Pleasant Lake

Waushara County, Wisconsin

Supplemental Lake Management Planning Project

September 2014



Sponsored by:

Pleasant Lake Management District

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Onterra LLC
Lake Management Planning

Pleasant Lake
Supplemental Lake Management Planning Project

Waushara County, Wisconsin
September 2014

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1.0 INTRODUCTION

Pleasant Lake, Waushara County, is an approximate 131.5-acre mesotrophic seepage lake (Map 1) with a maximum depth of 30 feet and mean depth of 15 feet at baseline water levels. Pleasant Lake's surficial watershed encompasses approximately 730 acres, the majority of which is comprised of forests (38%) and agricultural lands (28%) (UW-Stevens Point and Waushara County 2013).



Photo 1.0-1. Pleasant Lake, Waushara County, Wisconsin.

Since its creation in 2003, the Pleasant Lake Management District (PLMD) has worked to assure to the lake's continued health by annually monitoring the Pleasant Lake's water quality through the Wisconsin Department of Natural Resources (WDNR) Citizen Lake Monitoring Network, conducting watercraft inspections under the Clean Boats Clean Waters Program, and being involved with the Waushara County Lakes and Watershed Council, the Marquette County Lakes Association, and the Central Sands Water Action Coalition.

Over the past approximately 20 years, Pleasant Lake residents have seen water levels steadily recede. In addition to Pleasant Lake, other area lakes have recorded statistically significant water level reductions (Kraft and Mechenich 2010). In an effort to understand the factors driving this precipitous decline, the PLMD requested assistance from the UW-Extension. Dr. George Kraft, who has conducted studies on the hydrology of the Central Sands Region, was asked to complete two reports specifically addressing Pleasant Lake's hydrology. The conclusion drawn from his investigations is that pumping from high capacity wells has had a significant impact on the lowering water level of Pleasant Lake. Data collected by Waushara County indicate that Pleasant Lake's water level has fallen 4.43 feet since 1993.

To not only gain a more holistic understanding of the Pleasant Lake ecosystem, but to understand the current impacts the low water levels are having on the lake's ecosystem and future impacts incurred by continual water level decline, the PLMD has worked with several agencies and consultants that have carried out numerous surveys on Pleasant Lake. In 2010, Waushara County teamed with the UW-Stevens Point Center for Watershed Science to begin assessing the lake management planning needs of the 97 lakes in Waushara County. As the program progressed, lake, watershed, and stakeholder data were collected on many of the lakes, and now, in 2014, the project is in the process of constructing a lake management plan for Pleasant Lake.

The Waushara County project is comprehensive in nature and covers many of the important aspects of lake management planning, including assessments of the lake's water quality, surficial- and ground-watersheds, shoreland zone condition and habitat function, and aquatic plant composition. However, the nature of the project lacks in its ability to help groups such as the PLMD with the development of specific management actions aimed at understanding the

impacts of falling water levels and managing aquatic invasive plants. The primary objective of Onterra, LLC's involvement is to supplement the Waushara County planning efforts with two additional components: 1) investigate the impact of falling water levels of the lake's littoral area, and 2) develop hybrid water milfoil (HWM), curly-leaf pondweed (CLP), and other non-native species management strategies for Pleasant Lake. Following its discovery in 2007, HWM has been targeted with herbicide treatments since 2008 in an effort to reduce this population and its impact to Pleasant Lake's ecology, recreation, and aesthetics. While CLP has likely been in Pleasant Lake for some time, its populations have remained low, and no control actions have yet been implemented. Both continued water level decline and the presence of aquatic invasive species are ecologically significant to Pleasant Lake, and are primary concerns among district members.

Because the most recent bathymetric data from Pleasant Lake was nearly 50 years old, an acoustic survey was conducted by Onterra in 2013 to obtain updated bathymetric data. These data in combination with aquatic plant data were used to create water level reduction scenarios to assess the impact to the floral habitat in Pleasant Lake. To aid in understanding the ecological effects of receding water levels in Pleasant Lake, data collected from a WDNR 2012 fisheries assessment and from a littoral zone habitat survey conducted by Ecological Research Partners, LLC were also employed. In 2013, Onterra ecologists also conducted a freshwater mussel species assessment to catalogue the abundance and species present within the lake. Surveys aimed at locating and quantifying the levels of hybrid water milfoil and curly-leaf pondweed were also conducted in 2013.

First, this report discusses the current condition of Pleasant Lake's native and non-native aquatic plant communities. Aquatic plant data collected in 2012 and 2013 are compared with data collected in 2009 to gain an understanding of how the plant community has changed over this time period. Following discussion on Pleasant Lake's aquatic plant community, the current and potential future impacts of continual water level decline to Pleasant Lake's ecology will be discussed. This discussion incorporates the aquatic plant data collected by UW-Stevens Point and Onterra, LLC, fisheries data from the WDNR, littoral habitat data from Ecological Research Partners, LLC, and mussel assessment data collected by Onterra, LLC. Also included is the Implementation Plan, which includes goals and actions specific to Pleasant Lake's current and future management that were developed by both members of the Pleasant Lake Planning Committee and Onterra ecologists.

2.0 RESULTS AND DISCUSSION

2.1 Primer on Data Analysis and Data Interpretation

Aquatic Plant Sampling Methodology and Data Analysis

Native aquatic plants are an important element in every healthy aquatic ecosystem (Photo 1), providing food and habitat to wildlife, improving water quality, and stabilizing bottom sediments. 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 certain 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.

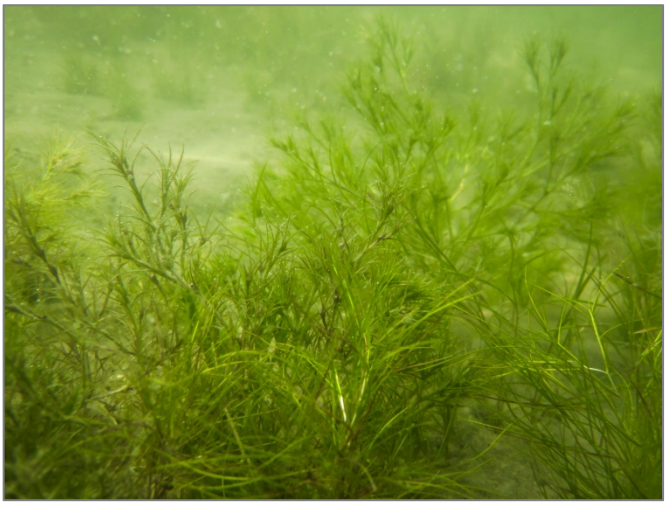


Photo 2.1-1. Native aquatic plants, like slender naiad and sago pondweed in Pleasant Lake (pictured), are an important component in maintaining a healthy aquatic ecosystem.

The **Littoral Zone** is the area of the lake where sunlight is able to penetrate and provide aquatic plants with sufficient light to carry out photosynthesis.

The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) was conducted in Pleasant Lake in 2009 by Onterra and in 2012 by UW-Stevens Point. Based upon guidance from the WDNR, a point spacing (resolution) of 34 meters was used resulting in 419 sampling points being evenly distributed across the lake (Map 1). 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 2.2-1) on the sampling rake were recorded.

A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 14 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 14 feet. Depth information was collected using graduated marks on the pole of the rake or using an onboard sonar unit at depths greater than 14 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. The 2009 and 2012 data are analyzed and compared and are presented in numerous ways; each is discussed in more detail the following section.

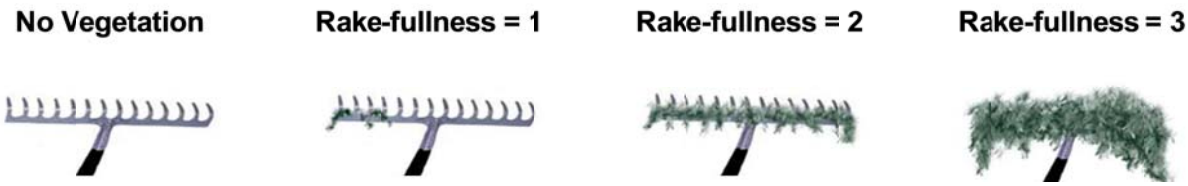


Figure 2.1-1. Aquatic plant rake-fullness ratings. Adapted from Hauxwell et al (2010).

Species List

The species list is simply a list of all of the aquatic plant species, both native and non-native, that were located during the 2009 and 2012 surveys on Pleasant Lake. 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 survey conducted on Pleasant Lake in 2009 and 2012, plant samples were collected from plots laid out on a grid that covered the 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 equal to or less than the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake is calculated using its native aquatic plant species richness and those species' average conservatism values. Species richness is simply the number of aquatic plant species that occur in the lake, and 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 can survive 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 survey. The floristic quality of Pleasant Lake's aquatic plant community will be compared to other lakes within the same *ecoregion*. Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Pleasant Lake falls within the North Central Hardwood Forests Ecoregion of Wisconsin (Figure 2.1-2).

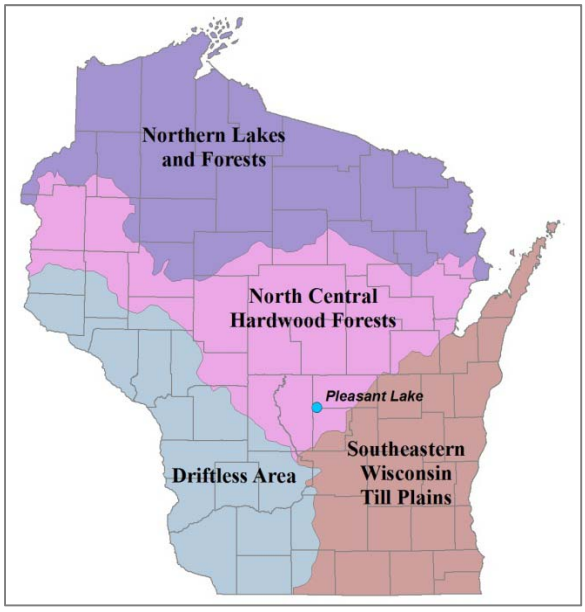


Figure 2.1-2. Location of Pleasant Lake within the ecoregions of Wisconsin. After Nichols (1999).

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 Pleasant Lake. Comparisons will be displayed using *boxplots* that show median values and upper/lower quartiles of lakes in the same ecoregion and in the state.

Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

Community Mapping

A key component to understanding a lake's aquatic plant community is the creation of an aquatic plant community map. The map represents a snapshot of the important emergent and floating-leaf plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. Examples of these communities include emergent species like cattails, bulrushes, and arrowheads, and floating-leaf species like white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible. Community mapping surveys were conducted in both 2009 and 2013 on Pleasant Lake.

2.2 Aquatic Plant Survey Results

On July 9, 2012, UW-Stevens Point Center for Watershed Science and Education staff conducted the whole-lake point-intercept survey on Pleasant Lake, while Onterra ecologists conducted the community mapping survey on September 26, 2013. During these surveys, a total of 36 aquatic plant species were located (Table 2.2-1). Four of these species, hybrid water milfoil, curly-leaf pondweed, giant reed, and reed canary grass are considered to be non-native, invasive species. Because of their importance, these invasive species will be discussed in detail in the next section. Of the 36 species located in 2012 and 2013, 24 were located during the 2009 point-intercept and community mapping surveys.

During the 2012 point-intercept survey, aquatic plants were found growing to a maximum depth of 24 feet, slightly deeper than the 22 feet recorded in 2009. Pleasant Lake has relatively high water clarity (average 2012 Secchi disk transparency = 10 feet), allowing sunlight to penetrate to deeper depths and sustain aquatic plant growth. In 2012, 413 sampling locations fell within Pleasant Lake's littoral zone (≤24 feet), compared to 386 in 2009 (≤22 feet). The difference in the number of littoral sampling locations between 2009 and 2012 is due to differences in the maximum depth of aquatic plant growth between the two surveys.

Of the 413 sampling locations that fell within the littoral zone in 2012, 259 (62%) contained aquatic vegetation. Similarly, in 2009, of the 386 littoral sampling locations, 260 (67%) contained aquatic vegetation. Chi-square analysis indicates that the overall occurrence of aquatic vegetation in Pleasant Lake was not statistically different between the 2009 and 2012 surveys ($\alpha = 0.05$) (Figure 2.2-1). Figure 2.2-2 displays the distribution of aquatic plants in Pleasant Lake as determined from the 2009 and 2012 point-intercept surveys, and illustrates that there were no significant changes in the spatial distribution of aquatic plants over this time period.

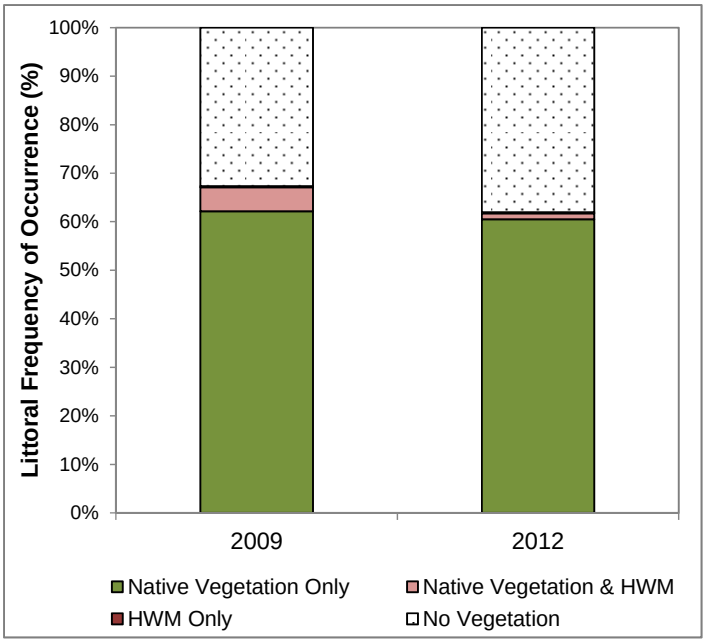


Figure 2.2-1. Pleasant Lake 2009 and 2012 littoral frequency of occurrence of native and non-native aquatic vegetation. Calculated using data from 386 and 413 littoral sampling locations from Onterra 2009 and UWSP point-intercept surveys, respectively.

Of the 36 aquatic plant species located during 2012 and 2013 surveys on Pleasant Lake, 24 were physically encountered on the rake during the whole-lake point-intercept survey; the remaining 12 species were located incidentally. Of the 24 species encountered on the rake, muskgrasses, flat-stem pondweed, and wild celery were the three-most frequently encountered (Figure 2.2-3).

Muskgrasses, the most frequently encountered aquatic plants in 2012, had a littoral frequency of occurrence of approximately 52% (Figure 2.2-3). A genus of macroalgae, muskgrasses are not true vascular plants, and are often abundant in lakes like Pleasant

Lake that are clear with higher alkalinity. While several species of muskgrasses occur in Wisconsin, the muskgrasses in Pleasant Lake were not identified to the species level. Often growing in dense beds to depths greater than most vascular plants, muskgrasses stabilize bottom sediments, provide excellent structural habitat for aquatic organisms, and are sources of food for fish, waterfowl, and other wildlife (Borman et al. 1997).

Table 2.2-1. Aquatic plant species located in Pleasant Lake in 2009, 2012, and 2013 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2009 (Onterra)	2012/2013 (UWSP & Onterra)
Emergent	*Carex hystericina*	Porcupine sedge	3		I
	Carex lacustris	Lake sedge	6	I	
	Carex stricta	Common tussock sedge	7		I
	Eleocharis erythropoda	Bald spike-rush	3	I	I
	Eleocharis palustris	Creeping spikerush	6		X
	Juncus arcticus	Arctic rush	5		I
	Phalaris arundinacea	Reed canary grass	Exotic		I
	Phragmites australis subsp. *australis*	Giant reed	Exotic		I
	Schoenoplectus acutus	Hardstem bulrush	5	I	I
	Schoenoplectus pungens	Three-square rush	5	I	I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I	I
	Typha angustifolia	Narrow-leaved cattail	1		I
	Typha latifolia	Broad-leaved cattail	1	I	I
FL	*Nymphaea odorata*	White water lily	6	X	X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Chara spp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3		X
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum sibiricum X M. spicatum	Hybrid water milfoil	Exotic	X	X
	Najas flexilis	Slender naiad	6	X	X
	Najas guadalupensis	Southern naiad	7		X
	Nitella spp.	Stoneworts	7	I	X
	Potamogeton amplifolius	Large-leaf pondweed	7		X
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	X
	Potamogeton foliosus	Leafy pondweed	6	X	X
	Potamogeton friesii	Fries' pondweed	8	X	X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton hybrid	Hybrid pondweed	N/A	X	
	Potamogeton illinoensis	Illinois pondweed	6	I	X
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5		X
	Potamogeton strictifolius	Stiff pondweed	8	X	
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Stuckenia pectinata	Sago pondweed	3	X	X
	Utricularia vulgaris	Common bladderwort	7		I
	Vallisneria americana	Wild celery	6	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	I	X
FF	*Spirodela polyrhiza*	Greater duckweed	5		I

FL = Floating-leaf; S/E = Submergent & Emergent; FF = Free-floating
X = Located on rake during point-intercept survey; I = Incidentally located

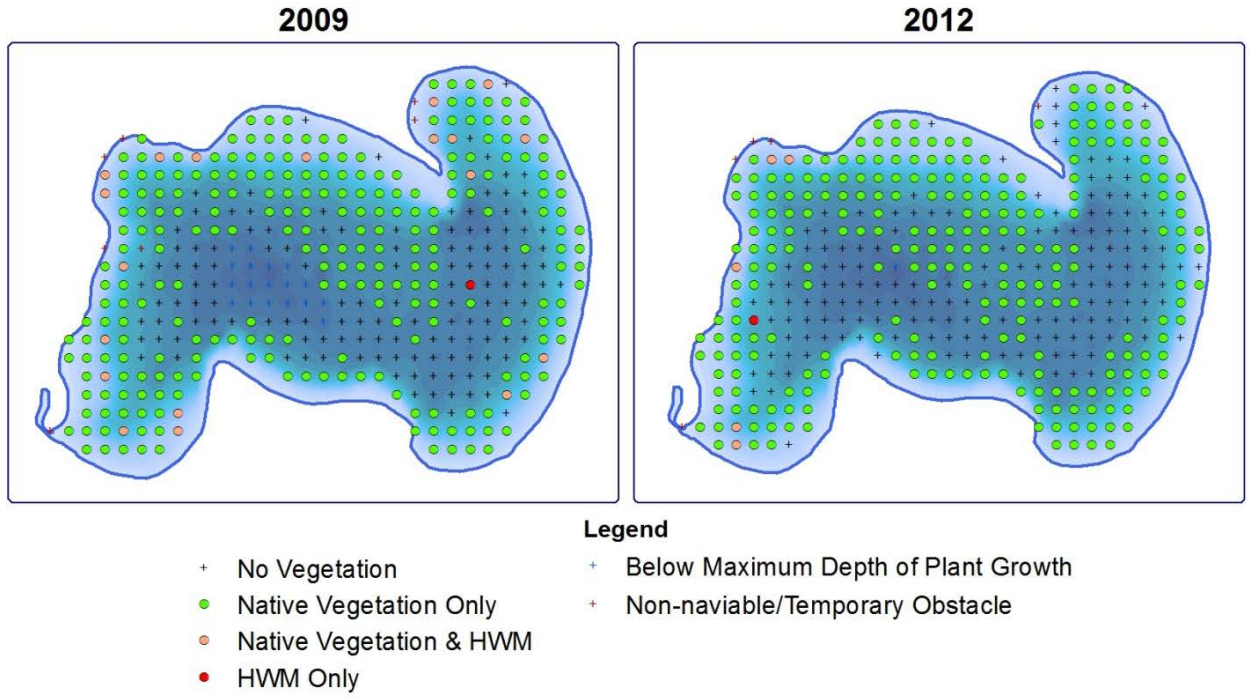


Figure 2.2-2. Pleasant Lake distribution of aquatic vegetation in 2009 and 2012. Created using data from Onterra 2009 and UWSP 2012 point-intercept surveys.

