Invasive Species Program 2019

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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 2019 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.

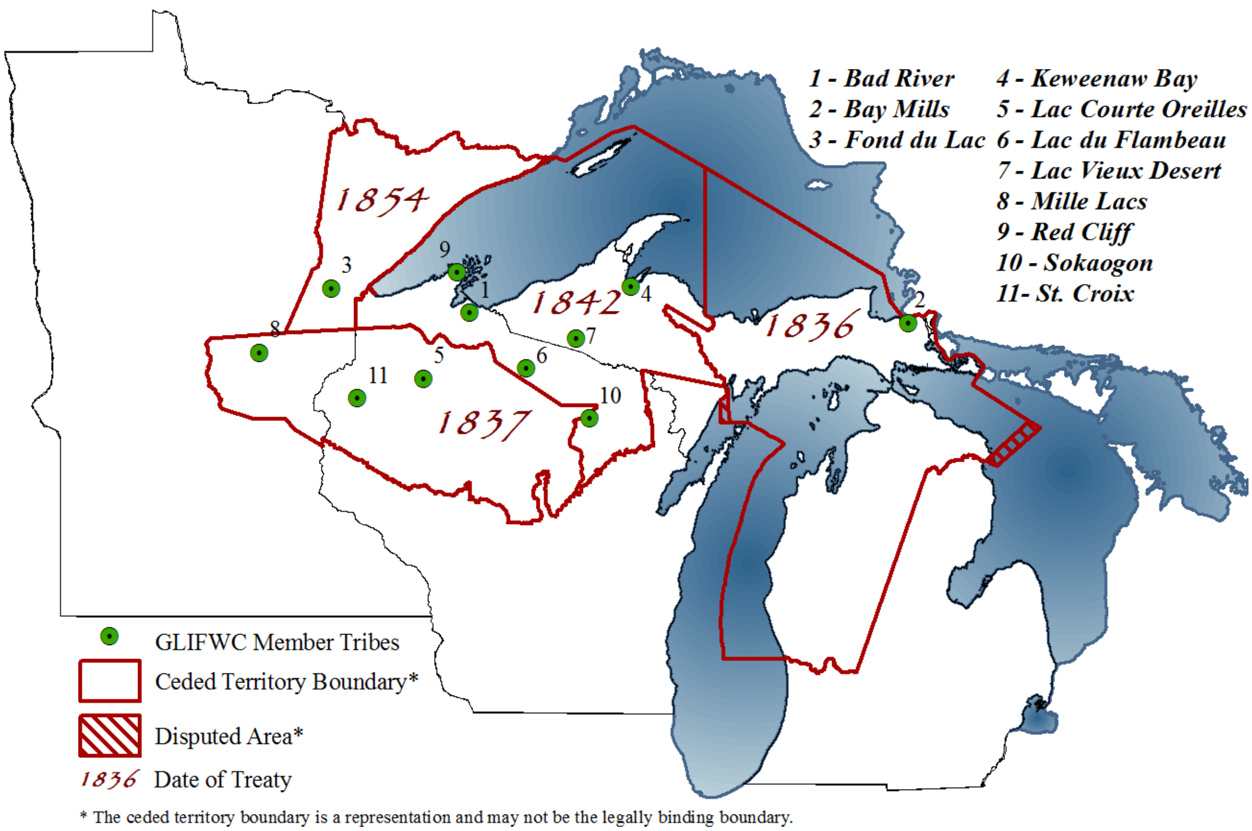

Figure 1. Location of GLIFWC member tribes and Ceded Territories.

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

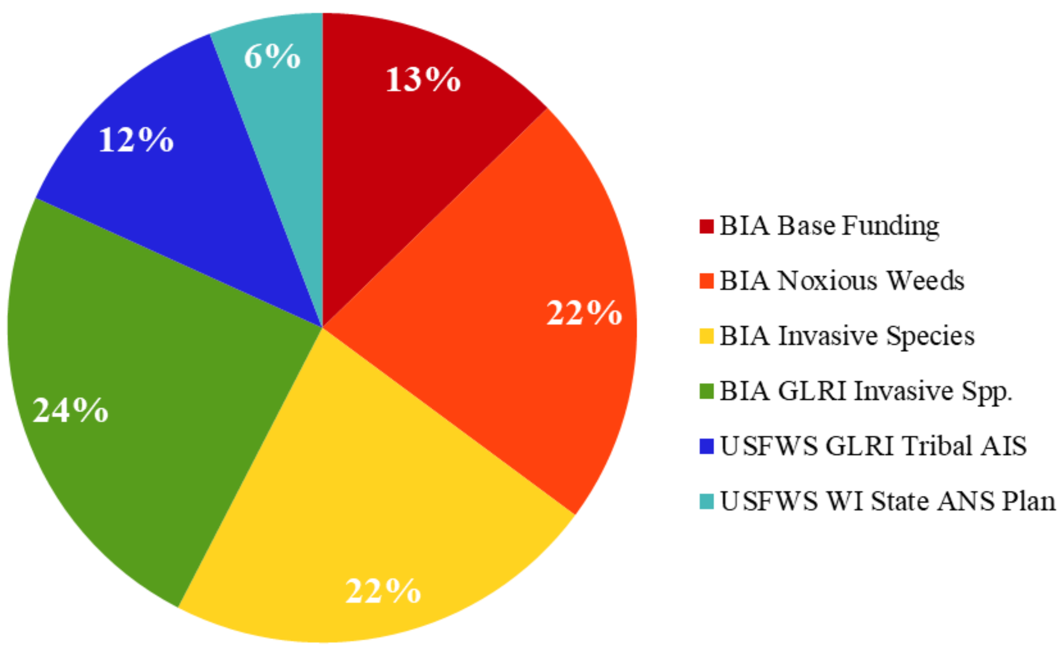

Figure 2: Funding sources for GLIFWC's Invasive Species Program in 2019.

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 2019 included:

- "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 .
- "The health of our lakes depends on everyone." Brief article by Steven Garske. Spring 2019. http://www.glifwc.org/Mazinaigan/Spring2019/index.html?page=2 .
- "11th annual Bad River garlic mustard pull is fast approaching" by Steven Garske. Spring 2019. http://www.glifwc.org/Mazinaigan/Spring2019/index.html?page=6 .
- "15th annual GLIFWC AIS survey just around the corner: Goal is to slow the spread of aquatic invasive species and protect treaty resources" by Steven Garske. Summer 2019. http://www.glifwc.org/Mazinaigan/Summer2019.pdf , page 9.
- "Invasive in focus: the grass carp" by Bill Mattes. Summer 2019. http://www.glifwc.org/Mazinaigan/Summer2019.pdf , page 11.
- "Do common carp like manoomin too?" by Aaron Shultz and Frank Zomer. Summer 2019. http://www.glifwc.org/Mazinaigan/Summer2019.pdf , page 20.
- "Soo Locks replacement project gains traction after 30+ years: Ballast water discharge and aquatic invasive species a concern for Great Lakes biologists" by Paula Maday. Summer 2019. http://www.glifwc.org/Mazinaigan/Summer2019.pdf , pages 7, 14.

- Sidebar with photo - GLIFWC's purple loosestrife control program, by Charlie Rasmussen. Fall 2019. http://www.glifwc.org/Mazinaigan/Fall2019.pdf , page 23.

Events, Presentations and Other Outreach Activities
Activities in 2019 included:

- 1180 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 2019).
- Fish measuring stickers with AIS prevention and tribal regulation information were distributed at tribal registration stations and at GLIFWC events.
- Updated Boat Disinfection Protocol and spiny water flea lake list and map for tribal wardens and harvesters.
- Assisted with invasive species education and garlic mustard (*Alliaria petiolata*) hand pulling event with 14 Northland College students along the Bad River in Mellen, WI (May 14, 2019).
- GLIFWC's invasive species website (http://invasives.glifwc.org/) 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 in 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 2019, 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 19 lakes and a segment of one river for multiple aquatic invasive species (AIS) in northern Wisconsin and eastern Minnesota in 2019 (Figure 3, Table 1). Eighteen 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. Three (Annabelle, Summit and Jag lakes) were chosen because no invasives had been recorded from them (WDNR 2019). Most lakes chosen had high visitation rates or were in close proximity to infested waters.

For the 18 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.

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 all public boat landings and some private boat landings for at least five minutes. The material retrieved by each rake throw was placed in a bin and inspected for invasive plants and animals.

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. Most Wisconsin collections were sent to the Wisconsin State Herbarium (WIS) at UW Madison, with duplicates of some of these collections mounted and accessioned into the GLIFWC herbarium cabinet. The two Minnesota specimens and one northwestern Wisconsin specimen were sent to the University of Minnesota herbarium (MIN) at the Bell Museum of Natural History in St. Paul. 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 were also documented. Location, patch size and other data for native phragmites populations

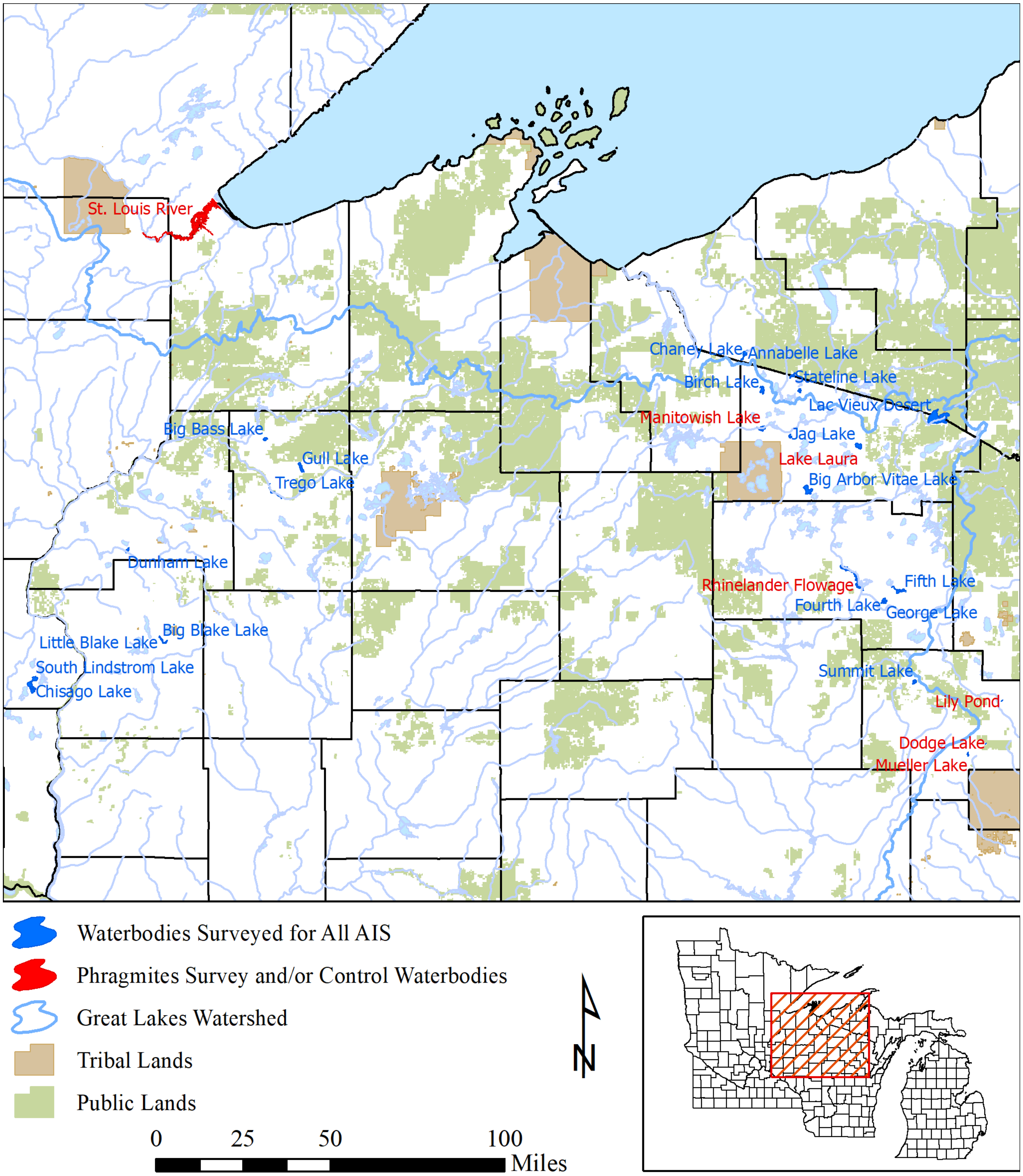

Figure 3: Lakes and rivers surveyed for aquatic invasive species in 2019.

