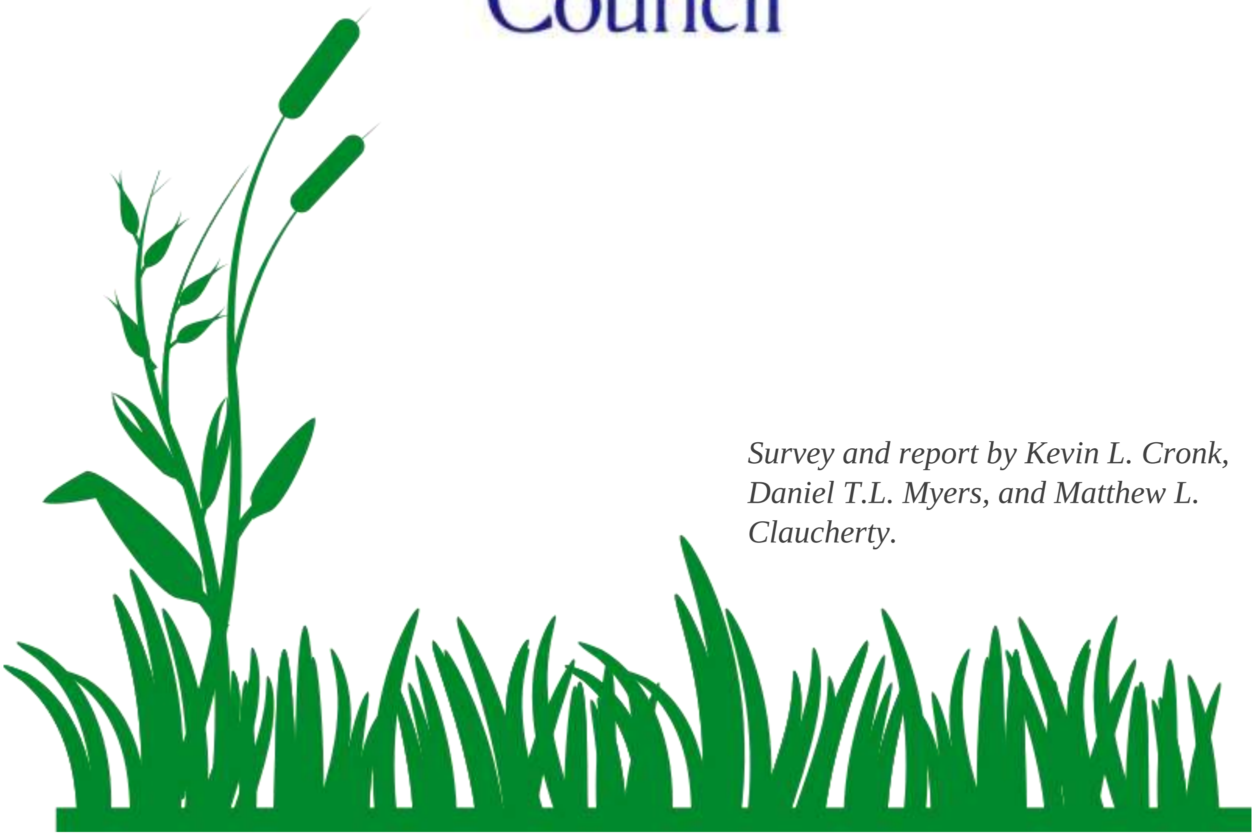
Mullett Lake Partial Aquatic Plant Survey 2015

Pigeon River Bay, Aloha State Park, Mullett Lake Marina, and Mullett Creek Bay

Tip of the Mitt Watershed Council



Survey and report by Kevin L. Cronk, Daniel T.L. Myers, and Matthew L. Claucherty.

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Summary

Aquatic plants provide many benefits to aquatic ecosystems, but can become a recreational nuisance when growth is excessive. Excessive aquatic plant growth also has the potential to disrupt lake ecosystems, particularly when non-native species are introduced. To aid lake management efforts, the Mullett Lake Area Preservation Society (MAPS) contracted with the Tip of the Mitt Watershed Council in 2015 to conduct a partial aquatic plant survey on Mullett Lake in north-central Cheboygan County, Michigan. The survey was conducted in four areas of concern: Pigeon River Bay, Aloha State Park, Mullett Lake Marina, and Mullett Creek Bay.

Fieldwork was conducted in July and August of 2015. Watershed Council staff surveyed aquatic vegetation at sample sites using a throw-able rake device attached to a rope. Two MAPS volunteers helped with the effort. Plants were collected until the surveyor believed all taxa at each site were documented. Community boundaries were mapped by creating lines on a Global Positioning System (GPS). Field notes were taken on a datasheet. All data was imported into a Geographic Information System (GIS) to create maps and charts.

A previous aquatic plant survey of the entire Lake was performed in 2007-2008. That survey documented concerns in Pigeon River Bay, Aloha State Park, Mullett Creek Bay, and Mullett Lake Marina. In 2007, Pigeon River Bay had very dense aquatic plant growth, signs of herbicide use or nutrient pollution, and invasive curly leaf pondweed. Mullett Creek Bay had dense aquatic plant growth. Aloha State Park had very dense aquatic plant growth, curly leaf pondweed, and invasive Eurasian watermilfoil. Mullett Lake Marina was experiencing dense aquatic plant growth and Eurasian watermilfoil. The 2015 aquatic plant survey was a follow up on these locations of concern.

Aquatic vegetation was found to occupy roughly the same areas in 2015 as documented in 2007. Subtle changes in species composition and density were observed. Very heavy vegetation, defined by the Watershed Council survey methods as submergent vegetation occupying the entire water column, occurred less frequently in Pigeon River Bay, Aloha State Park, and Mullett Lake Marina than in 2007. A reduction in this undesirable condition could be attributed to a reduction in nonpoint source nutrient pollution, alterations in benthic nutrient cycling, or recent cooler growing seasons with lower water temperatures. Mullett Creek Bay had no vegetation in the very heavy category, and has shown a reduction in moderate and heavy growth in the past eight years. An increase in thick algae growth throughout southwest portions of Pigeon River Bay was also noted.

Invasive Species are still present at many of the locations documented in 2007. Mullett Lake Marina's Eurasian watermilfoil infestation, although less dense than in 2007, has grown to occupy a larger area. Eurasian watermilfoil and curly leaf pondweed still persist throughout much of the Aloha State Park marina. In Pigeon River Bay, curly leaf pondweed documented in the 2007 survey was more precisely mapped. The plant is found in light densities over a 0.16 acre area of dredged channel on the east side of Pigeon River Bay near Rams Road. Mullett Creek Bay was found to be free of submergent invasive species. However, 1500 ft^2 of purple loosestrife was found growing along the shoreline just south of the Creek mouth.

MAPS should act in a timely manner to control existing invasive species in the Lake, as well as prevent the introduction of other exotic species. Shoreline areas should be surveyed on a regular basis to document evidence of nutrient pollution, erosion, riparian vegetation, and other factors that potentially contribute to nuisance aquatic plant growth. Problem areas identified during surveys should be addressed to prevent or reduce nuisance aquatic plant growth.

MAPS should share results from this survey to maximize benefits and assist in lake management efforts. Information and education efforts should be undertaken to promote an understanding of aquatic plant communities and the lake ecosystem among riparian property owners and other lake users, as well as encourage behaviors and practices that protect and improve lake water quality. Future surveys are recommended to collect the necessary data for determining trends over time, evaluating successes or failures of aquatic plant management projects, and documenting the locations and spread of non-native aquatic plant species.

Introduction

Aquatic plant communities provide numerous benefits to lake ecosystems. Aquatic plants provide habitat, refuge, and act as a food source for a large variety of waterfowl, fish, aquatic insects, and other aquatic organisms (Valley et. al. 2004, Dibble et. al. 1996, Engel 1985). Like their terrestrial counterparts, aquatic plants provide primary production to the ecosystem and oxygen via photosynthesis. Aquatic plants utilize nutrients in the water and sediments that could otherwise be used by algae and potentially result in nuisance blooms. A number of aquatic plants, including bulrush, water lily, cattails, and pickerelweed help prevent shoreline erosion by absorbing wave energy and moderating currents (Madsen and Warncke 1983). In addition, soft sediments along a lake bottom are held in place by rooted aquatic plants (Engel 1985).

In spite of all the benefits associated with aquatic plants, some aquatic ecosystems suffer from overabundance, particularly where non-native nuisance species have been introduced. Excessive plant growth can create a recreational nuisance by making it difficult or undesirable to boat, fish, and swim. It also has the potential to cause aquatic ecosystem disruptions. In lakes plagued by nuisance plant growth, it sometimes becomes necessary to develop and implement programs to control excessive growth and non-native species.

Control measures that reduce aquatic plants in a lake can have negative impacts on the lake ecosystem. Herbicide treatment causes oxygen loss, which can lead to fish and invertebrate mortality (Brooker and Edwards 1975). Phosphorus has been shown to increase following herbicide application (Morris and Jarman 1981). Blue-green algal blooms have been documented after herbicide treatment (Getsinger et al. 1982). Herbicides can be toxic to fish and invertebrates (Engel 1990), while mechanical harvesting of aquatic plants removes fish and invertebrates in the process (Wile 1978). Thus, aquatic vegetation control measures should be carefully considered in terms of impacts to the lake ecosystem.

