Elk River Invasive Species Monitoring Project Report 2014-2015

By Tip of the Mitt Watershed Council

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SUMMARY

The purpose of the Elk River Invasive Species Monitoring Project (ERISMP) was to establish comprehensive baseline monitoring data for priority aquatic invasive species in the Elk River Chain of Lakes (ERCOL) Watershed, in order to set the stage for implementation of effective control measures. The 14 lakes and connecting waterways of the ERCOL in the Northwestern Lower Peninsula of Michigan were monitored for five priority aquatic invasive species (AIS): Eurasian *Phragmites*, purple loosestrife, Eurasian watermilfoil, curly-leaf pondweed, and quagga mussels. Monitoring components included visual surveys of shoreline and nearshore areas, comprehensive aquatic vegetation surveys on four lakes, and benthic sampling in open water. ERISMP partners assisted with monitoring after attending AIS workshops. ERISMP results were regularly shared with project partners and other watershed stakeholders, and plans were developed to address AIS documented during surveys. This project was funded by the Michigan Department of Environmental Quality using Clean Michigan Initiative – Clean Water Fund monies and implemented by the Tip of the Mitt Watershed Council.

All priority aquatic invasive plants were found during ERCOL paddling surveys. Curly-leaf pondweed was found at one location in the Intermediate and seven locations in the Torch River. These infestations extended up into and were likely seeded from the Cedar and Rapid Rivers. Eurasian watermilfoil infestations were found in the upper and lower ends of the Chain, mostly in small and light-density patches, except in St. Clair Lake where multiple, moderately dense beds were documented. Small Eurasian *Phragmites* stands were found at three locations on Six Mile and Intermediate Lakes. Purple loosestrife was found in nine of 14 ERCOL lakes, as well as two interconnecting rivers. The greatest number of infestations occurred on Intermediate Lake (35), Six Mile Lake (32), and Elk Lake (29), while the largest combined infestation areas occurred on Hanley Lake (88,900 ft^2) and Six Mile Lake (42,200 ft^2). No quagga mussels were found in the 104 benthic tows performed in the 12 ERCOL lakes where sampling was feasible.

Comprehensive surveys on Hanley, Intermediate, Skegemog, and Elk Lakes found aquatic vegetation in 90%, 23%, 67%, and 3.7% of these lakes, respectively, and documented 29, 30, 30 and 26 plant taxa, respectively. From 1-2 invasive plant species found per lake, largely mirrored paddling survey results. Purple loosestrife was found in all four lakes, Eurasian *Phragmites* found in Intermediate Lake, and Eurasian watermilfoil found in Elk and Skegemog Lakes. Heavy-density vegetation, in terms of both native and invasive species, was common in Hanley Lake, but rare in the other lakes. Native species still dominate these lakes, with coontail being the most commonly collected and abundant plant in Hanley Lake, while muskgrass was the most common

and abundant in the other lakes. A few small Eurasian watermilfoil beds, less than 0.2 acres combined, were found in Elk Lake and Lake Skegemog.

A total of 25 individuals attended workshops to learn to identify, document, and report priority AIS. Workshop participants monitored ERCOL surface waters for a combined 440 hours during the project period. Project partner monitoring efforts resulted in invasive watermilfoil being found at two locations in the Torch River and one in Elk Lake.

Project updates and monitoring results were shared regularly with project partners and other watershed stakeholders via watershed committee meetings. Project progress and results were also shared through TOMWC and project partner newsletters, announcements, and web sites. TOMWC staff presented ERISMP monitoring results to Lower Chain project partners, fomenting discussion and development of action plans. TOMWC plans to meet with Upper Chain project partners in the summer of 2016 to present project results and discuss follow-up actions. The Charlevoix-Antrim-Kalkaska-Emmet Cooperative Invasive Species Management Area coordinator was and will be included in these meetings and follow-up actions.

Recommended follow-up actions include: continue to distribute ERISMP results and work with project partners to plan and implement control measures, reach out to private property owners to educate and facilitate AIS control, implement Eurasian *Phragmites* control measures to nip infestations in the bud, use *Galerucella* beetles to achieve purple loosestrife control in heavily-infested ERCOL water bodies while using appropriate control methods in other water bodies, focus Eurasian watermilfoil control efforts on St. Clair Lake to prevent downstream spread while also encouraging continued control efforts by project partners in other lakes, investigate curly-leaf pondweed sources and focus control efforts on the Torch River, incorporate ERISMP into the new ERCOL watershed management plan, continue education and collaboration efforts to encourage AIS control and prevention, continue training partners and volunteers to identify, document, and report AIS, and repeat AIS monitoring periodically.

INTRODUCTION

Background

The introduction and spread of non-native aquatic species in Michigan's surface waters is an issue of great concern, both environmentally and economically. Over 180 non-native aquatic species have been documented in the Great Lakes, the most prolific and problematic commonly labeled "aquatic invasive species" (AIS). These invasive species can have a myriad of negative impacts on Michigan's aquatic ecosystems, including displacement or loss of native aquatic organisms, food web and nutrient cycling alterations, and water quality degradation. Annual economic costs associated with AIS in terms of negative impacts to ecosystem services, such as commercial and sport fisheries, raw water use, and wildlife viewing, are estimated at $138 million dollars for the Great Lakes region (Rothlisberger et al. 2012).

AIS impacts to aquatic ecosystems and local economies of the ERCOL can be dramatically lessened via an early detection and rapid response strategy. Monitoring for AIS is a crucial element of such a strategy. The Grand Traverse Bay Watershed Management Plan, approved by the US Environmental Protection Agency and Michigan Department of Environmental Quality (DEQ), recognizes the need to monitor AIS per Task 3 under Invasive Species Implementation Task Category: "Monitor the spread of specific types of invasive species in the watershed (i.e., purple loosestrife, Eurasian watermilfoil, zebra mussels)" (TWC 2005).

Some of the most problematic AIS have only recently been observed in or near the Elk River Chain of Lakes Watershed (ERCOL). Eurasian *Phragmites (Phragmites australis)*, a tall perennial grass that dominates wet areas, now occurs along the Lake Michigan shoreline in areas adjacent to the ERCOL, but had not yet been found in any of the water bodies of the ERCOL. Purple loosestrife (*Lythrum salicaria*), another invasive plant inhabiting and dominating wet areas, has become established in some areas of the ERCOL, but its distribution is unknown. Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*), invasive submergent plants that grow densely and outcompete natives, have also been reported from the ERCOL Watershed. Quagga mussels (*Dreissena bugensis*) have not been observed in the ERCOL, though zebra mussels (*Dreissena polymorpha*) have invaded most water bodies in the Chain.

The Elk River Invasive Species Monitoring Project (ERISMP) was carried out to establish comprehensive baseline monitoring data in the ERCOL Watershed for five priority AIS described above, in order to inform stakeholders and set the stage for implementation of effective control measures. The ERISMP was funded by DEQ through a Clean Michigan Initiative - Clean Water Fund grant awarded to Tip of the Mitt Watershed Council (TOMWC) in 2013. The ERISMP Goals include:

> Goal 1: Survey all major water bodies in the ERCOL Watershed to document locations and characteristics of the five priority AIS (*Phragmites*, purple loosestrife, Eurasian watermilfoil, curly-leaf pondweed, quagga mussels), as well as other aquatic invasive species considered threats to the Watershed.
>
> Goal 2: Disseminate project findings to watershed stakeholders, other appropriate organizations and agencies, and the public to increase awareness of AIS and their status in the ERCOL Watershed.
>
> Goal 3: Encourage action by Watershed partners and others to manage and control the spread of invasive species in the Watershed.

Specific objectives associated with ERISMP goals are included in Appendix A.

Study Area and AIS Information

The ERCOL consists of 14 lakes and interconnecting stream channels located in the northwestern Lower Peninsula of Michigan (Figure 1). From headwaters near East Jordan, the ERCOL follows a circuitous route through Antrim, Charlevoix, Kalkaska, and Grand Traverse Counties, until emptying into East Grand Traverse Bay at Elk Rapids. The total shoreline length of the ERCOL is 192 miles and surface area totals 34,418 acres (Table 1). Lakes in the ERCOL range from 40 acres in size to nearly 19,000 acres, while interconnecting rivers and creeks range from less than a quarter mile in length to over 3 miles (USDA 2014).

Land cover data from 2010 show the 321,000-acre ERCOL Watershed to be dominated by natural types, primarily forest, grassland, and water (Table 2). Agriculture land cover accounts for just over 15% of the watershed. Urban land cover accounts for less than 5% of the watershed and includes the communities of Ellsworth, Central Lake, Bellaire, and Elk Rapids.

Table 1. ERCOL water body information.

Water Body Name	Counties	Lake Area (acres)	Shoreline (miles)	Longitude	Latitude
Beals Lake	Antrim	40.47	1.17	-85.17	45.06
Intermediate River	Antrim	NA	0.34	-85.17	45.07
Scotts Lake	Antrim	66.56	1.89	-85.18	45.07
Dingman River	Antrim	NA	4.94	-85.19	45.09
Sixmile Lake	Antrim, Charlevoix	369.69	9.19	-85.20	45.12
Intermediate River	Charlevoix	NA	1.52	-85.21	45.16
St. Clair Lake	Antrim, Charlevoix	59.98	2.62	-85.23	45.17
Sinclair River	Antrim	NA	0.68	-85.24	45.17
Ellsworth Lake	Antrim	106.01	3.69	-85.25	45.15
Intermediate River	Antrim	NA	0.60	-85.25	45.14
Wilson Lake	Antrim	89.17	3.41	-85.25	45.13
Intermediate River	Antrim	NA	0.84	-85.26	45.11
Ben-way Lake	Antrim	126.91	2.82	-85.26	45.10
Green River	Antrim	NA	1.42	-85.26	45.09
Hanley Lake	Antrim	90.70	3.43	-85.26	45.08
Intermediate River	Antrim	NA	0.52	-85.26	45.07
Intermediate Lake	Antrim	1,569.03	14.66	-85.23	45.03
Intermediate River	Antrim	NA	7.50	-85.21	44.98
Lake Bellaire	Antrim	1,788.62	12.00	-85.22	44.95
Grass River	Antrim	NA	4.80	-85.21	44.92
Clam Lake	Antrim	437.41	9.57	-85.25	44.93
Torch Lake	Antrim	18,713.70	41.75	-85.30	44.98
Torch River	Antrim, Kalkaska	NA	4.40	-85.32	44.84
Lake Skegemog	Antrim, Kalkaska, Gr. Traverse	2,765.85	22.72	-85.33	44.81
Elk Lake	Antrim, Grand Traverse	8,194.37	35.99	-85.38	44.86
TOTAL	**NA**	**34,418.47**	**192.47**	**NA**	**NA**

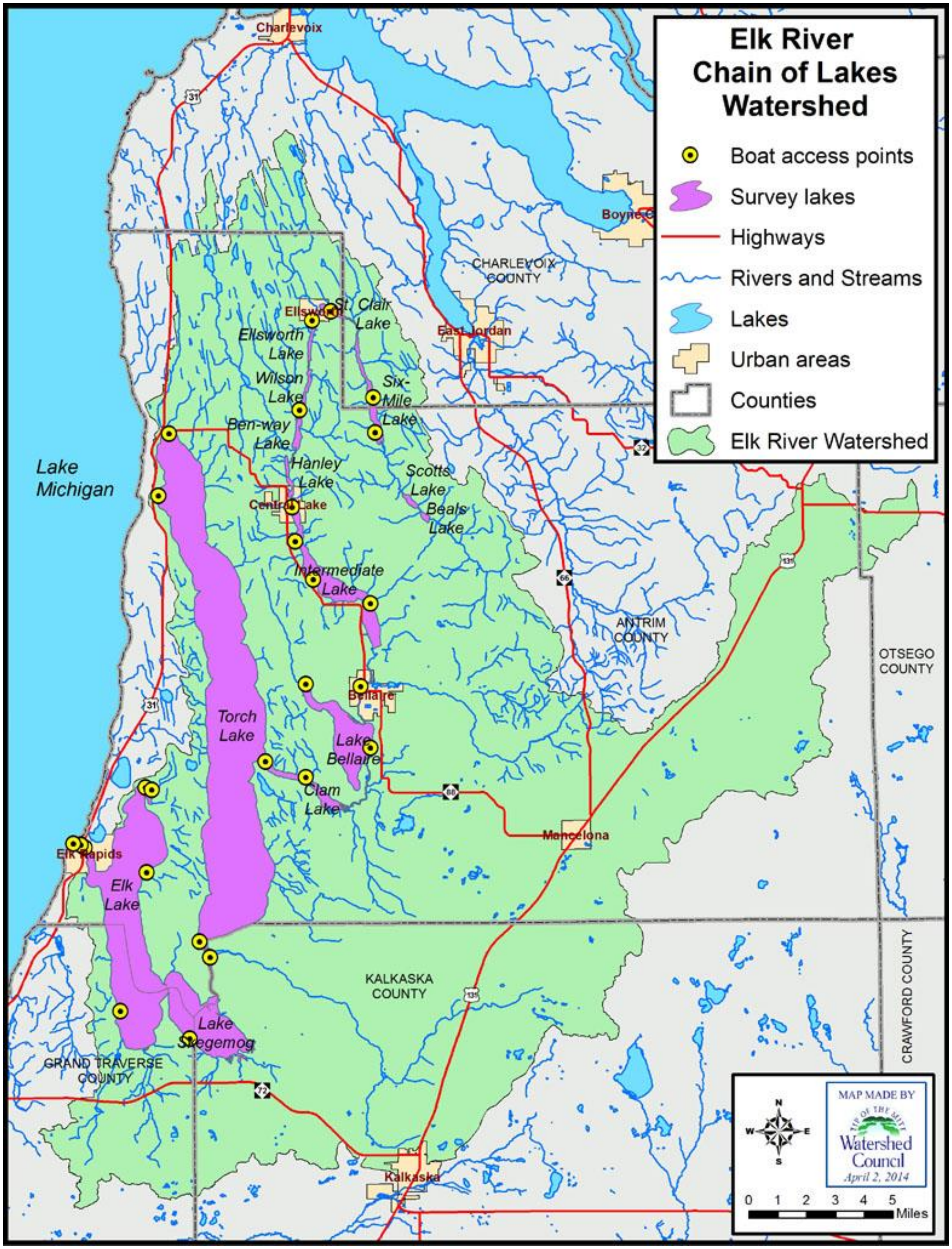

Figure 1. Water bodies monitored in the ERCOL Watershed.

Table 2. ERCOL Watershed land cover statistics (NOAA 2010).

Land Cover Type	**Acres**	**Percent**
Agriculture	51,142	15.9%
Barren	709	0.2%
Forest	137,935	43.0%
Grassland	37,000	11.5%
Scrub/Shrub	13,357	4.2%
Urban	13,632	4.2%
Water	36,372	11.3%
Wetland	30,906	9.6%
TOTAL	**321,053**	**100.0%**

Prior to the ERISMP, knowledge of AIS occurrence and distribution in the ERCOL were limited. Following discovery of Eurasian watermilfoil in Six Mile Lake in 2008, the Six Mile Lake Association contracted with EnviroScience, Inc. to implement biological control with weevils and more recently contracted with PLM Lake and Land Management Corps to treat with herbicide. Three Lakes Association (TLA) has worked to control Eurasian watermilfoil infestations at Butch's Marina in Clam Lake and at Stony Point and Alden Harbor in Torch Lake via hand-pulling, diver dredging (suction harvesting), herbicide application, and benthic barrier installation. No additional infestations were found during AIS surveys by TLA volunteers on Lake Bellaire, Clam Lake and Torch Lake in 2012. The Elk and Lake Skegemog Association (ESLA) found Eurasian watermilfoil infestations in the Torch River and Elk Lake during recent surveys, which were treated with herbicides. Genetic testing sponsored by ESLA and TLA showed that the hybrid watermilfoil, a cross between northern watermilfoil (*Myriophyllum sibiricum*) and Eurasian watermilfoil, is present in the Lower Chain from Clam Lake to Elk Lake. TOMWC worked with private property owners in 2008 to successfully control problematic purple loosestrife growth in Hanley Lake by releasing *Galerucella* beetles. The ERISMP helped to fill data gaps in the ERCOL for the five priority AIS.

METHODS

A broad partnership facilited successful implemntation of ERISMP. Partners that assisted with ERISMP include the Antrim County Conservation District (ACCD), Great Lakes Environmental Research Laboratory (GLERL), the Watershed Center Grand Traverse Bay (TWC), ESLA, TLA, the Intermediate Lake Association (IMA), and the Sixmile Lake Association (SMLA). ACCD committed staff time to assist with coordination and implementation of two AIS information and identification training sessions. GLERL provided equipment and technical expertise for performing benthic mussel surveys. TWC committed staff time to organizational meetings and will incorporate information into updates to the Grand Traverse Bay Watershed Management Plan. Following AIS information and identification trainings, the partner associations monitored for AIS and recorded and reported locations of any observations in the ERCOL. Lake associations, ACCD, and TWC will help disseminate project information by making this report, maps, and data available through their web sites and newsletters. These partners will also continue to participate in AIS management planning based on results of this project.

Due to the magnitude of ERISMP, two years were required to accomplish monitoring goals and objectives. AIS priority species monitoring in the Upper Chain (from Beals Lake through Intermediate Lake) was completed in 2014 and monitoring in the Lower Chain (Lake Bellaire to Elk Lake) completed in 2015. The comprehensive submergent aquatic plant surveys were similarly completed over the course of two years; Hanley and Intermediate Lakes were surveyed in 2014 while Elk and Skegemog were surveyed in 2015.

Priority AIS Paddle Surveys

TOMWC staff and interns monitored all water bodies in the ERCOL for four priority aquatic invasive species. Shoreline areas were surveyed for purple loosestrife and Eurasian *Phragmites*, while open waters capable of supporting aquatic macrophyte growth were surveyed for Eurasian watermilfoil and curly-leaf pondweed. Surveys were carried out using kayaks, taking advantage of the shallow drafting navigability of smaller vessels to reach near-shore areas. Each water body was surveyed once, with two kayaks working in tandem. Surveys were carried out on calm days whenever possible, to take advantage of increased visibility through the water column.

Visual observation at distance was the primary means of species identification, with sample collection as a backup when surveyors could not make a positive identification. Observation distances generally ranged from 5 to 50 feet, with greater distances occurring when observing inland riparian habitat. On the first pass, surveyors monitored the inner littoral zone within 50' of the shoreline and as deeply into the riparian zone as possible. On the return trip (back to the access point/vehicle) surveyors monitored the outer littoral zone, which varied in width, starting from approximately 50' from the shoreline and extending outward to include all areas visibly sustaining aquatic macrophyte growth. Although variable, aquatic macrophytes were generally not visible in areas of greater than 15' of depth. Surveyors zigzagged back and forth in broad sweeps to maximize the area monitored.

When AIS were found, surveyors documented infestations by recording relevant information on a standardized field datasheet (Appendix A). Each infestation was given unique site identification (ID) number using an alpha-numeric code reflecting different lakes or survey outings. If species identification was uncertain, samples were collected and sealed in a plastic bag for later identification by qualified TOMWC staff. Any fruiting structures were left at the site, minimally disturbed, to prevent further spread. The areal extent of each infestation was measured using a tape measure or record-line feature on a GPS. If measurement was not possible (stands underwater or on private property), lengths and widths were estimated. The density of each infestation was estimated and placed into one of three categories: light (1 – 5 stems per square foot), moderate (6 – 10 stems/ft^2), or heavy (>10 stems/ft^2).

Trimble GeoExplorer3 and Trimble Juno SB GPS units were used to record the infestation locations, with site identification numbers entered for each GPS reading. AIS infestations were recorded photographically with either a Ricoh G700SE or Nikon Coolpix AW110 digital GPS camera, which provided back-up spatial data in the event of GPS failure or data loss. Photo numbers were listed on the datasheet for future reference. GPS data were used to develop GIS data layers for display maps and examining spatial trends.

Quagga Mussel Surveys

The other priority AIS, quagga mussels, were the focus of benthic surveys conducted on the lower twelve lakes and several interconnecting waterways of the ERCOL. Lake and stream bottoms were monitored at varying depths with a focus on areas adjacent to boat launches and other public access sites deemed to be most at risk for quagga mussel introduction. GLERL provided a benthic sled for monitoring, which consisted of a heavy metal frame with an open rectangular mouth in the front and meshed netting in the rear. The benthic sled was attached to the back of a motor boat with rope, dropped carefully to the bottom of the lake, and then towed in a linear path for 30 seconds at idle speed. An onboard Hummingbird depth finder was used to measure water depth ranges during each tow. For each sled tow, Trimble GeoExplorer3 or Trimble Juno SB GPS units were used to record the 30-second survey line. These line features were assigned a unique site ID and stored GPS data were transferred to computer daily upon returning from fieldwork. GPS data were processed and used in a GIS to develop data layers for display maps.