Table 1. Lakes surveyed for aquatic invasive species in 2019. Trophic status of lakes located partly or entirely within Wisconsin was obtained from WI DNR 2019. Trophic status of South Lindstrom Lake was from MN DNR 2019. Trophic status of Chaney Lake (Michigan) and Chisago Lake (Minnesota) was based on our observations, and are followed by "?". 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 Samples
MN	Chisago Lake	13001200	Mississippi	930	June 17-19	All AIS taxa	Eutrophic?	177	1	1
MN	South Lindstrom Lake	13002800	Mississippi	664	June 19-20	All AIS taxa	Eutrophic	187	1	1
MI/WI	Lac Vieux Desert	1631900	Mississippi	4403	June 24-27	EWM and CLP	Mesotrophic	- - - -	0	0
WI	Big Bass Lake	2453300	Mississippi	201	July 1	All AIS taxa	Mesotrophic	59	0	1
WI	Gull Lake	2719400	Mississippi	518	July 2	All AIS taxa	Mesotrophic	102	1	1
WI	Trego Lake	2712000	Mississippi	383	July 3	All AIS taxa	Mesotrophic	163	1	1
WI	Big Blake Lake	2627000	Mississippi	208	July 8-9	All AIS taxa	Eutrophic	194	1	1
WI	Little Blake Lake	2627300	Mississippi	78	July 9	All AIS taxa	Mesotrophic	- - - -	0	0
WI	Dunham Lake	2651800	Mississippi	231	July 10	All AIS taxa	Mesotrophic	143	1	1
WI	George Lake	1569600	Mississippi	443	July 15-16	All AIS taxa	Eutrophic	86	0	1
WI	Fourth Lake	1572000	Mississippi	253	July 16-17	All AIS taxa	Mesotrophic	- - - -	0	1
WI	Fifth Lake	1571100	Mississippi	238	July 16-17	All AIS taxa	Mesotrophic	62	0	1
WI	North Branch Pelican R.	1570100	Mississippi	65	July 16	All AIS taxa	- - - -	- - - -	0	0
WI	Summit Lake	1445600	Mississippi	279	August 5-6	All AIS taxa	Mesotrophic	19	0	1
WI	Jag Lake	1855900	Mississippi	162	August 12	All AIS taxa	Mesotrophic	21	0	1
WI	Big Arbor Vitae Lake	1545600	Mississippi	1070	August 13	All AIS taxa	Eutrophic	103	1	1
WI	Rhinelander Flowage	1580100	Mississippi	1372	August 17	Phragmites	Eutrophic	- - - -	- - - -	- - - -
MI/WI	Stateline Lake	2952100	Lake Superior	205	August 19	All AIS taxa	Mesotrophic	93	0	1
MI	Chaney Lake	31-909	Lake Superior	496	August 20	All AIS taxa	Mesotrophic?	114	1	1
WI	Annabelle Lake	2953800	Lake Superior	194	August 21	All AIS taxa	Mesotrophic	22	0	1
WI	Birch Lake	2311100	Mississippi	506	August 29	All AIS taxa	Mesotrophic	66	0	1

Table 2: "Priority" species for the 2019 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	*Myriophyllum aquaticum*	Parrot feather
Cabomba caroliniana	Fanwort	*Myriophyllum spicatum*	Eurasian water-milfoil
Callitriche stagnalis	Pond water-starwort	*M. spicatum x M. sibiricum*	Hybrid water-milfoil
Crassula helmsii	Australian swamp stonecrop	*Najas minor*	Slender-leaved naiad
Egeria densa	Brazillian waterweed	*Nitellopsis obtusa*	Starry stonewort
Eichhornia crassipes	Water hyacinth	*Nymphoides pelata*	Yellow floating heart
Glyceria maxima	Tall manna grass	*Phragmites australis* subsp. *australis*	Non-native phragmites
Heracleum mantegazzianum	Giant hogweed	*Pistia stratiotes*	Water lettuce
Humulus japonicus	Japanese hop	*Fallopia japonica*	Japanese knotweed
Hydrilla verticillata	Hydrilla	*Fallopia sachalinensis*	Giant knotweed
Hydrocharis morsus-ranae	European frog-bit	*Fallopia* x *bohemica*	Bohemian knotweed
Lysimachia nummularia	Moneywort	*Potamogeton crispus*	Curly pondweed
Microstegium vimineum	Japanese stilt grass	*Trapa natans*	Water chestnut

were added to GLIFWC's database and shared with management partners.

Locations were mapped using 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.

Zebra and quagga mussel veligers were sampled for using vertical plankton tows, following Wisconsin Department of Natural Resources (WI DNR) protocol (WI DNR 2010). Plankton nets (50-cm diameter, 64-micron mesh) were used for these tows. 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.

Unlike the last several years, plankton tows instead of sediment samples were used to sample for waterfleas in 2019. Although the sediment sampling method is considered more reliable for detecting waterfleas (Walsh and Vander Zanden 2016), the Ekman dredge was being used for another project this year and so was unavailable. In early 2020 the AIS program acquired an Ekmann dredge for use in future sampling.

A 50-cm diameter, 250 µm mesh plankton net was used to sample for spiny and fishhook water fleas, following the protocol of Herman and Wickman (2014). Plankton samples were collected by doing a horizontal tow at the deepest part of each lake. A weight was clipped to the bridle ring. Next the net was placed in the water, and allowed to sink for several meters (depending on lake depth). The net was then towed at a low boat speed (about 3 km/hr) for about 120 seconds, covering approximately 100 meters. At the end of the tow the net was pulled out of the water, the weight was removed, and the net rinsed down by dipping the bottom half in the lake. 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, 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 36 new aquatic and wetland invasive species occurrences comprising 7 taxa were found in 2019 (Table 3). Previously unrecorded populations of *Iris pseudacorus* were found on 3 lakes. New water forget-me-not populations were found on 4 lakes, new narrow-leaved and hybrid cattail populations were found on 9 and 6 lakes, respectively, and Eurasian marsh thistle was recorded on 1 new waterbody. One fairly extensive moneywort population was found on and near the shore of Stateline Lake in Vilas County. New purple loosestrife populations were recorded on or very near 4 lakes. Chinese mysterysnail (*Cipangopaludina chinense*) and banded mysterysnail populations were recorded on Chisago and South Lindstrom Lakes.

During the first visit to Trego Lake (on July 3), two isolated plants that appeared to be intermediate (hybrids) between Eurasian and northern water milfoil were recorded and pulled, one just offshore from the west side boat landing and another about halfway between the landing and the south end of the lake. Then a fairly small population was found in a small bay at the south end of the lake. This population was revisited on August 26, and four complete plants were collected. Samples from three of these plants were sent to the Thum Lab at Montana State University in Bozeman, MT, where the identity of the two they tested was verified by genetic analysis as hybrid milfoil. Funding for this testing was provided by the Wisconsin DNR.

A total of 326 EWM and 8 CLP locations were mapped during the early summer survey of Lac Vieux Desert.

Sixteen veliger and 17 water flea plankton tow samples were collected from an equivalent number of lakes during 2019. No zebra or quagga mussel veligers, or spiny or fishhook water fleas were detected in any of the samples.

A small, previously unrecorded (at least by GLIFWC) population of *manoomin* was found in Dunham lake. The patch almost surely originated from a handful of seed tossed into the lake (Peter David, pers. comm. by email, September 9, 2019). Moderate to large populations of *manoomin* on Big Blake and Little Blake Lakes and on Trego Lake were also recorded and photographed for future reference.

Three lakes for which the Wisconsin DNR (WI DNR 2019) had recorded no invasives were surveyed. GLIFWC surveys found no target invasives in two of these three lakes (Summit and Jag Lakes). At Annabelle Lake, however, a fairly small patch of water forget-me-not was found near the boat landing, and the plant was well-established around the parking area and the short road to the landing ramp. A small patch of purple loosestrife was found next to this road as well. The flowerheads were removed from this patch and the patch treated with herbicide a few days later. Finally, a fragment of milfoil resembling hybrid milfoil was found floating near the east side of the largest island. This fragment was collected and pressed for our reference.

Plant collections for 2019 included 4 collections of hybrid water milfoil from Trego Lake. The specimens were sent to WIS, UWSP, and MIN, with the first collection preserved in the GLIFWC herbarium. with a duplicate kept in the GLIFWC herbarium.

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 to fully delineate hybrid water milfoil in Trego Lake, and control efforts initiated. Scharl (2018) recommends treating EWM 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.

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.

According to University of Minnesota biologist Julia Bohnen, volunteers from area Lake Associations also submitted some new non-native phragmites records on Chisago Lake, South Lindstrom and several other area lakes in 2019 (Julia Bohnen, 7-29-2019 email to Dara Unglaube). The Lake Associations were planning to do a lot of treatment in the fall, and had contracted with Mike O'Connell of Lake Management to do the treatment. Apparently they had mapped some of the phragmites sites that we mapped but not all of them, so we were able to supply that data.

As mentioned previously, Annabelle, Summit and Jag Lakes were chosen for sampling because no invasives had been recorded from them (WDNR 2019). All three were fairly shallow lakes with very low conductivity (Table 1) and low water clarity. Annabelle Lake will be revisited in 2020 to verify whether or not hybrid milfoil (and possibly Eurasian milfoil) occur there, and to re-treat the loosestrife population if needed.

Table 3: Aquatic and wetland invasive species found during GLIFWC 2019 survey lakes. Lac Vieux Desert was surveyed for curly-leaf pondweed and Eurasian water-milfoil only. The Rhinlander Flowage yellow iris occurrence was incidental to a phragmites survey.

LOCATION			PLANTS											MOLLUSKS				CRUSTA-CEANS		OTHER	
STATE	COUNTY	LAKE	Curly-leaf pondweed	Eurasian marsh thistle	Yellow iris	Moneywort	Purple loosestrife	Water forget-me-not	Eurasian water-milfoil	Hybrid water-milfoil	Narrow-leaf cattail	Hybrid cattail	Eurasian phragmites	Zebra mussel	Banded mystery snail	Chinese mystery snail	Japanese mystery snail	Spiny waterflea	Rusty crayfish	Freshwater jellyfish	Heterosporis sutherlandae
MI	Gogebic	Chaney Lake					G				G										
MI	Gogebic/ Vilas	Stateline Lake			G	G		G			G								X		
MI	Gogebic/ Vilas	Lac Vieux Desert	X						X												
MN	Chisago	Chisago Lake	G				G		X, G		G		G		G	G					
MN	Chisago	South Lindstrom Lake	G				G		X, G		G	G	G		G	G					
WI	Burnett	Dunham Lake	X, G								G					X, G					
WI	Langlade	Summit Lake																			
WI	Oneida	Fourth Lake			G										X*	X, G			X		
WI	Oneida	Fifth Lake		G				G							X						
WI	Oneida	George Lake						X*, G							X*	X			X		
WI	Oneida	Rhinelander Flowage			G																
WI	Polk	Big Blake Lake	X, G								G	G			X	X, G					
WI	Polk	Little Blake Lake	X*, G									G			X, G	X, G					
WI	Vilas	Annabelle Lake					G	G													
WI	Vilas	Big Arbor Vitae Lake	X												X, G	X, G			X		
WI	Vilas	Birch Lake						X*, G			G	G			X*, G	X, G			X		
WI	Vilas	Jag Lake																			
WI	Washburn	Big Bass Lake														X, G					
WI	Washburn	Gull Lake									G	G			X, G	X, G					
WI	Washburn	Trego Lake	X, G		G			G		G	G	G				X, G	X, G				

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

PHRAGMITES

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 2019. 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.

In 2019 GLIFWC assisted CAD with phragmites treatment on the Minnesota side by transporting their control crew (Ron Gurno and Eben Phillips) to 8 sites so they could treat them with herbicide. GLIFWC also drove them to two inland sites, one in a remnant wetland in Hermantown and the other along the County Highway 7 corridor near Zim, about 70 miles north-northwest of Duluth.

GLIFWC staff continued to monitor and control phragmites sites on the Wisconsin side of the river in 2019. Staff 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, which oversees phragmites management activities on the river.

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.

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

A total of 60 miles of roadsides were surveyed for phragmites in 2019 (Figure 4). About 12.8 miles of the Rhinelander Flowage shoreline were also surveyed for phragmites, and a population of phragmites previously reported to the Wisconsin DNR was verified.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 imazapyr (Polaris®) herbicide with backpack sprayers or by hand swiping the shoots. (CAD crews also used Habitat®, also an imazapyr formulation.) GLIFWC crews also treated a number of other sites across northern Wisconsin with Polaris®.

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 2019 GLIFWC staff monitored a total of 94 phragmites sites, including 24 considered to be on the Minnesota side of the river and 70 on the Wisconsin side of the river (Figures 4 and 5). Live phragmites shoots were found at 19 of the Wisconsin sites and 14 of the Minnesota sites.

Twenty-two of the 24 Minnesota sites were along the St. Louis River (Figure 5). Nine of these sites had live phragmites shoots and were treated by CAD, with logistical support from GLIFWC. (There are a number of other extant sites on the Minnesota side of the river as well.) The other two Minnesota sites were north of Duluth, in Hermantown and Zim. These were also treated by CAD, with GLIFWC providing transportation. About 26 additional phragmites patches on the Minnesota side of the river were treated with herbicide by CAD.

Along the Wisconsin side of the St. Louis River, 23 sites were monitored. Only 5 of these sites had live phragmites shoots, down from 15 sites in 2018. All 5 sites were treated by hand-swiping the shoots.

The water level of Lake Superior was officially just below last summer's record levels during this year's survey (GLERL 2020). The St. Louis River was clearly even higher than 2018 though, with marshy wetlands (two of which needed to be traversed to control phragmites patches) clearly deeper than last year, and last year's partly inundated sandbars now totally underwater. This includes the long sandbar island ("Kilchlis Meadow") just west of Chase's Point, which was only partly inundated last year but completely underwater this year.

On the west side of Chequamegon Bay in Wisconsin, 24 were monitored by GLIFWC, with Red Cliff staff monitoring an additional 6 sites that were on their reservation. Of these 30 sites, 11 required treatment.

Elsewhere in northern Wisconsin, 23 previously recorded sites representing 14 populations were monitored, and 9 of these sites representing 6 populations were treated. The County BB site in northwestern Douglas County still had between 51 and 100 shoots, although the shoots were shorter. All of the shoots were hand-swiped, as requested by the landowners. As in 2017 and 2018 no live phragmites was found on the north side of BB a little west of this site, where a small patch had once been.

