Pike Chain of Lakes
AIS Control & Prevention Project

2009 Controlling Established Infestations Grant
Summary Report

Bayfield County, Wisconsin
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1.0 INTRODUCTION

The Pike Chain of Lakes is comprised of six lake basins located in Bayfield County, Wisconsin (Figure 1.1). This system includes nearly 900 acres of surface water. This headwater drainage system leads to the White River which flows through the Bad River Indian Reservation on its way to Lake Superior. All lakes within the chain are considered Areas of Special Natural Resource Interest (ASNRI) as outstanding or exceptional resource waters per Section 281.15 of Wisconsin Statutes.

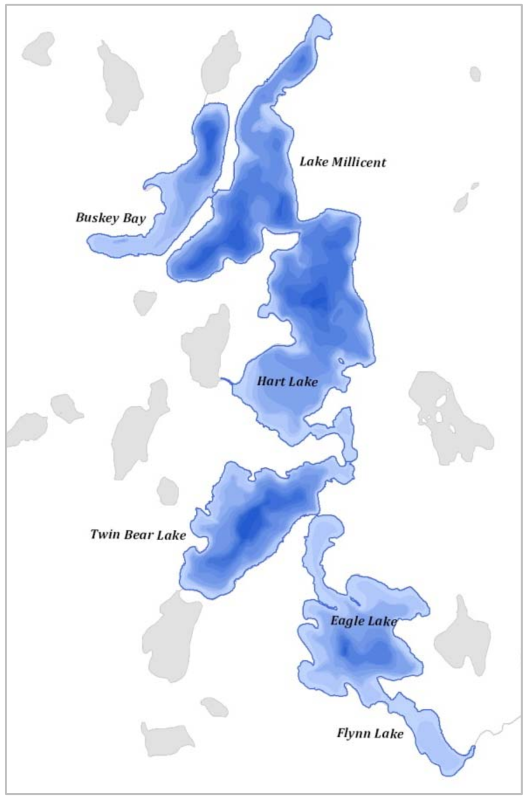


Figure 1.1. Pike Chain of Lakes, Bayfield County, Wisconsin.

Eurasian water milfoil (*Myriophyllum spicatum*) was first documented in the Pike Chain of Lakes in 2004, with plants being discovered first in the channel between Twin Bear and Hart Lake. The Town of Delta sponsored an aquatic invasive species grant to cover costs associated with boat inspections at the Twin Bear and Lake Delta boat landings starting in 2005. With the help of the Wisconsin Department of Natural Resources (WDNR) and Bayfield County, an Aquatic Invasive Species Rapid Response Grant was awarded to fund a six acre 2,4-D treatment in the Hart Lake channel and small sections of Twin Bear and Hart Lake in June 2005. A second herbicide treatment, funded by the Iron River Pike Chain of Lakes Association (IRPCLA), was conducted in June 2006 of approximately eight to ten acres targeting small colonies along the northwest shore of Twin Bear and colonies in Hart Lake including the Hart Lake channel. Further treatments have occurred since, as explained later on within this report.

In February 2007, the IRPCLA partnered with Onterra, LLC to complete seven grant applications in hopes of receiving partial funding for the development of a lake management plan for the Pike Chain of Lakes. In April 2007, the Iron River Lakes Association was notified that they were successful and would receive over $49,000 in funds. The Pike Chain of Lakes Comprehensive Management Plan was completed in December of 2008. Within the management plan, several management goals were developed by an IRPCLA planning committee and Onterra staff in order to continue managing the ecosystem in a responsible and ecologically sound manner. Among these defined goals was Management Goal 4, which called for the control of aquatic invasive species within the Pike Chain of Lakes. Consistent with the content of this goal, the IRPCLA pursued an Aquatic Invasive Species - Controlling Established Infestations grant (ACEI) through the WDNR. A grant application was submitted in February 2009 which proposed a five year aquatic invasive species control project. The project was approved and funded later that April.

As elaborated upon within the text below, the five-year aquatic invasive species control project was created with several goals in mind. The primary goal included minimizing the negative impact of Eurasian water milfoil and purple loosestrife on the ecology of the Pike Chain of Lakes. Secondarily, a goal of the project was to engage stakeholders to take active roles in managing the lakes through volunteer aquatic invasive species monitoring and direct actions such as monitoring and hand-pulling of invasive plants. This report discusses the extensive efforts that took place with both of these goals in mind.

During 2009-2013the original project intentions were to monitor the annual treatments on the Pike Chain of Lakes through quantitative methods using data collected from point-intercept sub-sampling locations within the herbicide application areas. Due to the decreasing size of treatment areas as a result of years of successful herbicide treatments and hand-removal operations, point-intercept sub-sampling became difficult to incorporate within the program. With a smaller treatment area, fewer points are sampled and therefore meaningful comparisons are not able to be conducted due to the smaller sample size. However, qualitative assessments (as described within this report) were still able to be conducted.

When quantitative monitoring was able to be conducted, the presence of Eurasian water milfoil and native aquatic plant species were recorded at point-intercept sub-sampling locations. These locations were visited the summer prior to treatment and summer immediately following the treatment to produce pre- and post-treatment data. By comparing data from the two surveys, expressed as frequency of occurrence, a determination could be made on the effectiveness of the treatment as well as if there were any impacts to non-target species. However, these data could only be used to make those determinations within the treatment areas and could not be extrapolated to the effects on the aquatic plant community at a lake-wide level. To determine if the multi-year Eurasian water milfoil control program has had detectable effects on the chain's aquatic plant communities at the lake-wide level, whole-lake point-intercept surveys were completed in 2013 that inventoried each lake's entire aquatic plant community. These surveys were replicates of surveys conducted by Onterra in 2007 through the management planning project.

As spelled out within the 2009 grant project description, annual reports have been created to keep IRPCLA stakeholders and WDNR staff up-to-date on the monitoring and control actions taken on the Pike Chain of Lakes each year. This report aims to summarize five years of Eurasian water milfoil management on the chain, and compare the data collected in 2013 to the data collected in 2007 with the intent of determining 1) if the Eurasian water milfoil control program had any detectable adverse impacts to the native aquatic plant community on a lake-wide level, and 2) if the control program was successful at reducing the chain's Eurasian water milfoil population. This report will provide first a chain-wide comparison of the aquatic plant community from 2007 to 2013 followed by comparisons of each individual lake.

2.0 RESULTS AND DISCUSSION

Aquatic Plant Sampling Methodology and Data Analysis

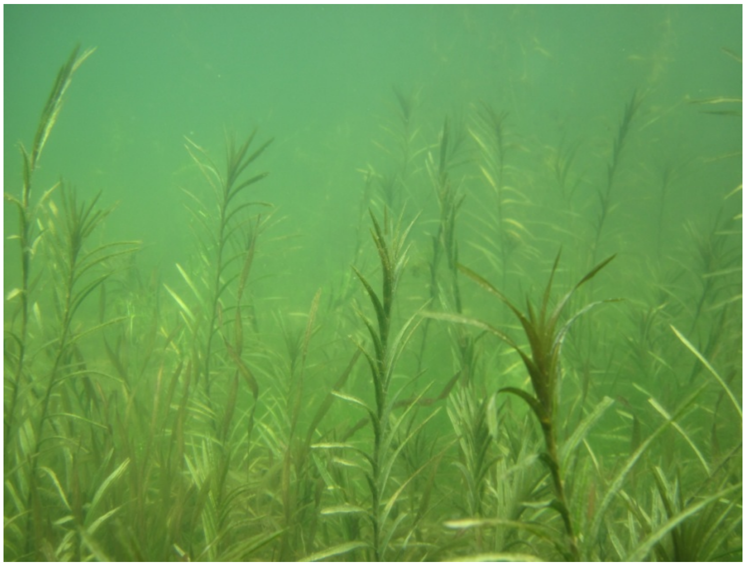


Photo 2.1. Native aquatic plant community, Lake Millicent.

As discussed previously, surveys were conducted on the Pike Chain of Lakes in 2013 to assess their aquatic plant communities following numerous years of large-scale herbicide treatments to control Eurasian water milfoil. Native aquatic plants are an important element in every healthy aquatic ecosystem, providing food and habitat to wildlife, improving water quality, and stabilizing bottom sediments (Photo 2.1). Because most aquatic plants are rooted in place and are unable to relocate in wake of environmental alterations, they are often the first community to indicate that changes may be occurring within the system. Aquatic plant communities can respond in variety of ways; there may be increases or declines in the occurrences of some species, or a complete loss. Or, certain growth forms, such as emergent and floating-leaf communities may disappear from areas of the waterbody. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide relevant information for making management decisions. During the course of this project, native and non-native plants were inventoried and assessed utilizing three survey methodologies, as described below.

Point-intercept survey

The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) was used to complete the whole-lake point-intercept surveys on the Pike Chain of Lakes in 2012. Based upon guidance from the WDNR, a point spacing (resolution) ranging from 30 to 80 meters was used resulting in 137 to 616 sampling points being evenly distributed across each lake (Table 2.1).

Table 2.1. Point-intercept survey methodology for the Pike Chain of Lakes. Survey design was utilized in 2005/2007 as well as 2013 surveys conducted by WDNR staff and Onterra.

Lake	Sample Locations	Resolution (m)
Buskey Bay	399	30
Millicent	514	38
Hart	953	33
Twin Bear	614	32
Eagle	734	30
Flynn	132	30

At each point-intercept location within the littoral zone, information regarding the depth, substrate type (muck, sand, or rock), and the plant species sampled along with their relative abundance (Figure 2.1) on the sampling rake was recorded. A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 13 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 13 feet. Depth information was collected using graduated marks on the pole of the rake or using an onboard sonar unit at depths greater than 13 feet. Also, when a rope rake was used, information regarding substrate type was not collected due to the inability of the sampler to accurately feel the bottom with this sampling device. The point-intercept survey produces a great deal of information about a lake's aquatic vegetation and overall health. These data are analyzed and presented in numerous ways; each is discussed in more detail the following section.

Figure 2.1. Aquatic plant rake-fullness ratings. Adapted from Hauxwell et al (2010).

When appropriate, a modified point-intercept sub-sampling methodology was used within Eurasian water milfoil treatment areas in an effort to quantitatively evaluate success of the treatment. These efforts are discussed thoroughly in annual treatment reports produced for the Pike Chain of Lakes, 2009-2012. In order to produce quantitative results that allow for statistical interpretation, adequate sampling locations are necessary. The number of sampling locations is determined by the size of a given treatment area. As discussed within the Introduction Section, this methodology was not utilized often due to the small size of treatment areas that were delineated within the Pike Chain of Lakes during the course of this management project.

Community mapping survey

The point-intercept methodology is very useful for capturing the species richness and diversity (discussed below) of a submersed aquatic plant community. However, often the presence of emergent or floating-leaf vegetation is not adequately sampled with this survey type. Emergent and floating-leaf vegetation are often found within shallow reaches of a lake and thus can be hard to access in watercraft. To document the presence of these aquatic plant communities, a community mapping survey was conducted on the Pike Chain of Lakes in 2007 and 2013. During this survey, emergent and floating-leaf aquatic plant communities were documented with sub-meter accuracy GPS technology in two formats, point-based and polygon-based methods. A single GPS waypoint was taken at the location of smaller communities (less than 40 ft diameter or length) while polygons were delineated around larger communities. Species presence was also documented in order of most prevalent within the community to least prevalent. As previously discussed, differences in these communities between time periods may indicate environmental disturbances or recoveries in a lake ecosystem.

Eurasian water milfoil peak-biomass survey

When studying an invasive plant such as Eurasian water milfoil, methodologies such as the point-intercept survey can be difficult to properly assess abundance and distribution of Eurasian water milfoil due to this species being present at a small frequency of occurrence in each lake in addition to it being a characteristically colonized plant. To adequately assess Eurasian water milfoil within the Pike Chain of Lakes, Onterra staff carried out a peak-biomass mapping survey in late summer of each year, 2007-2013. During this survey, plants are denoted with either point-based or polygon-based methods as described above in the community mapping discussion. Point-based Eurasian water milfoil locations are described as *Single or Few Plants*, *Clumps of Plants* or as a *Small Plant Colony*. Polygon-base distinctions include *Highly Scattered* and *Scattered* for lightly dense areas, with *Dominant*¸ *Highly Dominant* and *Surface Matted* left to describe denser Eurasian water milfoil colonies. These surveys produce maps which depict success/failures of herbicide treatments based upon qualitative observations. Additionally, they produce information that is vital for management planning for the following year.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species, both native and non-native, that were located during the whole-lake point-intercept surveys 2013 on the Pike Chain of Lakes. The list also contains the growth-form of each plant found (e.g. submergent, emergent, etc.), its scientific name, common name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept surveys conducted in 2007 and 2013 on the Pike Chain of Lakes, plant samples were collected from plots laid out on a grid that covered each lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, the occurrences of aquatic plant species are displayed as their littoral frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the littoral zone, and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake is calculated using its species richness and average species conservatism. Species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values (C-value) for each of those species in its calculation. A species coefficient of conservatism value indicates that species' likelihood of being found in an undisturbed system. The values range from 1 to 10. Species that can tolerate environmental disturbance and are can be located in disturbed systems have lower coefficients, while species that are less tolerant to environmental disturbance and are restricted to high quality systems have higher values. For example, coontail (*Ceratophyllum demersum*), a submergent native aquatic plant species with a C-value of 3, has a higher tolerance to disturbed conditions, often thriving in lakes with higher nutrient levels and low water clarity, while other species like algal-leaf pondweed (*Potamogeton confervoides*) with a C-value of 10, are intolerant of environmental disturbance and require high quality environments to survive.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys. The Pike Chain of Lakes falls within the Northern Lakes and Forests Ecoregion of Wisconsin, and the floristic quality of its aquatic plant community in 2007 and 2013 will be compared to other lakes within this ecoregion as well as the entire state (Figure 2.2). The comparative data within this ecoregion has been divided into two groupings: Northern Lakes and Forest Lakes (NLFL) and Northern Lakes and Forest Flowages (NLFF). Although the Pike Chain of Lakes is an impounded system, it will be compared to other natural lakes within this ecoregion due to the fact that the majority (>50%) of each lakes' volumes are not due to the impounded condition.

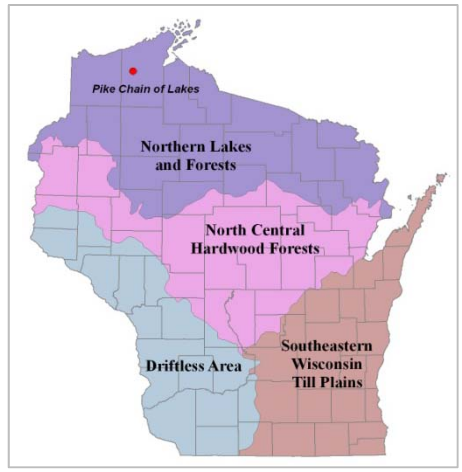


Figure 2.2. Location of the Pike Chain of Lakes within the ecoregions of Wisconsin. After Nichols (1999).

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. As defined previously, species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because species diversity also takes into account how evenly the species are distributed within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

An aquatic system with high species diversity is much more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity. Simpson's diversity index is used to determine this diversity in a lake ecosystem.
Simpson's diversity (1-D) is calculated as:

$$D = \sum (n/N)^2$$

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to the Pike Chain of Lakes. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Figure 2.2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

Native Aquatic Plant Survey Results

Photo 2.2. Native freshwater mussel amongst slender naiad, Lake Millicent.

Comprehensive aquatic plant inventories were completed on the Pike Chain of Lakes twice – once in 2005/2007 by WDNR and Onterra staff and once in 2013 by Onterra. Studies were completed in the late summer by the WDNR (July 12-13, 2005) and Onterra (August 7-9, 2007) as well as August 6-8 in 2013. A total of 68 aquatic plant species were located within the chain, two of which are considered to be non-native, invasive species: Eurasian water milfoil and purple loosestrife (Table 2.2 and 2.3).

Of the 68 species found in 2013, 56 were found in studies conducted in 2005 and 2007. Thirteen native aquatic plant species were observed during the 2005/2007 surveys that were not recorded during the surveys completed in 2013 (2.4). These species include some that were found in very low frequency during the 2005/2007 surveys, such as Oakes pondweed (*Potamogeton oakesianus*), spiral-fruited pondweed (*Potamogeton spirillus*) as well as others. One of these plants, the non-native curly-leaf pondweed, was found incidentally by WDNR staff in Hart Lake during 2005. It has not, however been found since. Several of the emergent and free-floating species included on Table 2.3 can be difficult to find due to the nature of their growth. Many emergent plants, such as sedges and bur-reeds are found in very shallow water, or areas with intermittent water. Free-floating species are often found on the windward side of a lake, pushed up along shoreline or emergent and floating-leaf vegetation. As it can be difficult to navigate to these shallow areas, they sometimes escape detection, even during the most rigorous of aquatic plant surveys. In short, it is believed that these 13 species were not located in 2013 due to their low occurrence or environmental variables, and not due to management actions conducted during this time period. More discussion on native aquatic plant population changes is discussed at the end of this section.

Table 2.2. Aquatic plant species found in the Pike Chain of Lakes during 2013 aquatic plant studies. Table includes emergent, floating-leaf, floating-leaf/emergent, submergent/emergent and free-floating species. Submergent species included on Table 2.-3.

Growth Form	Species	Common Name	C-value	Buskey Bay	Millicent	Hart	Twin Bear	Eagle	Flynn	Present in 2005/2007
Emergent	*Calla palustris*	Water arum	9	I		I				X
	Carex comosa	Bristly sedge	5			I			I	X
	Carex pellita	Broad-leaved woolly sedge	4		I			I		X
	Carex pseudocyperus	Cypress-like sedge	8	I	I	I				
	Carex sp. (sterile)	Carex sp.	NA	I	I					
	Dulichium arundinaceum	Three-way sedge	9					X	X	X
	Eleocharis palustris	Creeping spike-rush	6	I		I	X		I	X
	Equisetum fluviatile	Water horsetail	7	I						X
	Iris versicolor	Northern blue flag	5	I				I	I	X
	Juncus pelocarpus	Brown-fruited rush	8		X					X
	Lythrum salicaria	Purple loosestrife	Exotic	I	I					X
	Persicaria amphibia	Polygonum amphibium	4	X	I			I		X
	Phragmites australis subsp. americanus	Giant reed (native)	NA					I		
	Sagittaria latifolia	Common arrowhead	3	I			I	I		X
	Schoenoplectus acutus	Hardstem bulrush	5	I	X	X	X	X	X	X
	Schoenoplectus subterminalis	Water bulrush	9		X			X	X	X
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I				I		X
	Scirpus cyperinus	Wool-grass	4	I						
	Typha spp.	Cattail sp.	1	I	I	X		I	I	X
FL	*Brasenia schreberi*	Watershield	7	I	X	X		X	X	X
	Nuphar variegata	Spatterdock	6	X	I	X	X	X	X	X
	Nymphaea odorata	White water lily	6	X	X	X	X	X	X	X
FL/E	*Sparganium americanum*	Eastern bur-reed	8	X	I	I	I	X	I	X
	Sparganium angustifolium	Narrow-leaf bur-reed	9					I	I	X
	Sparganium emersum	Short-stemmed bur-reed	8					I		X
	Sparganium sp. (sterile)	Bur-reed sp.	NA						X	
S/E	*Eleocharis acicularis*	Needle spike-rush	5	X	X	X	X	X	X	X
	Sagittaria cristata	Crested arrowhead	9				X	X	X	X
	Sagittaria sp. (rosette)	Arrowhead sp. rosette	NA		I					
FF	*Lemna trisulca*	Forked duckweed	6	X				X	X	
	Riccia fluitans	Slender riccia	7	X						
	Wolffia spp.	Watermeal sp.	5					X		

FL = Floating-leaf; FL/E = Floating-leaf and Emergent; S/E = Submergent and Emergent; FF = Free-floating
X = Located on rake during point-intercept survey; I = Incidentially located
** = Species listed as 'special concern' in Wisconsin*

Table 2.3. Aquatic plant species found in the Pike Chain of Lakes during 2013 aquatic plant studies, continued. Table includes submergent species.

Growth Form	Species	Common Name	C-value	Buskey Bay	Millicent	Hart	Twin Bear	Eagle	Flynn	Present in 2005/2007
Submergent	*Bidens beckii*	Water marigold	8	X	X	X	X	X	X	X
	Ceratophyllum demersum	Coontail	3	X	X	X	X	X	X	X
	Ceratophyllum echinatum	Spiny hornwort	10			X	X			X
	Chara spp.	Muskgrasses	7	X	X	X	X	X	X	X
	Elodea canadensis	Common waterweed	3	X	X	X	X	X	X	X
	Heteranthera dubia	Water stargrass	6	X	X	X	X	X	X	X
	Isoetes spp.	Quilwort sp.	8			X		X		X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X	X	X	X	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X	X	X	I		X
	Myriophyllum tenellum	Dwarf water milfoil	10		X	X		X	X	X
	Myriophyllum verticillatum	Whorled water milfoil	8	X						
	Najas flexilis	Slender naiad	6	X	X	X	X	X	X	X
	Nitella spp.	Stoneworts	7	X	X	X		X		X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X	X	X	X	X	X
	Potamogeton berchtoldii	Slender pondweed	7	X	X	X	X	X		
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X	X	X			X
	Potamogeton foliosus	Leafy pondweed	6	X		X		X		X
	Potamogeton friesii	Fries' pondweed	8					X	X	
	Potamogeton gramineus	Variable pondweed	7	X	X	X	X	X	X	X
	Potamogeton illinoensis	Illinois pondweed	6	X	X	X	X	X		X
	Potamogeton natans	Floating-leaf pondweed	5	X	X	X		X	X	X
	Potamogeton praelongus	White-stem pondweed	8	X		X	X	X	X	X
	Potamogeton pusillus	Small pondweed	7	X	X	X	X	X	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X	X	X	X	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X	X	X	X	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X	X	X	X	X	X
	*Potamogeton vaseyi**	Vasey's pondweed	10					X		
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X	X	X	X	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	X	X	X		X	X
	Ranunculus flammula	Creeping spearwort	9		X	X		X		X
	Stuckenia pectinata	Sago pondweed	3	X				X		X
	Utricularia gibba	Creeping bladderwort	9	X	X	X		X	X	X
	Utricularia intermedia	Flat-leaf bladderwort	9		X					X
	Utricularia minor	Small bladderwort	10			X		X		
	Utricularia vulgaris	Common bladderwort	7	X	X	X		X	X	X
	Vallisneria americana	Wild celery	6	X	X	X	X	X	X	X

X = Located on rake during point-intercept survey; I = Incidentially located
** = Species listed as 'special concern' in Wisconsin*

Table 2.4. 2005/2007 aquatic plant species absent from 2013 surveys.

Growth Form	Species	Common Name	C-value
E	*Juncus effusus*	Soft rush	4
E	*Pontederia cordata*	Pickerelweed	9
E	*Schoenoplectus pungens*	Three-square rush	5
FF	*Lemna minor*	Lesser duckweed	5
FF	*Spirodela polyrhiza*	Greater duckweed	5
FL/E	*Sparganium eurycarpum*	Common bur-reed	5
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10
FL/E	*Sparganium glomeratum*	Clustered bur-reed	5
S	*Callitriche palustris*	Common water starwort	8
S	*Potamogeton crispus*	Curly-leaf pondweed	Exotic
S	*Potamogeton oakesianus*	Oakes pondweed	10
S	*Potamogeton spirillus*	Spiral-fruited pondweed	8
S/E	*Sagittaria graminea*	Grass-leaved arrowhead	9

E = Emergent; FF = Free-floating; FL/E = Floating/emergent; S = Submergent; S/E = Submergent/emergent

To determine if changes in the populations of native aquatic plant species had occurred between 2005/2007 and 2013, a Chi-square distribution analysis was used on the point-intercept data collected during these years. Figure 2.3 displays the native aquatic plant species with a littoral frequency of occurrence of at least 4% during these years. Six of these native species saw a statistically significant decrease: northern water milfoil, white water lily, slender naiad, wild celery, large-leaf pondweed and leafy pondweed. Northern water milfoil, a dicot and close relative to Eurasian water milfoil, was found to have a significant decrease in Buskey Bay, Lake Millicent and Flynn Lake. It's frequency of occurrence experienced a significant increase in Twin Bear Lake, and populations remained steady in Hart and Eagle Lakes. Four native species increased in their frequency between these time periods: coontail, variable pondweed, fern pondweed and small/slender pondweed. Three of these species are dicots, while the remaining seven are monocots or macroalgae.

These two groups of flowering plants, dicots and monocots/macroalgaes, differ in some of their morphological characteristics as well as their physiology. Due to these differences, it has historically been thought that monocot and macroalgae species are not susceptible to dicot-selective herbicides like 2,4-D. Emerging evidence by researchers with the US Army Corps of Engineers and WDNR may indicate that some monocot species can become impacted by 2,4-D under certain circumstances (herbicide dose, exposure time, etc.).

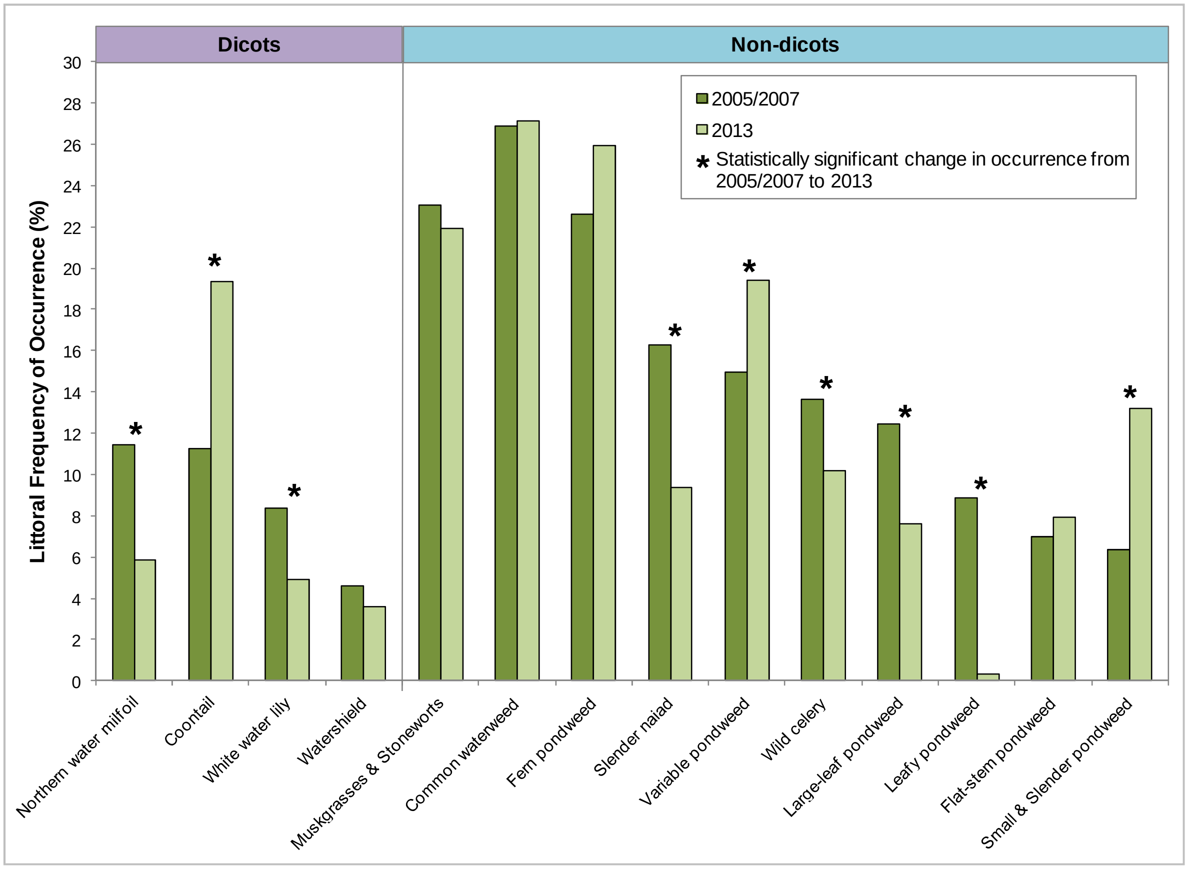


Figure 2.3. Pike Chain of Lakes littoral occurrence of native aquatic plants, 2005/2007 – 2013. Species with an occurrence of at least 4% in either survey represented. Created using data from 2005/2007 and 2013 point-intercept surveys.

It is plausible that the herbicide treatment strategy conducted on the Pike Chain of Lakes between the two point-intercept datasets (2005/2007 and 2013) caused the slight declines observed to the six native plant species. Unpublished data indicates that northern water milfoil, coontail, slender naiad, leafy pondweed, and small/slender pondweed are species that tend to decline following herbicide management actions. Within the Pike Chain of Lakes, three out these five species declined and two increased. It is important to note that while a reduction of a select few native aquatic plants was observed, the magnitude of their declines in most instances was quite small. Ongoing research indicates that some native species rebound quickly, whereas other species are slower to recover. Continued monitoring will be important to tease out the inter-annual population fluctuations of these plants versus the true collateral effects the herbicide treatment strategy is causing to these valuable plant species.

Twenty of the species depicted in Tables 2.2 and 2.3 were found in all six of the Pike Chain lakes. Interestingly, during the 2013 surveys 12 of the species that were found were determined to be unique to only one of the six lakes in the Pike Chain. This is a testament to the fact that the Pike Chain of Lakes, while connected and similar in many respects, are very much unique at the same time. Figure 2.4 illustrates that the average number of native aquatic plant species encountered at each point-intercept sampling location decreased slightly from an average of 2.4 in 2005/2007 to 2.3 in 2013. Hart, Twin Bear and Eagle Lakes all saw increases in the number of native aquatic plant species per site, while Buskey Bay, Lake Millicent and Flynn Lakes exhibited a reduction.

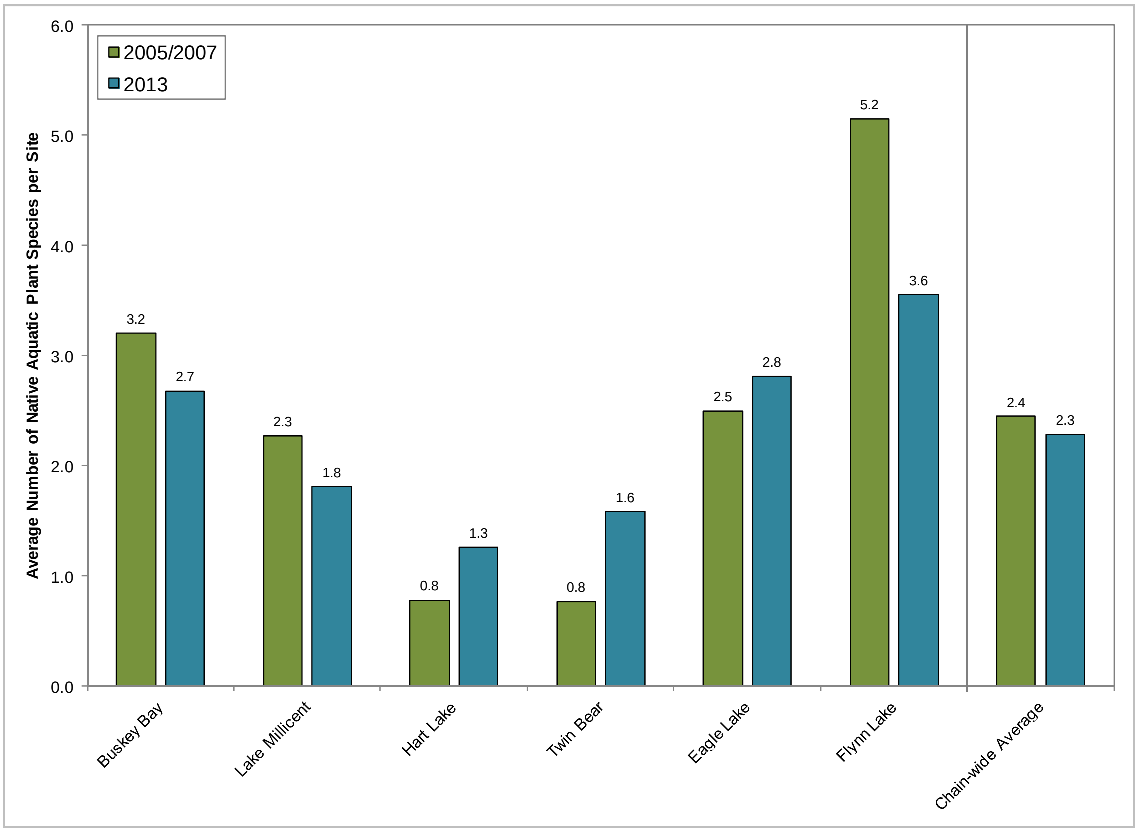


Figure 2.4. Pike Chain of Lakes average number of native aquatic plant species per site. Created using data from 2005/2007 and 2013 point-intercept surveys.

In 2013, 2,240 point-intercept locations fell at or below the maximum depth of plant growth. Of these points that fell within the chain's littoral zone, 71% contained aquatic vegetation. Looking at the total rake-fullness (TRF) ratings, 32% had a total rake-fullness of 1, 29% had a total rake-fullness rating of 2, and 8% had a total rake-fullness rating of 3, while 31% held no vegetation (Figure 2.5). The fact that 61% of the point-intercept sampling locations had a total rake-fullness rating of 1 or 2 indicates that aquatic vegetation in the chain is moderately to lightly dense where it occurs. This is expected for a moderately productive (low nutrient) system such as the Pike Chain of Lakes.

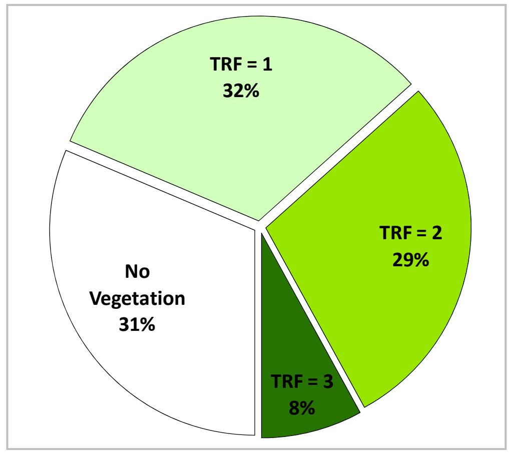


Figure 2.5. Pike Chain of Lakes total rake-fullness. Created using data from 2013 point-intercept surveys.

Of the six lakes, Eagle Lake held the greatest number of native species, at 50, while Twin Bear held the least, at 29. Figure 2.6 displays the native aquatic plant species richness values from the 2005/2007 and 2013 surveys. Only those species sampled directly during the point-intercept surveys are included in the species richness value; incidentally located species are not included. Since the Pike Chain of Lakes are interconnected, each lake has relatively similar water chemistry and water clarity. The differences in the number of aquatic plant species between lakes is therefore likely due to morphological attributes of the lakes themselves and the different habitat types they possess. The specifics of each lake's aquatic plant community is discussed within the individual lake sections that follow.

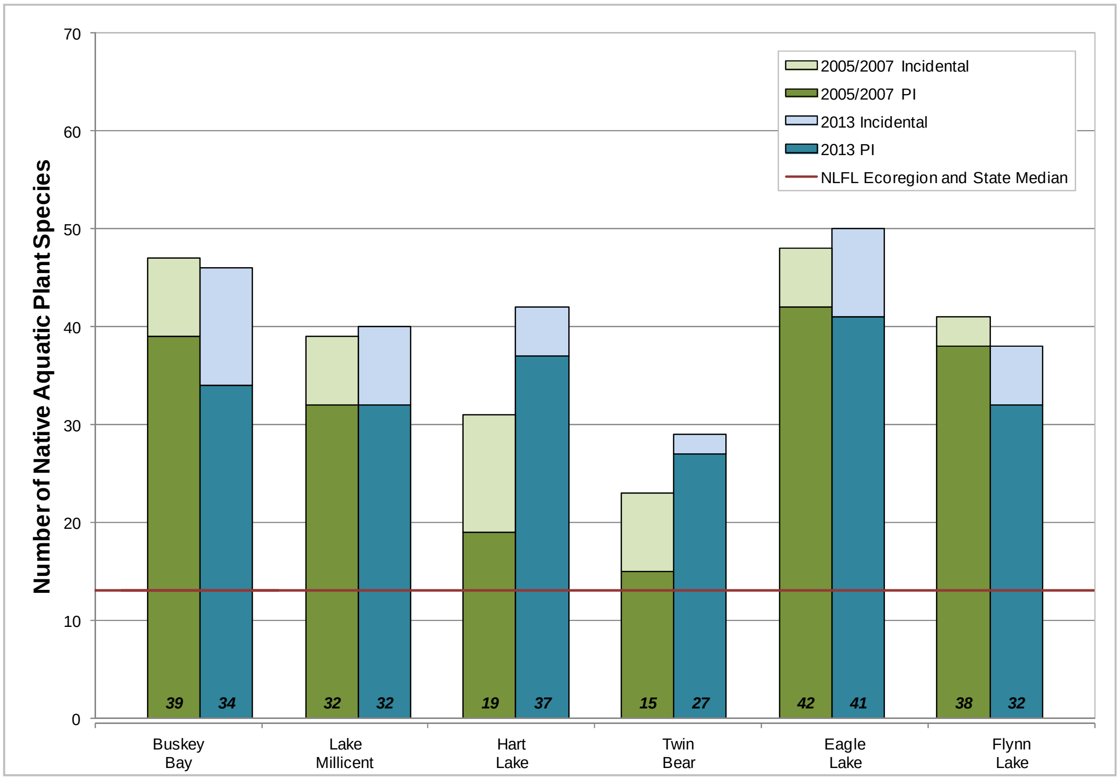


Figure 2.6. Pike Chain of Lakes native species richness. Created using data from 2005/2007 and 2013 point-intercept surveys.