Aquatic plant management is a critical component of lake management. In turn, aquatic vegetation surveys are necessary to effectively manage a lake's aquatic plant communities. With funding from the Mullett Lake Area Preservation Society (MAPS) and National Fish and Wildlife Foundation, Tip of the Mitt Watershed Council (TOMWC) surveyed the aquatic vegetation in Mullett Lake in 2007-2008. The 2007 survey documented aquatic plant types, density, and distribution, which were included in a report to MAPS, as well as options and recommendations for nuisance plant management. This survey documented concerns in Pigeon River Bay, Aloha State Park, Mullett Creek Bay, and Mullett Lake Marina. In 2007, Pigeon River Bay had very dense aquatic plant growth, signs of herbicide use or nutrient pollution, and invasive curly leaf pondweed. Mullett Creek Bay had dense aquatic plant growth. Aloha State Park had very dense aquatic plant growth, curly leaf pondweed, and invasive Eurasian watermilfoil. Mullett Lake Marina was experiencing dense aquatic plant growth and Eurasian watermilfoil. In 2015, MAPS contracted with the Watershed Council to perform a partial aquatic plant survey of Mullett Lake focusing on these four areas of concern. Survey field methods, data management procedures, project results, and discussion of results for the 2015 survey are contained in this report.

Methods

The aquatic plant communities of Mullett Lake were sampled and mapped during July and August of 2015. Additional follow-up to Aloha State Park was performed in June 2016 to confirm the existence of invasive species not found during 2015. Survey methods used during the survey were developed by the Watershed Council, incorporating the experience and knowledge of the Watershed Council surveyors, as well as elements of methods detailed in the Michigan Department of Environmental Quality's *Procedures for Aquatic Vegetation Surveys* (MDEQ, 2005). The methods were designed for comprehensive and detailed aquatic vegetation surveys that document aquatic plant species, community, and density information at specific sample sites while also mapping the areal extent and delineation of plant communities throughout the Lake. Survey methods are described below and procedural details are in Appendix A.

Sampling

To document aquatic plant taxa, specimens were collected, identified, photographed and recorded in a notebook at sample sites throughout the surveyed areas. Sample site locations were not random, but rather selected with the intent of collecting representative information on all aquatic plant communities currently inhabiting the areas. Most sampling was conducted along transects across the Lake that were spaced at regular intervals. In expansive, deep areas, transects began near the shoreline and continued linearly into deeper waters until plants were no longer found. 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 monitored using Hummingbird depth finders. 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. At times 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.

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. 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 included 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. Overall plant density for the site was determined and noted using the same categorization system.

Abundance rankings were determined at each site by summing the number of times individual taxon were found during rake throws. A plant found in all four rake tosses would be considered Abundant, three tosses Common, two tosses Uncommon, and one toss Rare. The abundance rankings do not account for density, but rather indicate frequency of occurrence.

If a plant specimen could not be identified immediately, it was stored in a sealed bag and identified later with the aid of taxonomic keys, mounted herbarium specimens, and, if necessary, assistance from other aquatic plant experts. All taxa names, relative taxa densities, overall site density, and comments were recorded in a field notebook. If no plants were encountered during sampling, “no vegetation” was recorded. Specimens representing each taxon found at the site were photographed.

To assist in mapping the aquatic vegetation in Mullett Lake, additional photographs were taken to document emergent vegetation. At each sample site located within or adjacent to emergent vegetation, pictures were taken of surrounding areas. Pictures were taken with either a Ricoh G700SE or Nikon Coolpix AW110 digital GPS camera.

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 mapped directly on foot or 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 resulted in sinuous community lines which were noted in the GPS and later smoothed into more accurate, straight lines in a GIS.

In spite of sampling 63 sites, as well as subsequent community line mapping, small or isolated plant communities could have been missed. Plants were not sampled between sites in survey transects and conditions occasionally prevented community mapping between sites. Upon several occasions, plant community mapping was impeded by poor visibility, whether from wave turbulence, turbidity, or simply water depth and attenuation of sunlight. Additionally, emergent plant bed mapping may contain errors resulting from misinterpretation of GPS data and associated comments collected in the field.

Data Processing and Map Development

GPS data from the Trimble Juno SB units were transferred to a computer in an ESRI shapefile format. GIS data layers developed using the GPS data consisted of point layers representing sample sites and polygon layers representing plant communities. All GIS work was performed using ESRI GIS software: ArcGIS 10.3 and 10.4.

Information collected at sample sites and written in field notes was entered into a Microsoft Access database. A record was entered into the database for each sample site, using the sample site number as the unique identifier. Field data were entered as separate attributes in the database table, including water depth, taxa names and densities, areas of no or little vegetation, overall community density, and comments. Additional columns were added to the database for the number of taxa at each site. Field data were then exported to a Microsoft Excel spreadsheet, which was imported into a GIS and joined to the sample site GIS point data layer. The joined data were exported to a new GIS point data layer containing attribute information collected at each sample site.

Delineations of aquatic plant communities recorded with GPS were used to develop polygons representing community types occurring in the Lake. If borders between plant communities were not mapped directly with GPS in the field, then divisions between plant communities were determined by interpolating between or extrapolating from sample sites. Field notes from sample sites were also consulted during on-screen delineation of plant communities. After developing polygons, area statistics for specific plant communities and associated densities 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 sample site ESRI shapefiles allow GIS users to view all tabular data associated with the site.

Results

A total of 63 sites were sampled between Pigeon River Bay, Aloha State Park, Mullett Lake Marina, and Mullett Creek Bay in 2015. Thirty eight aquatic plant taxa were documented, including seven emergent taxa documented in comments and not listed in the tables below: soft stem bulrush, cattail, sedge, three square bulrush, pickerelweed, purple loosestrife, and bur reed. Watermilfoils, muskgrass, eelgrass, and waterweed are among the plants most commonly collected. Invasive curly leaf pondweed, Eurasian watermilfoil, and purple loosestrife were documented during the survey. Results for sample sites and communities of the 2015 survey are presented, compared with results of the 2007 survey for the same areas. Summaries of the survey at each location are presented in the following sections.

Pigeon River Bay

Twenty-five aquatic plant taxa were documented in Pigeon River Bay (Table 1). Aquatic plant community densities were in the light-moderate to moderate-heavy categories for the majority of Pigeon River Bay (Table 2). Plants are densest in the south half of the Bay by the Pigeon River mouth, with moderate-heavy to very heavy growth dominating (Figure 2). Watermilfoil, arrowhead, and muskgrass dominated the communities (Figure 3). Density tapers to lighter density in the north half of the Bay. The 2007 survey documented higher density vegetation than in 2015, with a larger area of vegetation in the heavy and very heavy categories.

Table 1. Aquatic plant taxa occurrence at sample sites in Pigeon River Bay.

Scientific Name	Common Name	2007 Sites	2007 % Sites	2015 Sites	2015 % Sites
Myriophyllum heterophyllum	Variable Leaf Watermilfoil	50	66%	21	47%
Chara spp.	Muskgrass	41	54%	19	42%
Potamogeton zosteriformis	Flat Stem Pondweed	47	62%	18	40%
Sagittaria spp.	Arrowhead	17	22%	15	33%
Valisneria americana	Eelgrass	35	46%	15	33%
Utricularia vulgaris	Common Bladderwort	31	41%	13	29%
Elodea canadensis	Waterweed	27	36%	11	24%
Bidens beckii	Water Marigold	11	14%	9	20%
Najas flexilis	Slender Naiad	20	26%	9	20%
Potamogeton pusillus	Small Pondweed	0	0%	6	13%
Potamogeton richardsonii	Richardson's Pondweed	16	21%	6	13%
Potamogeton strictifolius	Straight Leaf Pondweed	4	5%	6	13%
Ceratophyllum demersum	Coontail	6	8%	5	11%
Algae	Algae	0	0%	5	11%
Potamogeton friesii	Fries' Pondweed	21	28%	5	11%
Potamogeton gramineus	Variable Leaf Pondweed	19	25%	5	11%
Stuckenia pectinata	Sago Pondweed	14	18%	4	9%
Nuphar variegata	Yellow Pond Lily	4	5%	3	7%
Heteranthera dubia	Water Stargrass	7	9%	2	4%
Potamogeton praelongus	White Stem Pondweed	11	14%	2	4%
Neobeckia aquatica	Lake Cress	0	0%	1	2%
Potamogeton amplifolius	Broad Leaf Pondweed	7	9%	1	2%
Potamogeton crispus	Curly Leaf Pondweed	0	0%	1	2%
Hippuris vulgaris	Mare's Tail	1	1%	0	0%
Myriophyllum sibiricum	Northern Watermilfoil	1	1%	0	0%
Nymphaea odorata	White Water Lily	2	3%	0	0%
Potamogeton illinoensis	Illinois Pondweed	5	7%	0	0%
Potamogeton natans	Floating Leaf Pondweed	6	8%	0	0%
Utricularia gibba	Floating Bladderwort	1	1%	0	0%

Significant algae growth was documented throughout Pigeon River Bay, often covering aquatic plants in a filamentous green slime (Figure 1). This algae indicates that nutrient pollution is still a concern in the Bay. Apparent cutting of plants in Pigeon River Bay was also noted during the survey. *Sagittaria spp.* (arrowhead) was identified as being the dominant vegetation in areas of high boat traffic near the crossing of Mullett Lake Road. This trend has been observed in other lakes where boat traffic is channeled to higher concentrations. This condition was occurring during the 2007 survey, and is not thought to be detrimental to the lake's health.