In 2018 GLIFWC treated the Manning Motel population by swiping the shoots with herbicide. Follow-up monitoring in 2019 found no live shoots at this site. As in 2018 there were also no live phragmites shoots at the site of the previously treated variegated patch in Price County.

According to BNSF Senior Environmental Manager, Suzanne Hattenberger, the population GLIFWC found on Burlington Northern Santa Fe Railway Company (BNSF) land was treated sometime in late spring or summer of 2019 by their vegetation control team (email from Hattenberger to Dara Unglaube, September 11, 2019). Their team revisited the site on September 6, 2019 and treated the remaining handful of shoots. We will continue to communicate with Hattenberger and remind BNSF to monitor this population annually to make sure it is eradicated.

Two phragmites populations treated by the WI DNR several years ago and by GLIFWC in 2018 were revisited in 2019. The Manitowish Lake population (two patches) in Vilas County was significantly sparser that the year before, and was again treated with herbicide. The population on private land just west of Minocqua in Oneida County consisted of around 20 suppressed shoots and was again treated by swiping the shoots with herbicide.

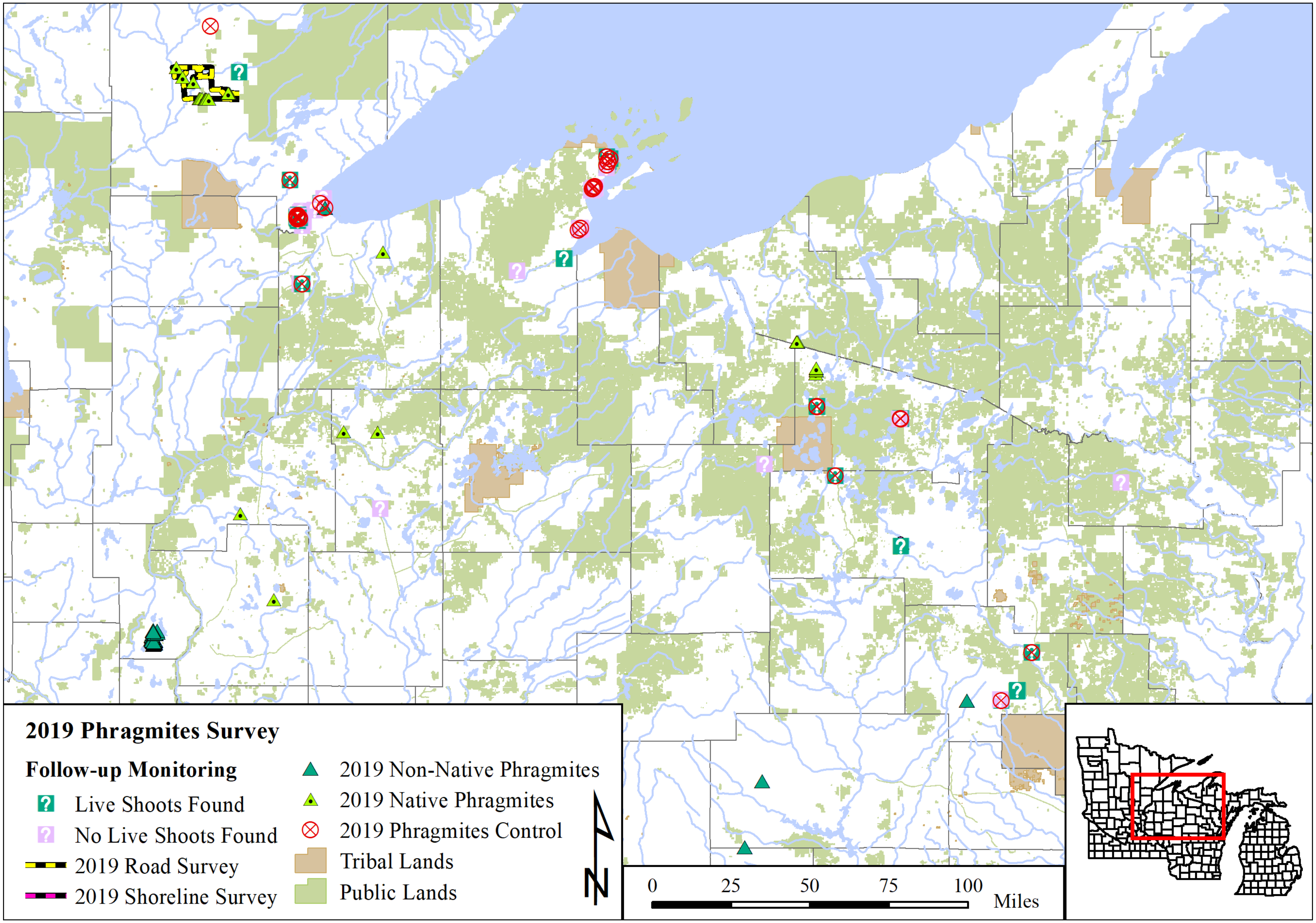

Figure 4: Overview of phragmites 2019 survey routes, monitoring, occurrences and treatment sites. The native phragmites and non-native phragmites occurrences are new records. The shoreline survey covered most of the Rhinelander Flowage shoreline in Oneida County.

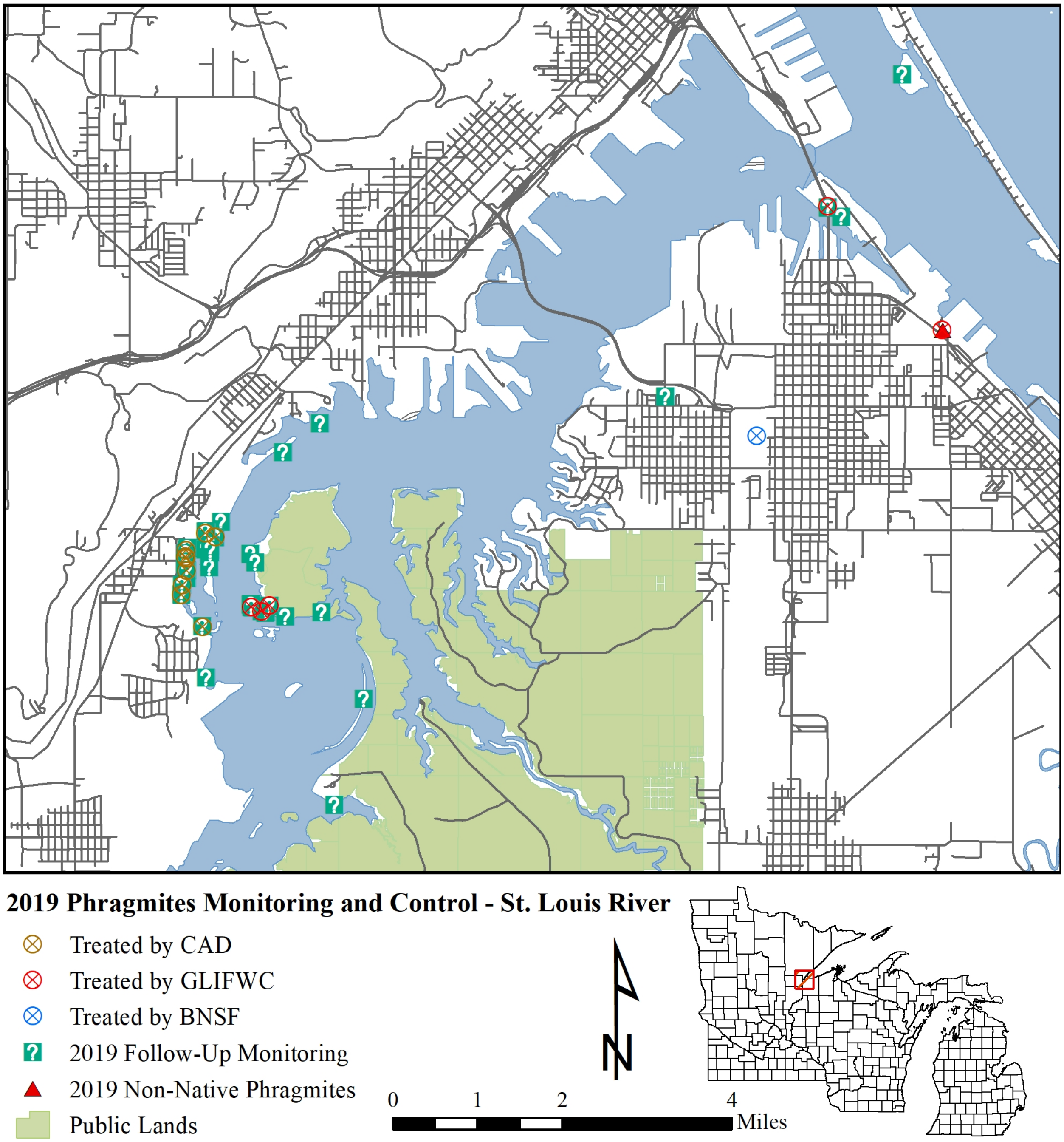

Figure 5: 2019 Phragmites occurrences and treatment sites. Minnesota sites were treated by CAD, with transportation provided by GLIFWC. Wisconsin sites were treated by GLIFWC, except for the BNSF railroad yard site. No live phragmites was found at the untreated follow-up monitoring sites.

In 2017 GLIFWC surveys found a large population of non-native phragmites on Lake Laura in Vilas County. In 2018 the main population was treated with glyphosate, though one small patch in shallow water was dug up with a shovel. Only about 12 shoots were found in 2019, and these were all swiped with herbicide. (The small patch that was treated manually was gone.)

Three previously known populations went untreated in 2019. The small US Highway 2 population west of Ashland had a few shoots in early summer but the site was subsequently mowed before it could be treated. The similar-sized population on the shoulder of a gravel road near Patten Lake in Florence County that was treated in 2018 was also mowed in 2019, before it could be monitored. The Dodge Lake population in Langlade County was monitored again – lake levels were even higher than in 2018 and appeared to be suppressing the population there, but the population remains untreated.

Chisago and South Lindstrom Lakes in Chisago County were surveyed in June 2019. Non-native phragmites was common along much of the shoreline of these two connected lakes. A total of 51 non-native phragmites sites were recorded there. A collection was made from one of the Chisago Lake populations and sent to MIN. Soon after these surveys it was learned that volunteers from the local lakes associations had been mapping non-native phragmites occurrences on these and other regional lakes in 2019, according to University of Minnesota biologist Julia Bohnen (July 19, 2019 email to GLIFWC Data Manager Dara Unglaube). They had apparently mapped some but not all of the phragmites sites that we mapped, so Unglaube forwarded the GLIFWC data to them. At the time they were planning on doing some herbicide treatments in the fall of 2019.

Two new Wisconsin non-native phragmites sites were recorded by GLIFWC in 2019. Both were fairly small (on the order of 1000 shoots but well under 0.25 acre). One new site in an industrial area of Superior (Douglas County) was subsequently treated with herbicide. The other new site inhabited a disturbed open area on the northeast side of Antigo (Langlade County). Two additional sites were recorded in December 2019: one in an open area on the north side of Marshfield, and another in a ditch along State Highway 97 about 18 miles north of Marshfield (both Marathon County). Both these sites had been previously reported to the Wisconsin DNR in fall of 2018 (WI DNR-BWQ 2020).

The small patch on the east side of Mueller Lake that was discovered by GLIFWC in 2018 was retreated in 2019. No live shoots were found at the site of the patch on the northwest side of Mueller Lake (Langlade County) next to the landing.

Approximately 6.0 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 2019 was similar to 2018 (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 responses among management partners. Sites treated in 2019 were also uploaded.

Discussion

The fact that only 5 of the more than 20 phragmites sites on the on Wisconsin side of the St. Louis River had live shoots in 2019 was very encouraging. All of the former sites on the Wisconsin side were monitored in 2017, and sites with live shoots were treated again. However, some of the sites that didn't have live shoots haven't been visited since then. The entire Wisconsin side should be resurveyed in 2020 to check these sites, as well as look for new sites that may have been initiated by propagules (such as the chunk of phragmites sod found on Kilchlis Meadow in 2018) since then.

As long as the phragmites stands on the Minnesota side of the river persist, this plant will continue to spread along the river. GLIFWC plans to continue to support CAD's efforts to control and hopefully eradicate non-native phragmites on the Minnesota side of the river and in northeast Minnesota.

The Dodge Lake (Langlade County) phragmites population is concerning. GLIFWC has informed both the Wisconsin DNR and the Timberland Invasives Partnership (TIP) of the presence of this population. These entities will be contacted again before the 2020 field season to hopefully come up with a management plan for non-native phragmites in this small, undeveloped seepage lake.

The Bad River Natural Resource Department removed the flowerheads from the phragmites population in the Kakagon Slough in 2019, but didn't treat it with herbicide (José Estrada, pers. comm., January 31, 2020).