Upon completion of each tow, the benthic sled was pulled back into the boat and all contents emptied into a large tub. The sled's net box was rinsed into the tub and inspected to ensure all sample contents were accounted for. The sample was then rinsed and examined on site. Manageable portions of the sample were transferred to white plastic trays to sort and identify specimens. Species names and numbers of invasive mussels found at each site were recorded on a field datasheet (Appendix B). Other information recorded on the field datasheet included water body name, date, unique sample ID number, water depth range, duration of tow (in seconds), location description and comments. Any mussels of questionable identification were photographed and preserved in a container with 70% ethanol along with a label filled out using pencil or waterproof pen that included lake name, sample line ID number, and date. Final identification of preserved specimens was carried out by the program manager. After examination of the entire sample, contents were returned to the water body at the site where collected. Following AIS decontamination protocols, all equipment, boat, and trailer were thoroughly inspected and cleaned after leaving a water body.

If quagga mussels were found in a sample, additional sled tows were required to determine the full extent of the infestation. A minimum of two follow-up tows were to be performed within 500' of the original sample line. If quagga mussels were found in follow-up samples, then sampling would continue outward from the sample line at 1000' intervals until no other quagga mussels were found.

Comprehensive Aquatic Vegetation Surveys

Comprehensive aquatic vegetation surveys were performed in Hanley Lake, Intermediate Lake, Elk Lake, and Lake Skegemog. Although the comprehensive surveys focused on documenting AIS, native plant communities were also surveyed in order to establish baseline data for assessing future AIS impacts. Time to complete individual surveys ranged from two to eight weeks. To capture greatest aquatic plant diversity and growth-density, surveys were conducted during the months of July, August, and September. Using methods comparable with Michigan Department of Environmental Quality procedures, aquatic plants were surveyed using rake tows and through visual observations (MDEQ, 2005). For full details on the plant survey methods used, see the Aquatic Vegetation Survey Standard Operating Procedure in Appendix C.

The majority of aquatic plant sampling was conducted along transects extending from the shoreline that were typically spaced at 500-foot intervals. Sampling began in the vegetated area closest to the shoreline and continued linearly into deeper waters until plants were no longer found. Sample site locations were selected with the intent of collecting representative information on all aquatic plant communities currently inhabiting the lake. Thus, the distance between sample points along transects varied depending upon plant community changes that were visible from the surface. In areas where plant communities were not visible, sample sites were selected based on interpretation of signals from the depth-finder or at regular intervals along the transect.

At each sample site, the boat was anchored, water depth noted, and GPS data recorded. Water depth was determined using Hummingbird depth finders. Trimble GeoExplorer3 and Trimble Juno SB GPS units were used to record sample site locations.

Plant specimens were collected using a sampling device consisting of two garden rake heads fastened together back to back with a length of rope attached. Using the sampling device, multiple throws were made at four directions each site: north, south, east, and west. Sometimes the exact direction of the throw would diverge from a cardinal direction due to natural or man-made features; in these cases, notes were taken for the updated direction. Sampling continued until the collector was satisfied that plant taxa present at the site were represented in the sample. Rigorous sampling techniques and effort were employed, but some species may have been missed.

Plant specimens were identified to the lowest taxonomic level possible and representative samples of each species were laid out and photographed with a slip of paper indicating the number assigned to that site. Specimens were photographed with either Ricoh G700SE or Nikon Coolpix AW110 digital GPS cameras, which provided backup site location information. To assist with mapping aquatic plant communities, additional photographs were taken at sample sites to document surrounding emergent vegetation.

Taxon density was determined by the surveyor for each taxon at each toss and recorded as light (L), moderate (M), or heavy (H), but also including the sub-categories of very light (VL), light-moderate (LM), moderate-heavy (MH) and very heavy (VH). In general, the category "very heavy" was assigned when plant growth was so heavy that it reached the surface and formed a continuous mat. At the other end of the spectrum, "very light" indicated sparse vegetation where only a few stems or pieces were found. The three surveyors involved in the surveys initially sampled plants together and came to a consensus regarding density category rankings. Overall plant density for all rake tosses combined at each site was determined and noted using the same categorization system.

Taxa abundance assignations were determined by summing the number of times a taxon was found in rake throws at a given site. A plant found in all four tosses would be considered "abundant", three tosses "common", two tosses "uncommon", and one toss "rare". Abundance categorizations were determined independent of growth densities.

All plant taxa names, densities, abundance, overall site density, and the total number of species were recorded on field datasheets (Appendix D). Additional information on datasheets included site identification, date, water depth, latitude, longitude, photograph numbers, and comments. If no plants were encountered during sampling, 'no vegetation' was recorded on the field datasheet. Plant specimens that could not be identified in the field were stored in sealed plastic bags and later identified with the aid of taxonomic keys, mounted herbarium specimens, and, when necessary, assistance from other aquatic plant experts.

Aquatic Vegetation Community Mapping

Aquatic plant communities can be delineated simply by interpolating or extrapolating between sample points, but the accuracy of such delineations is greatly improved by noting and mapping precise locations where one plant community type ends and another begins. Therefore, additional data were collected to improve the accuracy of delineations between distinct plant communities in the lake. During sampling, plant community details observed at or near sample sites were recorded in the field notebook. Plant communities that were visible from the boat were described in terms of species composition, areal extent, shape, and density. Changes in plant communities between sample sites and the absence of vegetation in any direction were also noted.

Distinct submerged aquatic plant beds and emergent vegetation were mapped with a GPS. Where feasible, the perimeter of submerged plant beds was followed as closely as possible in the boat and GPS data collected at major vertices to develop polygons representing the plant beds. The depth finder was also used to delineate plant communities as signals show transitions between vegetated and non-vegetated areas. Emergent plants growing directly along the shoreline were frequently mapped at an offset distance that was recorded in the GPS unit. Plant specimens were not collected while mapping community lines with GPS. Occasionally wind, poor visibility, or other factors created overly squiggly community lines which were later smoothed in a GIS to be more accurate and simple.

Aquatic Vegetation Data Processing and Map Development

After completing the field survey, data collected in the field were processed and used to produce maps displaying the lake's aquatic plant communities. GPS data were transferred to a computer and processed as necessary. GIS data layers developed using GPS data consisted of point layers representing sample sites and polygon layers representing plant communities. All GIS work was performed using ESRI ArcMap.

Sample site data were entered into a Microsoft Access database. Individual records were entered into the database for each sample site, using the sample site code for unique identification. Database table attributes included project name, project year, lake name, surveyor names, site identification, sampling data, water depth, taxa names, taxa densities, overall community density, plant abundance, total number of taxa, photograph numbers, latitude, longitude, and comments. Field data for individual lakes were exported from the database to Microsoft Excel spreadsheets and subsequently, imported into a GIS. Field data were joined to sample site points in a GIS and exported to create a new data layer containing all information collected at each sample site.

GPS field data delineating aquatic plant communities were used to develop polygons representing community types occurring in the lakes. If borders between plant communities were not mapped directly with GPS in the field, then divisions were determined by interpolating between or extrapolating from sample sites. Field notes and photographs from sample sites were also consulted to assist with on-screen delineation of plant communities. After developing a comprehensive polygon data layer representing plant communities, area and density statistics were calculated.

Final products include both maps and statistics generated from digital map layers. Presentation-quality maps were developed to depict sample site locations, plant community densities at sample sites, dominant plant communities, and plant community densities. In addition, the ArcMap project file allows GIS users to view all tabular data associated with the site.

RESULTS

Priority AIS Paddle Surveys

TOMWC staff and interns monitored priority aquatic invasive plants along all 192 miles of shoreline in the ERCOL, as well as nearshore areas capable of sustaining aquatic plant growth. The 2014 surveys began July 24th and were completed on September 3rd, while the 2015 surveys began July 10th and were completed on September 21st. All four priority aquatic invasive plants were found in the ERCOL to varying degrees. No AIS were found in Beals Lake and Scotts Lake, at the uppermost end of the ERCOL.

Curly-leaf pondweed was found in four water bodies, at the confluence of the Intermediate River and Cedar River and in the Torch River, where infestations also extended into the connecting Rapid Rivers (Table 3). The curly-leaf pondweed infestation at the confluence of the Intermediate and Cedar Rivers covered a large area, but growth density was light (Table 4). The infestation at the confluence of the Torch and Rapid Rivers was smaller in terms of surface area, but growth density classified as heavy. Six other curly-leaf pondweed infestations were found in the Torch River near the confluence with densities ranging from light to medium (Figure 2).

Table 3. Estimated area of priority aquatic invasive plants by water body.

Water Body	Curly-leaf Pondweed*	Eurasian Watermilfoil*	Eurasian *Phragmites**	Purple Loosestrife*
Six Mile Lake	0	5,764 (<1%)	450 (<1%)	42,228 (<1%)
St. Clair Lake	0	104,276 (4.0%)	0	0
Ellsworth Lake	0	0	0	16 (<1%)
Wilson Lake	0	0	0	709 (<1%)
Ben-Way Lake	0	0	0	43 (<1%)
Hanley Lake	0	0	0	88,886 (2.3%)
Intermediate Lake	0	0	300 (<1%)	11,088 (<1%)
Intermediate River	40,000 (2.3%)	0	0	1 (<1%)
Lake Bellaire	0	0	0	0
Clam Lake	0	0	0	0
Clam River	0	10 (<1%)	0	0
Torch Lake	0	20,040 (<1%)	0	2,354 (<1%)
Torch River	12,335 (<1%)	1,412 (<1%)	0	3,237 (<1%)
Lake Skegemog	0	500 (<1%)	0	10,379 (<1%)
Elk Lake	0	324 (<1%)	0	5,130 (<1%)
TOTAL	**52,335**	**132,326**	**750**	**164,071**

*units = square feet, %=percentage of water body infested.

Table 4. Number of infestations by density category for priority invasive plants.

Invasive Species	**Water Body**	**Light Density**	**Moderate Density**	**Heavy Density**	**Total Occurrences**
Curly-leaf Pondweed	Intermediate River	1	0	0	1
Curly-leaf Pondweed	Torch River	4	2	1	7
Eurasian Watermilfoil	Six Mile Lake	15	3	0	18
Eurasian Watermilfoil	St. Clair Lake	19	5	1	25
Eurasian Watermilfoil	Clam River	1	0	0	1
Eurasian Watermilfoil	Torch Lake	4	1	1	6
Eurasian Watermilfoil	Torch River	3	0	1	4
Eurasian Watermilfoil	Lake Skegemog	0	0	2	2
Eurasian Watermilfoil	Elk Lake	0	1	2	3
Eurasian *Phragmites*	Six Mile Lake	0	1	0	1
Eurasian *Phragmites*	Intermediate Lake	0	2	0	2
Purple Loosestrife	Six Mile Lake	19	13	0	32
Purple Loosestrife	Ellsworth Lake	1	1	0	2
Purple Loosestrife	Wilson Lake	4	0	0	4
Purple Loosestrife	Ben-Way Lake	2	1	2	5
Purple Loosestrife	Hanley Lake	9	9	2	20
Purple Loosestrife	Intermediate Lake	25	9	1	35
Purple Loosestrife	Intermediate River	1	0	0	1
Purple Loosestrife	Torch Lake	7	8	0	15
Purple Loosestrife	Torch River	8	3	1	12
Purple Loosestrife	Lake Skegemog	10	8	0	18
Purple Loosestrife	Elk Lake	18	8	3	29

Eurasian watermilfoil infestations were found in the upper and lower ends of the Chain (Figure 2, Figure 3). With regards to the Upper Chain, small, isolated and generally light-density infestations were found in Six Mile Lake, while larger, more tightly clustered, and somewhat denser patches were found in St. Clair Lake (Table 4). The area infested by Eurasian watermilfoil in St. Clair Lake was largest of all lakes in the ERCOL at 104,276 square feet (Table 3). Eurasian watermilfoil was found in all Lower Chain water bodies downstream of Clam Lake, with densities ranging from light to heavy (Table 4). Among Lower Chain lakes, invasive watermilfoil covered the largest area on Torch Lake at 20,400 square feet (Table 3).

Eurasian *Phragmites* was found at three locations, in the southwest corner of Six Mile Lake and at two locations in Intermediate Lake (Figure 3). All three infestations were classified as moderate-density growth.

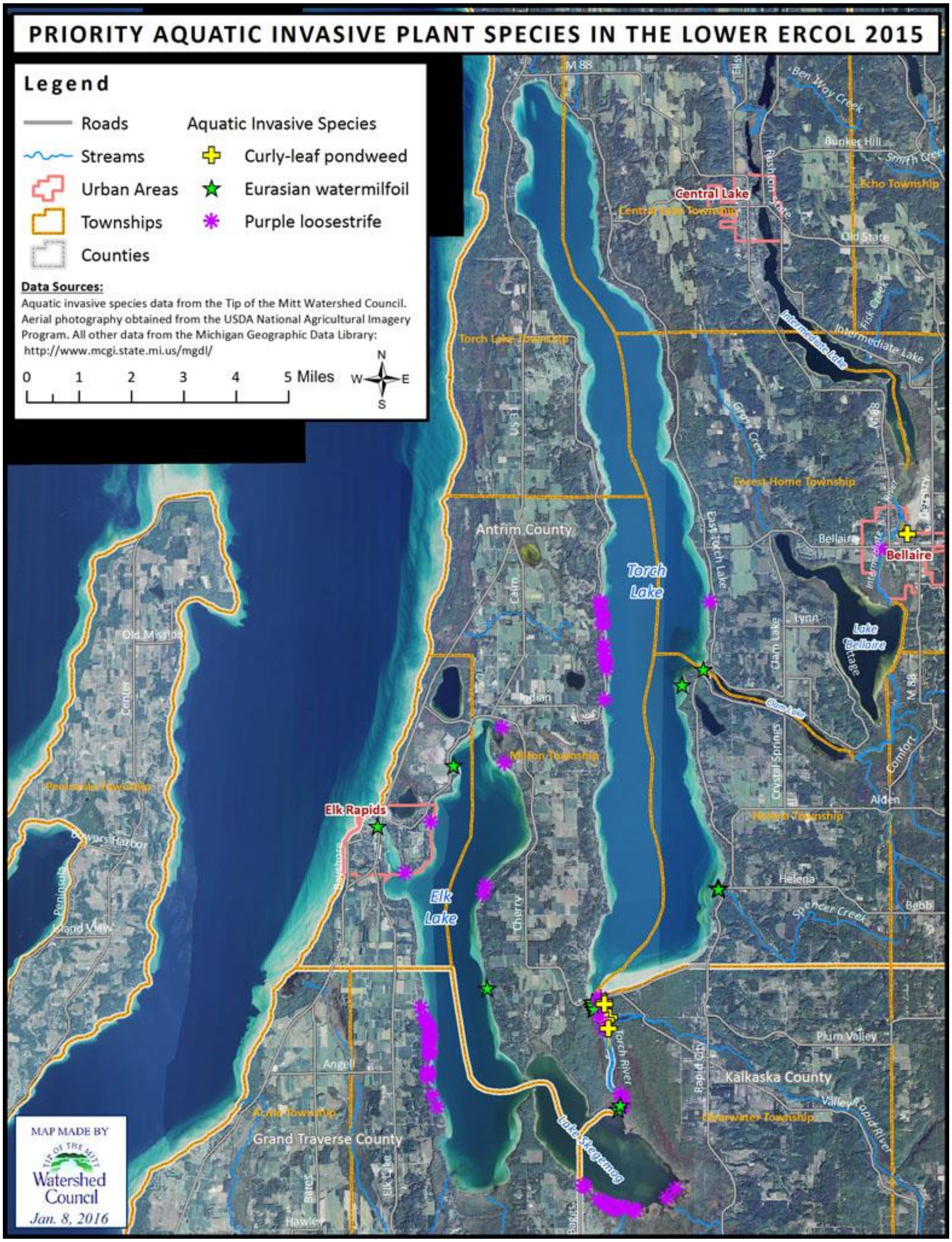

Figure 2. Priority aquatic invasive plant detections in the Lower ERCOL.

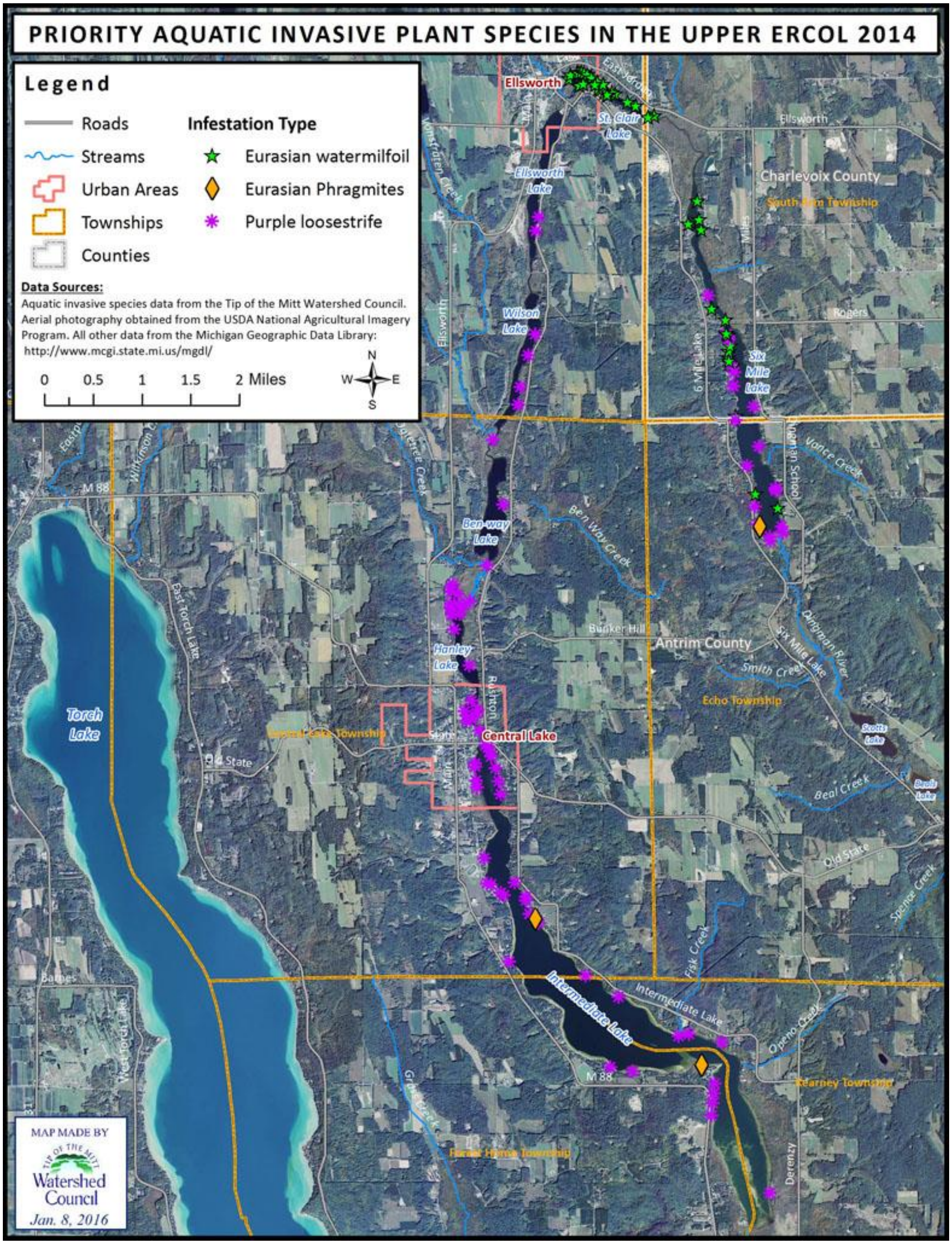

Figure 3. Priority aquatic invasive plant detections in the Upper ERCOL.

Purple loosestrife was pervasive in the ERCOL, occurring in nine of the 14 lakes and 2 of the interconnecting rivers (Figure 2, Figure 3). It encompassed the most area among the priority invasive plant species (Table 3). Hanley Lake had the greatest areal coverage of purple loosestrife at nearly 90,000 square feet, followed by Six Mile Lake at just over 42,000 square feet. Intermediate Lake, Six Mile Lake, and Elk Lake had the greatest number of infestations at 35, 32, and 29 respectively (Table 4).

Invasive Mussel Surveys

Invasive mussel surveys were conducted on water bodies of the ERCOL from Six Mile Lake to Elk Lake (Figure 4). The two uppermost lakes (Beals Lake and Scotts Lake) were not surveyed due to lack of motorboat access sites. In total, 104 benthic tows were performed, with the number of tows per water body ranging from 0 to 19 (Table 5). No quagga mussels were found in the ERCOL.

Table 5. Invasive mussel survey tows per lake.