The second-most frequently encountered aquatic plant in Pleasant Lake in 2012 was flat-stem pondweed with a littoral frequency of occurrence of approximately 11% (Figure 2.2-3). Flat-stem pondweed is generally found in lakes with higher productivity, and as its name indicates, possesses a conspicuously flattened stem. Its tall stature offers good habitat while its fruit has been shown to be a good source of food for waterfowl (Borman et al. 1997).

With a littoral frequency of occurrence of approximately 9%, wild celery was the third-most frequently encountered aquatic plant in Pleasant Lake in 2012 (Figure 2.2-3). The long, tapering leaves of wild celery provide excellent structural habitat for numerous aquatic organisms while its extensive root systems stabilize bottom sediments. Additionally, the leaves, fruit, tubers, and winter buds are food sources for numerous species of waterfowl and other wildlife.

In 2012, wetland ecologist Mary Linton conducted a survey on Pleasant Lake focusing on littoral and adjacent wetland habitats. During her survey, she recorded the presence of Torrey's bulrush (*Schoenoplectus torreyi*) within the Turtle Bay wetland on the southwest side of the lake. This species is currently listed as imperiled in Wisconsin (state rank = S2) due to its rarity within the state. Pleasant Lake does contain populations of the common three-square rush (*Schoenoplectus pungens*) which is very similar morphologically to Torrey's rush. It is not known if Mary Linton sent any specimens into a herbarium for verification, and further investigation will be needed to positively identify the existence of this species within the Turtle Bay wetland.

As discussed previously, a point-intercept survey was conducted in 2009 as part of an aquatic plant community assessment. Since the sampling methodology and sampling locations were the same as the survey conducted in 2012, the data that were collected during these surveys can be compared to determine if any changes in the occurrences of aquatic plant species occurred over this three-year period. Figure 2.2-4 displays the 2009 and 2012 littoral frequencies of occurrence

of aquatic plant species in Pleasant Lake that had an occurrence of at least 5% in one of the two surveys.

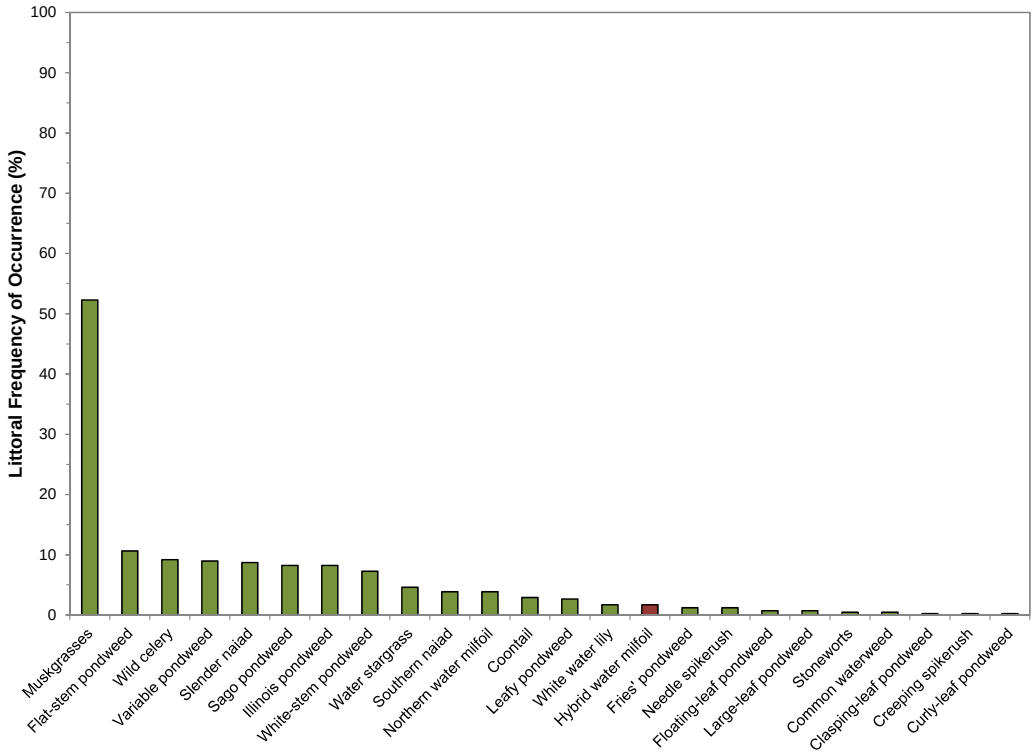


Figure 2.2-3. 2012 littoral frequency of occurrence of aquatic plant species in Pleasant Lake. Created using data from UWSP 2012 point-intercept survey. Non-native species indicated with red.

The plants in Figure 2.2-4 are divided between dicotyledons (dicots) and non-dicotyledons (non-dicots). These two divisions of plants differ in their morphological characteristics as well as their physiology. The herbicides that have been used in Pleasant Lake in an effort to control HWM have historically been believed to not affect non-dicot aquatic plants. However, emerging evidence by researchers with the US Army Corps of Engineers and WDNR may indicate that some non-dicots species can become impacted by these herbicides under certain circumstances (herbicide dose, exposure time, etc.). Unpublished data indicate that of the native plants present in Pleasant Lake, northern water milfoil and slender naiad tend to decline following herbicide management actions. It is important to note that the treatments that have been conducted on Pleasant Lake never reached levels that have been shown to have lake-wide impacts to native or non-native plant species, and any non-target impacts would like be contained to the areas of the lake where the herbicide was directly applied.

Two native plants exhibited statistically valid reductions in their littoral occurrence from 2009-2012 (Chi-square $\alpha = 0.05$), and include muskgrasses and the combined occurrences of narrow-leaf pondweeds (Figure 2.2-4). Because of their morphological similarity and often challenging identification, the occurrences of stiff pondweed, Fries' pondweed, and leafy pondweed were combined for this analysis. Three native species, slender naiad, sago pondweed, and Illinois pondweed all exhibited statistically valid increases in their littoral occurrence from 2009-2012, while the occurrences of the remaining five native species, including the dicot northern water

milfoil, were not statistically different (Figure 2.2-4). The occurrence of hybrid water milfoil was reduced from approximately 5% in 2009 to approximately 2% in 2012, representing a statistically valid reduction in occurrence of 67%.

Aquatic plant communities are dynamic, and the abundance of certain species can fluctuate from year to year depending on climatic conditions, water levels, herbivory, competition, and disease among other factors, and slight fluctuations are to be expected. The declines in the occurrences of muskgrasses and narrow-leaf pondweed species, while statistically valid, are minor, and no major reductions or complete losses of species were observed over this time period.

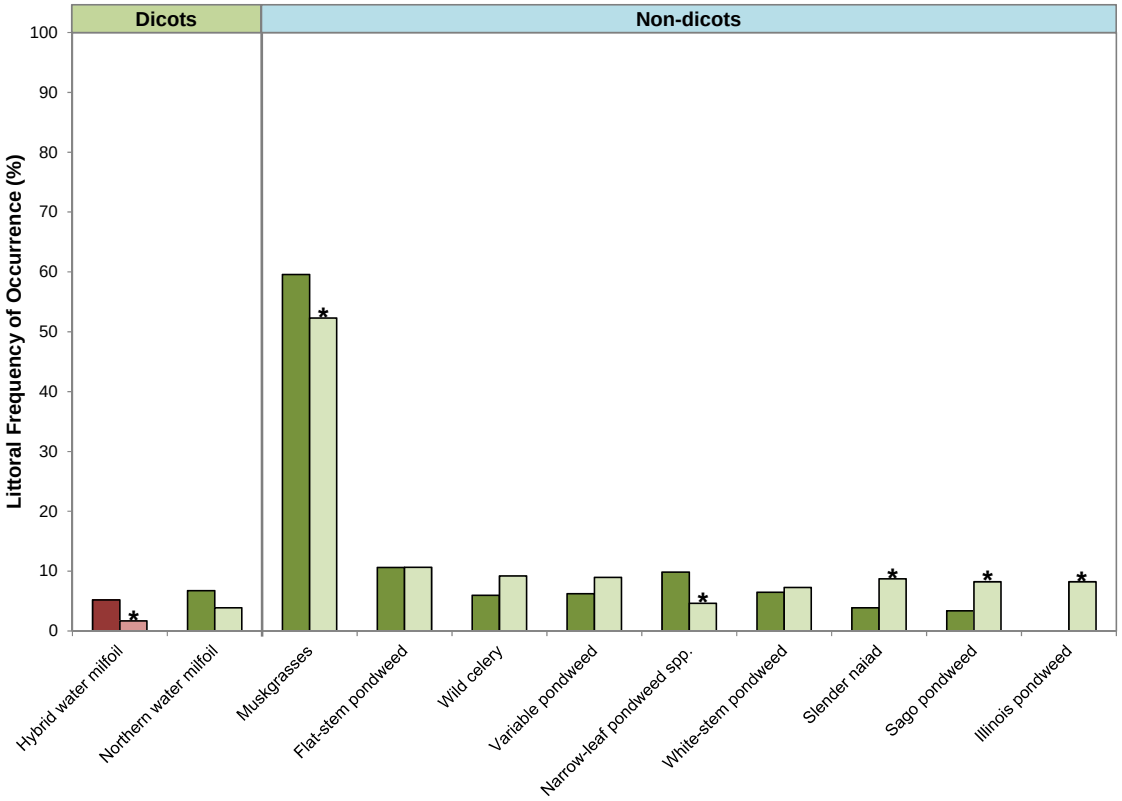


Figure 2.2-4. Statistical comparison of select aquatic plant species littoral frequency of occurrence from 2009 and 2012 in Pleasant Lake. Species with an occurrence of at least 5% in either survey represented. Created using data from Onterra 2009 (N = 386) and UWSP 2012 (N = 413) point-intercept surveys.

As discussed in the Primer Section (2.1), 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 native aquatic plant species were located in Pleasant Lake during the 2012 and 2013 surveys, 22 were encountered on the rake during the 2012 point-intercept survey. These 22 native species and their conservatism values were used to calculate the FQI of Pleasant Lake's aquatic plant community in 2012 (equation shown below).

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

Figure 2.2-5 compares the FQI components of Pleasant Lake from the 2009 and 2012 point-intercept surveys to median values of lakes within the North Central Hardwoods and Southeastern Till Plain (NCSE) Ecoregions as well as the entire State of Wisconsin. Both the 2009 and 2012 species richness values fall above the NCSE Ecoregion and state medians, while the 2012 richness exceeds the upper quartile value for lakes within the ecoregion and the state (Figure 2.2-5).

The average conservatism values for native aquatic plant species in Pleasant Lake were similar between the 2009 and 2012 surveys, with values of 5.8 and 5.9, respectively (Figure 2.2-5). These values fall above the median value for lakes in the NCSE Ecoregion but just below the median value for lakes throughout Wisconsin. Using the lake's species richness and average conservatism values to calculate the FQI values indicates that the floristic quality of Pleasant Lake's aquatic plant community is of higher quality than the majority of lakes within the NSCE Ecoregion and the state; the 2009 and 2012 FQI values exceed ecoregional and state-wide median values. These data also indicate that the quality of Pleasant Lake's aquatic plant community has not diminished over this time period.

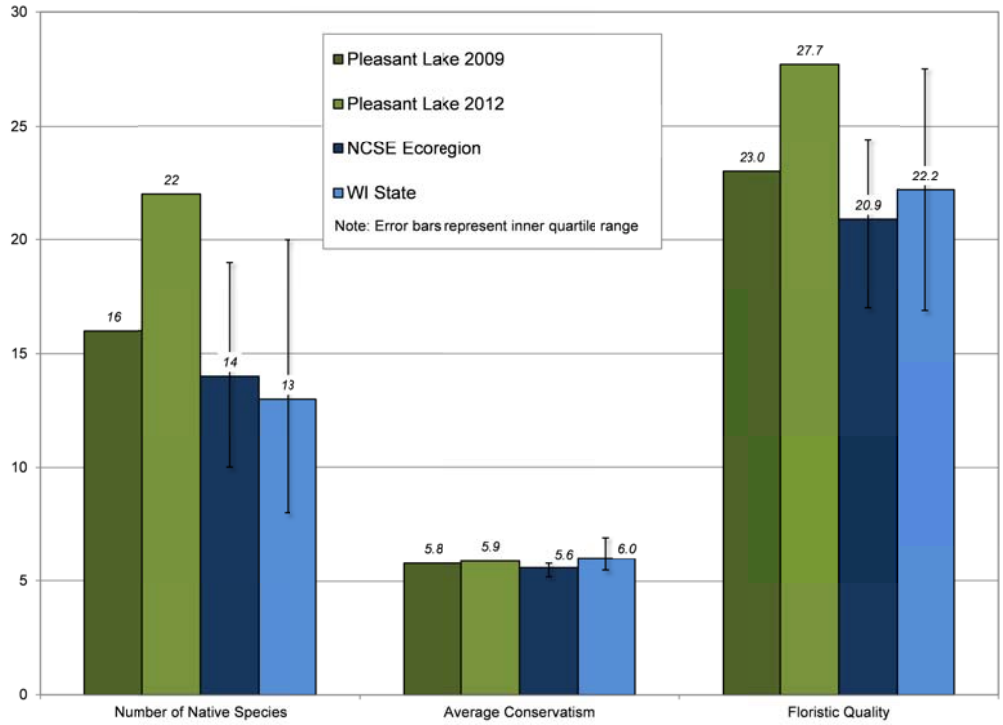


Figure 2.2-5. Pleasant Lake Floristic Quality Analysis. Created using data from Onterra 2006 and 2012 point-intercept surveys. Analysis follows Nichols (1999) where NCSE = North Central Hardwoods and Southeastern Till Plain Ecoregion.

As explained earlier, it is believed that 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 Pleasant Lake contains a relatively high number of native aquatic plant species, one may assume the aquatic plant community has high species diversity.

However, 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 Pleasant Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 71 lakes within the North Central Hardwood Forests (NCHF) Ecoregion (Figure 2.2-6). Using the data collected from the 2009 and 2012 point-intercept surveys, Pleasant Lake's aquatic plant community was shown to have low species diversity with a Simpson's diversity values of 0.75 and 0.82, respectively. These values fall below the median diversity values for lakes in the NCHF Ecoregion and lakes throughout Wisconsin (Figure 2.2-6).

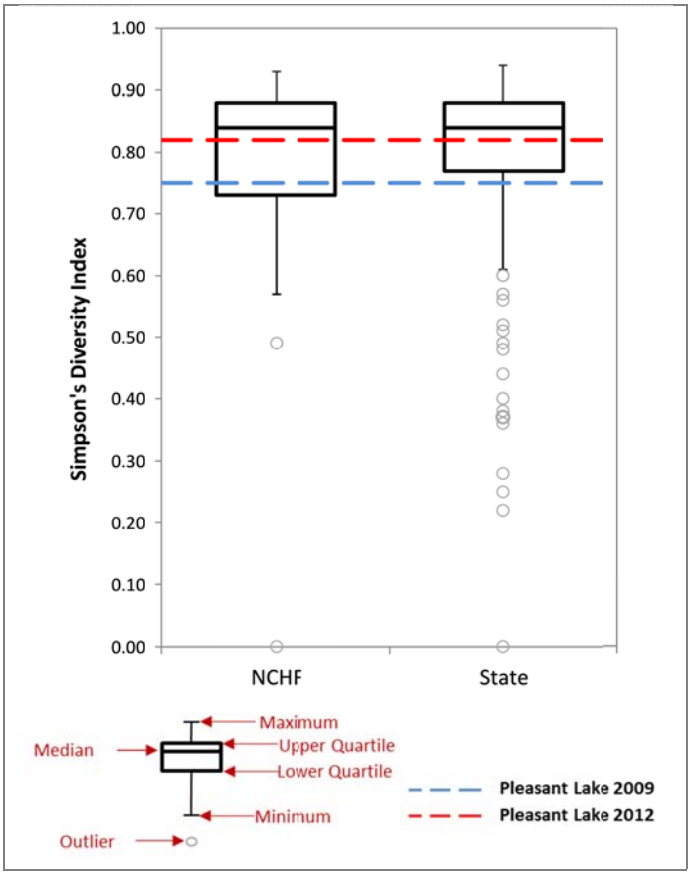


Figure 2.2-6. Pleasant Lake 2009 and 2012 Simpson's Diversity Index. Created using data from Onterra 2009 and UWSP 2012 point-intercept surveys.

As explained earlier, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while muskgrasses were found at approximately 52% of the littoral sampling locations in Pleasant Lake in 2012, its relative frequency of occurrence was 37%. Explained another way, if 100 plants were randomly sampled from Pleasant Lake, 37 of them would be muskgrasses. Figure 2.2-7 displays the relative occurrence of aquatic plant species from Pleasant Lake in 2012. The lake's low species diversity is illustrated by the fact that greater than 50% of the plant community is comprised of just three species.

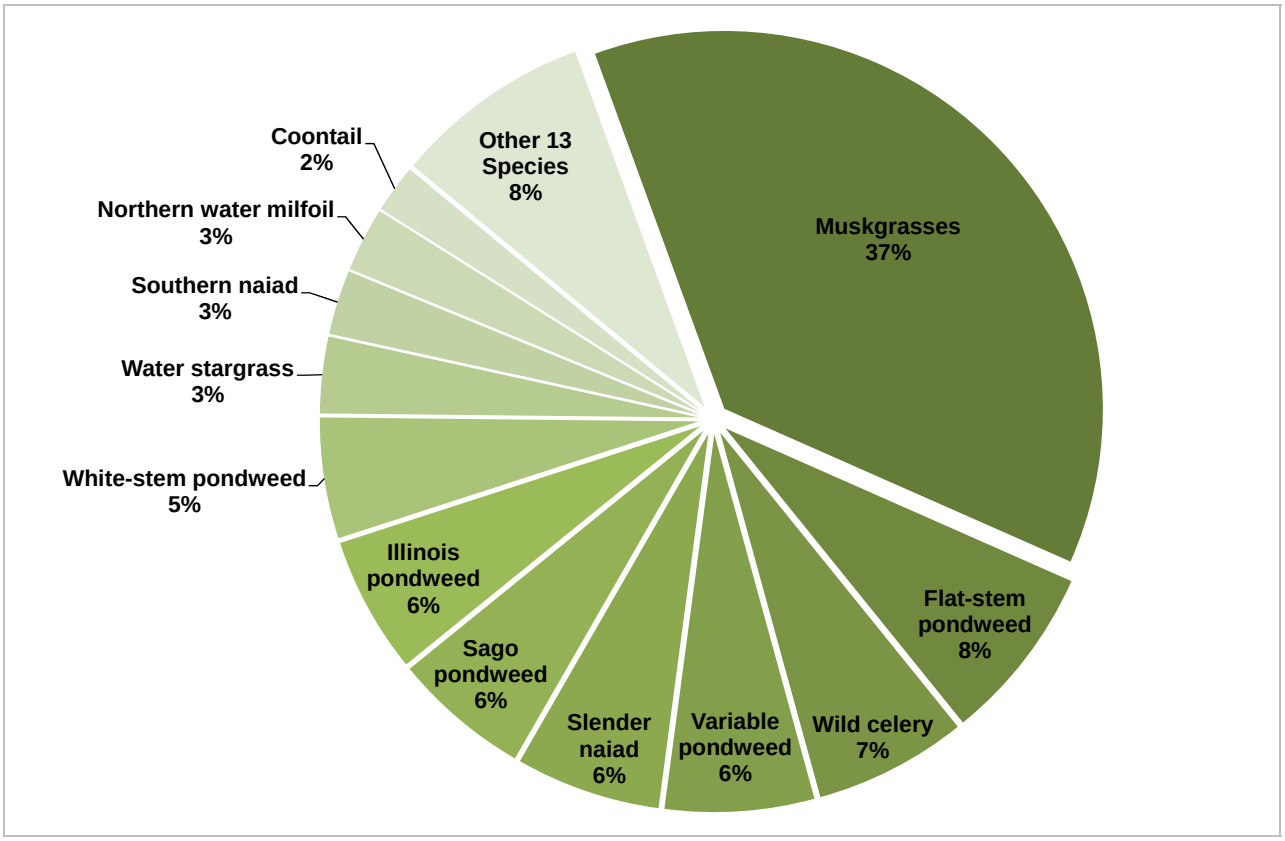


Figure 2.2-7. 2012 relative frequency of occurrence of aquatic plants in Pleasant Lake. Created using data from 2012 UWSP point-intercept survey.