Table 2. Aquatic plant community densities in Pigeon River Bay.

Dominant Community	2007 (acres)	2007 (percent)	2015 (acres)	2015 (percent)
Little/no Vegetation	90.88	28.9%	92.42	29.4%
Very Light	46.31	14.7%	1.97	0.6%
Light	36.06	11.5%	15.40	4.9%
Light to Moderate	43.40	13.8%	102.71	32.6%
Moderate	32.43	10.3%	39.88	12.7%
Moderate to Heavy	8.53	2.7%	56.85	18.1%
Heavy	13.38	4.3%	3.59	1.1%
Very Heavy	43.62	13.9%	1.81	0.6%
TOTAL	314.61	100.0%	314.61	100.0%

Approximately one sixth acre of curly leaf pondweed was documented in the southeast corner of Pigeon River Bay (Figure 4). This curly leaf pondweed infestation is interspersed with other plants and at light density.

Figure 1. Algae covering aquatic plant sampling device in Pigeon River Bay.

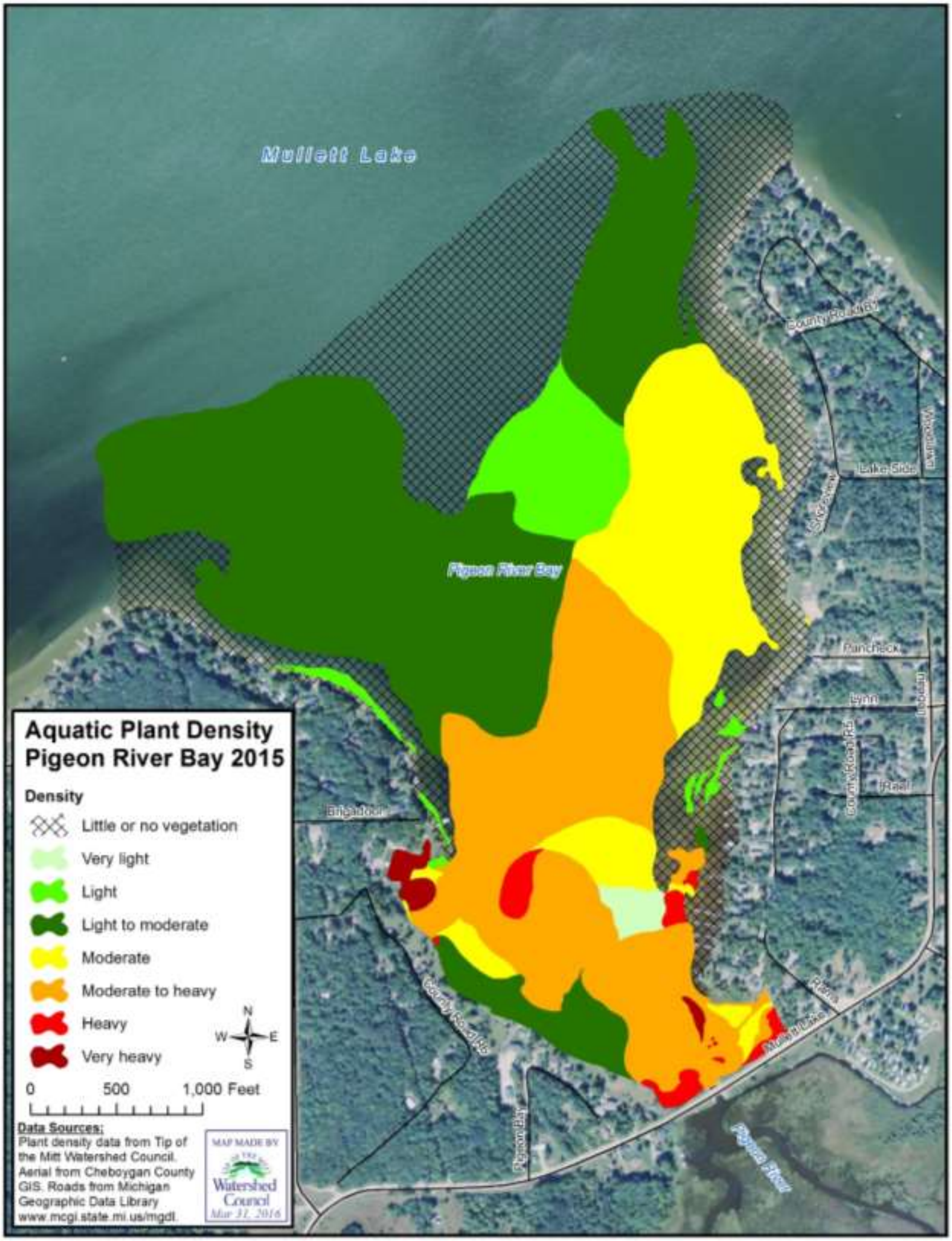

Figure 2. Aquatic plant density of Pigeon River Bay.

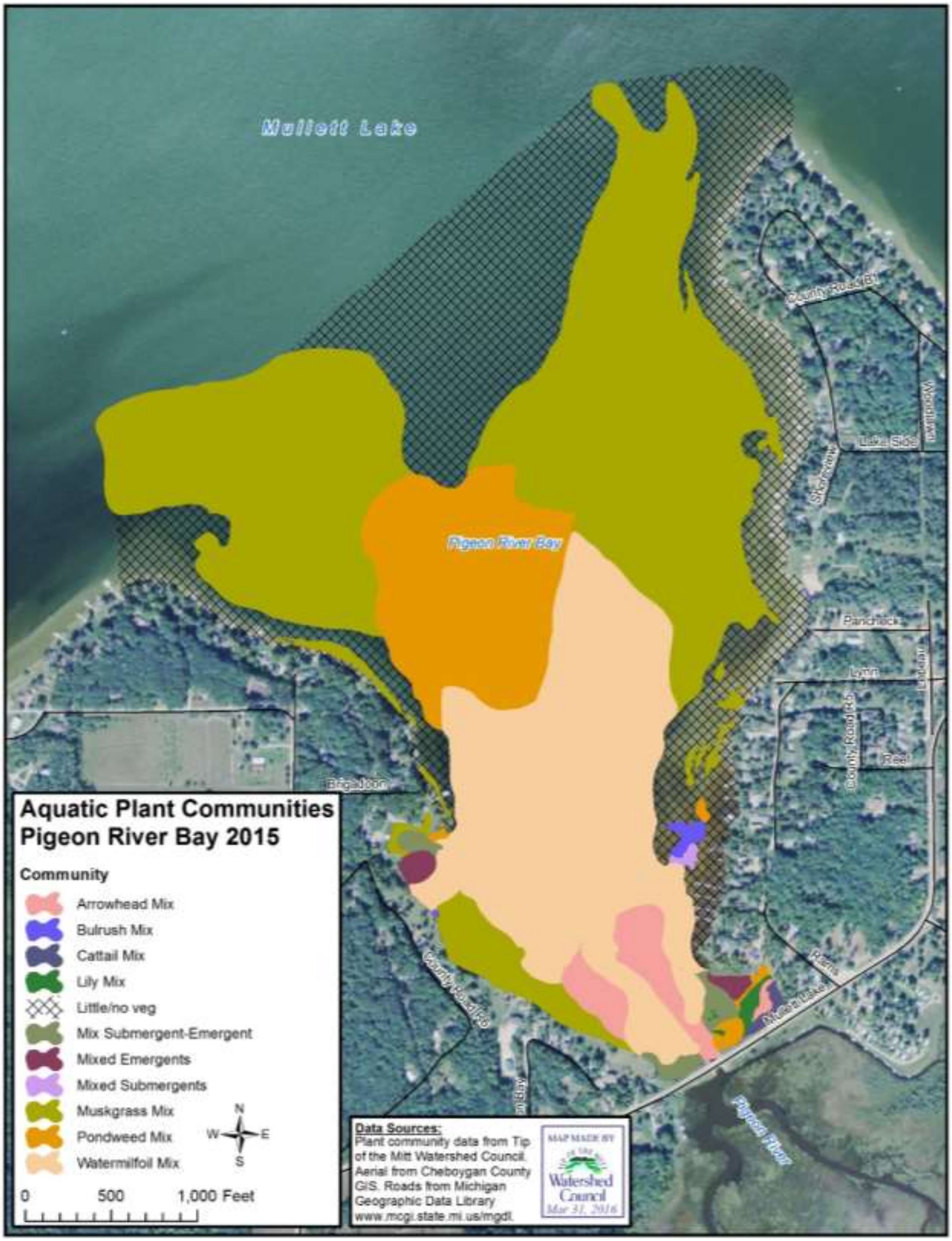

Figure 3. Aquatic plant communities of Pigeon River Bay.

Figure 4. Aquatic invasive plants of Pigeon River Bay.