Water Body (upstream to downstream)	**Number of Tows**
Six Mile Lake	7
Sinclair River	1
St. Clair Lake	4
Ellsworth Lake	3
Intermediate River	1
Wilson Lake	3
Intermediate River	1
Ben-Way Lake	2
Green River	0
Hanley Lake	3
Intermediate River	1
Intermediate Lake	9
Intermediate River	5
Lake Bellaire	8
Grass River	4
Clam Lake	6
Torch Lake	15
Torch River	4
Lake Skegemog	8
Elk Lake	19
Total:	**104**

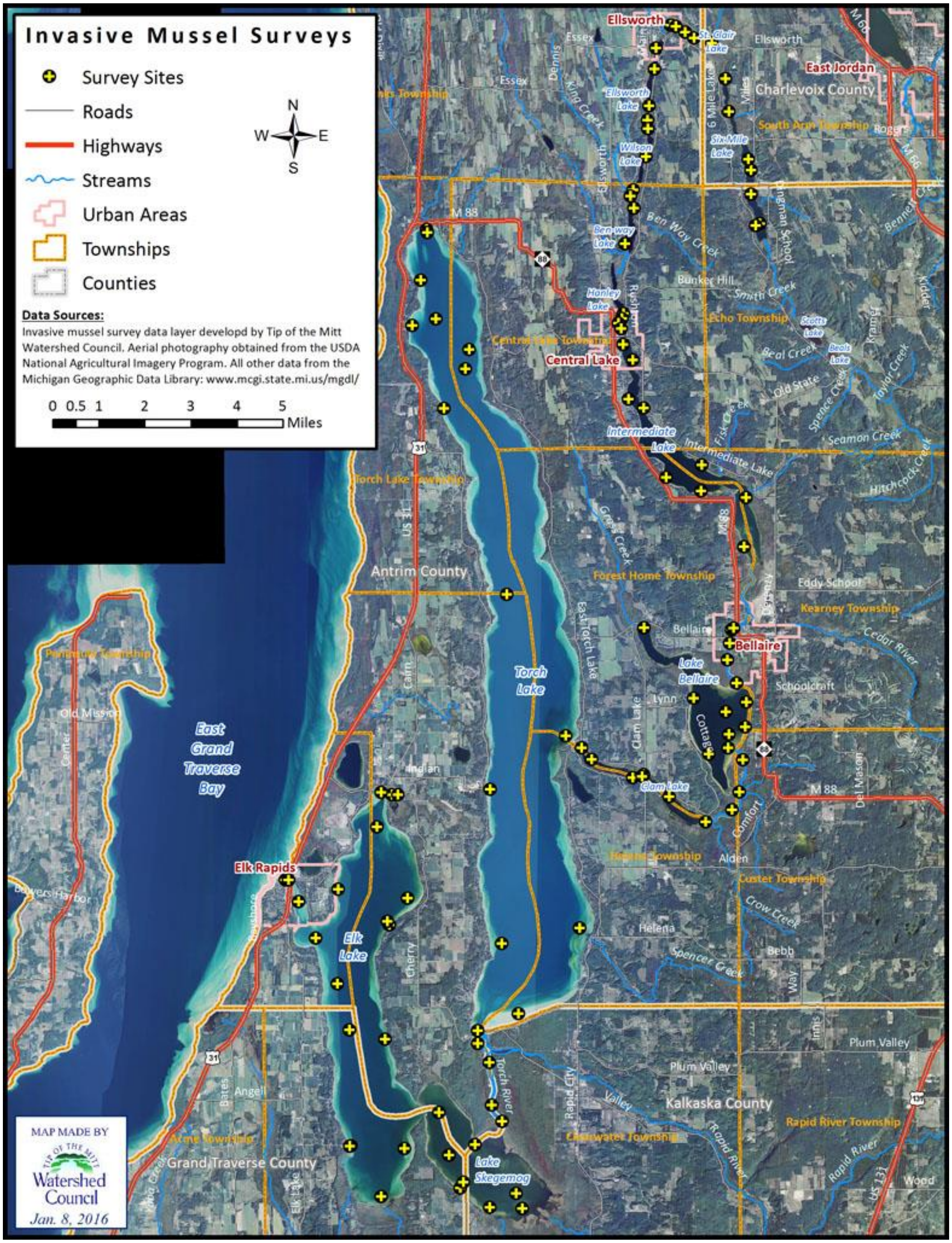

Figure 4. Quagga mussel survey locations.

Hanley Lake Aquatic Vegetation Survey

Aquatic vegetation sampling was conducted at 50 sites on Hanley Lake, starting on 7/2/14 and completed on 8/27/14 (Figure 5). A total of 29 taxa were documented during the survey, of which 28 were native and one was invasive. Purple loosestrife was found distributed throughout the lake during community mapping (Figure 6).

Aquatic vegetation was found at all sites sampled in Hanley Lake, with one to 12 aquatic plant taxa found per site and averaging 6.3. A total of 21 taxa were documented at sample sites (Table 6). Coontail, variable-leaf watermilfoil, bladderwort, and flat-stem pondweed were the most commonly encountered species, collected at 94%, 82%, 62%, and 60% of vegetated sites, respectively. Coontail was also the most abundant plant collected (Table 7). Variable-leaf watermilfoil and flat-stem pondweed followed with being the most abundant at 26% and 10% of vegetated sites, respectively.

Table 6. Hanley Lake aquatic plant taxa occurrence at sample sites.

Scientific Name	**Common Name**	**Total # of Sites**	**Total % of Sites***
Ceratophyllum demersum	Coontail	47	94
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	41	82
Utricularia vulgaris	Bladderwort	31	62
Potamogeton zosteriformis	Flat-stem Pondweed	30	60
Elodea canadensis	Waterweed	26	52
Myriophyllum sibiricum	Northern Watermilfoil	23	46
Heteranthera dubia	Water Stargrass	21	42
Potamogeton amplifolius	Broad-leaf Pondweed	19	38
Bidens beckii	Water Marigold	16	32
Valisneria americana	Eelgrass	14	28
Nuphar variegata	Yellow Pond Lily	10	20
Sagittaria spp.	Arrowhead	8	16
Chara spp.	Muskgrass	7	14
Potamogeton praelongus	White-stem Pondweed	6	12
Najas flexilis	Slender Naiad	5	10
Potamogeton richardsonii	Richardson's Pondweed	3	6
Ranunculus spp.	Water Crow-foot	3	6
Potamogeton gramineus	Variable-leaf Pondweed	2	4
Potamogeton natans	Floating-leaf Pondweed	1	2
Potamogeton spp.	Pondweed (unknown species)	1	2
Stuckenia spp.	Pondweed (Stuckenia)	1	2

**Percent of sites based on vegetated sites, which was all sites.*

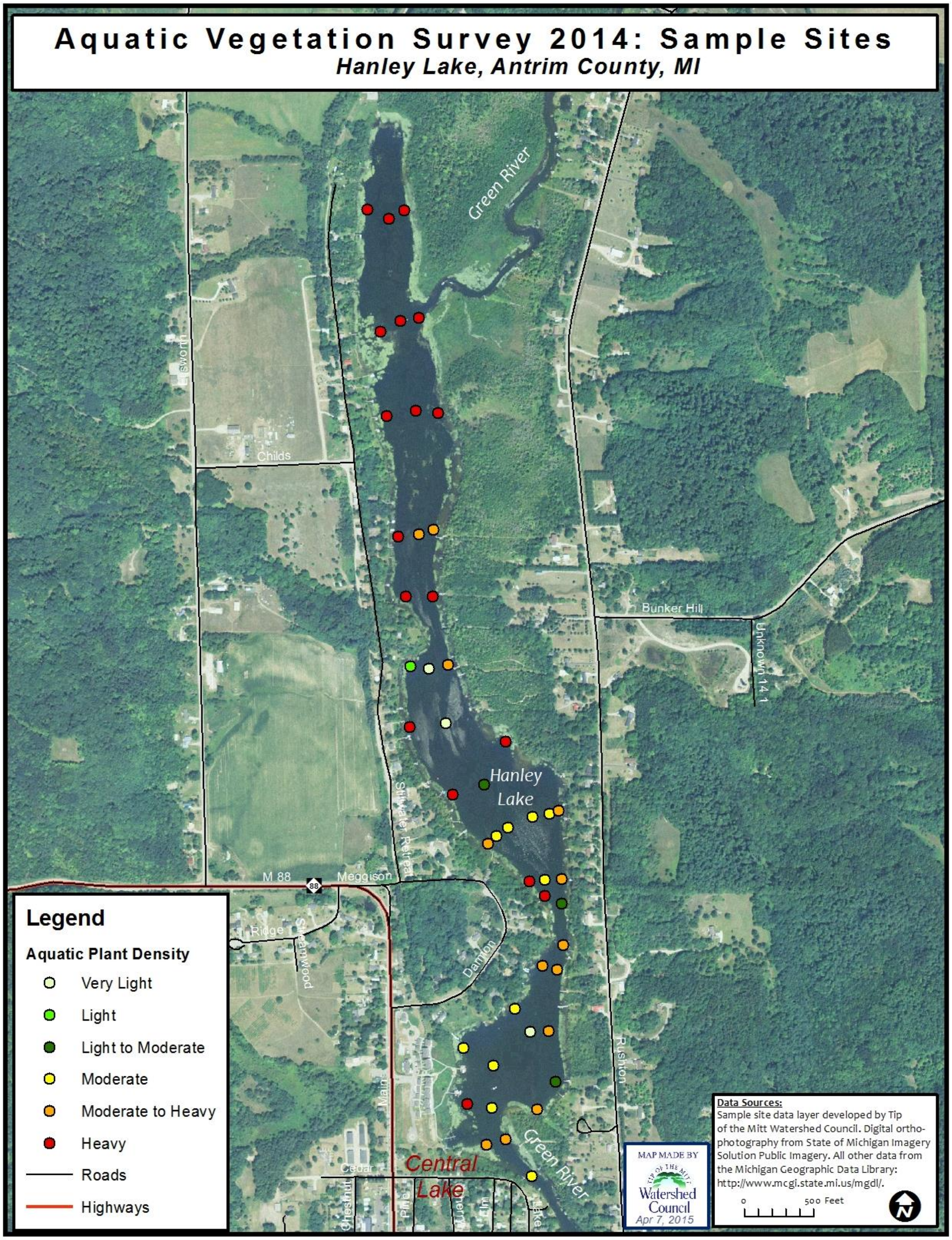

Figure 5. Sample sites for Hanley Lake vegetation survey.

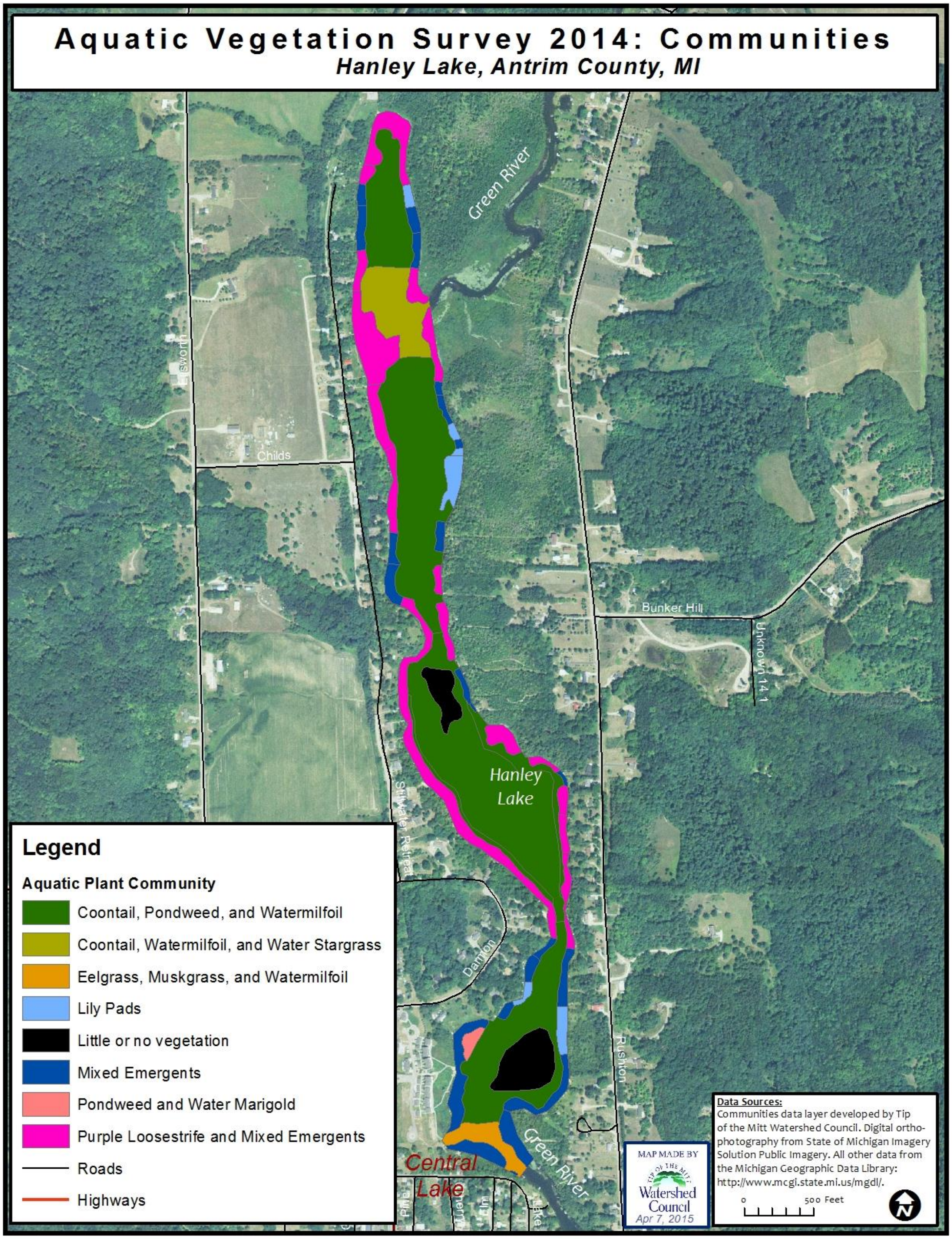

Figure 6. Aquatic plant communities in Hanley Lake.

Table 7. Hanley Lake plant taxa abundance at sample sites. *

Scientific Name	Common Name	Abundant % of Sites	Common % of Sites	Uncommon % of Sites	Rare % of Sites
Ceratophyllum demersum	Coontail	42	32	10	10
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	26	24	20	12
Potamogeton zosteriformis	Flat-stem Pondweed	10	28	14	8
Heteranthera dubia	Water Stargrass	8	4	12	18
Myriophyllum sibiricum	Northern Watermilfoil	6	6	12	22
Elodea canadensis	Waterweed	2	10	14	26
Bidens beckii	Water Marigold	2	2	8	20
Valisneria americana	Eelgrass	2	6	10	10
Nuphar variegata	Yellow Pond Lily	2	0	2	16
Utricularia vulgaris	Bladderwort	0	10	14	38
Potamogeton amplifolius	Broad-leaf Pondweed	0	6	10	22
Sagittaria spp.	Arrowhead	0	2	0	14
Potamogeton praelongus	White-stem Pondweed	0	4	2	6
Potamogeton richardsonii	Richardson's Pondweed	0	2	0	4
Chara spp.	Muskgrass	0	0	2	12
Ranunculus spp.	Water Crow-foot	0	0	2	4
Najas flexilis	Slender Naiad	0	0	0	10
Potamogeton gramineus	Variable-leaf Pondweed	0	0	0	4
Potamogeton natans	Floating-leaf Pondweed	0	0	0	2
Potamogeton spp.	Pondweed (unknown sp)	0	0	0	2
Stuckenia spp.	Sago Pondweed	0	0	0	2

**Abundance based on the number of rake throws the plant is collected in at each site. 4 = Abundant, 3 = Common, 2 = Uncommon, 1 = Rare.*

Plant community mapping showed that over 90% of Hanley Lake contained aquatic vegetation (Table 8). Species found in addition to those documented at sample sites include purple loosestrife, cattail (*Typha spp.*), sweet gale (*Myrica gale*), softstem bulrush (*Schoenoplectus tabernaemontani*), bur-reed (*Sparganium spp.*), white water lily (*Nymphaea odorata*), rushes (*Juncus spp.*), and swamp loosestrife (*Decodon verticillatus*). The majority of the lake was dominated by a mix of coontail, pondweed, and native watermilfoil. Mixed emergent species, including purple loosestrife, bur-reed, bulrush, cattail, and water lilies, was the next most extensive community type, dominating approximately 27% of vegetated areas. The combined acreage of plant communities that included purple loosestrife was 16 acres.

Table 8. Hanley Lake dominant aquatic plant communities.

Dominant Community Type	Lake Area (acres)	Lake Area (percent)
Coontail, Pondweed, and Watermilfoil	50.0	56.1
Purple Loosestrife and Mixed Emergents	15.7	17.6
Mixed Emergents	9.0	10.1
Coontail, Watermilfoil, and Water Stargrass	4.9	5.5
Lily Pads	2.2	2.5
Eelgrass, Muskgrass, and Watermilfoil	1.8	2.1
Pondweed and Water Marigold	0.5	0.5
Little or no vegetation	5.1	5.7
TOTAL	**89.1**	**100.0**

Heavy-density plant growth was common in Hanley Lake, found at the majority of samples sites and in approximately 45% of vegetated areas (Table 9, Table 10). Heavy-density plant growth was found throughout the lake, but was more prominent in the north basin (Figure 7). Over 80% of communities with purple loosestrife as a dominant species fell into the moderate or heavy-density growth categories. Light-density growth, including very light and light to moderate, was found at just 14% of sites and accounted for less than three acres.

Table 9. Hanley Lake plant densities at sample sites.

Density Category	Number of Sites	Percentage of Sites
Little/no vegetation	0	0
Very Light	3	6
Light	1	2
Light to Moderate	3	6
Moderate	10	20
Moderate to Heavy	13	26
Heavy	20	40
Very Heavy	0	0
TOTAL	**50**	**100**

Table 10. Hanley Lake plant community density statistics.

Aquatic Plant Density	Lake Area (acres)*	Lake Area (percent)*
Very Light	0.0	0.0
Light	0.6	0.7
Light to Moderate	2.1	2.5
Moderate	25.5	30.4
Moderate to Heavy	17.8	21.2
Heavy	37.7	44.8
Very Heavy	0.4	0.5
TOTAL	**84.1**	**100.0**

**Refers to percent of surface area with aquatic vegetation (i.e., 84.1 acres).*

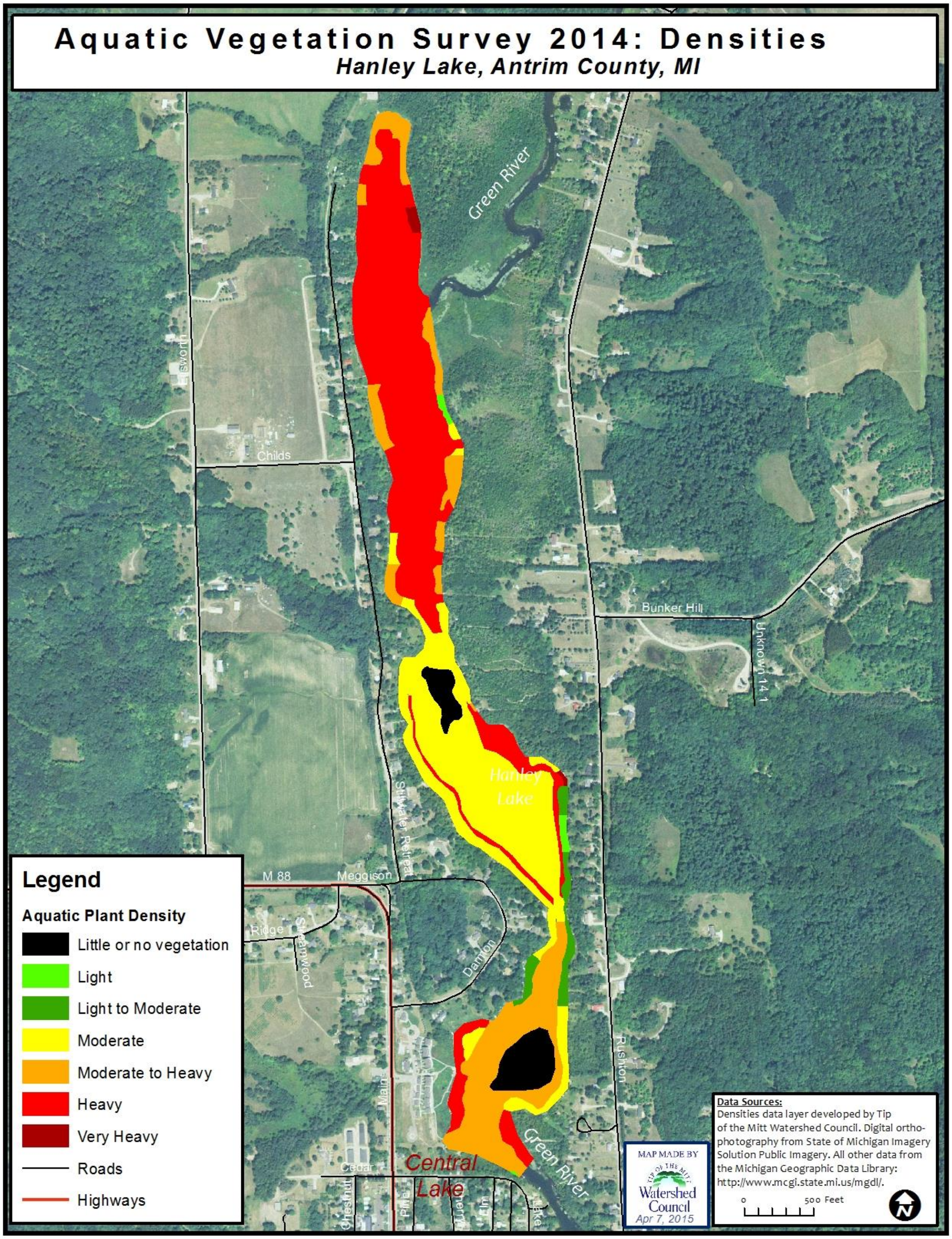

Figure 7. Hanley Lake aquatic plant community densities.