The point-intercept survey is an excellent method for assessing a lake's submergent aquatic plant community; however, it tends to underestimate the occurrence of emergent and floating-leaf aquatic plants that tend to grow in shallower, near-shore areas. Because of the importance of these communities, the community mapping survey is designed to map and identify the species that comprise these communities.

The 2013 community mapping survey conducted by Onterra on Pleasant Lake indicates that approximately 4.1 acres of the lake contain floating-leaf and emergent aquatic plant communities (Table 2.2-2, Figure 2.2-8, Map 2). Twelve emergent and floating-leaf aquatic plant species were located in the lake in 2013 (Table 2.2-1). These plant communities provide valuable fish and wildlife habitat important to the ecosystem of the lake. Compared to 2009, some of these communities saw retractions, while others saw expansions. While it may appear that areas delineated as *mixed emergent and floating-leaf* in 2009 were not relocated in 2013, these areas were relocated but were able to be delineated separately into distinct *emergent* and *floating-leaf* communities in 2013. Overall, there was approximately 0.2 acres less of floating-leaf and emergent plant communities in 2013 compared to 2009 (Map 2). As illustrated, large areas along Pleasant Lake's shoreline do not contain emergent and/or floating-leaf plant communities, and their absence may be an indicator of increased shoreline development. Studies have shown that these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelands when compared to the undeveloped shorelands 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 shorelands.

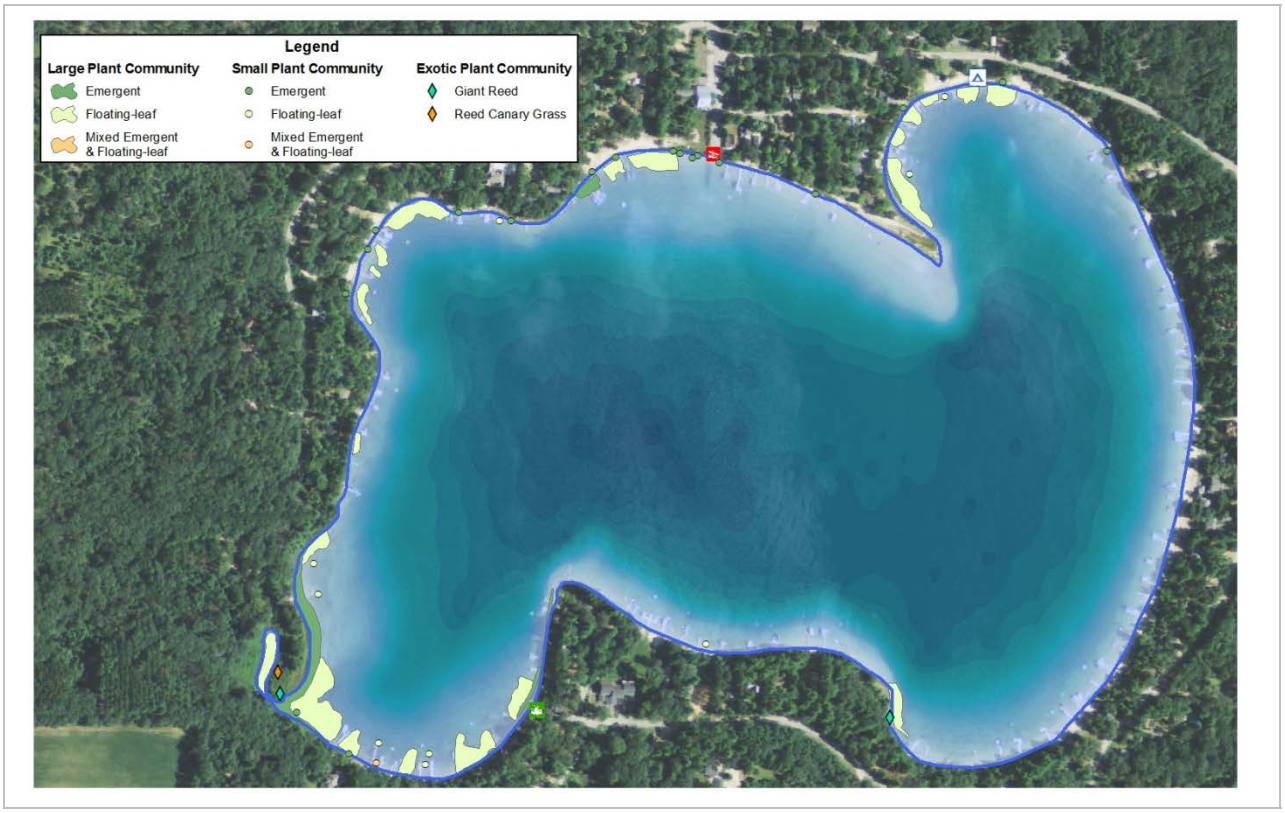


Figure 2.2-8. Pleasant Lake 2013 emergent and floating-leaf aquatic plant communities. Created using data from 2013 community mapping survey.

Table 2.2-2. Acres of emergent and floating-leaf aquatic plant communities in Pleasant Lake in 2009 and 2013. Created using data from Onterra 2009 and 2013 community mapping surveys.

Plant Community	2009 Acres	2013 Acres
Emergent	0.1	0.8
Floating-leaf	1.3	3.3
Mixed Emergent & Floating-leaf	2.9	0.0
Total	**4.3**	**4.1**

These communities provide valuable structural habitat for invertebrates, fish, and other wildlife, and also stabilize bottom sediments and shoreline areas by dampening wave action from wind and watercraft. These communities become even more important during periods of low water levels, as course woody habitat is left above the receding water line. Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Pleasant Lake.

Water levels play a key role in determining the establishment and expansion of emergent and floating-leaf plant communities (Coops et al. 2004). Natural water fluctuations promote healthy

emergent and floating-leaf aquatic plant communities. As water levels decline, these communities are able to expand and establish lakeward. Once established, these communities are often able to persist as water levels increase.

During the community mapping survey, Onterra ecologists were also looking to quantify the abundance and size of course woody habitat within Pleasant Lake. However, no course woody habitat of over two inches in diameter could be located around the lakes shoreline.

Non-native Plants in Pleasant Lake

Hybrid water milfoil

Eurasian water milfoil (*Myriophyllum spicatum*) was first documented in Pleasant Lake in 2007, and via DNA analysis was later determined to be hybrid water milfoil (*M. sibiricum X spicatum;* HWM), a cross between Eurasian water milfoil and the indigenous northern water milfoil (Photo 2.2-1). Following its discovery, approximately two acres were treated in 2008. In 2009, Onterra was contracted to map HWM within the lake and develop a treatment strategy. In 2010, the PLMD successfully applied for a WDNR AIS Early Detection and Response (EDR) Grant to aid in funding the cost of HWM treatments and associated monitoring from 2010-2012.

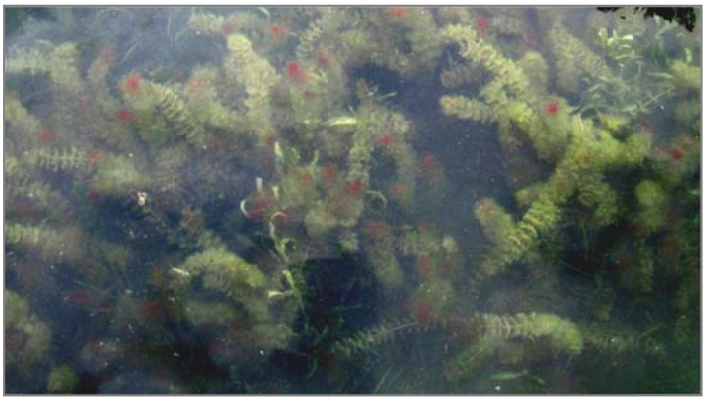


Photo 2.2-1. Hybrid water milfoil (*M. spicatum X sibiricum*) in Pleasant Lake.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding concentration-exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of a joint research project between the WDNR and US Army Corps of Engineers (USACE). Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2) spot treatments.

Whole-lake or whole-basin treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (of the lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of whole-lake treatments is dictated by the volume of water in which the herbicide will reach equilibrium with. Because exposure time is so much greater, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant effects outside of that area. Spot treatments typically rely on a short exposure

time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This is the strategy that has been utilized on Pleasant Lake from 2010-2012.

In 2010, granular 2,4-D (Navigate®) was the primary treatment strategy used to control HWM in Wisconsin, and was the largest treatment conducted on Pleasant Lake over this time period. The 2010 treatment was deemed successful, as HWM within the treatment areas was greatly reduced following the treatment (Map 3). Up until late-2010, granular 2,4-D treatments were conducted based upon surface acreage of the lake, and not based upon the depth of the water within that area. During the winter of 2010-2011, it became more common for application rates of granular 2,4-D to be formulated based upon the volume of water in which the herbicide application would occur.

This means that sufficient 2,4-D was applied within the *Application Area* such that if it mixed evenly with the *Treatment Volume*, it would equal the desired concentration (typically 2.0-4.0 ppm). This standard method for determining spot treatment use rates is not without flaw, as no physical barrier keeps the herbicide within the *Treatment Volume* and herbicide dissipates horizontally out of the area before reaching equilibrium (Figure 2.2-9). While lake managers may propose that a particular volumetric dose be used, such as 4.0 ppm ae, it is understood that actually achieving 4.0 ppm ae within the water column is not likely due to dissipation. And particularly with granular herbicides it is theorized that some of the 2,4-D granules sink into or bind with the sediment, not allowing a portion of the product to be included within herbicide measurements within the water column. Granular herbicides are also thought to release the herbicide more slowly in certain situations (e.g. lower pH); however more research is needed to quantify these statements.

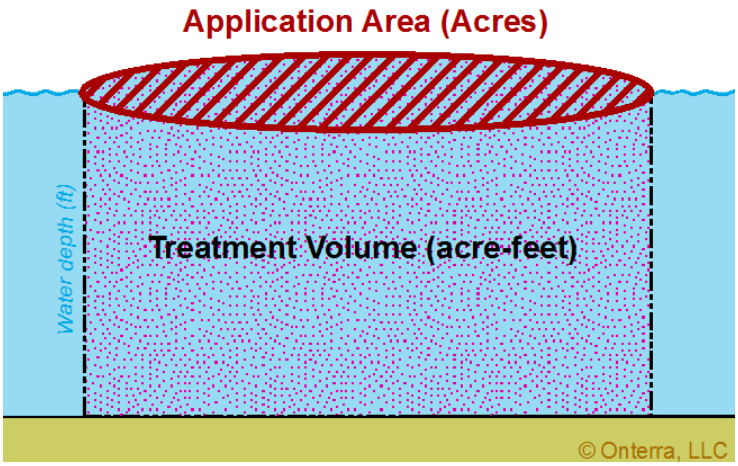


Figure 2.2-9. Herbicide Spot Treatment diagram.

With this new information, a different strategy was adopted in 2011 where HWM treatment areas in Pleasant Lake would be targeted with granular 2,4-D but with a volume-based concentration of 2.25 ppm acid equivalent (ae). At that time the most commonly used granular 2,4-D product (Navigate ®) had an EPA-approved label that only allowed the product to applied at a rate of up to 200 lbs/acre. The depth of the proposed 2011 treatment areas on Pleasant Lake would not allow Navigate ® to be used at a rate high enough to reach the desired concentration (2.25 ppm ae) within the treatment volume.

Another granular 2,4-D product (Sculpin G ®) was approved for use up to 4.0 ppm ae and soon became a more commonly used herbicide in Wisconsin lakes. This product was also comprised of a different chemical variation of 2,4-D. The active ingredient of Navigate ® is an ester formulation of 2,4-D, whereas Sculpin G ® uses the amine version of 2,4-D. While both herbicide formulations quickly dissociate into the acid form of 2,4-D when exposed to water, the

ester formulation has been shown to be more toxic to aquatic invertebrates and fish than the amine version. Updated EPA registration currently allows Navigate ® to be applied up to 4.0 ppm ae, although it carries a 24-hour swimming restriction whereas Sculpin G ® does not have any use restrictions. In 2011, approximately 3.9 acres of HWM were treated with Sculpin G ® to achieve a concentration of 2.25 ppm ae, and these treatments were very successful.

Because of the success seen in 2011, it was also recommended that the 2012 treatment utilize Sculpin G. However, data gathered on small treatment areas like those in Pleasant Lake indicate that herbicide dissipates very rapidly from the application areas. To combat this dissipation and attempt to maintain a high enough herbicide concentration to cause HWM mortality, it was recommended that the 2012 treatment areas be treated to attain a slightly higher concentration of 2.50 ppm ae. Unfortunately, despite the higher application rate, the 2012 treatment was not effective at controlling HWM within these areas.

In 2012, with the early spring and higher-than-normal temperatures, lakes throughout Wisconsin saw increases in the EWM/HWM populations; Pleasant Lake included (Map 3). With the increase in HWM observed, approximately 16.6 acres of HWM were proposed for treatment in 2013. However, given the size of this proposed treatment on Pleasant Lake and the amount of herbicide proposed to be applied, it was calculated that the herbicide dissipation would likely reach a concentration that could impact aquatic plants at the lake-wide level. Thus, this treatment would no longer be considered a spot treatment but a whole-lake treatment. While whole-lake 2,4-D treatment strategies are being utilized on many Wisconsin lakes to control EWM and HWM on a lake-wide level, it was not believed that the amount of HWM present in Pleasant Lake warranted this strategy. In addition, the bathymetric data available at that time for Pleasant Lake was based on water levels from a 1964 survey, making accurate lake-wide concentration calculations difficult. For these reasons, the MLMD agreed to forgo a treatment in 2013 until an accurate bathymetric survey of the lake could be completed.

Figure 2.2-10 shows the acreages of colonized HWM within Pleasant Lake mapped by Onterra from 2009 to 2013. In 2009, the majority of the HWM in Pleasant Lake was comprised of *dominant* and *highly dominant* colonies. These colonies were largely reduced following the 2010 treatment, and acreage increased again in 2012 but was mainly comprised of *scattered* HWM. Despite no treatment occurring in 2013, HWM acreage declined to approximately 2.2 acres. These data in combination with the whole-lake point-intercept data indicate that the treatments that have occurred from 2010-2012 have been effective at maintaining a small and low-density population of HWM within Pleasant Lake. Hybrid water milfoil has also been located within the Turtle Bay wetland on the southwest side of the lake. The HWM should be continued to be monitored within this area

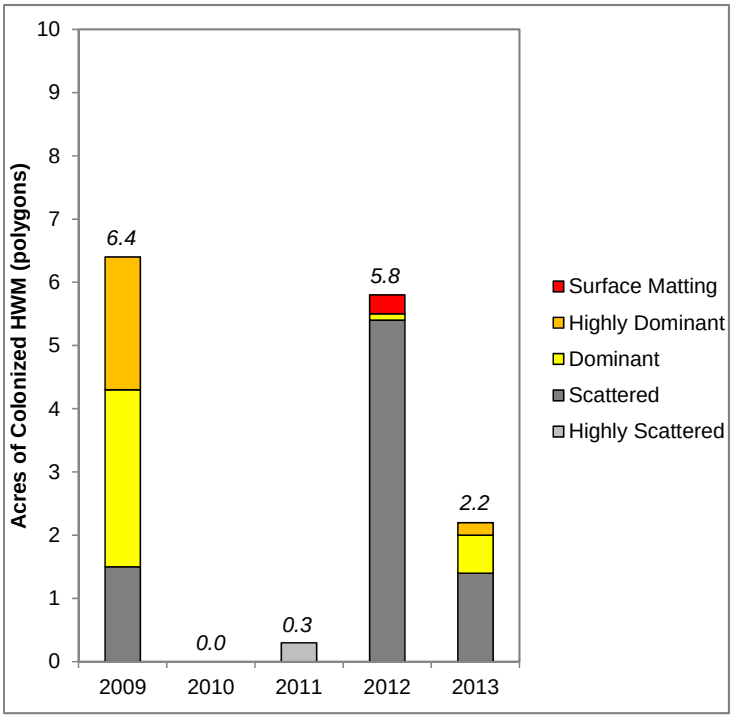


Figure 2.2-10. Acres of colonized HWM in Pleasant Lake from 2009-2013.

Curly-leaf pondweed

Curly-leaf pondweed (*Potamogeton crispus*; CLP) is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. CLP begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like EWM, CLP can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

It is not known when CLP was first introduced to Pleasant Lake, but it was present in very low abundance during the 2009 surveys. Because of its odd life-cycle, an Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted on Pleasant Lake on June 12, 2013 when CLP was at or near its peak growth. During this meander-based survey, no colonized areas of CLP were located, just plants denoted as *single or few plants*, *clumps of plants*, and one *small plant colony* (Map 4). Most of the CLP was located within the northeastern portion of the lake. At this time, it is not believed that the level of CLP within Pleasant Lake warrants chemical control, and may be best managed via hand removal techniques.

Giant Reed

Giant reed (*Phragmites australis* subsp. *australis*) is a tall, perennial grass that was introduced to the United States from Europe. While a native strain (*P. australis* subsp. *americanus*) of this species exists in Wisconsin, the plants located on the exposed shores of Pleasant Lake are the non-native, invasive strain. Giant reed forms towering, dense colonies that overtake native vegetation and replace it with a monoculture that provides inadequate sources of food and habitat for wildlife.

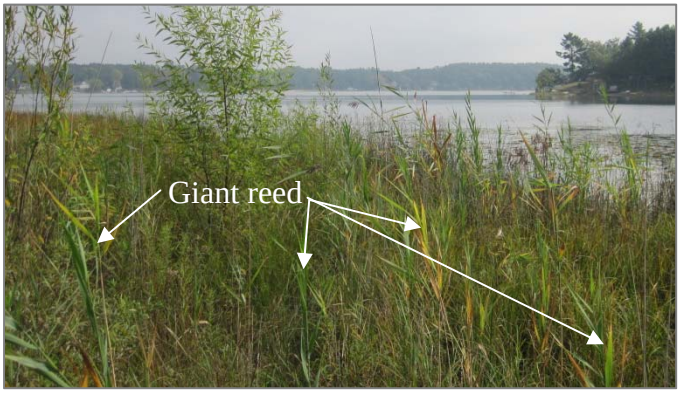


Photo 2.2-2. Giant reed along the shoreline of Turtle Bay.

Giant reed was found growing in two locations on Pleasant Lake's shoreline in 2013: one near the Turtle Bay wetland and the other on the southeastern shore (Photo 2.2-2, Map 2). Because this species has the capacity to displace the valuable wetland plants along the exposed shorelines of Turtle Bay and elsewhere, it is recommended that these plants be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. The giant reed infestation is in its very early stages, and eradication is likely a realistic outcome if control actions are taken quickly.

