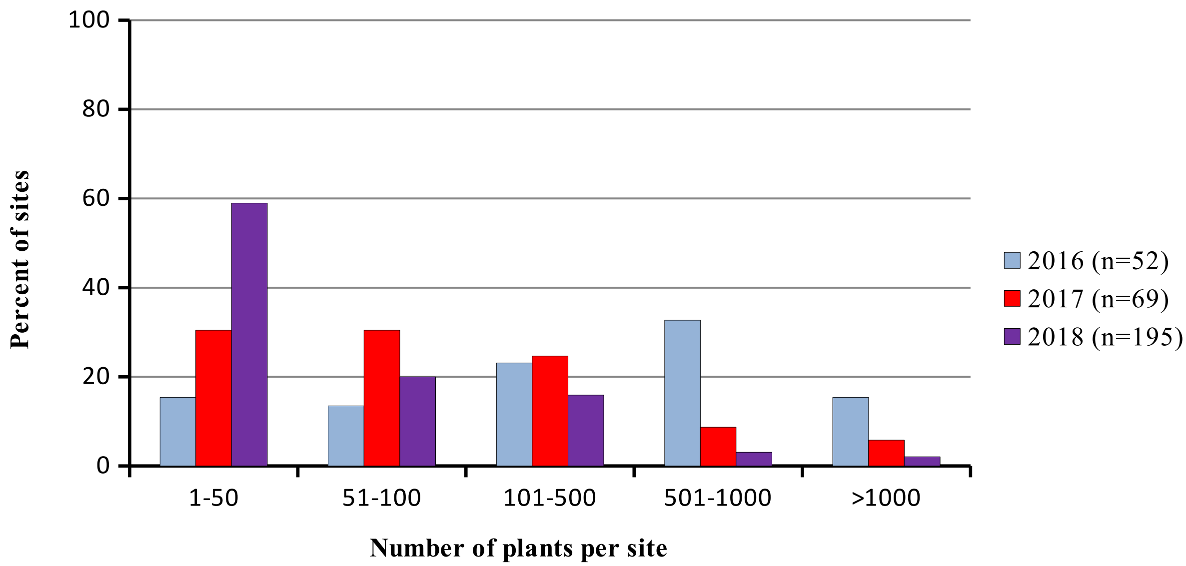

Figure 11: Abundance of wild parsnip at sites treated from 2016 through 2018.

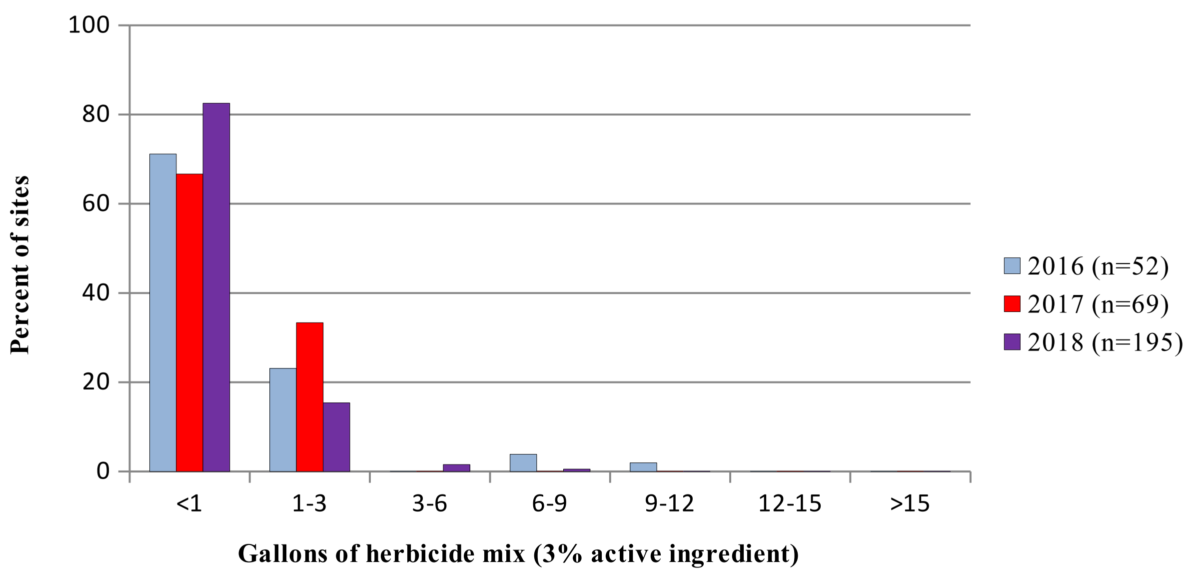

Figure 12: Amount of herbicide mix applied to wild parsnip sites treated from 2016 through 2018.

YELLOW IRIS

Introduction

Yellow iris (*Iris pseudacorus* L.) is native to Europe (except Iceland), western Asia and North Africa, where it is typical of lowlands and coastal sites (Sutherland 1990). It arrived in North America by 1771, when it was recorded as being cultivated at Thomas Jefferson's home of Monticello in Virginia (Wells and Brown 2000). It is now widely introduced in North America, especially in the northeastern U.S. and the Pacific Northwest. In the upper Great Lakes region it is sporadically established, but often common where found.

Yellow iris is a rhizomatous perennial. Plants flower in May and June, typically producing 5-6 seed pods. Pods examined in two different unpublished studies averaged 32 and 46 seeds per pod (Sutherland 1990). In one experiment, seedlings grown from seeds collected the previous fall produced their first flowers three summers later (Dymes 1920). Seed viability is apparently high - viability of seeds from 20 Pacific Northwest populations averaged 99.1% (Gaskin et al. 2016).

While yellow iris colonies spread locally through rhizome expansion, long-distance dispersal appears to be almost entirely by seed (Gaskin et al. 2016). The seeds are capable of floating for more than 1000 hours (Coops and Van Der Velde 1995), providing ample opportunity for dispersal by wind and flowing water. Seeds can potentially be carried long distances by diving birds, which may pick them up on their backs when resurfacing (Dymes 1920). The primary method of introduction to new waterbodies is by gardeners “naturalizing” yellow iris plants on lakeshores and wetland edges.

In Europe, yellow iris is a dominant member of the *Iris pseudacorus* - *Filipendula ulmaria* mire community, which frequently includes purple loosestrife as well (Sutherland 1990). It often grows in saturated soils or in shallow water, sometimes forming extensive vegetation mats over deeper water. While it is considered an obligate wetland plant, established plants are quite drought-tolerant, and are able to grow in dry sand (Dykes 1974, in Sutherland 1990). Yellow iris is highly tolerant of acidic soils, occurring at pH of 3.6-7.7 (Unit of Comparative Ecology, unpublished data, in Sutherland 1990). Yellow iris requires a fair amount of nitrogen (Ellenberg 1979, in Sutherland 1990), which may preclude it from invading fens and bogs. Typical habits include wet meadows, marshes, swamps, stream and riverbanks, lakeshores, and floodplain forests.

In England yellow iris readily colonizes areas sprayed for phragmites, forming exensive colonies (Sutherland 1990). Because it spreads well by seed, development of mature seed should be prevented as much as possible (Gaskin et al. 2016).

Yellow iris is established but not yet widespread in the Fish Creek slough of Chequamegon Bay of Lake Superior. It is listed as “restricted” under Wisconsin's NR 40 rule.

Methods

Locations of yellow iris sites were obtained from GLIFWC data and NCWMA cooperators. Yellow iris control in Chequamegon Bay began in 2014, when one site was treated. Ten sites were treated in the bay in 2016. Populations were controlled with herbicides. Isopropylamine salt of imazapyr (Polaris®) was used for chemically treating sites in 2017 and 2018.
Attribute data for each site was entered in the field using the mobile phone application to document yellow iris patches and control efforts. Data collected for each site included location, an estimate of the number of plants, acreage class, type of control used (chemical or manual), and an estimate of the amount of herbicide applied.

Results

A total of 19 yellow iris sites were recorded in 2018 (Figure 13). One site was on an island in Chequamegon Bay of Lake Superior, with the rest distributed among four inland lakes. A total of 19 sites were treated in 2018, with one of these sites treated manually. Seventeen of these treatment sites were in the Fish Creek slough or the adjacent Chequamegon Bay wetlands (Figure 13, inset). As in the previous two years, most “plants” consisted of clumps with an estimated 50 leaves/shoots or less, with a minority having 50-100 shoots (Figure 14). Less than one gallon of herbicide was used at each site.

Discussion

Because the number of yellow iris patches in the Fish Creek sloughs and Chequamegon Bay is still fairly limited, and patch sizes still relatively small, yellow iris in this area will continue to be a priority for eradication. Populations on most inland lakes are also still relatively small and could be controlled. The greatest obstacle to controlling these populations might be obtaining landowner permission to treat colonies on private lands, some of which are obviously being cultivated.