Figure 2.7 displays the average conservatism value for each lake from 2005/2007 and 2013 point-intercept surveys and compares them to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion and to lakes throughout the State of Wisconsin. Average conservatism values in 2013 ranged from 6.4 in Buskey Bay to 6.9 in Eagle Lake. Four lakes met or exceeded the NLFL ecoregion median, while all of the lakes exceeded the median for lakes in Wisconsin. Higher average conservatism values indicate the lake contains a greater number of aquatic plant species that have higher coefficients of conservatism, or are less tolerant to environmental disturbance. The chain-wide average conservatism increased from 6.6 in the 2005/2007 surveys to 6.7 in 2013. All of the lakes in 2013, with the exception of Lake Millicent had higher conservatism values than in 2005/2007.

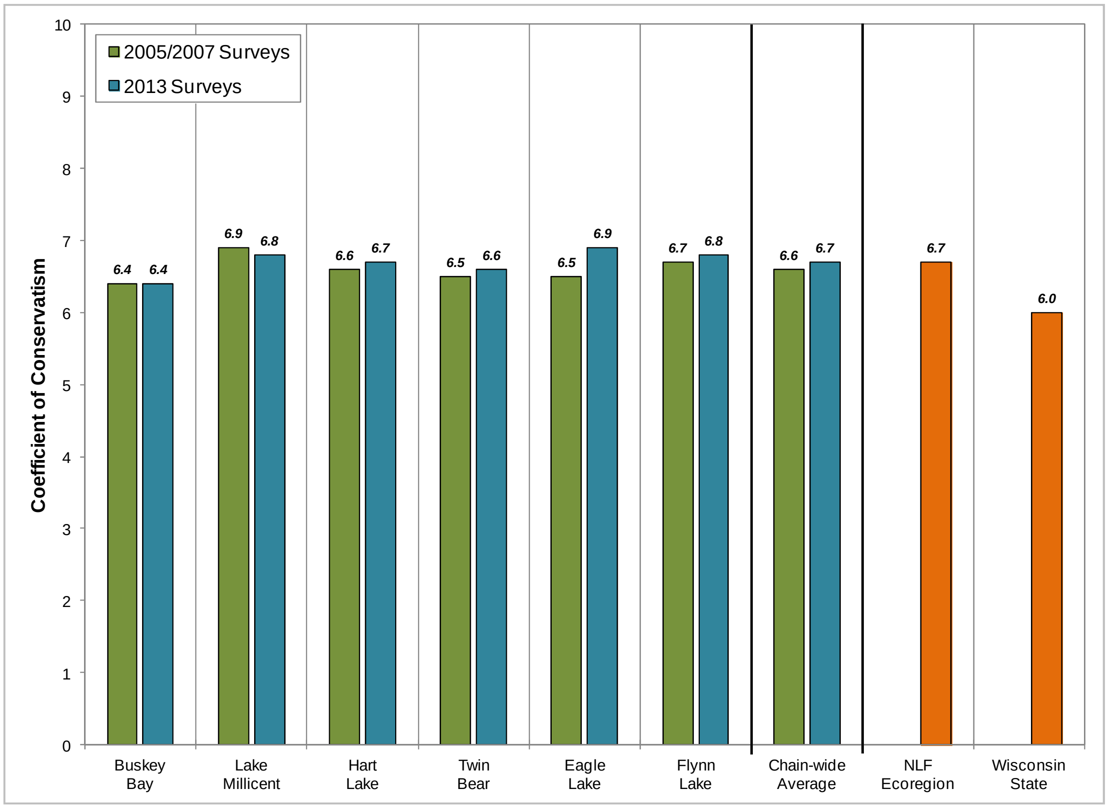


Figure 2.7. Pike Chain of Lakes average coefficients of conservatism. Created using data from 2005/2007 and 2013 point-intercept surveys.

As discussed in the primer section, all of the native aquatic plants that were sampled directly during the 2013 point-intercept surveys are used in calculating each lake's Floristic Quality Index (FQI). These calculations do not include species that were located "incidentally". The FQI for each lake is calculated using the native species richness and the average conservatism value (equation shown below).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

The 2013 FQI values ranged from 34.3 in Twin Bear Lake to 44.2 in Eagle Lake (Figure 2.8). All FQI values for 2013 exceeded the NLFL ecoregion and state medians, as they did in 2005/2007. This indicates that the aquatic plant community of the Pike Chain of Lakes is of higher quality than the majority of the lakes within the NLFL Ecoregion and lakes throughout Wisconsin.

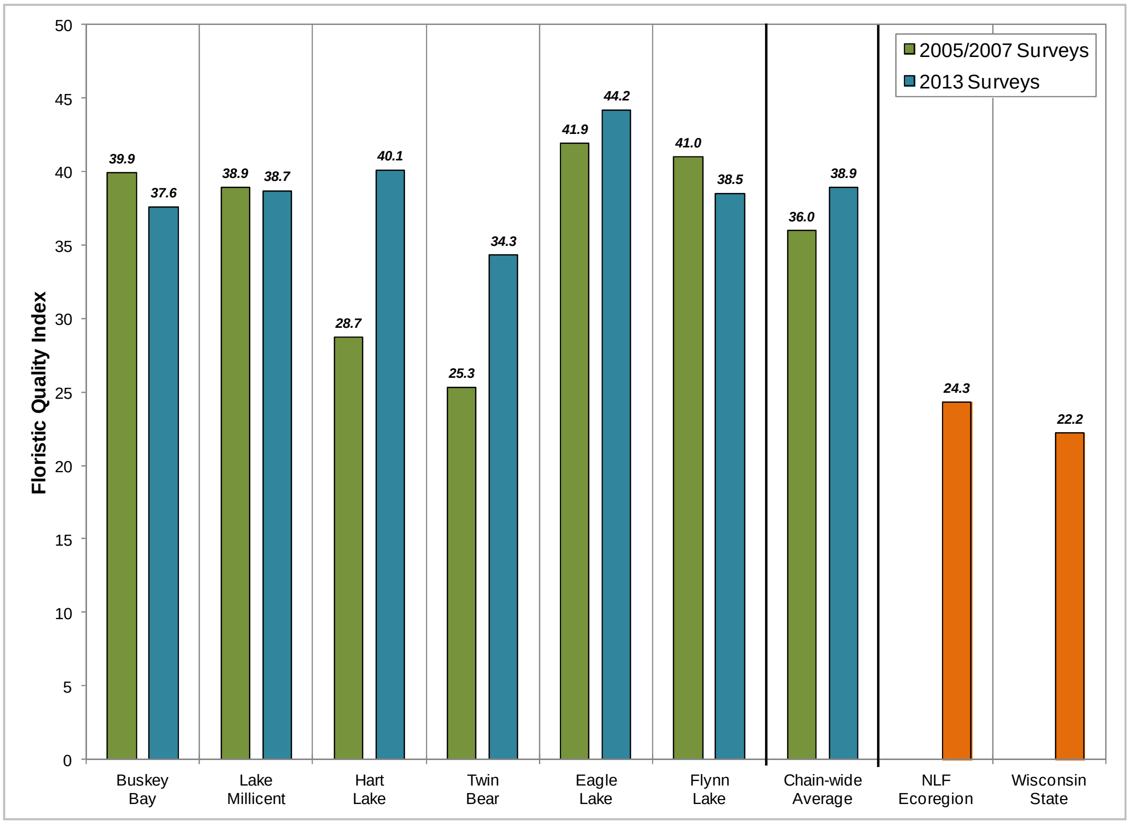


Figure 2.8. Pike Chain of Lakes Floristic Quality Index values. Created using data from 2005/2007 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLF = Northern Lakes and Forests Ecoregion.

As explained earlier, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because the Pike Chain of Lakes contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, as discussed, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how the chain's lakes' diversity values rank. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 2.9). Using the data collected from the 2005/2007 and 2013 point-intercept surveys, the diversity of each lake could be calculated. All six lakes exceeded the median value for lakes in the NLF Ecoregion in 2005/2007 and in 2013. In 2013, all six lakes exceeded the upper quartile value. The chain-wide average diversity value remained the same between these two periods, at 0.91. These values suggest that the aquatic plant community of the chain is exceptionally diverse.

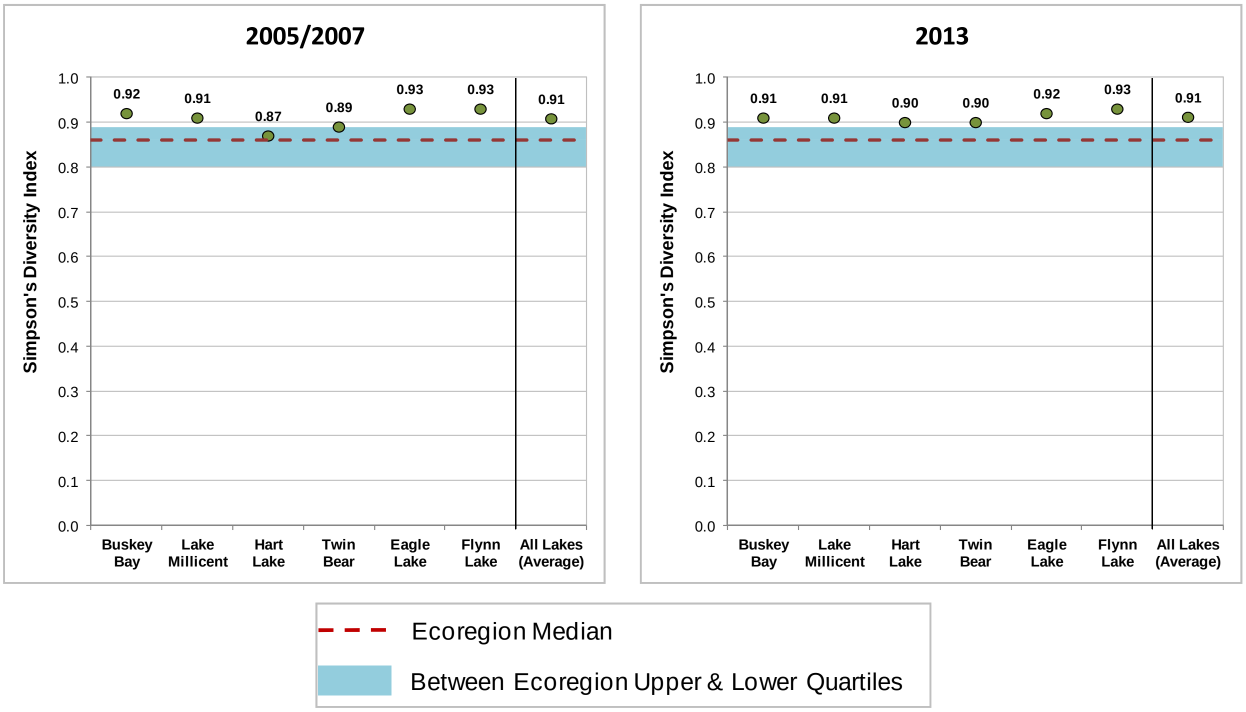


Figure 2.9. Pike Chain of Lakes Simpson's Diversity Index. Created using data from 2005/2007 and 2013 point-intercept surveys.

The quality of each lake's plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. These communities serve as a different, and sometimes preferred, type of habitat within a lake environment for mammals, birds, amphibians and fish. These communities are often impacted by recreational lake use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Mapping of emergent and floating-leaf communities took place in 2007 and 2013 by Onterra staff. Results of this survey can be viewed by lake within each respective lake section. Figure 2.10 displays the total areal coverage, in acres, during 2007 and 2013. Overall, these communities increased slightly in each lake of the Pike Chain. The chain-wide acreage of emergent and floating-leaf communities increased from 56.3 acres in 2007 to 60.7 acres in 2013.

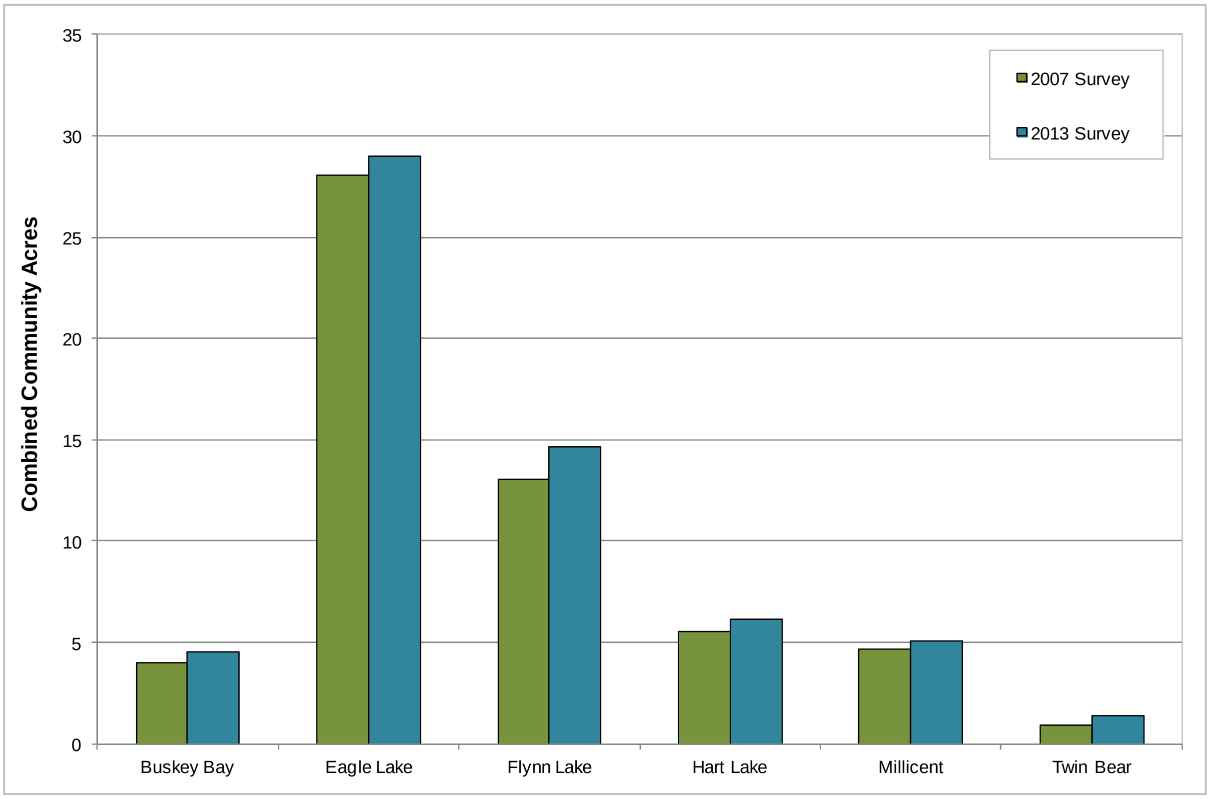


Figure 2.10. Pike Chain of Lakes emergent and floating-leaf areal cover. Created using data from 2007 and 2013 community mapping surveys. Total acreage includes areas delineated as emergent communities and floating-leaf communities.

Eurasian Water Milfoil Survey Results

During the AIS Control & Prevention Project, two types of assessments were attempted in order to determine efficacy of herbicide treatments on the Pike Chain of Lakes. These include quantitative assessments through sub-sample point-intercept studies and qualitative assessment assessments conducted each year through the peak-biomass mapping studies. As previously mentioned, the annual quantitative assessments proved difficult to conduct as treatment areas were often not large enough to provide ample sub-sampling sites, which led to difficulty in statistical analysis. Often, treatment areas were not of sufficient size due to the steep slopes of the Pike Chain lakes (narrow littoral zone). Additionally, the project centered on aggressive treatments in an early-detected Eurasian water milfoil population, which means that relatively small populations were targeted before they could expand to larger colonies.

While the quantitative treatment area sub-sampling studies were not conducted as often as hoped, whole-lake point-intercept surveys provide data that allows the Eurasian water milfoil population to be scrutinized under a lake-wide basis. As previously mentioned, these studies were conducted in 2005/2007, before many of the treatments had occurred, and in 2013. Figure 2.11 displays the change in frequency of occurrence in Eurasian water milfoil within each lake in the Pike Chain, as well as a total chain-wide comparison. Similar to the analysis conducted on the native plant dataset, a Chi-square distribution analysis was attempted to determine if differences had occurred in Eurasian water milfoil frequency of occurrence from 2005/2007 to 2013.

The Chi-square distribution analysis has two assumptions: 1) categories for the observations cannot overlap – each observation is independent, and 2) each category needs to have an expected frequency of at least five. This last assumption is difficult to meet when there are many categories and few observations.

Because of the low frequency of occurrence of Eurasian water milfoil in the Pike Chain lakes, it was rare that occurrences were greater than five plants on each individual lake sampling grid. For example, in Hart Lake, Eurasian water milfoil was not found at any of the 422 sampling locations in 2005, while it was detected at six of 696 locations in 2013. In Twin Bear Lake, Eurasian water milfoil was found at three of 157 locations in 2005 and only one location in 427 during the 2013 point-intercept study. Therefore, Chi-square tests were not able to detect statistically significant changes of this data. As shown on Figure 2.-11, the littoral frequency of Eurasian water milfoil during 2013 was less than 1% in all lakes, with a chain-wide occurrence of less than a half of a percent.

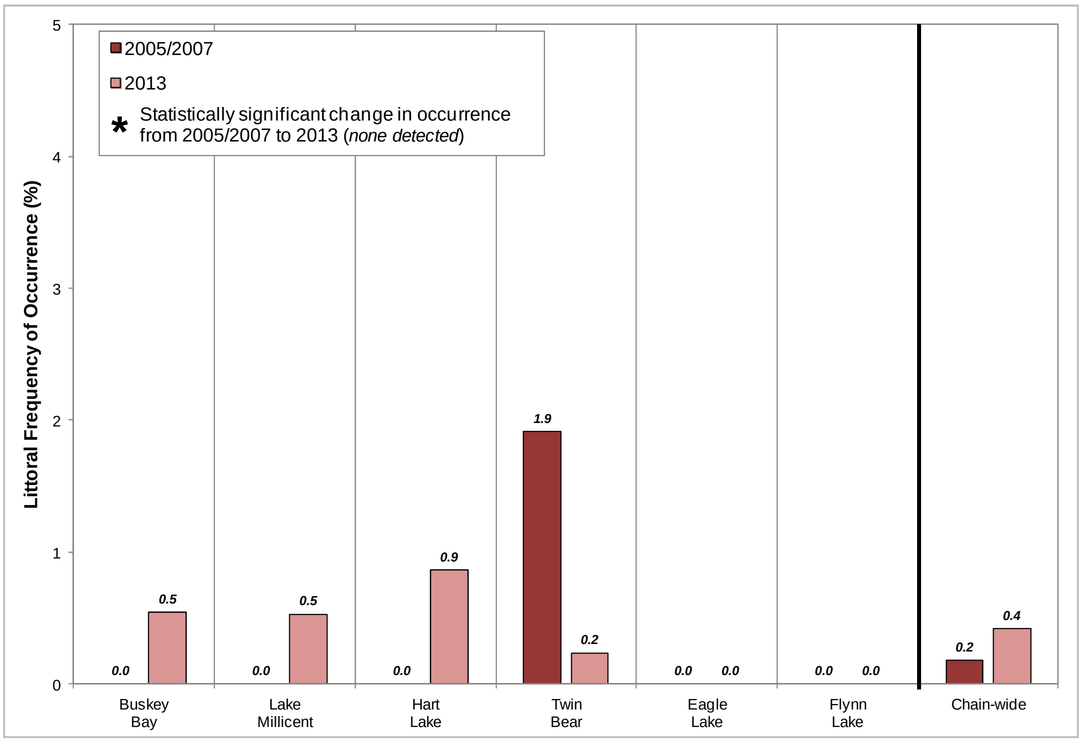


Figure 2.11. Pike Chain of Lakes Eurasian water milfoil littoral occurrence. Created using data from 2005/2007 and 2013 point-intercept surveys.

Aquatic Invasive Species Control Program Discussion

Eurasian water milfoil

Figure 2.12 displays Eurasian water milfoil treatment area summaries by lake for years in which the control project has been active (2009-2013) as well as several years prior. 2013 ranked as the second largest treatment during this five year project; however two items should be noted with respect to this year. First, during much of the Pike Chain of Lakes Eurasian water milfoil control program, volunteers conducted monitoring of the six lakes and relayed this information to Onterra. Onterra staff then visited known locations to accurately map Eurasian water milfoil locations in preparation for the upcoming year's management actions. In 2012, it was anticipated that funds would last that summer and then through 2013, so a complete meander-based survey was conducted on all six lakes in the Pike Chain of Lakes by Onterra staff. It is likely that more treatment acreage in 2013 was partially a result of more Eurasian water milfoil being found during the increased survey effort conducted in 2012.

Secondly, the climactic conditions of 2012 were conducive for Eurasian water milfoil growth state-wide, resulting in what some have managers have referred to as a "banner year" for Eurasian water milfoil. The early ice-out, coupled with above average warmth through a long summer provided optimal growing conditions for this invasive plant. Throughout the state of Wisconsin, lake staff and volunteers observed great Eurasian water milfoil growth. These occurrences were mapped in the Pike Chain of Lakes by Onterra staff in summer of 2012, resulting in a higher than anticipated treatment occurring in 2013.

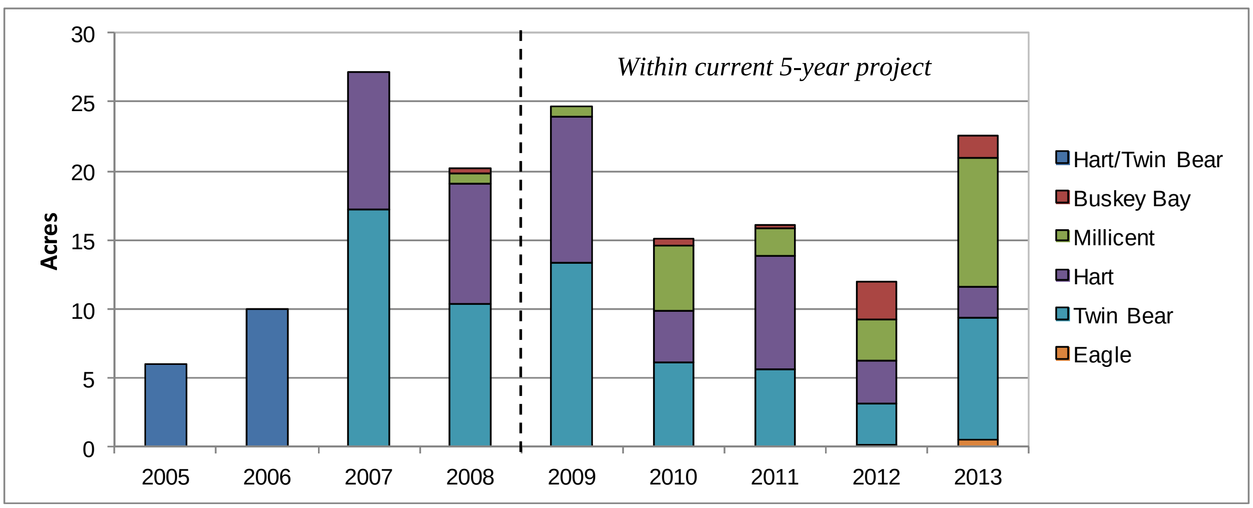


Figure 2.12. Pike Chain of Lakes annual Eurasian water milfoil treatment history, 2005-2013. Chart includes acreage of Eurasian water milfoil treated with 2,4-D during the discussed five-year project, and prior.

Along with the amount of acreage treated each year (Figure 2.12), lake managers investigate the spatially-specfic amount of acreage receiving treatment within a system. Over the course of the five year project, 59.4 surface acres of the Pike Chain of Lakes have been targeted for strategic control of Eurasian water milfoil through herbicide treatments. As shown on the pie chart within Figure 2.13, the vast majority of this footprint consists of acreage that was only treated once during this five year period. Acreage that was only treated once may be a result of an extremely effective treatment, where repeat treatments were not warranted. Or, in some instances, this acreage consists of areas treated for the first time during the last year of the project. Treatment acreage that was targeted for two or three years may be due to multiple treatments being required to bring the Eurasian water milfoil density below levels that warrant treatment. In some instances, this was the result of a successful treatment early in the project that had Eurasian water milfoil re-establish and require treatment later in the project. Treatment areas that were targeted for four or five years are areas where success criteria were not met. This concept will be discussed in more detail within the Individual Lake Sections.

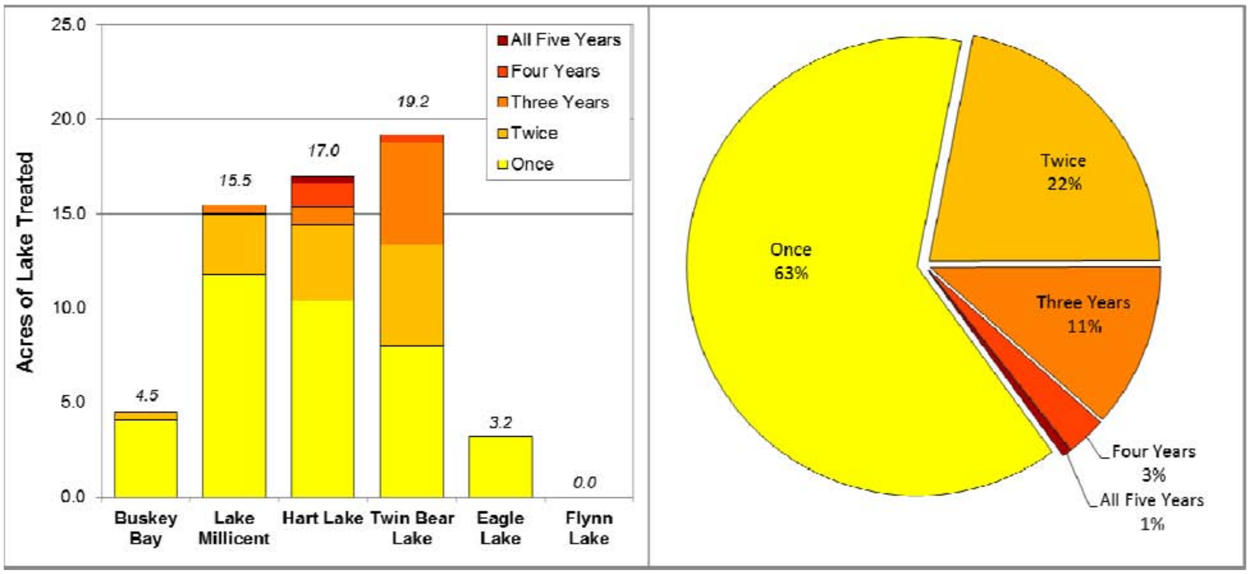


Figure 2.13. Surface acreage of Eurasian water milfoil treated on the Pike Chain of Lakes, 2009-2013.

Within the 2008 Management Plan, specific success criteria were outlined for the Eurasian water milfoil control program. These criteria were reviewed, and more stringent criteria applied to the control program through the February 2009 grant application. These criteria include annual treatment area based criteria as well as overall project evaluation criteria. As mentioned previously, quantitative assessments were typically unable to be analyzed properly due to the small treatment sizes that were commonly utilized within this control program. As a result, the quantitative aspect of annual treatment area criteria is unable to be evaluated.

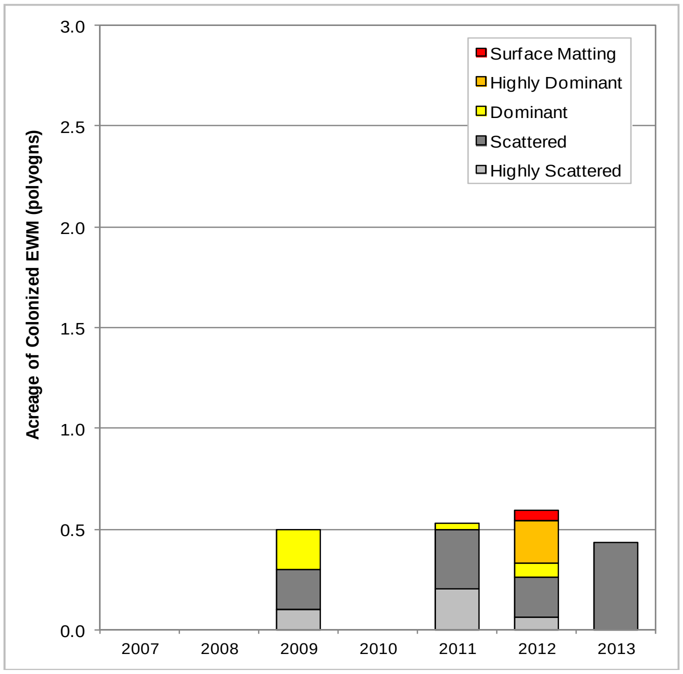


Figure 2.14. Pike Chain of Lakes Eurasian water milfoil acreage, 2007-2013.

Annual treatments were evaluated qualitatively in each annual treatment report. In all years 2009-2013, qualitative success was met, as determined by a reduction of at least one density rating within 75% of the treatment areas. That is, a treatment area with a density rating of *Highly Dominant* would be reduced to at least *Dominant*, *Scattered* to *Highly Scattered*, etc. A treatment area that included point-based data from a previous year's survey was determined to have been successful if the points were greatly reduced in their number or point-based density (*Small plant colony* to *Single or Few Plants*, etc.).

The IRPCLA has focused much effort on Eurasian water milfoil management since it was first learned the invasive plant had found its way into the Pike Chain of Lakes. In addition to monitoring and hand-pulling Eurasian water milfoil, IRPCLA President Al Bochler has taken a lead position in coordinating volunteers as well as documenting time spent on monitoring and hand-pulling activities. Table 2.-5 displays volunteer efforts completed during the course of this management project.

Table 2.5. Pike Chain of Lakes aquatic invasive species monitoring volunteer efforts, 2009-2013. Data provided by Al Bochler, IRPCLA.

Year	Hand-removal (hrs)	Volunteers	SCUBA (hrs)	Volunteers	Total Hours
2009	98	12	66.5	3	164.5
2010	77.5	12	95.5	4	173
2011	115	14	55.5	4	170.5
2012	155.5	14	52.5	2	208
2013	*Hours still being collected/tabulated as of November 2013*				-

Success Criteria Evaluation

The overall control program goal was to reduce Eurasian water milfoil colonies to the point where colonies would be present in colonies of *Scattered* or less. In 2013, approximately 0.43 acres of *Scattered* Eurasian water milfoil was mapped throughout the entire Pike Chain of Lakes, with no other polygon-based mapping warranted (Figure 2.14). This figure also shows that polygon-based mapping acreage was sustained to a minimum throughout the Pike Chain of Lakes Eurasian water milfoil control program. Quantitative criteria were set for each of the lakes in the Pike Chain based upon results from whole-lake point-intercept surveys conducted in 2005/2007 and 2013. Varying benchmarks were determined based upon the level of Eurasian water milfoil in each of the lakes in the Pike Chain. These benchmarks would be determined by the Eurasian water milfoil frequency of occurrence. Eurasian water milfoil success criteria and 2013 frequency of occurrence are displayed in Table 2.6.

Table 2.6. Pike Chain of Lakes Eurasian water milfoil control program success criteria and results. FOO refers to frequency of occurrence on a lake-wide basis, as determined through whole-lake point-intercept surveys.

Project Lake	Success criteria (2013 EWM FOO)	2013 EWM FOO	Success?
Buskey Bay	<1%	0.5	✓
Lake Millicent	<1%	0.5	✓
Hart Lake	<10%	0.9	✓
Twin Bear Lake	<10%	0.2	✓
Eagle Lake	<1%	0.0	✓
Flynn Lake	<1%	0.0	✓

The 2008 Management Plan projected Eurasian water milfoil treatments for the duration of the control project, from what was anticipated to be 2009-2012 (Table 2.7). An updated plan for 2013 was submitted with the 2009 control grant application.

Table 2.7. Pike Chain of Lakes estimated vs. actual treatment acreage, 2009-2013.

Project Year	Treatment Year	Estimated Treatment Acreage	Actual Acre Treated	Difference (acres)
2009	1	35.0	24.7	-10.3
2010	2	35.0	15.1	-19.9
2011	3	25.0	16.1	-8.9
2012	4	15.0	12.0	-3.0
2013	5	15.0	22.5	+7.5
Total		***125.0***	***90.4***	***-34.6***

Overall, the Pike Chain of Lakes Eurasian water milfoil control program has been largely successful. Annual density reductions within treatment areas have been achieved greater than 75%, colonies reduced to a density rating of *Scattered* or less and the Eurasian water milfoil frequency of occurrence criteria has been met for each lake at the culmination of this project. Furthermore, the treated acreage has been less than what was projected in this project. In short, all applicable success criteria have been met.

Purple Loosestrife

As discussed within the Introduction Section , an important part of the five-year aquatic invasive species control program has been integration of volunteers in management activities. Though the focus upon this report is on actions specific to Eurasian water milfoil, it should be noted that much time has been devoted by IRPCLA volunteers in management of purple loosestrife. These efforts include monitoring and flagging locations of purple loosestrife along the Pike Chain shorelands as well as appropriate actions for plant removal (hand-pulling, approved herbicide use and releasing *Galerucella* spp. beetles). Much assistance was given through WDNR staff, Bayfield County invasive species staff and Great Lakes Indian & Wildlife Commission (GLIFWC) staff.

3.0 SUMMARY & CONCLUSIONS

The 2008 Pike Chain of Lakes Management Plan contained specific goals with regards to how the Eurasian water milfoil would be managed within each lake of the Pike Chain of Lakes. At that point in time, Hart and Twin Bear Lakes had established populations of Eurasian water milfoil, which had been treated numerous times since 2005. Lake Millicent, Buskey Bay, and the channel leading to Eagle Lake held very limited levels of Eurasian water milfoil, while Eagle and Flynn Lakes were not known to contain the invasive plant. Therefore, different strategies were enacted based upon these circumstances. Twin Bear and Hart Lakes were managed to control further spread within the lakes themselves and to other lakes in the chain. Lake Millicent, Buskey Bay, and the Eagle Lake channel were managed aggressively with herbicides and hand-harvesting with the goal of eradicating the pioneer infestations.

The situation has changed since 2008, with all lakes but Flynn Lake now holding established populations of Eurasian water milfoil. This may be considered a failure, despite what has otherwise been a widely successful project. Though Eurasian water milfoil has its habitat preferences, the plant is opportunistic as well as adaptable, surviving in clear water/turbid water environments and in a variety of substrates. The reality of Eurasian water milfoil management is that currently, there is no known way to eradicate it from a lake ecosystem. As such, it was a matter of time before the plant established itself into the remaining lakes in the Pike Chain, with the exception of Flynn Lake. The IRPCLA is now facing the responsibility of managing five lakes with established populations of Eurasian water milfoil.

It is the intention of this report to stress several items. First, the native aquatic plant community of the Pike Chain of Lakes was determined to be of high quality in 2005/2007 and remains so in 2013. This has been exemplified through numerous parameters, including species richness and diversity, as well as the presence of high quality species that are commonly found in relatively undisturbed systems. Secondly, though Eurasian water milfoil has spread to new areas throughout the Pike Chain of Lakes between 2005 and 2013, the management strategies carried out by the IRPCLA has been successful in maintaining a low population of this invasive plant, which has not threatened the ecological condition or the recreational value of the chain.

It is now the responsibility of the IRPCLA to review the successes and failures learned through the past five years of management and examine the success criteria that were established for Eurasian water milfoil control five years ago. The IRPCLA plans to submit an AIS Established Population Control grant application in February of 2014 to partially fund further management actions. During the development of this application, it will be important for IRPCLA representatives, WDNR staff and professional consultants to weigh in on the specifics of further management, including new threshold criteria for hand-removal and herbicide treatments as well as plans for continued. Strategies and recommendations for future management are discussed below.

2014 Eurasian Water Milfoil Management Strategy

It is clear that although it has been difficult to prevent spreading Eurasian water milfoil within the Pike Chain of Lakes, achievements have been made in controlling the invasive plant to a manageable level. The IRPCLA needs to proceed with management of Eurasian water milfoil under a different set of circumstances now, compared to the situation in 2009. With this in mind, new thresholds need to be established for herbicide treatment actions as well as hand-harvesting.

Because Eurasian water milfoil is established within the majority of the chain, the necessity of aggressive management with the hopes of eradication is no longer warranted. In accepting this fact, the goal is to now prevent colonies from reaching densities and areal coverage that impairs recreational activities or worse, causes ecological harm to the lakes. This is opposed to the previously determined thresholds, in which areas of lightly dense Eurasian water milfoil was targeted in hopes that it could be knocked back before spreading elsewhere. Essentially, it is recommended that Eurasian water milfoil occurrences be targeted for herbicide treatment only when they reach a critical level that warrants treatment. In operating under these conditions, the IRPCLA will be able to experience cost savings through their management program by reducing the large number of small treatment areas that had been delineated in the past five years.

Strategy Outline

Reducing aggressiveness in Eurasian water milfoil control may be difficult mentally, as now a certain level of infestation will not be chemically controlled and must be tolerated or controlled by other means. The correct strategy, with well-defined thresholds for tolerance, must be identified in order to sustain these low levels of EWM. Therefore, the plan outlined below must be flexible in order for the PCLA to adapt to population fluctuations that may occur within the Pike Chain of Lakes. The threshold for herbicide treatment will be as follows:

1. Areas targeted for treatment will consist of Eurasian water milfoil in a scattered density or greater, mapped through polygon-based methodologies. It is believed that ecological impairment of a native aquatic plant community begins when and invasive reaches a dominant (roughly 50% aerial coverage) density. Therefore, this is a moderately aggressive threshold which should reduce colonies of Eurasian water milfoil from reaching excessive density.

2. Areas targeted for herbicide treatment will consist of at least 0.5 acres in size. Small treatment areas are often less successful due to rapid dissipation and dilution of the herbicide. In a larger treatment area, it is generally believed that the core of the location retains herbicide concentrations for a longer period of time, thus increasing herbicide effectiveness on the targeted plant community. The PCLA may elect to treat concerning Eurasian water milfoil colonies with treatment areas less than 0.5 acres in isolated, shallow areas of the chain where good success is anticipated based upon hydrologic and morphological features of the given area which provide for an effective dose of herbicide.