Intermediate Lake Aquatic Vegetation Survey

Aquatic vegetation sampling was conducted at 245 sites on Intermediate Lake, starting on 7/11/14 and completed on 9/12/14 (Figure 8). A total of 30 aquatic plant taxa were documented during the survey, of which 2 were invasive. Mirroring results of priority AIS paddle surveys, purple loosestrife was found at multiple locations distributed throughout the lake and Eurasian *Phragmites* was found at two locations (Figure 9).

Of the 30 taxa found in Intermediate Lake, 20 were documented at sample sites, with a range of zero to 13 taxa per site and an average of 2.7 (Table 11). Native aquatic plants, including muskgrass, eelgrass, variable-leaf watermilfoil, and slender naiad were the most common, collected at 76%, 67%, 41%, and 37% of vegetated sites, respectively (Table 11). Muskgrass, eelgrass, variable-leaf watermilfoil, and slender naiad were also found to be the most abundant plants, considered abundant at 32%, 17%, 4%, and 2% of vegetated sites, respectively (Table 12).

Table 11. Intermediate Lake aquatic plant taxa occurrence at sample sites.

Scientific Name	**Common Name**	**Total Sites**	**Total % Sites***
Chara spp.	Muskgrass	173	76.2
Valisneria americana	Eelgrass	153	67.4
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	93	41.0
Najas flexilis	Slender Naiad	84	37.0
Potamogeton amplifolius	Broad-leaf Pondweed	45	19.8
Sagittaria spp.	Arrowhead	31	13.7
Potamogeton gramineus	Variable-leaf Pondweed	18	7.9
Heteranthera dubia	Water Stargrass	15	6.6
Stuckenia pectinata	Sago Pondweed	15	6.6
Potamogeton zosteriformis	Flat-stem Pondweed	7	3.1
Nuphar variegata	Yellow Pond Lily	5	2.2
Ceratophyllum demersum	Coontail	3	1.3
Elodea canadensis	Waterweed	3	1.3
Myriophyllum sibiricum	Northern Watermilfoil	3	1.3
Potamogeton illinoensis	Illinois Pondweed	2	0.9
Potamogeton spp.	Pondweed (species unknown)	2	0.9
Nymphaea odorata	White Water Lily	1	0.4
Schoenoplectus subterminalis	Swaying Bulrush	1	0.4
Stuckenia filiformis	Fine-leaf Pondweed	1	0.4
Utricularia vulgaris	Bladderwort	1	0.4

**Percent of sites based on only those sites with vegetation (=227).*

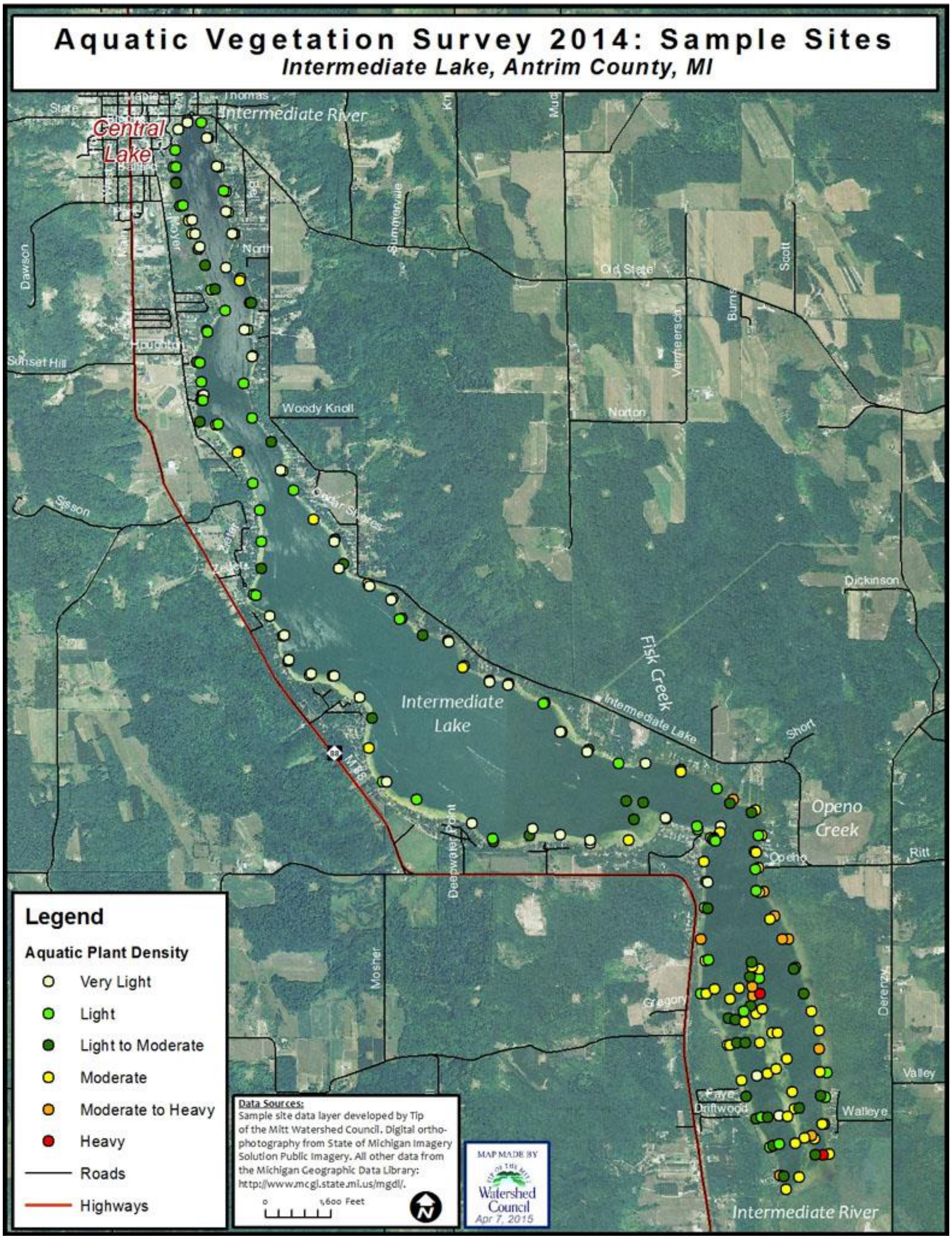

Figure 8. Intermediate Lake aquatic vegetation survey sites.

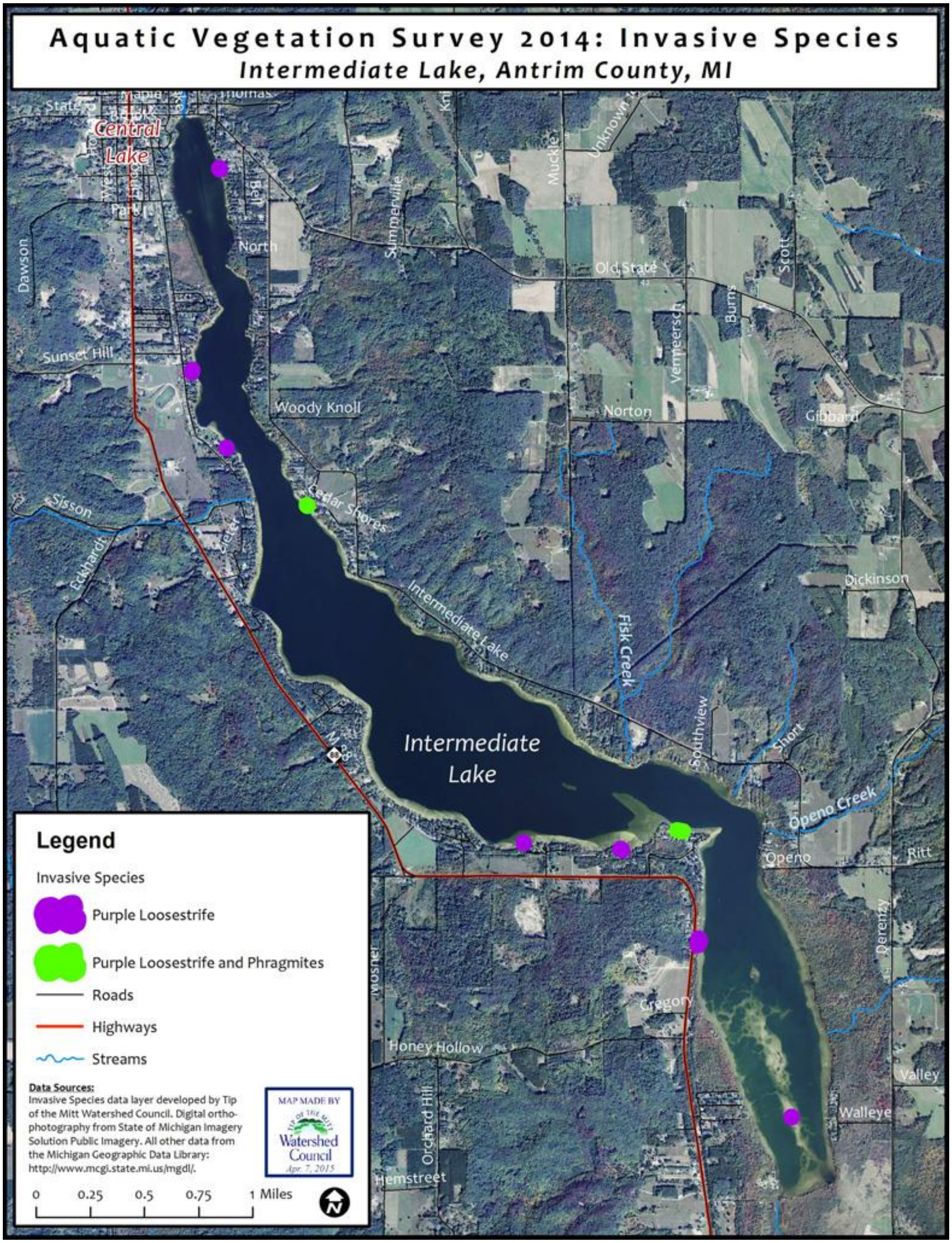

Figure 9. AIS occurrence in Intermediate Lake.

Table 12. Intermediate Lake aquatic plant abundance at sample sites.*

Scientific Name	Common Name	Abundant % of Sites	Common % of Sites	Uncommon % of Sites	Rare % of Sites
Chara spp.	Muskgrass	31.7	14.5	13.2	16.7
Valisneria americana	Eelgrass	16.7	12.8	18.5	19.4
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	3.5	5.7	12.3	19.4
Najas flexilis	Slender Naiad	2.2	6.2	10.1	18.5
Potamogeton gramineus	Variable-leaf Pondweed	1.3	2.2	0.4	4.0
Heteranthera dubia	Water Stargrass	0.4	0.0	0.9	5.3
Potamogeton spp.	Pondweed (unknown spp.)	0.4	0.0	0.0	0.4
Potamogeton zosteriformis	Flat-stem Pondweed	0.4	0.4	0.4	1.8
Sagittaria spp.	Arrowhead	0.0	3.5	3.1	7.0
Potamogeton amplifolius	Broad-leaf Pondweed	0.0	2.6	5.3	11.9
Stuckenia filiformis	Fine-leaf Pondweed	0.0	0.0	1.7	5.3
Stuckenia pectinata	Sago Pondweed	0.0	0.0	1.3	5.3
Ceratophyllum demersum	Coontail	0.0	0.0	0.4	0.9
Nuphar variegata	Yellow Pond Lily	0.0	0.0	0.4	1.8
Elodea canadensis	Waterweed	0.0	0.0	0.0	1.3
Myriophyllum sibiricum	Northern Watermilfoil	0.0	0.0	0.0	1.3
Potamogeton illinoensis	Illinois Pondweed	0.0	0.0	0.0	0.9
Nymphaea odorata	White Water Lily	0.0	0.0	0.0	0.4
Schoenoplectus subterminalis	Swaying Bulrush	0.0	0.0	0.0	0.4
Utricularia vulgaris	Bladderwort	0.0	0.0	0.0	0.4

**Abundance based on number of rake throws the plant is collected at each vegetated site. 4 = Abundant, 3 = Common, 2 = Uncommon, 1 = Rare.*

Aquatic plant community mapping revealed that approximately 77% of Intermediate Lake contained little or no aquatic vegetation. Emergent vegetation dominated approximately 6% of vegetated areas (369 acres), while the remaining 94% had submergent vegetation only. Ten additional emergent taxa were noted during community mapping, including purple loosestrife, Eurasian *Phragmites*, cattail, sweet gale, floating pondweed (*Potamogeton natans*), softstem bulrush, blue flag iris (*Iris versicolor*), horse tail (*Equisetum fluviatile*), bur-reed, and sedge (*Carex spp.*). As typical, the majority of emergent vegetation occurred along the shallow edges of the lake, though it extended outward in the south basin due to shallow depths (Figure 10). Muskgrass-dominated plant communities were found to be the most common and extensive, covering 159 acres of Intermediate Lake (Table 13). The area infested with purple loosestrife and Eurasian *Phragmites* totaled less than one acre.

Table 13. Intermediate Lake dominant aquatic plant communities.

Dominant Plant Community	**Lake Surface Area (acres)**	**Lake Surface Area (percent)**
Little or no vegetation	1201	76.5
Muskgrass	159	10.1
Mixed Submergents	127	8.1
Mixed Emergents	24	1.5
Watermilfoil	23	1.5
Muskgrass, Naiad, and Pondweed	22	1.4
Eelgrass	14	0.9
TOTAL	**1570**	**100.0**

The growth density of purple loosestrife and Eurasian *Phragmites* was considered heavy in 80% of the infestations. Although very light or light-density growth was found at over 40% of sample sites (Table 14), community mapping showed that moderate-density plant growth was the most extensive, accounted for 85% of vegetated areas in Intermediate Lake (Table 15). The limited heavy-density plant growth occurred primarily in the broad shallow areas of the lake's southern basin (Figure 11).

Table 14. Intermediate Lake aquatic plant densities at sample sites.

Density Category	**Number of Sites**	**Percentage of Sites**
Little/no vegetation	18	7.3
Very Light	46	18.8
Light	58	23.7
Light to Moderate	55	22.4
Moderate	53	21.6
Moderate to Heavy	13	5.3
Heavy	2	0.8
Very Heavy	0	0.0
TOTAL	**245**	**100.0**

Table 15. Intermediate Lake aquatic plant community densities.

Plant Community Density	**Lake Surface Area (acres)**	**Lake Surface Area (percent)**
Very Light	7	1.85
Light	41	11.08
Light to Moderate	131	35.62
Moderate	155	42.15
Moderate to Heavy	28	7.53
Heavy	7	1.78
TOTAL	**369**	**100.00**

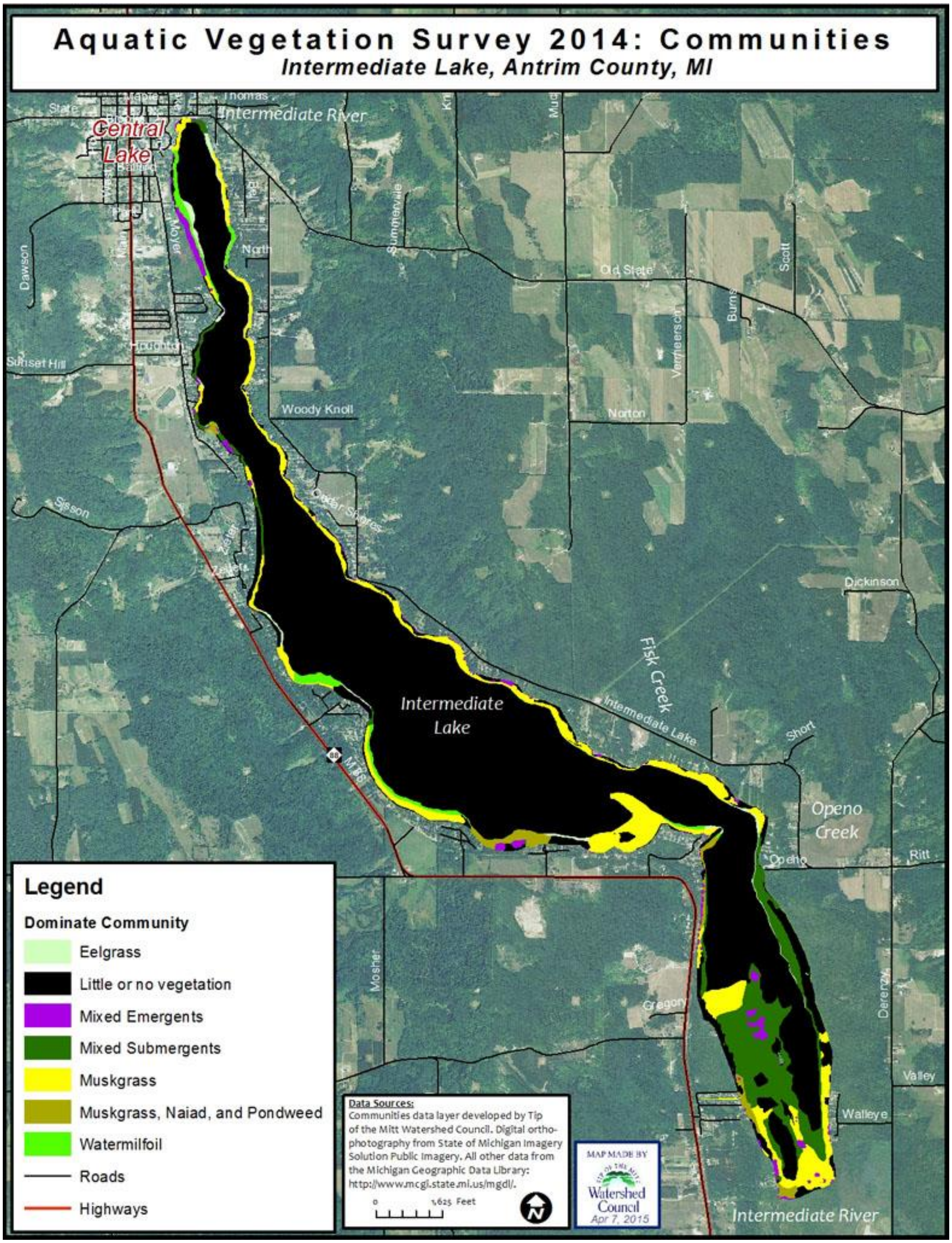

Figure 10. Aquatic plant communities in Intermediate Lake.

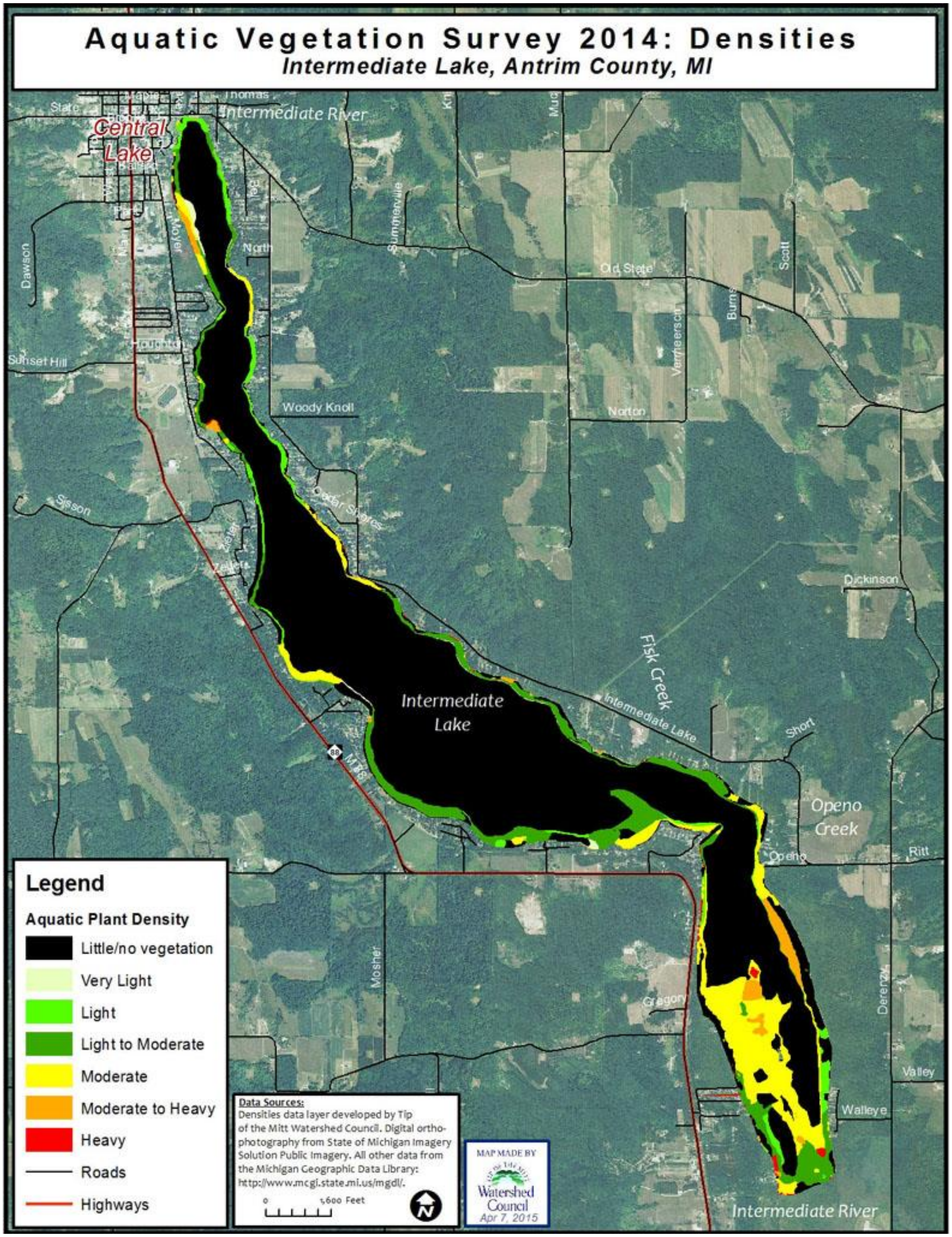

Figure 11. Intermediate Lake aquatic plant community densities.