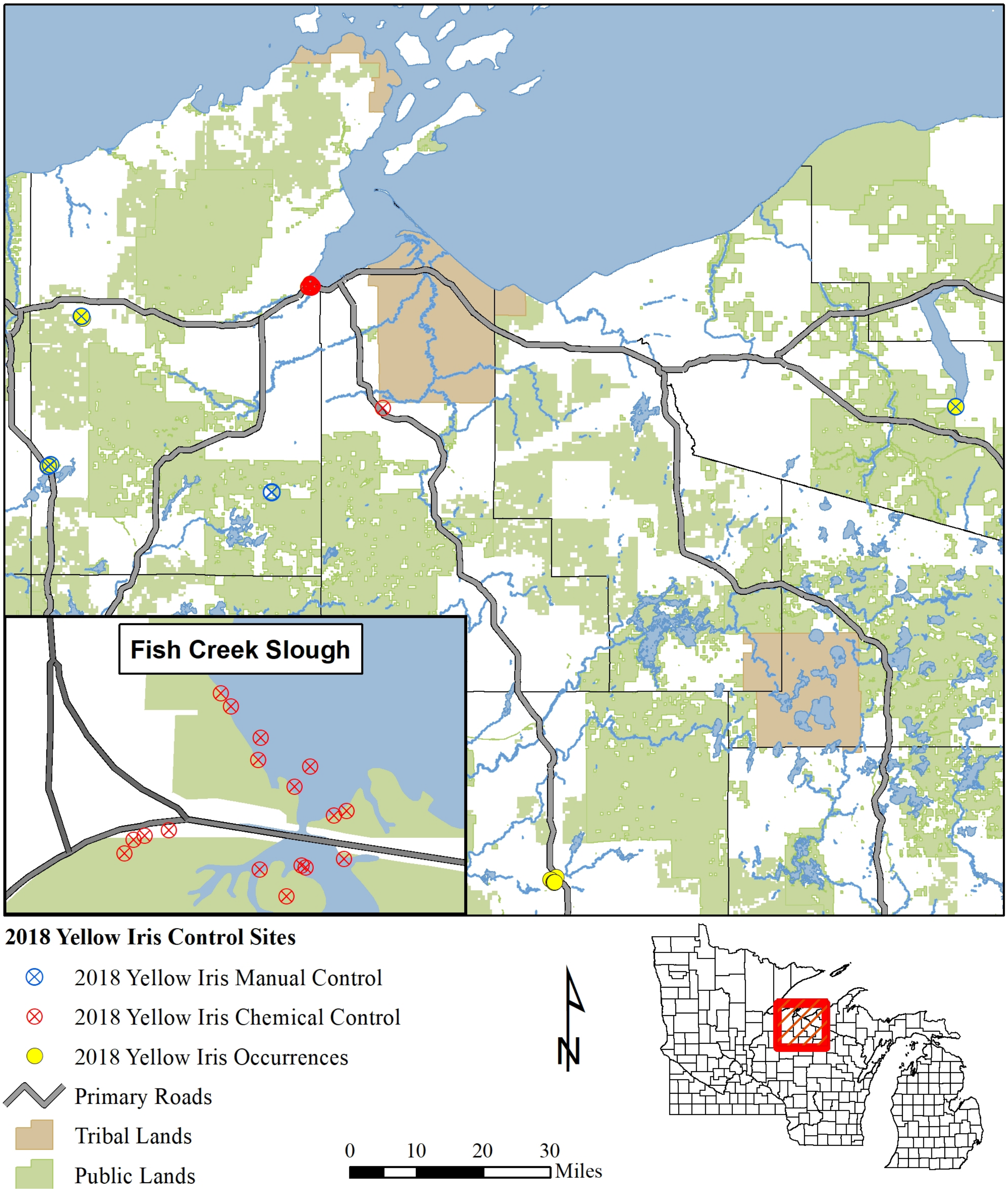

Figure 13: Yellow iris occurrences and control sites in 2018. Manual control sites were done by GLIFWC partners.

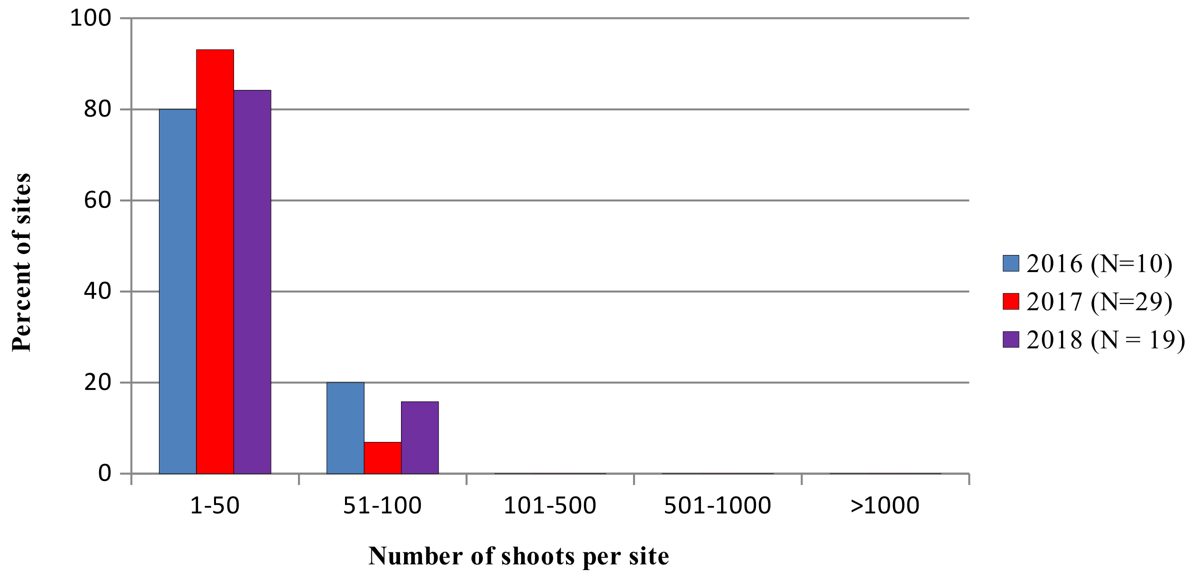

Figure 14: Abundance of yellow iris, at sites treated from 2016 through 2018.

DALMATIAN TOADFLAX

Introduction

Dalmatian toadflax is a herbaceous, branching, short-lived perennial native to southern Europe and the Middle East (Alex 1962, Vujnovic and Wein 1997). It was introduced to North America as an ornamental plant by the late 1800s (Alex 1962). Along with its close relative, yellow toadflax or "butter and eggs" (*Linaria vulgaris*), Dalmatian toadflax ranks among the most troublesome invasive weeds in western North America. It is a fairly recent escapee in the upper Great Lakes region, having been first collected in the region in Michigan in 1945 (Voss and Reznicek 2019).

First-year Dalmatian toadflax plants typically produce only prostrate stems that persist throughout the winter, while older plants produce herbaceous, upright flowering stems (Robocker 1974). Mature plants have a taproot that may reach a depth of 6 feet or more, with an extensive lateral root system extending up to 10 feet or more from the plant (Lajeunesse et al. 1993, Carpenter and Murray 1998). The erect flowering stems are produced from the taproot, while prostrate vegetative stems are produced from the lateral roots. Severed root segments as short as 0.4 inches can produce new plants (Sing et al. 2016).

Dalmatian toadflax is a prolific seed producer. Vujnovic and Wein (1997) estimate that one mature plant can produce as many as half a million seeds. Under favorable conditions seedlings can flower and produce seed their first year (Robocker 1974). The seeds can remain dormant in the soil for up to 10 years (Robocker 1974, Sing et al. 2016). Deer, cattle and other grazers can carry viable seeds on their fur and pass them in their excrement, thus assisting with dispersal (Lajeunesse et al. 1993, Whaley and Piper 2017).

Seedlings are apparently poor competitors for water, and have difficulty establishing without disturbance (Allen and Hansen 1999). Established plants, however, develop extensive, morphologically diverse root systems, making them drought-tolerant and aggressive competitors for available water (Carpenter and Murray 1998). Lateral roots produce prostrate stems that overwinter under the snow. Individual ramets (independent plants) typically live for about three to four years, with a few surviving for as long as five years (Robocker 1974).

Under favorable conditions, Dalmatian toadflax is capable of rapid vegetative spread. Zimmerman (1996, in Carpenter and Murray 1998) documents a patch expanding from one acre to 85 acres within a five year period.

Dalmatian toadflax is the most vigorous and aggressive on coarse, sandy soils (Carpenter and Murray 1998), though it tolerates heavier soils as well (Lajeunesse et al. 1993). It favors soils with a pH of 6.5-8.5 (Robocker 1974). Common habitats include roadsides, railroads, pastures, range lands, woods borders, clear cuts, and open, sandy woods (Voss and Reznicek 2019, Carpenter and Murray 1998). It typically becomes established along roadsides and other heavily disturbed areas, rapidly spreading vegetatively into less disturbed, more competitive habitats (Allen and Hansen 1999). Though it prefers full sun, Dalmatian toadflax is somewhat shade-tolerant, and can establish and grow in woods under as much as 85% canopy cover (Allen and Hansen 1999).

Dalmatian toadflax can displace native species and reduce species richness in natural communities (Carpenter and Murray 1998, Sing et al. 2016). It competes most heavily with winter annuals and shallow-rooted perennials (Lajeunesse et al. 1993). Serious adverse impacts on western rangelands are well-documented.

In the upper Great Lakes region, the natural habitats most at risk include barrens, open sandy woods, prairie remnants, and perhaps upper beaches and dunes of the Great Lakes. If allowed to spread into the Moquah sand plains, it will eventually diminish native plant communities and interfere with the exercise of treaty rights.

Methods

Surveys: In 2001 GLIFWC conducted an invasive plant survey of much of Bayfield and Ashland Counties. This survey found an extensive population of Dalmatian toadflax in eastern Bayfield County. From its eastern end, roughly 0.1 mile west of the intersection of Whiting Road and Hwy 13 (about 4 miles southwest of Bayfield), this population extends west along both sides of Whiting Road for more than 2 miles. Along much of this distance the population has spread into the open, sandy woods on either side of the road, although how far into the woods is unclear at this point.

In 2007 GLIFWC conducted additional surveys for Dalmatian toadflax. Seven small to fairly large populations were recorded along county roads north and west of Bayfield. Since then two more populations have been found in northern Bayfield County - one between Herbster and Cornucopia, and another on the western end of Madeline Island.

Control: Dalmatian toadflax control work was initiated in 2018. Sites were treated in the fall (mid-September) by applying imazapic ammonium salt (Plateau®) herbicide with backpack sprayers. The mobile phone application was used to record the locations and attribute data for each Dalmatian toadflax treatment site. Data collected included location, estimated number of plants, acreage class, type of control used, and an estimate of the amount of herbicide applied.

Results

A total of 44 Dalmatian toadflax control sites were treated with herbicide in northeastern Bayfield County (Figure 15). This included 38 locations along the entire length of the Whiting Road population, and 6 sites (four populations) on the outskirts of Bayfield. The populations just outside Bayfield that were treated included one population recorded in 2007 and three apparently new populations, but not the six other 2007 populations. Most of the treated populations were estimated to cover less that 0.25 acre, but three (all along Whiting Road) were estimated at 0.25 to 0.5 acres (Figure 16).

Most sites required <1 gallon of herbicide, with two requiring 1-3 gallons (Figure 17).

Discussion

The limited abundance and distribution of Dalmatian toadflax in northern Wisconsin and the ceded territories make it a good EDRR target. Because of their prolific seed production, extensive root systems, and ability to rapidly regenerate after control measures are discontinued, toadflax species are difficult to control. For this reason management will presumably be required for many years (Whaley and Piper 2017).