Aloha State Park

Sixteen aquatic plant taxa were documented around Aloha State Park (Table 3). Little vegetation was documented outside the park's marina breakwalls (Figure 5). Within the marina, heavy vegetation dominated the western two-thirds, from the entrance to halfway through the campsites. A combination of light and heavy density vegetation dominated the eastern third of the marina by the launch. A mix of waterweed, coontail, curly leaf pondweed, and Eurasian watermilfoil dominates the marina's aquatic plant communities (Figure 6). The very heavy vegetation documented in 2007 wasn't documented in 2015 (Table 4).

A 100 square foot patch of Eurasian watermilfoil was documented at the Aloha State Park boat launch in 2015 (Figure 7). Curly leaf pondweed and larger infestations of Eurasian watermilfoil weren't found during the 2015 survey, but their existence was confirmed during 2016 follow up. About half an acre (0.62 acres) of Eurasian watermilfoil and curly leaf pondweed mix was documented in the Aloha State Park marina during the follow up. An additional 0.1 acres of curly leaf pondweed mixed with other vegetation was documented by the marina breakwalls.

Table 3. Aquatic plant taxa occurrence at sample sites in Aloha State Park.

Scientific Name	Common Name	2007 Sites	2007 % Sites	2015 Sites	2015 % Sites
Ceratophyllum demersum	Coontail	2	67%	3	75%
Elodea canadensis	Waterweed	2	67%	3	75%
Heteranthera dubia	Water Stargrass	2	67%	2	50%
Myriophyllum heterophyllum	Variable Leaf Watermilfoil	2	67%	2	50%
Myriophyllum spicatum	Eurasian Watermilfoil	2	67%	2	50%
Sagittaria spp.	Arrowhead	0	0%	2	50%
Potamogeton friesii	Fries' Pondweed	0	0%	1	25%
Ranunculus spp.	Water Crow Foot	0	0%	1	25%
Valisneria americana	Eelgrass	1	33%	1	25%
Chara spp.	Muskgrass	1	33%	0	0%
Myriophyllum sibiricum	Northern Watermilfoil	1	33%	0	0%
Potamogeton crispus	Curly Leaf Pondweed	2	67%	0	0%
Potamogeton strictifolius	Straight Leaf Pondweed	1	33%	0	0%
Potamogeton zosteriformis	Flat Stem Pondweed	1	33%	0	0%
Stuckenia pectinata	Sago Pondweed	1	33%	0	0%

Table 4. Aquatic plant community densities in Aloha State Park.

Dominant Community	2007 (acres)	2007 (percent)	2015-16 (acres)	2015-16 (percent)
Little/no Vegetation	9.64	57.4%	13.77	81.9%
Very Light	4.09	24.4%	0.00	0.0%
Light	0.00	0.0%	0.65	3.9%
Light to Moderate	0.86	5.1%	0.00	0.0%
Moderate	0.00	0.0%	0.13	0.8%
Moderate to Heavy	0.00	0.0%	0.25	1.5%
Heavy	0.00	0.0%	2.01	12.0%
Very Heavy	2.20	13.1%	0.00	0.0%
TOTAL	16.79	100.0%	16.81	100.0%

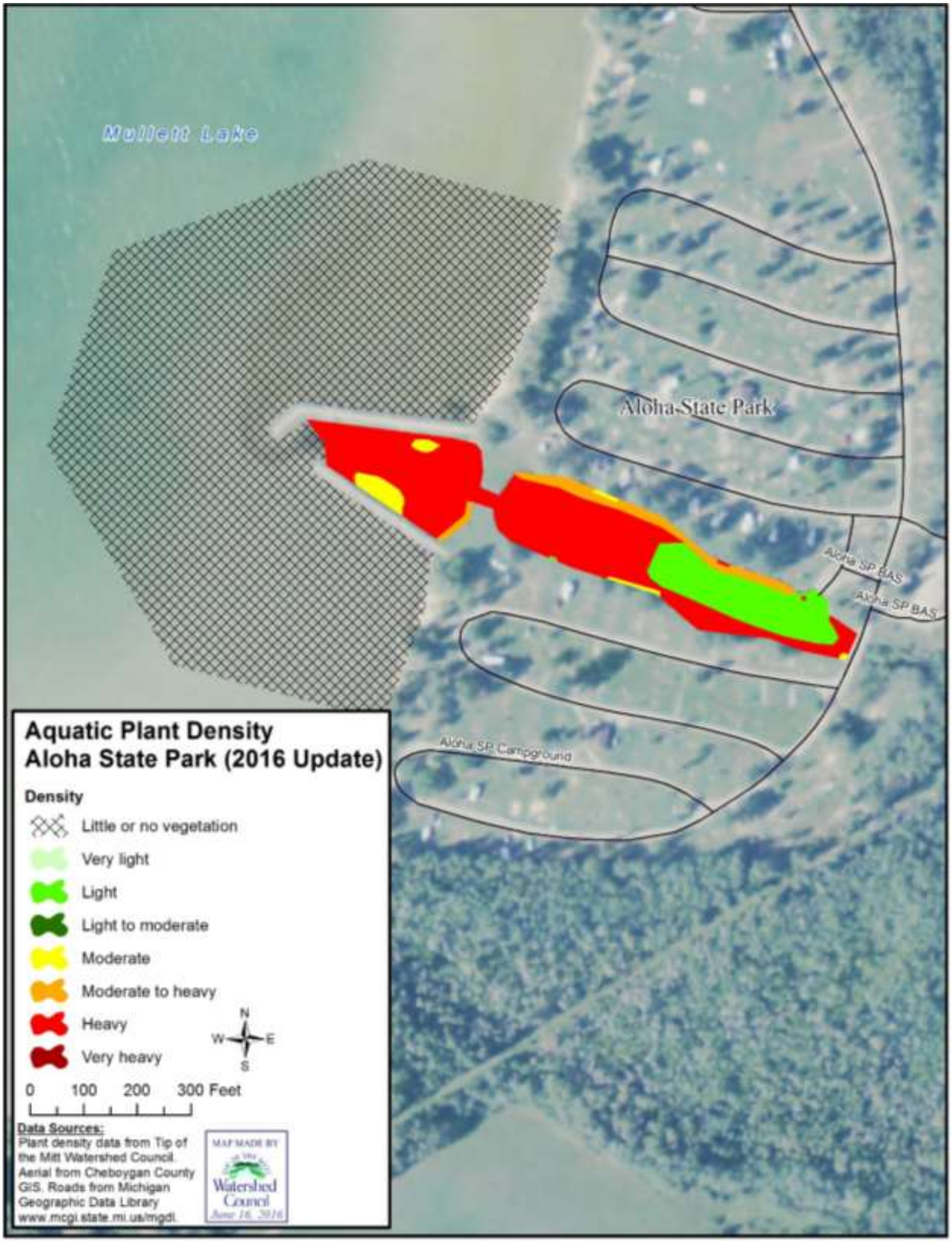

Figure 5. Aquatic plant density of Aloha State Park.

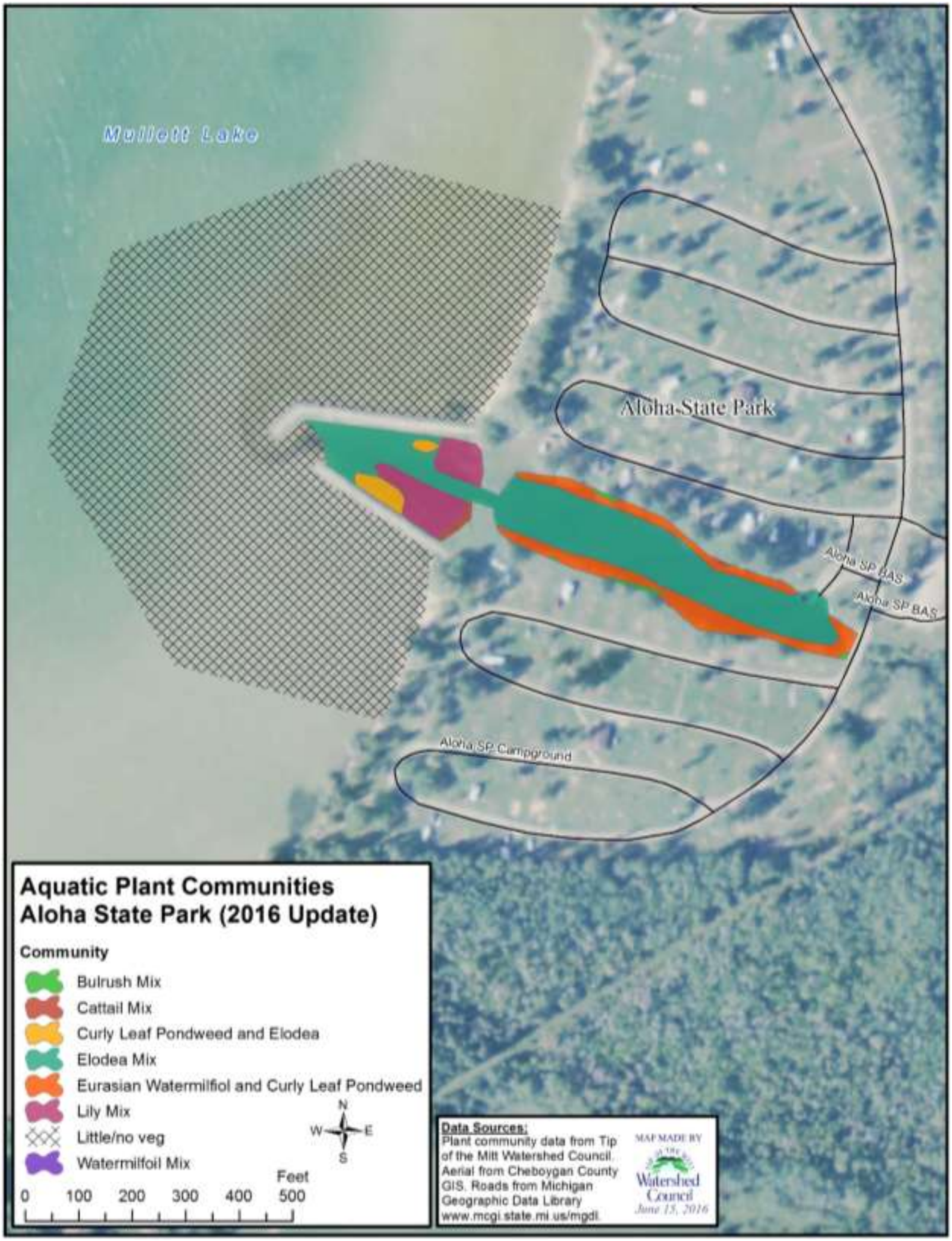

Figure 6. Aquatic plant communities of Aloha State Park.