Lake Skegemog Aquatic Vegetation Survey

Aquatic vegetation sampling was conducted at 299 sites on Lake Skegemog, starting on 7/21/15 and completed on 9/23/15 (Figure 12). A total of 30 aquatic plant taxa were documented during the survey, of which 2 were invasive. Purple loosestrife was found, though infestation locations all overlapped with Priority AIS Paddle Survey data and therefore, are not included in this section. Eurasian watermilfoil or a Eurasian hybrid watermilfoil was found at two locations near the outlet of the Torch River (Figure 13).

Of the total number of taxa found in Lake Skegemog, 21 were documented at sample sites, with a range of zero to 6 taxa per site and an average of 2.2 (Table 16). Native aquatic plants, including muskgrass, slender naiad, eelgrass, and flat-stem pondweed, were the most commonly encountered species, collected at approximately 77%, 60%, 50%, and 29% of vegetated sites, respectively (Table 16). Muskgrass was also the most abundant plant, found in abundance at 41% of vegetated sites (Table 17).

Table 16. Lake Skegemog aquatic plant taxa occurrence at sample sites.

Scientific Name	Common Name	Total Sites	Total % Sites*
Chara spp.	Muskgrass	166	76.9
Najas flexilis	Slender Naiad	130	60.2
Valisneria americana	Eelgrass	108	50.0
Potamogeton zosteriformis	Flat-stem Pondweed	63	29.2
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	45	20.8
Utricularia vulgaris	Bladderwort	42	19.4
Potamogeton gramineus	Variable-leaf Pondweed	30	13.9
Elodea canadensis	Waterweed	11	5.1
Potamogeton amplifolius	Broad-leaf Pondweed	11	5.1
Potamogeton praelongus	White-stem Pondweed	8	3.7
Potamogeton richardsonii	Richardson's Pondweed	6	2.8
Stuckenia pectinata	Sago Pondweed	6	2.8
Potamogeton strictifolius	Narrow-leaf Pondweed	5	2.3
Sagittaria spp.	Arrowhead	3	1.4
Schoenoplectus subterminalis	Swaying Bulrush	3	1.4
Carex spp.	Sedges	2	0.9
Myriophyllum spicatum	Eurasian Watermilfoil	2	0.9
Potamogeton pusillus	Lesser Pondweed	2	0.9
Potamogeton natans	Floating-leaf Pondweed	1	0.5
Potamogeton spp.	Pondweed (species unknown)	1	0.5
Utricularia gibba	Floating Bladderwort	1	0.5

**Percent of sites based on the total number of vegetated sites*

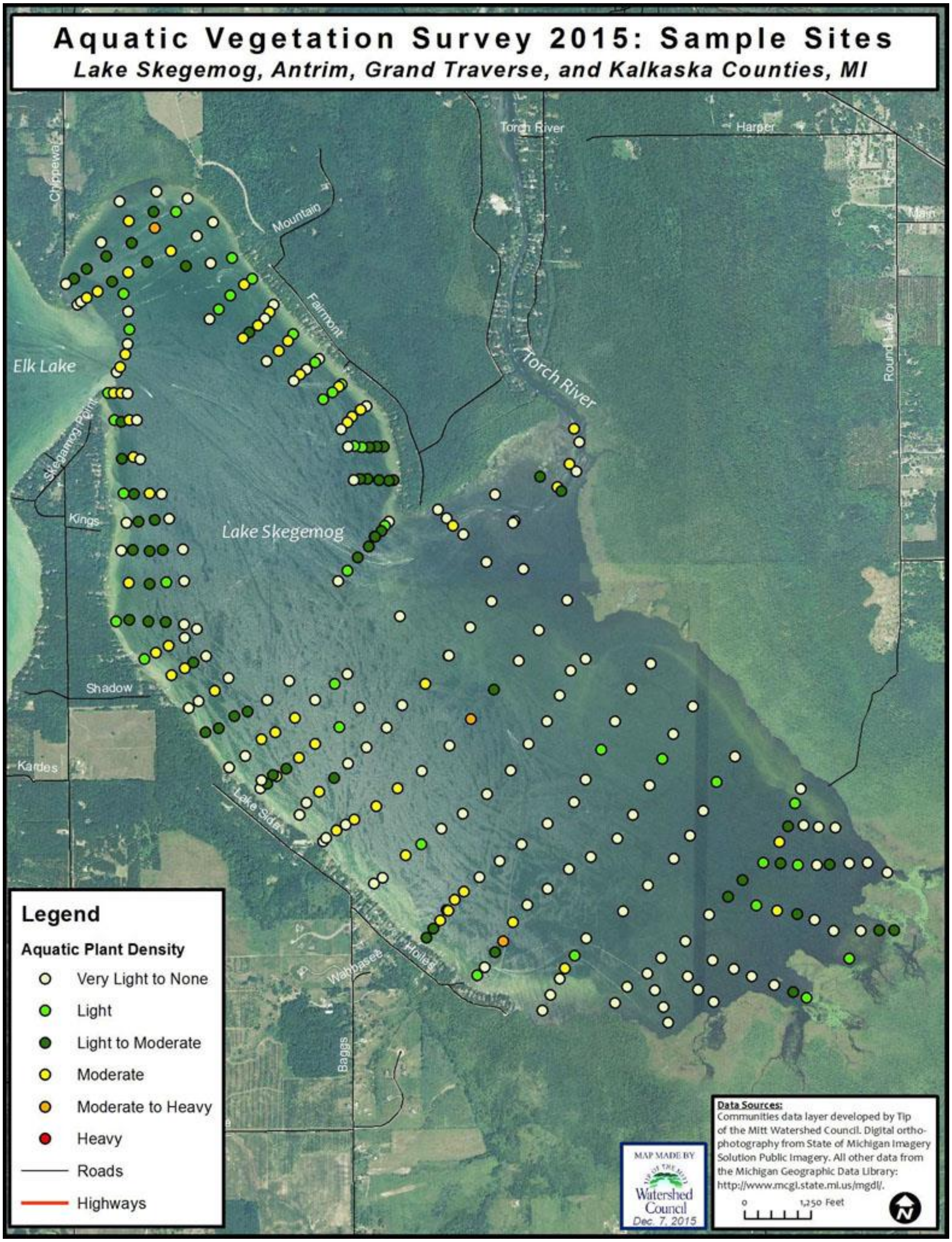

Figure 12. Sample sites for Lake Skegemog vegetation survey.

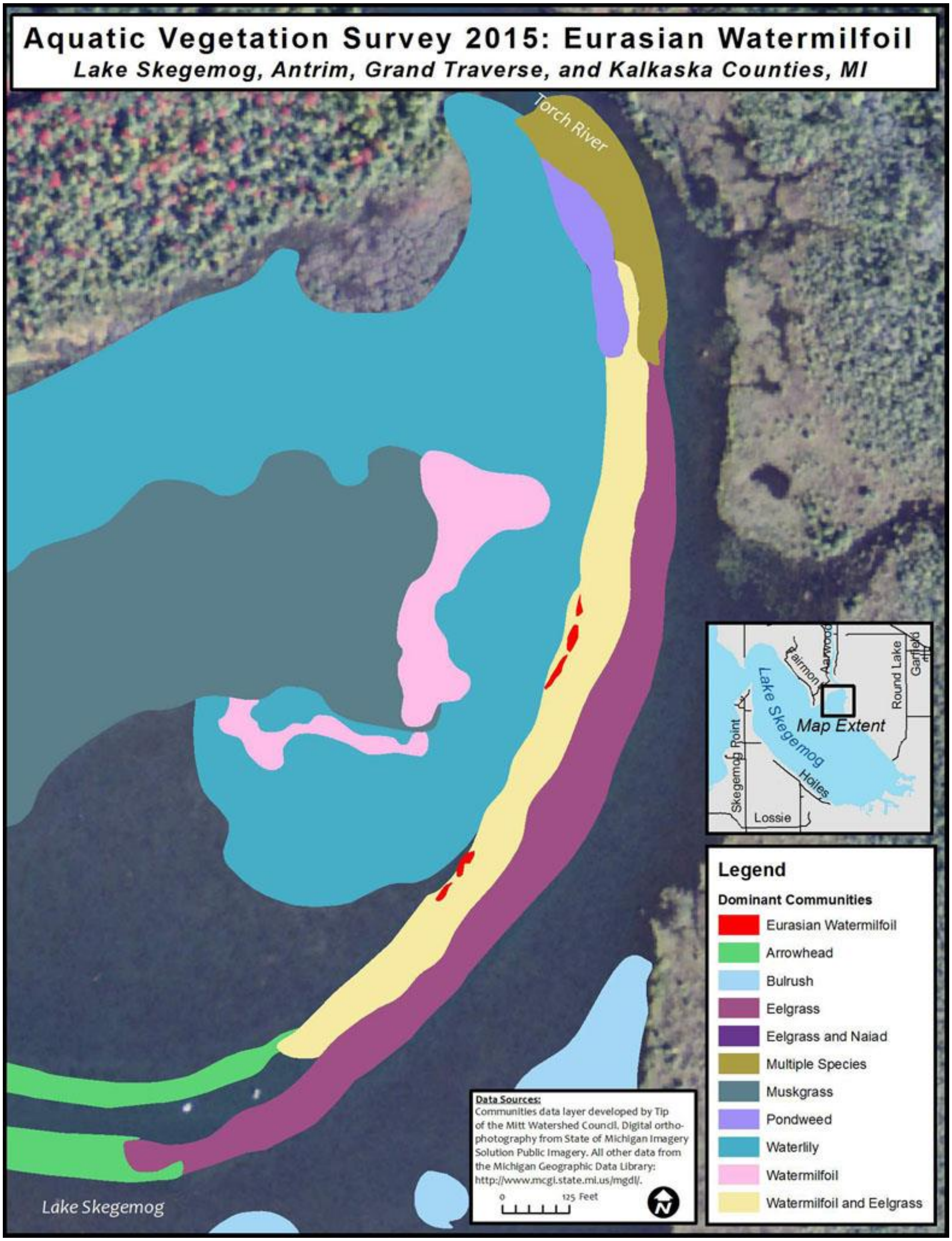

Figure 13. Eurasian watermilfoil infestation locations in Lake Skegemog.

Table 17. Lake Skegemog plant taxa abundance at sample sites.*

Scientific Name	Common Name	Abundant % of Sites	Common % of Sites	Uncommon % of Sites	Rare % of Sites
Chara spp.	Muskgrass	41.2	13.9	12.5	9.3
Najas flexilis	Slender Naiad	18.9	14.4	13.9	13.0
Valisneria americana	Eelgrass	10.6	13.4	12.5	13.4
Potamogeton zosteriformis	Flat-stem Pondweed	2.8	1.4	3.7	21.2
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	1.9	2.8	5.6	10.6
Utricularia vulgaris	Bladderwort	0.9	1.4	4.6	12.5
Potamogeton amplifolius	Broad-leaf Pondweed	0.5	0.9	0.9	2.8
Carex spp.	Sedges	0.5	0.5	0	0
Potamogeton gramineus	Variable-leaf Pondweed	0	2.8	4.6	6.5
Potamogeton strictifolius	Narrow-leaf Pondweed	0	0.9	0.5	0.9
Potamogeton praelongus	White-stem Pondweed	0	0.5	0.9	1.9
Stuckenia pectinata	Sago Pondweed	0	0.5	0.9	1.4
Schoenoplectus subterminalis	Swaying Bulrush	0	0.5	0.5	0.5
Sagittaria spp.	Arrowhead	0	0.5	0	0.9
Potamogeton richardsonii	Richardson's Pondweed	0	0	1.4	1.4
Elodea canadensis	Waterweed	0	0	0.9	4.2
Myriophyllum spicatum	Eurasian Watermilfoil	0	0	0.5	0.5
Potamogeton pusillus	Lesser Pondweed	0	0	0.5	0.5
Potamogeton spp.	Pondweed (unk. species)	0	0	0.5	0
Potamogeton natans	Floating-leaf Pondweed	0	0	0	0.5
Utricularia gibba	Floating Bladderwort	0	0	0	0.5

**Abundance based on the number of rake throws the plant is collected in at each site. 4 = Abundant, 3 = Common, 2 = Uncommon, 1 = Rare.*

Slender naiad and eelgrass followed with being the most abundant at 19% and 11% of vegetated sites, respectively. Based on plant community mapping, 67% of Lake Skegemog contained aquatic vegetation. An additional 9 taxa, all emergent, were noted during community mapping, including cattail, sweet gale, purple loosestrife, softstem bulrush, hardstem bulrush (*Schoenoplectus acutus*), yellow water lily (*Nuphar variegata*), white water lily, rushes (*Juncus spp.*), and native *Phragmites* (*Phragmites australis subsp. americanus*). Muskgrass alone dominated nearly 26% of the lake's vegetated area (Table 18). Combinations of naiad, muskgrass, pondweed, and eelgrass dominated over 40% of the lake's vegetated area. About 5% of the vegetated area was dominated by emergent vegetation, which occurred primarily in nearshore areas at the southeastern end of the lake (Figure 14). Areas of little to no vegetation generally occurred in near-shore shoals and deep areas near the center of the lake (Figure 14).

Table 18. Lake Skegemog dominant aquatic plant communities.

Dominant Community Type	Lake Surface Area (acres)	Lake Surface Area (percent)*
Muskgrass	293.5	25.9
Pondweed, Naiad, and Muskgrass	168.8	14.9
Naiad and Muskgrass	149.2	13.2
Eelgrass	94.2	8.3
Eelgrass, Muskgrass, and Naiad	75.9	6.7
Watermilfoils (Native)	52.5	4.6
Pondweeds and Eelgrass	46.9	4.1
Pondweeds and Muskgrass	37.7	3.3
Pondweeds, Watermilfoils, and Muskgrass	28.5	2.5
Pondweeds	27.6	2.4
Water-lily	26.0	2.3
Multiple Species	22.6	2.0
Pondweeds and Naiad	20.6	1.8
Watermilfoils and Muskgrass	19.7	1.7
Bulrush	16.0	1.4
Pondweed, Naiad, and Eelgrass	12.3	1.1
Eelgrass and Muskgrass	12.0	1.1
Cattail	8.5	0.7
Arrowhead	7.3	0.6
Watermilfoils, Naiad, and Muskgrass	4.3	0.4
Watermilfoils and Eelgrass	2.8	0.3
Native *Phragmites*	2.3	0.2
Eelgrass and Naiad	1.7	0.2
Sedge	1.2	0.1
Mixed Emergents	1.2	0.1
Eurasian Watermilfoil	0.1	0.01
TOTAL	**1133.4**	**100.0**

*Refers to percent of surface area with aquatic vegetation (i.e., 1133.4 acres).

Both sample site and community mapping data show that light-density growth predominated the aquatic vegetation in Lake Skegemog. Over half of sample sites and 77% of the vegetated lake area fell into the very light, light, and light to moderate categories (Table 19, Table 20). Heavy-density plant growth was nearly absent from Lake Skegemog, making up only 0.3% of vegetated areas and limited to emergent communities on the southeastern end of the lake (Figure 15). The invasive watermilfoil beds were classified as having moderate-density growth.

Table 19. Lake Skegemog plant densities at sample sites.

Density Category	Number of Sites	Percentage of Sites
Little/no vegetation	89	29.7
Very Light	55	18.3
Light	39	13.0
Light to Moderate	59	19.7
Moderate	54	18.0
Moderate to Heavy	3	1.0
Heavy	0	0
Very Heavy	0	0
TOTAL	**299**	**100**

Table 20. Lake Skegemog plant community density statistics.

Aquatic Plant Density	Lake Surface Area (acres)*	Lake Surface Area (percent)*
Very Light	360.3	31.8
Light	184.7	16.3
Light to Moderate	326.9	28.8
Moderate	244.6	21.6
Moderate to Heavy	13.1	1.2
Heavy	3.9	0.3
Very Heavy	0	0
TOTAL	**1133.4**	**100.0**

*Refers to percent of surface area with aquatic vegetation (i.e., 1133.4 acres).

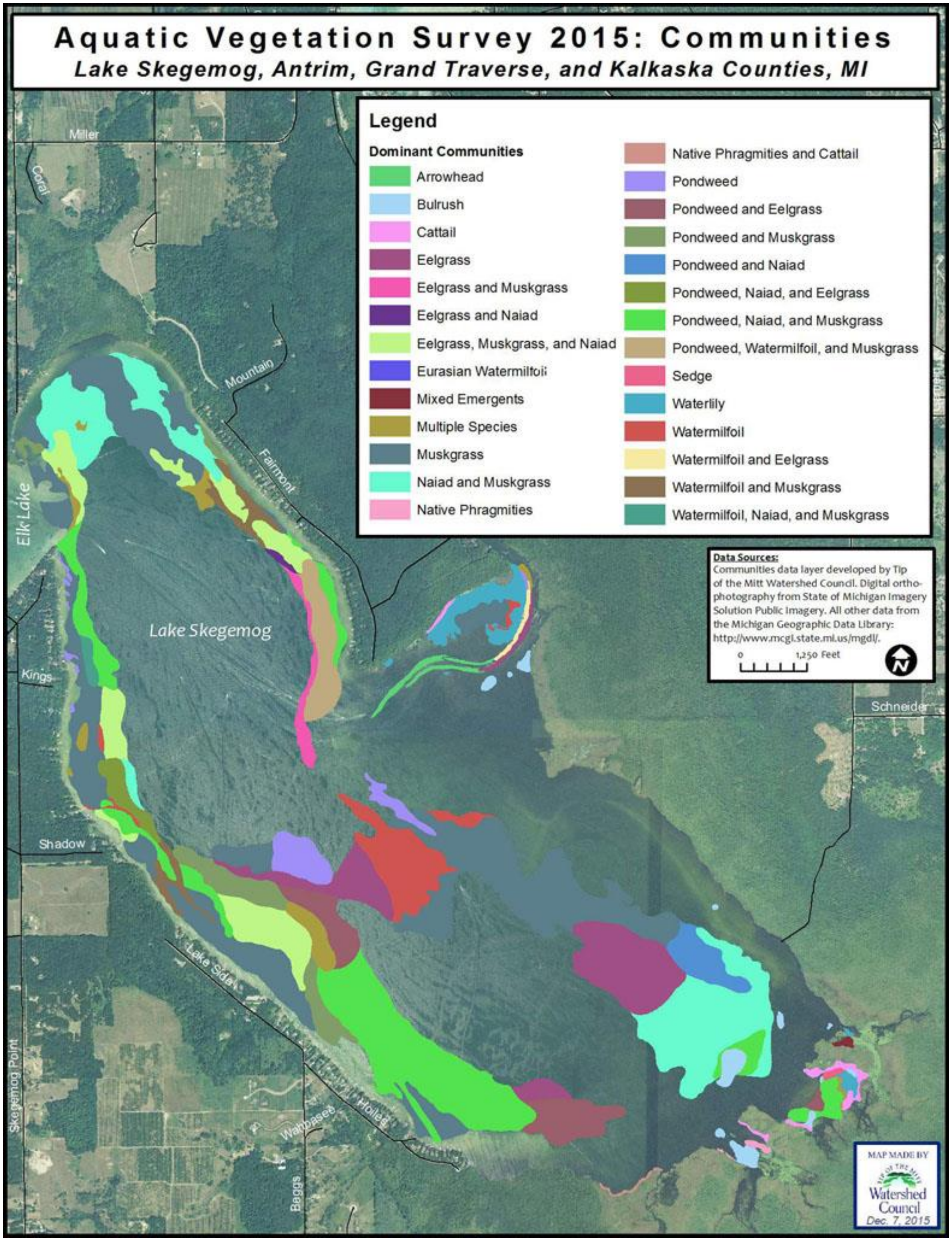

Figure 14. Aquatic plant communities in Lake Skegemog.