Because a significant amount of time (nearly 12 years) has passed since this toadflax population was delineated, the area should be surveyed again, to gather updated information on the extent of known populations and to map new sites. The effectiveness of the 2018 herbicide treatments should also be evaluated. Some of the known sites apparently extend beyond the road right-of-way, so we will likely need permission from landowners to fully treat these populations.

Once the current extent of this Dalmatian toadflax population is known,a general strategy should be outlined. The strategy should consider whether the goal is to to contain this population or eventually eradicate it. As with just about any invasive plant infestation, an effort should be made to control/eradicate the smaller outlier patches first before attempting to control the main patches (Moody and Mack 1988). An adaptive management approach should be used, evaluating past success and adjusting future plans accordingly.

A wide variety of insect species attack Dalmatian toadflax and yellow toadflax in their native Europe (Vujnovic and Wein 1997). Eight of these insects have been approved for biological control of these toadflax species in the US. These insects have generally had limited success in controlling toadflax, with the exception of two closely-related weevils, *Mecinus janthinus* and *M. janthiniformis*. *Mecinus janthiniformis* has been highly effective in controlling Dalmatian toadflax in North America (Whaley and Piper 2017). The adults of this weevil feed on the foliage and buds, sometimes to the point of killing the terminal portions of the stems, reducing flower production and seed formation. The larva tunnel short distances through the stems, further weakening and even killing the plants. In some Pacific Northwest sites, *M. janthiniformis* has provided 100% control of Dalmatian toadflax within three to five years of being released.

In areas with severe winters, *M. janthiniformis* may be unable to built up a large enough population to significantly impact toadflax. The newly formed adults overwinter in the toadflax stems. If snow cover is not deep enough to cover the stems, the adults may not survive periods of cold temperatures and low humidity. Mortality rates may reach 75% to 100% at temperatures of -18.5°F (-28°C) or lower (Sing et al. 2016). If the branches are covered with snow, however, survival can still be fairly high.

Biological control organisms can be effective at reducing the abundance of a target plant to an acceptable level, but they generally won't eradicate it. On the other hand, herbicides can be impractical and uneconomical against very large infestations and may have negative, long-term effects on plant communities (Sing et al. 2016). Because several of the other biocontrol insects released so far have become widespread in North America, toadflax plants should be examined for insect damage and the insect(s) identified if possible, before fall herbicide treatment.

Dalmatian toadflax poses huge potential impacts to treaty resources, particularly in the Moquah sand plains. It will continue to be a high priority for management efforts to contain it and eradicate it where possible.

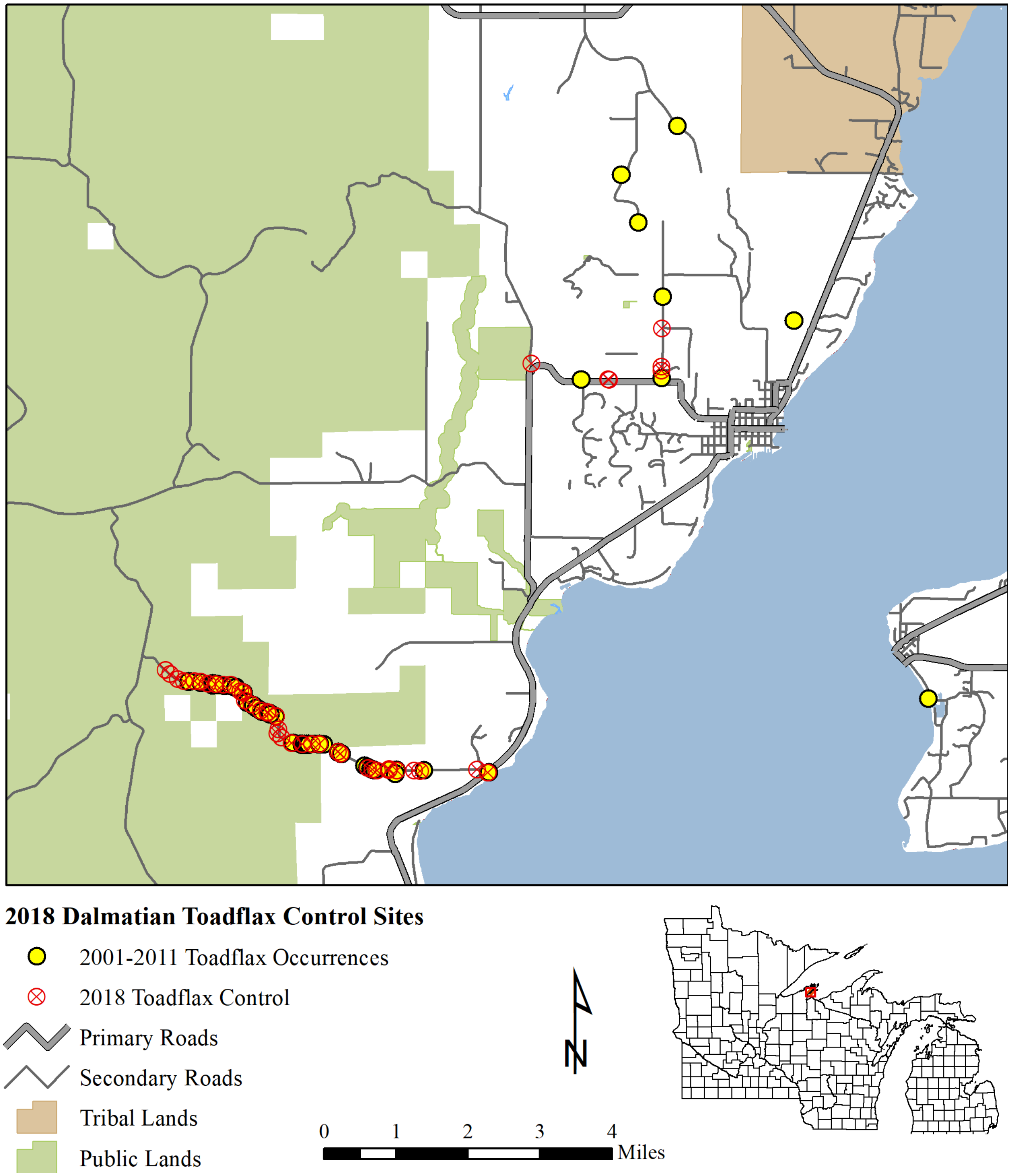

Figure 15: Dalmatian toadflax occurrences and 2018 control sites.

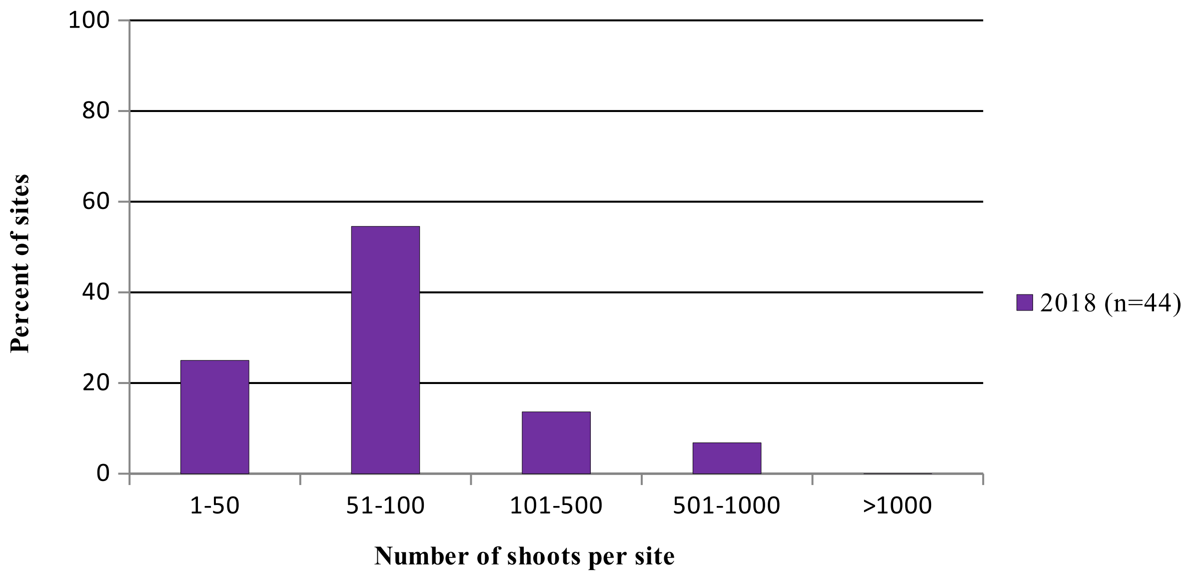

Figure 16: Abundance of Dalmatian toadflax at sites treated in 2018.

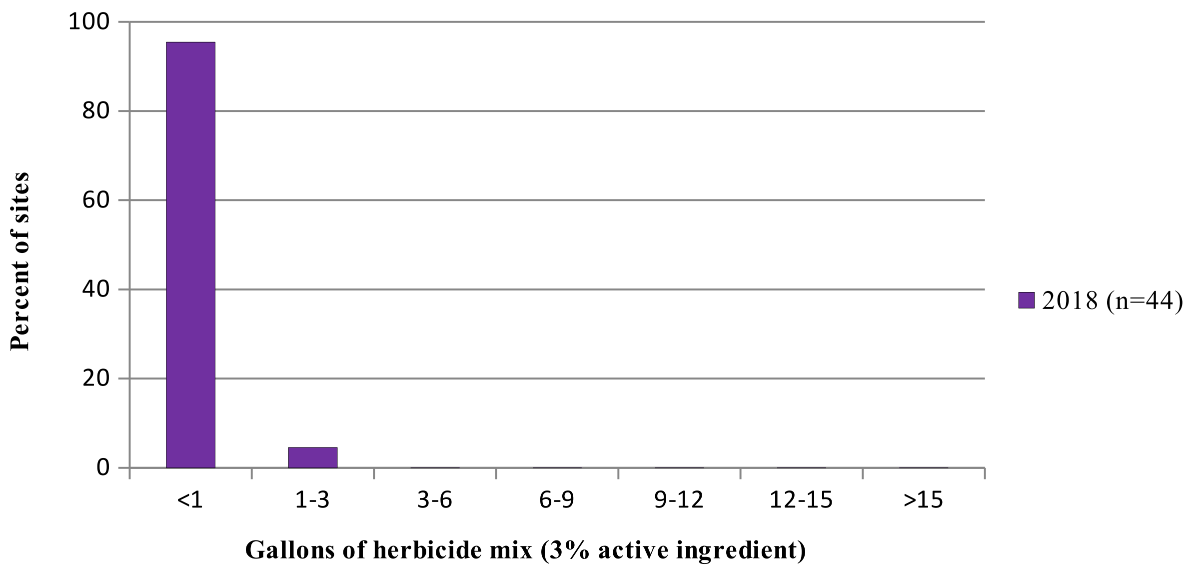

Figure 17: Amount of herbicide mix applied to Dalmatian toadflax sites treated in 2018.