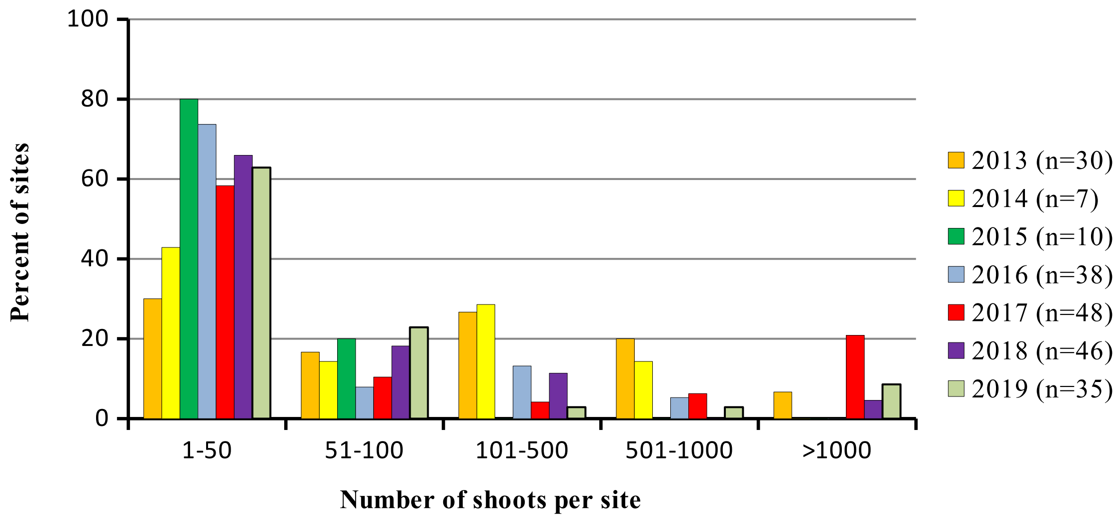

Figure 6: Abundance of non-native phragmites shoots, at sites treated from 2013 through 2019. One 2016 site lacking abundance data was omitted.

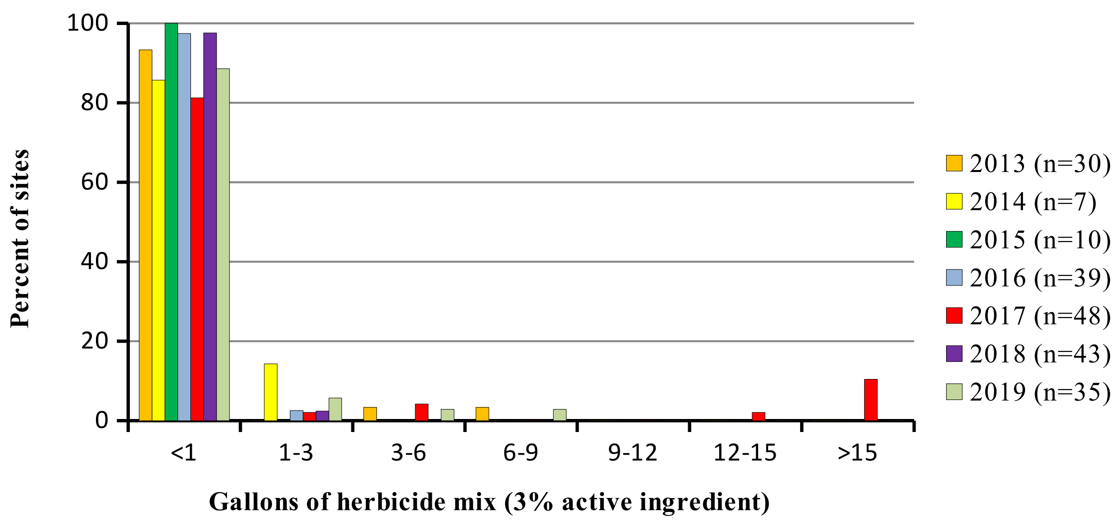

Figure 7: Amount of herbicide mix applied to non-native phragmites, at sites treated from 2013 through 2019. Three sites received some form of manual treatment in 2018.

TEASEL

Introduction

Common and cut-leaved teasel (*Dipsacus laciniatus* and *D. fullonum*) are closely related species that are established in 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: In 2019 GLIFWC crews controlled populations primarily manually. 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 part of one population (Stage North in Washburn).

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 2019, five common or cut-leaf teasel populations (recorded as 13 sites) were resurveyed and treated. This included a new population/site of over 100 plants, in an untended backyard in Ashland. Part of the Washburn population was chemically treated, and the rest was manually treated. With only a handful of plants, the Anderson Motel site in Ashland was manually treated. The new Ashland population and the Marengo population were both manually treated as well, as requested by the respective landowners. A population next to the entrance to the Wisconsin DNR office in Ashland that was thought to be eradicated reappeared and was manually treated.

Figure 8 illustrates the distribution of detected occurrences and control efforts. Figure 9 shows the abundance of teasel at each treatment site.

Discussion

With only five known locations 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. GLIFWC plans to continue to monitor these small teasel sites and (manually) treat them until they are eradicated.

Teasel is common along highways, in open fields, and similar sunny habitats across much of southern and eastern Wisconsin. While clearly still uncommon to rare in northern Wisconsin, new populations will undoubtedly eventually be detected. GLIFWC and partners must remain vigilant.

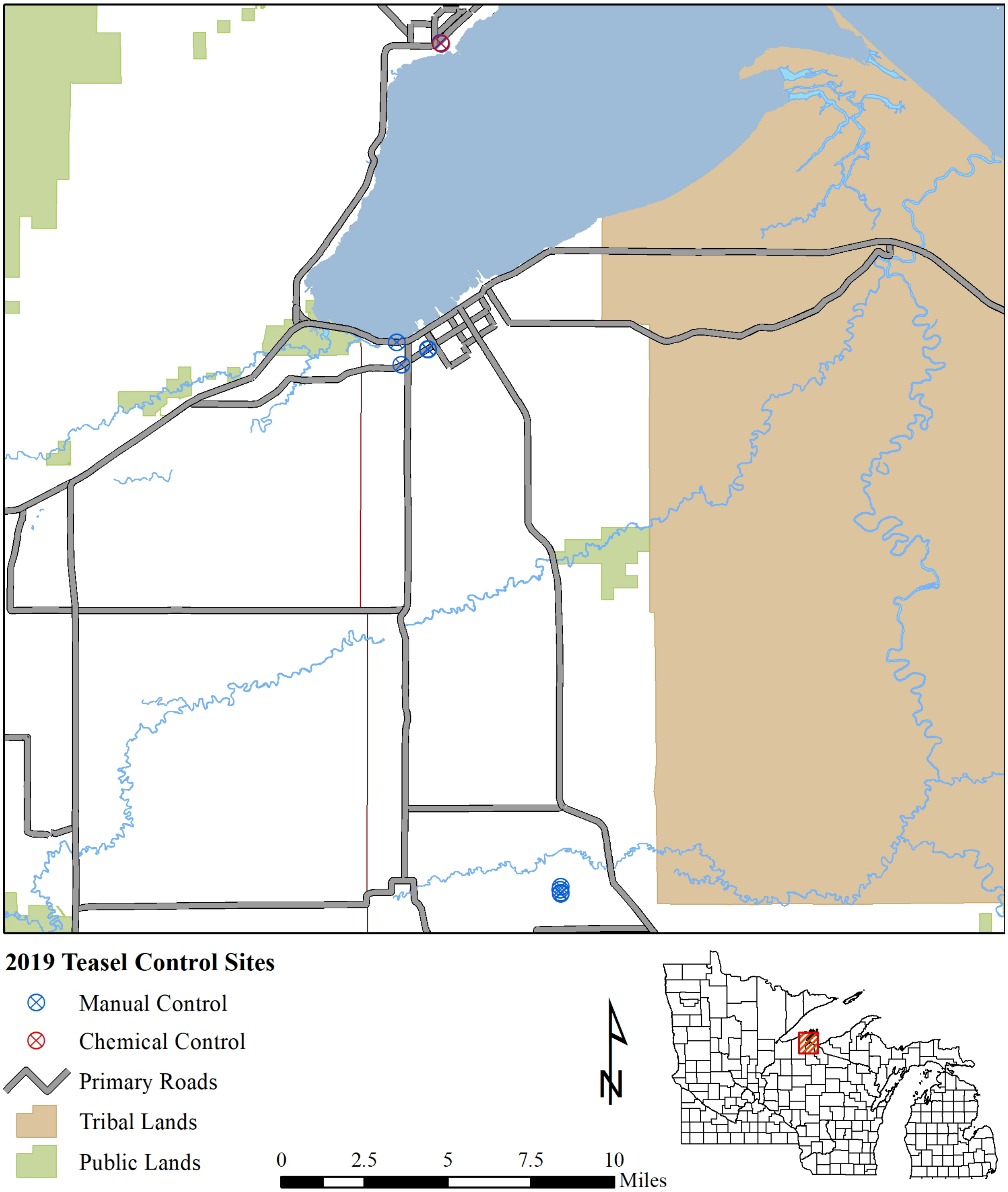

Figure 8: 2019 teasel control efforts.

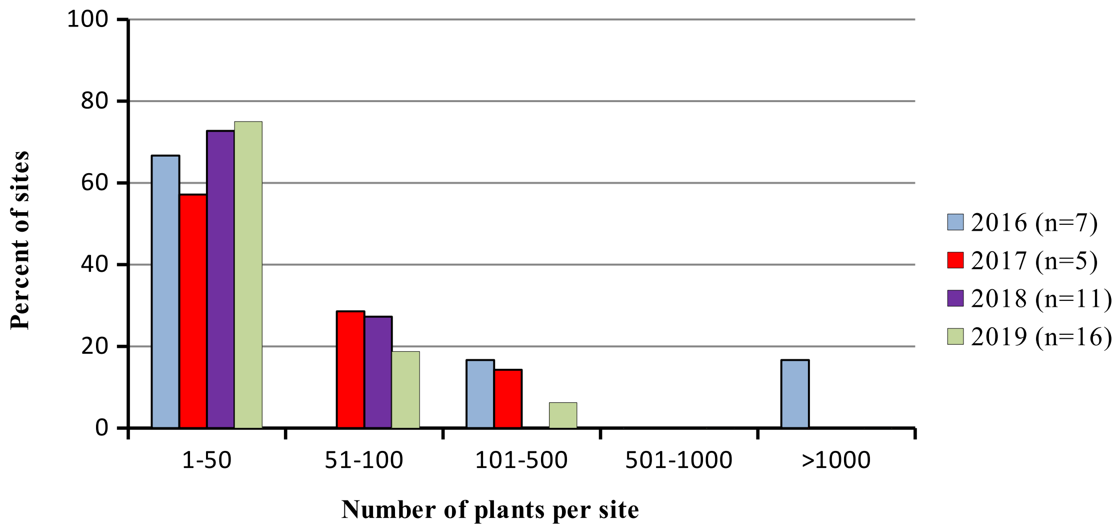

Figure 9: Abundance of common and cut-leaf teasel at sites treated from 2016 through 2019. The 11 sites represent three populations (see text).

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. One site was treated manually. 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 or 2019, though two additional sites were recorded by GLIFWC, both in Ashland. Cooperators at the NCWMA recorded 6 additional sites in 2019, 5 in Iron County and one in Bayfield County.

GLIFWC staff worked alone and cooperatively with partners to treat 157 wild parsnip sites in 2019, with partners treating an additional 13 sites. All these sites were within Iron, Ashland and northeast Bayfield Counties.

Figure 10 illustrates the distribution of detected occurrences and control efforts in 2019. 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 2019.

Discussion

In 2016 GLIFWC initiated survey and treatment efforts for wild parsnip in northern Wisconsin. Since then, follow-up treatment has been conducted in cooperation with multiple partners.

Of the 157 wild parsnip sites that GLIFWC treated in 2019, 22 were within the boundary of the Bad River reservation. These were treated with the cooperation Bad River Natural Resources staff. GLIFWC crews treated 65 sites in Ashland County near the towns of Marengo and High Bridge. As in previous years GLIFWC staff assisted the Iron County LWCD in treating an 0.9 mile long stretch of wild parsnip along State Highway 77 just east of Upson.

Overall the estimated size (in terms of number of shoots) of patches treated by GLIFWC in 2019 was smaller on average than those treated the previous three years (Figure 11). This continued the downward yearly trend since treatment began in 2016.

Despite substantial effort by GLIFWC and partners to control wild parsnip, this plant continues to spread. While control efforts in the established control area will presumably continue in 2020, it is unlikely that sites outside this area can be included in treatment efforts in the near future.