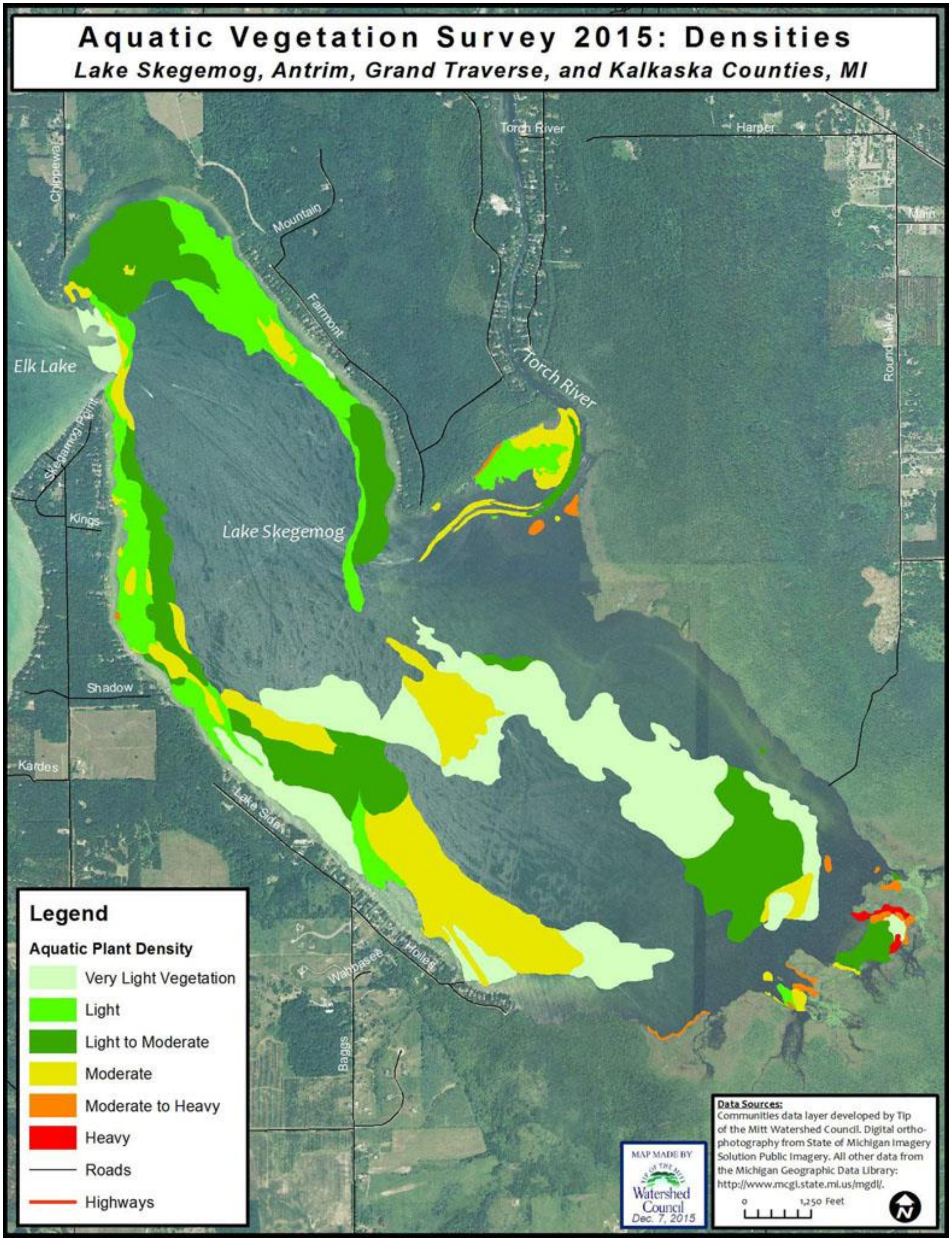

Figure 15. Lake Skegemog aquatic plant community densities.

Elk Lake Aquatic Vegetation Survey

Aquatic vegetation sampling was conducted at 349 sites on Elk Lake, starting on 8/10/15 and completed on 9/9/15 (Figure 16). A total of 26 aquatic plant taxa were documented during the survey, of which 2 were invasive. Purple loosestrife was found, though infestation locations all overlapped with Priority AIS Paddle Survey data and therefore, are not included in this section. Eurasian watermilfoil or a Eurasian hybrid watermilfoil was found at three locations in Elk Lake (Figure 17).

Table 21. Elk Lake aquatic plant taxa occurrence at sample sites.

Scientific Name	Common Name	Total Sites	Total % Sites*
Chara spp.	Muskgrass	119	52.0
Valisneria americana	Eelgrass	22	9.6
Potamogeton amplifolius	Broad-leaf Pondweed	18	7.9
Najas flexilis	Slender Naiad	18	7.9
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	15	6.6
Schoenoplectus subterminalis	Swaying bulrush	6	2.6
Potamogeton spp.	Pondweed (species unknown)	6	2.6
Potamogeton gramineus	Variable-leaf Pondweed	5	2.2
Myriophyllum spicatum x sibiricum	Hybrid Watermilfoil	3	1.3
Sagittaria spp.	Arrowhead	3	1.3
Stuckenia spp.	Sago Pondweed	3	1.3
Potamogeton zosteriformis	Flat-stem Pondweed	2	0.9
Potamogeton natans	Floating-leaf Pondweed	2	0.9
Elodea canadensis	Waterweed	2	0.9
Myriophyllum sibiricum	Northern Watermilfoil	2	0.9
Potamogeton richardsonii	Richardson's Pondweed	1	0.4
Potamogeton robbinsii	Robbin’s Pondweed	1	0.4
Potamogeton friesii	Frei’s Pondweed	1	0.4

**Percent of sites based on vegetated sites.*

Of the total number of taxa found, 18 were documented at sample sites, with a range of zero to 6 taxa per site and an average of 0.6 taxa per site (Table 21). Native plant taxa, including muskgrass, eelgrass, broad-leaf pondweed, and slender naiad were the most commonly encountered species, collected at approximately 52%, 10%, 8%, and 8% of vegetated sites, respectively (Table 21). In addition to being the most commonly collected plant, muskgrass was also the most abundant, found in abundance at 6.5% of vegetated sites (Table 22). Eelgrass and slender naiad followed with being the most abundant at 1.3% and 0.9% of vegetated sites, respectively.

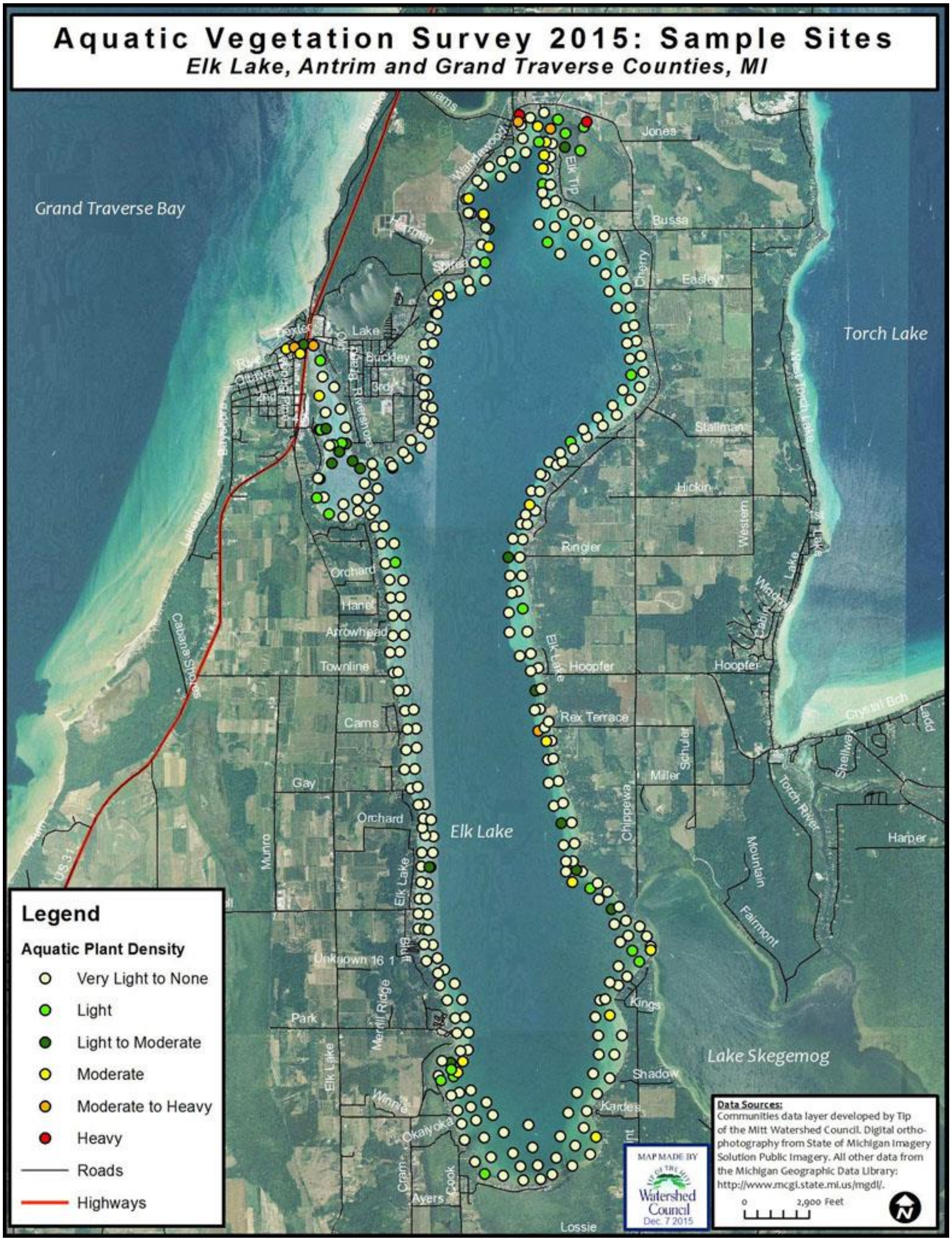

Figure 16. Sample sites for Elk Lake vegetation survey.

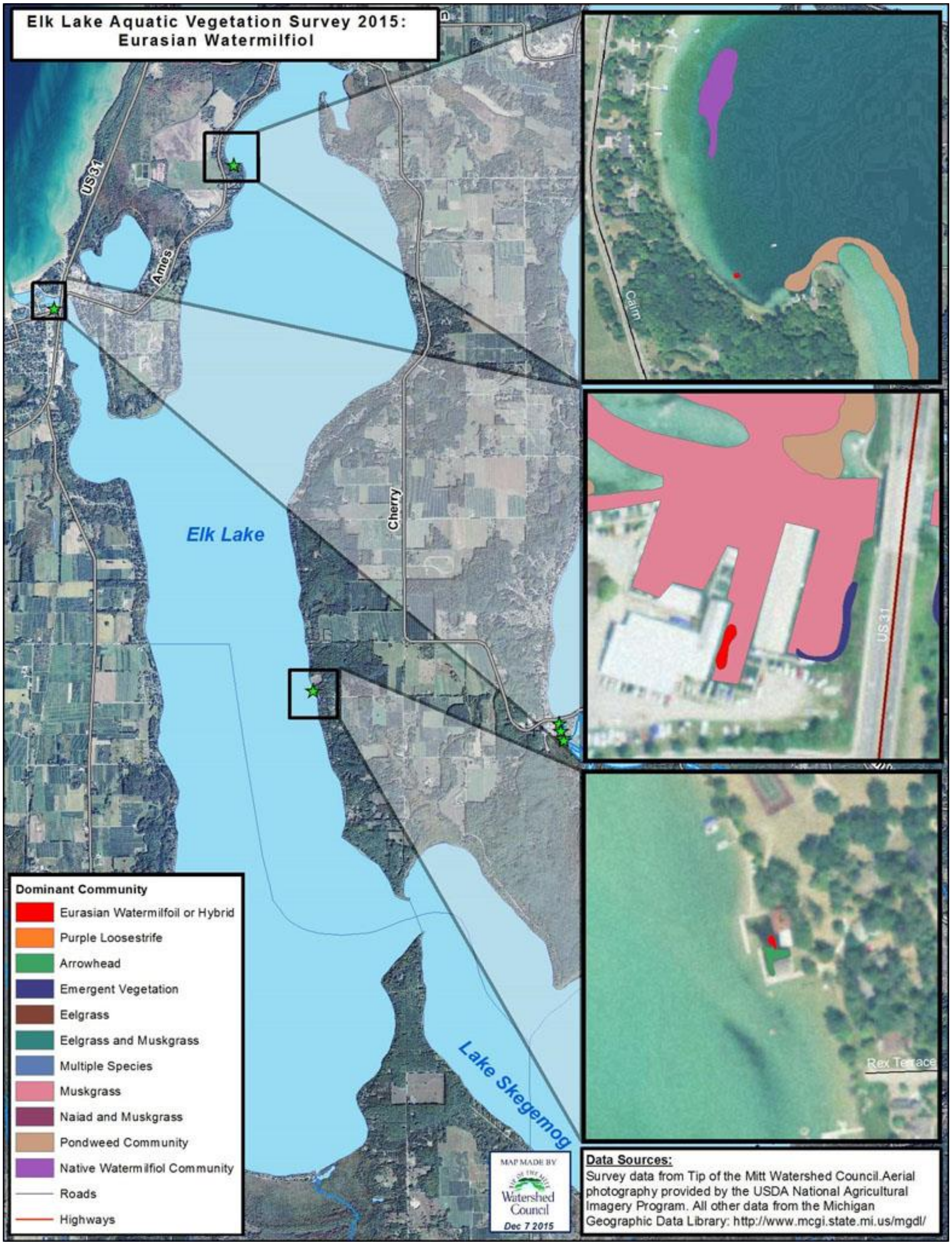

Figure 17. Eurasian watermilfoil hybrid infestation locations in Elk Lake.

Table 22. Elk Lake plant taxa abundance at sample sites.*

Scientific Name	Common Name	Abundant % of Sites	Common % of Sites	Uncommon % of Sites	Rare % of Sites
Chara spp.	Muskgrass	6.5	11.3	12.6	21.3
Valisneria americana	Eelgrass	1.3	1.7	0.9	5.6
Najas flexilis	Slender Naiad	0.9	0.4	5.2	1.3
Myriophyllum heterophyllum	Variable-leaf Watermilfoil	0.4	0.9	3.9	1.3
Potamogeton amplifolius	Broad-leaf Pondweed	0.4	0.4	0	5.2
Potamogeton spp.	Pondweed (unknown sp)	0.4	0.4	0.9	0.9
Potamogeton zosteriformis	Flat-stem Pondweed	0	0.9	0	0
Potamogeton gramineus	Variable-leaf Pondweed	0	0.4	1.3	0.4
Myriophyllum spicatum x sibiricum	Hybrid Watermilfoil	0	0	0.4	0.9
Potamogeton richardsonii	Richardson's Pondweed	0	0	0.4	0
Stuckenia spp.	Sago Pondweed	0	0	0.4	0.9
Sagittaria spp.	Arrowhead	0	0	0	1.3
Potamogeton natans	Floating-leaf Pondweed	0	0	0	0.9
Elodea canadensis	Waterweed	0	0	0	0.9
Myriophyllum sibiricum	Northern Watermilfoil	0	0	0	0.9
Potamogeton robbinsii	Robbin’s Pondweed	0	0	0	0.4
Potamogeton friesii	Fries’ Pondweed	0	0	0	0.4
Schoenoplectus subterminalis	Swaying bulrush	0	0	0	0.4

**Abundance based on the number of rake throws the plant is collected in at each site. 4 = Abundant, 3 = Common, 2 = Uncommon, 1 = Rare.*

Plant community mapping revealed that only 3.7% of Elk Lake contained aquatic vegetation. Of the area supporting aquatic plant growth, 61% was muskgrass (Table 23). The next most extensive plant community was water lilies, both yellow and white. Approximately 10% of the vegetated area was dominated by emergent vegetation, which occurred primarily in nearshore areas (Figure 18). Another 8 taxa, all emergent, were noted during community mapping, including cattail, sweet gale, purple loosestrife, softstem bulrush, three square bulrush (*Schoenoplectus americanus*), white water lily, yellow pond-lily, and rushes.

Table 23. Elk Lake dominant aquatic plant communities.

Dominant Community Type	Lake Surface Area (acres)	Lake Surface Area (percent)*
Muskgrass	189.29	61.08
Waterlily	27.63	8.92
Eelgrass	18.06	5.83
Naiad and Muskgrass	13.93	4.50
Watermilfoil and Sagittaria	10.75	3.47
Eelgrass and Muskgrass	10.51	3.39
Pondweed, Naiad, and Muskgrass	8.69	2.81
Pondweed and Watermilfoil	6.17	1.99
Pondweed, Eelgrass, and Naiad	5.05	1.63
Multiple Species	5.04	1.63
Pondweed and Muskgrass	4.25	1.37
Pondweed	3.22	1.04
Cattail	2.25	0.73
Watermilfoil	2.08	0.67
Pondweed, Eelgrass, and Muskgrass	1.27	0.41
Purple Loosestrife	0.53	0.17
Pondweed, Watermilfoil, and Muskgrass	0.43	0.14
Bulrush	0.39	0.13
Sweet Gale	0.20	0.07
Eurasian Watermilfoil	0.04	0.01
Arrowhead	0.02	0.01
TOTAL	**309.90**	**100.0**

*Refers to percent of surface area with aquatic vegetation (i.e., 309.90 acres).

Both sample site and community mapping data show that the majority of aquatic vegetation in Elk Lake (>75%) fell into the light-density growth categories, which include very light, light, and light to moderate (Table 24, Table 25). Heavy-density growth was limited to two sample sites and accounted for less than three acres. There were two main patches of moderate growth in Elk Lake, in the northern-most bay and on the west side of the lake near Elk Rapids (Figure 19). The invasive watermilfoil beds were classified as having light to moderate growth densities.

Table 24. Elk Lake plant densities at sample sites.

Density Category	Number of Sites	Percentage of Sites
Very Light	38	36.19%
Light	25	23.81%
Light to Moderate	16	15.24%
Moderate	19	18.10%
Moderate to Heavy	5	4.76%
Heavy	2	1.90%
Very Heavy	0	0.00%
TOTAL	**105**	**100.00%**

Table 25. Elk Lake plant community density statistics.

Aquatic Plant Density	Lake Surface Area (acres)*	Lake Surface Area (percent)*
Very Light	119.61	38.60
Light	81.63	26.34
Light to Moderate	35.90	11.58
Moderate	64.07	20.67
Moderate to Heavy	5.95	1.92
Heavy	2.43	0.78
Very Heavy	0.31	0.10
TOTAL	**309.90**	**100.00**

*Refers to percent of surface area with aquatic vegetation (i.e., 309.90 acres).

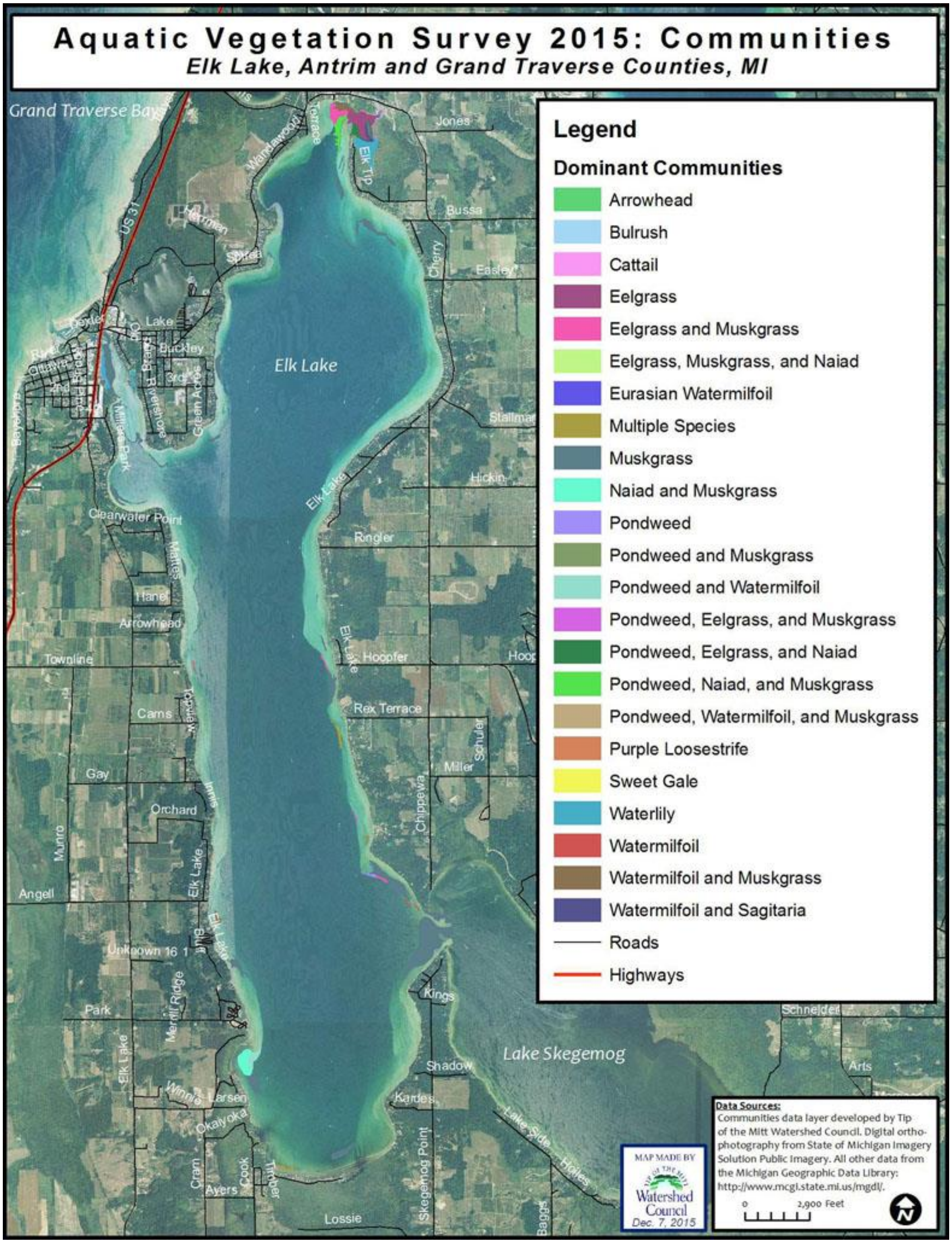

Figure 18. Aquatic plant communities in Elk Lake.