Reed canary grass

Reed canary grass was found growing in areas around the Turtle Bay wetland (Map 2). Reed canary grass (*Phalaris arundinacea*) is a large, coarse perennial grass that can reach three to six feet in height. Often difficult to distinguish from native grasses, this species forms dense, highly productive stands that vigorously outcompete native species. Unlike native grasses, few wildlife species utilize the grass as a food source, and the stems grow too densely to provide cover for small mammals and waterfowl. It grows best in moist soils such as wetlands, marshes, stream banks and lake shorelands.

Reed canary grass is difficult to eradicate; at the time of this writing there is no efficient control method. Small, discrete patches have been covered by black plastic to reduce growth for an entire season. However, the species must be monitored because rhizomes may spread out beyond the plastic.

2.3 Water Levels and Littoral Habitat

Lake water levels can fluctuate naturally over varied timescales due to changes in precipitation and/or changes in human land use. Water levels in seepage lakes, like Pleasant Lake, decline when the groundwater aquifer is not being replenished at the rate that water is declining. This decline can be due to natural or anthropogenic causes, or a combination of both. Groundwater levels can naturally decline due to periods of lower precipitation, while anthropogenic factors like pumping and land practices that reduce groundwater recharge such as the construction of impervious surfaces can reduce groundwater levels. While Pleasant Lake has likely seen many water level fluctuations due to natural factors since its creation, recent studies conducted by Dr. George Kraft on the Central Sands hydrology indicate that high capacity well pumping has had a significant impact of the lowering water level of Pleasant Lake (Kraft and Mechenich 2010).

While periodic natural water level fluctuations in lakes are beneficial as they generally create more diverse plant and animal communities, sustained water level decline due to human activities may not be ecologically beneficial. As discussed earlier, Onterra conducted an acoustic survey of Pleasant Lake in 2013 to obtain updated bathymetric data. Using these data, effects to Pleasant Lake's littoral area and the habitat it provides can be modeled across varying degrees of water level decline below the baseline water level. It must be noted that the baseline water level used in these analyses was from 1992, a period with some of the highest water levels recorded on Pleasant Lake.

Littoral area, or the littoral zone, of a lake is defined as the area of the lake where sunlight is able to penetrate to the lake bottom and support aquatic plant growth. In many macrophyte (aquatic plant)-dominated lakes, the littoral zone may contribute the majority of the lake's productivity (Wetzel 2001) and is where structural habitat provided by aquatic plants will be found. The depth to which the littoral zone extends is going to depend on the clarity of the water, which determines how deep sunlight can penetrate. Second, the amount of littoral area within a lake will depend on how much area of the lake falls within depth range that can support aquatic plants.

In 2012, the maximum depth of aquatic plant growth indicated Pleasant Lake's littoral zone extended to a depth of 24 feet. Assuming the depth range of the littoral zone does not change with fluctuating water levels, the bathymetric data collected in 2013 indicate that when Pleasant Lake is at or near the baseline water level, approximately 77 acres of the lake are comprised of littoral area (≤ 24 feet) (Figure 2.3-1, Figure 2.3-2, Map 5). Due to Pleasant Lake's morphology, as water levels decline from the baseline water level, littoral area increases as more area at deeper depths is gained than is lost to exposure above the waterline. However, this increase in littoral area with declining water levels reaches a maximum of approximately 129 acres at around five feet below the baseline water level (near present-day levels) (Figure 2.3-1, Figure 2.3-2, Map 5). At this point, the entire lake is nearly comprised of littoral area. As water levels decline past five feet below the baseline water level, littoral area now declines as no new deeper areas are gained and areas near shore become exposed (Figure 2.3-1, Figure 2.3-2, Map 5).

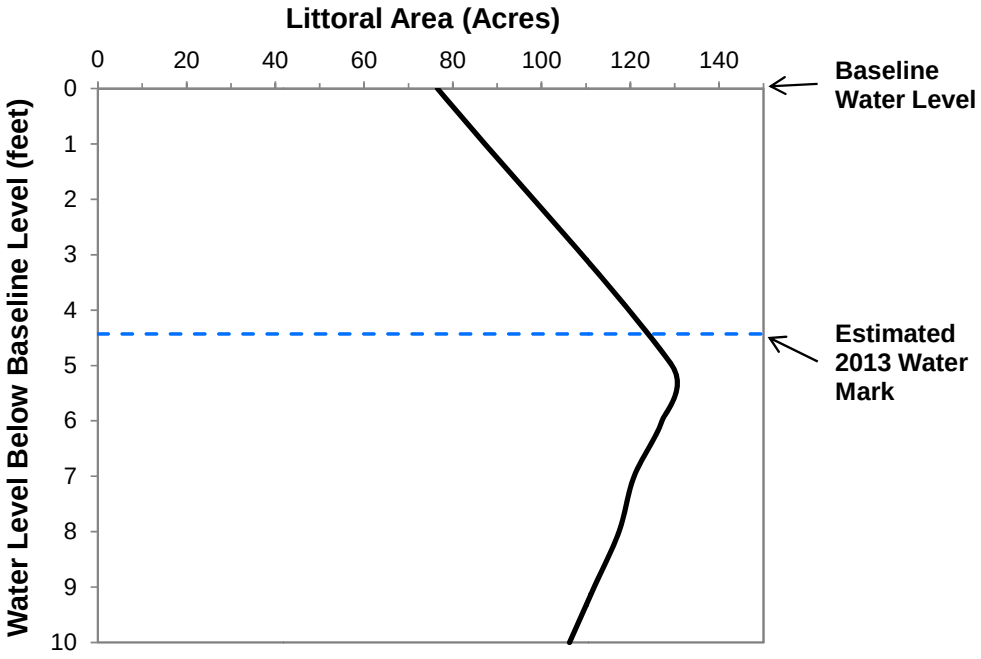


Figure 2.3-1. Relationship between littoral area and water levels in Pleasant Lake.

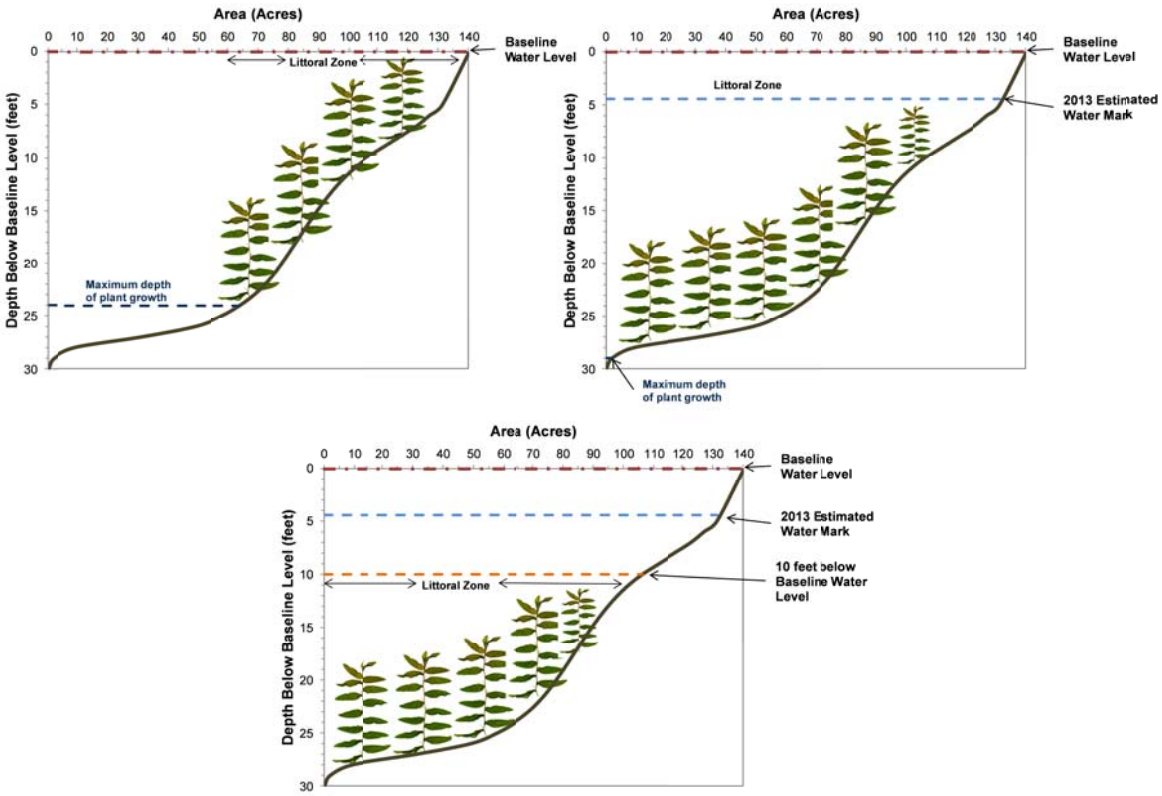


Figure 2.3-2. Pleasant Lake hypsographs displaying changes in littoral area at the baseline water level (top left), 2013 water levels (top right), and 10 feet below the baseline water level (bottom center).

As discussed, the current littoral zone of Pleasant Lake is near its maximum size. Increases or decreases in water levels from the current water level position will reduce the size of the lake's littoral area. However, the reduction in littoral area due to continued decline in water levels will likely have a greater impact ecologically than loss of littoral area due to increasing water levels. Data regarding the composition of Pleasant Lake's substrate were collected during the 2013 acoustic survey. These data indicate that the majority of the substrate within shallower areas of Pleasant Lake, mostly between 1-4 feet, is comprised of harder substrates (sand and/or rock) (Figure 2.3-3).

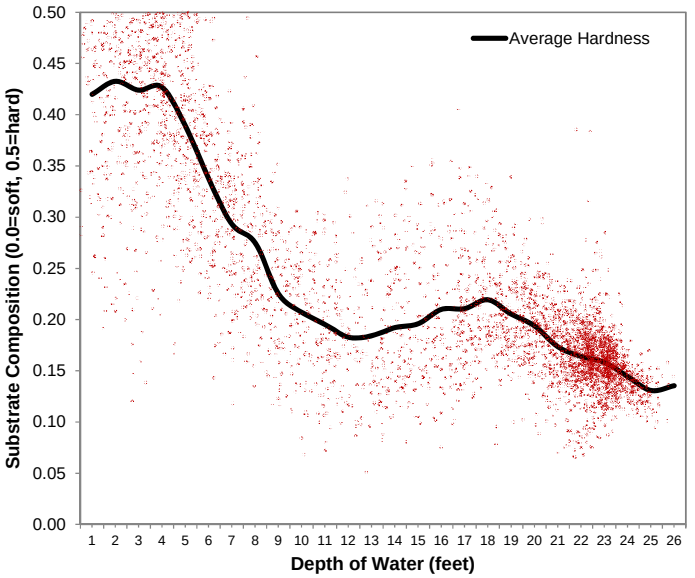


Figure 2.3-3. Pleasant Lake average substrate hardness across water depths. Created using data from 2013 acoustic survey.

The reduction of habitat comprised of harder substrate due to further water level decline in Pleasant Lake may affect certain floral and faunal populations. Of the aquatic plant species present in Pleasant Lake, slender naiad, variable pondweed, wild celery, and needle spikerush have an affinity for firm sediment (Borman et al. 1997). Figure 2.3-4 illustrates that the highest occurrence of these species occurred within areas of harder substrates in 2012. If water levels continue to decline and areas of hard substrate become reduced, the soft sediments may prove unsuitable for these species and their populations may decline. In contrast, populations of plants in Pleasant Lake which prefer soft sediments like flat-stem pondweed (Figure 2.3-4) would likely be able to migrate with receding water levels as new areas of softer sediment become habitable. However, as lake levels drop, soft material from the shallow reaches of the lake may be moved to deeper water through wind and wave action which would expose harder material. In addition, the exposure of these softer substrates to increased levels of oxygen may result in higher decomposition rates of this material, also exposing sandy substrates beneath.

During the 2013 acoustic survey, aquatic plant bio-volume data were also collected. Bio-volume is a measure of the percentage of the water column occupied by aquatic plants. Map 6 displays aquatic plant bio-volume in Pleasant Lake from 2013, and shows that areas of highest aquatic plant bio-volume occur in narrow bands around the lake. Figure 2.3-5 displays the average aquatic plant bio-volume and average substrate hardness across water depth. Two measures of average bio-volume are displayed: BVw is a measure of aquatic plant bio-volume within all areas of the lake regardless if plants were present or not, and BVp is the average bio-volume only in areas where plants were present.

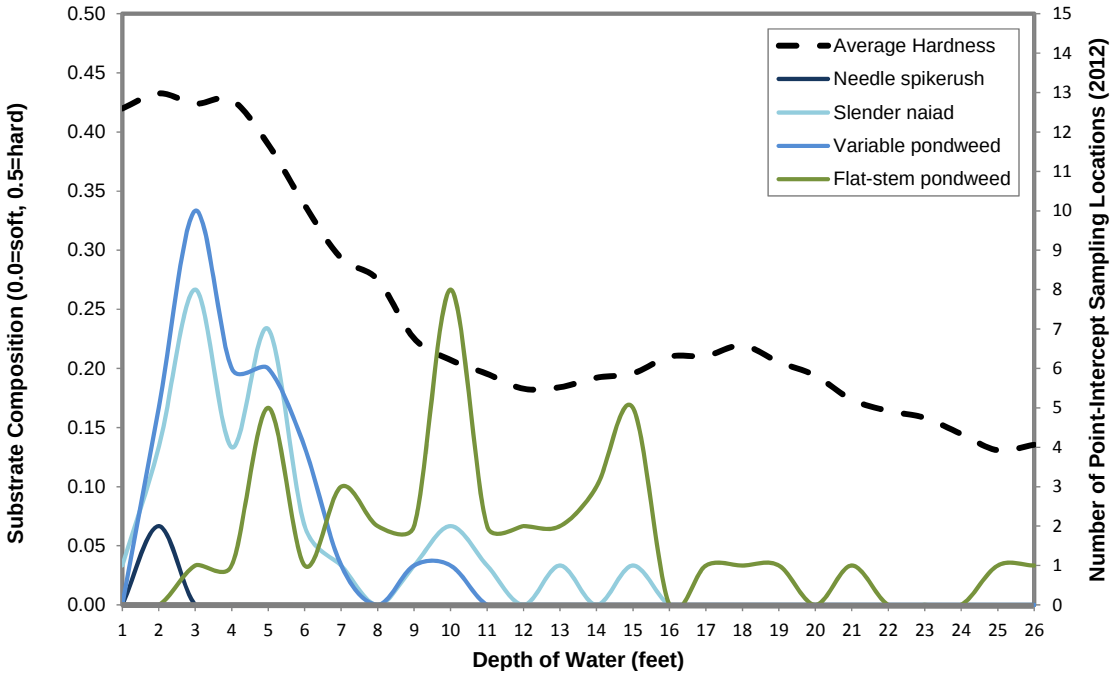


Figure 2.3-4. Pleasant Lake average substrate hardness and frequency of occurrence of select aquatic plant species across water depths. Created using data from 2013 acoustic survey.

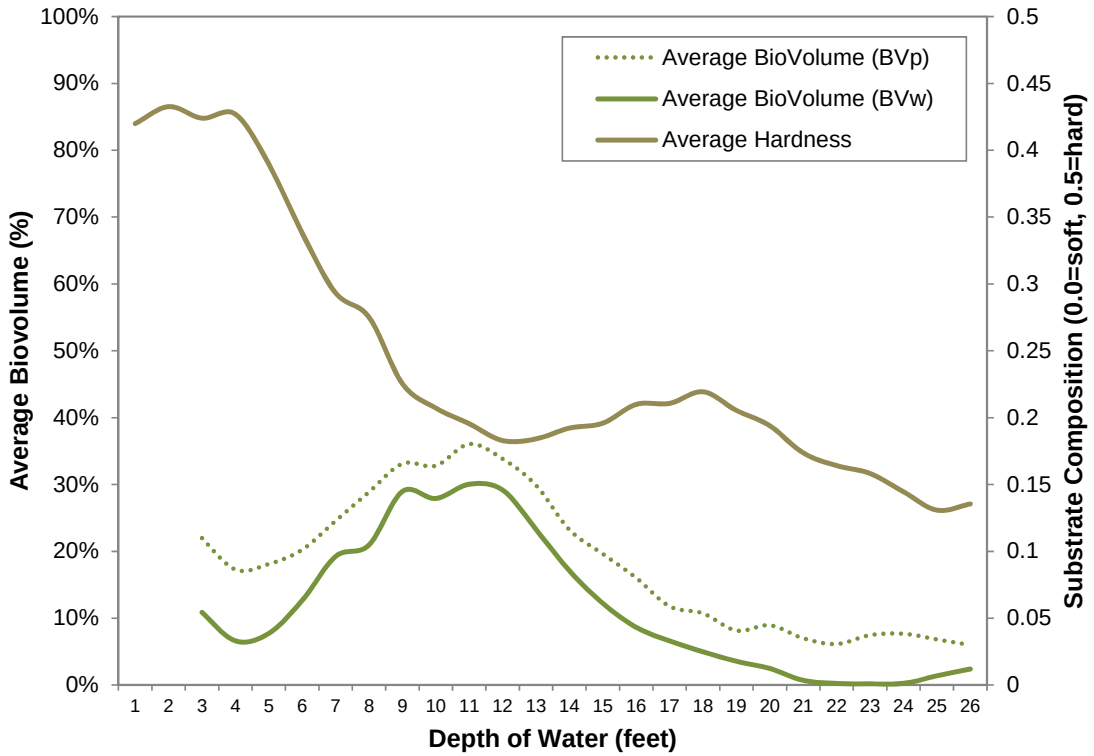


Figure 2.3-5. Pleasant Lake average aquatic plant volume across water depth. Created using data from 2013 acoustic survey.

As illustrated, the highest average aquatic plant bio-volume in Pleasant Lake occurs between depths of approximately 5-15 feet over areas of softer sediment. While muskgrasses are the most abundant aquatic plant in Pleasant Lake, the higher aquatic plant bio-volume is created from the taller vascular aquatic plants, such as flat-stem pondweed, white-stem pondweed, and northern water milfoil. Restricted from shallower areas of Pleasant Lake due to the harder substrates and from deeper areas due to inadequate light, these plants thrive in Pleasant Lake's intermediate depths where substrate and light are suitable. As water levels decline from their current level and deeper areas begin to receive adequate light, it is likely that these taller plants will be able to establish lakeward as substrate hardness appears suitable. However, as water levels increase, these bands of higher aquatic plant bio-volume may become narrower as they lose light on the lakeward edge and are restricted by harder substrates on the shoreward edge.

Like many of the native aquatic plants, both HWM and CLP show an affinity for softer sediments. Currently, the majority of the HWM population within Pleasant Lake occurs within areas of highest aquatic plant bio-volume over soft sediments (Map 3). Like many invasive species, both HWM and CLP are considered pioneer species, or species that tend to establish areas first following disturbance. As water levels decline in Pleasant Lake, deeper areas that currently do not receive adequate light will be suitable for both CLP and HWM. Their pioneering nature may give these species a competitive foothold over native aquatic plants trying to establish themselves in these newly habitable areas.

In addition to altering the aquatic plant community within Pleasant Lake proper, the aquatic plant community within the Turtle Bay wetland, located on the southwest side of the lake (Photo 2.3-1), would also be impacted from continued water level decline. This wetland is fed via groundwater and maintains a direct connection with Pleasant Lake proper. This wetland would likely see dramatic changes in plant community composition with continued water level declines of one to two feet. This perennial open marsh wetland contains a diverse plant community, supporting submergent, floating-leaf, free-floating, and emergent aquatic plants. The Turtle Bay wetland supports the only known population of common bladderwort (*Utricularia vulgaris*) within Pleasant Lake (Photo 2.3-1). This carnivorous plant is truly aquatic and would not survive desiccation following prolonged water level decline. Appendix A contains an assessment of the Turtle Bay wetland by Mary Linton, certified wetlands ecologist, and she states that "permanent loss of groundwater would significantly and negatively impact the plant community."