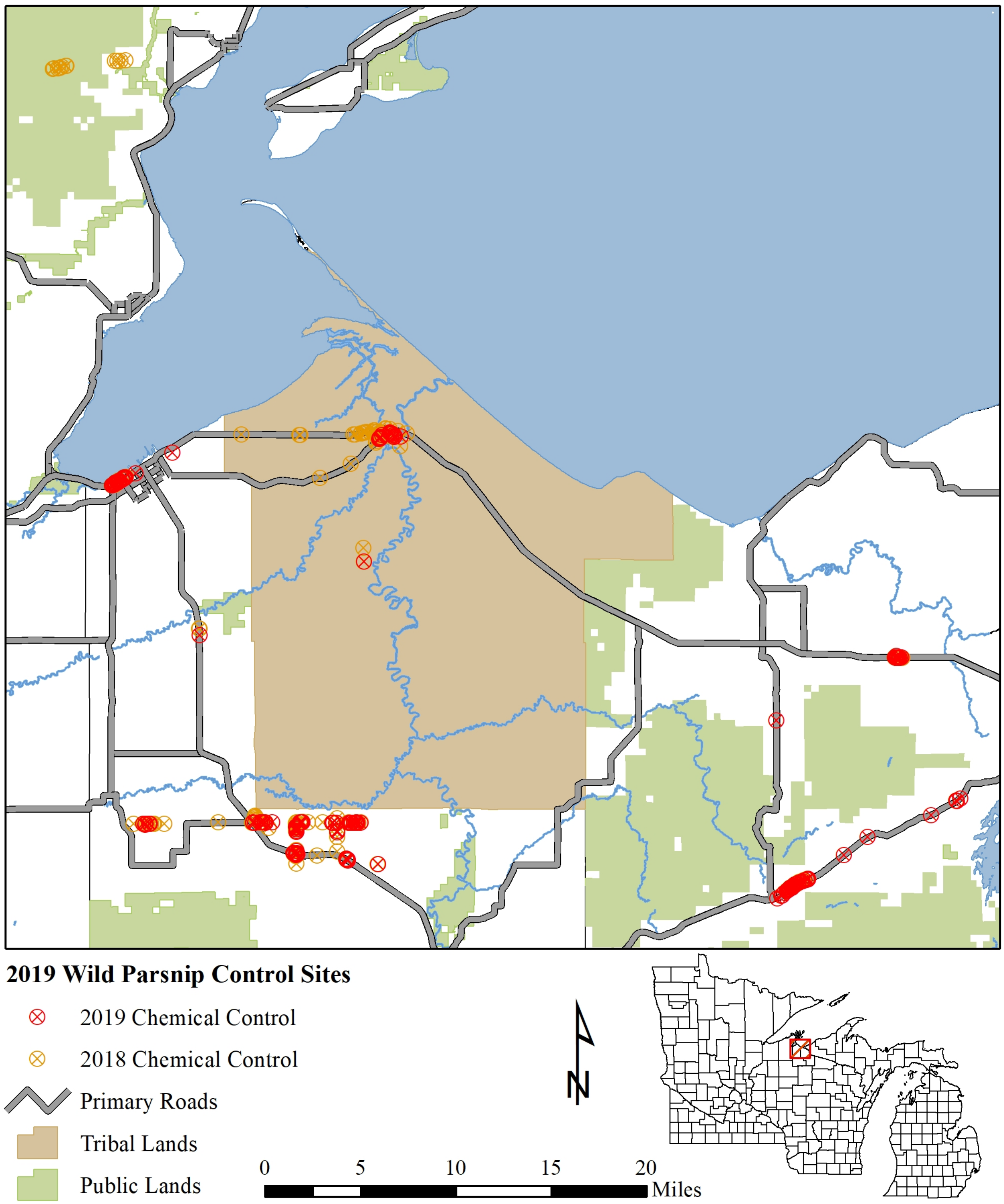

Figure 10: Wild parsnip control sites in 2018 and 2019.

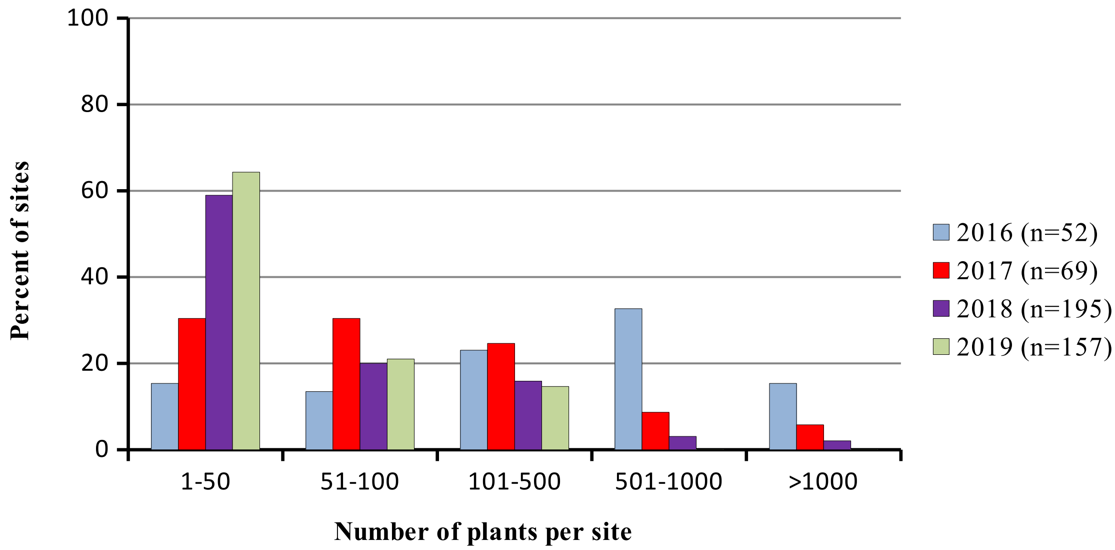

Figure 11: Abundance of wild parsnip at sites treated from 2016 through 2019.

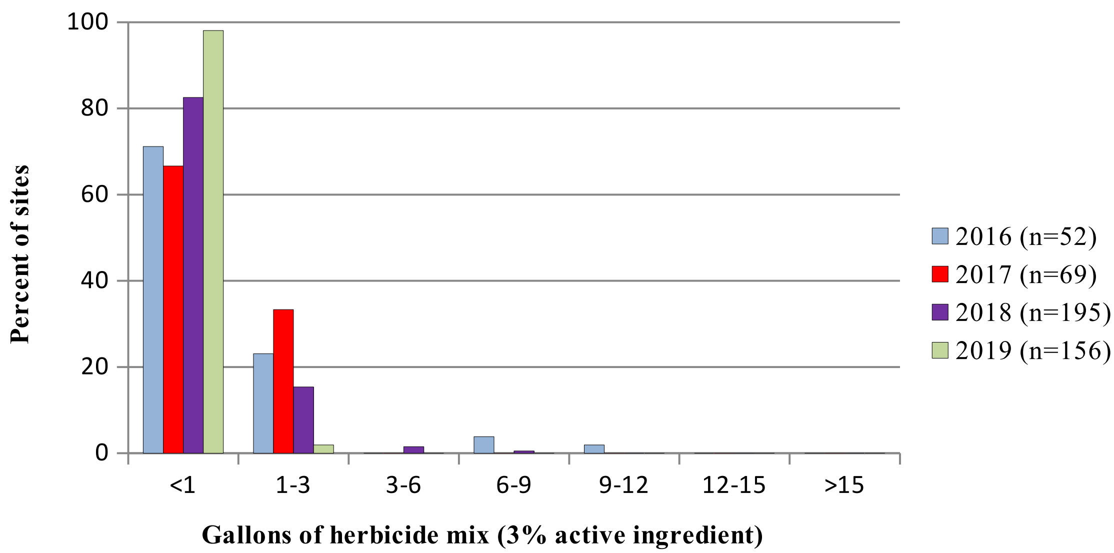

Figure 12: Amount of herbicide mix applied to wild parsnip sites treated from 2016 through 2019. One population was treated manually in 2019.

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 yellow iris 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 in the bay were treated in 2016. As in previous years, Isopropylamine salt of imazapyr (Polaris®) was used for chemically treating yellow iris sites.

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 21 yellow iris sites were recorded by GLIFWC in 2019. Two of the sites were within the Fish Creek slough. Of the rest, 16 occurred on Trego Lake in Washburn County, with one each on three inland lakes. Five more sites were recorded by partners in 2019.

A total of 23 yellow iris sites were treated by GLIFWC in 2019, all chemically. All of these treatment sites were in the Fish Creek slough or the adjacent Chequamegon Bay wetlands (Figure 13). All “plants” consisted of clumps with an estimated 50 leaves/shoots or less (Figure 14). Less than one gallon of herbicide was used at each site. Two additional sites were treated by partners, both in Iron County.

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 many 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, where some patches are obviously being cultivated. Nonetheless, consideration should be given to treating yellow iris on lakes where the populations are still small.

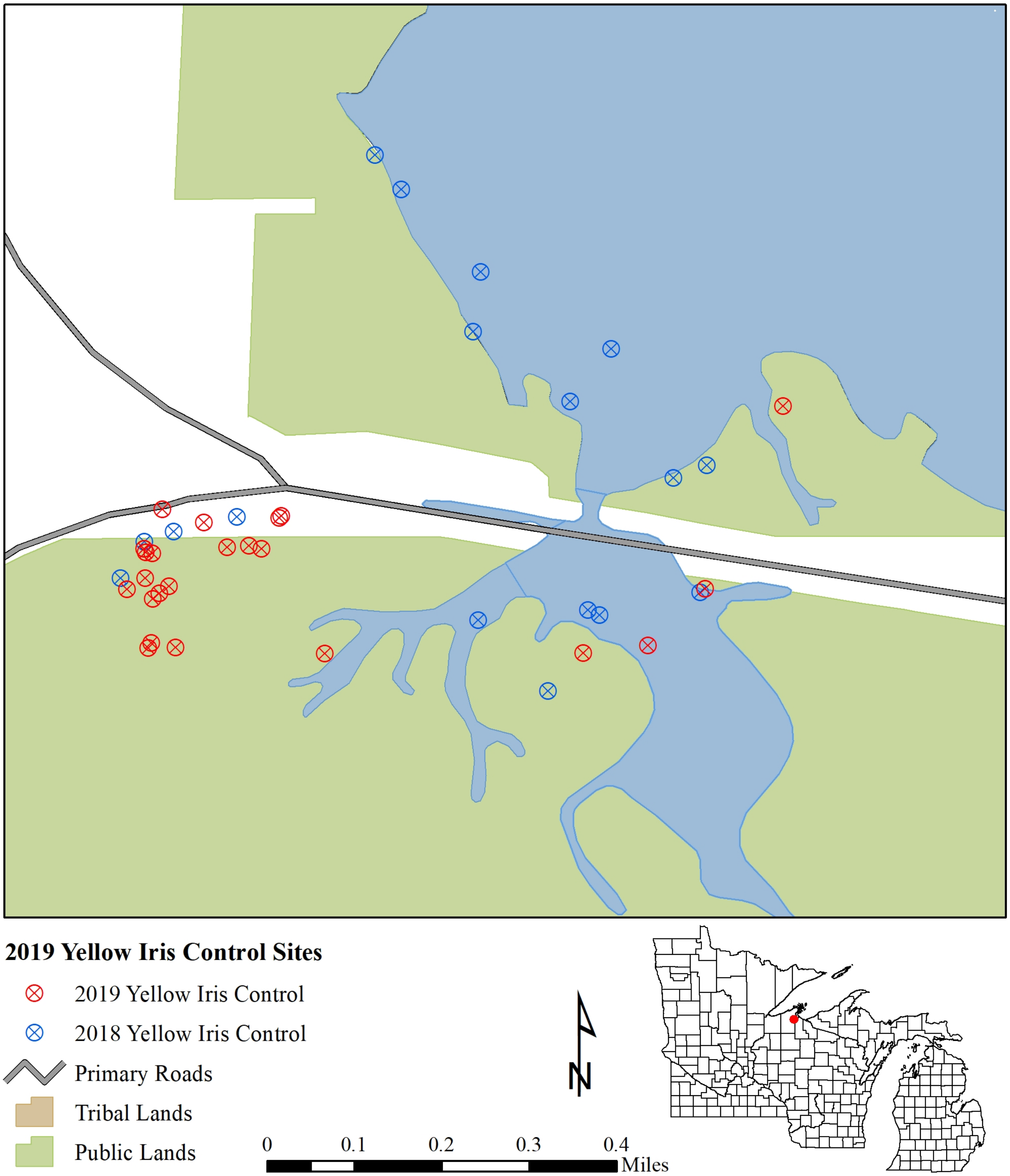

Figure 13: Yellow iris occurrences and control sites in 2018 and 2019.

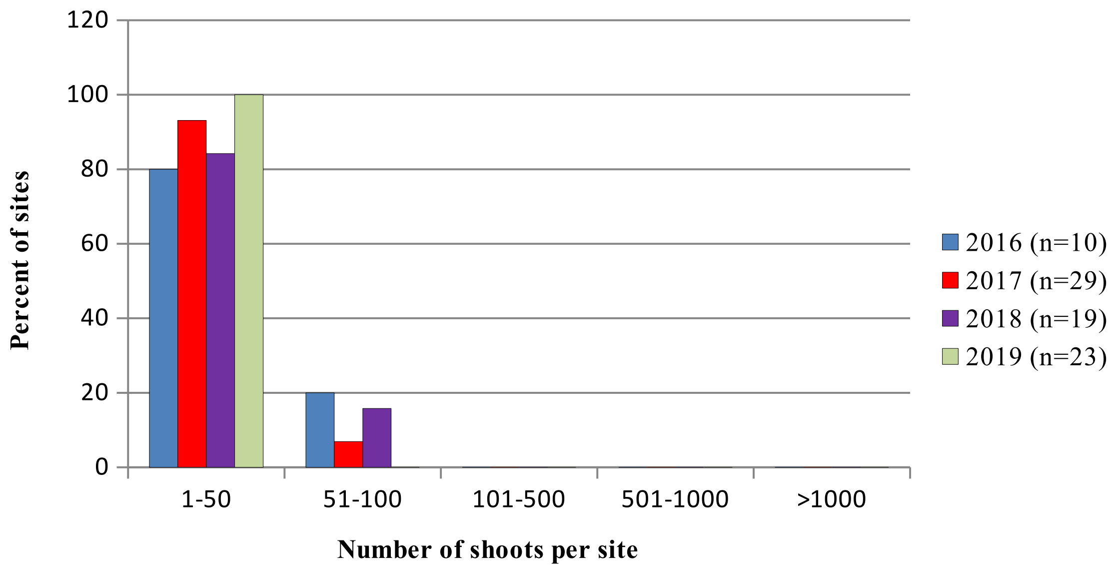

Figure 14: Abundance of yellow iris, at sites treated from 2016 through 2019.