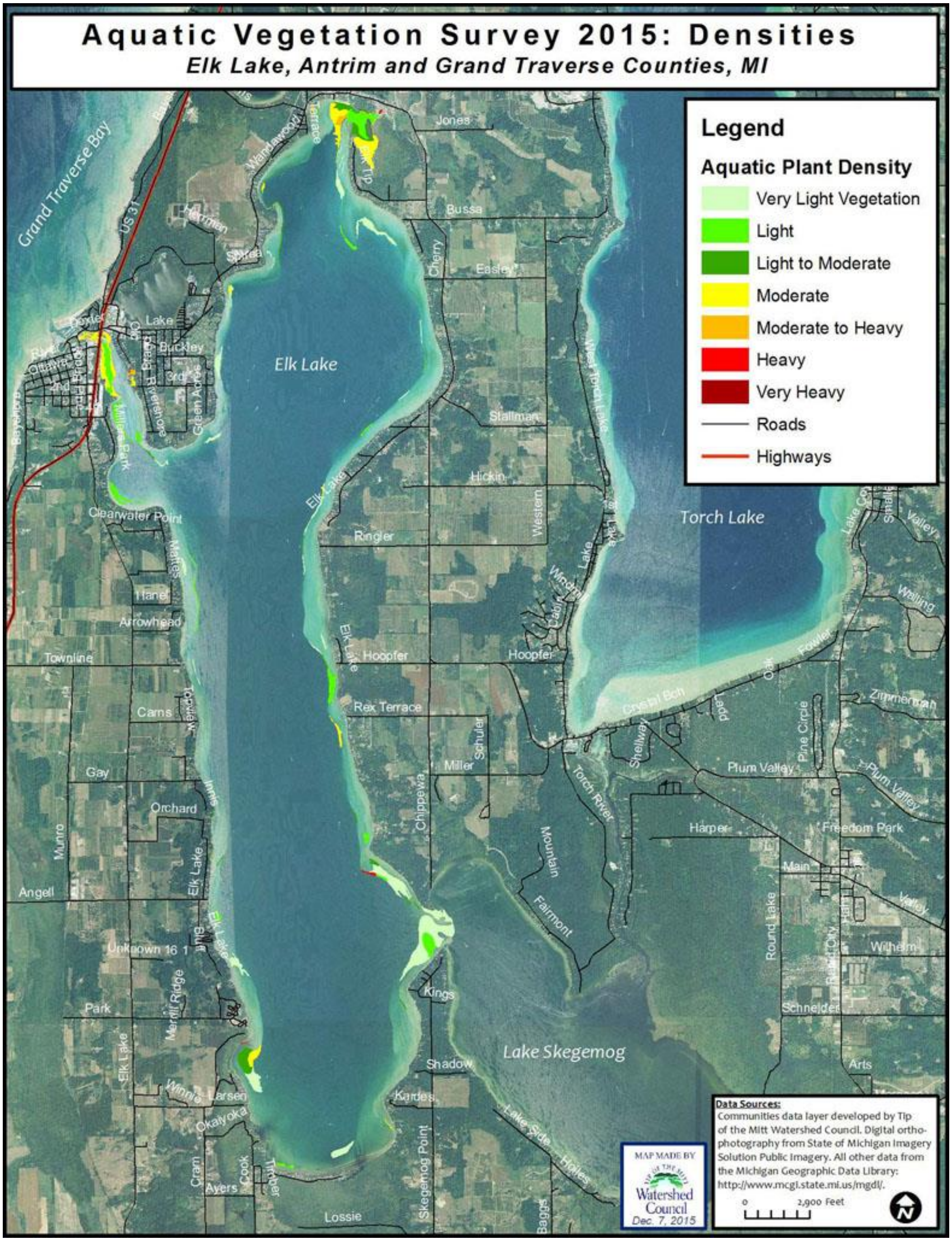

Figure 19. Elk Lake aquatic plant community densities.

AIS Workshops and Partner Monitoring Results

Two AIS workshops were successfully coordinated and implemented by TOMWC and ACD during the project period. The workshops were held on October 22, 2014 and June 17, 2015. A total of 25 participants from partner organizations attended the workshops and were trained to assist with priority AIS monitoring in the ERCOL. The workshop included presentations on ERISMP project goals and objectives, project progress and results to date, local and regional AIS control efforts, identification and biology of the priority invasive species, AIS documentation protocols, and occurrence reporting directions (see Appendix F). Hands-on practicums were held following each workshop, wherein trainers and attendees visited nearby sites to practice identification skills and run through documentation protocols. Feedback from the workshop participants was consistently positive.

AIS workshop participants utilized their new abilities to identify, document, and report the five priority invasive species by monitoring ERCOL surface waters. In total, 17 workshop participants from project partner organizations assisted with AIS monitoring. These individuals monitored ERCOL surface waters for a combined 440 hours during the project period. Project partner monitoring efforts resulted in invasive watermilfoil being found at two locations in the Torch River and one in Elk Lake.

Project Results Dissemination and Follow-up Facilitation

Project updates and monitoring results were shared regularly with project partners and other watershed stakeholders via bimonthly ERCOL Watershed Planning Implementation Team (WPIT) committee meetings. Project progress and results were also shared in the TOMWC *Current Reflections* newsletter. TOMWC, TWC, TLA, ESLA, IMA, SMLA, and ACD promoted the project and associated workshops in their publications, meetings and/or via internet communications. This project report will also be made available to the public via the TOMWC website, shared with all project partners, and all members of the ERCOL WPIT.

TOMWC staff presented ERISMP monitoring results to ESLA on December 10, 2015 and with TLA and other Torch Lake groups on March 16, 2016. Follow-up actions and control strategies were discussed at these meetings and tentative action plans developed. TOMWC will meet with other project partners (IMA and SMLA) in the summer of 2016 to present project results and discuss follow-up actions. The Charlevoix-Antrim-Kalkaska-Emmet Cooperative Invasive Species Management Area coordinator was and will be included in these meetings and follow-up actions.

DISCUSSION

Successful completion of the ERISMP produced a detailed inventory of five priority AIS throughout the 14 lakes and interconnecting waterways of the ERCOL. Via paddle surveys, benthic sled tows, and comprehensive aquatic vegetation surveys, TOMWC has gathered location, area, and density information for the five target species. This information is critical for the planning and successful implementation of control measures. Furthermore, effective control of priority AIS will be facilitated by TOMWC's involvement as an active steering committee member of the newly formed Charlevoix-Antrim-Kalkaska-Emmet Cooperative Invasive Species Management Area (CAKE CISMA).

Considering the large project area size and limited resources, it is possible that priority AIS infestations in monitored ERCOL water bodies were missed despite intensive monitoring efforts. Visibility into riparian areas and into deeper waters was at times limited during AIS paddling surveys. In addition, infestations could have been missed while zigzagging during paddling surveys. Although benthic tows were performed throughout ERCOL water bodies and with a focus on public access points, these surveys were by no means exhaustive. In terms of comprehensive aquatic vegetation surveys, plants were not sampled between sites in survey transects and plant community mapping may have not occurred in those areas either if conditions did not allow. In addition, plant community mapping was sometimes impeded by poor visibility, whether from wave turbulence, turbidity, or simply water depth and attenuation of sunlight. These shortcomings underlie the need to periodically repeat this type of monitoring effort. Furthermore, continued efforts to capacitate partner organizations and volunteer monitors in AIS identification and reporting methods will help ensure early detection of AIS in the ERCOL.

The following sections include assessments of the current status of the priority AIS, as well as guidance for follow-up actions.

Eurasian *Phragmites*

Based on monitoring results, Eurasian *Phragmites* has not yet become entrenched in the ERCOL. Small infestations were found at just three locations in the ERCOL, one site on Six Mile Lake and two sites on Intermediate Lake. However, monitoring efforts may not have detected all Eurasian *Phragmites* infestations, and additional infestations could be present in other areas of the Elk River Watershed. Regardless, control measures should be implemented immediately at these locations due to the aggressive and highly problematic nature of this invasive reed.

Purple Loosestrife

ERISMP results show that purple loosestrife is widely distributed in the ERCOL, documented at 173 locations on 11 water bodies (Table 4). The widespread distribution aligns with results from other AIS monitoring projects implemented by TOMWC, such as those in the Bear River and Cheboygan River Watersheds (TOMWC 2010, TOMWC 2007). Infestations were more numerous and larger found in lakes at the top (Six Mile), middle (Hanley and Intermediate), and bottom (Elk) of the chain. Prior treatment of purple loosestrife infestations in Hanley Lake using *Galerucella* beetles had seemingly long-term effectiveness, considering that ERISMP results showed that the once heavy-density purple loosestrife beds at that site now range from light to moderate. Therefore, focused biological control efforts with the *Galerucella* beetles in the four lakes listed above could potentially extend benefits to nearby lakes and others in the ERCOL with purple loosestrife via beetle migration.

Although *Galerucella* beetles potentially provide long-term control, it is important that control strategies account for infestation areas, densities, and separation distances for a given water body or area within a water body. In some situations, such as Torch Lake, most purple loosestrife infestations are grouped in one shoreline area, but the size of individual infestations is very small. In this situation, hand-pulling and herbicide application may prove to be more effective than beetle releases.

Eurasian Watermilfoil

Eurasian watermilfoil infestations were concentrated in two areas of the ERCOL, in the upper end of the chain in Six Mile and St. Clair Lakes and at the lower end from the Clam River to Elk Lake. The results were not surprising considering that, prior to ERISMP, there were known infestations in Six Mile Lake, Clam Lake the Clam River, Torch Lake, the Torch River, and Elk Lake. The new Eurasian watermilfoil infestations found in St. Clair Lake and Lake Skegemog were likely the result of downstream spread via either currents or boat traffic from Six Mile Lake and the Torch River.

Fortunately, Six Mile Lake Association, Three Lakes Association, and Elk-Lake Skegemog Association have already engaged in implementing control measures, ranging from herbicide treatment to benthic barrier installations. In fact, little or no Eurasian watermilfoil was Six Mile Lake, Clam Lake, and the Torch River due to successful treatment. St. Clair Lake, the worse affected in terms of number of infestations and total infestation area is, has no formal association to coordinate and implement control measures. This is concerning because St. Clair Lake is situated near the top of the chain and there is great propensity for Eurasian watermilfoil to spread via downstream drift of plant fragments. Therefore, implementing control and prevention measures in St. Clair Lake should be given priority.

Curly-leaf Pondweed

Curly-leaf pondweed was found in just two areas, at the confluence of the Intermediate and Cedar Rivers and in the Torch River near the confluence with the Rapid River. There was only one infestation found in the Intermediate River, the majority of which actually extended up into the Cedar River. Seven infestations were found in the Torch River, both upstream and downstream of the confluence of the Rapid River. In both situations, the connecting cold-water rivers appear to be sources of curl-leaf pondweed.

Little information about how far this AIS extends up into these rivers is available, though it has been documented far upstream on the Rapid River at Rugg Pond. Although both areas warrant treatment, priority should be given to treating infestations in the Torch River because monitoring data show that curly-leaf pondweed is spreading up and down the river. Furthermore, a dam just downstream of the confluence of the Cedar and Intermediate Rivers will likely slow downstream migration. It is also important to survey the connecting river systems to set the stage for addressing the curly-leaf pondweed at the source.

Quagga Mussels

ERISMP results indicate that quagga mussels have not yet invaded the ERCOL. Considering the proximity to heavily-infested Lake Michigan, the absence of quagga mussels in the ERCOL is notable. The dam at Elk Rapids and the difficulty of transferring boats from Lake Michigan to ERCOL water bodies are likely pivotal factors that have slowed the spread of this invasive mussel. Although efforts were made to monitor the most likely locations of AIS introduction, the 104 benthic tows that were conducted in the ERCOL covered only a small fraction of the nearly 35,000-acre project area. However, the fact that zebra mussels were documented in every water body surveyed in the ERCOL indicates that methods used were effective in sampling invasive mussel populations. In addition, the presence of zebra mussels indicates that conditions of the ERCOL are suitable for sustaining quagga mussels, given their close genetic relationship and similar ecological needs.

Narrow-leaf Cattail

Narrow-leaf cattail (*Typha angustifolia*) was documented in most water bodies of the Lower ERCOL during the latter half of the paddle surveys. Although this invasive cattail was not included in the ERISMP as a priority species, it was added to the monitoring list when infestations became noticeable in the second year of field surveys. It was found at 20 locations in the Intermediate River, Lake Bellaire, Clam Lake, Torch River, and Elk Lake. All infestations combined totaled an estimated 68,000 square feet. This invasive cattail species probably occurs in the Upper Chain as well, but was not monitored. In many areas, narrow-leaf cattail populations are extensive, such that it is not a priority for early detection and rapid response strategies. However, the Lower Chain data suggest that treatment could be administered to effectively control this invasive species. Narrow-leaf cattail monitoring data have been shared with project partners and other stakeholders from the Lower Chain.

Recommendations

Although goals of the ERISMP were achieved during the project period, tasks for accomplishing Goals 2 and 3 are somewhat perpetual in nature. There is a continued need to disseminate and act upon project results. Informed watershed partners and an informed public will foment effective follow-up actions to control existing priority AIS populations, as well as prevent the introduction of other AIS. The CAKE CISMA coordinator and other committee members are expected to assist with most of the recommended follow-up actions presented here.

1. Continue to share ERISMP results. ERISMP project updates and results were shared regularly with watershed partners, including the ERCOL WPIT and lake associations in the ERCOL. However, to ensure AIS controls are implemented, efforts to present and discuss project results and recommended follow-up actions should continue. In addition, upon completion, this full project report should be shared with all ERISMP partners and watershed stakeholders, who should be encouraged to make the report available via web sites.

2. Assist private property owners to implement control measures for AIS found on their waterfront properties. Although outreach strategies were planned during meetings between TOMWC and ERISMP partners, project period and resources did not allow for individual private property owner outreach. TOMWC will continue to promote watershed partnerships that engage affected waterfront property owners, inform them of survey results, educate them about AIS, and encourage and facilitate control measures.

3. Implement Eurasian *Phragmites* control measures as soon as possible. *Eurasian Phragmites* was observed in just three locations and therefore, should be treated quickly to prevent spread. Work with affected private property owners to facilitate permit acquisition and treatment. Conduct follow-up to assess treatment effectiveness and treat again as necessary. Collaborate with the Six Mile Lake Association and Intermediate Lake Association on Eurasian *Phragmites* outreach and education to members and other lakeshore residents, so that they are aware and able to identify and report any additional infestations.
4. Control purple loosestrife using methods appropriate for infestation sizes, densities, and distributions. Utilize biological control methods to address infestations in the worst afflicted lakes, including Six Mile, Hanley, Intermediate, and Elk Lakes. *Galerucella* beetle releases in these water bodies and subsequent migration will potentially achieve control of purple loosestrife in other ERCOL lakes. Implement purple loosestrife control with beetles, hand-pulling, or herbicide application in other ERCOL lakes depending on circumstances.

5. Prioritize Eurasian watermilfoil control efforts in St. Clair Lake to prevent downstream spread. Engage the Village of Ellsworth and St. Clair Lake waterfront property owners to collaboratively address this AIS problem and thereby, more efficiently and effectively implement control measures. Install and maintain boom interceptors in the channel between St. Clair and Ellsworth Lakes to prevent the downstream spread of Eurasian watermilfoil.

6. Continue current Eurasian watermilfoil control efforts in the ERCOL and expand to address new infestations found in the Lower Chain. Encourage collaboration among watershed partners to promote treatment efficacy.

7. Control curly-leaf pondweed at known locations, investigate sources, and develop action plans for controlling sources. Focus curly-leaf pondweed control efforts on the Torch River infestations. Monitor the Cedar and Rapid Rivers to

determine the extent of curly-leaf pondweed infestations and utilize the monitoring information to develop and implement AIS control plans.

8. Ensure that ERISMP results are incorporated into the current draft of the ERCOL Watershed Management Plan that is being developed by University of Michigan School of Natural Resources master's project team and the WPIT.

9. Continue to encourage AIS control and prevention through broad-scale and targeted education and collaboration efforts. Work with watershed partners to educate riparians, local government officials, and the general public about AIS, providing outreach and educational materials.

10. Continue training watershed partners to identify, document, and report AIS. Support the TOMWC AIS Patrol, a new component of volunteer monitoring programs, wherein volunteer monitors are trained to identify, document, and report AIS.

11. Repeat AIS monitoring in the ERCOL periodically (ideally every 3-5 years), coupled with the follow-up actions.

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Appendix A. ERISMP Goals and Objectives.

1. Goal 1: Survey all major water bodies in the ERCOL Watershed to document locations and characteristics of the five priority AIS (*Phragmites*, purple loosestrife, Eurasian watermilfoil, curly-leaf pondweed, quagga mussels), as well as other aquatic invasive species considered threats to the Watershed.
    a. Objective 1: Develop Quality Assurance Protection Plan (QAPP) and acquire approval of QAPP from DEQ Water Resources Division prior to monitoring; implement QAPP throughout duration of project.
    b. Objective 2: Hold 2 training session to train project partners to identify AIS and properly document invasive species occurrence.
    c. Objective 3: Survey the shorelines of the 14 lakes and connecting tributaries to document the occurrence and extent of invasive riparian plant species, including *Eurasian Phragmites* and purple loosestrife.
    d. Objective 4: Perform visual surveys of all 14 lakes and connecting tributaries to document the presence of invasive submergent plant species, with a focus on Eurasian watermilfoil and curly-leaf pondweed.
    e. Objective 5: Intensively survey the plant populations of four lakes of concern (Intermediate, Hanley, Elk, and Skegemog) to comprehensively document plant species, communities, and densities, with a focus on AIS currently considered as threats.
    f. Objective 6: Survey the benthic zone of all major lakes and connecting tributaries in the ERCOL to detect invasive quagga mussels.
2. Goal 2: Disseminate project findings to watershed stakeholders, other appropriate organizations and agencies, and the public to increase awareness of AIS and their status in the ERCOL Watershed.
    a. Objective 1: Compile all data gathered from the project and any additional AIS information available, and write a summary report.
    b. Objective 2: Share project findings with Watershed residents and the public in general by making summary report and data available on project partners' web sites and via summary articles in partners' newsletters.
    c. Objective 3: Present project findings and provide summary report and project data to the ERCOL Watershed Planning Committee (Committee).
    d. Objective 4: Provide project reports and data to relevant water resource management organizations and agencies, including DEQ, Michigan Department of Natural Resources (DNR), Michigan Natural Features Inventory (MNFI), and Midwest Invasive Species Information Network (MISIN).
3. Goal 3: Encourage action by Watershed partners and others to manage and control the spread of invasive species in the Watershed.
    a. Objective 1: Work with the Committee to plan and implement AIS management and control strategies.
    b. Objective 2: Encourage state agencies and other organizations to assist the Committee with planning and implementing AIS management and control strategies.

Appendix B. Aquatic invasive species monitoring form.

Aquatic Invasive Species Monitoring Form

Tip of the Mitt Watershed Council

Project Name: ____________________________ **Survey Location:** ____________________________

Surveyor Name(s): ____________________________

Priority Species: curly-leaf pondweed, Eurasian watermilfoil, Phragmites, purple loosestrife, and quagga mussel

Site ID	Date	Water Body Name	Invasive Species Name	Average Length of Infestation (feet)	Average Width of Infestation (feet)	Density (Light, Moderate, or Heavy)	Sample Collected? (yes or no)	Photo Taken? List	Comments

Appendix C. Quagga mussel survey form.

Benthic Sled Monitoring Form

Tip of the Mitt Watershed Council

Project Name: ____________________ **Survey Location:** ____________________

Surveyor Name(s): ____________________

Site ID	Date	Water Body Name	Describe location on water body	Duration of sample line (seconds)	Depth range of sample line (feet)	Number of zebra mussels	Number of quagga mussels	Photo Taken? List	Comments

Appendix D. Aquatic vegetation survey standard operating procedure.