This strategy would result in about 9.3 acres to be targeted for treatment in 2014 (Map 1). As previously mentioned, it is vital that the PCLA be able to maintain a low level of Eurasian water milfoil in the Pike Chain of Lakes. Therefore, the aforementioned thresholds for herbicide treatment may be modified in the future. This "fine-tuning" of the strategy will ensure that adequate success and efficient allocation of resources is met.

Annual Success Criteria

A successful treatment (herbicide or hand-removal methods) on a given mapped colony would include a reduction of Eurasian water milfoil density as demonstrated by a decrease in one density rating on a 5-tiered density rating scale. In other words, *Dominant* colonies would be reduced to *Scattered*, *Scattered* to *Highly Scattered*, etc. In terms of a treatment as a whole (lake-wide and chain-wide), at least 75% of the acreage treated that year would decrease by one level of density for an individual site.

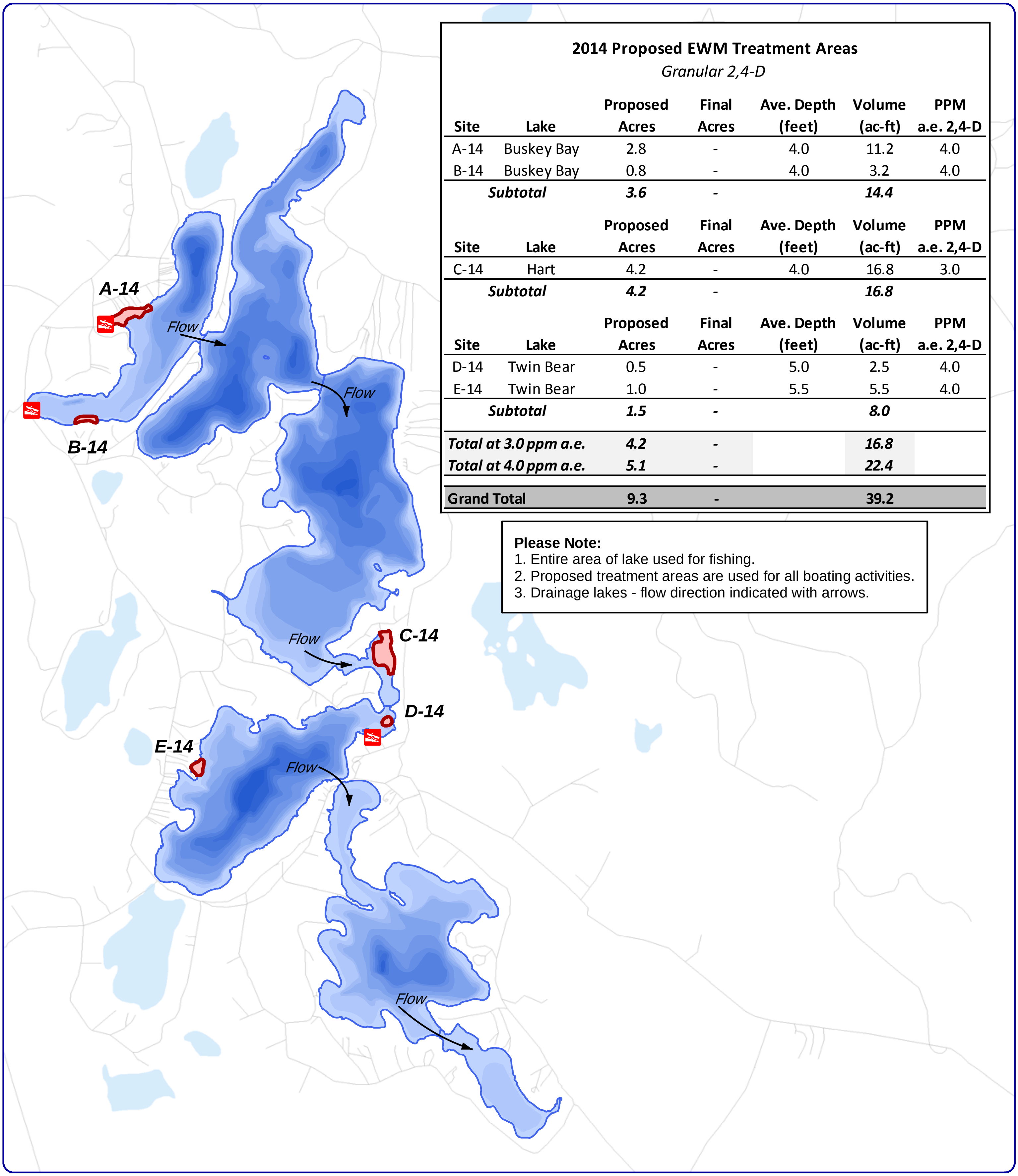
As mentioned within this report, quantitative monitoring was often impossible due to the small treatment areas that were targeted. Should adequately sized treatment areas be delineated (at least 10 acres) monitoring would include quantitative methods using a modified point-intercept methodology consistent with the Appendix D of the WDNR Guidance Document, *Aquatic Plant Management in Wisconsin* (WDNR 2010). In general, a sub-sample point-intercept grid would be placed over the larger treatment areas to yield approximately four points per acre. Success would be determined through a statistically significant result per a Chi-square distribution analysis.

Project Evaluation Criteria

Quantitative monitoring of the Pike Chain of Lakes would also occur on a lake-wide basis, with comprehensive whole-lake point-intercept surveys occurring at the end of a five year period (2018). Comparisons may be made between 2013 and 2018 datasets, and success criteria evaluated based upon five year of Eurasian water milfoil control. By the end of this five year period, it would be expected that Eurasian water milfoil will be present in the Pike Chain of Lakes in a low abundance, yet likely slightly greater than what it was found to be in 2013. Qualitatively, all Eurasian water milfoil locations in the Pike Chain of Lakes would have a scattered or lighter occurrence in 2018. Quantitatively, success of the project for the Pike Chain of Lakes would be indicated by Eurasian water milfoil frequency being observed at 2% or less of the littoral point-intercept locations within a whole-lake survey. This benchmark would be held for Buskey Bay, Millicent, Hart, Twin Bear and Eagle Lakes. At this time, it is not believed that Flynn Lake holds Eurasian water milfoil. Should Eurasian water milfoil be introduced to Flynn Lake, aggressive actions may be warranted to reduce the population as much as realistically possible. If an introduction occurs, it is expected that this population will be held at 1% frequency of occurrence or less in 2018.

Concluding Notes

The IRPCLA has led an aggressive and arguably quite successful campaign against Eurasian water milfoil. Even though monitoring of herbicide treatments has demonstrated that the native plant community on the Pike Chain of Lakes has not been compromised in terms of its quality, the IRPCLA should continue to conduct herbicide treatments in a manner that minimizes the risk to these species. Moving forward, treatments should be conducted prior to water temperatures reaching 60-65°F as to minimize exposure of herbicide to native plants that begin actively growing during this time. Pre and post treatment monitoring will also be an important aspect of determining not only success/failure in a Eurasian water milfoil treatment program, but also documenting the health of native plant communities during management actions.



2014 Proposed EWM Treatment Areas

Granular 2,4-D

Site	Lake	Proposed Acres	Final Acres	Ave. Depth (feet)	Volume (ac-ft)	PPM a.e. 2,4-D
A-14	Buskey Bay	2.8	-	4.0	11.2	4.0
B-14	Buskey Bay	0.8	-	4.0	3.2	4.0
	Subtotal	***3.6***	**-**		***14.4***	
Site	**Lake**	**Proposed Acres**	**Final Acres**	**Ave. Depth (feet)**	**Volume (ac-ft)**	**PPM a.e. 2,4-D**
C-14	Hart	4.2	-	4.0	16.8	3.0
	Subtotal	***4.2***	**-**		***16.8***	
Site	**Lake**	**Proposed Acres**	**Final Acres**	**Ave. Depth (feet)**	**Volume (ac-ft)**	**PPM a.e. 2,4-D**
D-14	Twin Bear	0.5	-	5.0	2.5	4.0
E-14	Twin Bear	1.0	-	5.5	5.5	4.0
	Subtotal	***1.5***	**-**		***8.0***	
Total at 3.0 ppm a.e.		***4.2***	**-**		***16.8***	
Total at 4.0 ppm a.e.		***5.1***	**-**		***22.4***	
Grand Total		**9.3**	**-**		**39.2**	

Please Note:
1. Entire area of lake used for fishing.
2. Proposed treatment areas are used for all boating activities.
3. Drainage lakes - flow direction indicated with arrows.

N W E S

2,250

Feet

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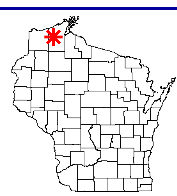
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, 2013
Map Date: January 8, 2014
File Name: PkChn_T2014_EWM_Cond1.mxd



Project Location in Wisconsin

Legend

Public Access

2014 Proposed Treatment Area

Map 1

Pike Chain of Lakes

Bayfield County, Wisconsin

2014 Preliminary EWM Control Strategy

4.0 INDIVIDUAL LAKE SECTIONS

4.1 Buskey Bay

Buskey Bay spans roughly 100 acres in area, and serves as the uppermost lake in the Pike Chain of Lakes. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 6, 2013 (Figure 4.1-1). During this survey, a total of 48 aquatic plant species were located, two of which are considered to be a non-native, invasive species: Eurasian water milfoil and purple loosestrife (Table 4.1-1). Of the 46 native species that were encountered, 34 of these were sampled during the point-intercept survey and 12 were found incidentally during studies on the lake. Comparatively, 39 species were found during the point-intercept survey in 2007 with 9 being found incidentally that year.

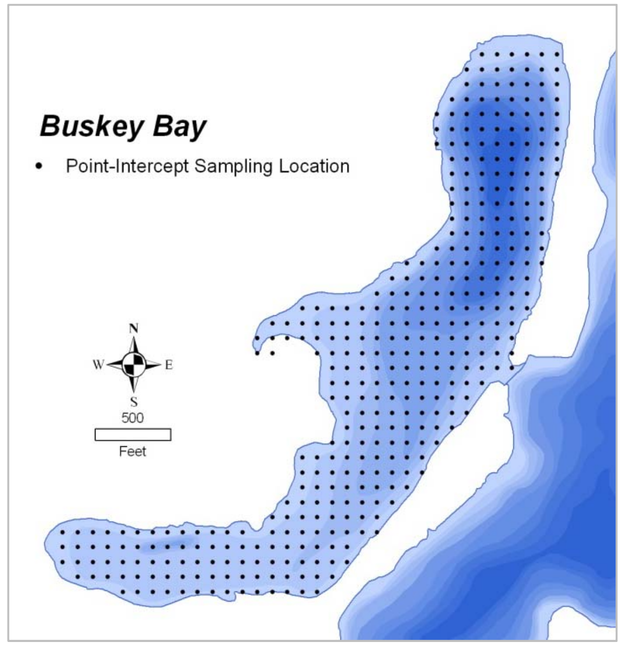


Figure 4.1-1. Point-intercept locations on Buskey Bay.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. As a result of this survey, it was determined that 78% of the point-intercept locations within littoral areas contained fine, organic sediments (muck), 21% contained sand, and 1% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing to a maximum depth of 32 feet, which is similar to the 30 foot maximum depth determined through the 2007 survey. The water within the Pike Chain of Lakes is exceptionally clear, which allows the sun's rays to penetrate deep into the water column and allow plants to photosynthesize at great depths. Light availability is often considered the most important factor that regulates abundance and distribution of aquatic plants in freshwater lakes. However, in some lake ecosystems other factors such as atmospheric pressure (Hutchinson 1975) or substrate characteristics (Bachmann et al. 2001) influence plant distribution greatly.

Of the 330 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2013, approximately 82% contained aquatic vegetation. This is slightly lower than what was found in the 2007 survey where approximately 90% of 292 sampling locations contained aquatic vegetation. Buskey Bay Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.1-1. Aquatic plant species located in Buskey Bay during 2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2007 (Onterra)	2013 (Onterra)
Emergent	*Calla palustris*	Water arum	9		I
	Carex comosa	Bristly sedge	5	I	
	Carex pseudocyperus	Cypress-like sedge	8		I
	Carex sp. (sterile)	Sedge sp. (sterile)	N/A	I	I
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis palustris	Creeping spikerush	6	X	I
	Equisetum fluviatile	Water horsetail	7	I	I
	Iris versicolor	Northern blue flag	5	I	I
	Juncus effusus	Soft rush	4	I	
	Lythrum salicaria	Purple loosestrife	Exotic		I
	Pontederia cordata	Pickerelweed	9	I	
	Sagittaria latifolia	Common arrowhead	3	I	I
	Schoenoplectus acutus	Hardstem bulrush	5	I	I
	Schoenoplectus pungens	Three-square rush	5	X	
	Schoenoplectus tabernaemontani	Softstem bulrush	4		I
	Scirpus cyperinus	Wool grass	4		I
	Typha spp.	Cattail spp.	1	X	I
FL	*Brasenia schreberi*	Watershield	7	X	I
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
	Persicaria amphibia	Water smartweed	5	X	X
FL/E	*Sparganium americanum*	Eastern bur-reed	8	X	X
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10	X	
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic		X
	Myriophyllum verticillatum	Whorled water milfoil	8		X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8		X
	Potamogeton foliosus	Leafy pondweed	6	X	X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton illinoensis	Illinois pondweed	6	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	X
	Stuckenia pectinata	Sago pondweed	3	X	X
	Utricularia gibba	Creeping bladderwort	9	X	X
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5		X
	Juncus pelocarpus	Brown-fruited rush	8	X	
	Sagittaria cristata (rosette)	Crested arrowhead (rosette)	9	X	
	Schoenoplectus subterminalis	Water bulrush	9	X	
FF	*Lemna minor*	Lesser duckweed	5	X	
	Lemna trisulca	Forked duckweed	6	X	X
	Riccia fluitans	Slender riccia	7		X
	Spirodela polyrhiza	Greater duckweed	5	X	

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

Table 4.1-1 displays the aquatic plant species located in Buskey Bay during the 2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2007. Additionally, there were species found in 2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Buskey Bay's aquatic plant frequency of occurrence is presented later on within this section.

Of the 34 aquatic plant species sampled during the 2013 point-intercept survey, common waterweed, coontail and fern pondweed were the three most frequently encountered (Figure 4.1-2). Able to obtain the majority of their essential nutrients directly from the water, common waterweed and coontail do not produce extensive root systems, making them susceptible to uprooting by water-action and water movement. Fern pondweed is a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. These three species are widely distributed throughout Wisconsin lakes, as well as many other regions of North America.

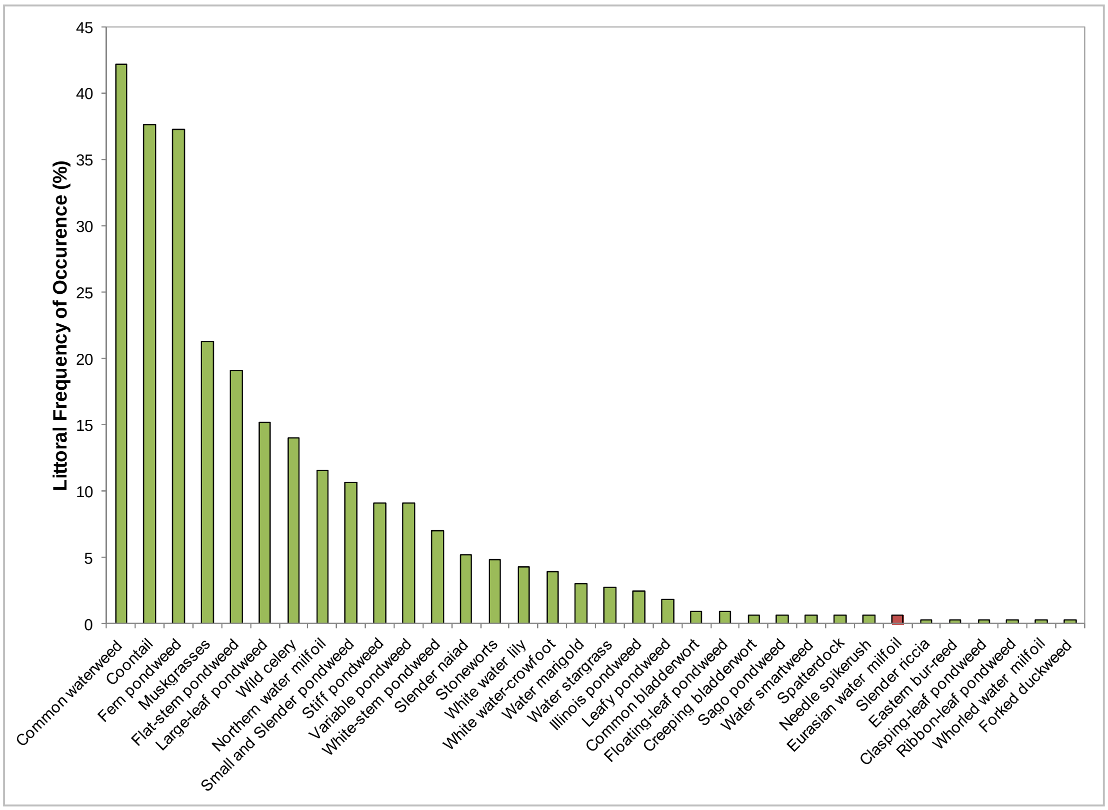


Figure 4.1-2. Buskey Bay aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Buskey Bay contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While Figure 4.1-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.1-3 displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas common waterweed has a 42% frequency of occurrence, it has a relative occurrence of 16% when compared to the other plant species. This means that if 100 aquatic plants were randomly sampled from Buskey Bay, it would be expected that 16 of them would be common waterweed. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Buskey Bay is not overly dominated by a single or few species.

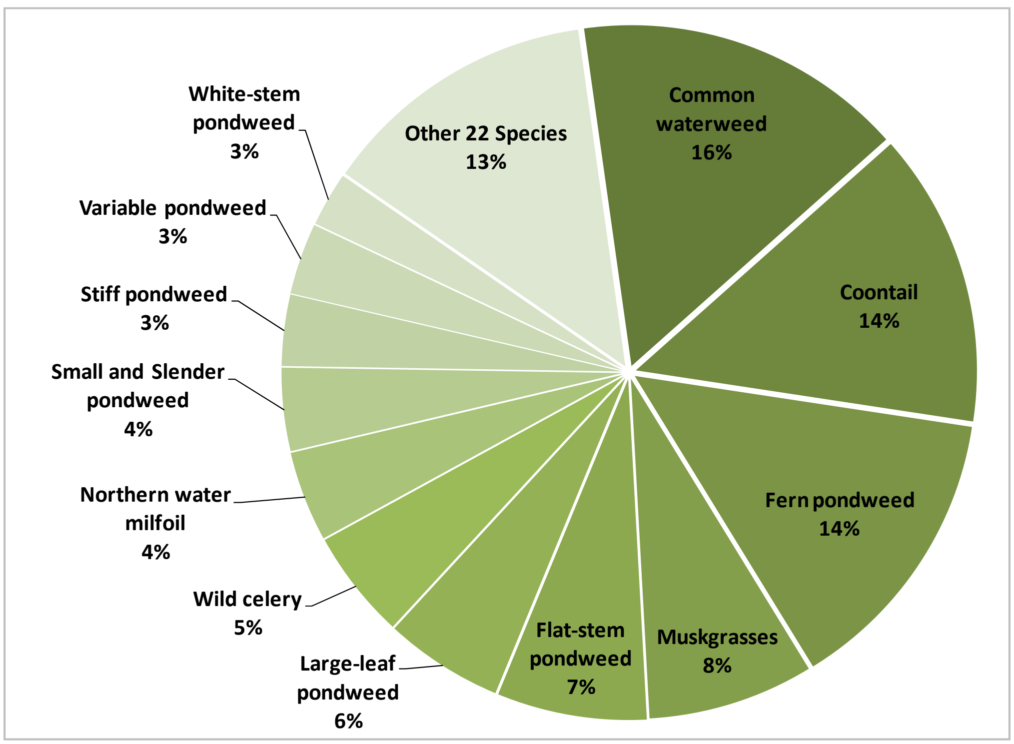


Figure 4.1-3. Buskey Bay aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Buskey Bay's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.1-4). Using the data collected from the 2007 and 2013 point-intercept survey, Buskey Bay's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.91 in 2013, falling above the upper quartile value for lakes in both the ecoregion and the state. Buskey Bay's 2013 diversity value is very similar to the diversity calculated from data collected during the 2007 point-intercept survey (0.91).

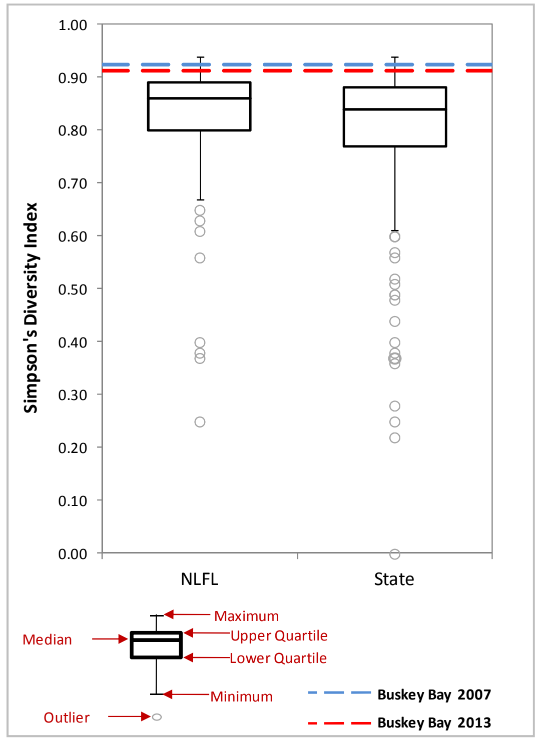


Figure 4.1-4. Buskey Bay species diversity index. Created using data from 2007 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 46 native aquatic plant species were located in Buskey Bay during the 2013 survey, 34 were sampled directly and 12 were incidentally located. These 34 native species and their conservatism values were used to calculate the FQI of Buskey Bay's aquatic plant community in 2013.

Figure 4.1-5 compares the FQI components of Buskey Bay from the 2007 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2013, Buskey Bay's native species richness (34) is much higher than the median values for lakes within the ecoregion and the state. The average conservatism value in 2013 (6.4) exceeds the state medians but, as it did in 2007, falls slightly under the ecoregion value. Combining Buskey Bay's 2013 native species richness and average conservatism values yields a FQI value of 37.6, which greatly exceeds the ecoregion and state median values.

While it appears as though species richness and the overall floristic quality have dropped from 2007 to 2013, there are several caveats to these data. First, more species were identified incidentally in 2013 than in 2007 (12 native species in 2013 vs. 8 in 2007). Many of these species are emergent or floating-leaf species, which as previously discussed are not always quantified well using the point-intercept methodology. If these species had been sampled directly during the 2013 point-intercept surveys, they would be included in the analysis described above and would result in a higher species richness and Floristic Quality score for 2013. Overall, this analysis indicates that Buskey Bay's aquatic plant community is of higher quality than the majority of lakes within the ecoregion and the entire state, as determined through 2007 and 2013 comprehensive plant surveys.

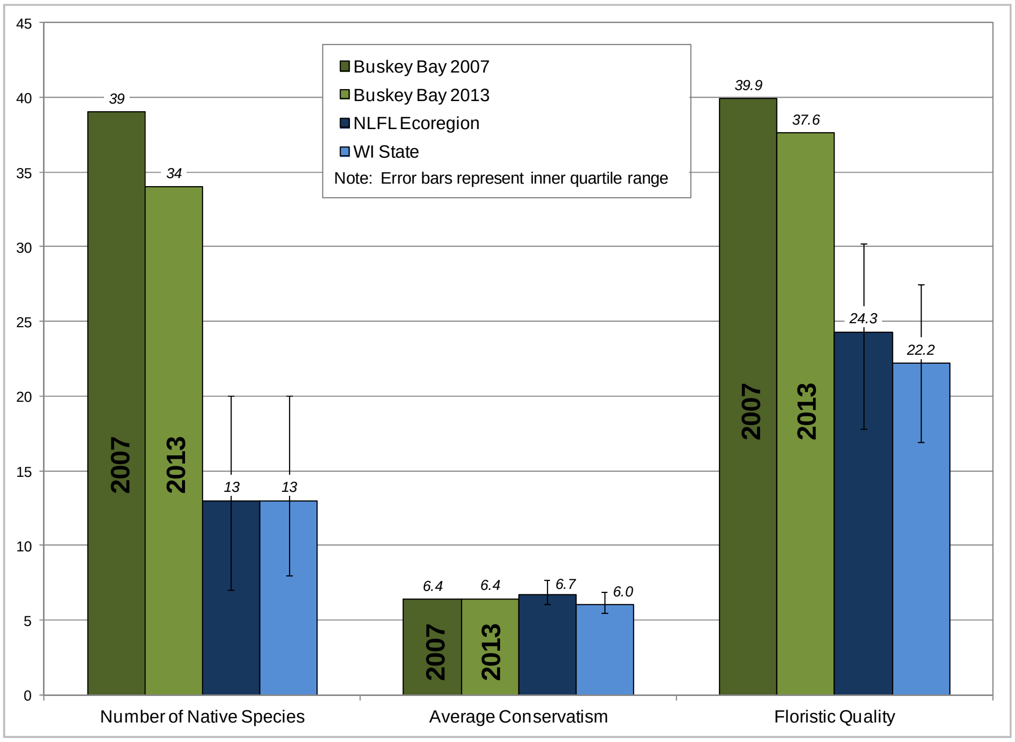


Figure 4.1-5. Buskey Bay Floristic Quality Index values. Created using data from 2007 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

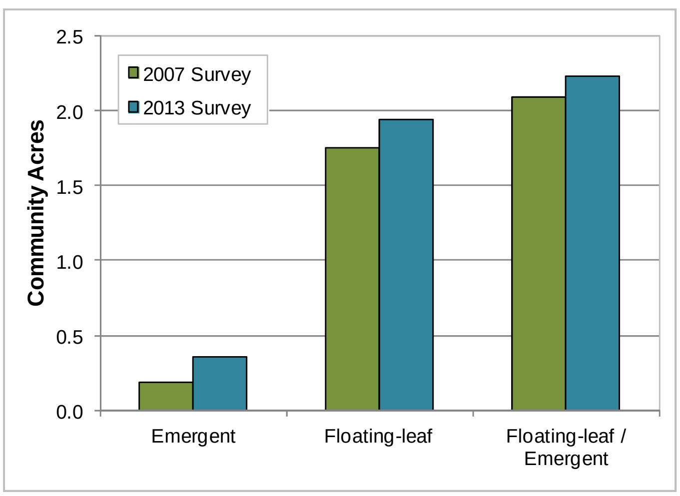


Figure 4.1-6. Buskey Bay community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Buskey Bay to map emergent and floating-leaf communities. As Figure 4.1-6 illustrates, the spatial coverage of these species remained similar from 2007 to 2013, with slight increases in acreage for emergent communities, floating-leaf communities and floating-leaf/emergent communities. Overall, total acreage of these communities increased from 4.0 acres in 2007 to 4.5 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Buskey Bay, an analysis between 2007 and 2013 datasets is presented below. A Chi-square distribution analysis (α = 0.05) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence during the point-intercept survey as the primary indicator. Figure 4.1-7 displays the littoral occurrences of Eurasian water milfoil and native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that have occurred in Buskey Bay.

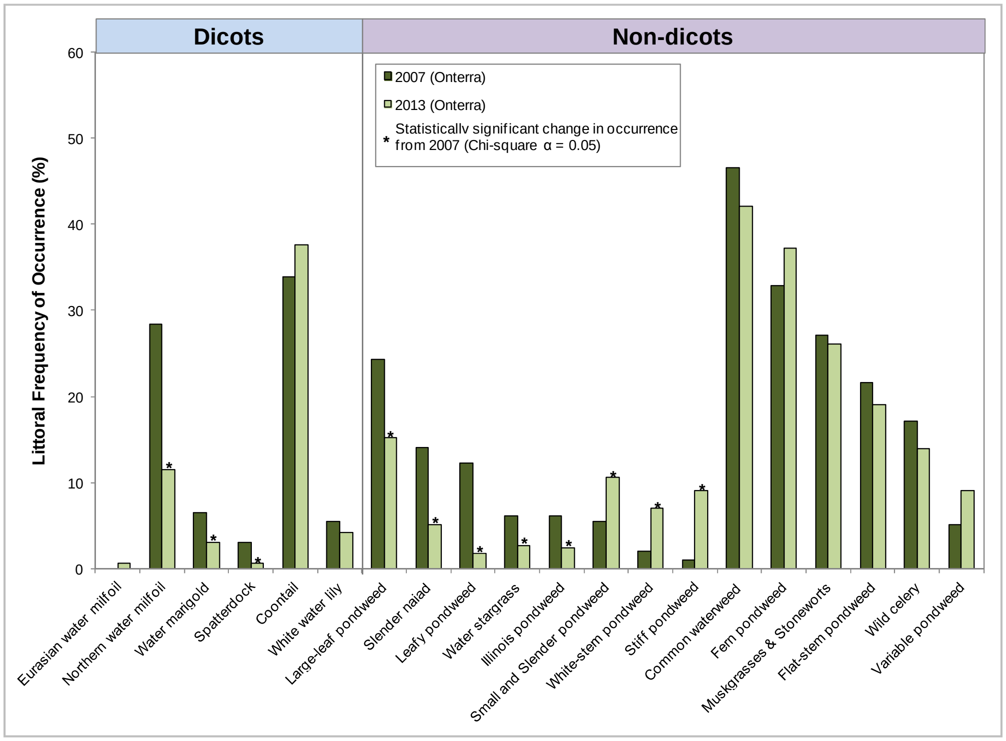


Figure 4.1-7. Buskey Bay littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2007 and 2013 point-intercept surveys.

As illustrated, the occurrence of Eurasian water milfoil in Buskey Bay was found to be not significantly different from 2007 to 2013. Though it was not believed to be in the lake in 2007 and was observed on two sampling points in 2013, this "increase" in occurrence is not beyond happening by chance alone (not statistically significant). From the annual Eurasian water milfoil mapping surveys, it is clear that Eurasian water milfoil did increase within Buskey Bay since 2007 in terms of both its distribution and biomass (Figure 4.1-8). It is believed however that the herbicide treatments have been effective at maintaining a low population of Eurasian water milfoil in the lake, keeping relatively large colonies from forming but unfortunately not preventing spread of the aggressive plant to other areas of the waterbody.

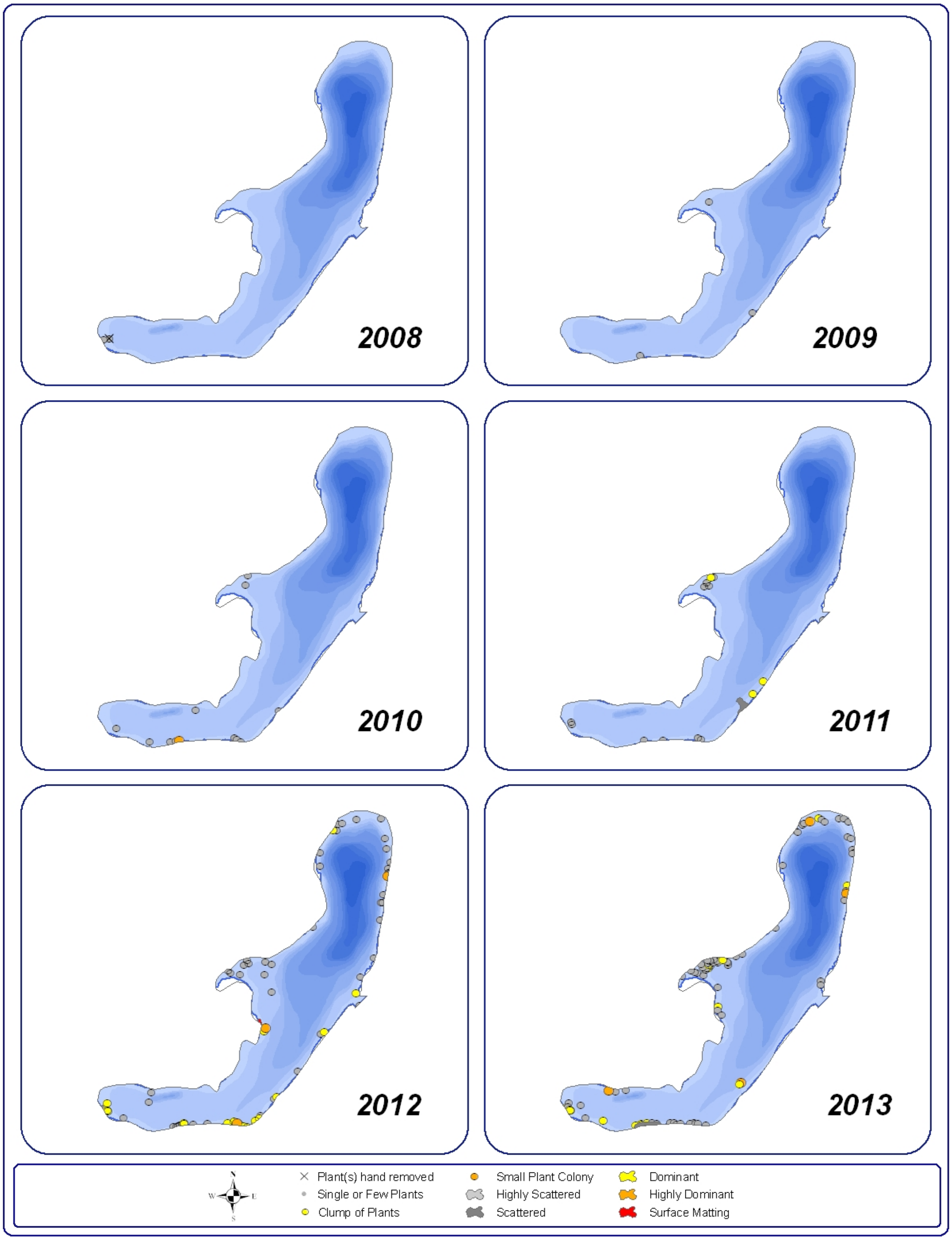


Figure 4.1-8. Buskey Bay Eurasian water milfoil peak-biomass mapping results, 2008-2013. Maps indicate qualitative mapping survey results, conducted in late summer of each respective year.

Three of the native aquatic plant species that had an occurrence of at least 5% in 2007 or 2013 saw statistically significant increases in their littoral occurrence, while nine native species saw a statistically significant change as a decrease of their frequency of occurrence. Though it is important to examine changes in the aquatic plant community, it is also important to review the scale of these changes, most of which were extremely small in magnitude.

As shown in Figure 4.1-9, 4.5 acres of Buskey Bay have been targeted for Eurasian water milfoil control during the five year project, with only 0.5 acres (10%) being treated more than once. This 4.5 acres represents approximately 6.6% of Buskey Bay's littoral zone (>20 ft). Though it is possible that these treatments could have contributed towards observed declines in some native species, it is unlikely given the small scale of the treatments that have occurred in Buskey Bay over the course of the Eurasian water milfoil control project.