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 course, 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

<u>Surveys</u>: 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.

<u>Control:</u> 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 25 Dalmatian toadflax control sites were treated with herbicide in northeastern Bayfield Countyin 2019 (Figure 15). All of these sites were along Whiting Road. All of the treated populations were estimated to cover less that 0.25 acre, and only one was estimated to include more than 1000 plants (Figure 16). Twenty-three of the 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 13 years) has passed since this toadflax population was delineated, the Bayfield area should be surveyed again, to update the extent of known populations and to map new sites. The effectiveness of the 2018 and 2019 herbicide treatments should also be evaluated. Some of the known sites apparently extend beyond the road right-of-way, so landowner permission will be needed 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 GLIFWC management efforts.

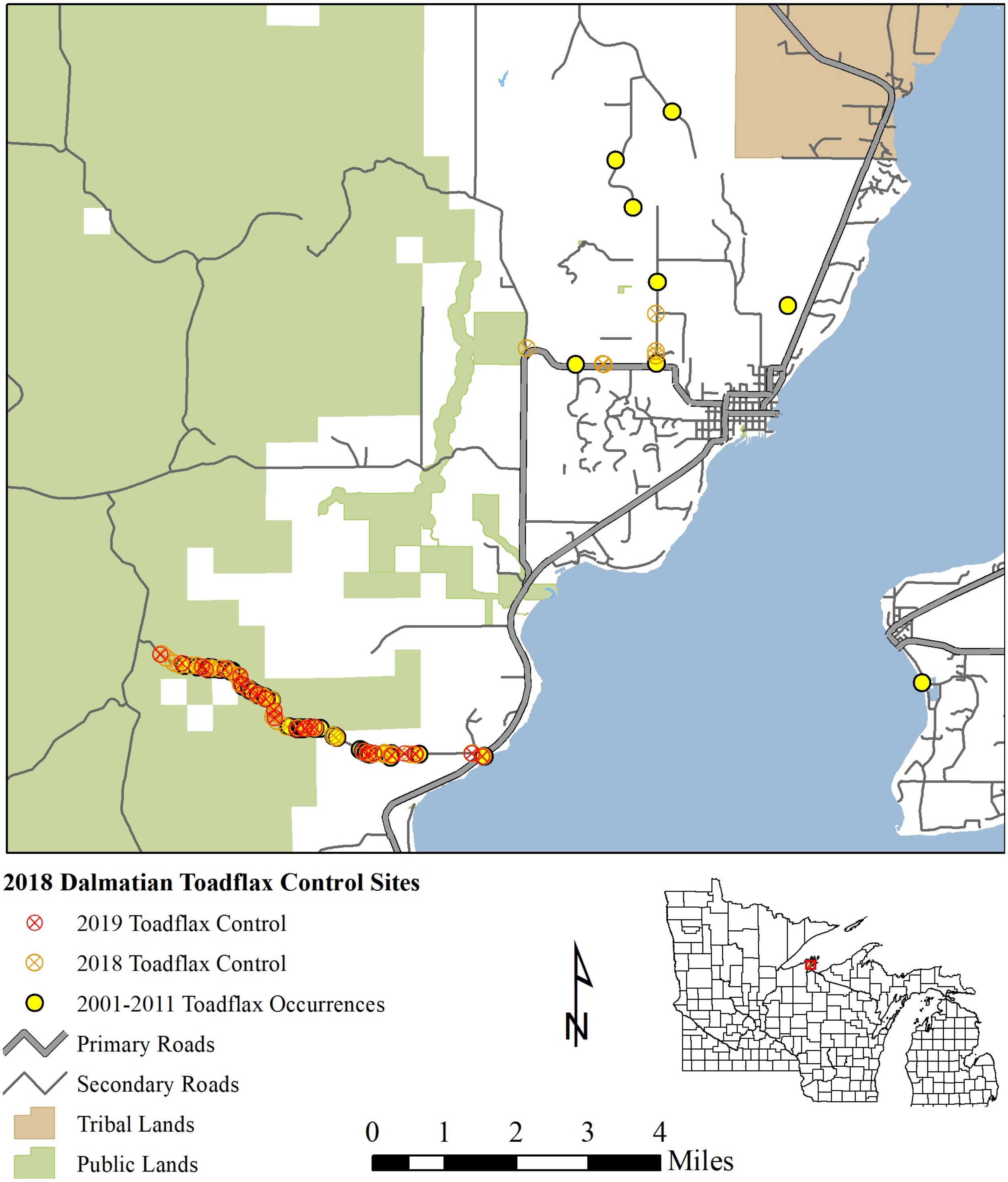

Figure 15: Dalmatian toadflax occurrences, and 2018 and 2019 control sites.

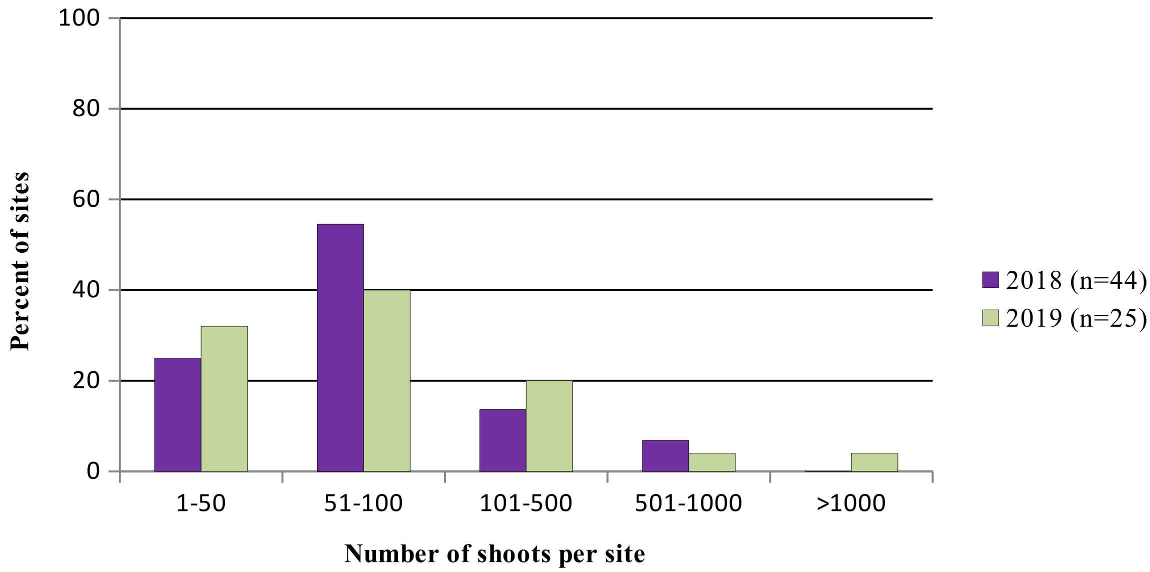

Figure 16: Abundance of Dalmatian toadflax at sites treated in 2018 and 2019.

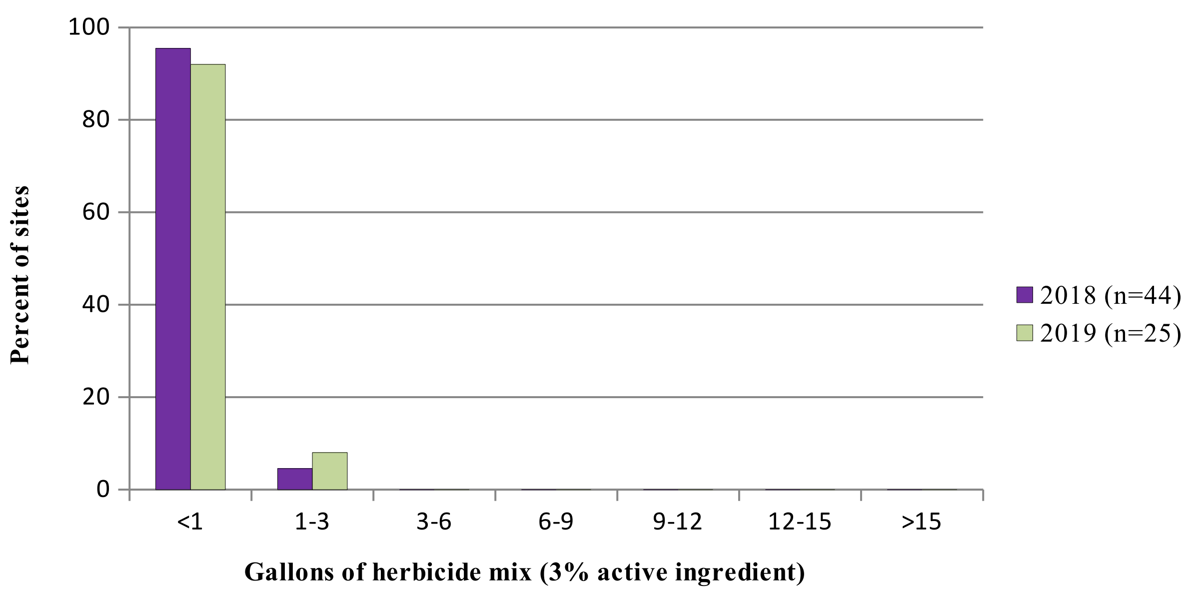

Figure 17: Amount of herbicide mix applied to Dalmatian toadflax sites treated in 2018 and 2019.

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: 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 29 spurge sites were treated in 2019 (Figure 18). Herbicide was applied to 27 leafy spurge sites and 2 cypress spurge sites in northwestern Iron, northern Ashland and northeastern Bayfield Counties. All but one of the treated populations were estimated to cover less that < 0.25 acre (Figure 19).

Twenty-three of the spurge sites required <1 gallon of herbicide, with 6 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 August 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.

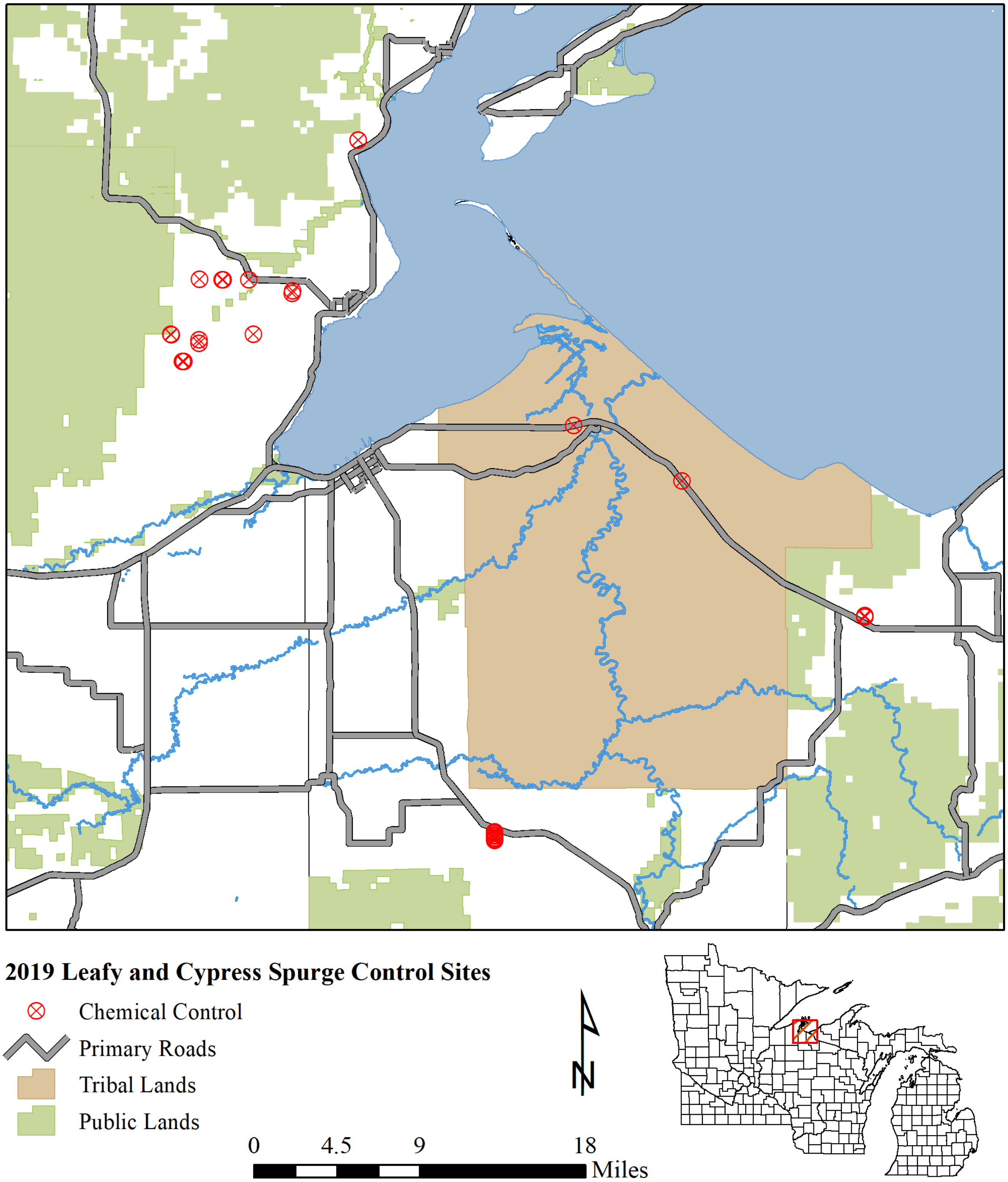

Figure 18: 2019 leafy and cypress spurge control sites.