Aquatic Vegetation Survey Standard Operating Procedure
Tip of the Mitt Watershed Council
Last updated: 4/24/15

Summary

This Standard Operating Procedure (SOP) was developed by Tip of the Mitt Watershed Council (TOMWC) incorporating the experience and knowledge of TOMWC surveyors, as well as elements of methods detailed in the Michigan Department of Environmental Quality's *Procedures for Aquatic Vegetation Surveys*. This SOP is designed for comprehensive and detailed aquatic vegetation surveys that document aquatic plant taxa, abundance, density, and community information at specific sample sites while also delineating and mapping the areal extent of plant communities throughout the lake. These surveys can be and typically have been conducted by one person, but if resources are available (i.e., extra boat, GPS, camera, surveyor, etc.), then two or more people or crews can work on the surveys simultaneously.

Periodic aquatic vegetation surveys should be conducted on lakes to effectively manage the aquatic plant communities. Surveys are necessary to establish baseline data, examine trends, evaluate success or failure of aquatic plant management projects, and document the locations and spread of non-native aquatic plant species. Although dependent upon many different variables, surveying the aquatic plant community on a 5-10 year basis is generally sufficient.

Equipment and Preparation

1. Sampling Device. A heavy grapple-type device is needed to sample aquatic macrophytes at sample sites. Although many types of samplers have been developed, one of the most commonly used consists of two rake heads clamped together. Securely fasten a rope of approximately 30 feet in length to the sampler (1/4" to 3/8" diameter preferable). Secure the other end of the rope to the boat when using the sampler.
2. Datasheets. Information collected at sample sites must be recorded on a field datasheet (Appendix A). Attributes recorded on the datasheet include lake name, site identification number, macrophyte species names, macrophyte densities, water depth at the site, and overall community density at the site. If available, print five to ten datasheets on waterproof paper to use if it rains.
3. Global Position System (GPS). A precise mapping-grade handheld GPS unit with attribute input capabilities is needed to accurately record the location of sample sites, delineate aquatic macrophyte communities, and record locations of other observations about

macrophyte species and communities. The GPS unit should have an accuracy of five meters or less and capability of collecting both point and line data. The GPS should allow for inputting relevant information, such as site identification number, that is associated with the feature being mapped. Ideally, the GPS unit has the capability of exporting field data into a format that can be readily used in a Geographical Information System (GIS).

4. Camera. A camera is required to photo-document the macrophyte species found at a site, as well as visible aquatic plant communities at the site (e.g., a nearby patch of pond-lilies). A camera with GPS capabilities is preferable because it provides a back-up for the handheld GPS unit and photographs from a GPS camera can usually be directly displayed in a GIS.
5. Boat. A small motor boat is generally required to perform aquatic vegetation surveys, though oars may be sufficient for some small lakes. A stable boat with open workspace is ideal for collecting samples, sorting samples, and displaying specimens for photographs. Boats in the 13-15' length range are preferable because they provide enough space to perform the work, but yet are highly maneuverable and generally have a shallow draft. Maneuverability is important for delineating aquatic plant communities while the draft is important for sampling and mapping in nearshore or other shallow areas. An electric motor trim is preferred for regular adjustments needed while sampling or mapping shallow areas. Ideally, the boat will also have a compass installed, though a handheld compass can be used if needed.
6. Polarized Sunglasses. Polarized sunglasses are among the most important items for effectively surveying aquatic vegetation. Beyond protecting the surveyor's eyes from solar radiation, polarized sunglasses allow the surveyor to see more clearly and deeper into the water. Polarized glasses greatly assist in determining what macrophyte species are present in the water, the density of growth, and where divisions between communities lie.
7. Personal Safety and Safety Equipment. Personal flotation devices are required to be on board when operating or riding in a boat and should be worn at all times, particularly if working alone. A waterproof marine radio is recommended for emergencies. In lieu of a marine radio, a cell phone can also be used for emergencies, but should be kept in a waterproof case. Maintain a stocked first aid kit on the boat at all times. Sun protection is recommended (sunscreen, hat, sunglasses, etc.) and insect repellant may be needed in some situations. Weather conditions should be evaluated each day prior to performing surveys. If thunderstorms or winds above 10 miles per hour are predicted, then the survey should be delayed. If a thunderstorm approaches while on the water, halt the survey immediately, drive the boat to the nearest public shoreline property and take refuge in a safe area until the storm passes over.
8. Lake Maps and Planning. For planning purposes, acquire and review maps of the lake prior to conducting the survey. Lake maps with bathymetry (depth contours) will help determine which areas will have to be surveyed, typically those less than 20 feet deep. Sources of bathymetry maps include the Michigan Department of Natural Resources (http://www.michigan.gov/dnr/0,4570,7-153-67114_67115-67498--,00.html) and the Sportsman's Connection (http://www.sportsmansconnection.com/). Lake areas can also be assessed with aerial imagery in a GIS or using internet-based mapping services such as Google Earth.
9. Additional Equipment. Only use pencils or waterproof pens for recording data on datasheets. Large sealable plastic bags are needed to hold and transport specimens that

cannot be identified in the field. At least one large (5-gallon) bucket or other container is recommended to help with sorting grapple samples.

Sampling Procedures

1. Sample Lines. Aquatic macrophyte populations are methodically sampled by collecting specimens at sites in sample lines. The sample lines are spaced at regular intervals throughout all lake areas capable of supporting aquatic vegetation (typically less than 20’ in depth). Sample lines begin at the shoreline and continue linearly into deeper waters until plants are no longer found (for an example, see Appendix B). In shallow lake areas, the sample line continues to the opposite side of the lake. Landmarks on both shorelines should be identified prior to beginning a sample line to stay on track. Alternatively, a GPS unit can be used to maintain the sample line course. Although highly variable, the distance between sample lines is typically 500’ or less. Upon completing a sample line, the surveyor follows a zigzag path to the starting point of the next sample line to observe (both by eye and depth finder) aquatic macrophyte species and communities in between sample lines. Changes in plant communities, the presence of invasive plant species, or other relevant information that the surveyor observes in the area between sample lines is included in the field notes and recorded with a GPS when applicable. Additional sample sites between sample lines are sometimes required.
2. Sample Points. To assist in delineating and mapping the lake’s plant communities, sample sites should be chosen at transition points between communities when possible. Therefore, the distance between sample points along a sample line varies depending upon plant community changes that are visible to the naked eye from the surface. In areas where plant communities are not visible due to depth, turbidity, or other factors, select sample sites based on plant community transitions observed in depth-finder signals. Although experience improves one’s ability to interpret depth-finder signals, the presence and height of aquatic macrophytes are usually obvious in the depth-finder output display, which provides the necessary information to identify transitional areas between plant communities. Continue sampling at points along the sample line until vegetation is no longer found. Keep in mind that lake bottom morphology can vary, such that aquatic vegetation may disappear due to depth and reappear in shallow areas further out in the lake. Therefore, it is very important to review the bathymetry of all lake areas prior to sampling to ensure all areas capable of supporting macrophyte growth are sampled. Due to a variety of reasons, including irregularities in the shape of the lake shoreline, variability in lake depths, isolated plant communities, or the presence of invasive plant species, additional sample sites outside of the sample lines may be necessary to adequately document and map the lake’s plant communities.
3. Sampling: the following are step-by-step instructions for each sample site.
    a. At each sample site, the boat must first be securely anchored.
    b. Record water depth at the site on the field datasheet based on depth-finder readings. Because the surveyor will often sample in transitional areas in terms of both plant communities and water depth, the depth readings may change frequently at the site, so record the average depth at the site.
    c. Fill in the descriptive site information on the field datasheet. If visible, take a look at the macrophyte community around the boat and write relevant comments on the field datasheet (e.g., “muskgrass dominant to north” or

"vegetation continues 20' in and then no vegetation to shore"). Also, note any observations made in plant species or communities since the last sample site (e.g., "dense vegetation began ~100' back toward last site").

d. Record the site location in the GPS as a point feature. Type the site identification number into the GPS and save the feature to internal memory.
e. Sample plants at the site with a grapple. Ensure that plant grapple is tied securely to the boat. Throw the grapple in four directions: shoreward, outward, and parallel to shore in each direction, noting cardinal directions (north, south, east, and west). Alert other crew and check that there are no bodies or equipment behind you before you throw to avoid injury or damage. Throw the grapple as far as able in the required direction and allow it to sink to the lake bottom. Steadily pull the grapple along the lake bottom until reaching the boat (Warning! Do not pull too quickly or grapple may be pulled over plants instead of through plants). Carefully pull the grapple with plants up from the lake bottom and into the boat. Grab any specimens that fall off the grapple and remain within reaching distance of the boat. Taxa by taxa, write names on the datasheet, along with densities using the following system: Very Heavy = grapple full of plants and vegetation reaches surface; Heavy = grapple full of plants; Moderate = grapple half full of plants; Light = grapple tongs lined lightly with plants though not accumulated; Very Light = virtually no plants on grapple; Moderate-Heavy = in between Moderate and Heavy; Light-Moderate = in between Light and Moderate density; No Vegetation = grapple empty. Assign the densest taxa the overall density of the grapple (i.e. if a grapple is overall heavy, the dominate taxa will be assigned heavy). Keep one specimen for each taxa found in the sample and place apart. Repeat for the other sides of the boat, keeping one specimen of each unique taxa. Determine if there are plant species observed at the site that are not represented in the collected specimens. Continue sampling with the grapple until you are satisfied that all plant taxa present at the site are represented in the sample. If no plants are encountered during sampling, write 'no vegetation' for that site on the datasheet and move to the next sample site. Note: if required directions (shoreward, outward, and parallel to shore in each direction) do not match well with cardinal directions, utilize intercardinal directions and note on the datasheet.
f. Identify specimens to the lowest taxonomic level possible and lay out in open area of boat. Write the name of each taxa on the field data sheet. Write "unknown" in a row on the datasheet for each taxa that you are unable to identify. Count the number of throws each taxa was documented to determine and record occurrence at the site using the following system:
    i. Abundant (A) = taxa specimens found on all four sides of the boat.
    ii. Common (C) = taxa specimens found on three sides of the boat.
    iii. Uncommon (U) = taxa specimens found on two sides of the boat.
    iv. Rare (R) = taxa specimens found on one side of the boat.

    Include taxa found in additional grapple tosses.

g. Using the density of plants noted in each rake throw, determine the overall plant density at the site using the average density of the four throws (i.e., if two throws are heavy density and two throws are light density, the average density would be moderate).

h. Place completed datasheet next to display specimens that were used to determine occurrence and photograph the specimens and datasheet together. To assist in map development of aquatic plant communities, take additional photographs of surrounding areas at sample sites located within or adjacent to emergent vegetation. Write the photograph numbers on the datasheet.
i. Place any specimens that cannot be identified in a plastic sealable bag and add an ounce or two of lake water to keep specimen moist. Write the lake name, site identification number, and sample date on a scrap piece of paper with pencil or waterproof pen and place inside the sealable bag. Only use one bag per site.
j. Return all other plants collected at the site to the lake.

4. Community Mapping. Aquatic plant communities can be delineated simply by interpolating or extrapolating between sample points, but the accuracy of such delineations is greatly improved by noting and mapping precise locations where one plant community type ends and another begins. Therefore, additional data are collected to improve the accuracy of delineations between distinct plant communities in the lake. The following methods are used to gather information helpful for delineating plant communities, some of which have previously been mentioned.
    a. During sampling, write plant community details observed at or near the sample site on the field datasheet in the comments section including the absence of vegetation in any direction.
    b. Upon completing a sample line, return to the shoreline where you started in the direction of where you intend on starting your next sample line and review the area between sample lines in a zigzag motion to observe (both by eye and depth finder) aquatic macrophyte species and communities. Note changes in plant communities, the presence of invasive plant species, or other relevant information observed in the area between sample lines on field datasheet or in separate field notes, and record with a GPS when applicable.
    c. Note changes in plant communities between sample sites on the field datasheet and record the precise location on the GPS (with description of the feature inputted into the GPS) when feasible.
    d. Delineate lake areas that lack vegetation by following visible lines between vegetated and non-vegetated areas and recording it in the GPS as a line feature. In lake areas that are too deep to support aquatic macrophytes, utilize the depth-finder display to locate the line between vegetated and non-vegetated areas (typically between 17 and 20 feet of depth). Follow this vegetation/depth line and record it with the GPS as a line feature. Begin GPS data recording when the delineation line is located, immediately pause the GPS data recording, and then restart/pause each time the community line is crossed while zigzagging back and forth. Other deep-water macrophyte community transitions visible in the depth finder (e.g. tall plants growing up through the water column such as white-stem pondweed versus low-growing plants like slender naiad) can be mapped using the same technique. These line features should include descriptive comments, such as “no vegetation toward shore” or “vegetation/depth line”.
    e. Delineate emergent plant communities by following the edge of the plant bed as closely as possible and recording it in the GPS as a line feature. Keep in mind that the GPS unit collects point data along the line (i.e., vertices) in time

intervals that generally range between one and five seconds. Therefore, pause at each point along the line where the direction shifts to ensure all vertices are recorded. Remember to include descriptive comments in the GPS about the line feature, such as taxa name and density (e.g., "Nuphar variegata H inside" or "Pond-lilies L to shore").

f. Density categorization for community mapping is more subjective than the sample site procedure and based on the following:
    i. Very Heavy (VH) = >90% of the area mapped with vegetation.
    ii. Heavy (H) = 70-90% of the area mapped with vegetation.
    iii. Moderate-Heavy (MH) = >60-70% of the area mapped with vegetation.
    iv. Moderate (M) = 40-60% of the area mapped with vegetation.
    v. Light-Moderate (LM) = 30-40% of the area mapped with vegetation.
    vi. Light (L) = 10-30% of the area mapped with vegetation.
    vii. Very Light (VL) = <10% of the area mapped with vegetation.

g. Plant communities can be mapped with the GPS while in the boat as depth permits. In shallow areas, it is sometimes necessary to get out of the boat and map a plant bed on foot. Ideally, use waders to collect data on foot, but at a minimum, protective footwear should be worn. Beware of soft, mucky substrate as you can get stuck or sink completely under the water. Emergent plant beds that extend up on to dry land can be mapped on foot if the land is public.

h. If it is not feasible to map macrophyte communities directly due to soft substrate, private property or other reasons, the delineations can be mapped at an offset distance with comments in the GPS describing the offset. Follow the direction and shape of the macrophyte community feature as closely as possible and record it as a line feature in the GPS (often this means that you are simply following a parallel course to the shoreline). Include descriptive comments, such as "3square bulrush H at shore 5-20' wide" or "pond-lily M from shore 20' out with Typha spp. H x 5' at shore."

i. Whenever possible take GPS photographs that show plant delineations, which will help interpret comments and map the delineations more precisely, particularly if mapping with an offset distance.

5. Laboratory Identification. Upon returning from fieldwork, identify the unknown taxa from sample sites with the aid of taxonomic keys and mounted herbarium specimens. Recommended taxonomic keys include *Aquatic and Wetland Plants of Northeastern North America* by G. E. Crow and C. B. Hellquist and *Michigan Flora* by E. Voss. Note that unknown specimens should be identified within one week of collection because the condition of specimens will deteriorate with time. If necessary, make arrangements to send samples to other aquatic plant experts via mail. Warning! Empty all water from bags sent via mail to avoid problems with USPS – simply place a moist paper towel in the bag with the specimens. After successfully identifying specimens, update the "unknown" entries on the appropriate field datasheets with the correct taxonomic information.

6. Data Management. File field datasheets and transfer GPS data and digital photographs to computer daily following fieldwork. Ensure that a file back-up system is in place to safeguard GPS data and digital photographs. Input information on field datasheets into a template aquatic vegetation survey Microsoft Access® database (database template stored on the TOMWC server). Review 10% of data entered from spreadsheets for quality control. If data entry errors are found, review all data entered for that field day

to check for errors and fix. Store the database, GPS data, and digital photographs in in the TOMWC GIS Projects directory. If a Projects directory does not exist for the lake being surveyed, create a new projects folder by copying the template in the GIS/Projects folder. All data should be stored in the GIS/Projects/data folder.

7. GIS Data Layer Development: Sample Sites. After survey is completed, export all fieldsheet data from the database into a Microsoft Excel® spreadsheet. Start a new working project document in the GIS and add the GPS point data. Select all features from point data file that represent sample sites (one point per sample site only). Export to a new shapefile with an appropriately descriptive title (e.g., LongLake_VegSurvey2013_SampleSites.shp). Add the spreadsheet with field datasheet information to the GIS project file. Join the spreadsheet to the GIS sample site point file and export to create a new shapefile with an appropriately descriptive title (e.g., LongLake_VegSurvey2013_SampleSites_Data.shp).
8. GIS Data Layer Development: GPS Photographs. Use the Geo Tagged Photos to Points tool in ESRI ArcGIS (or other equivalent software) to create a new point shapefile that associates all GPS photographs with physical locations on the lake. Give the new shapefile an appropriately descriptive title (e.g., LongLake_VegSurvey2013_Photos.shp).
9. GIS Data Layer Development: Communities.
    a. Add all GIS data to the project file: original GPS point and line data from the field, sample site point file with field data, and GPS photograph point file. For the GPS photo file, right click to select "properties," select "display," check the box for "support hyperlinks using field:," and select the appropriate field that provides the link/path to the photographs.
    b. Add the most accurate lake shoreline polygon shapefile available (preferably made based on recent digital orthophotography) to the project file and export to create a new polygon shapefile in the GIS with an appropriately descriptive title (e.g., LongLake_VegSurvey2013_Communities.shp).
    c. Add the following text fields to the communities shapefile: "Dominant," "OtherSpp," and "Density." "Dominant" is the dominant community within the polygon and should include the common name of the dominant species. Be consistent with which common names are used, the spelling of the common names, and how they are ordered (generally in alphabetical order). "OtherSpp" attribute should be populated with any other non-dominant species that field GPS data indicate are in the polygon. "Density" is the density as indicated in the field GPS line data.
    d. Start editing the communities shapefile and use the split tool to create polygons representing macrophyte beds and no vegetation areas based on the GPS line data collected in the field. Populate the new attribute columns based on comments from the GPS field line data. The dominant communities and respective densities of the remaining unclassified areas must be determined by interpolating or extrapolating from the sample site data layer and using any other information that can be gleaned from the other point and line data collected in the field. The GPS photographs can also be referenced to assist with community mapping by using the hyperlink tool and clicking on features in the GIS photograph point file. Once all lake areas in the communities shapefile have been categorized and attribute columns populated, create a new field called "Acres" and right click on attribute column to calculate geometry as "Acres US."

10. Data Summarization. Summarize dominant community data by right clicking on the "Dominant" attribute column heading and selecting "Summarize." Select a field to summarize = "Dominant," choose summary statistics for the output table = "acres," check the "sum" box, specify output table: choose location on server and title file appropriately, and click "okay." This same procedure can be performed for other attributes in both the sample site and communities GIS data layers as needed.
11. Map Development. After completing both sample site and communities GIS data layers, display maps can be developed in a GIS. Suggested maps include: sample sites map displaying density results, communities map with dominant communities, communities map with community densities, and map with results from both sample site and community layers (Appendix C). Optionally, tables from data summarization can be included on the maps.

Literature Cited

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Appendix E. Aquatic vegetation survey form.

Aquatic Vegetation Survey Form

Tip of the Mitt Watershed Council

Project Name: ________________________________ Lake Name: __________________________

Surveyor Name(s): ____

SITE ID: DATE: WATER DEPTH: PLANT COMMUNITY DENSITY:

PHOTO NUMBERS: LATITUDE: LONGITUDE:

Plant Species Name	Occurrence	Comments:
Total Species:		

SITE ID: DATE: WATER DEPTH: PLANT COMMUNITY DENSITY:

PHOTO NUMBERS: LATITUDE: LONGITUDE:

Plant Species Name	Occurrence	Comments:
Total Species:		

SITE ID: DATE: WATER DEPTH: PLANT COMMUNITY DENSITY:

PHOTO NUMBERS: LATITUDE: LONGITUDE:

Plant Species Name	Occurrence	Comments:
Total Species:		

Appendix F. AIS partner workshop agenda.

Tip of the Mitt Watershed Council

Antrim Conservation District

Aquatic Invasive Species Partner Workshop

AGENDA

October 22nd

1:00 to 4:00 pm

Antrim Conservation District Office
4820 Stover Rd
Bellaire, MI

- Introductions
- Aquatic Invasive Species (AIS) Project
  - Goals & Methods
  - Preliminary results of Elk River Chain of Lakes AIS Project
- Local and Regional AIS Prevention and Control Efforts
  - Early Detection/Rapid Response, Midwest Invasive Species Information Network and Cooperative Weed Management Areas
  - Prevention and Clean Boating Practices
- Priority Invasive Species: Exploring the Biology, Ecology, and Identification
- AIS Threats on the Horizon
- Partner Updates
- Documentation: Reporting & Mapping
- Field Practicum: Identification, Reporting, and Mapping
- Adjournment