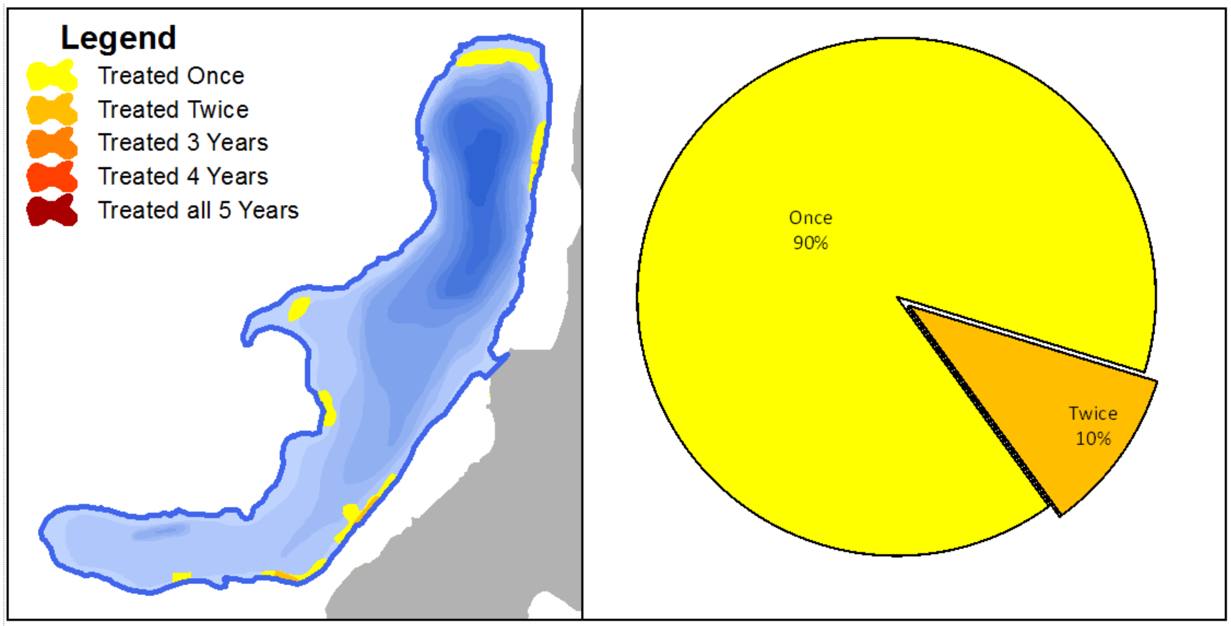
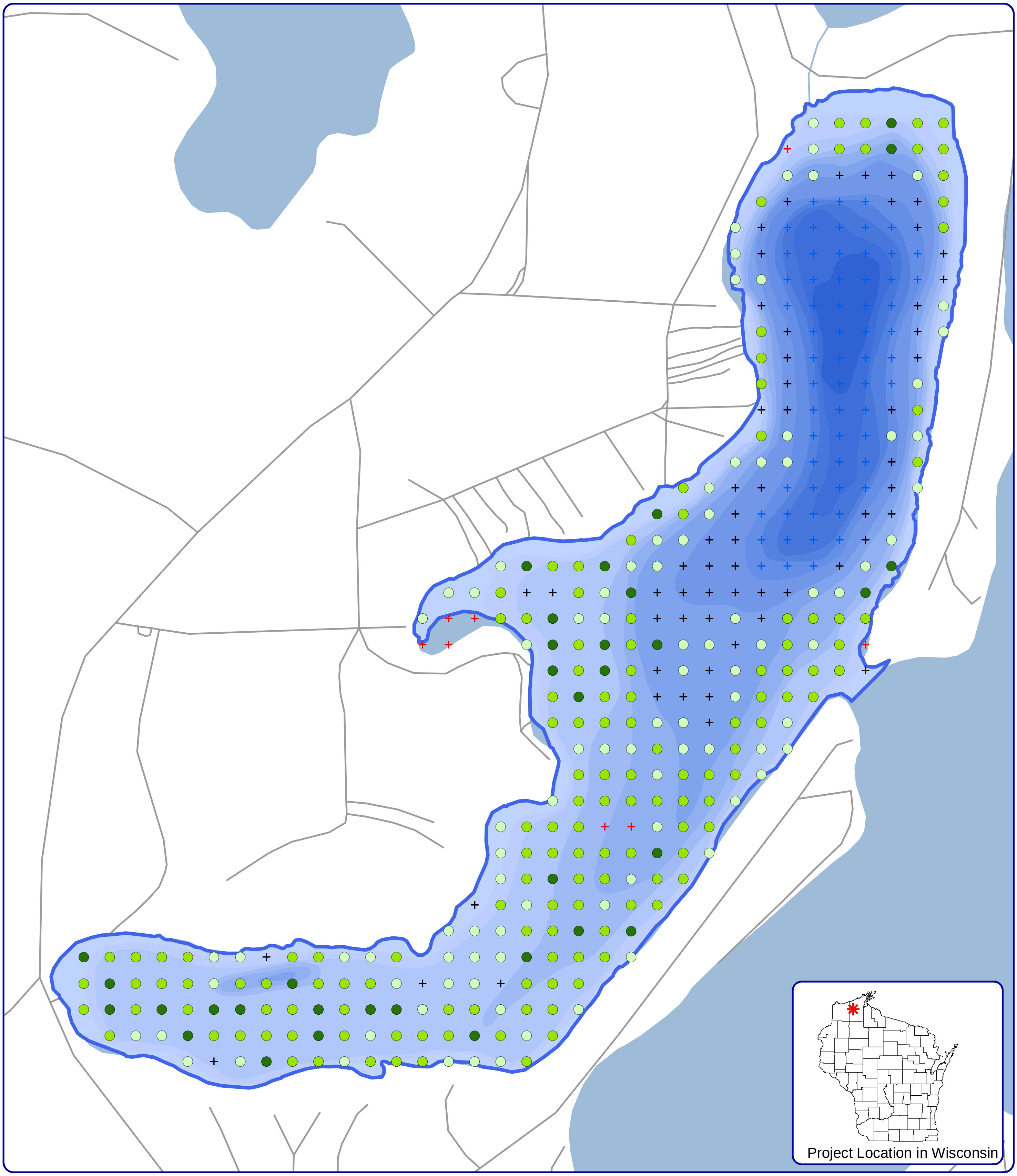


Figure 4.1-9. Surface acreage of Eurasian water milfoil treated on Buskey Bay, 2009-2013.

Overall, the 2013 point-intercept survey on Buskey Bay indicated that the native aquatic plant community of the lake has remained relatively unchanged over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have shifted only slightly between 2007 and 2013, likely from the circumstances. Furthermore, though some decreases in species abundance have been documented, increases in similar (dicot/monocot) similar species have occurred alongside this, indicating that environmental fluctuations in plant populations could be the cause of this observation.



Legend

2013 Total Rake Fullness

- No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- Too Deep
- Non-navigable/Temporary Obstacle

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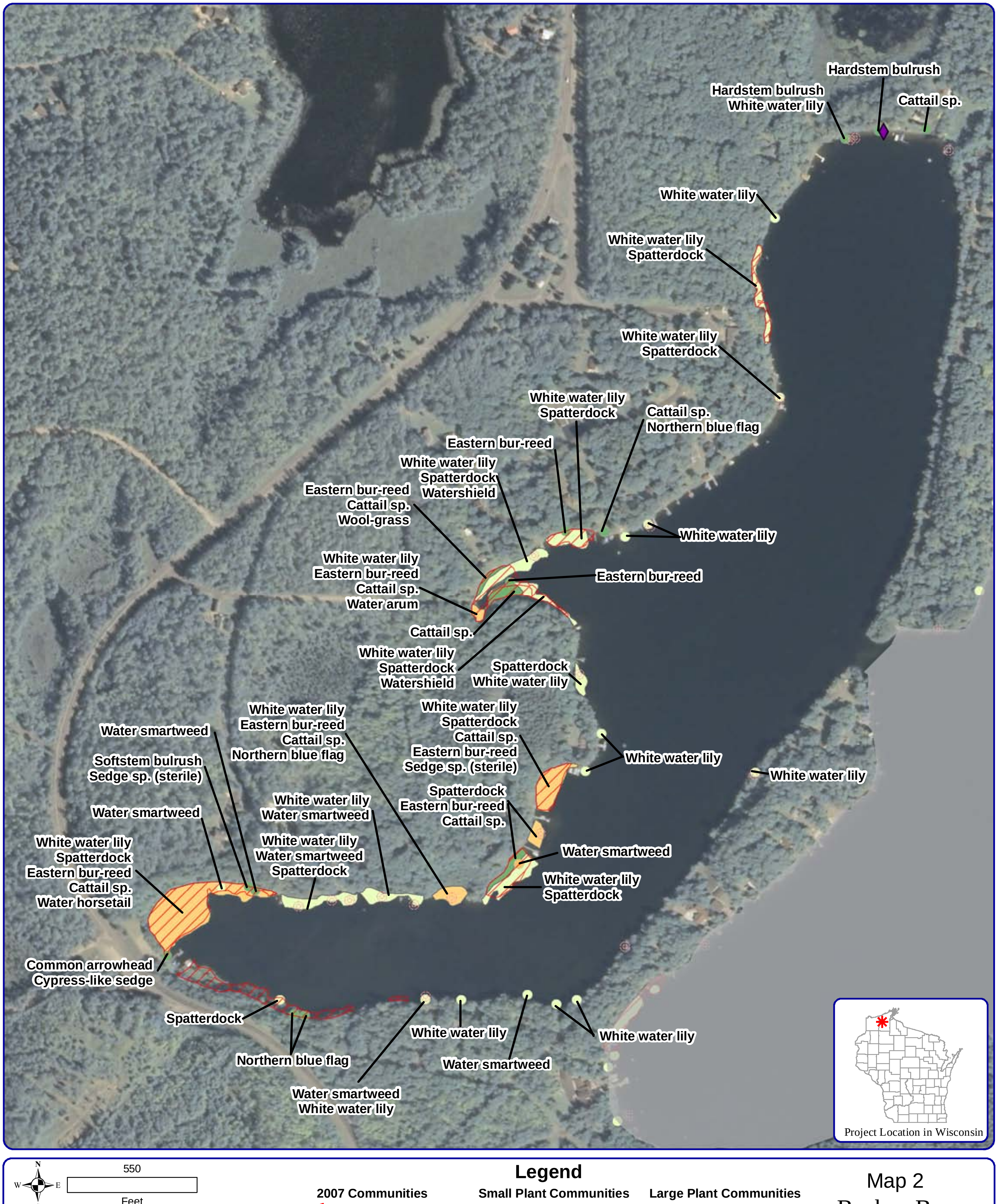
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_BuskeyBay_2013TRFPI.mxd

Map 1
Buskey Bay
Bayfield County, Wisconsin
2013 PI Survey: Aquatic Vegetation Distribution



Legend

2007 Communities
- Large Plant Community
- Small Plant Community

Exotic Communities
- Purple Loosestrife

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

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Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: October 31, 2013
Filename: *BuskeyBay_Comm_2013.mxd*

Map 2
Buskey Bay
Bayfield County, Wisconsin

Aquatic Plant Communities

4.2 Lake Millicent

Lake Millicent is 183 acres in size, and is located towards the headwaters of the Pike Chain of Lakes. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 8, 2013 (Figure 4.2-1). During this survey, a total of 42 aquatic plant species were located, two of which are considered to be a non-native, invasive species: Eurasian water milfoil and purple loosestrife (Table 4.2-1). Of the 40 native species that were encountered, 32 of these were sampled during the point-intercept survey and eight were found incidentally during studies on the lake. Comparatively, 32 species were found during the point-intercept survey in 2007 with seven being found incidentally that year.

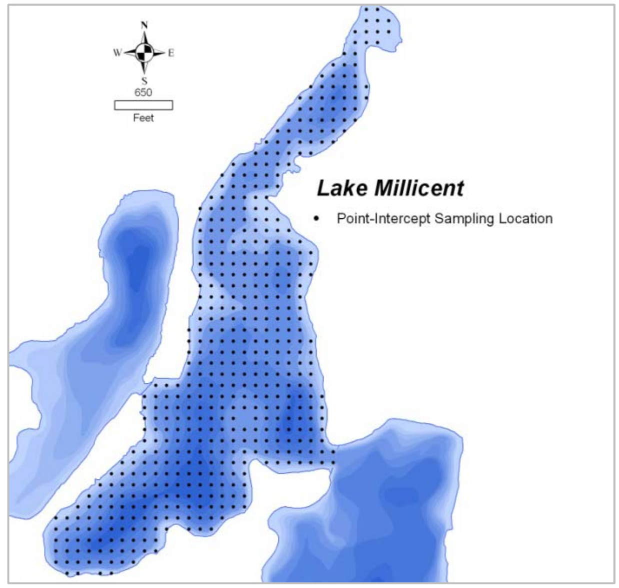


Figure 4.2-1. Point-intercept locations on Lake Millicent.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. As a result of this survey, it was determined that 78% of the point-intercept locations within littoral areas contained sand, 17% consisted of fine, organic sediments (muck), and 5% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing to a maximum depth of 26 feet, which is similar to the 27 foot maximum depth determined through the 2007 survey. The water within the Pike Chain of Lakes is exceptionally clear, which allows the sun’s rays to penetrate deep into the water column and allow plants to photosynthesize at great depths. Light availability is often considered the most important factor that regulates abundance and distribution of aquatic plants in freshwater lakes. However, in some lake ecosystems other factors such as atmospheric pressure (Hutchinson 1975) or substrate characteristics (Bachmann et al. 2001) influence plant distribution greatly.

Of the 221 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2013, approximately 66% contained aquatic vegetation. This is slightly lower than what was found in the 2007 survey where approximately 77% of 171 sampling locations contained aquatic vegetation. Lake Millicent Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.2-1. Aquatic plant species located in Lake Millicent during 2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2007 (Onterra)	2013 (Onterra)
Emergent	*Carex pellita*	Broad-leaved woolly sedge	4		I
	Carex pseudocyperus	Cypress-like sedge	8		I
	Carex sp. (sterile)	Sedge sp. (sterile)	N/A		I
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis palustris	Creeping spikerush	6	I	
	Equisetum fluviatlie	Water horsetail	7	I	
	Iris versicolor	Northern blue flag	5	I	
	Lythrum salicaria	Purple loosestrife	Exotic	I	I
	Pontederia cordata	Pickerelweed	9	I	
	Sagittaria sp. (sterile)	Arrowhead sp. (sterile)	N/A		I
	Schoenoplectus acutus	Hardstem bulrush	5	I	X
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	
	Typha spp.	Cattail spp.	1	I	I
FL	*Brasenia schreberi*	Watershield	7	X	X
	Nuphar variegata	Spatterdock	6	X	I
	Nymphaea odorata	White water lily	6	X	X
	Persicaria amphibia	Water smartweed	5		I
FL/E	*Sparganium americanum*	Eastern bur-reed	8	X	I
	Sparganium eurycarpum	Common bur-reed	5	I	
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10	X	
	Chara spp.	Muskgrasses	7		X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	I	X
	Myriophyllum tenellum	Dwarf water milfoil	10	X	X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8		X
	Potamogeton foliosus	Leafy pondweed	6	X	
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton illinoensis	Illinois pondweed	6	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	X
	Ranunculus flammula	Creeping spearwort	9	X	X
	Utricularia gibba	Creeping bladderwort	9	X	X
	Utricularia intermedia	Flat-leaf bladderwort	9		X
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	I	X
	Juncus pelocarpus	Brown-fruited rush	8	X	X
	Sagittaria graminea	Grass-leaved arrowhead	9	I	
	Schoenoplectus subterminalis	Water bulrush	9	X	X
FF	*Lemna minor*	Lesser duckweed	5	I	
	Spirodel polyrhiza	Greater duckweed	5	I	

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

Table 4.2-1 displays the aquatic plant species located in Lake Millicent during the 2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2007. Additionally, there were species found in 2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Lake Millicent's aquatic plant frequency of occurrence is presented later on within this section.

Of the 32 native and one non-native aquatic plant species sampled during the 2013 point-intercept survey, variable pondweed, muskgrasses and common waterweed were the three most frequently encountered (Figure 4.2-2). Variable pondweed is a submersed plant that produces a thin, cylindrical stem that has numerous branches. This plant can appear quite variable in size and shape and is named appropriately. The term muskgrasses describes a grouping of macroalgae consisting of *nitella* and *chara*. Nitella species, or stoneworts as they may be called, have whorls of forked branches that are attached to the "stems" of the plant, which are long, slender, smooth-textured algae. Because they lack roots, stoneworts remove nutrients directly from the water. Chara, the other grouping within the class muskgrasses, is also a macroalgae with stems, whorls of forked branches and no true roots. Chara is often encrusted by calcium carbonate, giving it a harsh, crusty feel. Common waterweed, arguably one of the most common aquatic plants in Wisconsin, is able to obtain the majority of its essential nutrients directly from the water. The plant does not produce extensive root systems, making it susceptible to uprooting by water-action and water movement.

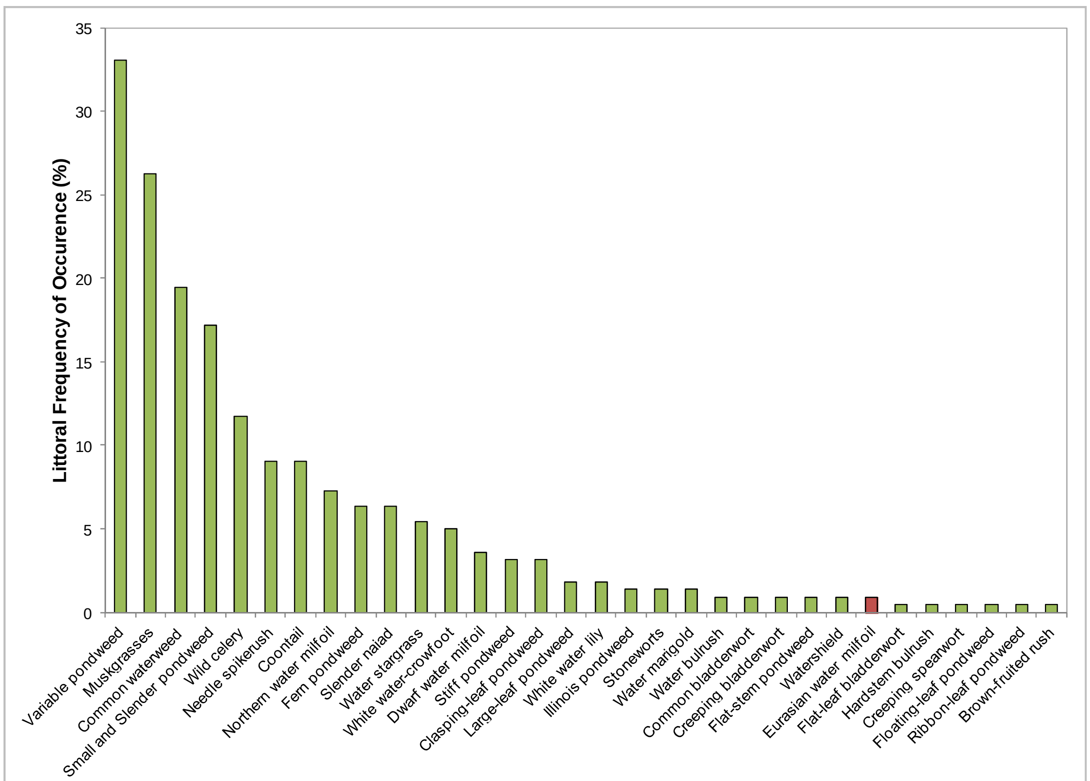


Figure 4.2-2. Lake Millicent aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Lake Millicent contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While Figure 4.2-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.2-3 displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas variable pondweed has a 33% frequency of occurrence, it has a relative occurrence of 18% when compared to the other plant species. This means that if 100 aquatic plants were randomly sampled from Lake Millicent, it would be expected that 18 of them would be variable pondweed. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Lake Millicent is not overly dominated by a single or few species.

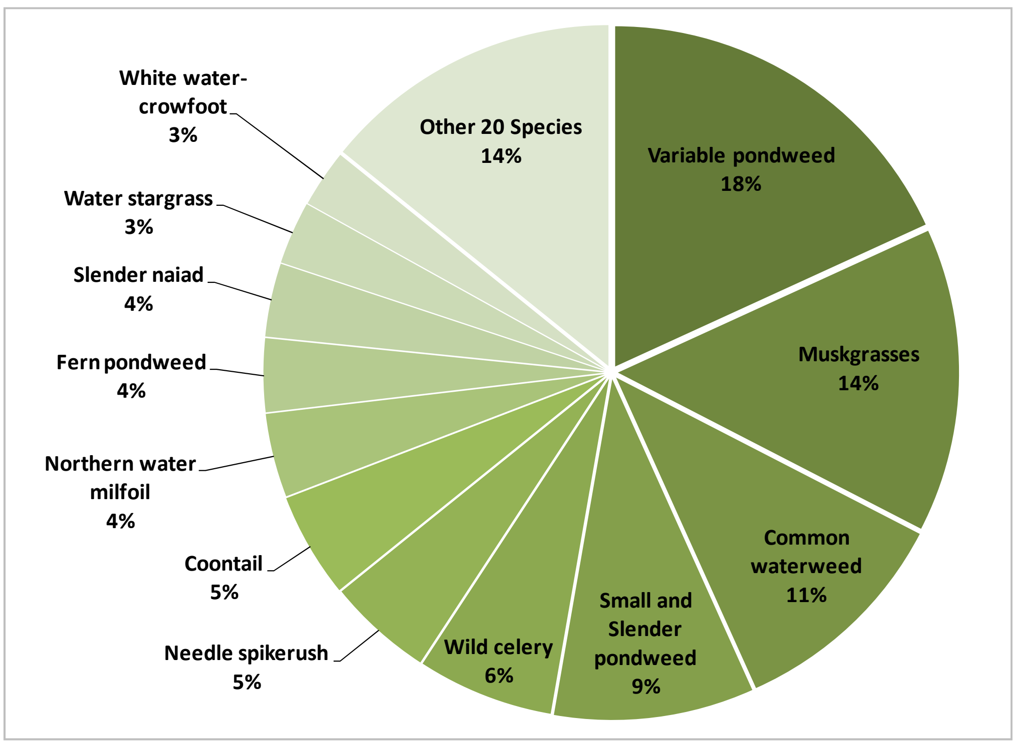


Figure 4.2-3. Lake Millicent aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Lake Millicent's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.2-4). Using the data collected from the 2007 and 2013 point-intercept survey, Lake Millicent's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.91 in both 2007 and 2013, falling above the upper quartile value for lakes in both the ecoregion and the state.

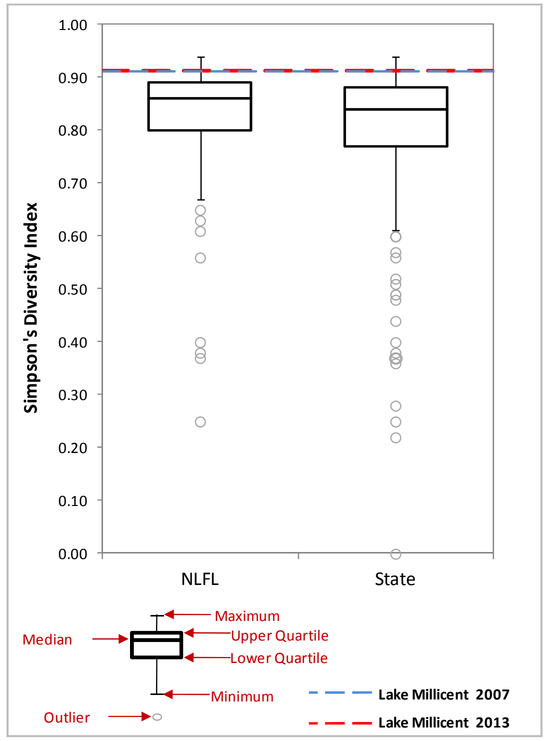


Figure 4.2-4. Lake Millicent species diversity index. Created using data from 2007 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 40 native aquatic plant species were found in Lake Millicent during the 2013 survey, 32 were sampled directly and eight were incidentally located. These 32 native species and their conservatism values were used to calculate the FQI of Lake Millicent's aquatic plant community in 2013.

Figure 4.2-5 compares the FQI components of Lake Millicent from the 2007 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2007 as well as 2013, Lake Millicent's native species richness (32) is much higher than the median values for lakes within the ecoregion and the state. The average conservatism values in 2007 (6.9) and 2013 (6.8) exceed the state medians as well as the ecoregion value. Combining Lake Millicent's native species richness and average conservatism values yields a FQI value of 38.9 for the 2007 dataset, and 38.7 in the 2013 dataset, both of which greatly exceeds the ecoregion and state median values. Further, these data indicate that the aquatic plant community of Lake Millicent has held its richness, diversity and overall quality during this five-year management project.

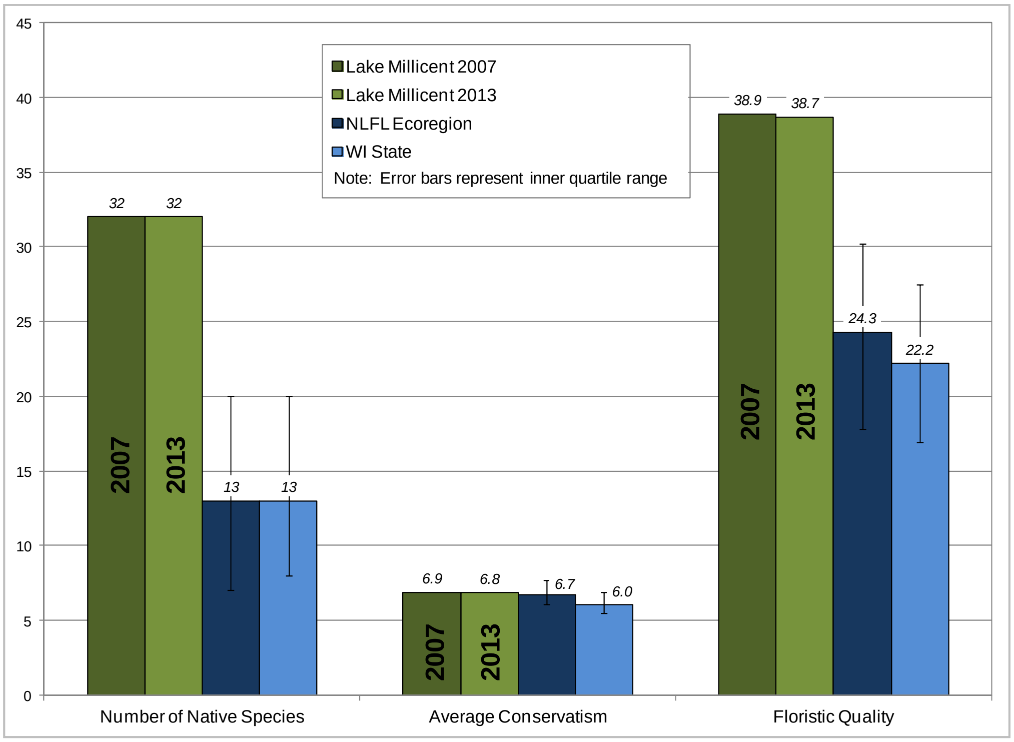


Figure 4.2-5. Lake Millicent Floristic Quality Index values. Created using data from 2007 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

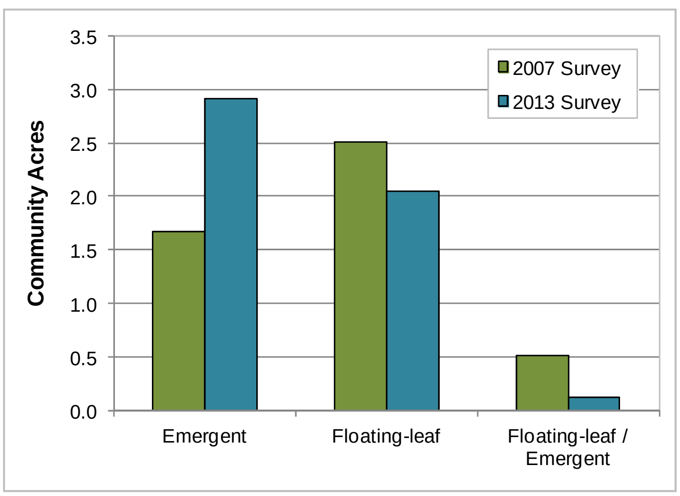


Figure 4.2-6. Lake Millicent community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Lake Millicent to map emergent and floating-leaf communities. As Figure 4.2-6 illustrates, the spatial coverage of these species changed slightly during this timeframe. Emergent communities increased, while floating-leaf communities decreased slightly. Floating-leaf/emergent communities also experienced a slight decrease. Overall, total acreage of these communities increased from 4.7 acres in 2007 to 5.1 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Lake Millicent, as well as to determine if the control project was successful at reducing the Eurasian water milfoil population, an analysis between 2007 and 2013 datasets is presented below. A Chi-square distribution analysis ($\alpha = 0.05$) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence during the point-intercept survey as the primary indicator. Figure 4.2-7 displays the littoral occurrences of Eurasian water milfoil and native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that have occurred in Lake Millicent.

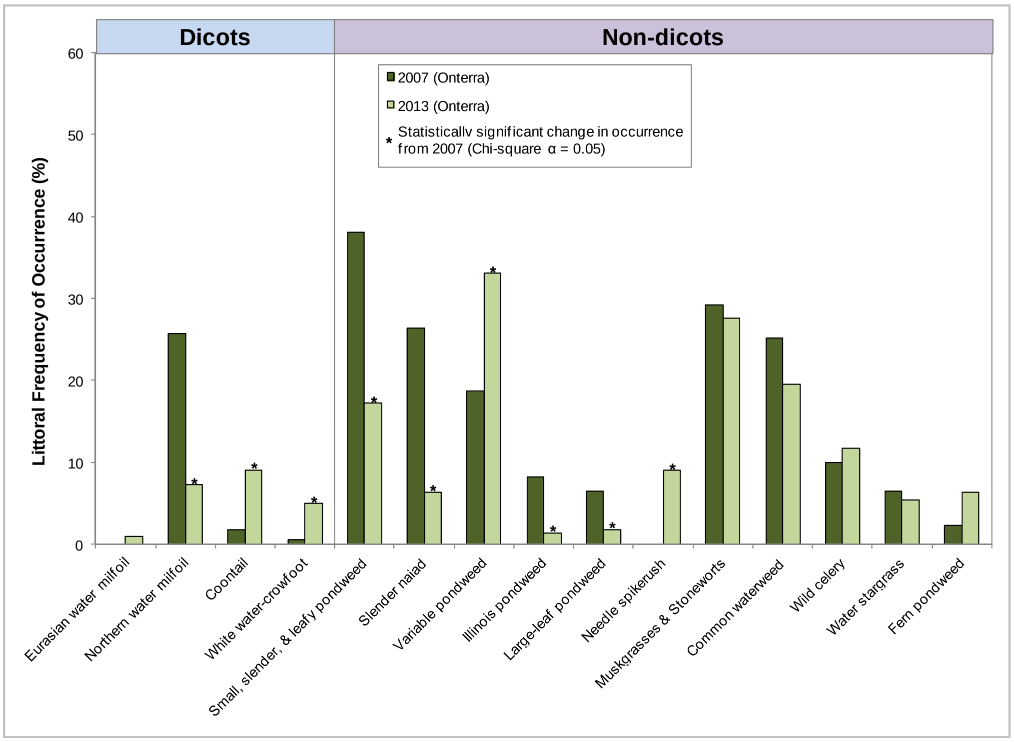


Figure 4.2-7. Lake Millicent littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2007 and 2013 point-intercept surveys.

As illustrated, the occurrence of Eurasian water milfoil in Lake Millicent was found to be not significantly different from 2007 to 2013. Though it was not believed to be in the lake in 2007 and was observed on two sampling points in 2013, this “increase” in occurrence is not beyond happening by chance alone (not statistically significant). From the annual Eurasian water milfoil mapping surveys, it is clear that Eurasian water milfoil has increased its presence within Lake Millicent since 2008 (Figure 4.2-8). It is believed however that the herbicide treatments have been effective at maintaining a low population of Eurasian water milfoil in the lake, keeping relatively large colonies from forming but unfortunately not preventing spread of the aggressive plant to other areas of the waterbody.

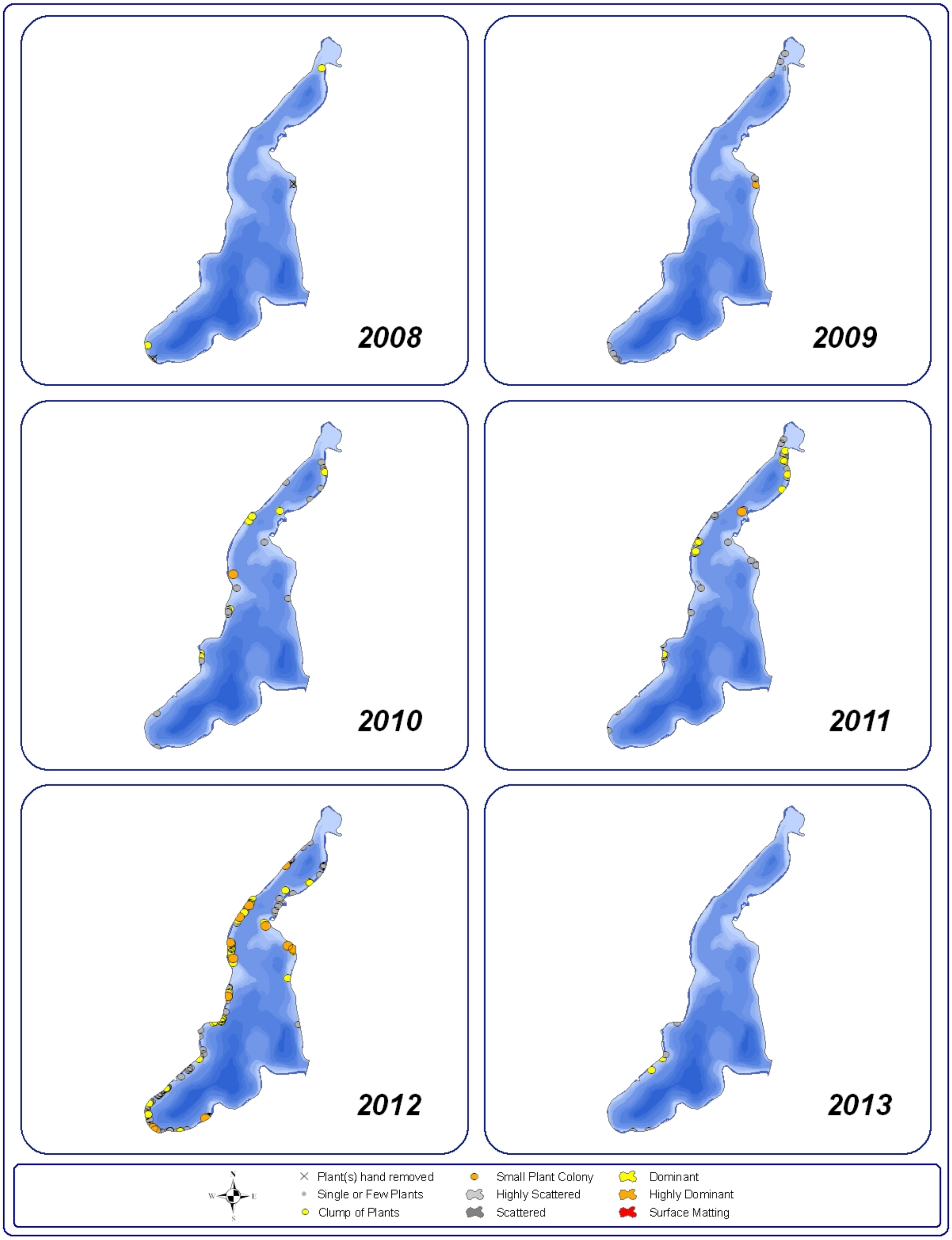


Figure 4.2-8. Lake Millicent Eurasian water milfoil peak-biomass mapping results, 2008-2013. Maps indicate qualitative mapping survey results, conducted in late summer of each respective year.

Four of the native aquatic plant species that had an occurrence of at least 5% in 2007 or 2013 saw statistically significant increases in their littoral occurrence, while five native species saw a statistically significant change as a decrease of their frequency of occurrence. Though it is important to examine changes in the aquatic plant community, it is also important to review the scale of these changes, most of which were extremely small in magnitude.

Though it is possible that herbicide treatments could have contributed towards observed declines in some native species, it is unlikely given the small scale of the treatments that have occurred in Lake Millicent over the course of the Eurasian water milfoil control project. As shown in Figure 4.2-9, 15.5 acres of Lake Millicent have been targeted for Eurasian water milfoil control during the five year project, with only 3.2 acres (24%) being treated more than once. This 15.5 acres represents approximately 25.7% of Lake Millicent's littoral zone (>20 ft). In the case of Lake Millicent, the areas treated more than once have been difficult Eurasian water milfoil populations to control due to these occurrences being located on narrow, steep shelves where herbicide dilution is rapid.

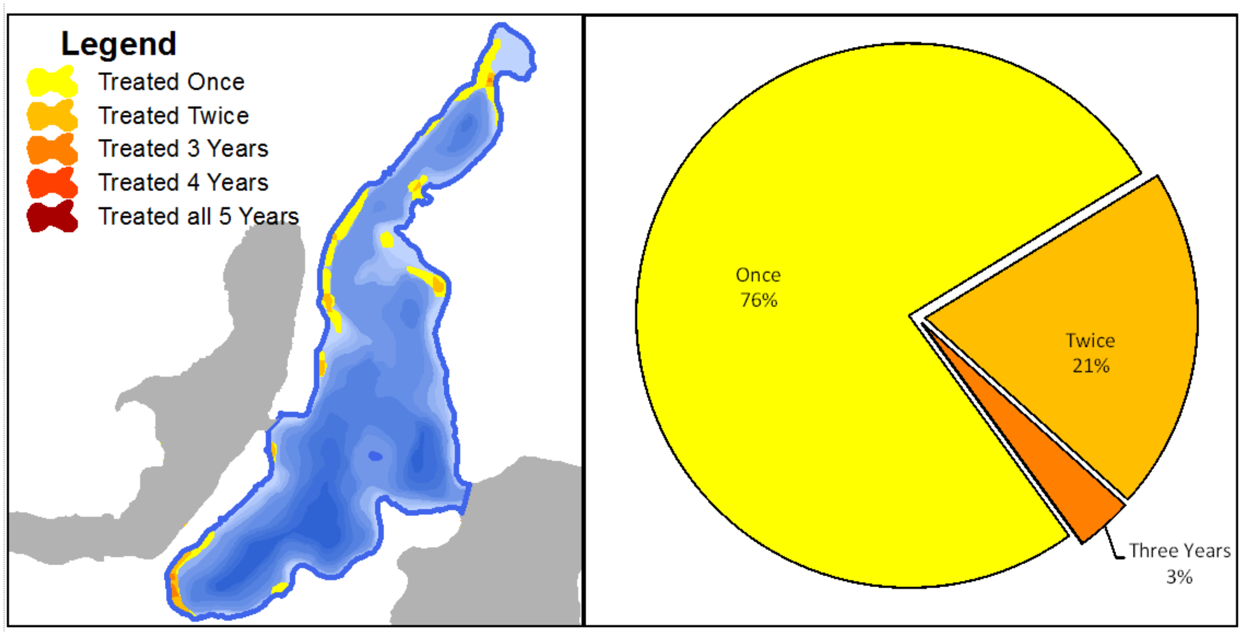
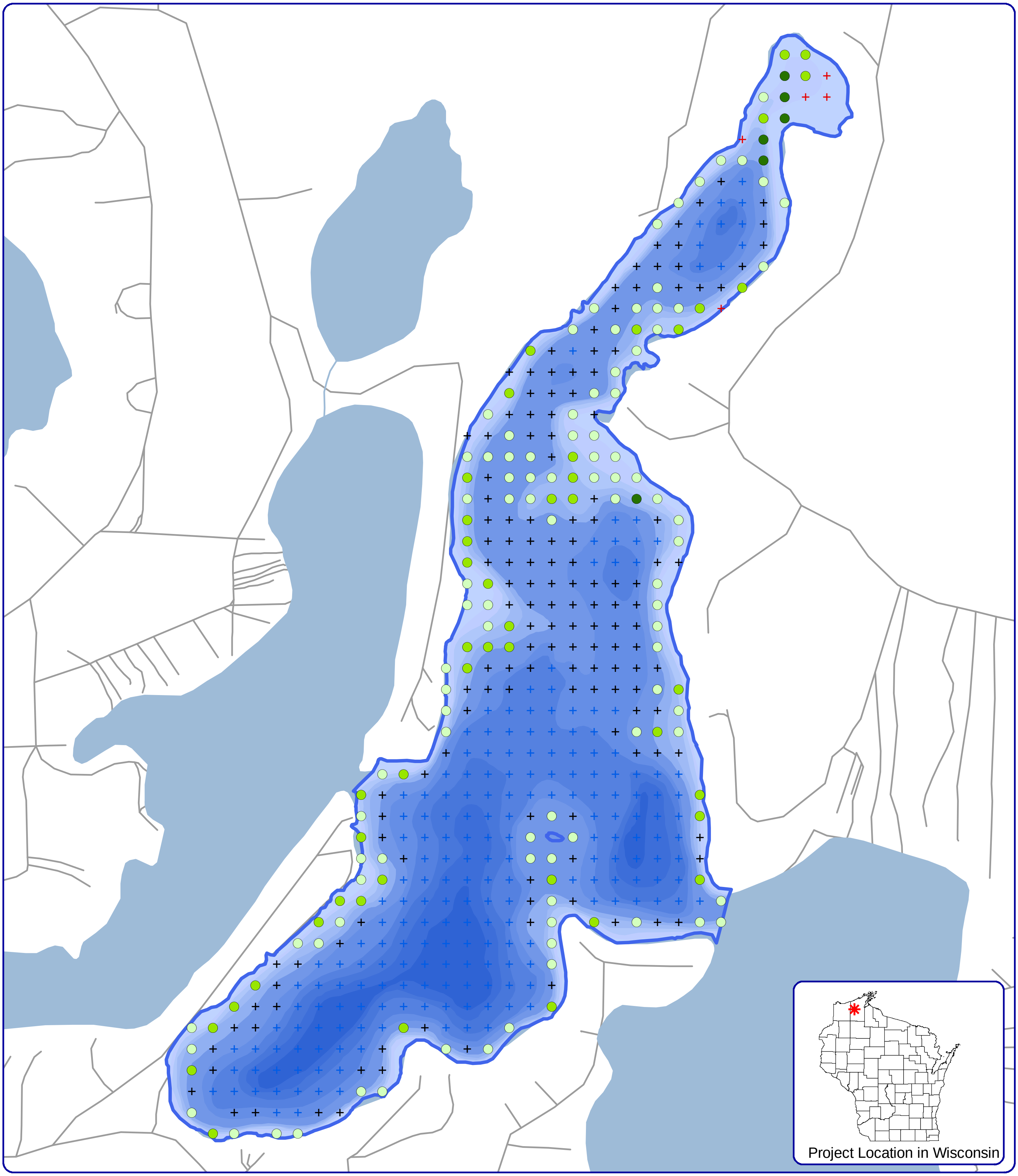


Figure 4.2-9. Surface acreage of Eurasian water milfoil treated on Lake Millicent, 2009-2013.