Mary Linton also surveyed the Turtle Bay wetland for reptiles and amphibians in 2012, and found this area hold a diverse frog community. She recorded the presence of spring peepers (*Pseudacris crucifer*), American toads (*Anaxyrus americanus*), leopard frogs (*Lithobates pipiens*), Cope's gray treefrog (*Hyla chrysoscelis*), gray treefrog (*Hyla versicolor*), and American bullfrogs (*Lithobates catesbeianus*). While not recorded, she also believes that the Turtle Bay wetland is suitable breeding habitat for boreal chorus frogs (*Pseudacris maculata*). Of the frog species she recorded, both the leopard frog and bullfrog are listed as species of special concern in Wisconsin. The Turtle Bay wetland provides ideal habitat for leopard frogs as they not only require cold spring-fed waters for breeding, but nearby warmer water for development (Appendix A). Further water level decline would likely erode this exceptional habitat for the amphibian species that are found there.



Photo 2.3-1. Turtle Bay wetland (left) and population of common bladderwort (*Utricularia vulgaris*) (right). Photos taken in 2013.

On August 29, 2013, Onterra ecologists conducted snorkel-based surveys in three locations around Pleasant Lake to determine the species of freshwater mussels (*Unionidae*) that were present. Freshwater mussels are most diverse in northeastern North America, with nearly 300 species (Cummings and Mayer 1992). Unfortunately, nearly half of the 51 species that occur in Wisconsin are listed as endangered, threatened, or species of special concern (WDNR 2011). Freshwater mussels are long-lived, and improve water quality by filtering out sediments, algae, and pollutants. Most species are found in rivers and streams, but a number can be found in lakes and ponds (Cummings and Mayer 1992).

Three areas in Pleasant Lake were surveyed for freshwater mussels (Map 7). These areas were comprised of larger expanses of sandy substrate, and have been areas where mussels have been observed during plant surveys in the past. During the 2013 survey on Pleasant Lake, only six live individuals comprised of one species, the giant floater mussel (*Pyganodon grandis*), were located (Photo 2.3-2). Appendix B contains photos of all the individuals located during the 2013 survey. All of the live mussels were located in sand, at depths of three to five feet. Five individuals were located in one area on the sandy peninsula in the northeastern portion of the lake, while one individual was located in sand off the southern shore (Map 7). Two non-live mussel shells were also located in areas surveyed along the southern shore (Map 7). Counting growth rings on the external surface of the live shells, the ages of the live individual mussels ranged from five to 15 years.

The giant floater mussel is common in Wisconsin, and can be found in a variety of habitats including lakes, rivers, and streams (Cummings and Mayer 1992), and is not currently listed as a species of special conservation need in Wisconsin (WDNR 2011). However, further water level decline leading to the loss of hard substrates may impact the giant floater population in Pleasant Lake. As mentioned, all six giant floater individuals located in Pleasant Lake were found in substrate comprised of sand at depths of 3-5 feet. Other field studies have shown that substrates comprised of sand or gravel are the preferred habitats for freshwater mussels (Green 1971; Harman 1972; Stern 1983; Downing et al. 2000). As water levels continue to decline from their present levels, these areas of firmer substrate will be exposed, and may reduce available habitat for the giant floater mussels.



Photo 2.3-2. Live giant floater mussels (*Pyganodon grandis*) located in Pleasant Lake during the 2013 mussel survey.

2.4 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the biologists overseeing Pleasant Lake. The goal of this section is to provide an overview of some of the data that exists, particularly in regards to specific issues (e.g. fish stocking, angling regulations, etc) that were brought forth by the PLD stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR (WDNR 2014 and personal communication).

Pleasant Lake Fishery

Fishing Activity

Table 2.4-1 shows the popular game fish that are present in the system, while Table 2.4-2 shows some of the non-gamefish present. When examining the fishery of a lake, it is important to remember what "drives" that fishery, or what is responsible for determining its mass and composition. The gamefish in Pleasant Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscovorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary

productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 2.4-1.

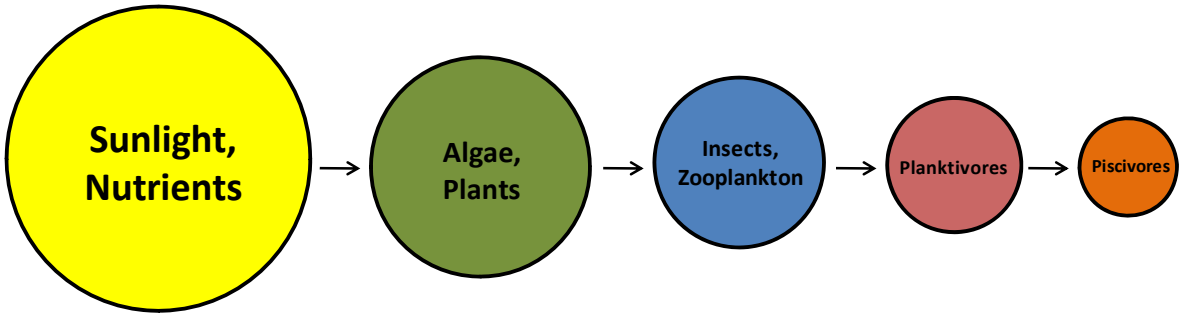


Figure 2.4-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

Pleasant Lake is a meso-eutrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. Simply put, this means Pleasant Lake should be able to support an appropriately sized population of predatory fish (piscovores).

Table 2.4-1. Gamefish present in the Pleasant Lake with corresponding biological information (Becker, 1983)**.** Species confirmed through a WDNR 2012 survey (Appendix D).

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Warmouth	*Lepomis gulosus*	13	Mid May - Early July	Shallow water 0.6 - 0.8 m, with rubble slightly covered with silt	Crayfish, small fish, odonata, and other invertebrates
Walleye	*Sander vitreus*	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Table 2.4-2. Non-gamefish present in the Pleasant Lake Species confirmed through a WDNR 2012 survey (Appendix D).

Common Name	Scientific Name
Banded killifish**	*Fundulus diaphanus*
Brown bullhead	*Ameiurus nebulosus*
White sucker	*Catostomus commersonii*
Yellow bullhead	*Ameiurus natalis*

***State Special Concern species*

Table 2.4-3. WDNR fishing regulations for Pleasant Lake, 2013-2014.

Species	Season	Regulation
Panfish	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth and smallmouth bass	May 4, 2013 to March 2, 2014	The minimum length limit is 14" and the daily bag limit is 5.
Northern pike	May 4, 2013 to March 2, 2014	The minimum length limit is 26" and the daily bag limit is 2.
Walleye, sauger, and hybrids	May 4, 2013 to March 2, 2014	The minimum length limit is 15" and the daily bag limit is 5.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rock, yellow, and white bass	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Catfish	Open All Year	No minimum length limit and the daily bag limit is 25.

Fisheries Habitat and Management

Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody material or aquatic plants, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

Pleasant Lake is managed for a largemouth bass and bluegill fishery primarily, with a smaller component of northern pike and other panfish species. The WDNR does not stock the lake with fish currently, though northern pike have been stocked in the past. Walleye have been stocked within the lake by the PLD, most recently in 2010. These stockings have been largely unsuccessful, as reproduction of mature walleyes has not been observed within the lake following stocking. A 2012 comprehensive survey (Appendix D) does note that largemouth bass

populations are doing well, and bluegill populations are average when compared to other lakes statewide. Growth and condition rates for these species are, however, are below average.

Currently, the WDNR is focusing upon habitat protection and restoration as a fishery goal for the lake. This includes the use of large woody habitat (tree drops and "fish sticks") that would provide direct benefit through "cover for juvenile fish and forage species, improvements in growth of both pan and gamefish species and better overall balance of the fish community" (David Bartz - WDNR, personal communication). The presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone.

As discussed within the aquatic plant section, substrate composition was shown to vary by depth. Changes that may occur to the substrate as a result of water fluctuation would force fish species to adapt accordingly. However, the degree of change and difficulty of adaption is difficult to predict. In general, as lake levels drop, soft material from the shallow reaches of the lake may be moved to deeper water through wind and wave action which would expose harder material.

One Pleasant Lake fish, the banded killifish, is listed as a state species of special concern. This listing means that the fish is of concern in Wisconsin, though not to the extent that it is extensively tracked by the National Heritage Inventory database. The WDNR has monitored banded killifish on two recent occasions, in 1999 and 2012, and found that the populations have remained healthy between this time period (David Bartz – WDNR, personal communication). The banded killifish prefer clear water of bays and quiet backwaters of large lakes and medium to large streams with sparse to no vegetation over gravel, sand, silt, marl, clay, detritus or cobble (WDNR website http://dnr.wi.gov/topic/EndangeredResources/Animals.asp?mode=detail&SpecCode=AFCNB04060). WDNR fisheries biologists believe that these habitat requirements are met in certain areas of Pleasant Lake. It is not thought that the population has been significantly affected by loss of habitat in the near shore areas, as the littoral zone has continued to migrate out as water levels have dropped within Pleasant Lake and small pockets of "micro habitats" seem to have allowed this species to continue in Pleasant Lake (David Bartz – WDNR, personal communication). As such, WDNR fisheries biologists do not currently have concern on this species' presence in Pleasant Lake.

4.0 SUMMARY AND CONCLUSIONS

The design of this supplemental management planning project was intended to fulfill two main objectives:

1) Conduct an assessment of Pleasant Lake's aquatic plant community and develop realistic management goals that will enhance and protect it.
2) Conduct a littoral habitat assessment on Pleasant Lake and determine the potential ecological effects of continued water level decline.

These two objectives were fulfilled during this project and have led to an understanding of the positive and negative attributes of Pleasant Lake's aquatic plant community. In addition, potential impacts to the Pleasant Lake ecosystem have been identified if water levels within the lake continue to decline.

Through the studies conducted on Pleasant Lake, the aquatic plant community was found to be of higher quality when compared to other lakes within the North Central Hardwood Forests Ecoregion and of comparable quality when compared to other lakes around the state. The plant community contains a relatively high number of native species, and is dominated by muskgrasses. The dominance of muskgrasses yielded a species diversity index value lower than regional and median values, but the abundance of muskgrasses is to be expected in a lake like Pleasant Lake with relatively high calcium carbonate concentrations.

While the submersed invasive aquatic plants hybrid water milfoil (HWM) and curly-leaf pondweed (CLP) are present within the lake, the 2012 point-intercept survey indicated both populations are in relatively low abundance. In addition, with the HWM control actions taken in 2010-2012, its occurrence was found to have declined by a statistically valid 67% from 2009-2012. However, at present, the HWM in Pleasant Lake is the largest threat to the lake's native aquatic plant community, as annual data collected on Pleasant Lake indicate this population has the capacity to spread and grow rapidly. While CLP has likely been present within the lake for many years, it has not yet been observed forming large, monotypic colonies; CLP plants are currently widespread throughout the lake and are not likely having any significant impact on the lake ecosystem.

Additionally, the emergent invasive plants giant reed and reed canary grass along the shorelines of Pleasant Lake are of concern. Both giant reed and reed canary grass have the capacity to spread rapidly and displace valuable native flora. Of most concern, is the proximity of these plants to the Turtle Bay wetland on the southwest side of the lake, which harbors diverse floral and faunal communities.

The littoral habitat assessment revealed that one of the largest impacts Pleasant Lake's ecosystem would likely be a decline of hard substrate habitat. The acoustic survey revealed that the majority of the hard substrates (i.e. sand and rock) are located within four feet of water or less, and continued water level decline may reduce this habitat type. A number of aquatic plants as well as aquatic animals, like the giant floater mussel, have an affinity for harder substrates. A reduction of this habitat type may impact the populations of these species in Pleasant Lake. In addition, a continued reduction of the groundwater table would likely result in the loss of the plant and animal communities within the Turtle Bay wetland. Under natural conditions, fluctuating water levels in a seepage lake like Pleasant Lake are normal and are a required part of

the life cycle of a number of plants and animals. However, continued or sustained water level decline due to high capacity wells may have detrimental impacts to Pleasant Lake's ecology.

Through the process of this supplemental lake management planning effort, the PLMD has learned much about their lake's aquatic plant community, both in terms of its positive and negative attributes. Overall, the plant community is healthy, but there are certain aspects which require attention. It is now the PLMD's responsibility to maximize the positive attributes while minimizing the negative attributes as much as possible. The Implementation Plan that follows this section stems from discussions between Onterra ecologists and the PLMD Planning Committee on which action items the district may implement to properly maintain and care for this resource.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Pleasant Lake Management District (PLMD) Planning Committee and ecologists/planners from Onterra. Along with the goals created as part of the Waushara County Lake Management Planning Project, these goals represent the path the PLMD will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Pleasant Lake stakeholders as portrayed by the members of the Planning Committee. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Control Existing and Prevent Further Introductions of Aquatic Invasive Species to Pleasant Lake

Management Action: Enact hybrid water milfoil monitoring and control strategy.

Timeframe: Begin 2014

Facilitator: Pleasant Lake Board of Directors

Description: As described within the Aquatic Plant Results Section, one of the most pressing threats to the health, recreation, and aesthetics of Pleasant Lake is the non-native, invasive species hybrid water milfoil (HWM). Following its discovery in 2007, the PLMD acted quickly and enacted herbicide spot treatments to control areas of HWM. In 2010, with the assistance of Onterra, the PLMD received a WDNR AIS Early Detection and Response Grant to aid in funding HWM monitoring and control from 2010-2012. This program was successful, as HWM acreage and occurrence within the lake was reduced over this time period.

However, surveys in 2012 indicated that HWM is rebounding/re-colonizing areas that were treated in 2010-2012. A treatment was initially proposed for 2013, but calculations of the amount of herbicide proposed indicated that concentrations were approaching levels that could potentially impact aquatic plants on a lake-wide level. Because the bathymetric data available from the lake was from 1967 and a more accurate estimate of the lake's volume could not be made, it was decided that the 2013 treatment would be suspended until updated bathymetric data could be collected.

As described in the Aquatic Plant Survey Results Section, Pleasant Lake was found to contain approximately 2.2 acres of HWM in 2013. At this time, a combination of manual hand-removal and herbicide applications are the most feasible methods of control. Historically, the spot treatment strategy has been utilized in Pleasant Lake to target specific areas of HWM. While a whole-lake treatment has not yet been

found to be warranted in Pleasant Lake, a whole-lake treatment strategy may be applicable in the future if HWM becomes more widespread throughout the lake. However, if a whole-lake treatment is found to be warranted, whole-lake point-intercept surveys will have to be conducted the summer prior to the treatment and the summer immediately following the treatment to assess the aquatic plant community at the lake-wide level.

The objective of this management action is not to eradicate HWM from Pleasant Lake, as that is impossible with the currently available tools and techniques. The objective is to maintain an HWM population that exerts little to no detectable impacts on the lake's native aquatic plant community and overall ecology, recreation, and aesthetics. Monitoring is a key aspect of any AIS control project, both to prioritize areas for control and to monitor the strategy's effectiveness. The monitoring also facilitates the "tuning" or refinement of the control strategy as the control project progresses. The ability to tune the control strategies is important because it allows for the best results to be achieved within the plan's lifespan. It must be noted that hand-removal methodology is still experimental, and success criteria for assessing the efficacy of hand-removal have never been defined. Because of this, the following series of steps to manage HWM via hand-removal and herbicide applications in Pleasant Lake should remain flexible to allow for modifications as the project progresses. The series includes:

1. A lake-wide assessment of HWM (Early-Season AIS Survey) would be completed in early June to assess areas of HWM. By completing this survey in June, these areas of HWM can be provided to Golden Sands RC&D so they can better coordinate their hand-removal efforts.
2. A lake-wide assessment of HWM completed while the plant is at or near its peak biomass (July or August).
3. Creation of an herbicide treatment strategy (if warranted) for the following spring.
4. Verification and refinement of treatment plan immediately before the treatments are implemented.
5. Completion of treatments.
6. Assessment of treatment results (summer after treatment).

Two types of monitoring would be completed to determine treatment effectiveness; 1) quantitative monitoring using WDNR protocols, and 2) qualitative monitoring using observations at individual treatment sites and on a treatment wide basis. Results of both of these monitoring strategies would be used to create the subsequent treatment strategies. The quantitative strategies include sampling plants, both HWM and native species, at predetermined locations (points) within treatment areas, while the qualitative monitoring includes the determination of HWM abundance based upon a continuum of density. The density

continuum ranges from non-detectable levels of HWM to what is considered a monoculture where HWM is essentially the only plant that exists in the area. Both monitoring types would be completed before and after the treatments (pretreatment surveys and post treatment surveys). Comparing the monitoring results from the pretreatment and post treatment surveys would determine the effectiveness of the treatment on a site-by-site basis and on a treatment wide basis. Finally, a lake-wide plant survey (point-intercept survey) would be completed after this management action is completed (3 years) to determine the effectiveness of the intense control program.

Qualitatively, a successful treatment on a particular site would include a reduction of exotic density, as demonstrated by a decrease in density rating. Quantitatively, a successful treatment would include a significant reduction in HWM frequency following the treatments, as exhibited by at least a 50% decrease in exotic frequency from the pre- and post treatment point-intercept sub-sampling. Funds from the WDNR AIS Program in will be sought to partially fund this control program from 2015-2017. Specifically, funds would be applied for under the Education, Planning and Prevention Project classification.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing cyclic series of steps discussed above.
2. Apply for WDNR Education, Planning and Prevention Grant based on developed project design in 2014 cycle.
3. Initiate control plan.
4. Revisit control plan in two years.
5. Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Action: Monitor curly-leaf pondweed population in Pleasant Lake.

Timeframe: Begin 2015

Facilitator: Pleasant Lake Board of Directors

Description: As discussed in the Aquatic Plant Section, Pleasant Lake also contains the non-native, invasive plant curly-leaf pondweed (CLP). While it is not known when CLP was first introduced to Pleasant Lake, it has likely been present in the lake for some time. Surveys conducted in 2013 found a very small CLP population, with no large colonized areas being observed. At this time, CLP control strategies utilizing herbicides are not warranted, and hand-removal of these plants is the most feasible control option.

However, the CLP population in Pleasant Lake should be monitored so that control strategies can be enacted quickly if necessary. As discussed in the previous management action, a WDNR Education Planning and Prevention Grant will be sought to aid in funding

professional monitoring of HWM from 2015-2017. This will include an Early-Season AIS Survey in June of each year. Because CLP senesces (dies back) by early summer, occurrences of CLP in Pleasant Lake would also be be mapped during the June Early-Season AIS Survey. While the CLP will be monitored professionally from 2015-2017, it should be the goal of the PLMD to eventually monitor the CLP population annually utilizing trained volunteers. These volunteers could then relay their findings to resource managers and control actions could be initiated if necessary.

Action Steps:

1. See previous management action.

Management Action: Control populations of giant reed (*Phragmites australis subsp. australis*) on the shorelines of Pleasant Lake.

Timeframe: Begin 2014

Facilitator: PLMD Board of Directors with assistance of Golden Sands RC&D Staff

Description: During Onterra's 2013 aquatic plant surveys, the non-native, invasive wetland plant species giant reed was located in two locations along Pleasant Lake's southern shore (Map 2). These populations are believed to be in an early stage of infestation, and eradication of these plants is highly likely if control is initiated quickly. Staff from Golden Sands RC&D will be initiating control of these giant reed populations during the summer of 2014. This will include the cutting of the giant reed stems followed by the application of glyphosphate directly to the cut stems. Following this initial treatment, PLMD volunteers will be able to implement this control strategy annually as new plants are observed.

Action Steps:

1. Contact Golden Sands RC&D to see when they plan on visiting Pleasant Lake to initiate giant reed control strategy.
2. PLMD volunteers join Golden Sands RC&D staff during giant reed cutting and herbicide application to learn control methodology.
3. PL MD volunteers initiate giant reed control strategy annually as needed.

Management Action: Monitor Pleasant Lake for zebra mussels.