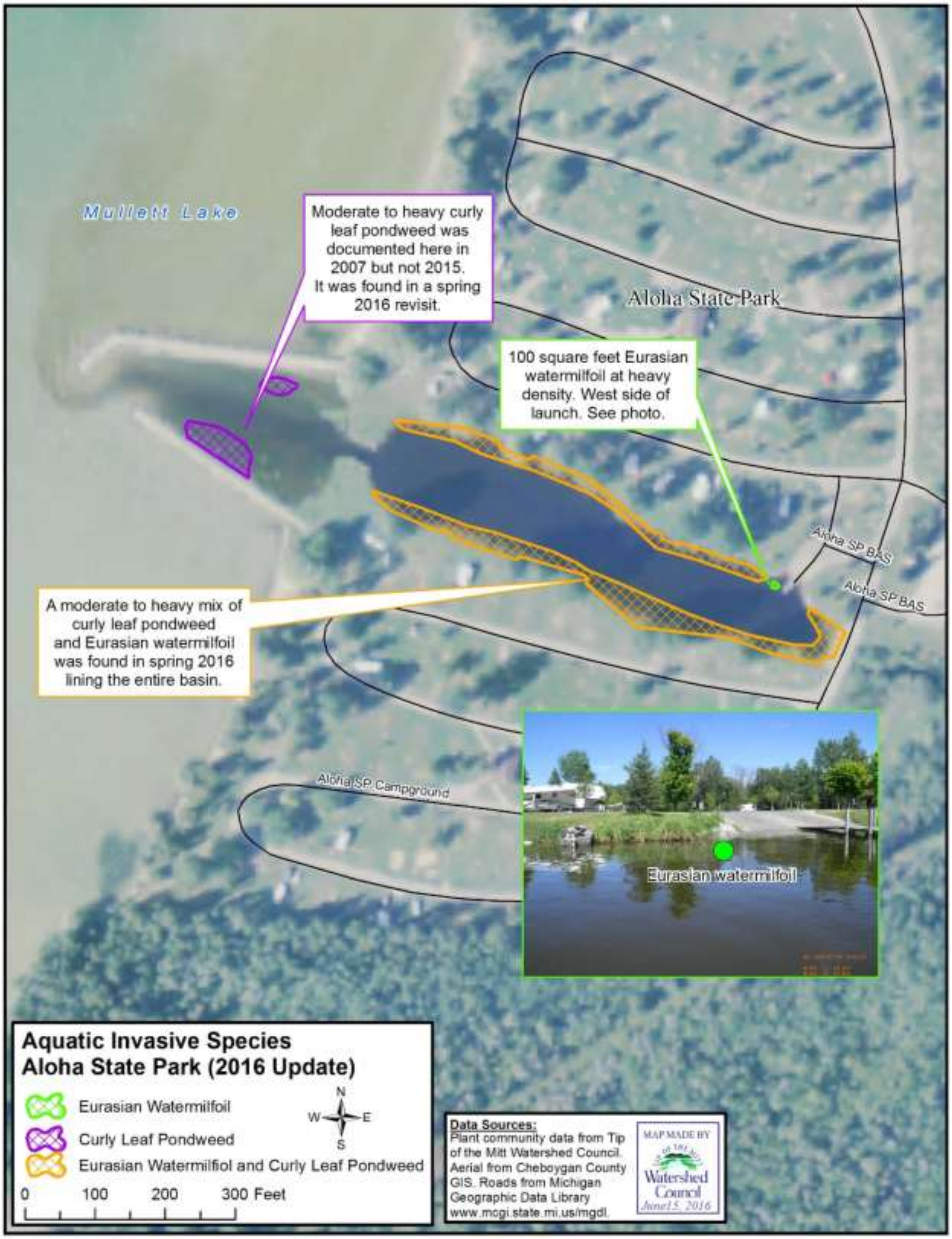

Figure 7. Aquatic invasive plants of Aloha State Park.

Mullett Lake Marina

Fourteen aquatic plant taxa were documented around Mullett Lake Marina (Table 5). Very light density vegetation was documented in the surveyed area outside the marina (Figure 8). Nearly all heavy vegetation was documented within the marina, dominated by watermilfoil (Figure 9). This heavy vegetation surrounds the docks. The very heavy vegetation documented in 2007 wasn't documented in 2015 (Table 6).

Approximately a half acre of Eurasian watermilfoil was documented at the Mullett Lake Marina surrounding the docks (Figure 10). This watermilfoil has characteristics of both invasive Eurasian watermilfoil and native northern watermilfoil, and could be a hybrid of the two species. Confident identification could require molecular testing.

Table 5. Aquatic plant taxa occurrence at sample sites in Mullett Lake Marina.

Scientific Name	**Common Name**	**2007 Sites**	**2007 % Sites**	**2015 Sites**	**2015 % Sites**
Chara spp.	Muskgrass	2	67%	3	100%
Elodea canadensis	Waterweed	1	33%	2	67%
Myriophyllum spicatum	Eurasian Watermilfoil	1	33%	2	67%
Najas flexilis	Slender Naiad	1	33%	2	67%
Potamogeton richardsonii	Richardson's Pondweed	1	33%	2	67%
Valisneria americana	Eelgrass	1	33%	2	67%
Heteranthera dubia	Water Stargrass	0	0%	1	33%
Potamogeton friesii	Fries' Pondweed	1	33%	1	33%
Potamogeton zosteriformis	Flat Stem Pondweed	1	33%	1	33%
Sagittaria spp.	Arrowhead	1	33%	1	33%
Myriophyllum heterophyllum	Variable Leaf Watermilfoil	1	33%	0	0%
Potamogeton gramineus	Variable Leaf Pondweed	1	33%	0	0%
Potamogeton pusilis	Small Pondweed	1	33%	0	0%
Stuckenia pectinata	Sago Pondweed	3	100%	0	0%

Table 6. Aquatic plant community densities in Mullett Lake Marina.

Dominant Community	2007 (acres)	2007 (percent)	2015 (acres)	2015 (percent)
Little/no Vegetation	4.48	63.0%	2.07	29.1%
Very Light	0.00	0.0%	3.70	51.9%
Light	0.00	0.0%	0.00	0.0%
Light to Moderate	0.25	3.5%	0.00	0.0%
Moderate	0.00	0.0%	0.00	0.0%
Moderate to Heavy	1.38	19.5%	0.00	0.0%
Heavy	0.00	0.0%	1.36	19.0%
Very Heavy	0.99	14.0%	0.00	0.0%
TOTAL	7.10	100.0%	7.14	100.0%