Overall, the 2013 point-intercept survey on Lake Millicent indicated that the lake's native aquatic plant community has not changed in quality over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have shifted only slightly between 2007 and 2013. Furthermore, though some decreases in species abundance have been documented, increases in similar (dicot/monocot) similar species have occurred alongside this, indicating that environmental fluctuations in plant populations could be the cause of this observation.



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Onterra LLC
Lake Management Planning

815 Prosper Road
De Pere, WI 54115
920.338.8860
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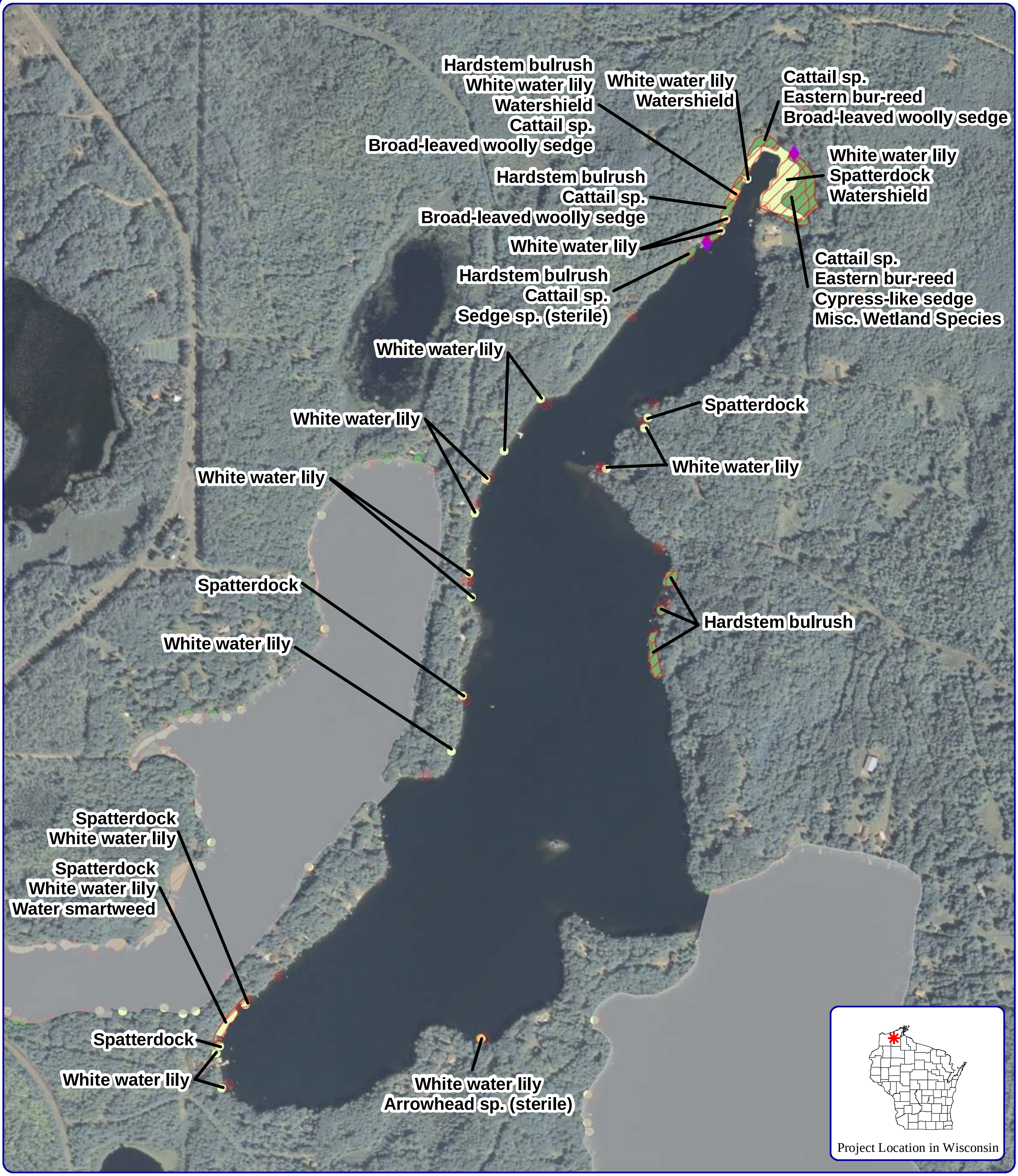
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_Millicent_2013_TRFPI.mxd

Legend

2013 Total Rake Fullness

- No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- Too Deep
- Non-navigable/Temporary Obstacle

Map 1
Lake Millicent
Bayfield County, Wisconsin
2013 PI Survey: Aquatic Vegetation Distribution



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Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: October 31, 2013
Filename: Millicent_Comm_2013.mxd

Legend

2007 Communities
Large Plant Community
Small Plant Community

Exotic Communities
Purple Loosestrife

Small Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent

Large Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent

Map 2
Lake Millicent
Bayfield County, Wisconsin

Aquatic Plant Communities

4.3 Hart Lake

The largest lake within the Pike Chain of Lakes, Hart Lake, is 259 acres in size, and is located downstream of Buskey Bay and Lake Millicent. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 7, 2013 (Figure 4.3-1). During this survey, a total of 42 aquatic plant species were located, one of which is considered to be a non-native, invasive species: Eurasian water milfoil (Table 4.3-1). Of the 41 native species that were encountered, 36 of these were sampled during the point-intercept survey and five were found incidentally during studies on the lake. Comparatively, 19 native species were found during the point-intercept survey in 2005 conducted by the WNDR with 12 native plants being found incidentally during Onterra's 2007 studies.

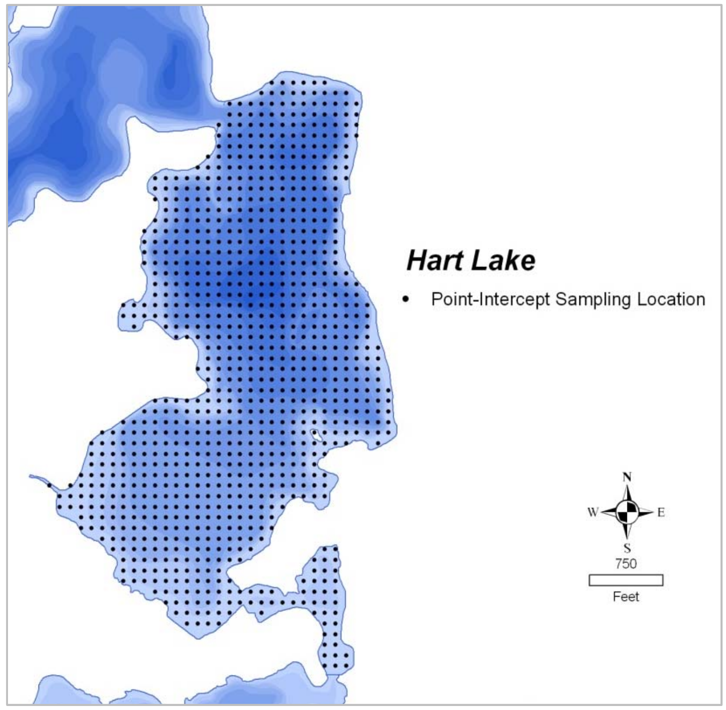


Figure 4.3-1. Point-intercept locations on Hart Lake.

Lakes with varying substrates often support a higher number of plant species due to the different habitats that are available. Like terrestrial plants, aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. From this survey, it was determined that 44% of point-intercept locations contained sand, 41% contained fine, organic sediments (muck), and 15% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing to a maximum depth of 33 feet, which is the same maximum depth determined through the 2005 WDNR survey. The water within the Pike Chain of Lakes is exceptionally clear, which allows the sun's rays to penetrate deep into the water column and allow plants to photosynthesize at great depths. Light availability is often considered the most important factor that regulates abundance and distribution of aquatic plants in freshwater lakes. However, in some lake ecosystems other factors such as atmospheric pressure (Hutchinson 1975) or substrate characteristics (Bachmann et al. 2001) influence plant distribution greatly.

Table 4.3-1. Aquatic plant species located in Hart Lake during 2005/2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2005 (WDNR) & 2007 (Onterra)	2013 (Onterra)
Emergent	*Calla palustris*	Water arum	9	I	I
	Carex comosa	Bristly sedge	5	I	I
	Carex pseudocyperus	Cypress-like sedge	8		I
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis palustris	Creeping spikerush	6		I
	Equisetum fluviatile	Water horsetail	7	I	
	Schoenoplectus acutus	Hardstem bulrush	5	I	X
	Typha spp.	Cattail spp.	1	I	X
FL	*Brasenia schreberi*	Watershield	7	I	X
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
FL/E	*Sparganium americanum*	Eastern bur-reed	8	I	I
	Sparganium eurycarpum	Common bur-reed	5	I	
	Sparganium fluctuans	Floating-leaf bur-reed	10	I	
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10	X	X
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Isoetes spp.	Quillwort species	N/A		X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	I	X
	Myriophyllum tenellum	Dwarf water milfoil	10	X	X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X
	Potamogeton foliosus	Leafy pondweed	6	X	X
	Potamogeton gramineus	Variable pondweed	7		X
	Potamogeton illinoensis	Illinois pondweed	6		X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8		X
	Potamogeton pusillus	Small pondweed	7		X
	Potamogeton richardsonii	Clasping-leaf pondweed	5		X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8		X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8		X
	Ranunculus flammula	Creeping spearwort	9		X
	Utricularia gibba	Creeping bladderwort	9		X
	Utricularia minor	Small bladderwort	10		X
	Utricularia vulgaris	Common bladderwort	7		X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5		X
	Sagittaria graminea	Grass-leaved arrowhead	9	I	
FF	*Spirodela polyrhiza*	Greater duckweed	5	I	

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

Of the 641 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2013, approximately 59% contained aquatic vegetation. This is slightly higher than what was found in the 2005 WDNR survey where approximately 50% of 421 sampling locations contained aquatic vegetation. Hart Lake Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.3-1 displays the aquatic plant species located in Hart Lake during the 2005/2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2005/2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2005/2007. Additionally, there were species found in 2005/2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Hart Lake's aquatic plant frequency is presented later on within this section.

Of the 37 aquatic plant species sampled during the 2013 point-intercept survey, muskgrasses, small/slender pondweed and variable pondweed were the most frequently encountered (Figure 4.3-2). The term muskgrasses describes a grouping of macroalgae consisting of nitella and chara. Nitella species, or stoneworts as they may be called, have whorls of forked branches that are attached to the "stems" of the plant, which are long, slender, smooth-textured algae. Because they lack roots, stoneworts remove nutrients directly from the water. Chara, the other grouping within the class muskgrasses, is also a macroalgae with stems, whorls of forked branches and no true roots. Chara is often encrusted by calcium carbonate, giving it a harsh, crusty feel. Chara is typically low growing and can be identified by its musky odor.

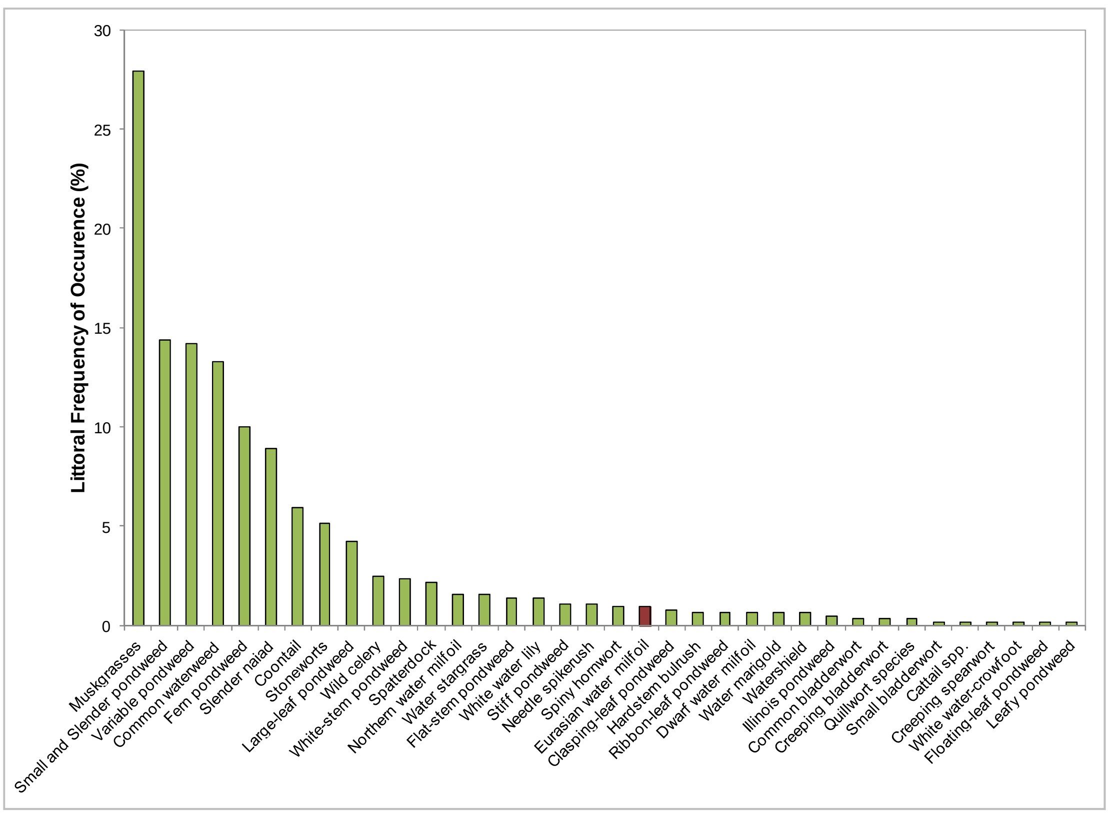


Figure 4.3-2. Hart Lake aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

Small/slender pondweed was the second-most abundant aquatic plant encountered in Hart Lake in 2013. This grouping consists of two species, small pondweed (*Potamogeton pussilus*) and slender pondweed (*Potamogeton berchtoldii*). These two species are very similar in morphology, with their differences only apparent to the trained eye. Often, fine hand lenses are necessary for proper identification. Because of the difficulty in differentiating these two species while conducting aquatic plant surveys on the lake, they have been grouped together in their abundance for the purposes of this report. Small/slender pondweed was observed growing in large stands in Hart Lake, where its long, narrow submersed leaves provide excellent structural habitat for aquatic organisms. Variable pondweed was found in similar abundance to small/slender pondweed. It is a submersed plant that produces a thin, cylindrical stem that has numerous branches. This plant hybridizes easily with other pondweed (*Potamogeton*) species; thus, this plant can appear quite variable in size and shape and is named appropriately.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Hart Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

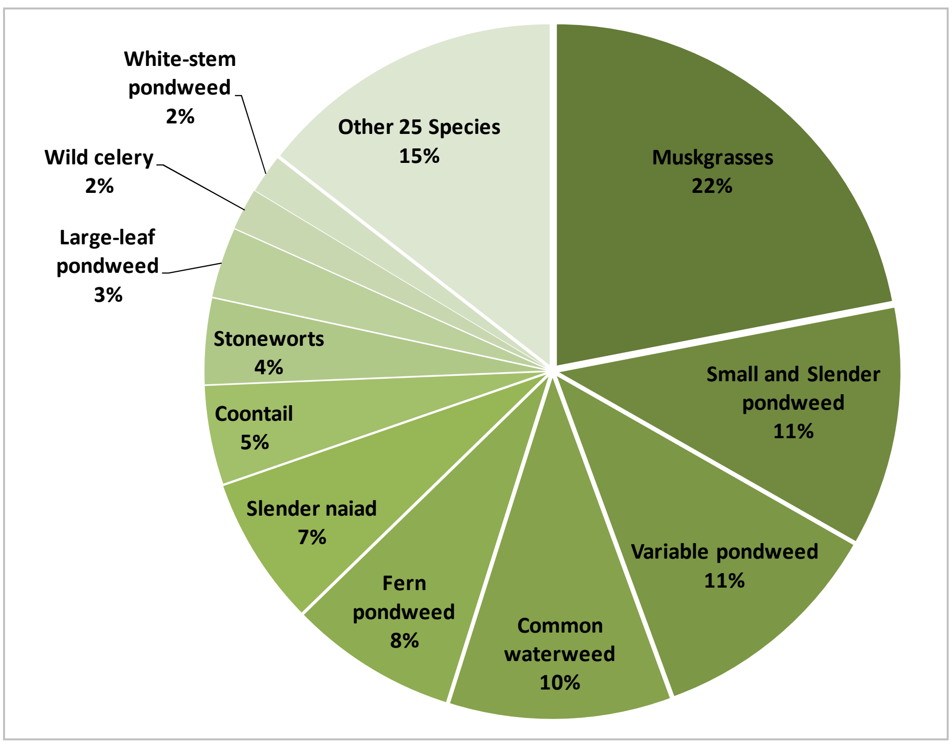


Figure 4.3-3. Hart Lake aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While Figure 4.3-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.3-3 (above) displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas muskgrasses have a 28% frequency of occurrence, they have a relative occurrence of 22% when compared to the other plant species in Hart Lake. This means that if 100 aquatic plants were randomly sampled from Hart Lake, it would be expected that 22 of them would be muskgrasses. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Hart Lake is not overly dominated by a single or few species.

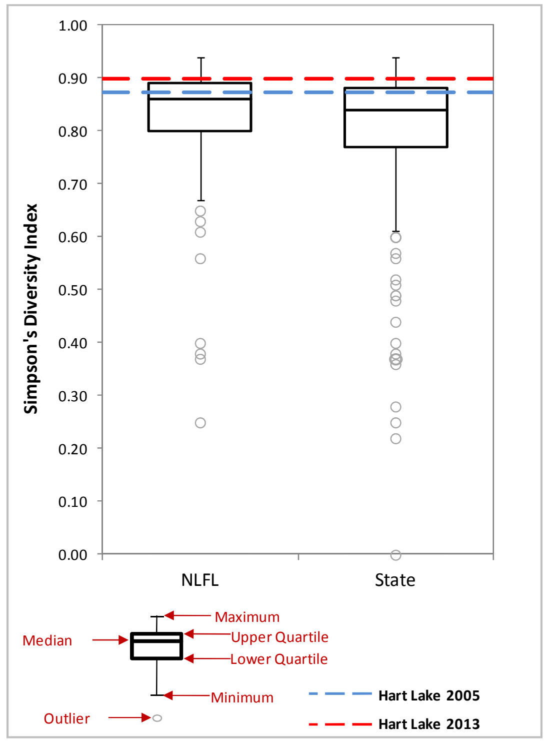


Figure 4.3-4. Hart Lake species diversity index. Created using data from 2007 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Hart Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.3-4). Using the data collected from the 2005 and 2013 point-intercept survey, Hart Lake's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.90 in 2013, falling above the upper quartile value for lakes in both the ecoregion and the state. Hart Lake's 2013 diversity value is slightly higher than the diversity calculated from data collected during the 2007 point-intercept survey (0.87).

As discussed earlier, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 42 aquatic plant species were located in Hart Lake during the 2013 survey, 37 were sampled directly and five were incidentally located. One species, Eurasian water milfoil, is considered non-native. The 36 native species and their conservatism values were used to calculate the FQI of Hart Lake's aquatic plant community in 2013. The FQI was also calculated based on the species located during the 2005 survey.

Figure 4.3-5 compares the FQI components of Hart Lake from the 2007 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2013, Hart Lake's native species richness (36) is much higher than the median values for lakes within the ecoregion and the state. The average conservatism value in 2013 (6.7) exceeds the state medians but, as it did in 2007 with a value of 6.6, but falls slightly under the ecoregion value. Combining Hart Lake's 2013 native species richness and average conservatism values yields a FQI value of 40.1, which greatly exceeds the ecoregional and state median values. Overall, this analysis indicates that Hart Lake's aquatic plant community is of higher quality than the majority of lakes within the ecoregion and the entire state, as determined through 2005 and 2013 comprehensive plant surveys.

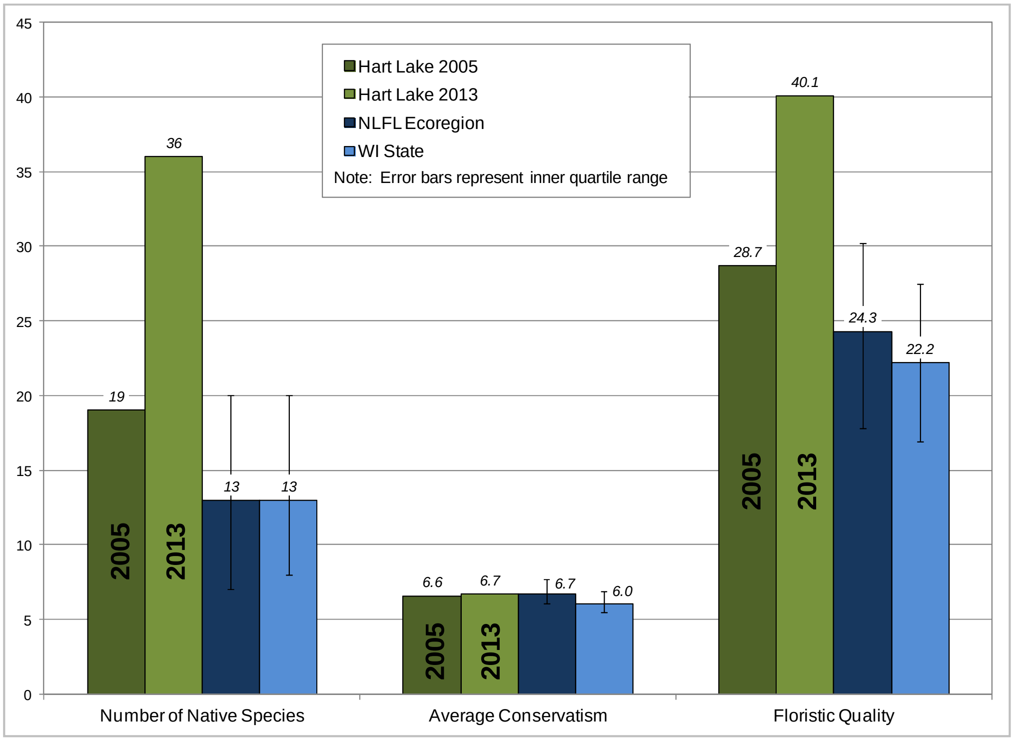


Figure 4.3-5. Hart Lake Floristic Quality Index values. Created using data from 2005 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

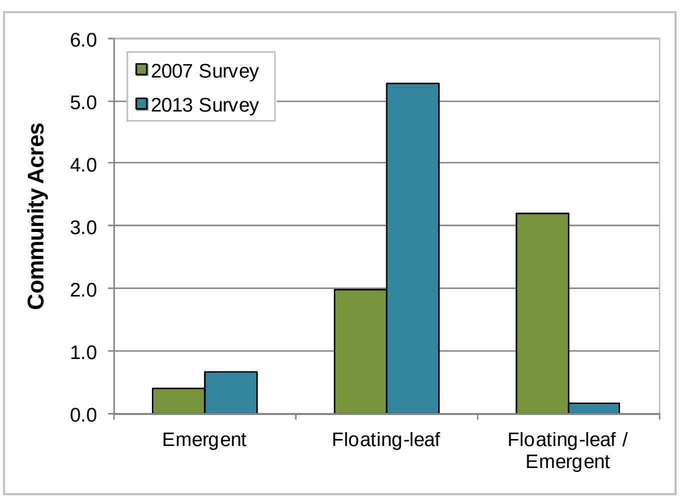


Figure 4.3-6. Hart Lake community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Hart Lake to map emergent and floating-leaf communities. As Figure 4.3-6 illustrates, the spatial coverage of these species changed during this time. Emergent communities increased slightly, while floating-leaf communities increased by 60%. However, the acreage of combined floating-leaf/emergent communities decreased from 3.2 acres to 0.2 acres. Overall, total acreage of these communities increased from 5.6 acres to 6.1 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Hart Lake, as well as to determine if the control project was successful at reducing the Eurasian water milfoil population, an analysis between 2005 and 2013 datasets is presented below. A Chi-square distribution analysis ($\alpha = 0.05$) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence during the point-intercept survey as the primary indicator. Figure 4.3-7 displays the littoral occurrences of Eurasian water milfoil and native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that have occurred in Hart Lake.

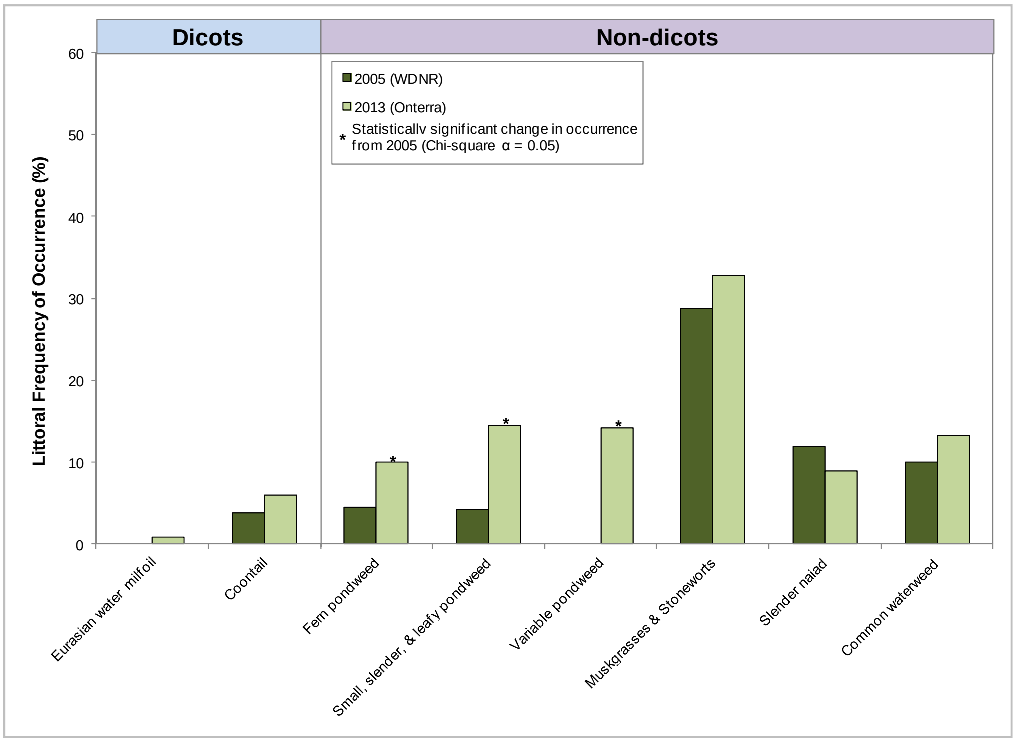


Figure 4.3-7. Hart Lake littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2005 and 2013 point-intercept surveys.

Besides Eurasian water milfoil, the native species in Figure 4.3-7 all have at least a 5% littoral frequency of occurrence. Three native aquatic plant species that had an occurrence of at least 5% in 2005 or 2013 saw statistically significant increases in their littoral occurrence, while no species were found to display a statistically significant decrease in their frequency of occurrence.

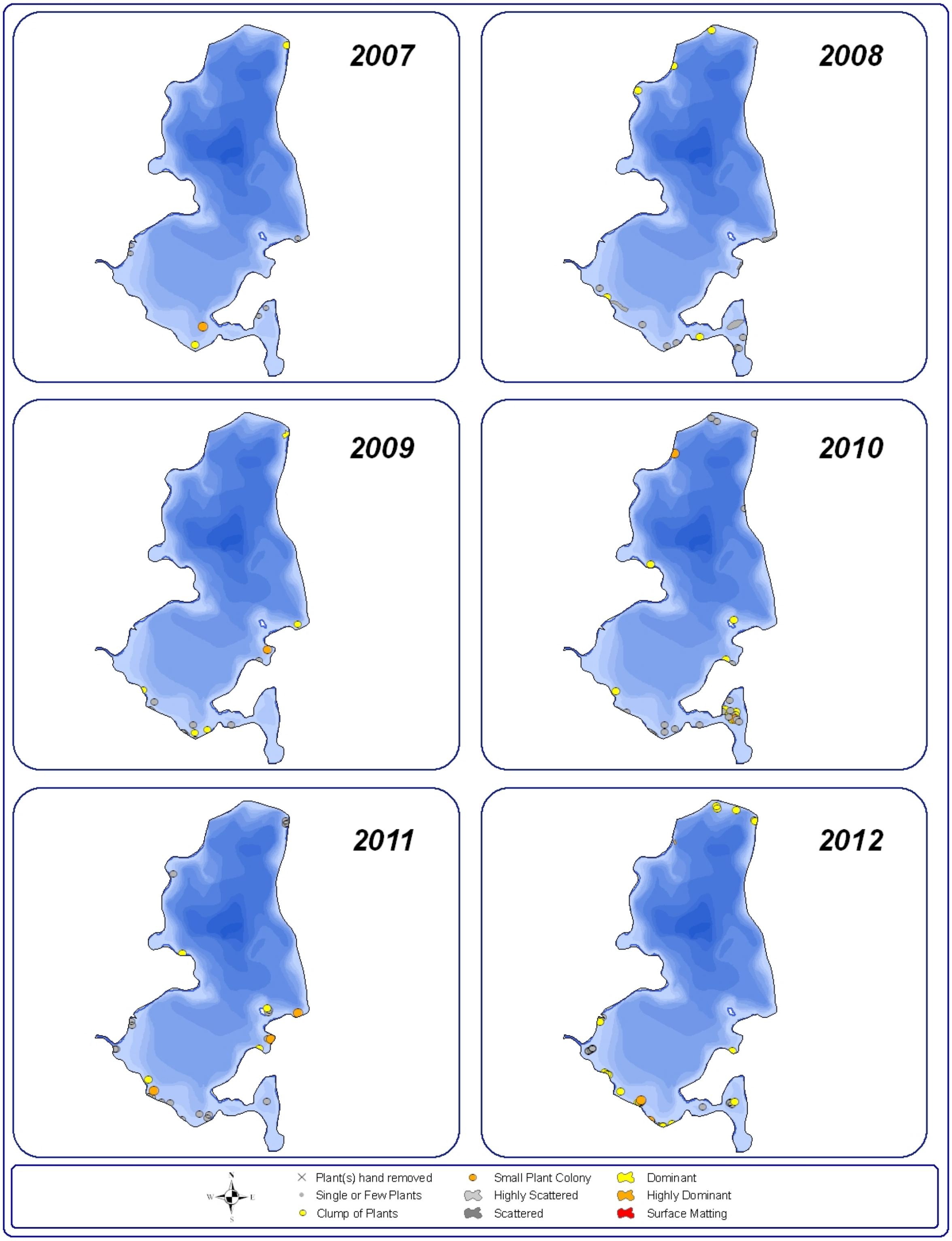


Figure 4.3-8. Hart Lake Eurasian water milfoil peak-biomass mapping results, 2007-2012. Maps indicate qualitative mapping survey results, conducted in late summer of each respective year.

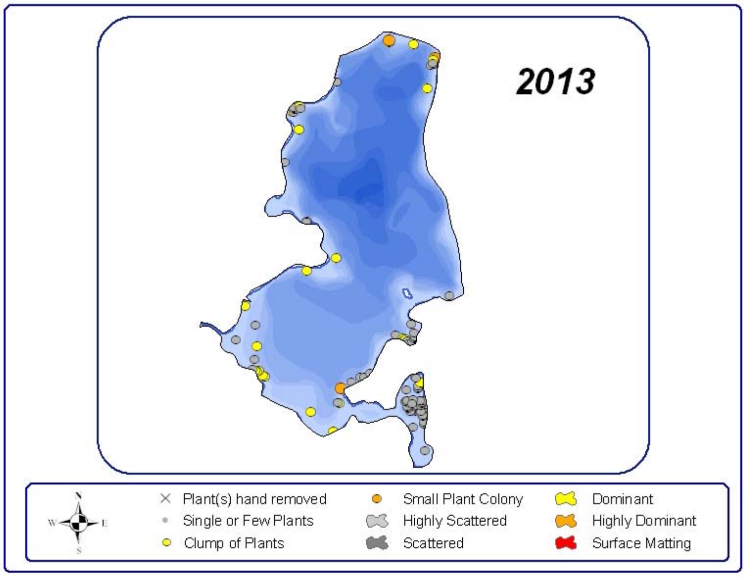


Figure 4.3-9. Hart Lake Eurasian water milfoil peak-biomass mapping results, 2013. Maps indicate qualitative mapping survey results, conducted in late summer of 2013.

In examining the qualitative survey results from Eurasian water milfoil peak biomass surveys over 2008-2013, it is apparent that this invasive has taken residence in numerous areas in the lake (Figures 4.3-8 and 4.3-9). However, it is believed that the herbicide treatments have been effective at reducing and maintaining a low population of Eurasian water milfoil in the waterbody.

As shown in Figure 4.3-9, 17.0 acres of Hart Lake have been targeted for Eurasian water milfoil control during the five year project, with 6.6 acres (43%) being treated more than once. This 17.0 acres represents approximately 21.2% of Hart Lake’s littoral zone (>20 ft). Eurasian water milfoil has been established in Hart and Twin Bear Lakes the longest of the Pike Chain of Lakes. In some instances, multiple years of treatments were required to bring the Eurasian water milfoil population below levels warranting retreatment. Other areas, such as those areas treated four and five years, have not completely met expectations with lake managers continually striving for more effective treatments strategies each consecutive year.