Timeframe: Begin 2015

Facilitator: PLMD Board of Directors

Description: The calcium concentrations in Pleasant Lake indicate that the lake is suitable and highly susceptible to zebra mussel establishment if they are introduced to the lake. In addition, nearby lakes like Silver Lake contain populations of zebra mussels. While the PLMD monitors the lake's boat landing through the Clean Boats Clean Waters Program in

an effort to prevent the introduction of zebra mussels and other invasive species, the PLMD also wishes to monitor the lake for adult zebra mussels in an effort to detect an early infestation. While there are currently no strategies to control zebra mussels once they are established, knowing if they are present in a waterbody is important so lake users can take extra precautions when removing their watercraft from Pleasant Lake.

The PLMD wishes to monitor Pleasant Lake for adult zebra mussels following the methodology outlines in the WDNR's *Dreissenid (Zebra and Quagga) Mussel Monitoring Protocol*. Specifically, the PLMD would like to purchase substrate sampler materials, where a specially-designed samples containing metal plates is suspended in the water and periodically checked for adult zebra mussels. If zebra mussels are located on the sampler, the PLMD will notify the WDNR.

Action Steps:

1. PLMD contacts Cathy Cleland (WDNR) at 715.365.8997 to order a zebra mussel substrate sampler.
2. Following protocols outlined in *Dreissenid (Zebra and Quagga) Mussel Monitoring Protocol*, the PLMD will deploy the substrate sampler and periodically check it for attached adult zebra mussels.
3. PLMD will report any occurrences of zebra mussels to the WDNR.

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Pleasant Lake public access location.

Timeframe: Continuation of current effort

Facilitator: PLMD Board of Directors

Description: Currently the PLMD monitors the public boat landing using training provided by the Clean Boats Clean Waters program. Pleasant Lake is a popular destination for recreationalists, making it vulnerable to new infestations of exotic species. The intent of the boat inspections would not only be to prevent additional invasives from entering the lake through its public access point, but also to prevent the infestation of other waterways with invasives that originated in Pleasant Lake. The goal would be to cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on lakes and educating people about how they are the primary vector of their spread.

Action Steps:

1. See description above as this is an established program.

Management Goal 2: Assure and Enhance the Communication and Outreach of the Pleasant Lake Management District with Lake Stakeholders

Management Action: Support an Education and Communication Committee to promote stakeholder involvement, inform stakeholders on various lake issues, as well as the quality of life on Pleasant Lake.

Timeframe: Develop in 2014

Facilitator: PLMD Board of Directors to form Education and Communication Committee

Description: Education represents an effective tool to address lake issues like shoreline development, invasive species, water quality, lawn fertilizers, as well as other concerns such as community involvement and boating safety (Map 8). An Education and Communication Committee will be created to promote lake preservation and enhancement through a variety of educational efforts.

Currently, the PLMD regularly publishes and distributes a newsletter and maintains a district website that provides district-related information including current district projects and updates, meeting times, volunteer opportunities, and educational topics. Both of these mediums are an excellent source for communication and education to both district and non-district members.

The PLMD would like to increase its capacity to reach out to and educate district and non-district members regarding Pleasant Lake and its preservation. In addition to creating a newsletter, a variety of educational efforts will be initiated by the Education and Communication Committee. These may include educational materials containing information about the PLMD (projects, finances, etc.) as well as facts about Pleasant Lake and steps lake residents can take to maintain and enhance the quality of the lake, as well as quality of life for those who live and recreate on it. The Education and Communication Committee will also organize workshops and speakers surrounding lake-related topics.

Education of lake stakeholders on all matters is important. During the second planning meeting with PLMD Planning Committee members, the list below of educational topics was discussed. These topics will be included within the district's newsletter and/or website or distributed as separate educational materials. In addition, the PLMD can invite professionals who work within these topics to come and speak at the district's annual meeting or hold workshops if available.

Example Educational Topics

- Shoreline restoration and protection
- Boating regulations and safety
- Importance of maintaining course woody habitat
- Effect lawn fertilizers/herbicides have on the lake
- Pier regulations and responsible placement to minimize habitat disturbance
- Importance of maintaining a healthy native aquatic plant community and minimizing impacts to it
- Aquatic invasive species (AIS) prevention and updates for AIS in Pleasant Lake
- Water quality monitoring updates from Pleasant Lake

Action Steps:

1. Recruit volunteers to from Education and Communication Committee.
2. Investigate if WDNR Small-Scale Lake Planning or AIS Education, Planning, and Prevention Grants would be appropriate to cover initial setup costs.
3. The PLMD Board will identify a base level of financial support for educational activities to be undertaken by the Education and Communication Committee on an annual basis.

7.0 LITERATURE CITED

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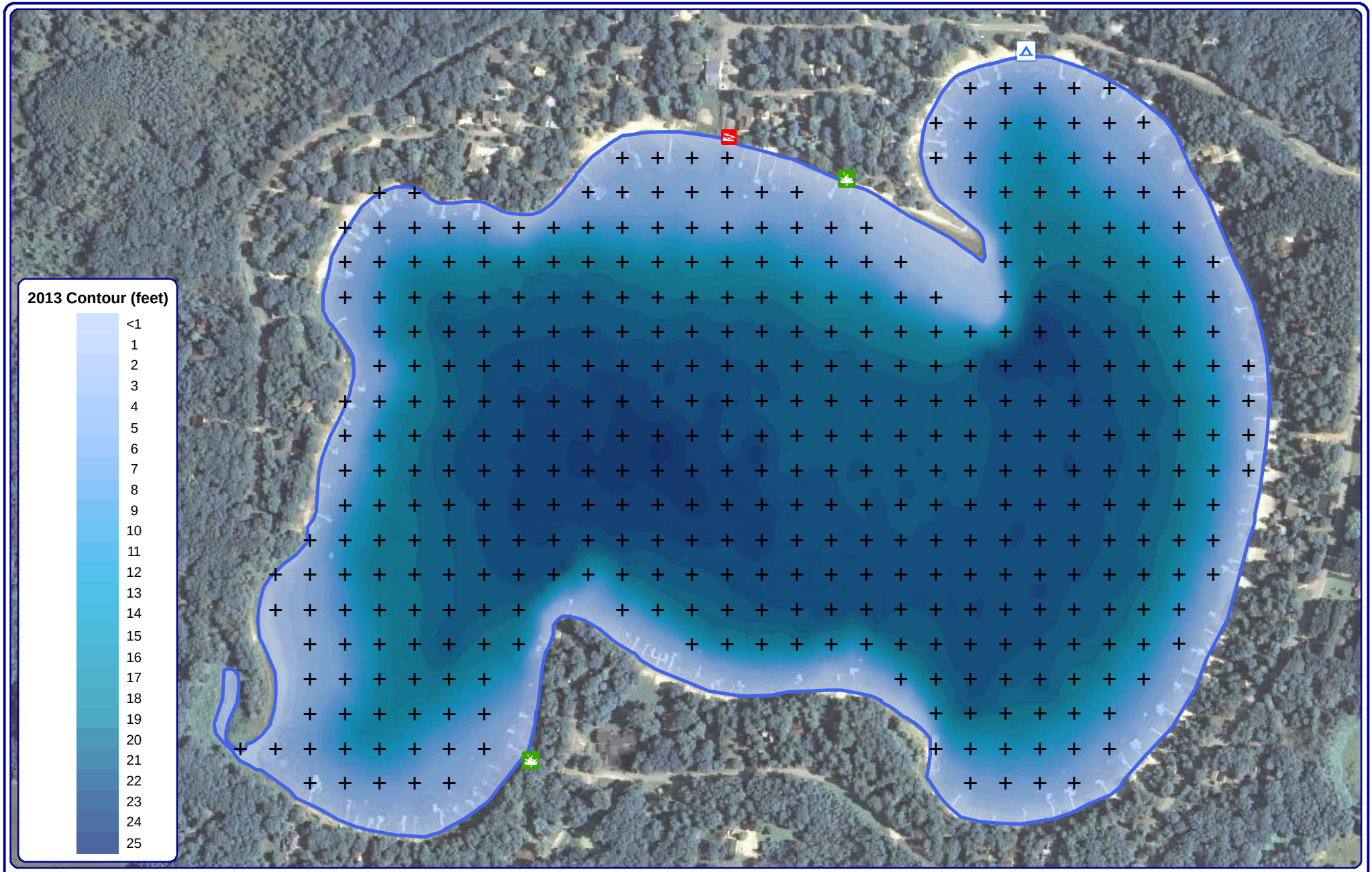
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Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map1_Pleasant_Location.mxd


Project Location in Wisconsin

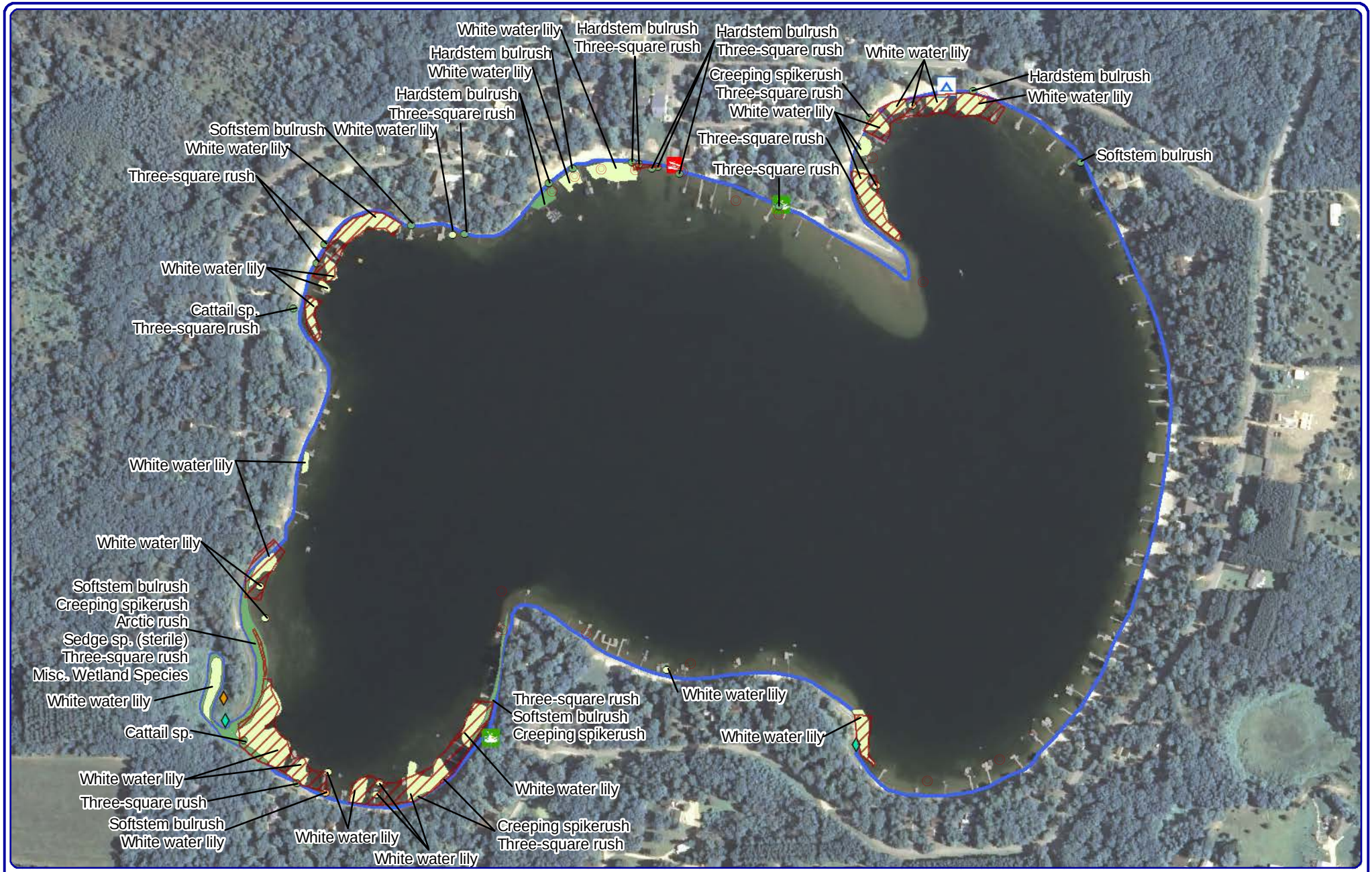
Legend

Pleasant Lake ~127acres
WDNR Definition

\+ Point-Intercept Survey Location
34-meter spacing, 419 total points

Public Access
Carry-In Access
Public Beach

Map 1
Pleasant Lake
Waushara County, Wisconsin
Project Location & Lake Boundaries



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Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: February 14, 2014
Filename: Map2_Pleasant_Comm_2013.mxd



Project Location in Wisconsin

Legend

Large Plant Community
- Emergent
- Floating-leaf
- Mixed Emergent & Floating-leaf
- 2009 Emergent and/or Floating-leaf

Small Plant Community
- Emergent
- Floating-leaf
- Mixed Emergent & Floating-leaf
- 2009 Emergent and/or Floating-leaf

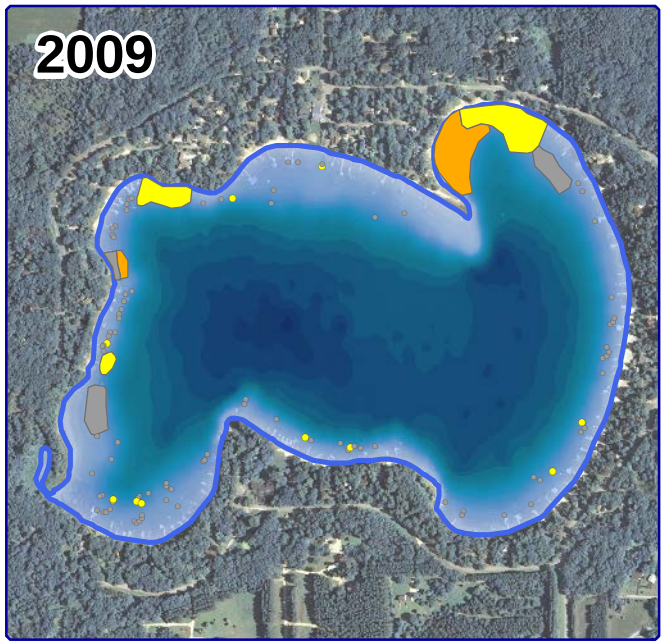
Exotic Plant Community
- Giant Reed
- Reed Canary Grass

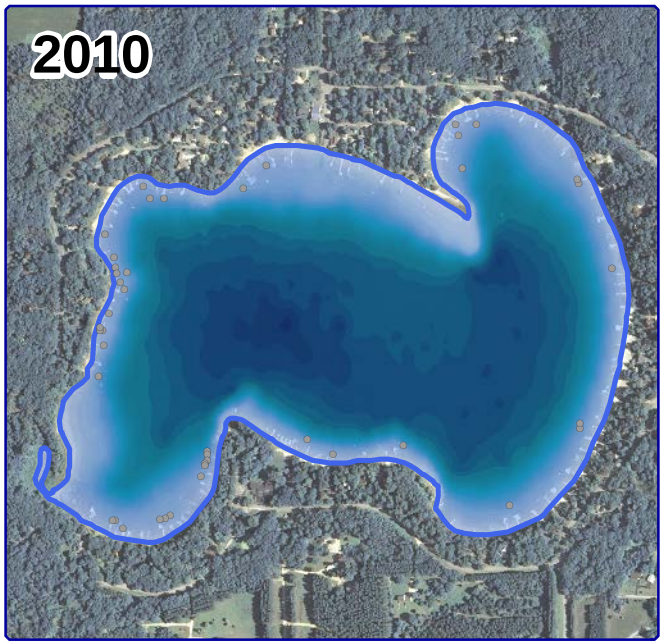
Map 2

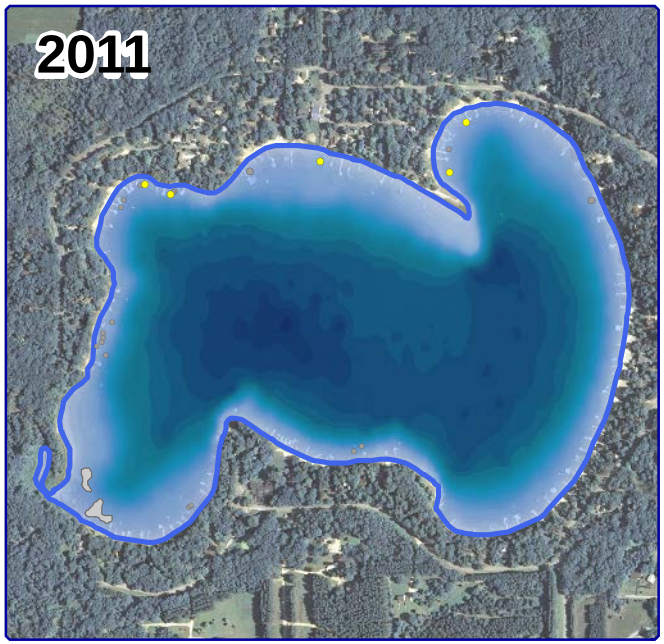
Pleasant Lake

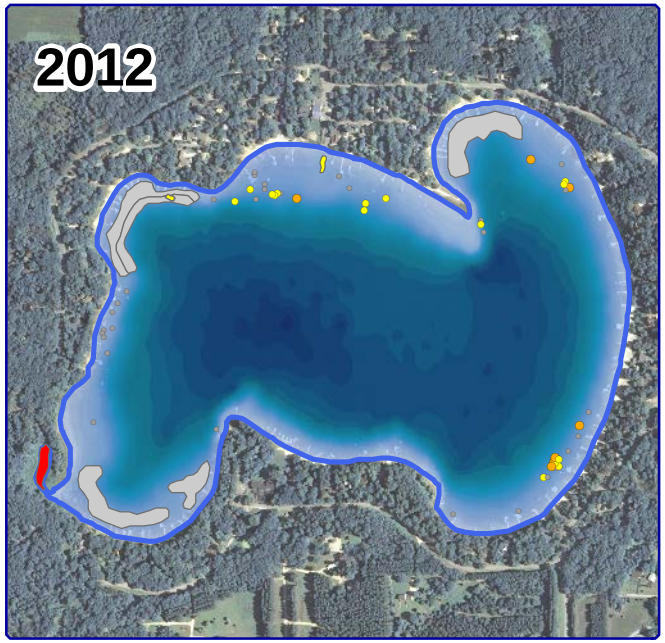
Waushara County, Wisconsin

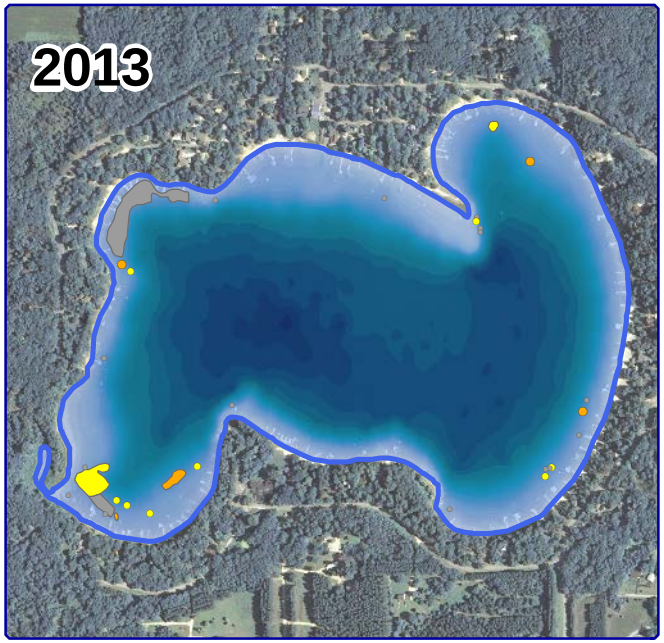
Emergent & Floating-leaf Aquatic Plant Communities