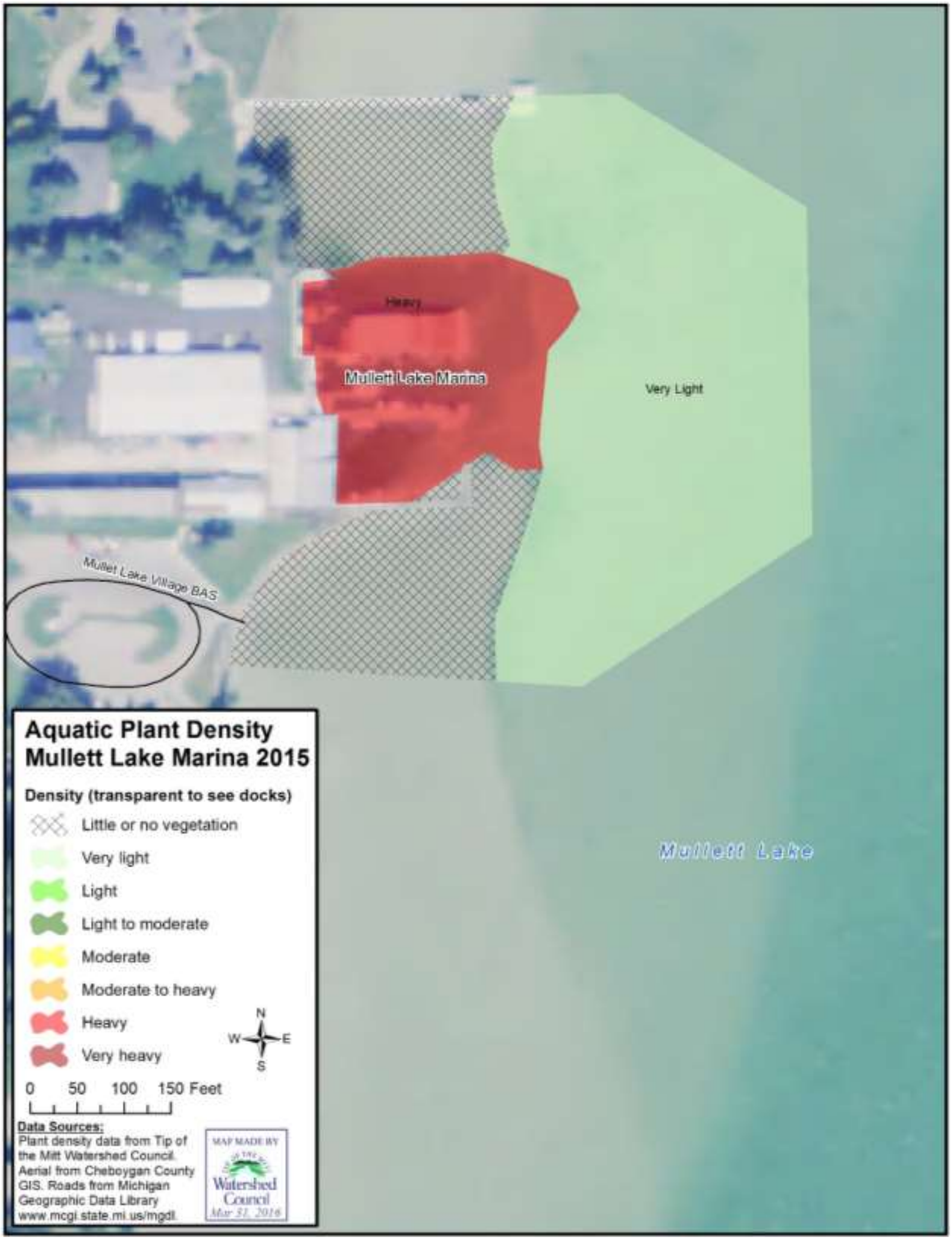

Figure 8. Aquatic plant density of Mullett Lake Marina.

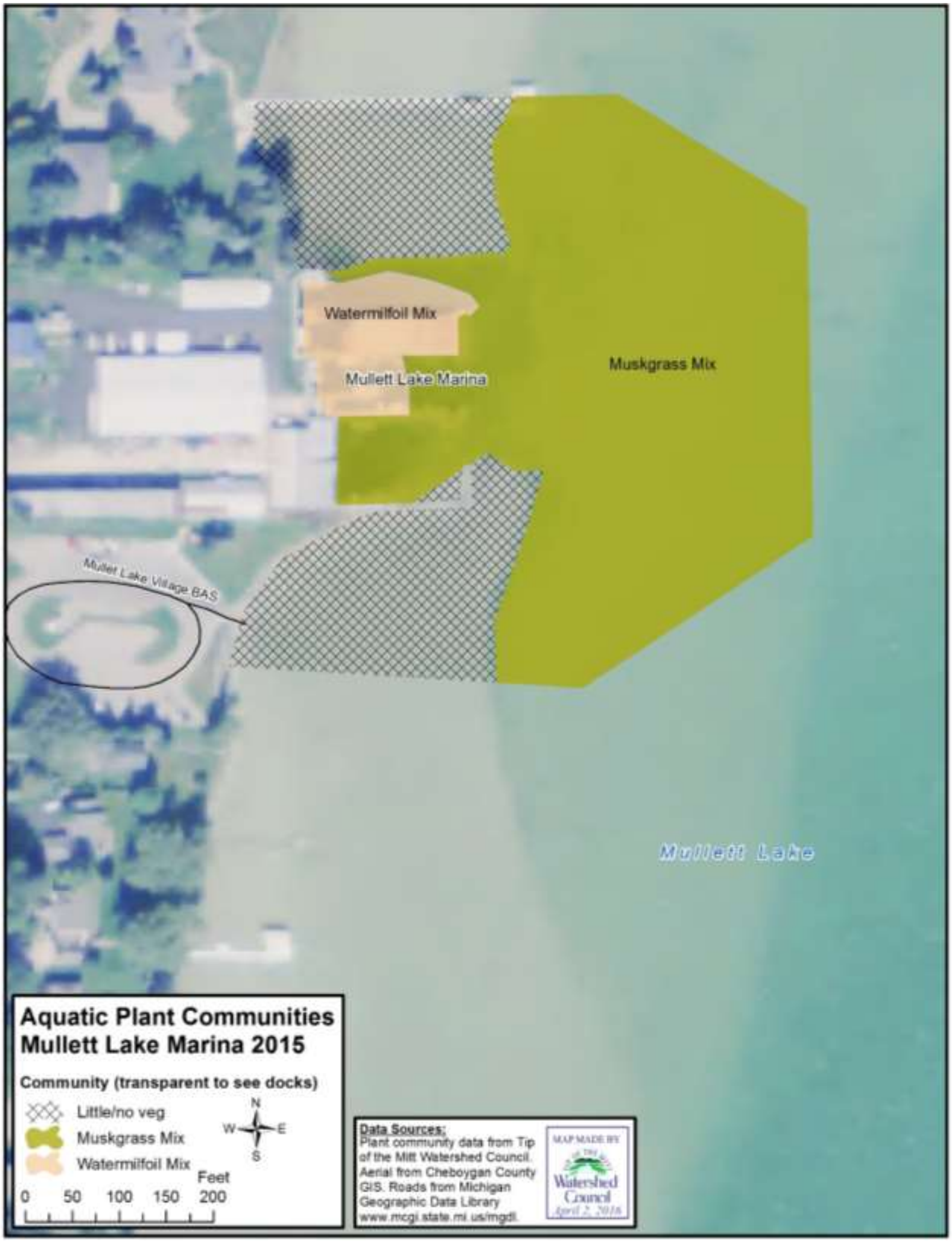

Figure 9. Aquatic plant communities of Mullett Lake Marina.

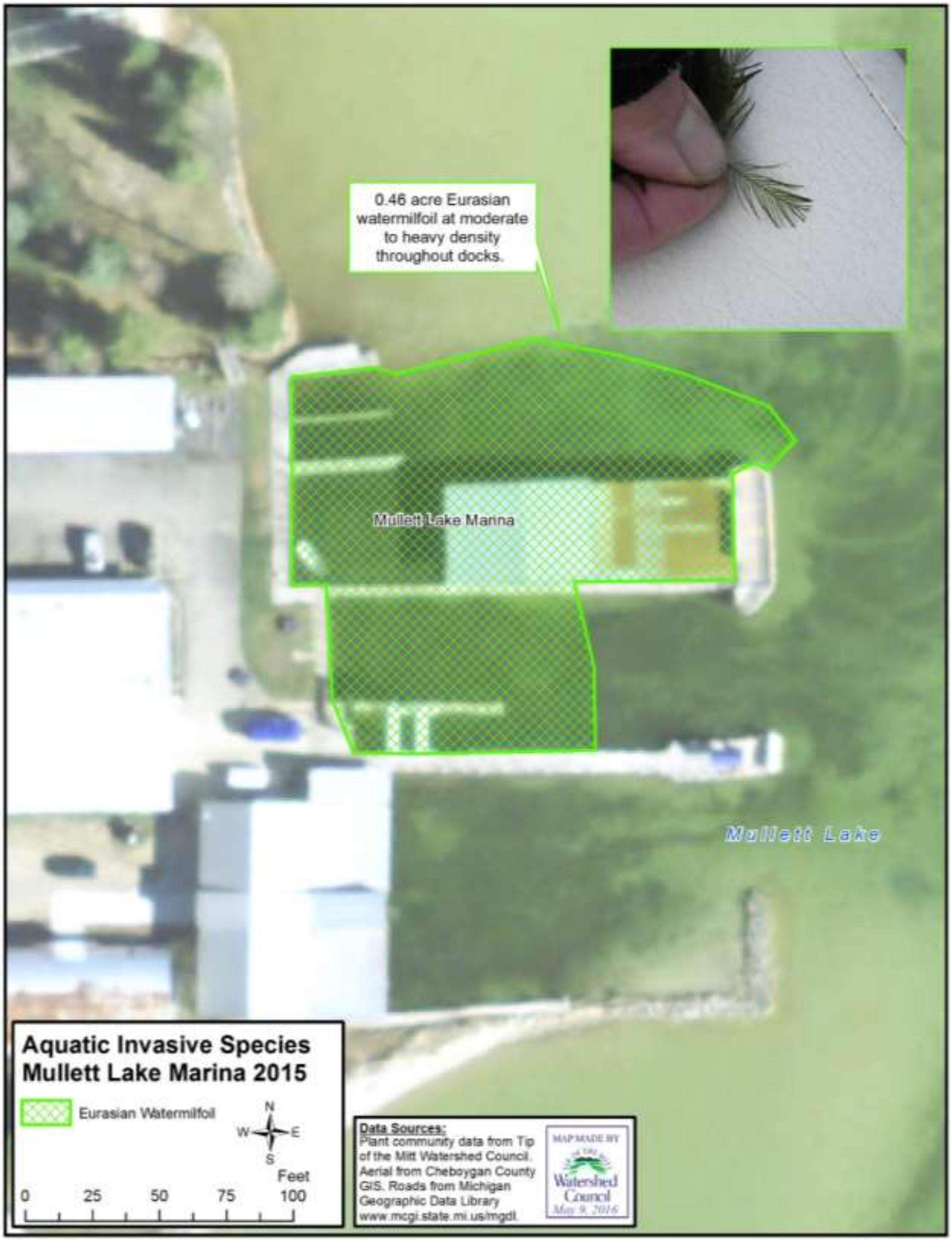

Figure 10. Aquatic invasive plants of Mullett Lake Marina.