CONTROL AND MANAGEMENT

Once invasive species become widely established, the most effective action is to prevent their spread or minimize their impacts through control measures. Integrated pest management (IPM) uses the most effective method or combination of methods available, while attempting to minimize the cumulative environmental impacts of treatment. Methods may include manual, chemical and biological control. GLIFWC includes three plants in this category: garlic mustard, purple loosestrife and leafy spurge.

LEAFY SPURGE

Leafy spurge (*Euphorbia virgata*) is native to Europe and Asia (Moore 1958). Until recently it has generally been treated as *E. esula* in North America (Levin and Gillespie 2016). First recorded in North America in a Massachusetts garden in 1827, leafy spurge is now found throughout the US and southern Canada, except for the southeastern and south central US (USDA-NRCS 2009, Best et al. 1980). In the western US, leafy spurge is a notorious ecological and economic pest, inhabiting more than 1.1 million acres (Di'Tomaso 2000). Direct and secondary economic losses to grazing and wildlands from leafy spurge in the Dakotas, Montana, and Wyoming alone have been estimated at $129 million annually (Leitch et. al. 1994).

Because of the cooler and wetter climate, leafy spurge tends to be less common in eastern North America. Leafy spurge is sporadically established across the ceded territory, including northern Wisconsin, Upper Michigan, and northern Minnesota. It is listed as a "Prohibited Noxious Weed" in Michigan, a "Restricted Invasive Species" in Wisconsin, and is on the “Control list” (as opposed to the “Eradicate list”) as a "Prohibited Noxious Weed" in Minnesota (MDARD 2019, WDNR 2017, MDA 2019).

Leafy spurge is a strongly rhizomatous, herbaceous perennial. The pale bluish-green shoots often form dense clumps from the woody root crown. The shoots may reach more than three feet tall, but are usually shorter. As with all *Euphorbia* species, a milky, sticky latex sap is found throughout the plant (Best et al. 1980, Gleason and Cronquist 1991).

Spurge species have a unique floral arrangement. The flowers are small and inconspicuous, greenish, and imperfect (containing only male or female parts). They are arranged in clusters, with each cluster consisting of one female flower, with its ovary on a short stalk, closely surrounded by several male flowers, each having one stamen. Each cluster is surrounded by a cup-shaped structure called a cyathium. Yellow-green heart-shaped bracts surround each cyathium, giving the whole structure the appearance of a single greenish-yellow "flower".

Leafy spurge begins flowering as early as May and continues through mid-July (Gleason and

Cronquist 1991, Selleck et al. 1962). Lateral branches may produce flowers and seeds into the fall (Best et al. 1980). Pollination is facilitated almost entirely by ants and other insects, drawn by the large amounts of nectar produced by glands of the cyathium (Selleck et al. 1962). Leafy spurge has mechanisms to promote outcrossing (Selleck et al. 1962), but can produce seeds autonomously as well (Selbo and Carmichael 1999).

Dispersal usually begins when the capsules burst on warm sunny days, propelling the seeds as much as 15 ft from the parent plant (Bakke 1936, in Selleck et al. 1962, p. 25). The seeds may then be spread further by a number of biotic and abiotic vectors. They are sometimes cached by small mammals, and ants may also have a role in their dispersal (Selleck et al. 1962). The seeds float and can germinate on top the water, allowing plants to become established in areas of occasional flooding, such as riverbanks and low prairies (Selleck et al. 1962).

Most leafy spurge seeds germinate the following spring, though some sprout throughout the growing season (Selleck et al. 1962). Selleck et al. (1962) found that 99% of the seed germinated by the end of the second year, but a few seeds take as long as 5 years. A small percentage may remain viable in the soil for as long as 13 years (Selleck et al. 1962).

Seedlings begin to develop an extensive root system as early as 7-10 days after germination (Selleck et al. 1962). Often the seedling's original shoot dies, to be replaced by new shoots from the expanding root system (Selleck et al. 1962). Roots can reach a depth of a meter or so by the end of the first season (source in Selleck et al. 1962). Seedlings generally don't produce seed until the second year (Selleck et al. 1962).

Part of what makes leafy spurge such an aggressive competitor is its extensive, dimorphic root/rhizome network. The initial (primary) root is a long, indeterminate root that travels more or less downward (vertically) through the soil, producing secondary long roots along the way (Raju et al. 1963). These long roots are woody and are protected from water loss by thick, corky bark (Raju et al. 1963). Long roots have been found as deep as 30 ft below the soil surface (Holmgren 1958, in Best et al. 1980). Pink buds, capable of producing new shoots, are formed along nearly the entire root network (Best et al. 1980). Long roots typically persist for several to many years (Raju et al. 1963).

Local spread of leafy spurge is primarily accomplished vegetatively. Selleck et al. (1962) measured the average vegetative rate of spread at 2 ft per year in ungrazed native grassland. The fastest yearly advance was 11 ft. In most years vegetative growth continues throughout the summer, though growth slows significantly while the plants are flowering (Selleck et al. 1962).

Leafy spurge is tolerant of a broad range of climates and environmental conditions. It tolerates a wide variety of soil types, but is most aggressive on coarse, well-drained soils (Selleck et al. 1962). Its shoots are adapted to dry habitats, and its deep and extensive root system may reach down to the water table, thus avoiding the effects of drought (Lym and Zollinger 1995). Nonetheless plants can withstand weeks of flooding, as long as the shoots are able to grow above the water surface (Selleck et al. 1962).

In the Ceded Territory common leafy spurge habitats include roadsides, pastures, old fields, and other disturbed areas, as well as prairies, savannas, dry woodlands, and riverbanks. It readily invades and dominates native grasslands, and flourishes in the open oak woods of southern Wisconsin (Selleck et al. 1962). Sand plains habitats such as the Moquah Barrens of Bayfield County are particularly vulnerable to invasion by leafy spurge.

Cypress spurge (*Euphorbia cyparissias*) is a close relative of leafy spurge. It is also introduced from Eurasia. It tends to be a shorter, bushier plant than leafy spurge, with shorter leaves and numerous side branches near the tops of the main stems (Stahevitch et al. 1988). It reaches a maximum of about 1.3 ft tall.

Cypress spurge is a strongly rhizomatous perennial, and can produce dense colonies in some habitats. It is known to cross with leafy spurge in Europe (Moore 1958). It often spreads from plantings to fields, banks, roadsides, and rocky shores, and is locally established in the Ceded Territories.

Methods

Surveys: In 2001 GLIFWC conducted an invasive plant survey of much of Bayfield and Ashland Counties. Many of the spurge populations treated in recent years were recorded that year. Since then additional populations have been recorded by GLIFWC and partners.

Control: After two year break, GLIFWC resumed control efforts for leafy and cypress spurge in the Bad River/Chequamegon Bay watershed and the Bayfield peninsula in 2018. Sites were treated in the fall (mid-September) by applying imazapic ammonium salt (Plateau®) herbicide with backpack sprayers. Chemical control efforts focused primarily on road rights-of-way. The mobile phone application was used to record the locations and attribute data for each spurge treatment site. Data collected included location, estimated number of plants, acreage class, type of control used, and an estimate of the amount of herbicide applied.

Results

A total of 37 spurge sites were treated in 2018 (Figure 18). Herbicide was applied to 33 leafy spurge sites and 3 cypress spurge sites in northwestern Iron, northern Ashland and northeastern Bayfield Counties. Most of the treated populations were estimated to cover less that < 0.25 acre, but three leafy spurge sites covered between 0.25 and 0.5 acres (Figure 19). A large population (> 1 acre) of leafy spurge just south of the Bad River reservation in north central Ashland county was treated biologically, by releasing *Aphthona* flea beetles collected from the Douglas County Wildlife Area near Solon Springs, Wisconsin.

Twenty-nine of the spurge sites required <1 gallon of herbicide, with 7 larger leafy sites requiring 1-3 gallons (Figure 20).

Discussion

Though much more common and widespread than Dalmatian toadflax, leafy spurge is still relatively uncommon in northern Wisconsin and the ceded territories. Leafy (and cypress) spurge are quite similar to toadflax in their extensive root systems, prolific seed production, adaptation to dry or droughty habitats and poor soils, and ability to rapidly regenerate after control measures are discontinued.

An IPM approach that includes biological control is the best way to reduce the abundance and spread of well-established leafy spurge populations (Merritt et al. 2002). Once established, Aphthona beetles can suppress spurge populations with little additional time, effort and expense, greatly reducing leafy spurge vigor and abundance. On heavily-infested sites, reductions in spurge canopy cover of up to 95% are not uncommon (Merritt et al. 2002).

Herbicides and biological control can be complementary if properly used. Timing is the most important factor. Late season applications (after Aug. 15) are compatible with flea beetle survival, and can enhance population establishment. Spring and summer applications will remove the top growth need\ed by adult flea beetles to complete their life cycle, and should be avoided. (Merritt et al. 2002)

Over a decade has passed since leafy spurge populations were systematically delineated. If feasible given current resources, known populations should be resurveyed to gather updated information on their extent and status. The effectiveness of previous herbicide treatments and biocontrol introductions should also be evaluated. New populations (e.g., along roadsides) could be recorded during summer control work, as time permits. Power corridors often facilitate the spread of small-seeded invasive plants such as leafy spurge (S. Garske, pers. obs.). As with Dalmatian toadflax, an adaptive management approach should be used in formulating future management plans.