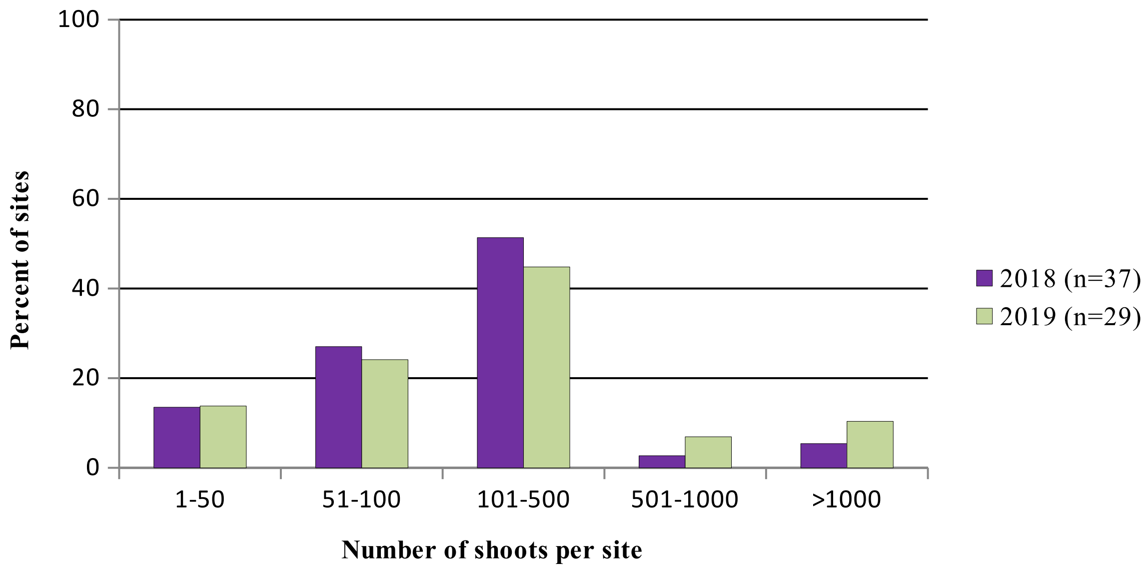

Figure 19: Abundance of spurge at sites treated in 2019. Three 2018 and two 2019 sites consisted of cypress spurge.

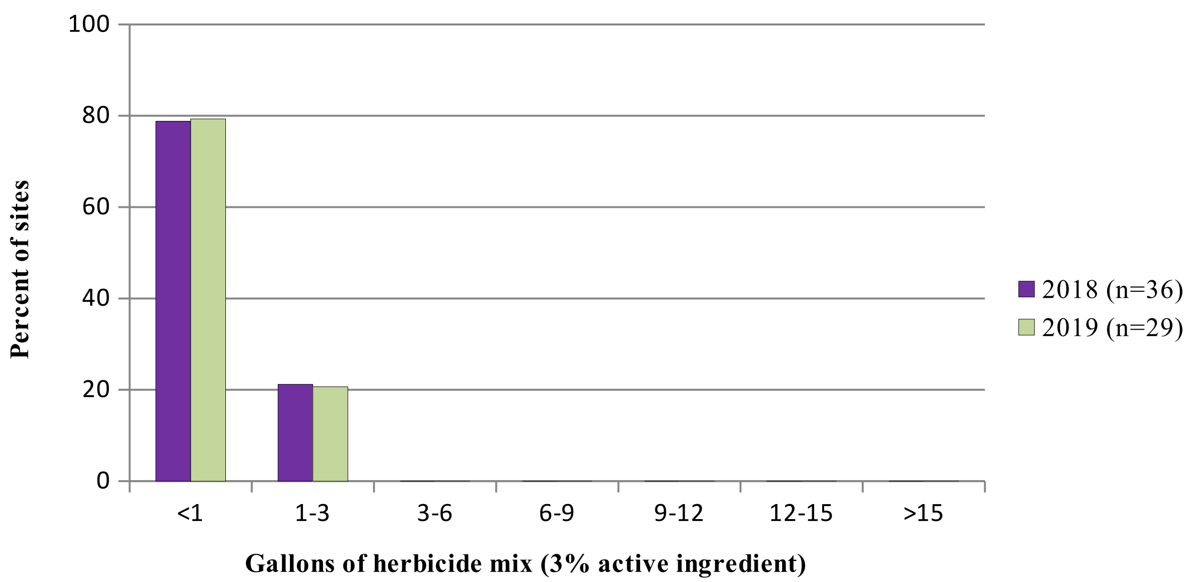

Figure 20: Amount of herbicide mix applied to leafy spurge sites treated in 2018 and 2019. Three 2018 and two 2019 sites consisted of cypress spurge. One 2018 leafy spurge biocontrol site was omitted.

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, with the first North American releases made 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 2019 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 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.) Unlike the previous two years, no chemical control was done on the site in 2019.

Results

A total of 152 garlic mustard sites were recorded within the Mellen control area on the Bad River floodplain. Manual control was conducted on at least 108 of these sites. Because the garlic mustard plants were so sparse, no chemical treatment was done on the site in 2019.

Three new locations were recorded by GLIFWC staff, one downstream of the main population on the Montreal River floodplain and two in Ashland. All three were hand-pulled.

GLIFWC staff followed up with manual control on 6 known Ashland sites. As for the last two years, GLIFWC assisted NCWMA partners with hand-pulling at the Kimball site south of Superior.

Figure 21 gives an overview of the distribution of detected occurrences and control efforts in 2019. Figure 22 shows the distribution of garlic mustard on the 70-acre treatment site and upstream of Mellen (2016 data), along the Bad River floodplain.

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.

The NCWMA took the lead for survey and management efforts along the Bad River in Mellen, with GLIFWC providing significant support. NCWMA cooperators lead management efforts on most of the rest of the 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.

Recent internet searches for new developments regarding the release of the root crown miner in Ontario, or recent progress towards the release of this weevil in the US have found almost no relevant information. Meanwhile the NCWMA and GLIFWC seem headed towards attempting to treat at least portions of the extensive garlic mustard population in and upriver from Mellen. The NCWMA and GLIFWC will also continue to treat the recently discovered populations in Ashland.

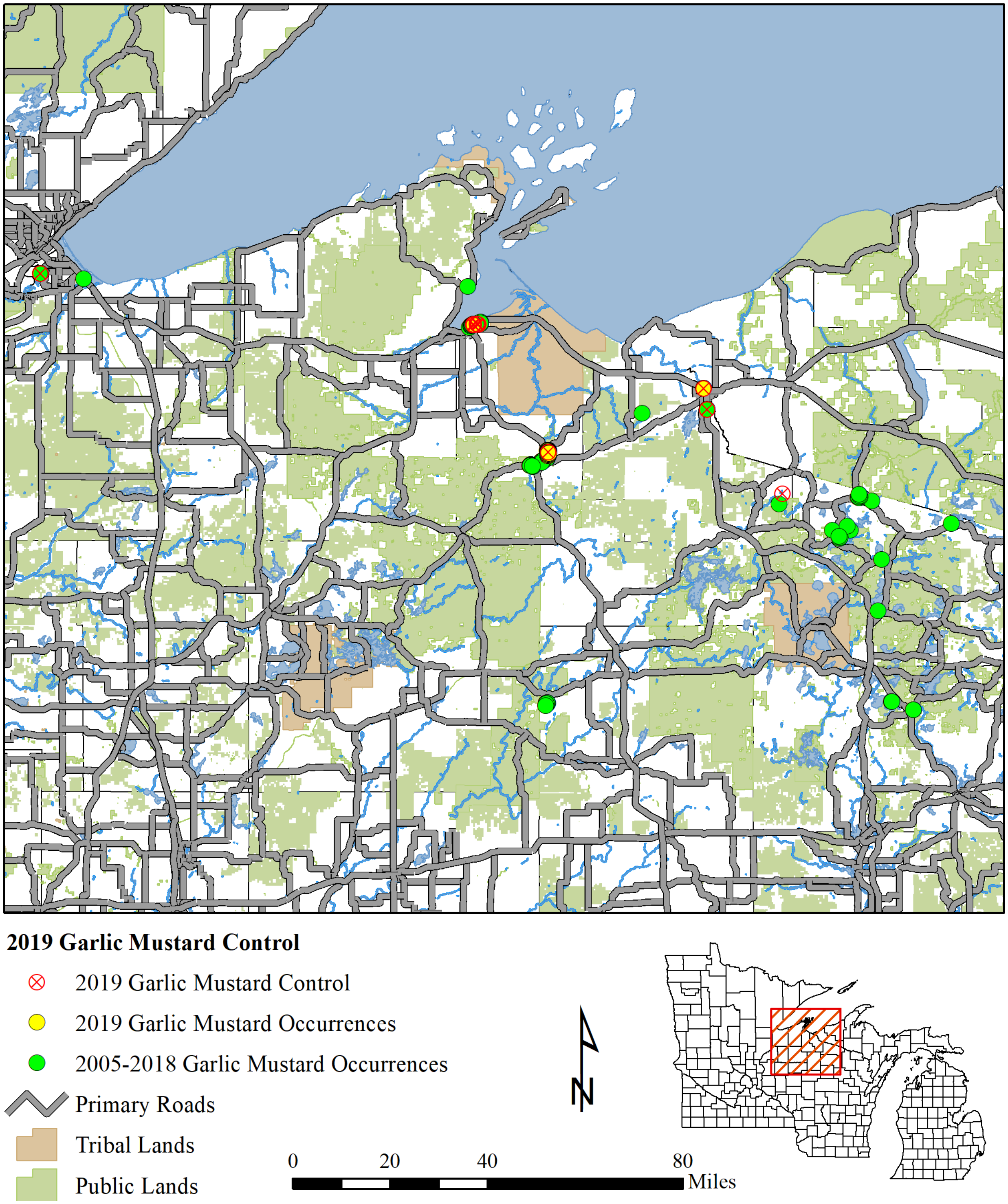

Figure 21: Garlic mustard occurrences and 2019 management efforts.

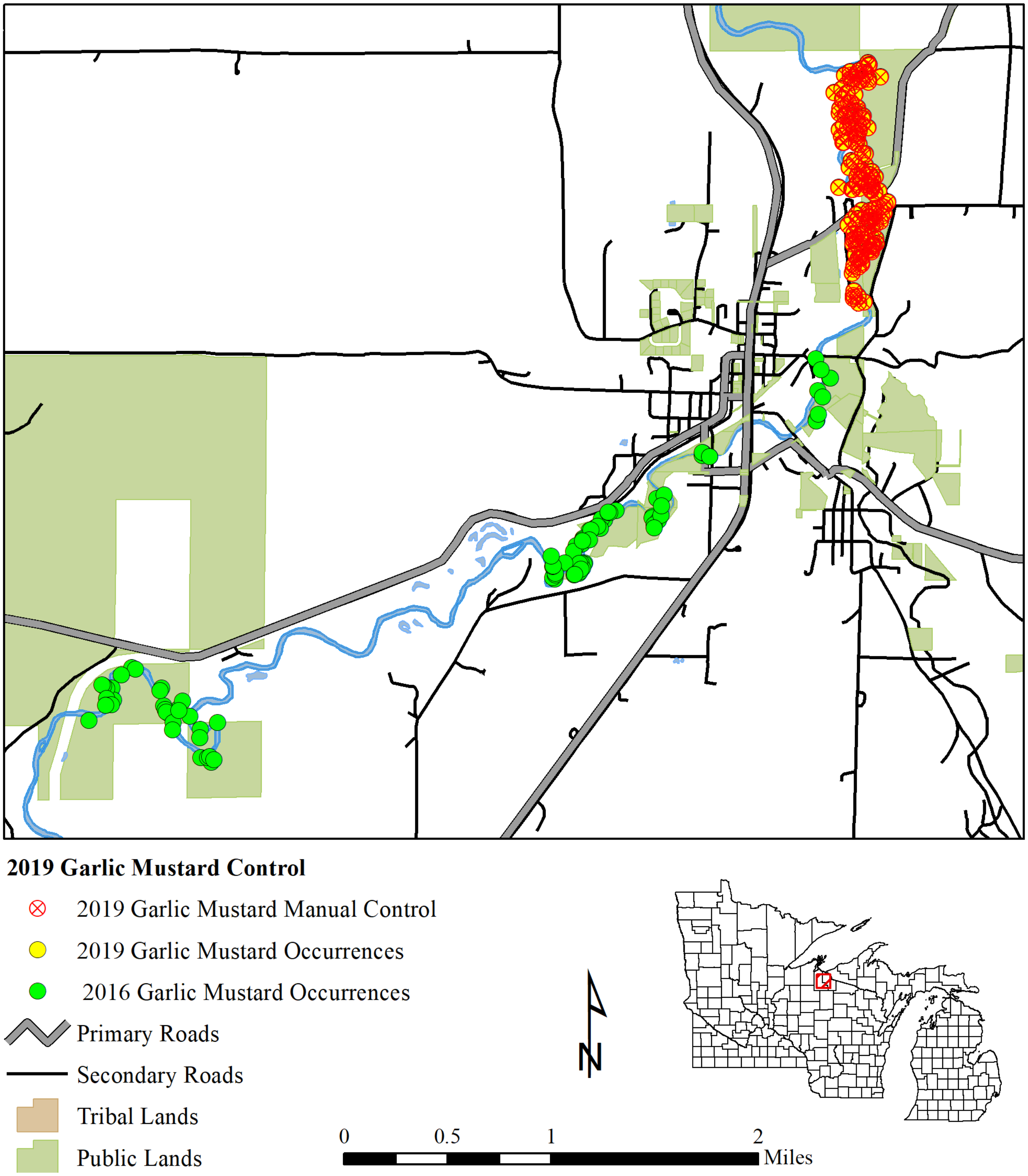

Figure 22: Garlic mustard occurrences and 2019 management efforts on the Bad River floodplain, on the north side of Mellen. Data is not available for private lands upstream. Some upstream sites (lower left, on public land) have been treated by the US Forest Service.