Mullett Creek Bay

Eleven aquatic plant taxa were documented in Mullett Creek Bay (Table 7). The Bay has a band of moderate density vegetation in front of the Mullett Creek mouth, dominated by a mix of muskgrass, naiad, and eelgrass (Figure 12). Shallower than this band is very light density vegetation by shore (Figure 11). The center of the Bay is light-moderate density vegetation dominated by eelgrass. More moderate density vegetation was documented in 2007 than 2015 (Table 8).

A small patch of purple loosestrife, approximately 1500 square feet, was documented south of the Mullett Creek mouth at light-moderate density (Figure 13). As a side note, invasive quagga mussels were also documented at one site in Mullett Creek Bay during the survey.

Table 7. Aquatic plant taxa occurrence at sample sites in Mullett Creek Bay.

Scientific Name	Common Name	2007 Sites	2007 % Sites	2015 Sites	2015 % Sites
Chara spp.	Muskgrass	11	65%	8	73%
Valisneria americana	Eelgrass	6	35%	6	55%
Najas flexilis	Slender Naiad	3	18%	4	36%
Ceratophyllum demersum	Coontail	2	12	1	9%
Elodea canadensis	Waterweed	0	0%	1	9%
Myriophyllum heterophyllum	Variable Leaf Watermilfoil	6	35%	1	9%
Stuckenia pectinata	Sago Pondweed	3	18%	1	9%
Potamogeton amplifolius	Broad Leaf Pondweed	3	18%	0	0%
Potamogeton illinoensis	Illinois Pondweed	1	6%	0	0%
Potamogeton natans	Floating Leaf Pondweed	1	6%	0	0%
Potamogeton praelongus	White Stem Pondweed	2	12%	0	0%

Table 8. Aquatic plant community densities in Mullett Creek Bay.

Dominant Community	**2007 (acres)**	**2007 (percent)**	**2015 (acres)**	**2015 (percent)**
Little/no Vegetation	60.36	70.2%	32.00	37.2%
Very Light	0.00	0.0%	29.92	34.8%
Light	0.00	0.0%	7.61	8.8%
Light to Moderate	3.73	4.3%	6.77	7.9%
Moderate	21.06	24.5%	9.61	11.2%
Moderate to Heavy	0.00	0.0%	0.07	0.1%
Heavy	0.84	1.0%	0.00	0.0%
Very Heavy	0.00	0.0%	0.00	0.0%
TOTAL	85.98	100.0%	85.98	100.0%

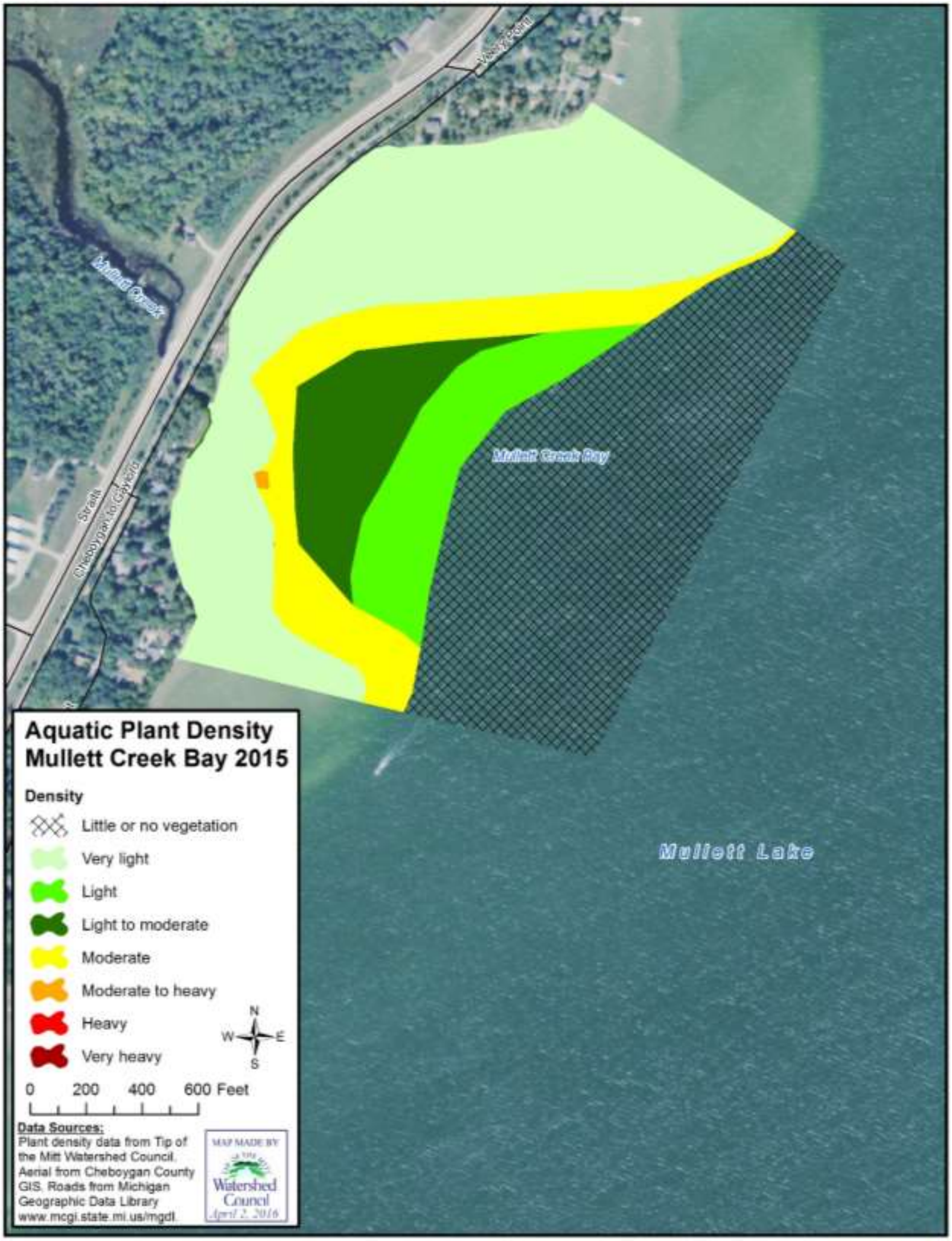

Figure 11. Aquatic plant density of Mullett Creek Bay.