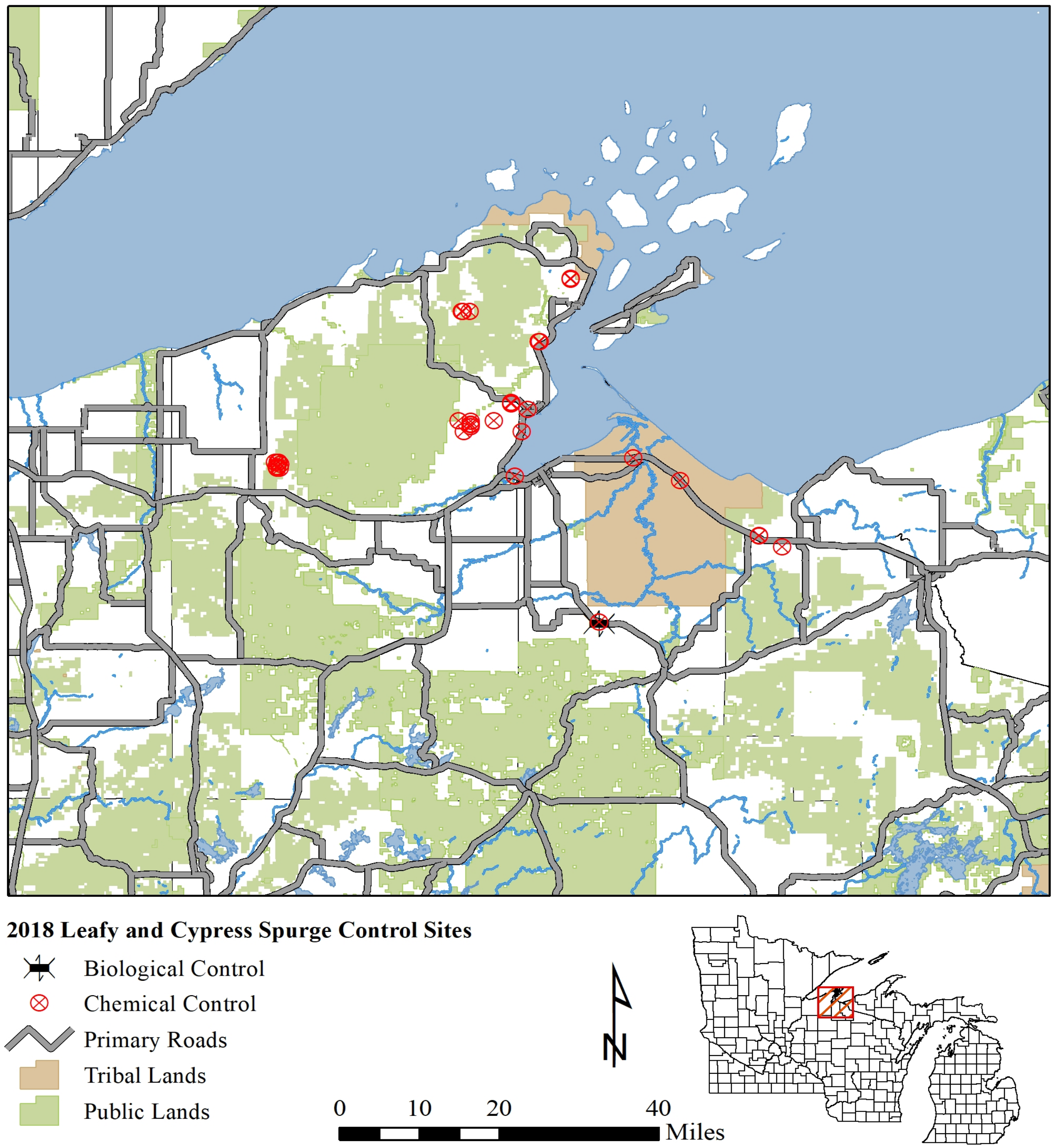

Figure 18: 2018 leafy and cypress spurge control sites.

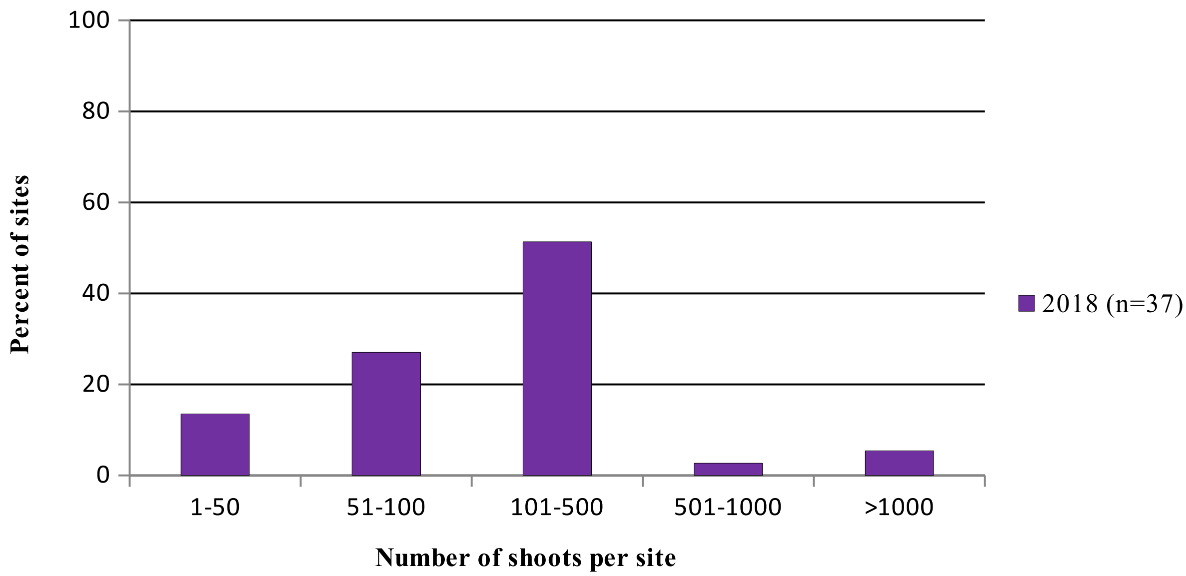

Figure 19: Abundance of spurge at sites treated in 2018. Three of the sites consisted of cypress spurge.

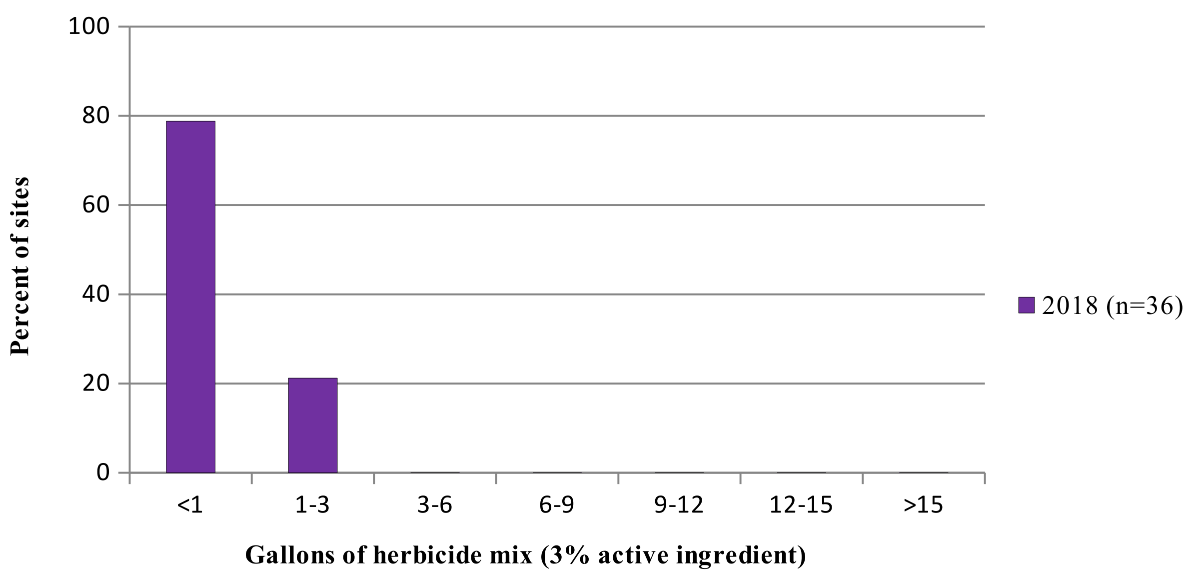

Figure 20: Amount of herbicide mix applied to leafy spurge sites treated in 2018.Three of the sites consisted of cypress spurge. One leafy spurge biocontrol site was omitted.

GARLIC MUSTARD

Introduction

Garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande] is a shade-tolerant, highly invasive forest herb native to Europe. All parts of the plant smell like garlic. It was likely introduced to North America by early European colonists as a medicinal and salad plant. First recorded outside cultivation on Long Island, New York in 1868 (Nuzzo 1993), it is now widely established and locally abundant in the eastern and midwestern US and in adjacent Canada, and occurs in scattered locations in western North America as well (USDA-FHTET 2014).

Garlic mustard is a strict biennial. In cold temperate climates including the Ceded Territory, most seeds lay dormant for about 20 months, germinating in early spring of the second year (Cavers et al. 1979). A small percentage of seeds may remain dormant for up to 5 years and possibly longer.

Garlic mustard plants spend their first year as rosettes, with each plant developing a slim white taproot that often forms a shallow "S" shape just below the base of the shoot. Rosettes bolt and flower in the spring of their second year, producing stalks up to 3 ft or more tall. Clusters of small, white, 4-petaled flowers are produced from mid-May through June, with seed pods ripening in June and early July. It is not unusual to see plants only two inches tall flowering and producing seed (S. Garske, pers. obs.).

Although tolerant of sunny habitats, garlic mustard grows best in light to moderate shade, and is quite capable of growing and reproducing in deep shade. It prefers moist, well-drained soil, but tolerates a wide variety of soil conditions from wet clay to well-drained sandy soil (Cavers et al. 1979). Like most mustard family (Brassicaceae) members it is intolerant of very acid soils, though (Grime et al. 1988). It does well on seasonally inundated habitats such as floodplains. Common habitats include moist to wet riverbanks, floodplains, woodland edges, and interior woods. In favorable habitats garlic mustard is a transformative species, forming nearly monotypic carpets that largely displace the native plant community, eliminating the food and habitat for native insects and other invertebrates, and altering the habitat for birds and mammals that depend on native ecosystems for survival (Nuzzo 1993).

Garlic mustard plants are green all their lives. The rosettes resume growth within days after snow melt, when most native forest plants are still dormant. Thus the two-week period just after snow melt is an excellent time to look for new patches, and to treat existing patches with herbicide.