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 23). 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 2019, GLIFWC staff treated 127 purple loosestrife sites with herbicide. Figure 24 shows the decrease in relative patch size from 2012 through 2019. Figure 25 shows the decrease in relative amount of herbicide mix being applied per patch of purple loosestrife from 2012 through 2019. 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 26-27) illustrate the effectiveness of *Galerucella* beetles in substantially reducing the abundance of loosestrife at two northern Wisconsin sites.

NCWMA partners treated an additional 61 purple loosestrife sites in 2019, all in Iron County. All but one of these were treated by the Iron County LWCD.

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 microclimate, 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.

While GLIFWC's *Galerucella* program has generally been successful in reducing the abundance and vigor of purple loosestrife populations, loosetrife continue to be a troublesome invasive in some areas, and new patches continue to appear. GLIFWC and partners might consider attempting to establish another USDA-approved beetle, the root-boring weevil *Hylobius transversovittatus*. The larvae of this beetle mine the root tissue (Wilson et al. 2004). This feeding reduces shoot growth, seed output, and shoot and root biomass, and can eventually kill the plants. The larvae take 1-2 years to develop, emerging as adults between July and October.

Adults can live for several years (Wilson et al. 2004).

The loosestrife root weevil can be used effectively on sites where *Galerucella* beetles are established (Wilson et al. 2004). Together they have more impact on loosestrife than either insect alone. Purple loosestrife regrowth following defoliation by *Galerucella* leaf beetles is greatly reduced when plants are also attacked by the root weevil.

A fourth insect has also been approved by the USDA and released in the US to control purple loosestrife. *Nanophyes marmoratus* is a tiny flower-feeding weevil that can reduce seed production by up to 60% (Wilson et al. 2004). The adults emerge from hibernation in May to early June, and begin to feed on the young purple loosestrife leaves. As soon as flower buds develop, the weevils feed on the buds, mate, and begin to lay eggs. The newly emerging larvae then feed on the developing ovaries, hollowing out the buds. These damaged buds senesce and most drop off the inflorescence before they can flower.

Because *Galerucella* beetles can cause high levels of defoliation and suppress purple loosestrife flowering, the loosestrife flower weevil should only be released where these beetles do not occur or where they are present at low densities (Wilson et al. 2004).

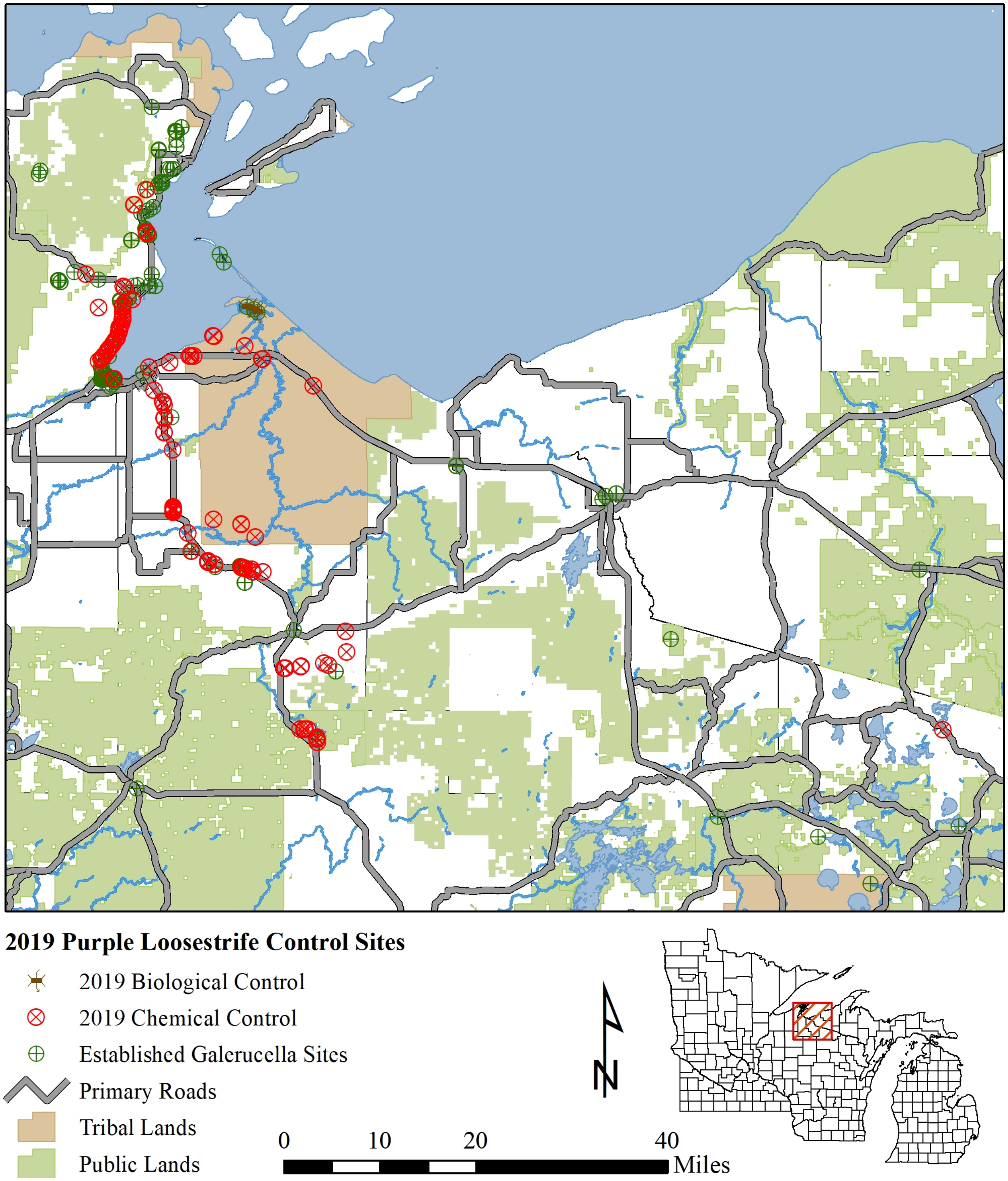

Figure 23: Purple loosestrife occurrences and GLIFWC control efforts in 2019.

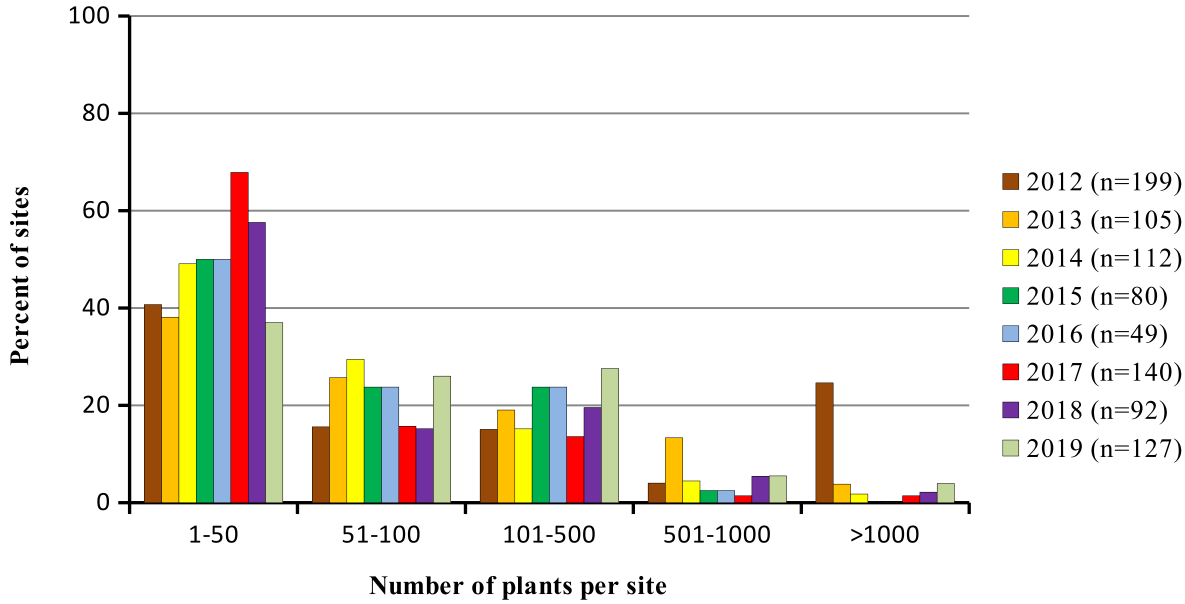

Figure 24: Purple loosestrife abundance at sites treated in 2012-2019. Four sites were treated with biological control (Galerucella beetles) in 2019.

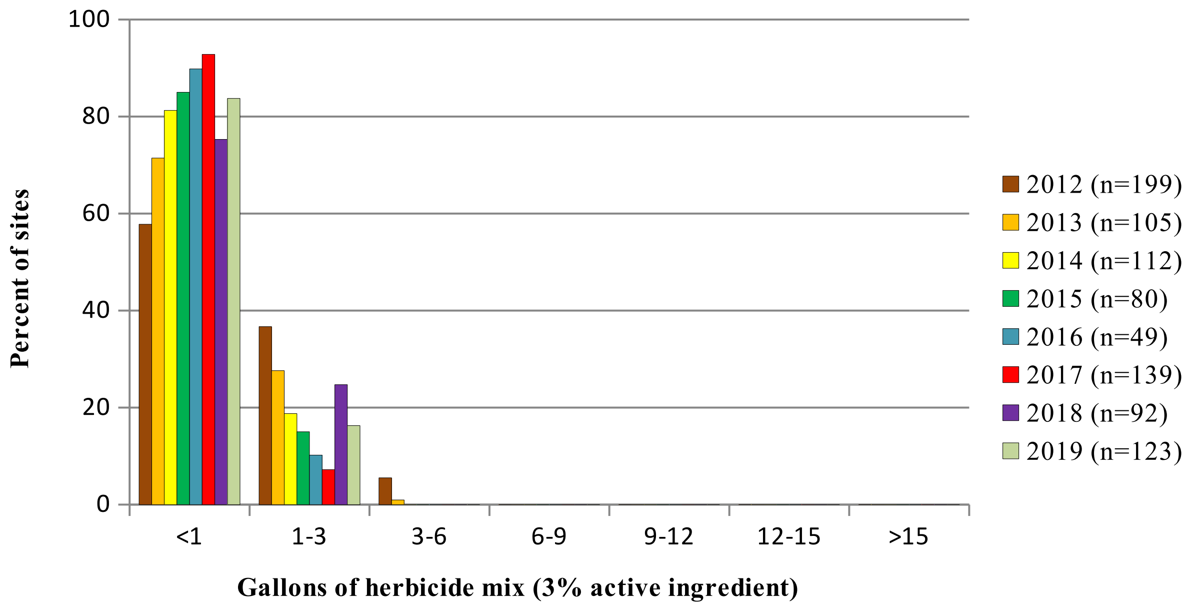

Figure 25: Amount of herbicide mix applied to purple loosestrife sites, 2012-2019. One 2017 and three 2018 sites that were treated manually was omitted, as were 4 sites treated with biological control (Galerucella beetles) in 2019.

Figure 26: *Galerucella* release site west of Bayfield, Wisconsin. 2019 photo not available.

Figure 27: Galerucella release site. Treatment plant, Washburn, Wisconsin. 2019 photo not available.

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 2019 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:
  - Wisconsin DNR AIS Kickoff meeting and workshop in Spooner, WI, May 29, 2019.
  - Participated in the Forest Health Operational Partner Group, to provide input and technical review on Wisconsin's 2020 Forest Action Plan.
  - Genetic Biocontrol of Invasive Species conference, held by the Minnesota DNR in St. Paul, MN, June 25-27, 2019.
  - AIS Partnership Meeting at the Northern Great Lakes Visitor's Center in Ashland. October 9-10, 2019. Gave a GLIFWC Invasive Species Program presentation on October 9.

- 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 reviewed and provided comments on Wisconsin DNR Aquatic Plant Management permits, as provided by the Wisconsin DNR. (Ongoing.)

- 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, as part of the Species Assessment Group for invasive plants. (Ongoing.)

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 2019, GLIFWC staff again 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 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. As in 2017 and 2018, staff conducted follow-up monitoring and treatment of sites on the Wisconsin side of the Estuary in 2019. 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.

Upper Peninsula Resource and Conservation and Development Council (UP RC&D):
The UP RC&D is a non-profit corporation formed to “promote the conservation of the natural resources of the Upper Peninsula for the benefit of its current and future residents.” For the last several years GLIFWC has coordinated informally with the UP RC&D, helping to survey for and monitor non-native phragmites populations in western Upper Michigan. We are partners in their new project, *Life After Phragmites: Wetland Restoration and Landowner Stewardship in Michigan's UP and Northeastern Wisconsin*. This project will continue their phragmites control work in Upper Michigan and expand it into the three Wisconsin counties (Marinette, Florence, and Forest) that are part of Wild Rivers Invasive Species Coalition (WRISC).

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