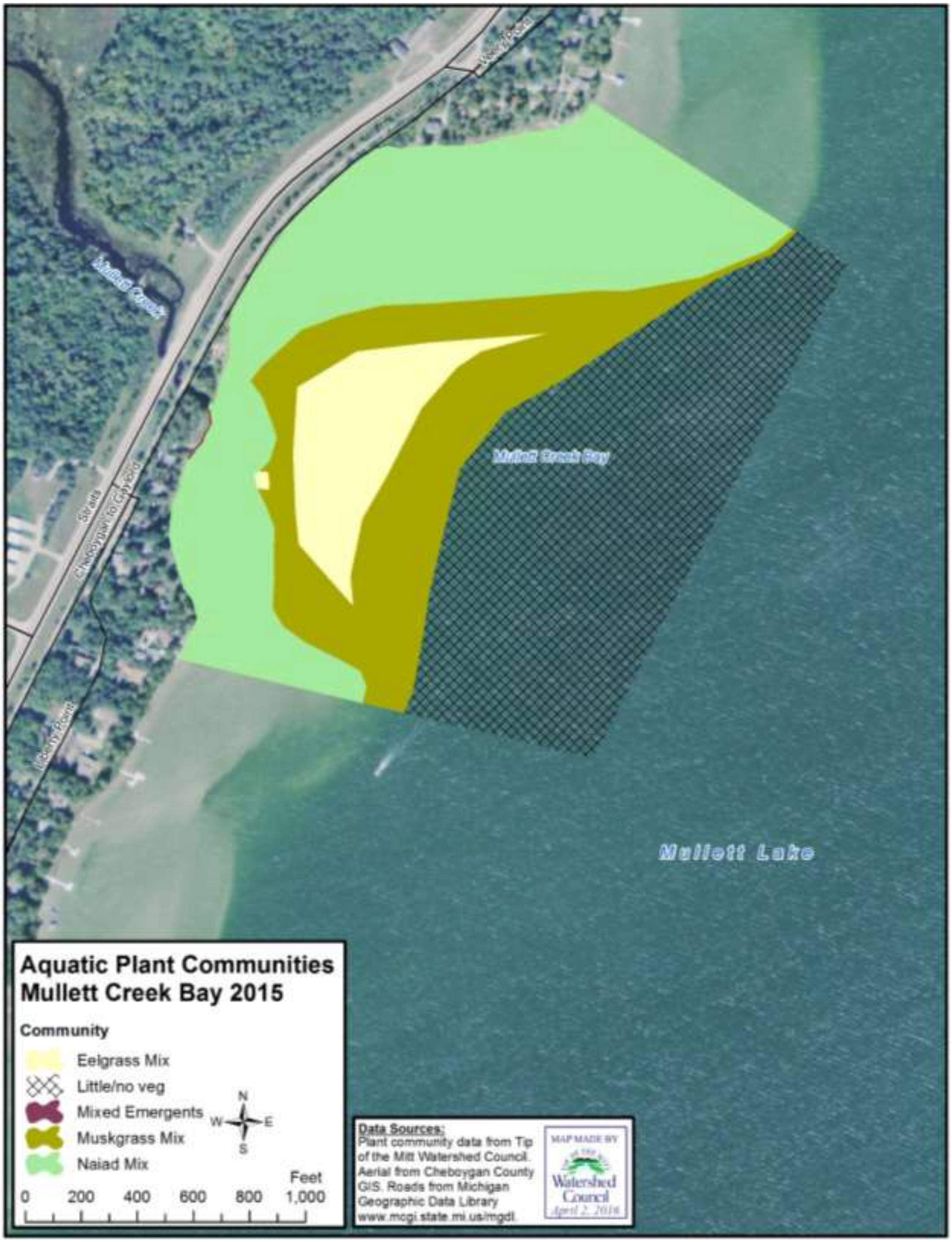

Figure 12. Aquatic plant communities of Mullett Creek Bay.

Figure 13. Aquatic invasive plants of Mullett Creek Bay.

Discussion

The 2015 aquatic plant survey of Pigeon River Bay, Aloha State Park, Mullett Lake Marina, and Mullett Creek Bay followed up on concerns of the 2007-2008 comprehensive survey of Mullett Lake. In Pigeon River Bay, heavy plant and algae growth indicate that nutrient pollution is still a concern. The majority of these nutrients likely originate in the Pigeon River Watershed and enter the bay through the Pigeon River. However, shoreline management problems such as fertilizing lawns, erosion, and faulty septic systems could also be contributing nutrients to the Bay. Heavy vegetation is still dominate in Aloha State Park, and Eurasian watermilfoil and curly leaf pondweed persist in the Park's marina. Eurasian watermilfoil is still prevalent in Mullett Lake Marina at heavy density. Mullett Creek Bay has dense vegetation and also invasive purple loosestrife.

Similar to other lakes surveyed by the Watershed Council, aquatic plants were generally not found at depths exceeding 20 feet in Mullett Lake, which was noticeable while surveying the northern part of Pigeon River Bay. Prevailing wind direction is another important determinant of aquatic plant distribution. Past surveys in this region show that prevailing winds from the northwest tend to create lightly or non-vegetated areas in the eastern and southeastern sides of lakes (as a result of wind and wave action). Impacts from winds tend to be more pronounced in lakes with a long fetch or in lake areas that are highly exposed. The effect of prevailing winds was apparent on the east side of Pigeon River Bay and outside the marina of Aloha State Park, though there were areas of little or no vegetation along the western shoreline of Pigeon River Bay, Mullett Lake Marina, and Mullett Creek Bay as well. This points out that other factors beyond depth and prevailing winds contribute to a lake's plant distribution, such as substrate types, nutrient availability, water clarity, structure, and water currents.

Three invasive plant species were found in 2015: Eurasian watermilfoil, curly leaf pondweed, and purple loosestrife. An invasive mollusk, the quagga mussel, was documented as well at one site. Considering the repercussions associated with the spread of these highly invasive species, in terms of negative impacts to the lake ecosystem, recreation, and the local economy, it is important to respond rapidly and implement control measures to control these problematic invasive species.

The following recommendations are presented based on the results of the 2015 survey:

1. <u>Educate and inform lake users.</u> Human activity in a multitude of forms typically has the greatest impact on a lake's aquatic plant communities. Therefore, effectively managing a lake's aquatic plants requires information and education outreach projects that target shoreline property owners, watershed residents, and all lake users. Residents can improve land management practices to reduce nutrient loading (to control excessive plant growth) by establishing naturally vegetated buffers along the shoreline, reducing or eliminating yard fertilizers, and properly maintaining septic systems. Lake associations can help prevent the introduction of non-native species, such as the nuisance algae starry stonewort that looms on the horizon, by posting signs and educating members and other lake users. Outreach activities should not be limited to dos and don'ts, but also include general information about aquatic plants and their importance to the lake ecosystem.

2. <u>Share the results of this survey.</u> The results of this study should be widely dispersed to get a maximum return on MAPS' investment. Sharing the results with members, non-member lake users, government officials, and others will inform the public about problems occurring in the Lake and progress of MAPS' efforts at aquatic plant and lake

management. An informed public will be more supportive of the efforts to manage the Lake ecosystem and its aquatic plants. Furthermore, an informed public may result in behavioral changes that benefit aquatic plant management, such as reducing lake nutrient loads and preventing the introduction of additional non-native species.

3. Develop an aquatic plant management plan. MAPS should consider developing an aquatic plant management plan to enhance lake management efforts over the long-term. The aquatic plant community is a vital component of the aquatic ecosystem, such that good aquatic plant management translates to good lake ecosystem management. MAPS has already taken an important step in aquatic plant management by sponsoring two aquatic plant surveys. There are a number of guides available to help develop such a plan, including *Management of Aquatic Plants* by Michigan Department of Environmental Quality, *Aquatic Plant Management in Wisconsin* by University of Wisconsin Extension, and *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans* by the Washington State Department of Ecology.

4. Control invasive species. This survey documented aquatic invasive plant infestations in Pigeon River Bay, Aloha State Park, Mullett Lake Marina, and Mullett Creek Bay. Due to these plants' history of outcompeting native vegetation and becoming a nuisance in other lakes, MAPS should implement control efforts as soon as possible. Early detection and rapid response are critical for effective control, while also economically efficient and inflicting relatively little collateral damage to native species. Known infestations should be revisited frequently to assess efforts and continue with treatment as necessary.

Additionally, MAPS should regularly survey other lake areas for the presence of these aquatic invasive plants and implement control measures as necessary to prevent their spread. Various controls exist for each species documented.

5. Regularly survey the Lake for other priority invaders. Other aquatic invasive species documented in Michigan lakes and rivers include European frog bit (*Hydrocharis morsus-ranae*), starry stonewort (*Nitellopsis obtusa*), and Carolina fanwort (*Cabomba caroliniana*). These species can be spread from lake to lake by transport on trailers and watercraft. Due to their proximity on other lakes, these species have high potential of infesting Mullett Lake. It is important that MAPS regularly survey the Lake for these and other invasive species to facilitate early detection and rapid response efforts.

6. Monitor boat launches for aquatic invasive species. Volunteers from MAPS can help prevent the introduction of aquatic invasive species and educate lake users by monitoring boat launches. Volunteers can inform and educate lake users about the impacts of invasive species and encourage them to take the necessary steps to prevent their spread, such as cleaning boats and trailers. It is important that monitoring be carried out during busy weekends, such as Memorial Day and the Fourth of July when boat launches are used the most and the potential for invasive species introduction is at its greatest.

7. Preserve the Lake ecosystem and natural diversity. Mullett Lake contains a vibrant native aquatic plant population that may be considered a nuisance by many shoreline residents and other lake users. While pursuing nuisance plant management and control options,

MAPS should strive to protect the diverse assemblage of plants present in the Lake, which are critical for sustaining a healthy fishery and maintaining a healthy aquatic ecosystem. In addition, a healthy community of diverse native plants makes it more difficult for invasive species to become established and proliferate.

8. Investigate potential nutrient pollution issues. Nutrient pollution from shoreline properties can lead to excessive plant growth and should be controlled wherever and whenever possible. MAPS can make positive steps toward controlling nutrient pollution by communicating and working with shoreline property owners. In particular, property owners around the Lake should be encouraged to properly maintain septic systems, replace old or failing septic systems, reduce or eliminate fertilizer use, compost and mulch far from the shoreline, and prevent stormwater from flowing directly into the Lake. MAPS is on the right track by funding the 2016/2017 shoreline survey of Mullett Lake. Shoreline surveys are an effective tool for locating sources of nutrient pollution. Information gathered from a shoreline survey can be used to work with lakeshore property owners to verify nutrient pollution, identify sources, and correct any problems. Shoreline surveys should be carried out once every 3-5 years to document conditions and address any problem areas.

9. Regularly survey the aquatic plants of Mullett Lake. To effectively manage the aquatic plant community of Mullett Lake, periodic aquatic plant surveys should be conducted. Future surveys will provide the necessary data for determining trends over time, evaluating successes or failures of aquatic plant management projects, and documenting

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.

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Appendix A. 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. 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. 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.
    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. <u>Laboratory Identification</u>. 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. <u>Data Management.</u> 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. <u>GIS Data Layer Development: Sample Sites.</u> 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. <u>GIS Data Layer Development: GPS Photographs.</u> 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. <u>GIS Data Layer Development: Communities.</u>
    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. <u>Data Summarization.</u> 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. Optionally, tables from data summarization can be included on the maps.

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