Scattered small to moderate-sized populations of garlic mustard probably grow undetected across much of the Ceded Territory. GLIFWC invasive plant surveys in northern Wisconsin in the mid- to late 2000s revealed at least two dozen small patches growing in flowerbeds, in yards and adjacent woods, in campsites (usually at the back of the site, where people unload their equipment), and along back roads. Dozens of small sites have also been found in the Ottawa National Forest (ONF) and western Upper Michigan (Ian Shackleford, ONF botanist, pers. comm., S. Garske, pers. obs.). Eradication is possible at many of these sites, given landowner cooperation and a sustained effort over a period of years.

Large garlic mustard populations are apparently still rare in northern Wisconsin and Upper Michigan. Known infestations include one around the former WI DNR fish hatchery ponds on the northwest side of Presque Isle in Vilas County, Wisconsin, and another along the Montreal River, which forms the border of Wisconsin and Upper Michigan. A third occurs along the Bad River floodplain from upstream of Mellen to just downstream of Mellen, near the southern border of Copper Falls State Park. The Presque Isle population was treated by volunteers for a number of years, until the town began contracting with a professional weed control specialist. Garlic mustard numbers there have been reduced to a small fraction of what they once were, but the population has not been completely eradicated. The Montreal River population is being controlled by a coalition led by the Ottawa National Forest and the Iron County (WI) Land & Water Conservation Department, with GLIFWC, the WI DNR and volunteers assisting as well.

The Bad River population is the most extensive population known in northern Wisconsin. Since its discovery in 2007, a broad spectrum of groups and individuals including the WI DNR, GLIFWC, the NCWMA, Bad River Head Start students, school groups from Ashland and Mellen, and local volunteers have participated in controlling this infestation. The infestation has been controlled with manual pulling of second-year plants in spring, followed by spring herbicide treatment of particularly densely infested sites, and fall herbicide treatment of first-year rosettes. This effort has reduced the number of plants in the treatment area to a small fraction of what it was originally, and turned dense carpets of garlic mustard into scattered plants amid a diversity of mostly native vegetation. Unfortunately, despite the reduction in the relative number of plants, the total area infested by garlic mustard appears to be roughly the same (S. Garske, pers. obs.). Even more disappointing, a systematic survey for garlic mustard by GLIFWC in 2016 revealed extensive, previously undetected infestations for nearly three miles upstream of the treatment area.

Research into possible biological control organisms has resulted in the identification of four weevil species (Coleoptera: Circulionidae) that are host-specific and show promise of being effective in controlling garlic mustard (USDA-FHTET 2014). One of these, a root crown miner (*Ceutorhynchus scrobicollis*) was recommended for release by the USDA-APHIS Technical Advisory Group for Biological Control Agents of Weeds (TAG) in early 2017, but has not yet been approved for release in the United States (Van Riper et al 2017). Meanwhile *C. scrobicollis* was approved for release in Canada in June 2018, followed by the first North American release in Ontario in August 2018 (Hinz 2018).

Methods

Surveys: GLIFWC staff resurveyed the approximately 70-acre main control area along the Bad River floodplain in the City of Mellen, in preparation for 2018 management efforts. Each site was flagged with two strips of flagging having the same site number. A mobile phone application was used to record the locations of garlic mustard sites, the estimated number of plants, and acreage class. GLIFWC shared distribution data with management partners and cooperators for coordinated management.

Control: Sites were manually controlled in spring by hand pulling second year plants, in order to reduce seed production at the site. Follow-up fall treatment was conducted by applying triclopyr (Garlon 3A) herbicide with backpack sprayers, targeting first-year rosettes after the native plants were mostly dormant.

After manual control at each site, one site flag was (usually) removed. The second flag was removed after chemical control. The flagging was returned to the office, and the site numbers were documented in order to verify control of each site. (Participants occasionally removed both flags during manual control, which made follow-up treatment and tracking a bit more difficult.) As a practical matter the 70-acre area was divided into 7 treatment areas, instead of recording each patch treated.

Results

A total of 125 garlic mustard sites were recorded on the Bad River floodplain. Manual control was conducted on 119 of these sites. Follow-up chemical treatment was done on nearly all the sites, plus additional sites on an adjacent landowner's property. (Permission to access this landowner's property was obtained after the spring pull.)

The control crew followed up on 15 known sites in Ashland and two sites in Washburn, treating 15 with herbicide and manually controlling two of the Ashland sites.

Figure 21 illustrates the distribution of detected occurrences and control efforts in 2018.

Discussion

Until 2016 garlic mustard was considered a GLIFWC early detection rapid response species. Due to the large infestations found upstream of the known infested area that year, eradication no longer seems feasible. This species poses huge potential impacts to treaty resources, so it will continue to be a high priority for management efforts including containment and eradication where possible.

While GLIFWC took the lead for survey and management efforts along the Bad River in Mellen and in the City of Ashland, NCWMA cooperators lead management efforts on multiple additional sites. GLIFWC staff assisted with spring manual control along the Montreal River in Iron County, Wisconsin, and in a wooded residential area above the St. Louis River in Superior, Wisconsin. Staff also assisted with early fall treatment in Washburn near the Lake Superior shoreline. They also monitoring and treated sites near the City of Bayfield's composting facility, on the Red Cliff Reservation, and near Lake Namekagon in Bayfield County.

Several additional garlic mustard populations were documented in Ashland and Superior by the NCWMA director and a cooperator in 2018.

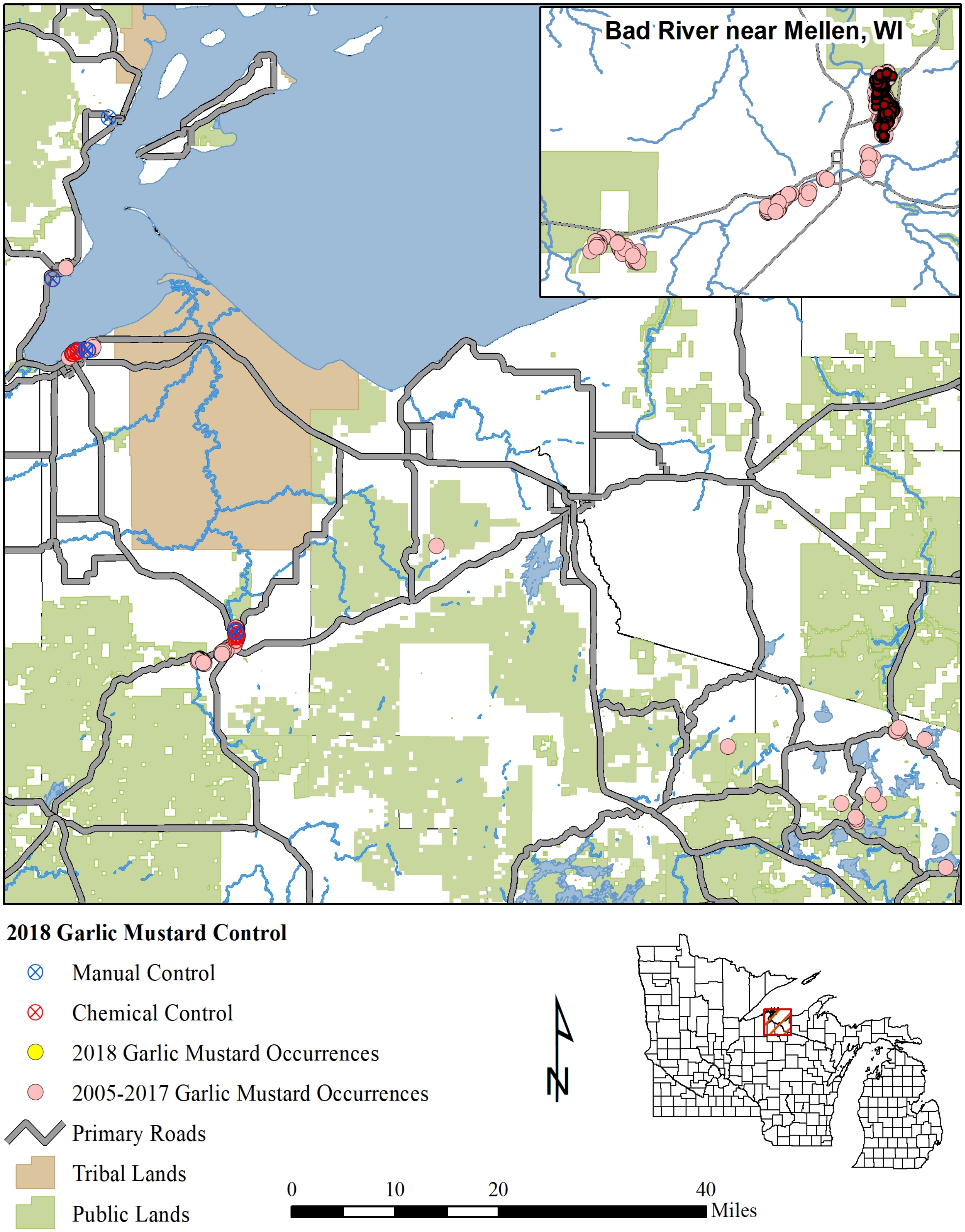

Figure 21: Garlic mustard occurrences and 2018 integrated management efforts.

PURPLE LOOSESTRIFE

Introduction

Purple loosestrife is a perennial, herbaceous wetland plant native to Europe. It arrived in eastern North America in the early 1800's via plants brought by settlers, seeds carried within livestock, and in ballast soil carried by ships (Thompson *et al*. 1987). It is currently distributed across much of the U.S. and southern Canada.

Purple loosestrife can germinate in moist, exposed soils. It tolerates a wide range of pH, nutrient, and light levels. Once established, seedlings can survive temporary flooding. The plant develops a large root crown and dense shoots that are square in cross-section, and can reach 6.6 ft tall. The distinctive pink-purple spikes of 6-petaled flowers appear from mid-July through early September in the upper Great Lakes region.

Purple loosestrife degrades wetland habitats by out-competing native vegetation. On exposed substrates, purple loosestrife seeds germinate at such high densities that they crowd out native vegetation. Except for two closely related species of *Galerucella* beetles (Coleoptera: Chrysomelidae), which have been widely released as biocontrols, herbivores and pathogens that keep loosestrife from dominating European wetlands are absent in North America. This lack of natural enemies combined with prolific seed production gives purple loosestrife a substantial advantage over native vegetation. Diverse wetland plant communities can quickly be displaced by monotypic stands of purple loosestrife. Reductions in native plant diversity result in a loss of food and shelter for numerous insect, amphibian, mammal, and bird species that depend on healthy wetlands for their survival.