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Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map1_Pleasant_Location.mxd


Project Location in Wisconsin

Legend

Hybrid Water Milfoil

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

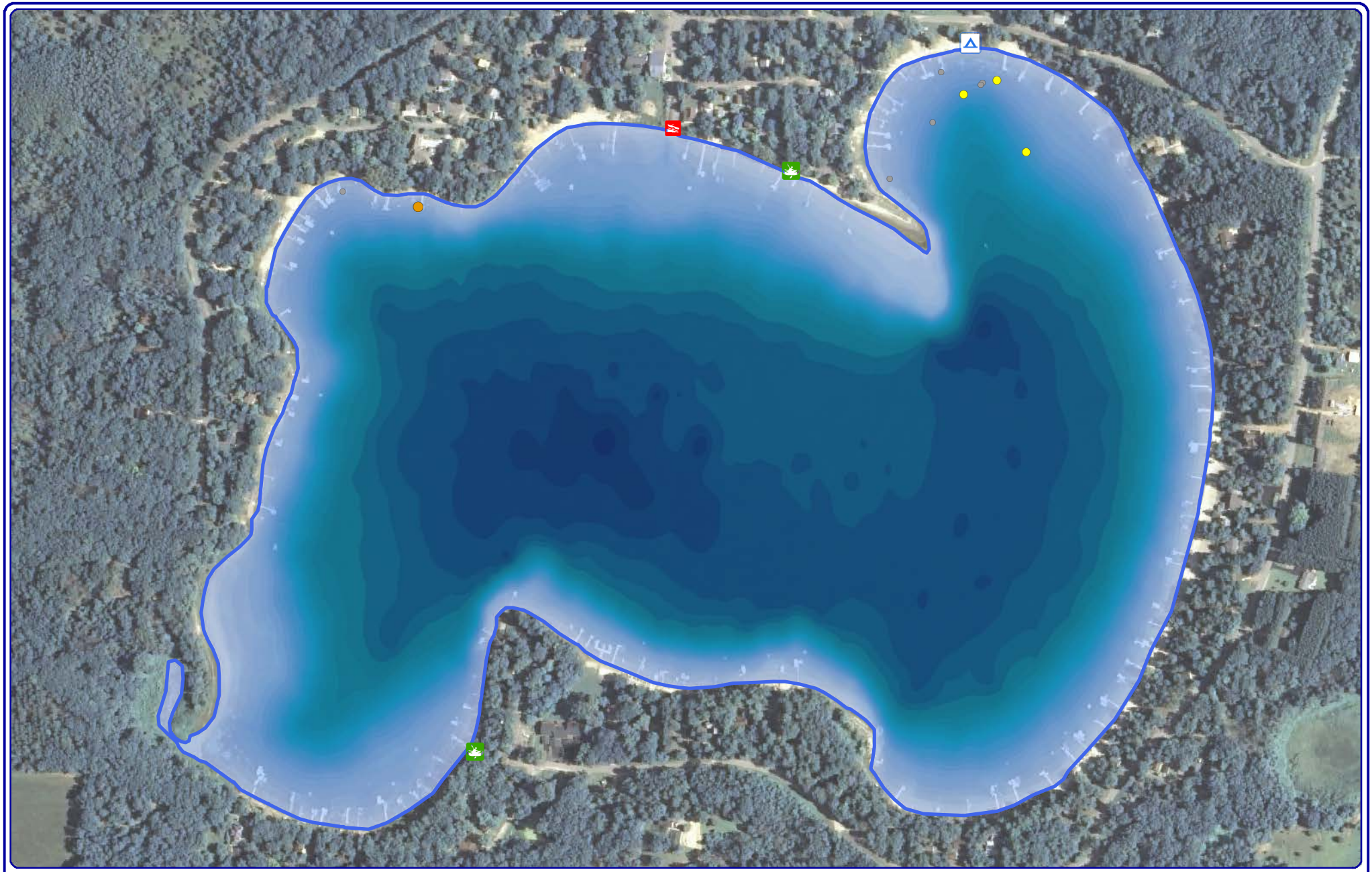
Map 3

Pleasant Lake

Waushara County, Wisconsin

2009-2013

HWM Locations



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Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map4_Pleasant_CLPPB_June2013.mxd



Project Location in Wisconsin

Legend

Curly-leaf pondweed

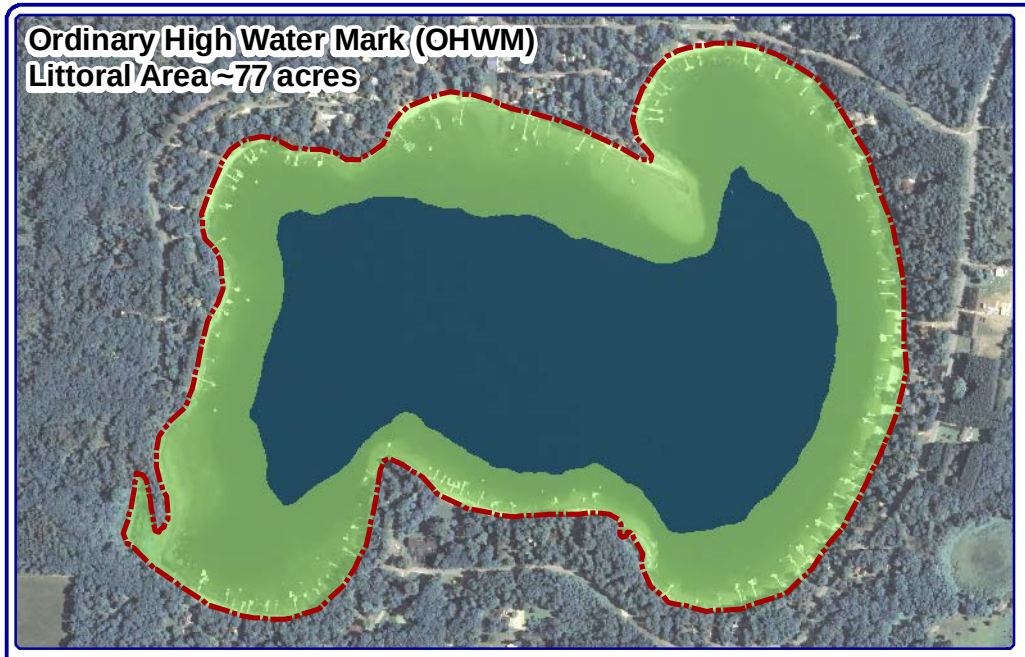
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

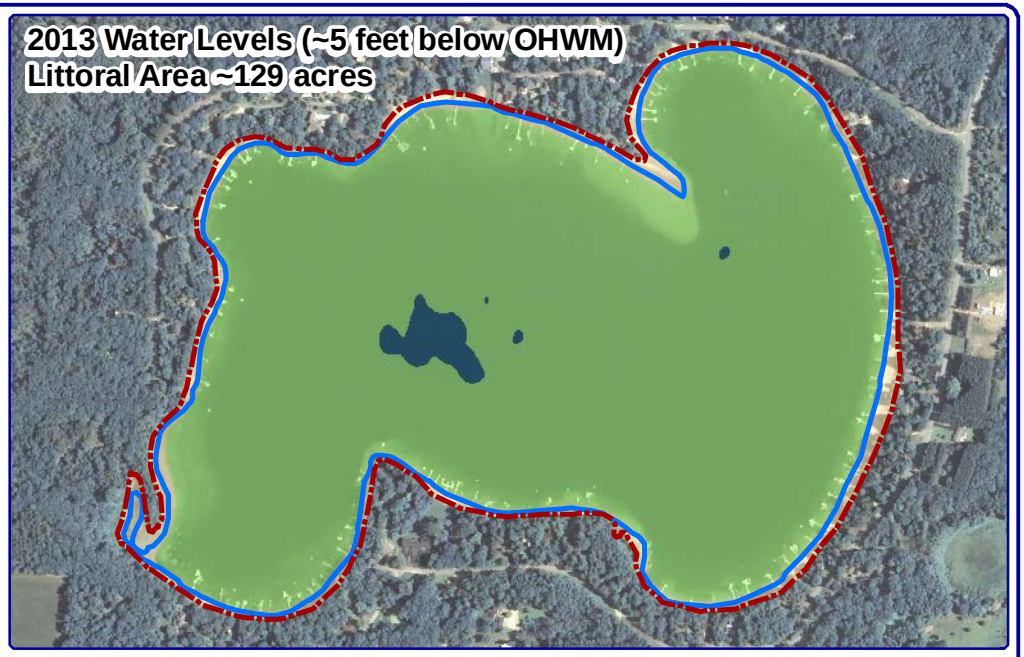
Map 4

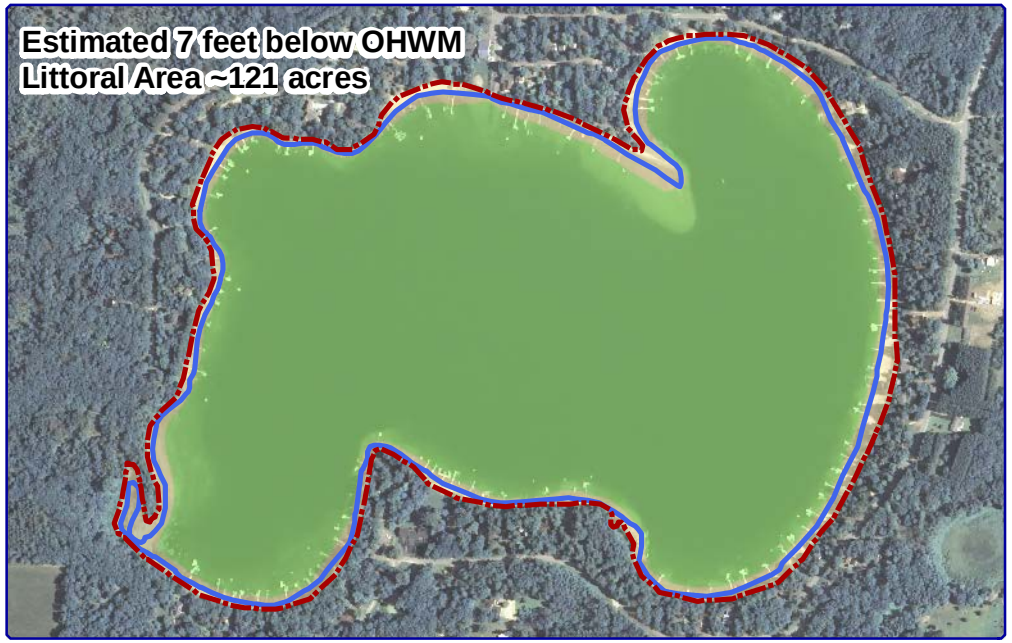
Pleasant Lake

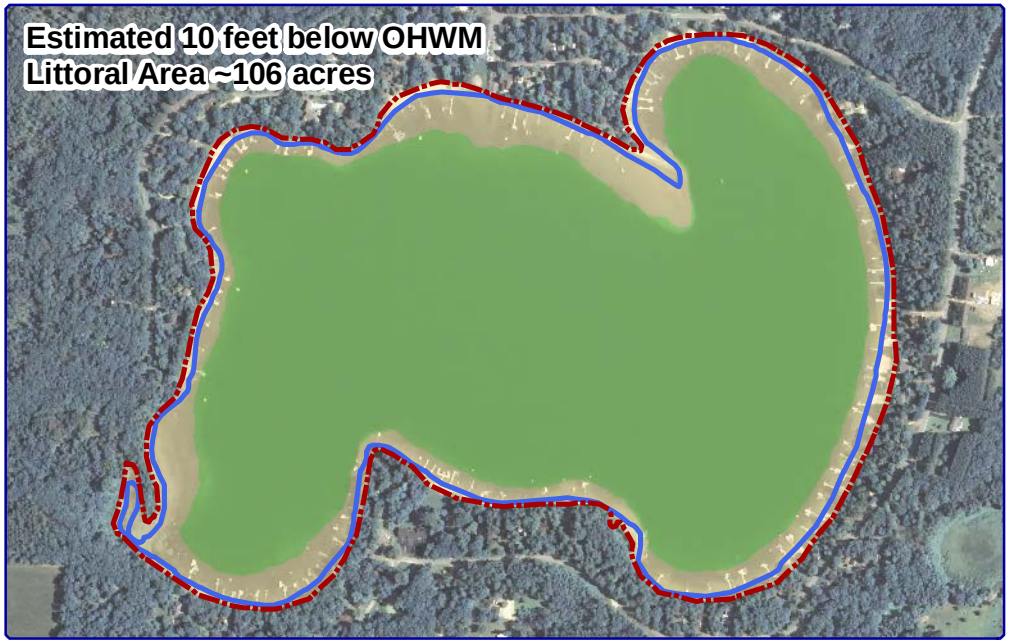
Waushara County, Wisconsin

2013 CLP Locations









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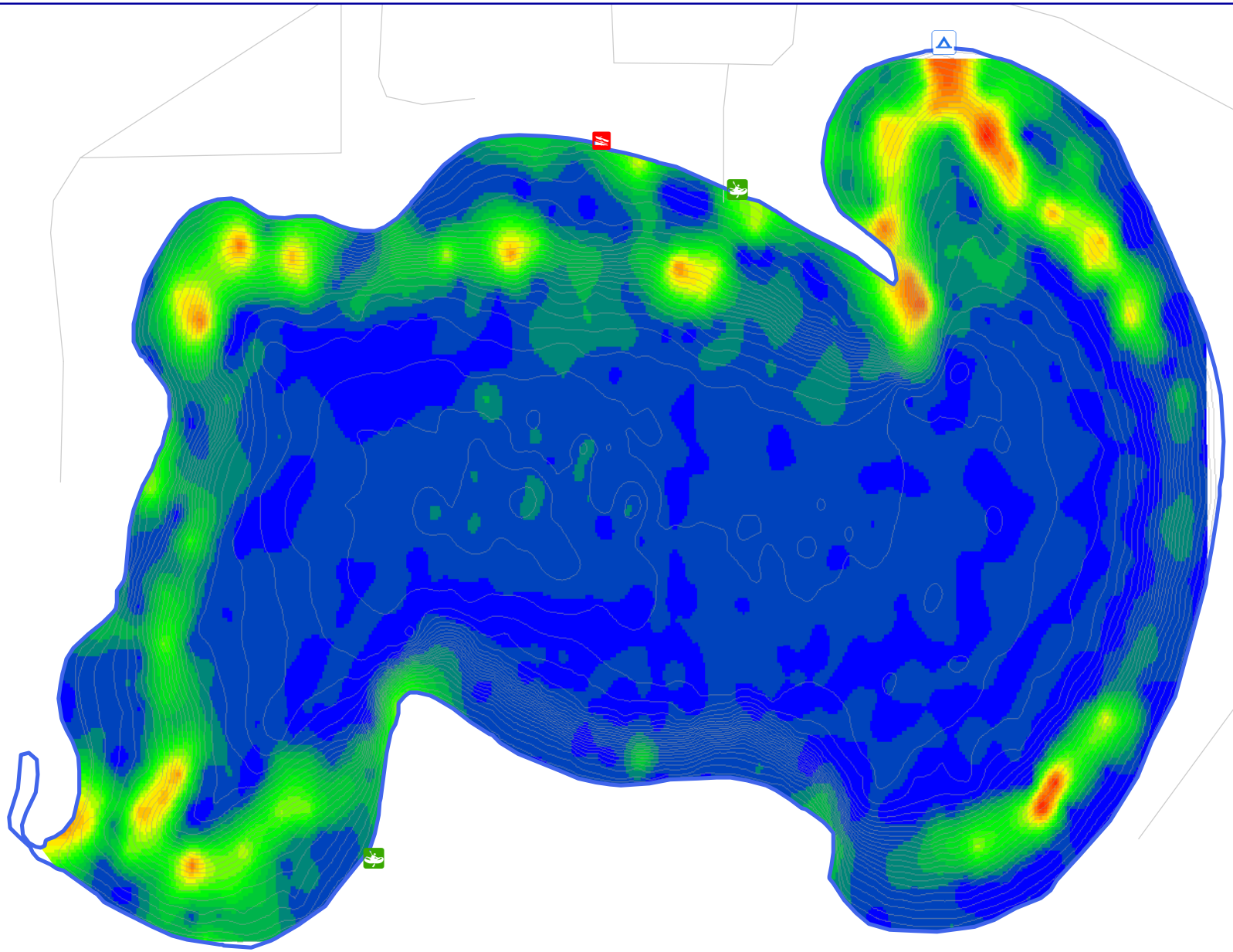
Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map5_Pleasant_LittoralArea_Scenario.mxd


Project Location in Wisconsin

Legend

- Pleasant Lake Estimated Ordinary High Water Mark (OHWM)
- Pleasant Lake Estimated 2013 Water Mark
- Littoral Area ≤ 24 feet
- Non-Littoral Area >24 feet
- Exposed Lakebed

Map 5
Pleasant Lake
Waushara County, Wisconsin
Littoral Area in Relation to Water Levels



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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, June 2013
Map Date: June 24, 2013
Filename: Map6_Pleasant_Biovolume_2013.mxd



Project Location in Wisconsin

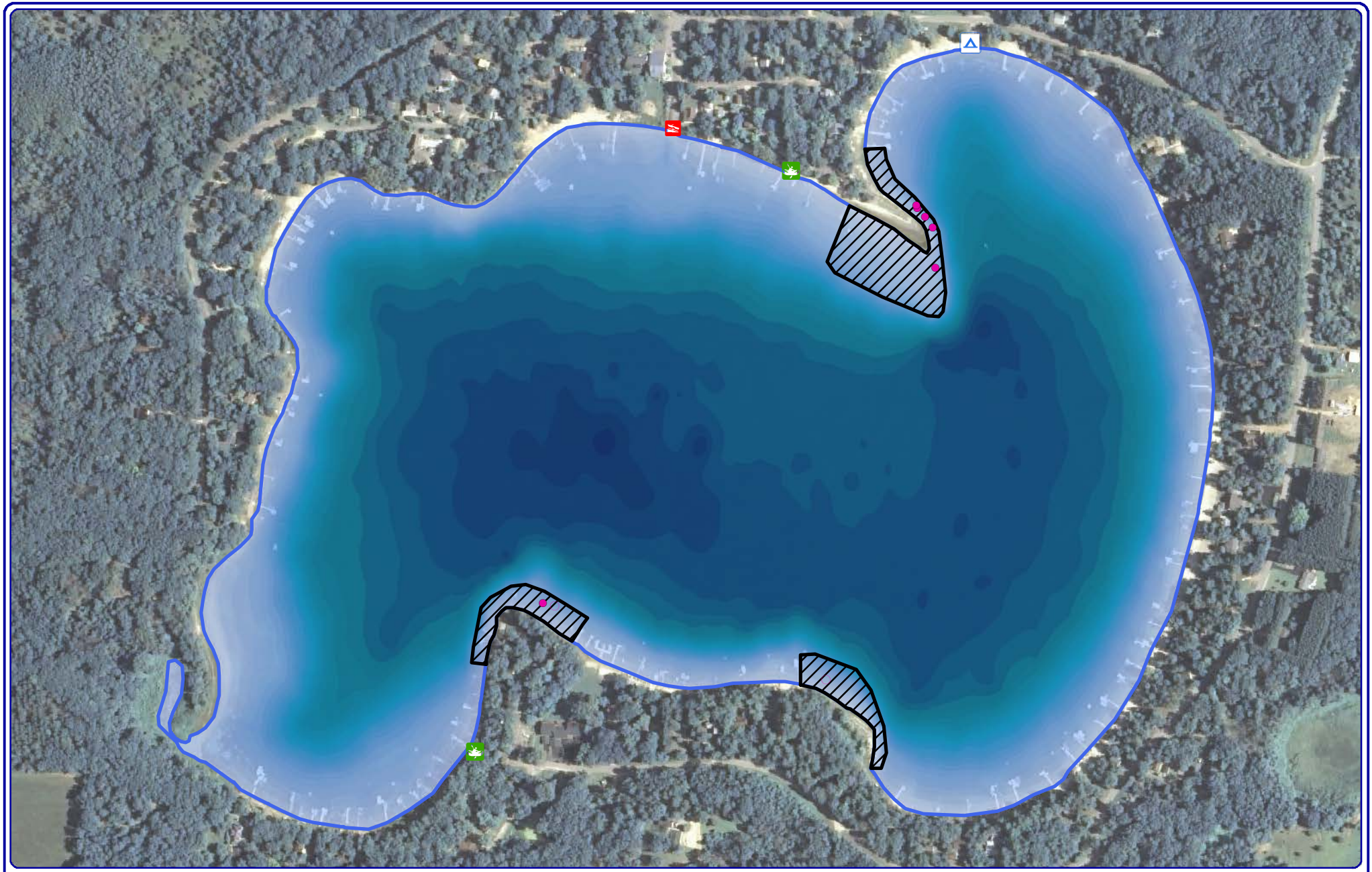
Legend

0% 50% 100%

Aquatic Plant Bio-volume (%)