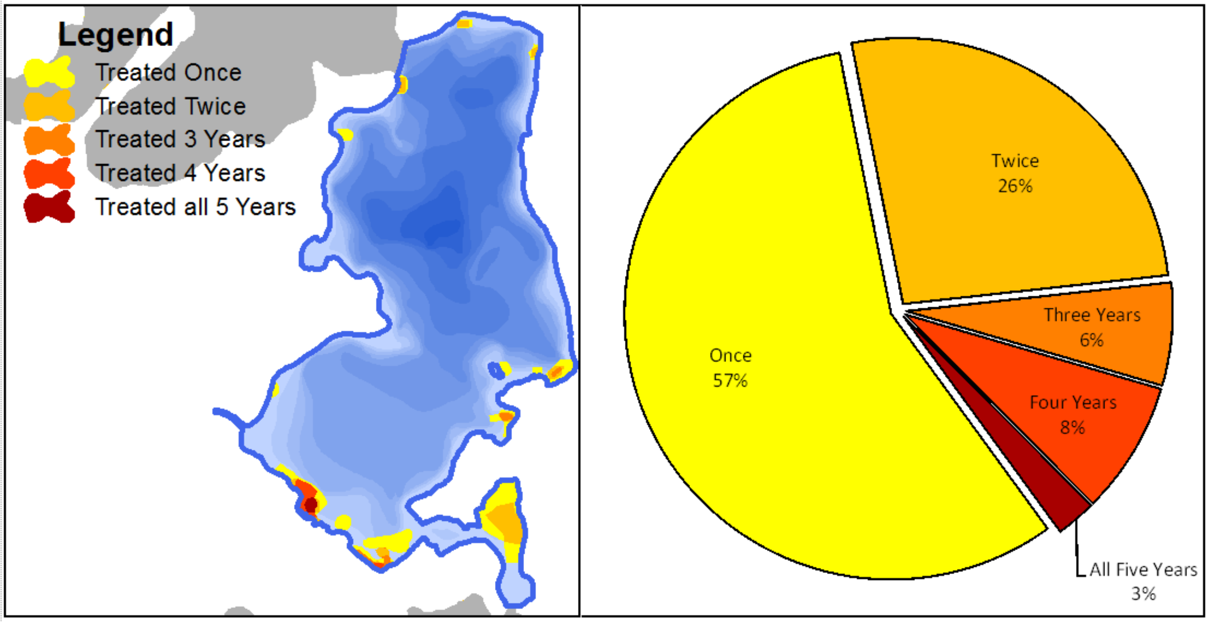
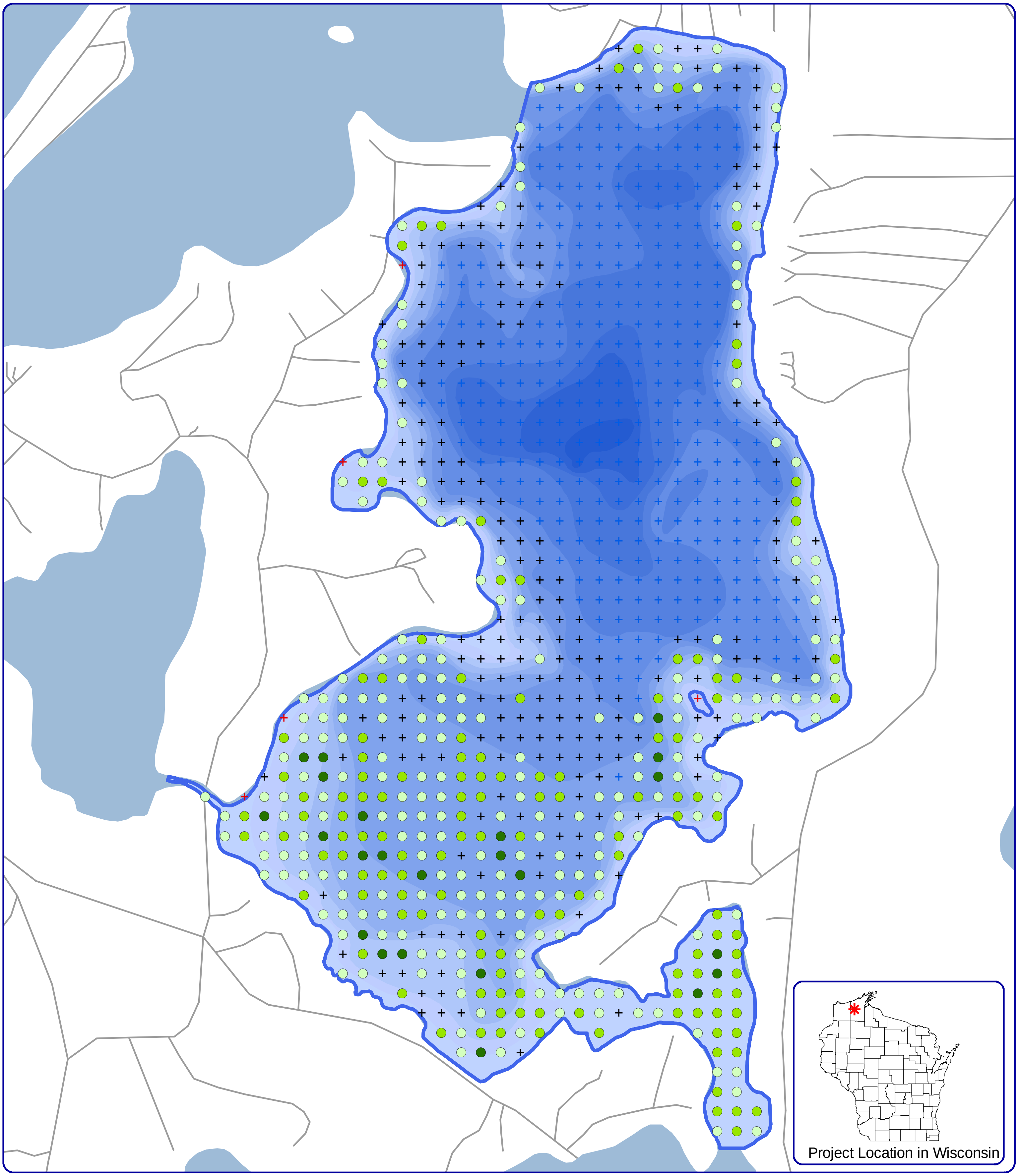


Figure 4.3-9. Surface acreage of Eurasian water milfoil treated on Hart Lake, 2009-2013.

Overall, the aquatic plant studies conducted on Hart Lake have indicated that the lake's native aquatic plant community has not been compromised in quality over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have all increased between 2005/2007 and 2013. Furthermore, no decreases in species abundance have been documented, and healthy populations of native aquatic plants continue to be found within the lake.



N W E S

700

Feet

Legend

2013 Total Rake Fullness

- + No Vegetation
- + Too Deep
- Total Rake Fullness = 1
- + Non-navigable/Temporary Obstacle
- Total Rake Fullness = 2
- Total Rake Fullness = 3

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920.338.8860
www.onterra-eco.com

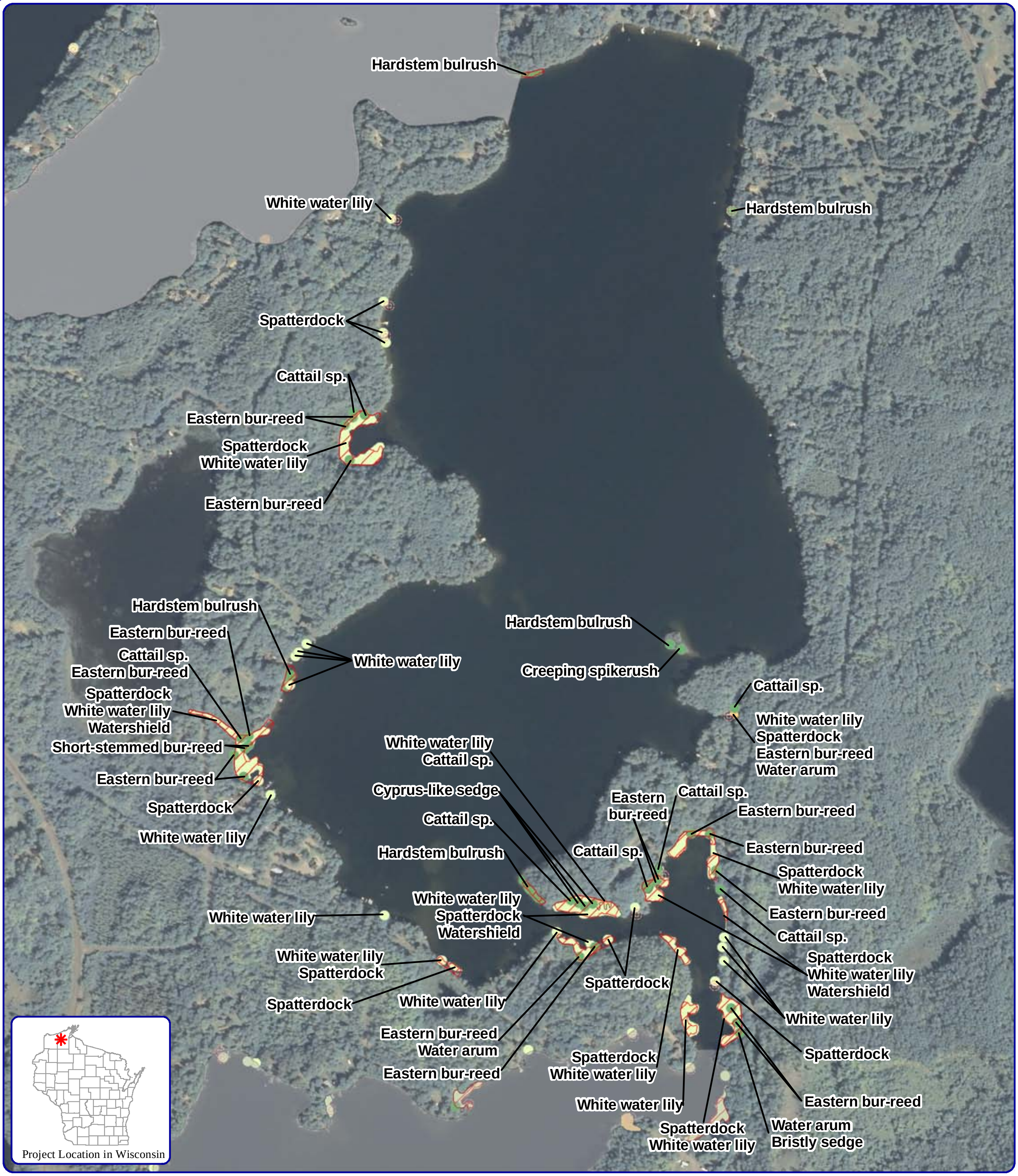
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_Hart_2013_TRFPI.mxd

Map 1

Hart Lake

Bayfield County, Wisconsin

2013 PI Survey: Aquatic Vegetation Distribution



N
W E
S
800
Feet

Legend

2007 Communities
- Large Plant Community
- Small Plant Community

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

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Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: November 7, 2013
Filename: *Hart_Comm_2013.mxd*

Map 2
Hart Lake
Bayfield County, Wisconsin

Aquatic Plant Communities

4.4 Twin Bear Lake

The third largest lake within the Pike Chain of Lakes, Twin Bear Lake, is 172 acres in size and is located downstream of Hart Lake. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 7, 2013 (Figure 4.4-1). During this survey, a total of 30 aquatic plant species were located, one of which is considered to be a non-native, invasive species: Eurasian water milfoil (Table 4.4-1). Of the 29 native species that were encountered, 27 of these were sampled during the point-intercept survey and two were found incidentally during studies on the lake. Comparatively, 15 native species were found during the point-intercept survey in 2005 conducted by the WNDR with eight native plants being found incidentally during Onterra's 2007 studies (Table 4.4-1).

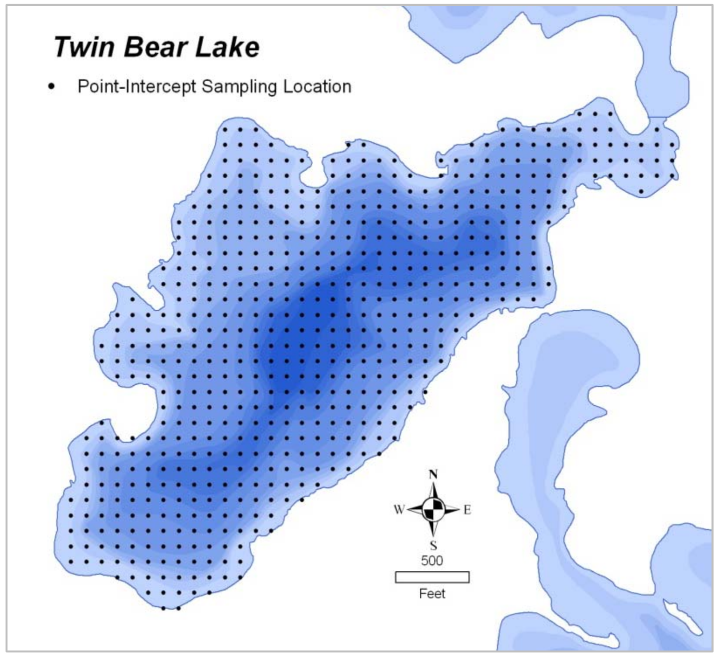


Figure 4.4-1. Point-intercept locations on Twin Bear Lake.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. As a result of this survey, it was determined that 54% of point-intercept locations fine, organic sediments (muck), 30% contained sand and 16% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing to a maximum depth of 28 feet, which is deeper than the maximum depth determined by the WDNR in 2005 (11 ft). The water within the Pike Chain of Lakes is exceptionally clear, which allows the sun's rays to penetrate deep into the water column and allow plants to photosynthesize at great depths. Light availability is often considered the most important factor that regulates abundance and distribution of aquatic plants in freshwater lakes. However, in some lake ecosystems other factors such as atmospheric pressure (Hutchinson 1975) or substrate characteristics (Bachmann et al. 2001) influence plant distribution greatly. It is unknown why the maximum depth is much greater in 2013 than it was in 2005; it is assumed that water clarity, pressure, and substrate characteristics are similar between these time periods.

Table 4.4-1. Aquatic plant species located in Twin Bear Lake during 2005/2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2005 (WDNR) & 2007 (Onterra)	2013 (Onterra)
Emergent	*Carex comosa*	Bristly sedge	5	I	
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis palustris	Creeping spikerush	6		X
	Sagittaria latifolia	Common arrowhead	3	I	I
	Schoenoplectus acutus	Hardstem bulrush	5	I	X
	Typha spp.	Cattail spp.	1	I	
FL	*Nuphar variegata*	Spatterdock	6		X
	Nymphaea odorata	White water lily	6		X
FL/E	*Sparganium americanum*	Eastern bur-reed	8	I	I
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Callitriche palustris	Common water starwort	8	I	
	Ceratophyllum demersum	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10		X
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8		X
	Potamogeton gramineus	Variable pondweed	7		X
	Potamogeton illinoensis	Illinois pondweed	6		X
	Potamogeton natans	Floating-leaf pondweed	5	I	
	Potamogeton praelongus	White-stem pondweed	8		X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5		X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8		X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5		X
	Sagittaria cristata (rosette)	Crested arrowhead (rosette)	9	X	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent
X = Located on rake during point-intercept survey; I = Incidental Species

Of the 352 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2013, approximately 57% contained aquatic vegetation. This is slightly higher than what was found in the 2005 WDNR survey where approximately 44% of 147 sampling locations contained aquatic vegetation. Twin Bear Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.4-1 displays the aquatic plant species located in Twin Bear Lake during the 2005/2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2005/2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2005/2007. Additionally, there were species found in 2005/2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Twin Bear Lake's aquatic plant frequency of occurrence is presented later on within this section.

Of the 28 aquatic plant species sampled during the 2013 point-intercept survey, common waterweed, coontail and fern pondweed were the most frequently encountered (Figure 4.4-2). Able to obtain the majority of their essential nutrients directly from the water, common waterweed and coontail do not produce extensive root systems, making them susceptible to uprooting by water-action and water movement. Fern pondweed is a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. These three species are widely distributed throughout Wisconsin lakes, as well as many other regions of North America.

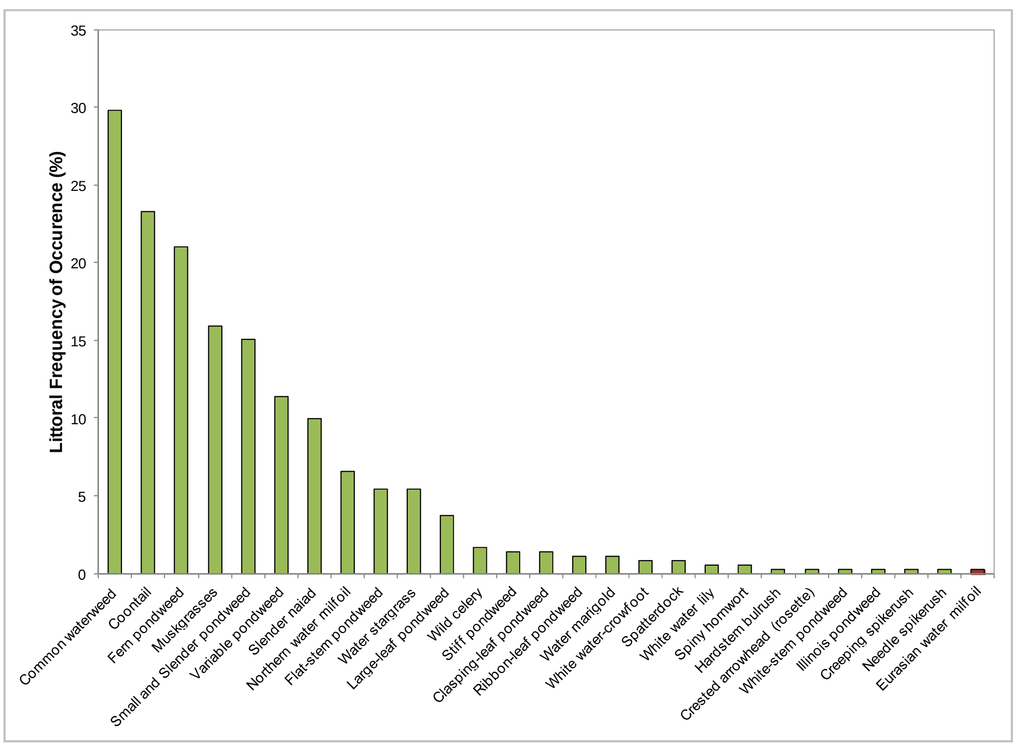


Figure 4.4-2. Twin Bear Lake aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Twin Bear Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While Figure 4.4-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.4-3 displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas common waterweed has a 30% frequency of occurrence, it has a relative occurrence of 19% when compared to the other plant species in Twin Bear Lake. This means that if 100 aquatic plants were randomly sampled from Twin Bear Lake, it would be expected that 19 of them would be common waterweed. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Twin Bear Lake is not overly dominated by a single or few species.

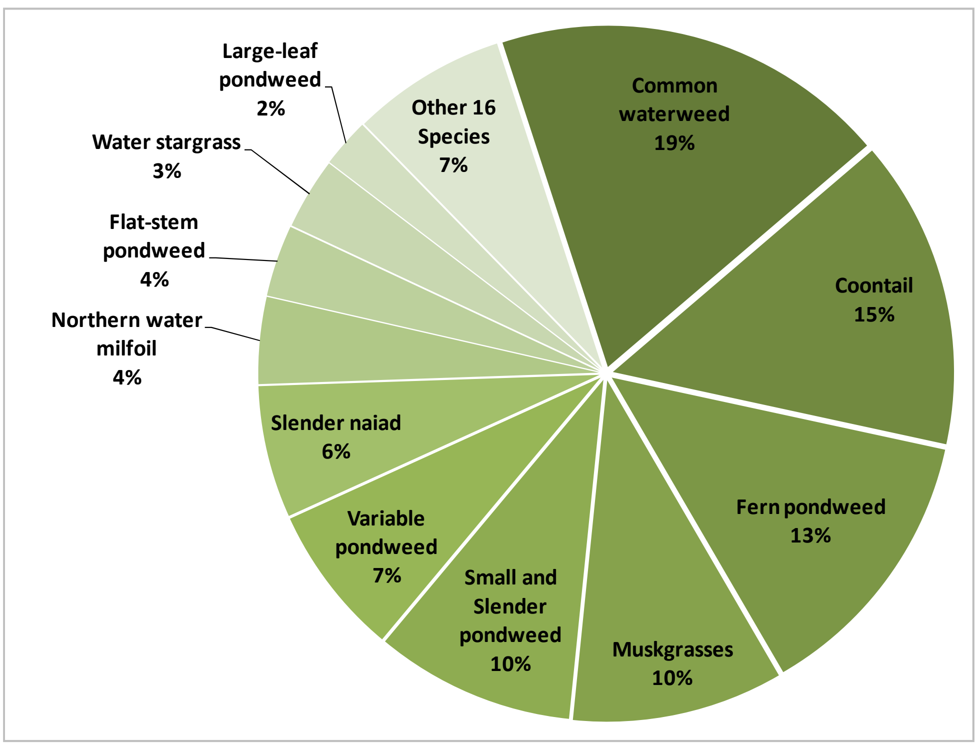


Figure 4.4-3. Twin Bear Lake aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Twin Bear Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.4-4). Using the data collected from the 2005 and 2013 point-intercept survey, Twin Bear Lake's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.90 in 2013, falling above the upper quartile value for lakes in both the ecoregion and the state. Twin Bear Lake's 2013 diversity value is slightly higher than the diversity calculated from data collected during the 2005 point-intercept survey (0.89).

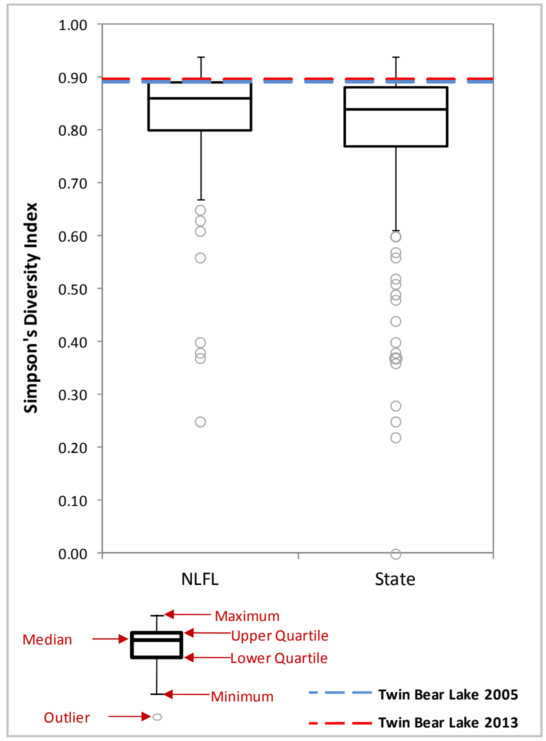


Figure 4.4-4. Twin Bear Lake species diversity index. Created using data from 2005 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 30 aquatic plant species were located in Twin Bear Lake during the 2013 survey, 28 were sampled directly and two were incidentally located. One species, Eurasian water milfoil, is considered non-native. The 27 native species and their conservatism values were used to calculate the FQI of Twin Bear Lake's aquatic plant community in 2013. The FQI was also calculated based on the species located during the 2005 survey.

Figure 4.4-5 compares the FQI components of Twin Bear Lake from the 2005 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2013, Twin Bear Lake's native species richness (27) is much higher than the median values for lakes within the ecoregion and the state. The average conservatism value in 2013 (6.6) is above the state median, as it was in 2007 with a value of 6.5, but falls slightly under the ecoregion value. Combining Twin Bear Lake's 2013 native species richness and average conservatism values yields a FQI value of 34.3, which greatly exceeds the ecoregional and state median values. Overall, this analysis indicates that Twin Bear Lake's aquatic plant community is of higher quality than the majority of lakes within the ecoregion and the entire state, as determined through 2005 and 2013 comprehensive plant surveys.

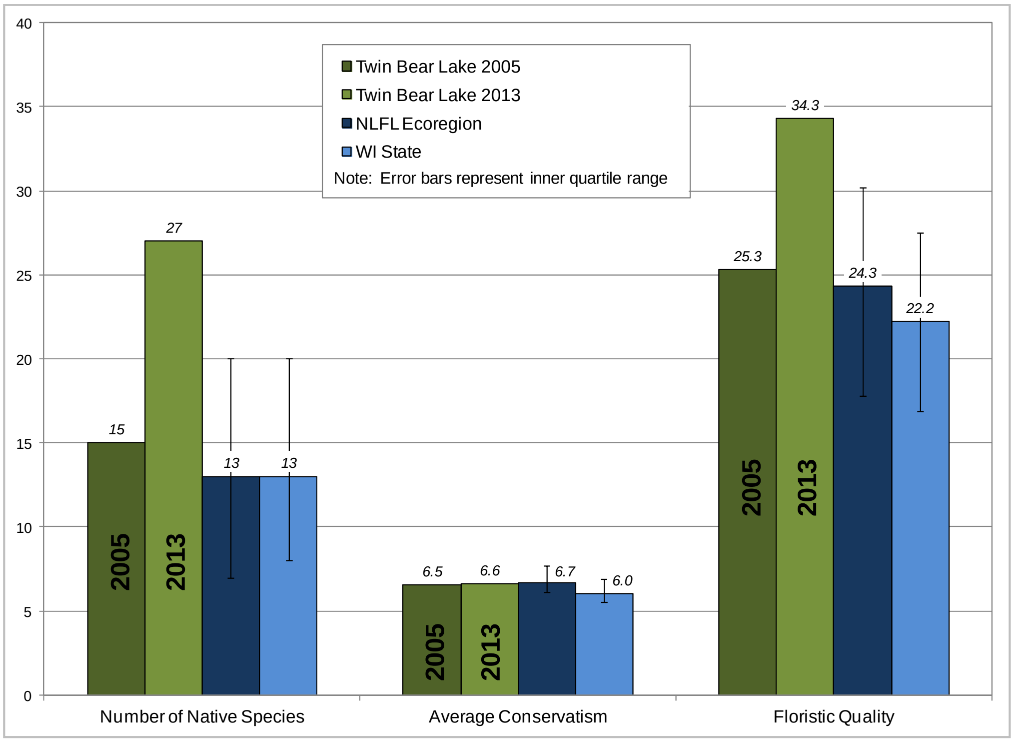


Figure 4.4-5. Twin Bear Lake Floristic Quality Index values. Created using data from 2005 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

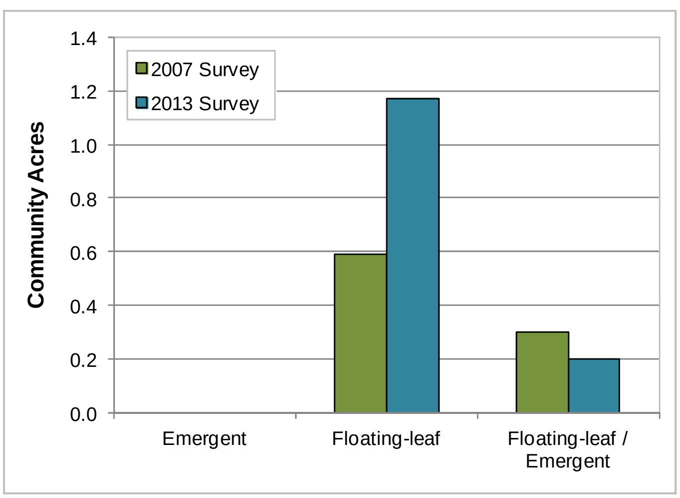


Figure 4.4-6. Twin Bear Lake community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Twin Bear Lake to map emergent and floating-leaf communities. As Figure 4.1-6 illustrates, the spatial coverage of these species changed during this timeframe. Strictly emergent communities were not mapped during either survey, while the acreage of floating-leaf communities increased by 50%. The acreage of combined floating-leaf/emergent communities decreased from 0.3 acres to 0.2 acres. Overall, total acreage of these communities increased from 0.9 acres in 2007 to 1.4 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Twin Bear Lake, as well as to determine if the control project was successful at reducing the Eurasian water milfoil population, an analysis between 2005 and 2013 datasets is presented below. A Chi-square distribution analysis ($\alpha = 0.05$) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence as the primary indicator. Figure 4.4-7 displays the littoral occurrences of Eurasian water milfoil and native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that have occurred in Twin Bear Lake. Eight native aquatic plant species that had an occurrence of at least 5% in 2005 or 2013 saw statistically significant increases in their littoral occurrence, while a single species was found to display a statistically significant decrease in its frequency of occurrence.

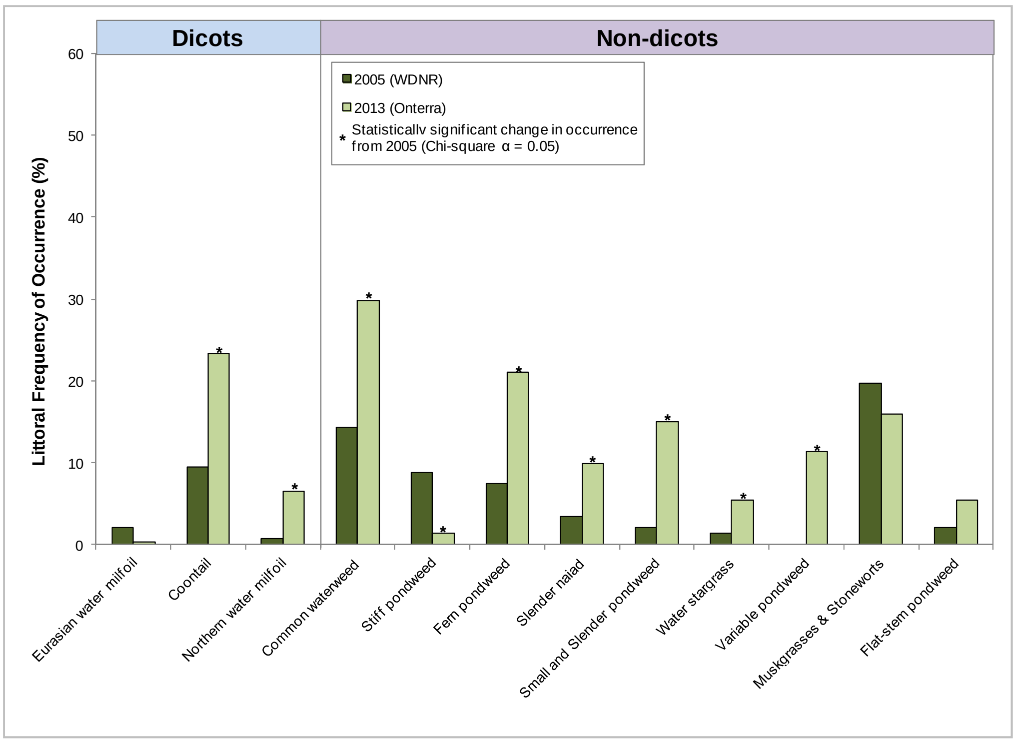


Figure 4.4-7. Twin Bear Lake littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2005 and 2013 point-intercept surveys.

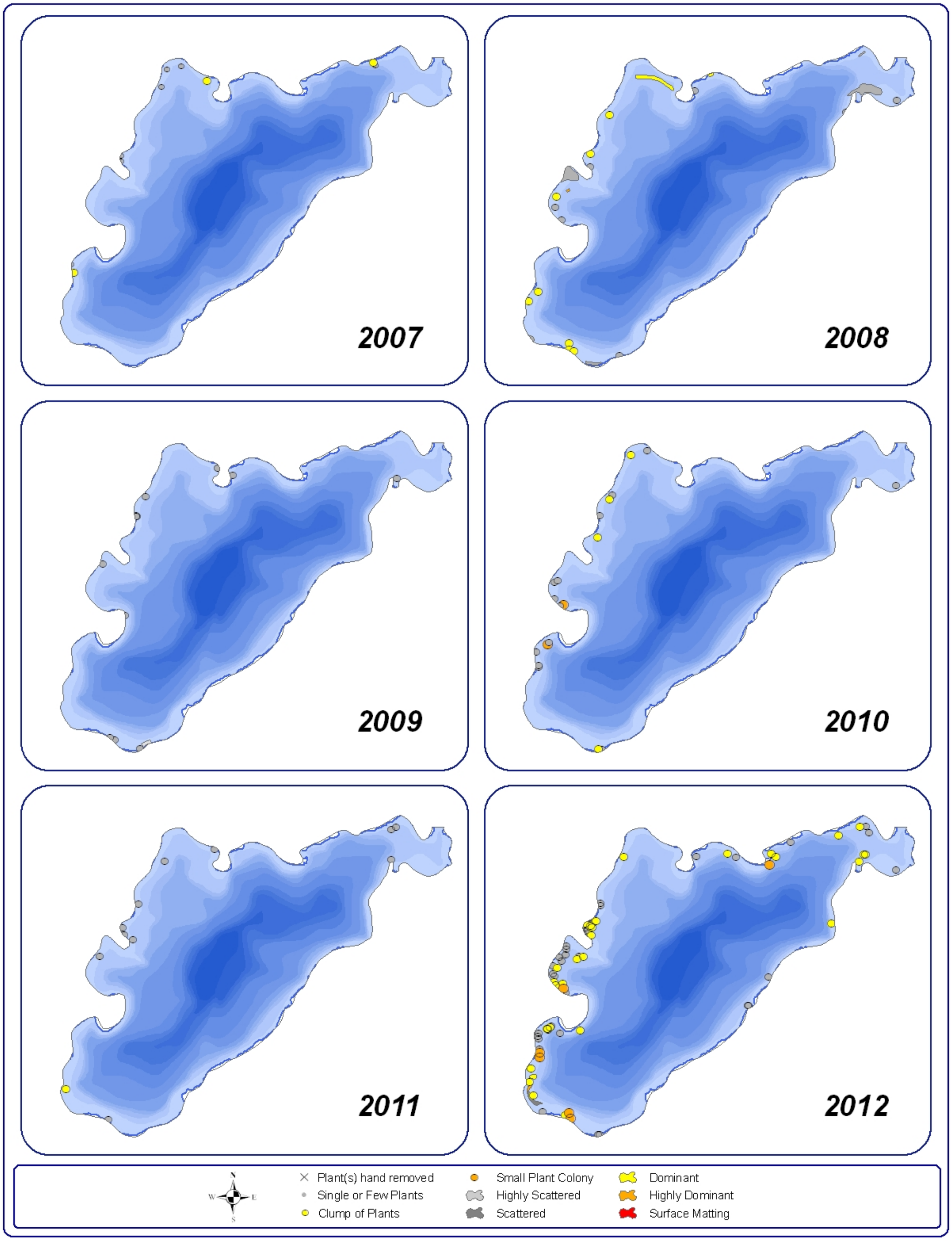


Figure 4.4-8. Twin Bear Lake Eurasian water milfoil peak-biomass mapping results, 2007-2012. Maps indicate qualitative mapping survey results, conducted in late summer of each respective year.

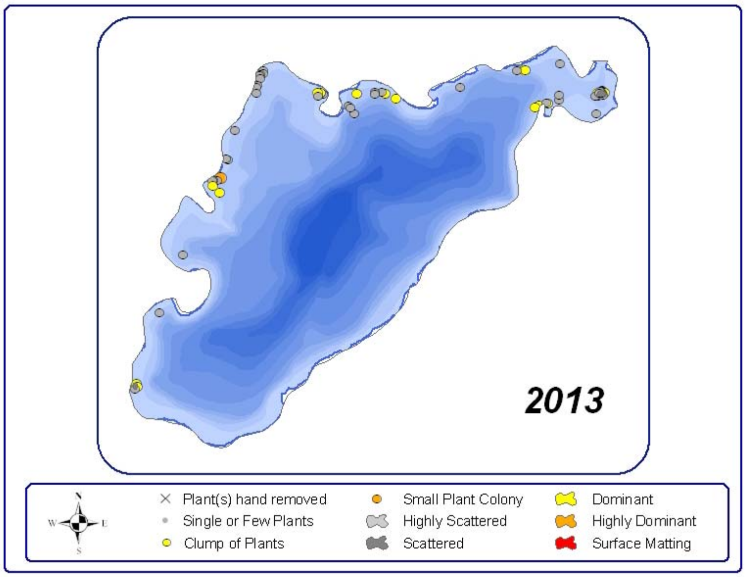


Figure 4.4-9. Twin Bear Lake Eurasian water milfoil peak-biomass mapping results, 2013. Maps indicate qualitative mapping survey results, conducted in late summer of 2013.

The results of several years of Eurasian water milfoil peak biomass mapping show that the invasive has spread to much of the littoral zone of the lake (Figure 4.4-8 and 4.4-9). It is believed however that herbicide treatments have been effective at maintaining a low population of Eurasian water milfoil in the lake.

As shown in Figure 4.4-10, 19.2 acres of Twin Bear Lake have been targeted for Eurasian water milfoil control during the five year project, with 11.2 acres (58%) being treated more than once. This 19.2 acres represents approximately 24.8% of Twin Bear Lake's littoral zone (>20 ft). Eurasian water milfoil has been established in Hart and Twin Bear Lakes the longest of the Pike Chain of Lakes. In some instances, multiple years of treatments were required to bring the Eurasian water milfoil population below levels warranting retreatment. Other areas, such as those areas treated 4 years, have not completely met expectations with lake managers continually striving for more effective treatments strategies each consecutive year.

Overall, the aquatic plant studies conducted on Twin Bear Lake have indicated that the lake's native aquatic plant community has not been compromised in quality over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have all increased between 2005/2007 and 2013, and healthy populations of native aquatic plants are still found within Twin Bear Lake.