Methods

GLIFWC's integrated control efforts continue to focus on purple loosestrife within the Bad River/Chequamegon Bay watershed in northern Wisconsin (Figure 22). Small sites (< 0.5 acres) in upper reaches of the watershed were prioritized for chemical control. Control crews generally applied triclopyr (Garlon 3A® or Renovate®) to purple loosestrife plants. Renovate® is approved for over-water use and was used on sites with standing water, while Garlon 3A® was used where standing water was absent. Triclopyr is dicot-specific, allowing grasses and sedges to persist and re-colonize sites in a shorter time period. A few sites were treated with glyphosate (Rodeo®) Chemical control efforts focused primarily on road rights-of-way between Mellen and Bayfield, Wisconsin. Private properties were also treated after consent forms were signed by the landowner.

Large sites (> 1 acre) and sites with poor access were a high priority for biological control. The release of *Galerucella* beetles (native to Europe) in the United States for biological control of purple loosestrife was approved by USDA-APHIS in 1992. GLIFWC has been rearing and releasing *Galerucella* beetles and collecting and redistributing them within the watershed since 2000. Release sites from prior years were visited in late summer to ascertain overwinter survival and to take site photos documenting the effects of beetle herbivory.

Treated sites were mapped using a mobile phone application to document the locations of purple loosestrife sites and control efforts. Attribute data collected for each site included an estimate of the number of plants, acreage class, type of control used (chemical or biological), and an estimate of the amount of herbicide applied.

Results

In 2018, GLIFWC staff treated 92 purple loosestrife sites with herbicide. Figure 23 shows the decrease in relative patch size from 2012 through 2018. Figure 24 shows the decrease in relative amount of herbicide mix being applied per patch of purple loosestrife from 2012 through 2018. Biological control efforts since 2000 have established over 60 *Galerucella* populations throughout the Bad River - Chequamegon Bay watershed, and site visits continue to document their impacts. Time series photos (Figures 25-26) illustrate the effectiveness of *Galerucella* beetles in substantially reducing the abundance of loosestrife at three northern Wisconsin sites.

Discussion

The use of biological controls has allowed GLIFWC's control crew to place greater emphasis on treating small populations with herbicide before they become significant source populations. This strategy also reduces the amount of herbicide applied at each site (Figure 24). Biological control has been effective at most sites throughout the watershed, although results vary with loosestrife population size, disturbance, native seed bed quality, weather, and wetness of the site. Loosestrife vigor and abundance also may vary from year to year. While *Galerucella* beetles will not eliminate loosestrife from the landscape, they can greatly reduce its density and abundance, and its impacts on natural ecosystems and native species.

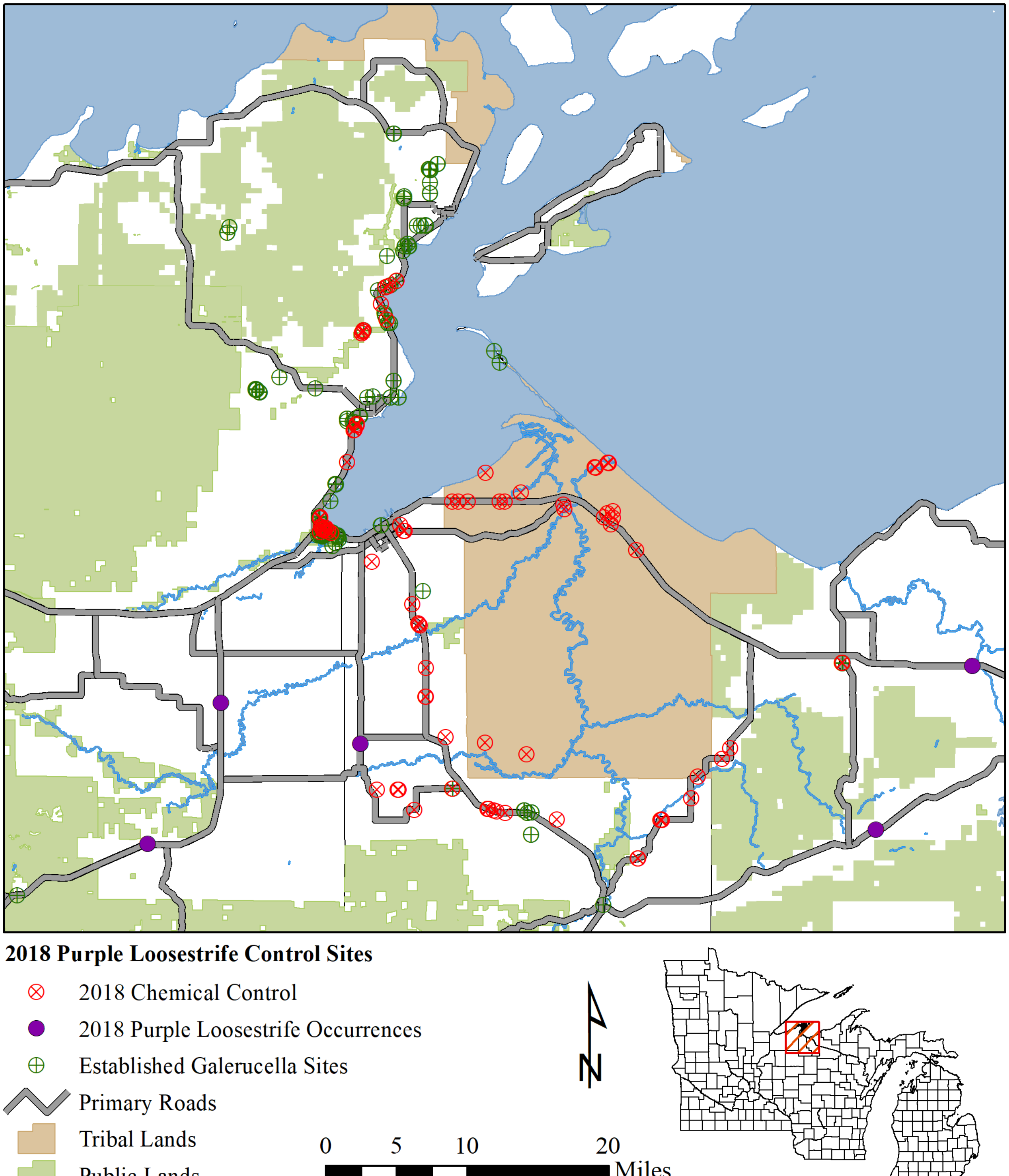

Figure 22: Purple loosestrife occurrences and GLIFWC control efforts in 2018. Occurrences found by GLIFWC and partners.

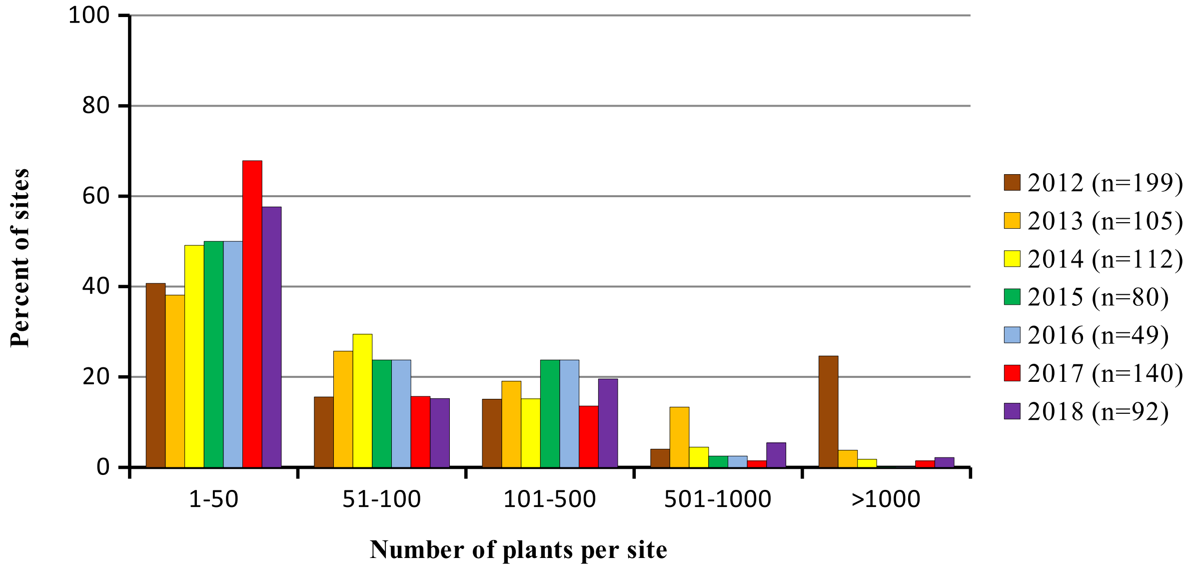

Figure 23: Purple loosestrife abundance at sites treated in 2012-2018.

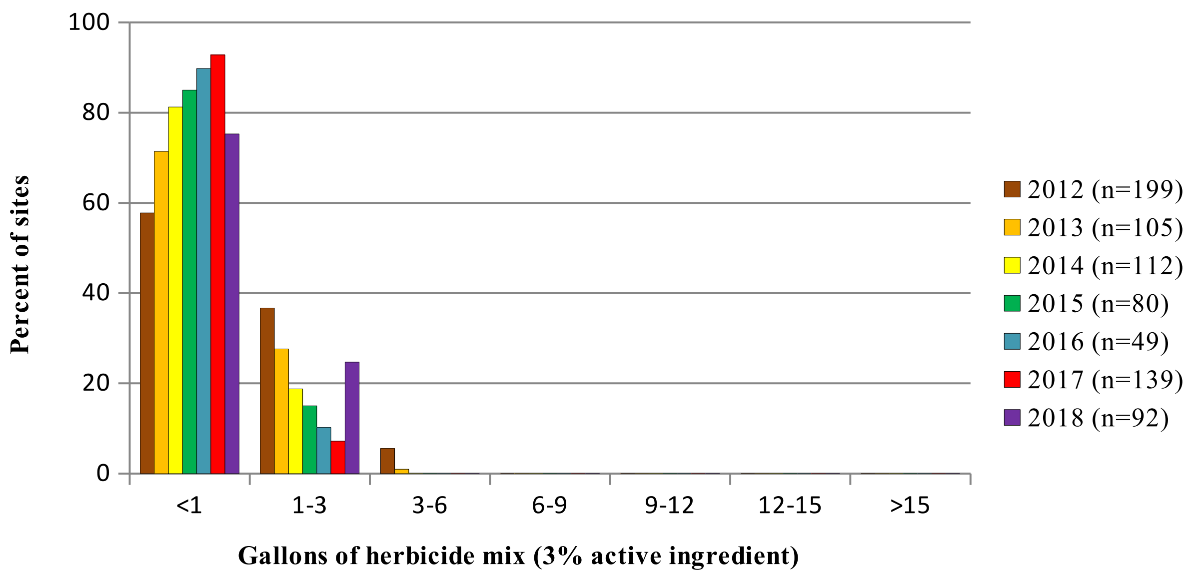

Figure 24: Amount of herbicide mix applied to purple loosestrife sites, 2012-2018. One 2017 and three 2018 sites that were treated manually was omitted.