No Data

Map 6
Pleasant Lake
Waushara County, Wisconsin
2013 Aquatic Plant Biovolume



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Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map7_Pleasant_MusselLocations.mxd



Project Location in Wisconsin

Legend

- Mussel Snorkel Survey Transect Area
- Live *Pyganodon grandis*
- Non-Live *Pyganodon grandis*
- Public Access
- Carry-In Access
- Public Beach

Map 7
Pleasant Lake
Waushara County, Wisconsin
2013 Freshwater Mussel Survey Results



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Sources:
Data: Bathymetry: Onterra, 2013
Orthophotography: NAIP, 2010
Map Date: February 10, 2014
Filename: Map8_Pleasant_Watercraft_RegAreas.mxd



Project Location in Wisconsin

Legend

All Watercraft
Slow-No-Wake Area (100 feet)

Personal Watercraft
Slow-No-Wake Area (200 feet)

Public Access
Carry-In Access
Public Beach

Map 8
Pleasant Lake
Waushara County, Wisconsin
Watercraft Regulation Areas

A

APPENDIX A

Survey of Littoral Zone and Associated Wetlands of Pleasant Lake

10 July 2012

To: Carl Sinderbrand
Axley Brynelson, LLP
2 East Mifflin St., Suite 200
Madison, Wisconsin, 53701-1767

From: Mary Linton, PhD
Certified Ecologist (Ecological Society of America)

Re: Survey of Littoral Zone and Associated Wetlands of Pleasant Lake

I conducted visual and auditory surveys of the shoreline and littoral zone of Turtle Bay and three wetlands near to or associated with Pleasant Lake on May 2 and 23/24, and June 13/14, 2012. In this paper I provide the data collected during that time and my interpretation of what the data predicts regarding possible biotic effects of further permanent drawdown of water levels in Pleasant Lake. My investigations focus on the anuran (frog and toad) community, and evidence of groundwater inputs to Pleasant Lake and associated wetlands. I also estimate the effect of drawdown on shallow, near-shore areas as well as the very rich Turtle Bay littoral zone (habitat for banded killifish, a Wisconsin Species of Special Concern) and boggy sedge meadow directly connected to Turtle Bay via a small channel.

A. Wetlands

Only one of the three wetlands I surveyed had an established name: Turtle Bay Wetland. Turtle Bay Wetland (N43^{o} 58.950' W89^{o} 33.528') is found adjacent to Turtle Bay in the southwest corner of Pleasant Lake. Turtle Bay Wetland is connected to Pleasant Lake via a shallow channel that appears to have been excavated. Wetland 2 (N43^{o} 58.892' W89^{o} 33.260') is east of Turtle Bay, approximately 400 feet from lake edge, has no surface water connection to the lake, and is located on Fairwood Camp property. Wetland 3 (N43^{o} 59.341' W89^{o} 32.859') also has no surface water connection to the lake and is approximately 500 feet north of the northeast lobe of the lake. All wetlands have similar elevations to Pleasant Lake.

1.Turtle Bay Wetland
Turtle Bay Wetland, whose entire basin is fully exposed to the sun, has the most diverse plant community of the three wetlands studied even though the site has been disturbed. The current wetland vegetation contains almost all of the plant species found in the rich shoreline wetland community found in adjacent Turtle Bay (see Table 2).

According to lake residents dredging occurred in Turtle Bay Wetland approximately 15 years ago. The wetland was deepened near Pleasant Lake and a shallow channel to the lake was added. Wetland plants continue to the edge of the woodlands west and south of the opening, a distance of at least 30 feet. Obligate (OBL) wetlands plants found distant

from the current smaller wetland pool include *Carex stricta* (Tussock Sedge), *Carex lacustris* (Lake Sedge), *Eupatorium maculatum* (Joe-Pye-Weed), *Salix exigua* (Sand Bar Willow) and *Schoenoplectus tabournaemontani* (Softstem Bullrush). *Phalaris arundinacea* (Reed Canary Grass, FACW+), and *Impatiens capensis* (Jewelweed, FacW) were also abundant distant from the pool.

This distribution of plants in the upland suggests that the basin of this wetland was much larger within in recent decades. The presence of groundwater near the surface, including springs and seeps (see Fig. 1), may help the survival of the obligate wetland plants, as well as the others that prefer wetter places. It is likely that the dredging and loss of water level due to current groundwater removal by high-capacity wells contributed to the shrinking of this exceptional wetland. Further permanent loss of groundwater would significantly and negatively impact the plant community now growing in the old wetland basin.

Turtle Bay Wetland also contained the most numerous populations of frogs and toads (See Table 1). Due to unusually warm spring temperatures, Wisconsin's earliest frog species to emerge from hibernation started breeding before our survey began. It is likely that Boreal Chorus Frogs (*Pseudacris maculata*) breed in large numbers in early March. The wetland would also provide good breeding habitat for the Pickerel Frog (*Lithobates palustris*, Wisconsin Species of Special Concern) because it prefers cold, spring-fed waters for breeding. The cold waters must be near warmer waters for juveniles to development. The shallow channel or the littoral zone of Pleasant Lake would supply juvenile habitat.

In Turtle Bay Wetland frogs and toads were so abundant that they called not only from the water in the wetland, but also from the larger wetland basin and the surrounding woodlands. In addition, Leopard Frogs (declining in Wisconsin) and Bullfrogs (Wisconsin Species of Special Concern) were associated with the outlet to Pleasant Lake and the shoreline nearest Turtle Bay Wetland. Due to the abundance and diversity of frogs and toads in Turtle Bay, it should be protected as the prime anuran breeding area in the Pleasant Lake area.

Finally, Snapping Turtles (*Chelydra serpentina*) and Western Painted Turtles (*Chrysemys picta belli*) were observed at Turtle Bay Wetland.

2. Wetland 2

Wetland 2 is a shallow wetland almost completely covered by tree canopy. Woodland wetlands can be breeding ponds for *Ambystoma* salamanders. These amphibians would have bred in February and March this year so would not have been observed. No juveniles were captured. Only Spring Peepers bred in Wetland 2 with the same abundance as Turtle Bay Wetland. Other frogs and toads, including the Leopard Frog and Cope's Gray Treefrog (both species declining in Wisconsin) were present in smaller numbers (see Table 1). Even though numbers of breeding anurans was not as large as Turtle Bay, this pond still served as a good breeding site and contained breeders from declining species. Western Painted Turtles were observed basking on logs in sun patches.

Evidence of groundwater input could be seen in numerous spots in this wetland (see Fig. 1) In May the surface of the wetland was almost completely covered with Purple-fringed Riccia (*Ricciocarpus natans*), an uncommon aquatic liverwort. By June duckweed shared the surface with the Purple-Fringed Riccia.

3. Wetland 3

Wetland 3 had clearly been altered in the past and was surrounded almost entirely by Reed Canary Grass. As with Turtle Bay Wetland and Wetland 2, evidence of groundwater input was seen in Wetland 3. Large numbers Spring Peepers, Cope's Gray Treefrogs, and American Toads chorused at Wetland 3. Green Frogs and Gray Treefrogs were less abundant. Even with it's low plant diversity. Wetland 3 should be protected from further permanent drawdown because it is also a fine site for amphibian breeding.

As at the other wetlands, evidence of groundwater input was present at Wetland 3.

B. Turtle Bay Littoral Zone

The littoral zone in the shallow water on the east shore of Turtle Bay is a significant resource for animal populations of Pleasant Lake. All amphibians heard calling in Pleasant Lake were calling from this area. A Bullfrog (Species of Special Concern), several leopard frogs (declining in Wisconsin) and numerous American Toads were heard calling from the macrophyte beds of this littoral zone. The macrophyte beds provided structure and protection for calling male amphibians, and egg-laying habitat for female amphibians.

On June 13/14, 2012, I surveyed the macrophytes of the shallows and noted the animal species using the habitat provided. Table 2 contains the plant and algae species found in the macrophyte bed with an estimate of their coverage/abundance. The plant species diversity is high for this macrophyte bed with no single species dominating. All but Reed Canary Grass are native species. Stonewort (*Chara)* is a submerged alga that grows under the emergent vegetation in the bed and in more open areas where macrophytes that prefer shallower water thin out and submerged plants, such as the pondweeds, and plants with floating leaves, such as White Water Lily, grow.

Stonewort is a calciphile and it's abundance here is due to ground water input. Springs and seeps were easily located in the macrophyte bed by noting quick changes in water temperature from the typical warm waters of the lake to very cold spring water. Mineral deposits left by spring were observed in the macrophyte bed (see Fig. 1). Groundwater input was also indicated by the abundance of snails that need calcium for their shells.

The shallows of Turtle Bay supply nesting areas for sunfish and bass. They also provide food and protection for the young sunfish and bass. I observed a school of Banded Killifish (*Fundulus daiphanus*, Wisconsin Species of Special Concern) feeding in the macrophyte bed. Killifish use the beds for protection from larger predatory fish - its

striped coloration serves as camouflage in plant beds. They also contain killifish prey such as the abundant small crustaceans also found in weed beds.

The macrophyte bed was being used by many species of dragonflies and damselflies (Odonata). In a short period I was able to identify 20 species, most fairly common. Of special interest were numerous Red Saddlebags (*Tramea onusta*) that are uncommon in Wisconsin. The macrophyte bed also contained many common Hemiptera (water striders, backswimmers, water boatmen and water scorpions), Coleoptera (predacious diving beetles, water scavenger beetles, and whirlygig beetles), and minnow Mayflies. The juvenile and adult insects are prey for the fish of Pleasant Lake.

Shallow water is essential for the health of the Turtle Bay macrophyte bed, as well as a smaller bed associated with the point of sand that extends into Pheasant Lake, forming the northeast lobe of the lake that contains the county park and dock. Turtle Bay has the largest shallow bench in the lake and provides the most complex habitat for lake animals. I mapped the bottom contours at these shallows by measuring the depth of water in inches every 2 feet along transects established at each location. Figure 2 contains the depth contour of the Turtle Bay shallows and the shallows from the sand point into the main body of Pleasant Lake.

Permanent drawdown of up to 5 inches would lead to a loss of 6 feet of shallow water but little loss of habitat. A drawdown of 3 to 5 inches would lead to a serious loss of 7 to 10 feet of the shallows at Turtle Bay, effectively stranding the littoral zone community. It would take years to re-establish the bed's plant and animal community ten feet distant from it's current location and would significantly decrease the viability of the Banded Killifish population in the lake.

It would also change the interaction of Turtle Bay wetland with Pleasant Lake. I studied the flow in the channel between the Lake and wetland on three dates and on 2 dates water flowed from the Lake into the wetland, while on one date it flowed from the wetland into the lake. The flow into the wetland from the lake would cease with a stranding of the channel.

Summary

The wetlands and littoral zones currently provide habitat for a rich variety of aquatic plants and animals. Another permanent drawdown would negatively impact habitat in the littoral zone of Pleasant Lake and could seriously impact the water levels and plant and animals diversity of the three wetlands closely associated with the lake.

Table 1. Anuran Call Survey of Pleasant Lake and Associated Wetlands. Method used was the Wisconsin Frog and Toad Survey, the national standard. On April 14, 2012, Dr. Francine Rowe recorded anuran calls that were then analyzed by Dr. Mary Linton. Mary Linton conducted the May 2, May 23 ad June 13, 2012 surveys. Plea. Lake = Pleasant Lake. SP = Spring Peepers, LF = Leopard Frogs, AT = American Toads, CGTF = Cope's Gray Treefrog, EGTF = Gray Treefrog, GF = Green Frog, BF = Bullfrog

Date	Site Name	Water Temps ^{o} C	Anuran Species						
			SP	LF	AT	CGTF	GTF	GF	BF
4/14/12	Wetland 3	--	3*		1				
	Wetland 2	--	2						
	Turtle Bay	--	3		2				
	Plea. Lake	--	--	--	--	--	--	--	--
5/2/12	Wetland 3	24.5	3		3	3			
	Wetland 2	26	3			2			
	Turtle Bay	27	3	1	2	3			
	Plea. Lake	--							
5/23/12	Wetland 3	18	2			3	1		
	Wetland 2	18.5					2	1	
	Turtle Bay	21				3		2	
	Plea. Lake	--				3			1
6/13/12	Wetland 3	21						1	
	Wetland 2	21			1				
	Turtle Bay	18.5						3	
	Plea. Lake	22.5			1			2	

*1 = individuals can be counted, there is space between calls
2 = calls of individuals can be distinguished but there is some overlapping of calls
3 = full chorus. Calls are constant, continuous and overlapping

Table 2. Turtle Bay Macrophytes. Species abundance in the bed scored as abundant (A), common (C), uncommon (U), and rare (R).

Species	Common Name	Abundance
Carex comosa	Bristly Sedge	C
Chara sp.	Stonewort Algae	A
Decodon verticillatus	Water Willow	U
Eleocharis acicularis	Least Spikerush	R
Eleocharis obtuse	Blunt Spikerush	U
Nymphaea odorata	White Water-lily	C
Phalaris arundanaceae	Reed Canary Grass	A
Polygonum amplifolius	Aquatic Smartweed	R
Potemogeton amplifolius	Big-leafed Pondweed	R
Potamogeton natans	Floating Pondweed	R
Potamogeton pectinatus	Sago-pondweed	R
Rhizoclonium sp.	Hair Algae	C
Salex sp.	Willow	C
Schoenoplectus tabernaemontani	Softstem Bulrush	A
Scirpus torreyi	Torrey Threesquare Bulrush	U
Typha latifolia and hybrids	Common cattail	U
Utricularia sp	Bladderwort	R



Figure 1. Evidence of significant groundwater seepage into Turtle Bay (above) and Fairwood Camp Wetland (below).

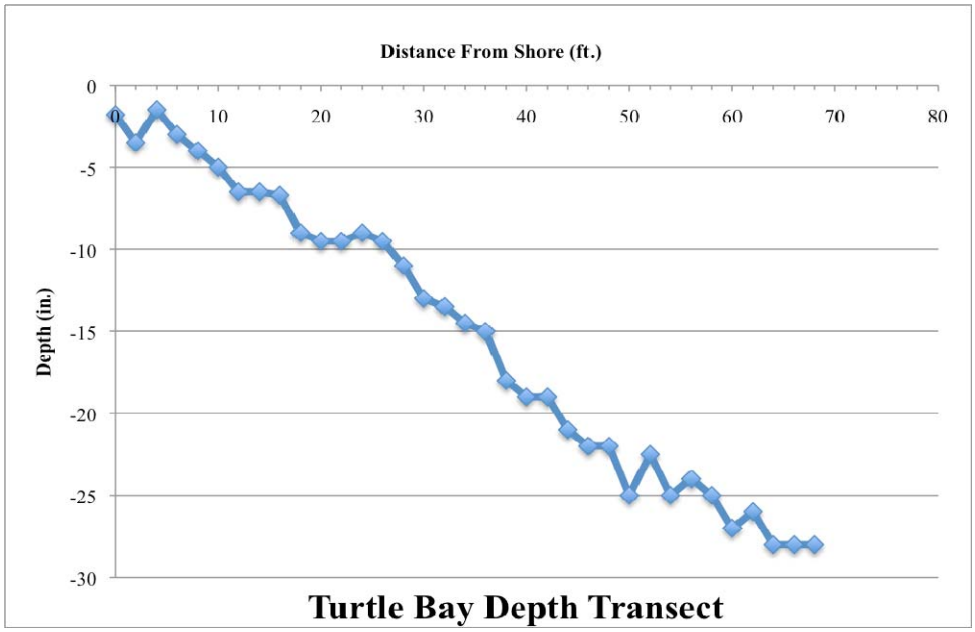


Figure 2. Turtle Bay Depth Transect. Transect began on shore at N43^{o} 58.965', W83^{o} 33.499', and extended due E into Pleasant Lake.

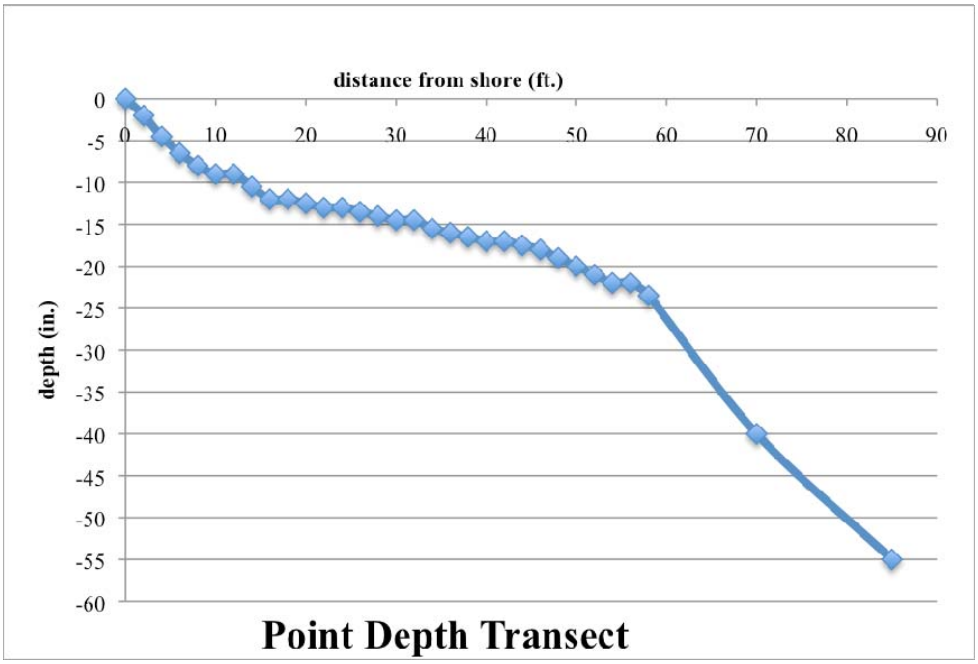


Figure 3. Depth transect of shallow zone extending into the main body of the lake from the sand point south of the county park. Transect began on shore at N43^{o} 59.207', W89^{o} 32.988' and extended due south into Pleasant Lake.

B

APPENDIX B

Pleasant Lake Freshwater Mussel Survey Specimen Photographs



Specimen 1: Live **Location:** 43.983526, -89.55419



Specimen 2: Live **Location:** 43.986991, -89.549588



Specimen 3: Live **Location:** 43.987013, -89.549608



Specimen 4: Live **Location:** 43.986909, -89.549501



Specimen 5: Live **Location:** 43.986817, -89.549402



Specimen 6: Live **Location:** 43.986457, -89.549381