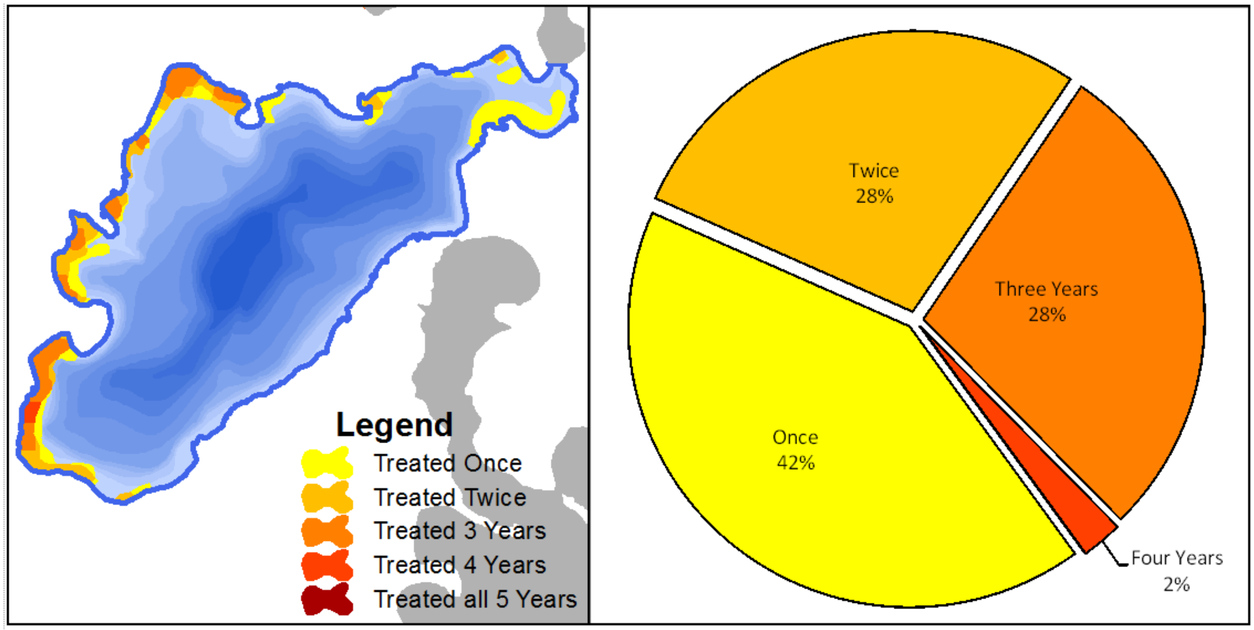
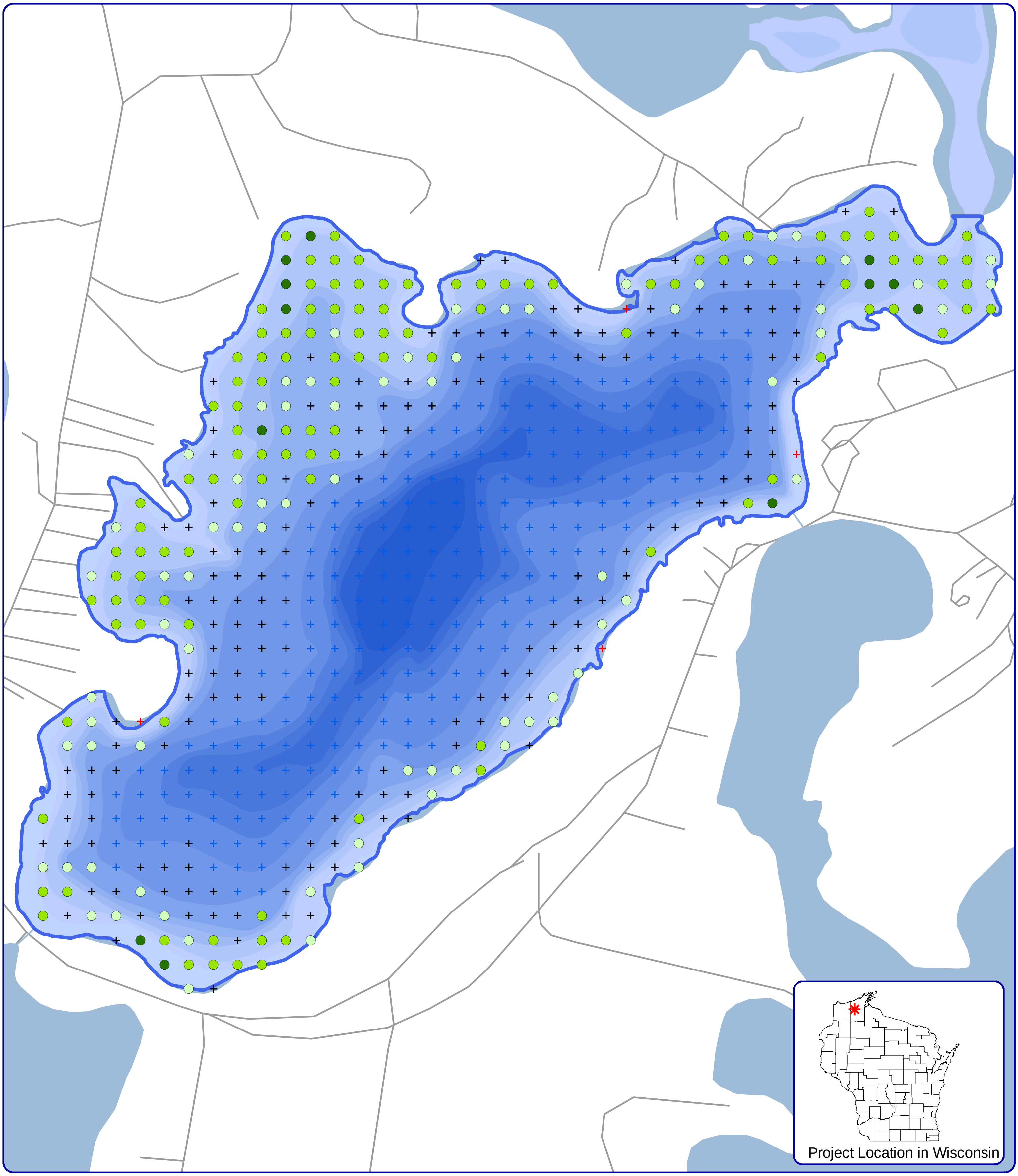


Figure 4.4-10. Surface acreage of Eurasian water milfoil treated on Twin Bear Lake, 2009-2013.



N
S
E
W

550
Feet

Legend
2013 Total Rake Fullness

+ No Vegetation
Total Rake Fullness = 1
Total Rake Fullness = 2
Total Rake Fullness = 3
+ Too Deep
+ Non-navigable/Temporary Obstacle

Onterra LLC
Lake Management Planning
815 Prosper Road
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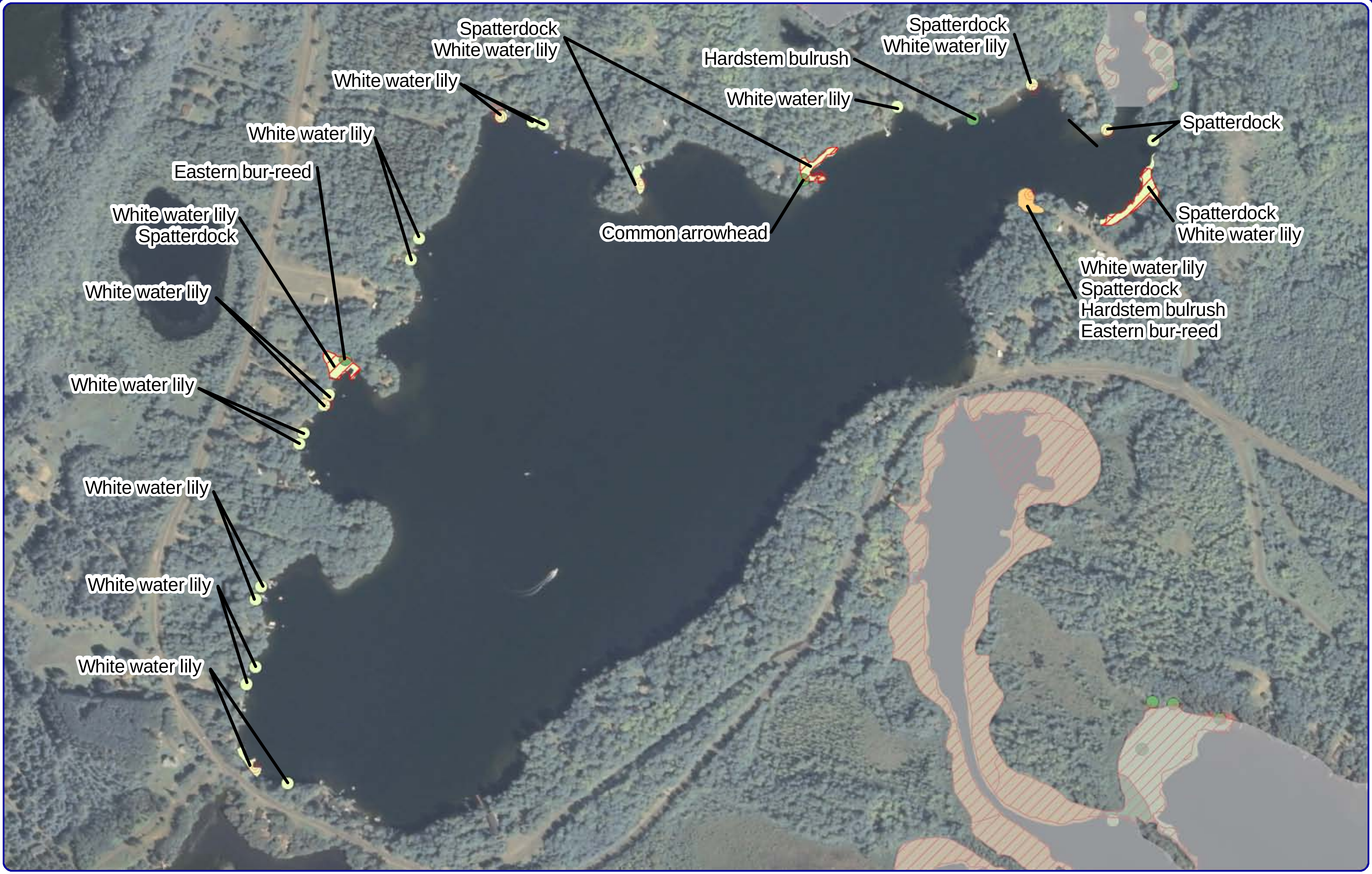
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_TwinBear_2013_TRFPI.mxd

Map 1
Twin Bear Lake
Bayfield County, Wisconsin
2013 PI Survey: Aquatic Vegetation Distribution



N
W E
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Feet

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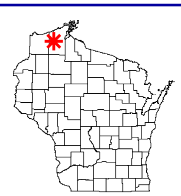
Sources:
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: October 31, 2013
Filename: TwinBear_Comm_2013.mxd


Project Location in Wisconsin

Legend

2007 Communities
- Large Plant Community
- Small Plant Community

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Map 2
Twin Bear Lake
Bayfield County, Wisconsin
Aquatic Plant Communities

4.5 Eagle Lake

Eagle Lake is 170 acres in size, and falls downstream of Twin Bear Lake and upstream of Flynn Lake within the Pike Chain. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 8, 2013 (Figure 4.5-1). During this survey, a total of 51 aquatic plant species were located, one of which is considered to be a non-native, invasive species: Eurasian water milfoil (Table 4.5-1). Of the 50 native species that were encountered, 41 of these were sampled during the point-intercept survey and nine were found incidentally during studies on the lake. Comparatively, 43 species were found during the point-intercept survey in 2007 with five being found incidentally that year (Table 4.5-1).

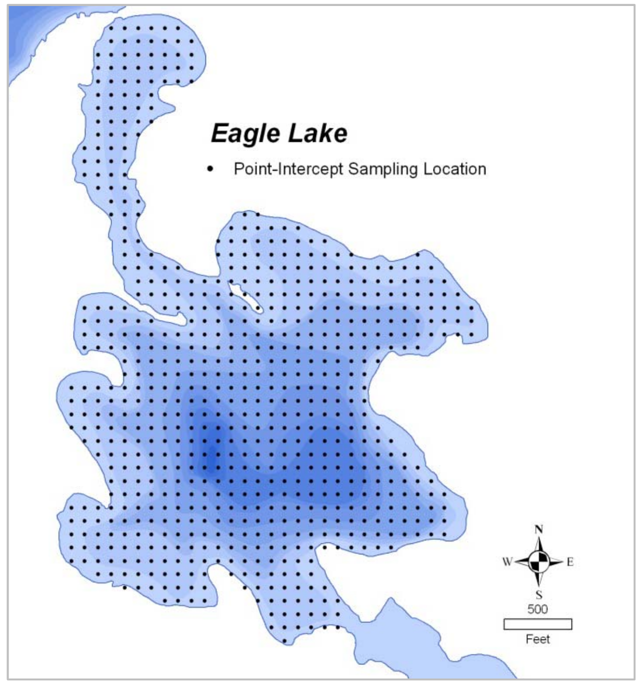


Figure 4.5-1. Point-intercept locations on Scattering Rice Lake.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. As a result of this survey, it was determined that 78% of the point-intercept locations within littoral areas consisted of fine, organic sediments (muck), 18% contained sand, and 3% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing to a maximum depth of 25 feet, which is similar to the 20 foot maximum depth determined through the 2007 survey. The water within the Pike Chain of Lakes is exceptionally clear, which allows the sun's rays to penetrate deep into the water column and allow plants to photosynthesize at great depths. Light availability is often considered the most important factor that regulates abundance and distribution of aquatic plants in freshwater lakes. However, in some lake ecosystems other factors such as atmospheric pressure (Hutchinson 1975) or substrate characteristics (Bachmann et al. 2001) influence plant distribution greatly.

Of the 577 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2013, approximately 83% contained aquatic vegetation. This is comparable to what was found in the 2007 survey where approximately 84% of 512 sampling locations contained aquatic vegetation. Eagle Lake Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.5-1. Aquatic plant species located in Eagle Lake during 2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2007 (Onterra)	2013 (Onterra)
Emergent	*Calla palustris*	Water arum	9	X	
	Carex pellita	Broad-leaved woolly sedge	4	X	I
	Dulichium arundinaceum	Three-way sedge	9	X	X
	Eleocharis palustris	Creeping spikerush	6	X	
	Equisetum fluviatile	Water horsetail	7	I	
	Iris versicolor	Northern blue flag	5	X	I
	Phragmites australis subs. americanus	Common reed	5	I	I
	Sagittaria latifolia	Common arrowhead	3	X	I
	Schoenoplectus acutus	Hardstem bulrush	5	X	X
	Schoenoplectus tabernaemontani	Softstem bulrush	4		I
	Typha spp.	Cattail spp.	1	X	I
FL	*Brasenia schreberi*	Watershield	7	X	X
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
	Persicaria amphibia	Water smartweed	5	X	I
FL/E	*Sparganium americanum*	Eastern bur-reed	8		X
	Sparganium angustifolium	Narrow-leaf bur-reed	9	I	I
	Sparganium emersum	Short-stemmed bur-reed	8	X	I
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Isoetes spp.	Quillwort species	N/A	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic		I
	Myriophyllum tenellum	Dwarf water milfoil	10	X	X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton berchtoldii	Slender pondweed	7		X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	
	Potamogeton foliosus	Leafy pondweed	6	X	X
	Potamogeton friesii	Fries' pondweed	8		X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton illinoensis	Illinois pondweed	6		X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton oakesianus	Oaks' pondweed	10	I	
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X	
	Potamogeton strictifolius	Stiff pondweed	8	X	X
	*Potamogeton vaseyi**	Vasey's pondweed	10		X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus flammula	Creeping spearwort	9		X
	Stuckenia pectinata	Sago pondweed	3	I	X
	Utricularia gibba	Creeping bladderwort	9	X	X
	Utricularia minor	Small bladderwort	10		X
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X	X
	Sagittaria cristata (rosette)	Crested arrowhead (rosette)	9	X	X
	Sagittaria graminea	Grass-leaved arrowhead	9	I	
	Schoenoplectus subterminalis	Water bulrush	9	X	X
FF	*Lemna trisulca*	Forked duckweed	6	X	X
	Wolffia spp.	Watermeal species	N/A		X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species
** = Species listed as 'special concern' in Wisconsin*

Table 4.5-1 displays the aquatic plant species located in Eagle Lake during the 2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2007. Additionally, there were species found in 2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Eagle Lake's aquatic plant frequency of occurrence is presented later on within this section.

Of the 41 native and one non-native aquatic plant species sampled during the 2013 point-intercept survey, fern pondweed, common waterweed, and coontail were the most frequently encountered (Figure 4.5-2). Fern pondweed is a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. Able to obtain the majority of their essential nutrients directly from the water, common waterweed and coontail do not produce extensive root systems, making them susceptible to uprooting by water-action and water movement. These three species are widely distributed throughout Wisconsin lakes, as well as many other regions of North America.

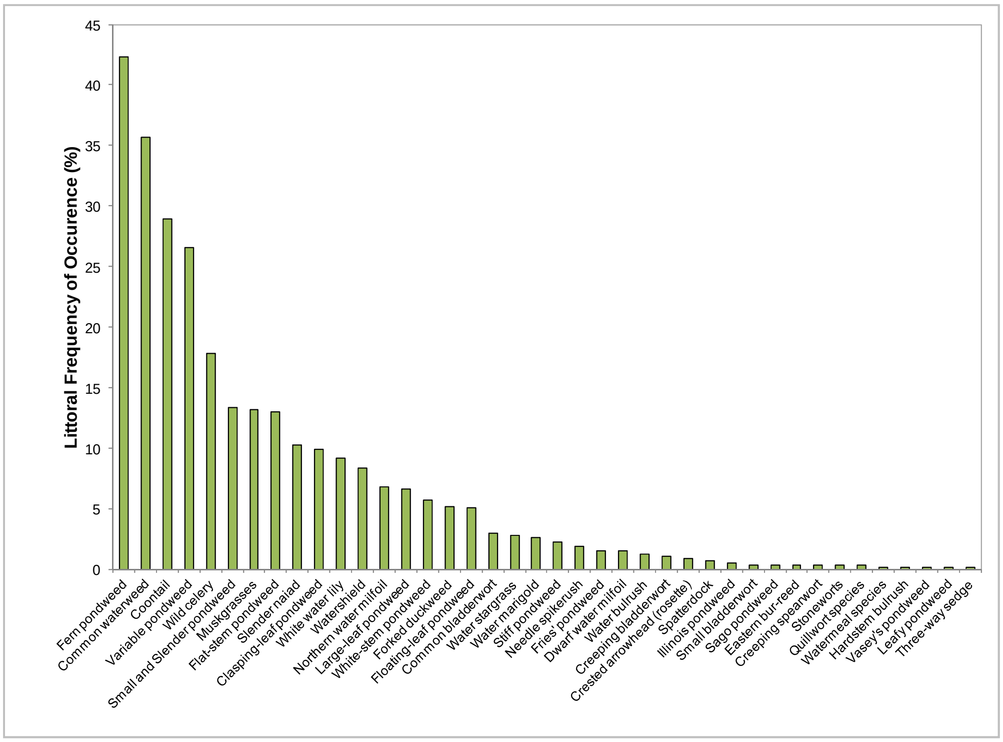


Figure 4.5-2. Eagle Lake aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Eagle Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While Figure 4.5-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.5-3 displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas fern pondweed has a 42% frequency of occurrence, it has a relative occurrence of 15% when compared to the other plant species. This means that if 100 aquatic plants were randomly sampled from Eagle Lake, it would be expected that 15 of them would be fern pondweed. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Eagle Lake is not overly dominated by a single or few species.

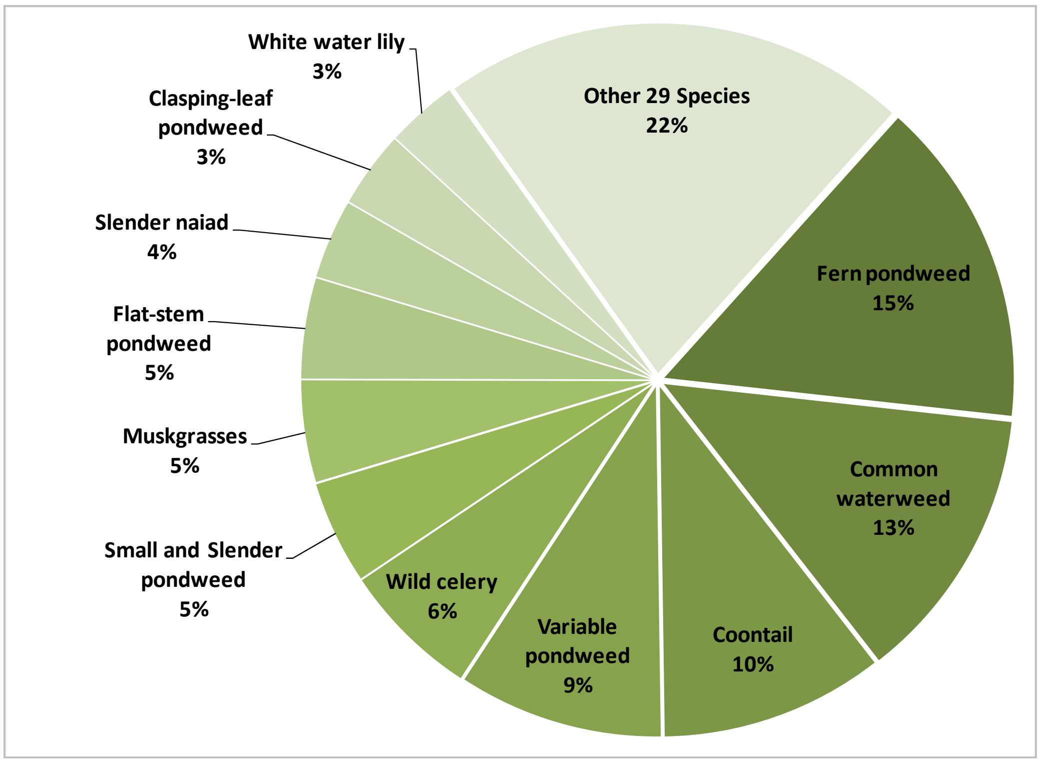


Figure 4.5-3. Eagle Lake aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Eagle Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.5-4). Using the data collected from the 2007 and 2013 point-intercept survey, Eagle Lake's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.92 in 2013, falling above the upper quartile value for lakes in both the ecoregion and the state. This value was determined to be very similar (0.93) in 2007.

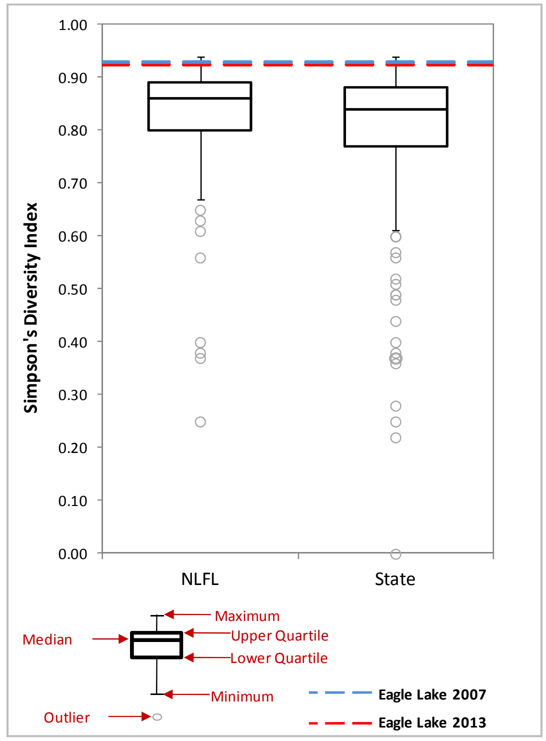


Figure 4.5-4. Eagle Lake species diversity index. Created using data from 2007 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 50 native aquatic plant species were found in Eagle Lake during the 2013 survey, 41 were sampled directly and nine were incidentally located. These 41 native species and their conservatism values were used to calculate the FQI of Eagle Lake's aquatic plant community in 2013. The FQI was also calculated based on the species located during the 2007 survey.

Figure 4.5-5 compares the FQI components of Eagle Lake from the 2007 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2007 as well as 2013, Eagle Lake's native species richness is much higher than the median values for lakes within the ecoregion and the state. The average conservatism values in 2007 (6.5) and 2013 (6.9) exceed the state medians, and the 2013 value exceeds the ecoregion value. Combining Eagle Lake's native species richness and average conservatism values yields a FQI value of 41.9 for the 2007 dataset, and 44.2 in the 2013 dataset, both of which greatly exceeds the ecoregion and state median values. Further, these data indicate that the aquatic plant community of Eagle Lake has held its richness, diversity and overall quality during this five-year management project.

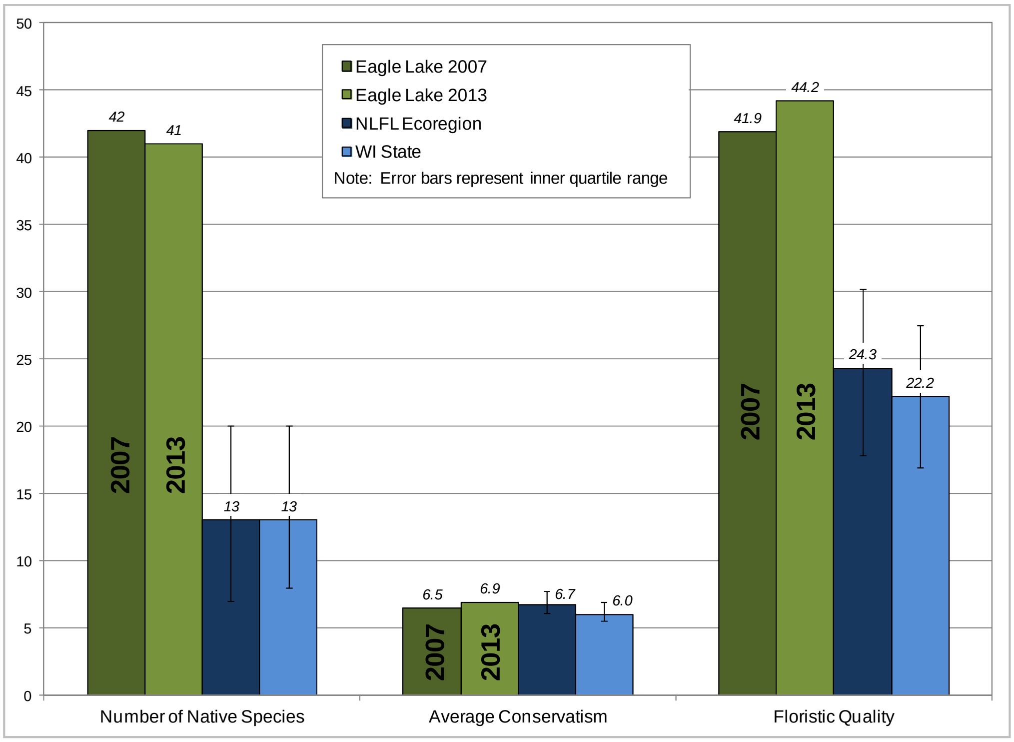


Figure 4.5-5. Eagle Lake Floristic Quality Index values. Created using data from 2007 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

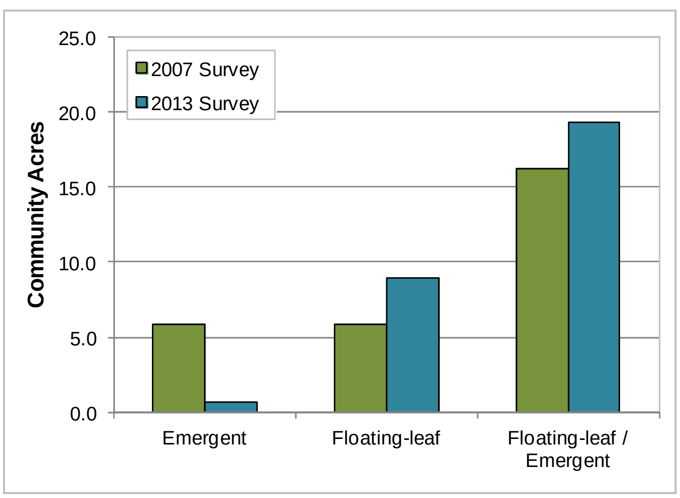


Figure 4.5-6. Eagle Lake community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Eagle Lake to map emergent and floating-leaf communities. As Figure 4.5-6 illustrates, the spatial coverage of these species changed during this timeframe. Emergent communities decreased from 5.9 acres in 2007 to 0.7 acres in 2013, while the acreage of floating-leaf communities increased from 5.9 to 9.0 acres. The acreage of combined floating-leaf/emergent communities increased slightly during this time frame. Overall, total acreage of these communities increased from 28.0 acres in 2007 to 29.0 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Eagle Lake, an analysis between 2007 and 2013 datasets is presented below. Eurasian water milfoil cannot be analyzed in this case due to its very low occurrence in Eagle Lake, it was not observed at any point-intercept location during both the 2007 or 2013 surveys. A Chi-square distribution analysis (α = 0.05) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence as the primary indicator. Figure 4.5-7 displays the littoral occurrences of native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that have occurred in Eagle Lake.

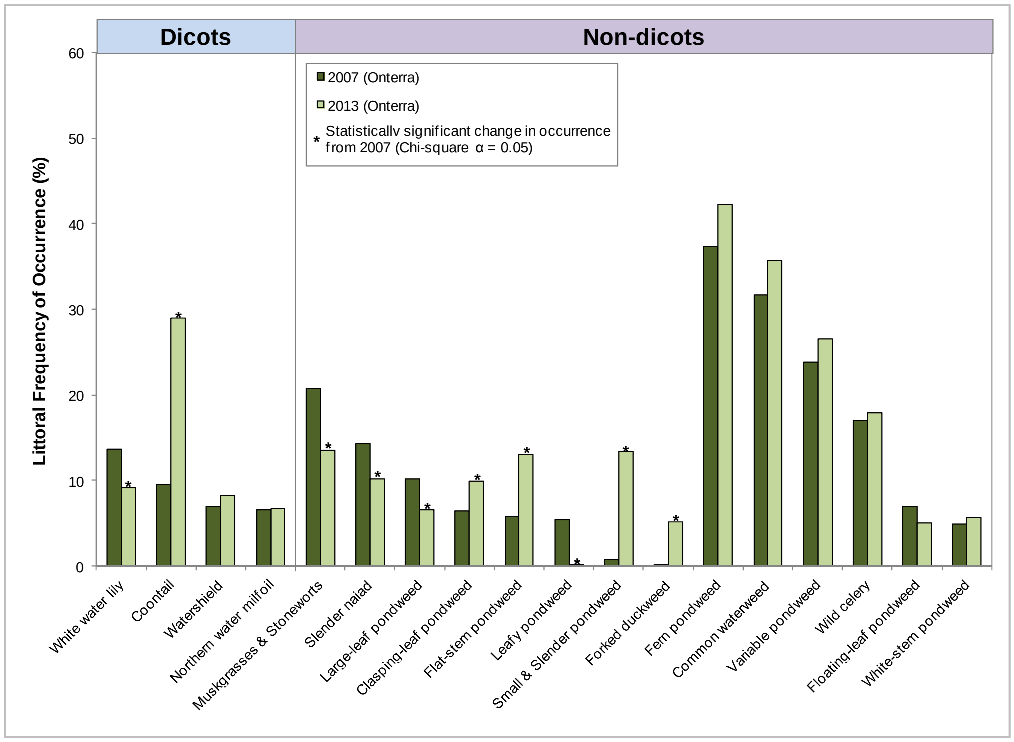


Figure 4.5-7. Eagle Lake littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2007 and 2013 point-intercept surveys.

Five of the native aquatic plant species that had an occurrence of at least 5% in 2007 or 2013 saw statistically significant increases in their littoral occurrence, while five native species saw a statistically significant change as a decrease of their frequency of occurrence.

Figure 4.5-8 displays the Eurasian water milfoil peak biomass results from several consecutive years of surveys. In 2008 several single plants were hand-removed from the northern end of Eagle Lake as it leads into Twin Bear Lake. Following removal of these plants, no Eurasian water milfoil was observed within Eagle Lake in 2009 or 2010. In 2011 and 2012, several plants were observed in the lake that brought about small herbicide treatments. It was hopeful that these treatments would prevent establishment of the invasive in Eagle Lake and prevent its spread to other areas. However, with the results of the 2013 survey it became apparent that Eurasian water milfoil has gained a foothold within Eagle Lake.

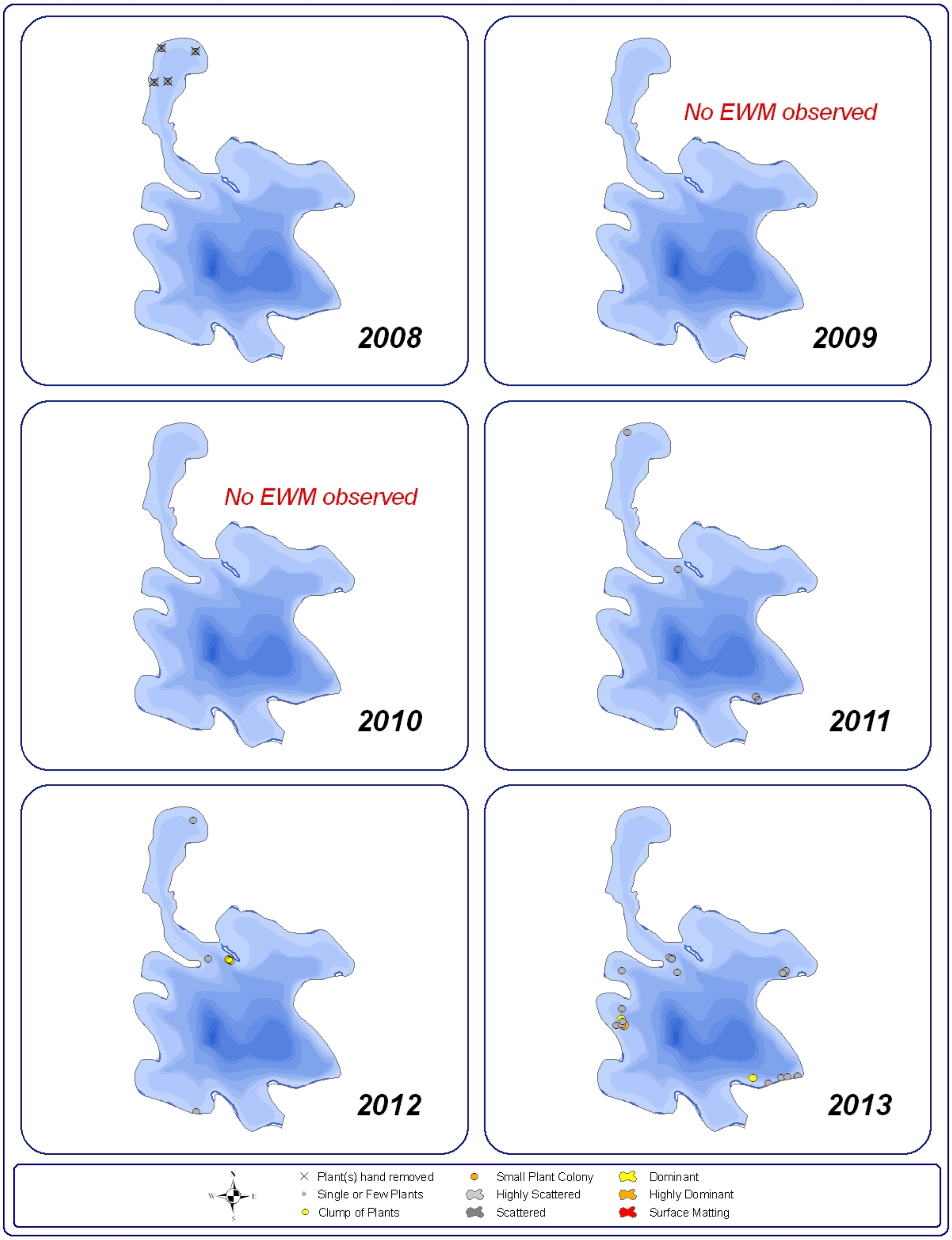


Figure 4.5-8. Eagle Lake Eurasian water milfoil peak-biomass mapping results, 2008-2013. Maps indicate qualitative mapping survey results, conducted in late summer of each respective year. Please note that no Eurasian water milfoil was observed within Eagle Lake in 2007.

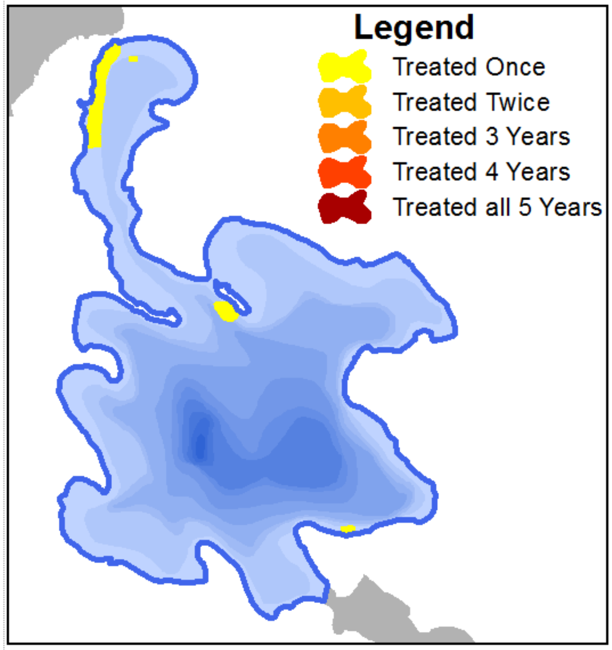
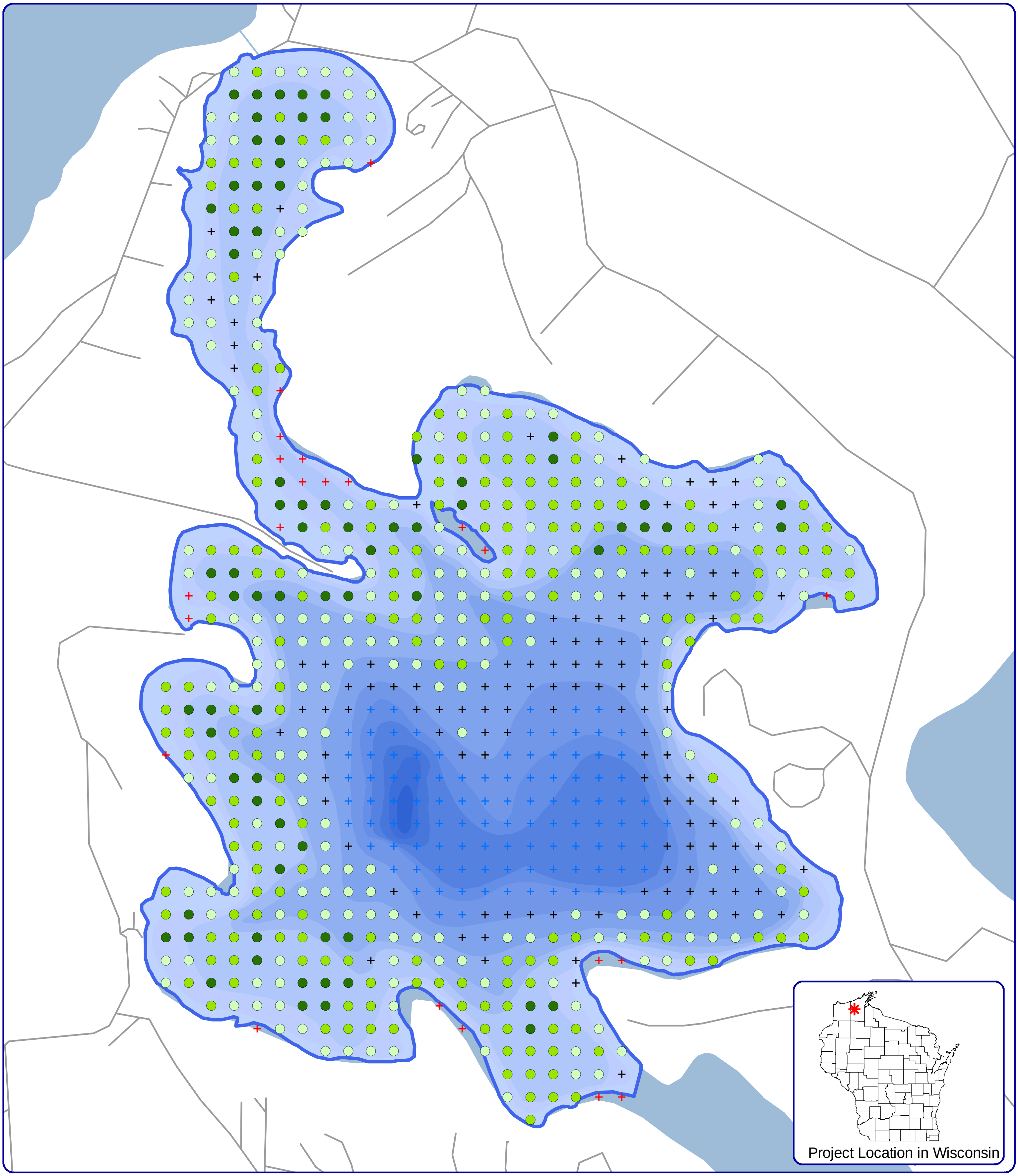
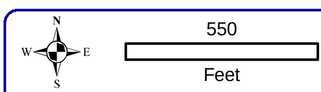


Figure 4.5-9. Surface acreage of Eurasian water milfoil treated on Eagle Lake, 2009-2013.