Figure 25: *Galerucella* release site. Port Superior, south of Bayfield, Wisconsin.

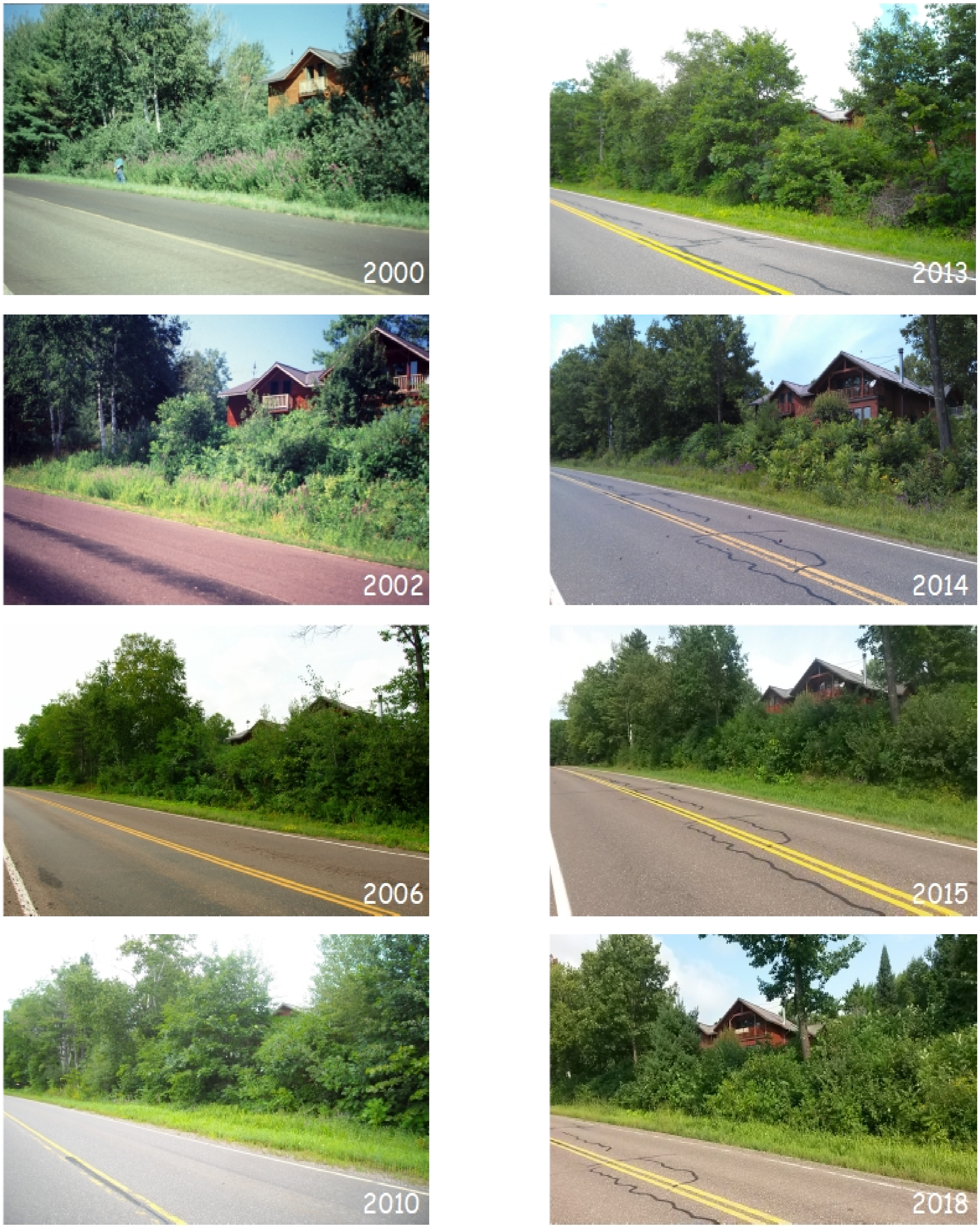

Figure 26: *Galerucella* release site. County Highway J near Bayfield, Wisconsin.

RESEARCH AND TRAINING

Introduction

New invasive species continue to be introduced to the Ceded Territory, and new management techniques continue to be developed to reduce their spread. Research is required to address gaps in knowledge as they become evident, especially with respect to understanding potential impacts of invasive species and identifying or informing selection of cost-effective management actions.

Accomplishments

Activities in 2018 included:

- Staff attended several conferences and workshops to stay informed of new invasive species making their way to the Ceded Territories, new prevention and monitoring measures, and research and management techniques. Events attended included:
  - USDA-APHIS/Wisconsin Tribal Conservation Advisory Council Rapid Response and Preparedness tabletop simulation. January 30, 2018, Odanah, WI.
  - Wisconsin DNR Zebra Mussel Strategy meeting. February 15, 2018, Spooner, WI.
  - Attended the AIS-CISMA meeting. March 13-14, Fall Creek, WI.
  - Upper Midwest Invasive Species Conference. October 15-17, 2018, Rochester, MN.
  - Vilas County Lakes Partnership, October 26, 2018, Boulder Junction, WI.

- Staff obtained and reviewed various reports, management plans, and peer-reviewed scientific literature on invasive plant biology, ecology, distribution and control. These publications were primarily obtained from online sources, and accessioned into a literature database using ProCite 5.0 software.

- Staff researched and recommended non-native, invasive plants for consideration for inclusion in the WI DNR's NR 40 list of restricted and prohibited species.

COOPERATION AND COORDINATION

Introduction

Because invasive species disperse widely across the landscape and administrative boundaries, it is necessary to work cooperatively to achieve success. The introduction and spread of new invasive species in the region continues to out-pace control activities, and the problem is too much for any one agency to manage alone. GLIFWC strives to coordinate its activities with invasive species management partners to maximize the efficient use of limited resources. Management partners include Tribes, U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, state agencies, county governments, municipalities, universities, and non-government organizations.

Accomplishments

GLIFWC staff are actively engaged in several long-term initiatives that seek to enhance inter-agency cooperation and coordination of invasive species management and planning:

Northwoods Cooperative Weed Management Area (NCWMA): Formally established in 2006, the NCWMA provides a forum to share information, collaborate on planning and cooperate on management activities in Douglas, Bayfield, Ashland, and Iron Counties in northern Wisconsin. In 2018, GLIFWC staff worked with NCWMA partners to organize the spring garlic mustard control week in Ashland County and helped with garlic mustard control activities in Iron County. Staff shared herbicide with partners for wild parsnip control activities. Staff also helped monitor giant hogweed sites and participated in wild parsnip control efforts in Iron County.

Wisconsin Aquatic Invasive Species Management Plan. Completed in June 2019 in cooperation with the Wisconsin Department of Natural Resources and other partners, this update to the 2003 Wisconsin AIS Management Plan makes GLIFWC eligible for funding from the U.S. Fish and Wildlife Service to implement tasks identified in the plan and helps facilitate cooperation with the WI DNR on AIS issues.

Wisconsin Headwaters Invasives Partnership (WHIP): Formally established in 2010, WHIP provides a forum to share information, collaborate on planning, and cooperate on management activities in Vilas and Oneida Counties in northern Wisconsin. GLIFWC has a history of surveying inland waters in Vilas and Oneida Counties for AIS and sharing the findings with WHIP partners.

St. Croix National Scenic Riverway Comprehensive Interstate Management Plan for the Prevention and Control of Aquatic Nuisance Species: Completed in March of 1998 in cooperation with the Lower St. Croix Management Commission, Minnesota Department of Natural Resources, Minnesota-Wisconsin Boundary Area Commission, National Park Service, Wisconsin Department of Natural Resources, U.S. Fish and Wildlife Service, and the Upper St. Croix Management Commission. This plan makes GLIFWC eligible for funding from the U.S. Fish and Wildlife Service to implement tasks identified in the plan, and helps facilitate cooperation on AIS issues within the St. Croix watershed.

Phragmites Management and Cooperation in the Lower St. Louis River Estuary: In 2014, GLIFWC staff facilitated a multi-agency meeting to share survey results and coordinate follow-up monitoring and control efforts for non-native phragmites along the Lower St. Louis River. In 2016, GLIFWC staff continued to work cooperatively to manage non-native phragmites along the St. Louis River Estuary. GLIFWC staff were instrumental in the creation of a new partnership with the Minnesota DNR, 1854 Treaty Authority, Fond du Lac Band, and St. Louis River Alliance to plan and conduct phragmites control efforts on the Minnesota side of the St. Louis River Estuary. In 2017 and 2018, staff conducted follow-up monitoring and treatment of sites on the Wisconsin side of the Estuary. GLIFWC staff are members of the technical advisory team overseeing the planning and management activities on the Minnesota side. GLIFWC staff also created a database application to better manage and share information with technical team partners. Data includes non-native phragmites site information, monitoring, management efforts, contacts and landowner permissions.

Lake Namekagon aquatic plant management meeting: GLIFWC staff attended the first Lake Namekagon aquatic plant management meeting, held by the WI DNR in 2017. In late 2017, one staff member accepted an invitation to serve on the Lake Namekagon Lake Association's Aquatic Plant Management Planning Committee. In early 2018, two staff members attended that committee's first meeting, where they gave GLIFWC's input on the development of the management plan.

maps.glifwc.org: The goal of this project is to facilitate collaboration by providing a common communications infrastructure. maps.glifwc.org provides a portal for viewing invasive species distribution and management in the context of the Ceded Territories and other GIS layers relevant to GLIFWC's member tribes such as *manoomin* and *ogaa* waters.

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