As shown in Figure 4.5-9, 0.8 acres of Eagle Lake have been targeted for Eurasian water milfoil control during the five year project, with 100% of the areas only be treated once. This acreage represents approximately 2.6% of Eagle Lake's littoral zone (>20 ft). The low-density Eurasian water milfoil populations targeted for control have been extremely successful, not warranting retreatment. Much of these treatments occurred in later years of the project, where lake managers have incrementally adapted more aggressive dosing patterns.

Overall, the aquatic plant studies conducted on Eagle Lake have indicated that the native aquatic plant community of the lake has remained relatively unchanged over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have all remained consistent between 2007 and 2013, and healthy populations of native aquatic plants are still found within Eagle Lake.





Legend

2013 Total Rake Fullness

- No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- Too Deep
- Non-navigable/Temporary Obstacle

Map 1
Eagle Lake
Bayfield County, Wisconsin

2013 PI Survey: Aquatic Vegetation Distribution

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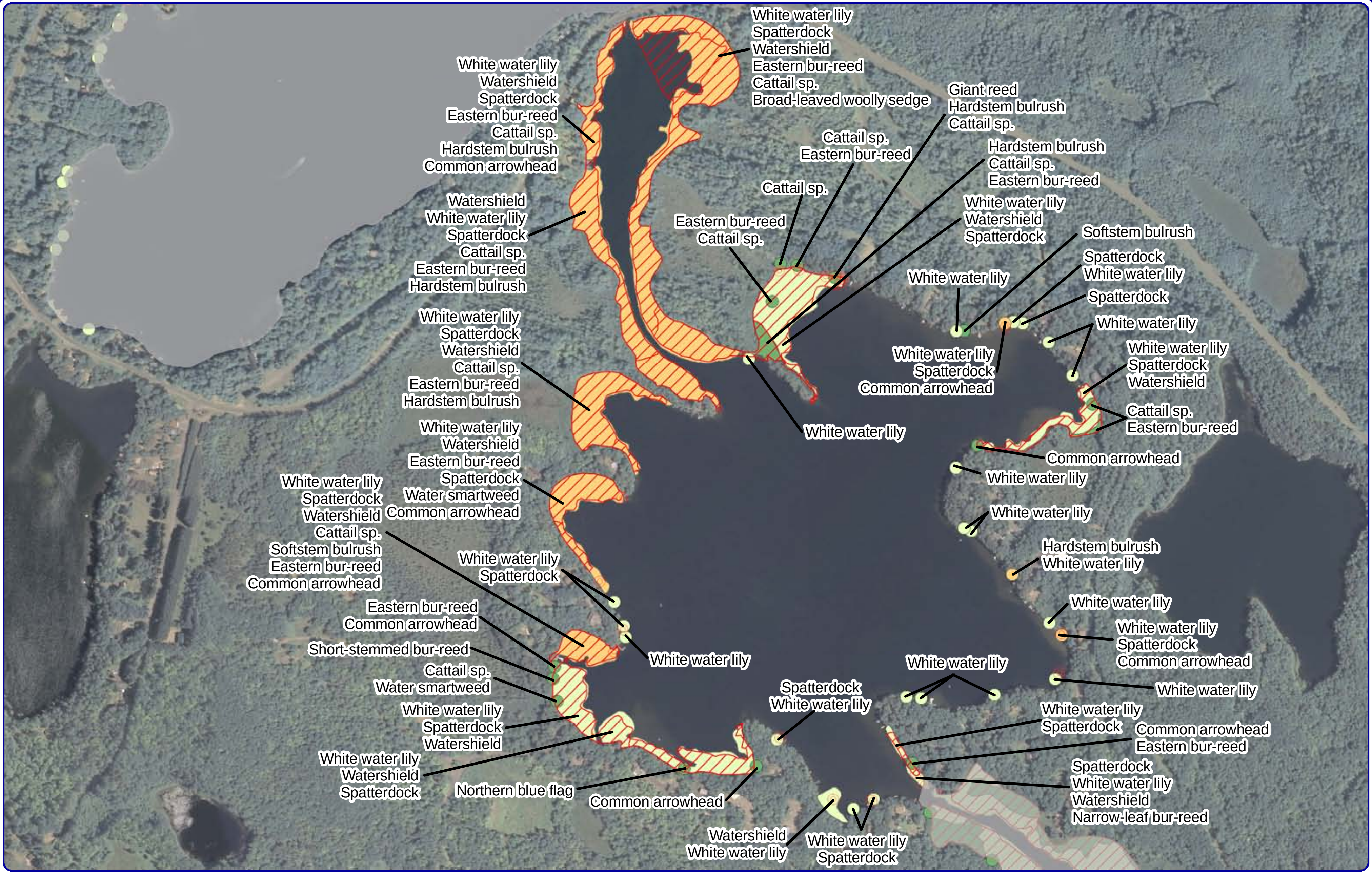
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_Eagle_2013_TRFPI.mxd



N
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750

Feet

Onterra LLC
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815 Prosper Road
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Sources:
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: October 31, 2013
Filename: Eagle_Comm_2013.mxd

Project Location in Wisconsin

Legend

2007 Communities
Large Plant Community
Small Plant Community

Small Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent

Large Plant Communities
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent

Map 2
Eagle Lake
Bayfield County, Wisconsin

Aquatic Plant Communities

4.6 Flynn Lake

Flynn Lake is 29 acres in size, and is the furthest downstream of the six Pike Chain of Lakes. Comprehensive aquatic plant studies, including the point-intercept survey, community mapping survey and Eurasian water milfoil peak biomass mapping survey were completed by Onterra on August 8, 2013 (Figure 4.6-1). During this survey, a total of 38 aquatic plant species were located, none of which are considered to be non-native (Table 4.6-1). Of the 38 native species that were encountered, 32 of these were sampled during the point-intercept survey and six were found incidentally during studies on the lake. Comparatively, 38 species were found during the point-intercept survey in 2007 with three being found incidentally that year (Table 4.6-1).

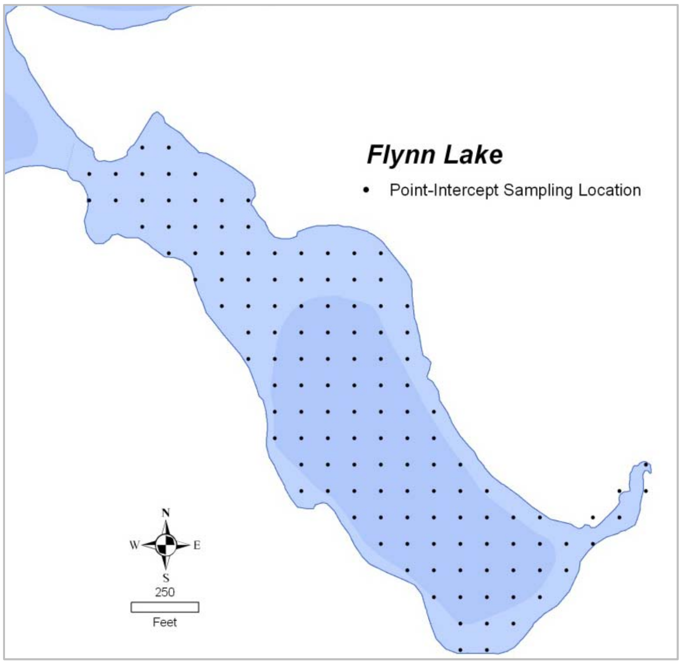


Figure 4.6-1. Point-intercept locations on Otter Lake.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. As a result of this survey, it was determined that 89% of the point-intercept locations within littoral areas consisted of fine, organic sediments (muck), 10% contained sand, and 1% contained rock.

During the 2013 point-intercept survey, aquatic plants were found growing throughout the entire lake (maximum depth is eight feet). Plants were throughout the entire lake in 2007 as well. In fact, aquatic vegetation was found at 94% of point-intercept sampling locations in 2013, and 99% of locations in 2007. Flynn Lake Map 1 displays the point-intercept locations that contained aquatic vegetation in 2013, and the total rake-fullness ratings at those locations.

Table 4.6-1. Aquatic plant species located in Flynn Lake during 2007 and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2007 (Onterra)	2013 (Onterra)
Emergent	*Calla palustris*	Water arum	9	X	
	Carex comosa	Bristly sedge	5	I	I
	Dulichium arundinaceum	Three-way sedge	9	X	X
	Eleocharis palustris	Creeping spikerush	6		I
	Iris versicolor	Northern blue flag	5		I
	Sagittaria latifolia	Common arrowhead	3	X	
	Schoenoplectus acutus	Hardstem bulrush	5	X	X
	Sparganium sp. (sterile)	Bur-reed sp. (sterile)	N/A		X
	Typha spp.	Cattail spp.	1	X	I
FL	*Brasenia schreberi*	Watershield	7	X	X
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
	Persicaria amphibia	Water smartweed	5	I	
FL/E	*Sparganium americanum*	Eastern bur-reed	8	X	I
	Sparganium angustifolium	Narrow-leaf bur-reed	9	X	I
	*Sparganium glomeratum**	Northern bur-reed	8	X	
Submergent	*Bidens beckii*	Water marigold	8	X	X
	Ceratophyllum demersum	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10	X	
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum tenellum	Dwarf water milfoil	10		X
	Najas flexilis	Slender naiad	6	X	X
	Nitella spp.	Stoneworts	7	X	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton foliosus	Leafy pondweed	6	X	
	Potamogeton friesii	Fries' pondweed	8		X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8		X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Ranunculus aquatilis	White water-crowfoot	8		X
	Stuckenia pectinata	Sago pondweed	3	X	
	Utricularia gibba	Creeping bladderwort	9	X	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X	
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5		X
	Sagittaria cristata (rosette)	Crested arrowhead (rosette)	9	X	X
	Sagittaria graminea	Grass-leaved arrowhead	9	X	
	Schoenoplectus subterminalis	Water bulrush	9	X	X
FF	*Lemna minor*	Lesser duckweed	5	X	
	Lemna trisulca	Forked duckweed	6		X
	Riccia fluitans	Slender riccia	7	I	

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species
** = Species listed as 'threatened' in Wisconsin*

Table 4.6-1 displays the aquatic plant species located in Flynn Lake during the 2007 and 2013 aquatic plant surveys. The vast majority of species observed in 2007 were found in 2013 as well. Some species were found in 2013 that were not observed in 2007. Additionally, there were species found in 2007 that were not observed in 2013. It is possible that species, particularly those occurring infrequently in the lake, were simply found during one survey but not during the other due to their low occurrence. A statistical analysis of changes in Flynn Lake's aquatic plant frequency of occurrence is presented later on within this section.

Of the 38 native aquatic plant species sampled during the 2013 point-intercept survey, fern pondweed, variable waterweed, and large-leaf pondweed were the most frequently encountered (Figure 4.6-2). Fern pondweed is a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. Variable pondweed is a submersed plant that produces a thin, cylindrical stem that has numerous branches. This plant hybridizes easily with other pondweed (*Potamogeton*) species; thus, this plant can appear quite variable in size and shape and is named appropriately. Large-leaf Pondweed has the broadest leaf (3.5-7 cm wide) of any pondweed in our region. These leaves are arched and slightly folded, and often take on a reddish appearance. The plant is commonly referred to as "musky cabbage" or "cabbage" because of the fish species that prefers to hunt prey within it and also because of its appearance.

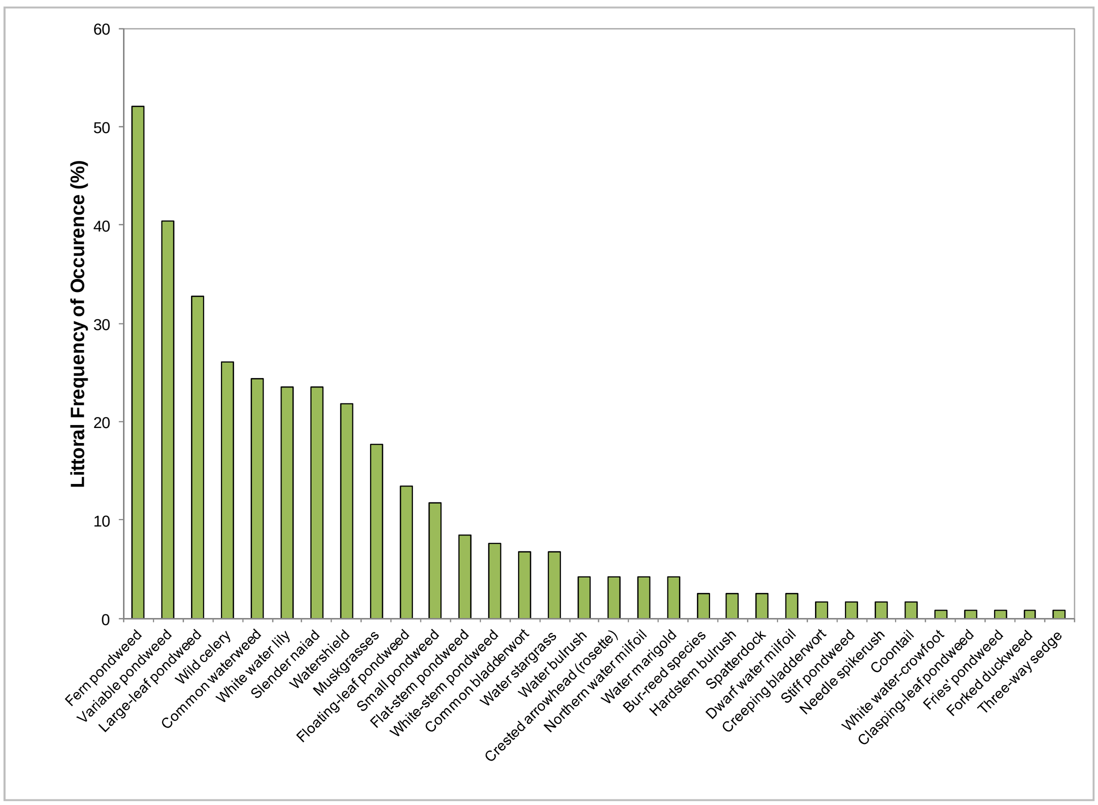


Figure 4.6-2. Eagle Lake aquatic plant littoral frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

As explained in the primer section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Flynn Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While Figure 4.6-2 displays a frequency of occurrence of species sampled during the point-intercept survey, Figure 4.6-3 displays a different type of frequency – the relative frequency of occurrence. This graphic illustrates the relative abundance of species within the community to one another. For example, whereas fern pondweed has a 52% frequency of occurrence, it has a relative occurrence of 15% when compared to the other plant species. This means that if 100 aquatic plants were randomly sampled from Flynn Lake, it would be expected that 15 of them would be fern pondweed. This is an indication of diversity within the plant community; if a community were highly dominated by one or two species (an unfavorable condition), these few species would have a high relative frequency of occurrence. As illustrated, the aquatic plant community of Flynn Lake is not overly dominated by a single or few species.

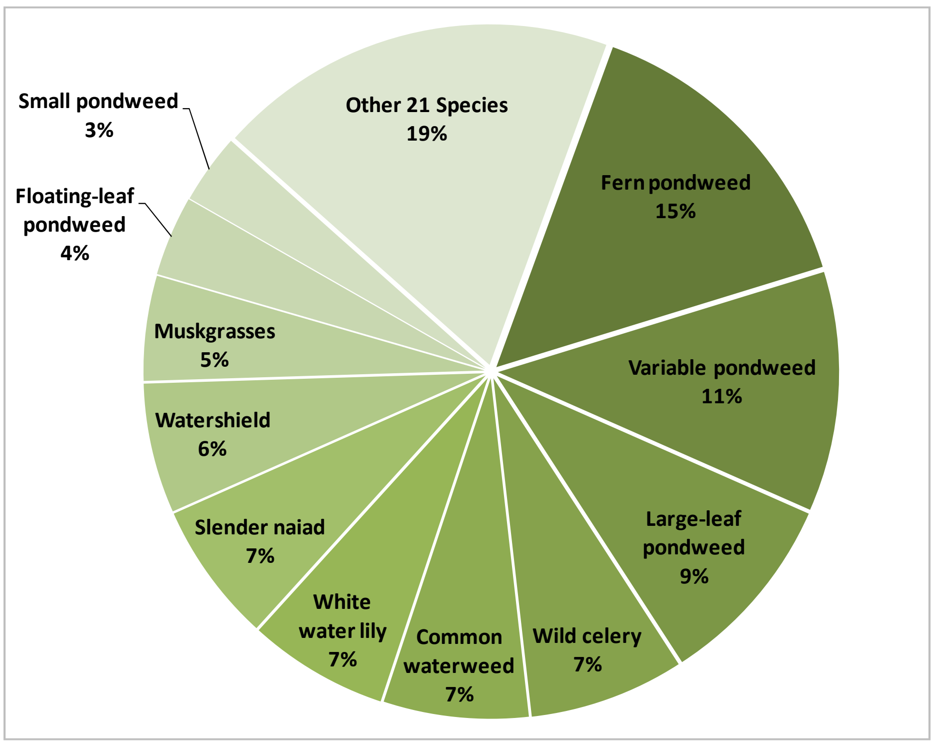


Figure 4.6-3. Flynn Lake aquatic plant relative frequency of occurrence. Created using data from a 2013 aquatic plant point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Flynn Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.6-4). Using the data collected from the 2007 and 2013 point-intercept survey, Flynn Lake's aquatic plant community was shown to have high species diversity with a Simpson's diversity value of 0.93 in 2013, falling above the upper quartile value for lakes in both the ecoregion and the state. This value was determined to be very similar in 2007.

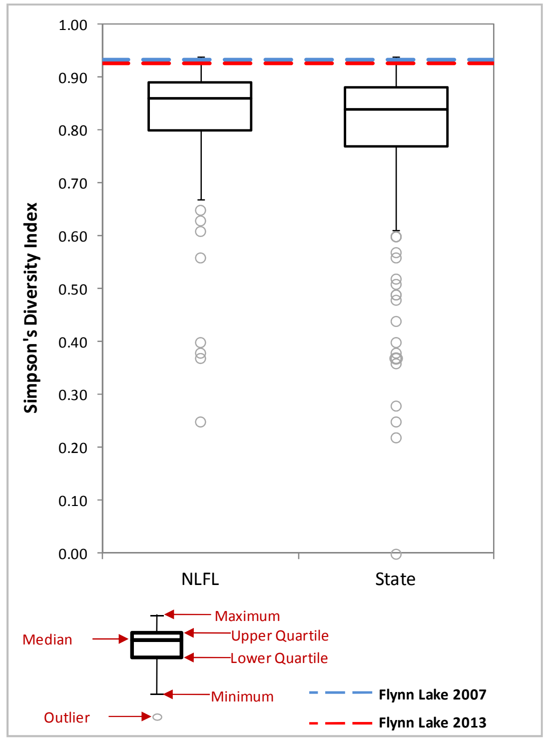


Figure 4.6-4. Flynn Lake species diversity index. Created using data from 2007 and 2013 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 38 native aquatic plant species were found in Flynn Lake during the 2013 survey, 32 were sampled directly and six were incidentally located. These 32 native species and their conservatism values were used to calculate the FQI of Flynn Lake's aquatic plant community in 2013. The FQI was also calculated based on the species located during the 2007 survey.

Figure 4.6-5 compares the FQI components of Flynn Lake from the 2007 and 2013 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2007 as well as 2013, Flynn Lake's native species richness is much higher than the median values for lakes within the ecoregion and the state. The average conservatism values in 2007 (6.7) and 2013 (6.8) exceed the state medians, and the 2013 value exceeds the ecoregion value. Combining Flynn Lake's native species richness and average conservatism values yields a FQI value of 41.0 for the 2007 dataset, and 38.5 in the 2013 dataset, both of which greatly exceeds the ecoregion and state median values. Further, these data indicate that the aquatic plant community of Flynn Lake has held its richness, diversity and overall quality during this five-year management project.

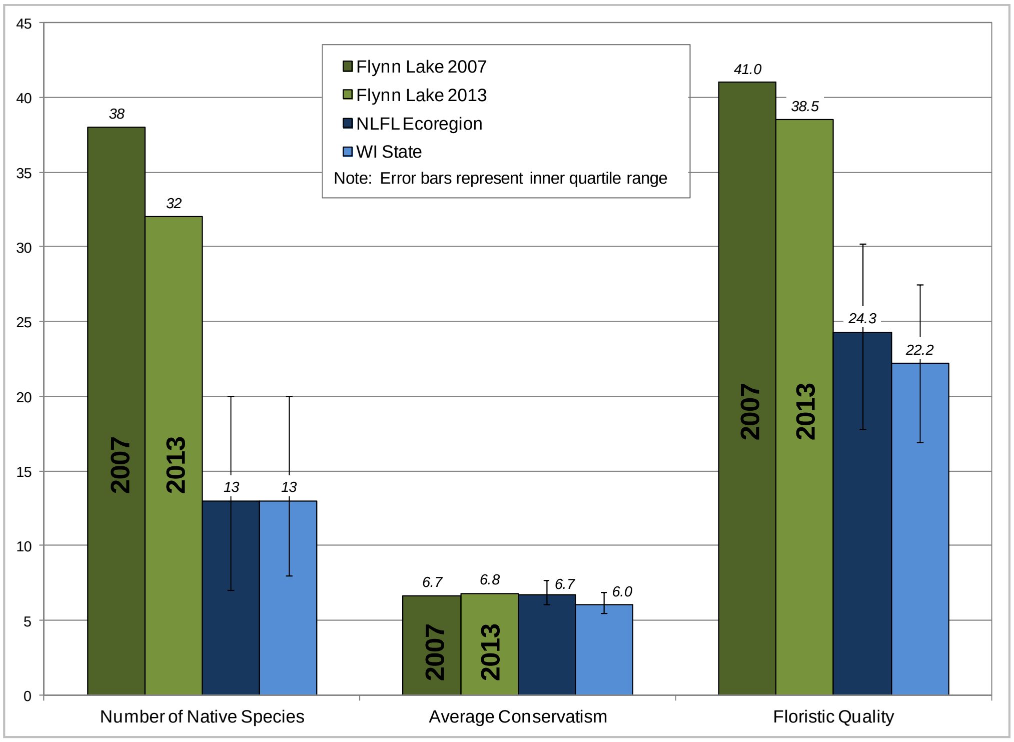


Figure 4.6-5. Flynn Lake Floristic Quality Index values. Created using data from 2007 and 2013 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

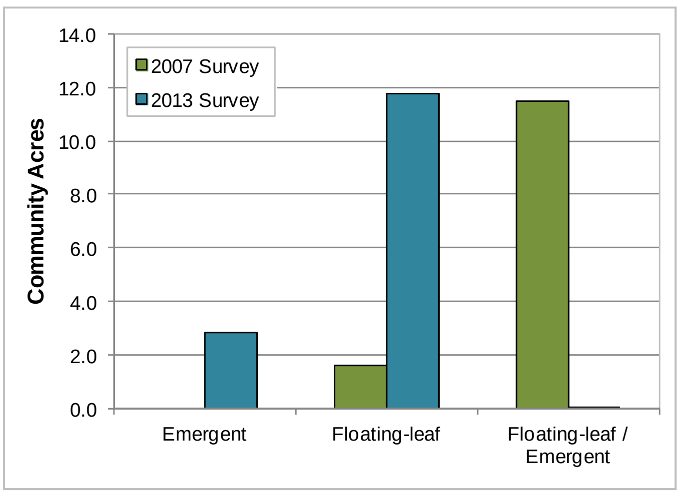


Figure 4.6-6. Flynn Lake community mapping comparison, 2007 to 2013.

Community mapping surveys were completed in 2007 and 2013 on Flynn Lake to map emergent and floating-leaf communities. As Figure 4.6-6 illustrates, the spatial coverage of these species changed during this timeframe. Emergent communities, not found during 2007, increased to 2.8 acres of coverage in 2013. Floating-leaf acres also increased from 1.6 to 11.8 acres. The species composition within these locations are changing, as the number of combined floating-leaf/emergent communities decreased from 11.5 acres to under 0.1 acres in 2013. This is an indication that what was observed to be combined floating-leaf and emergent communities in 2007 are now either emergent or floating-leaf communities. Overall, total acreage of these communities increased from 13.1 acres in 2007 to 14.7 acres in 2013.

To determine if any changes have occurred within the aquatic plant community during the Eurasian water milfoil control project on Flynn Lake, an analysis between 2007 and 2013 datasets is presented below. Eurasian water milfoil cannot be analyzed in this case because it is not believed to exist in Flynn Lake as it does in the rest of the Pike Chain of Lakes. A Chi-square distribution analysis ($\alpha = 0.05$) was used to determine if there were any statistically significant changes in the plant community during this time period, using frequency of occurrence during the point-intercept survey as the primary indicator. Figure 4.6-7 displays the littoral occurrences of native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys.

Ten of the native aquatic plant species that had an occurrence of at least 5% in 2007 or 2013 saw statistically significant decreases in their littoral occurrence, while one native species saw a statistically significant change as an increase of its frequency of occurrence. During this time period, no herbicide treatments were conducted directly on Flynn Lake. Being the furthest downstream of the Pike Chain of Lakes, one may suggest that the herbicide from upstream lakes may funnel through Flynn Lake, causing the slight native population changes observed. While it is true that herbicide dissipation generally moves in the direction of flow, the diluted herbicide concentrations that the plant community of Flynn Lake may be exposed are too low and for too short of an exposure period to cause impacts.

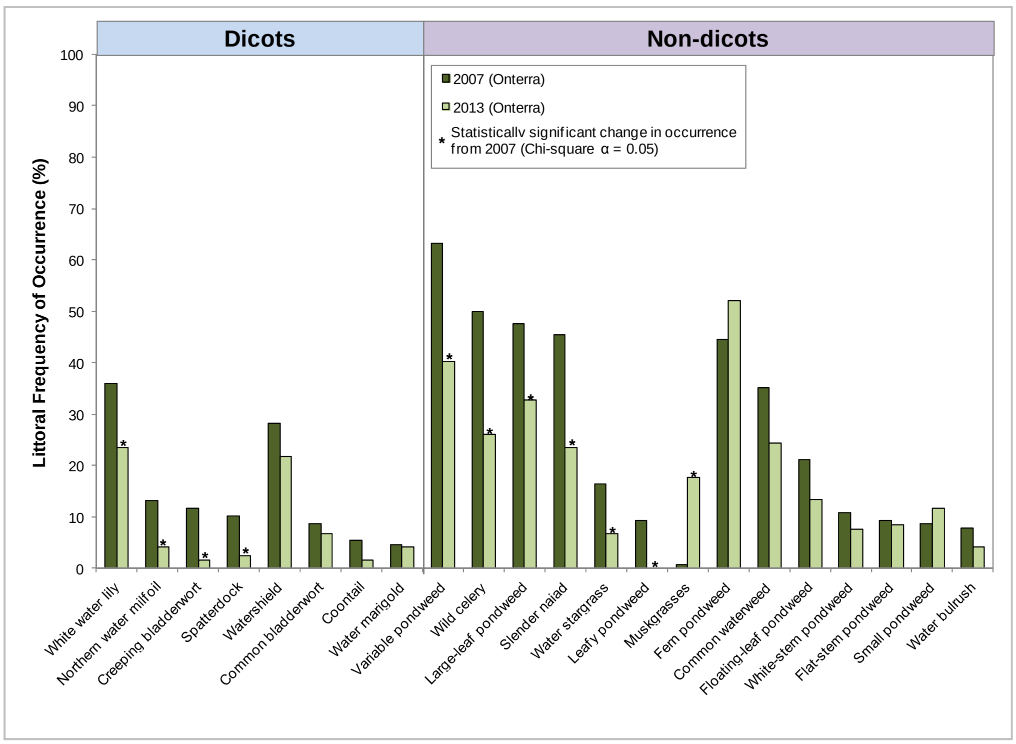
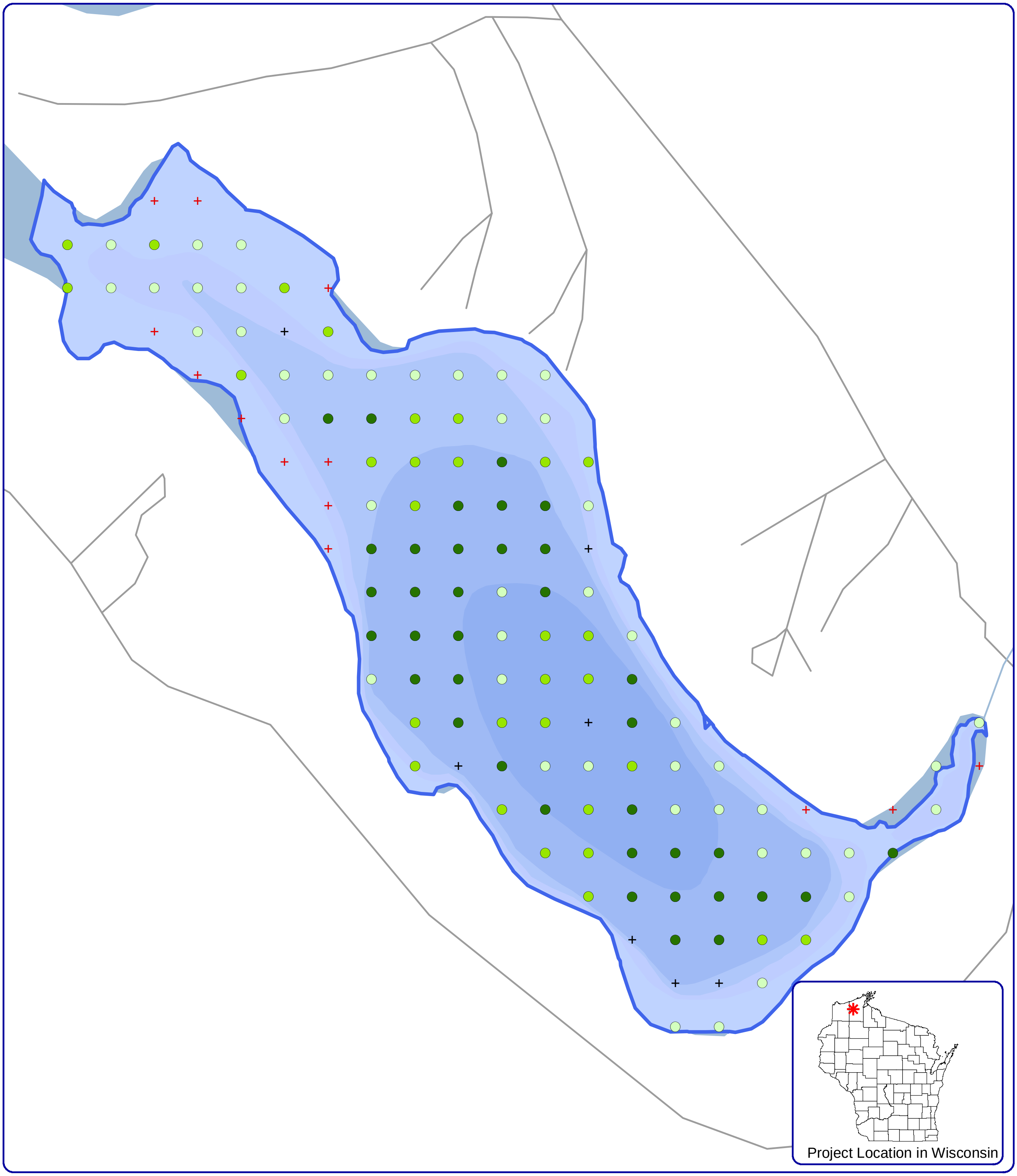


Figure 4.6-7. Flynn Lake littoral frequency of occurrence of select aquatic plant species. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2007 and 2013 point-intercept surveys.

Overall, the aquatic plant studies conducted on Flynn Lake have indicated that the lake's native aquatic plant community has not changed in quality over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity have all remained consistent between 2007 and 2013, and healthy populations of native aquatic plants are still found within Flynn Lake. Furthermore, though some decreases in species abundance have been documented, increases in similar (dicot/monocot) similar species have occurred alongside this, indicating that environmental fluctuations in plant population are the likely cause of this observation.



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Feet

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www.onterra-eco.com

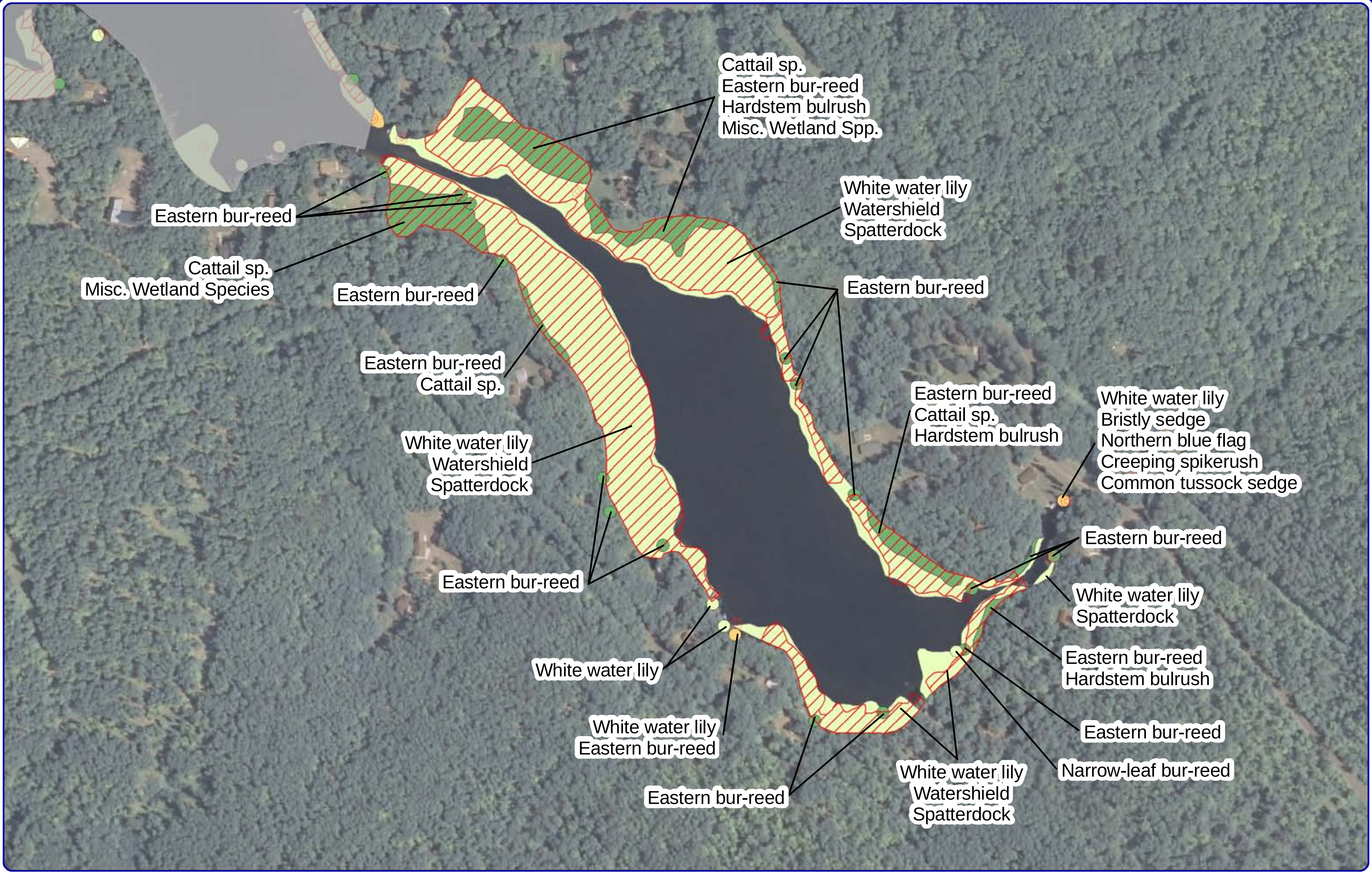
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
PI Survey: Onterra, 2013
Map Date: November 7, 2013
Filename: Map1_Flynn_2013_TRFPI.mxd

Legend

2013 Total Rake Fullness

- + No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- + Too Deep
- + Non-navigable/Temporary Obstacle

Map 1
Flynn Lake
Bayfield County, Wisconsin
2013 PI Survey: Aquatic Vegetation Distribution



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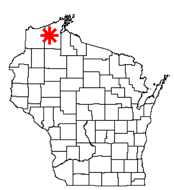
Sources:
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: October 31, 2013
Filename: Flynn_Comm_2013.mxd


Project Location in Wisconsin

Legend

2007 Communities
- Large Plant Community
- Small Plant Community

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Map 2
Flynn Lake
Bayfield County, Wisconsin
Aquatic Plant Communites

5.0 LITERATURE CITED

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