Presque Isle Wilderness Waters Program

Aquatic Plant Management Plan – Big Lake

Prepared for:

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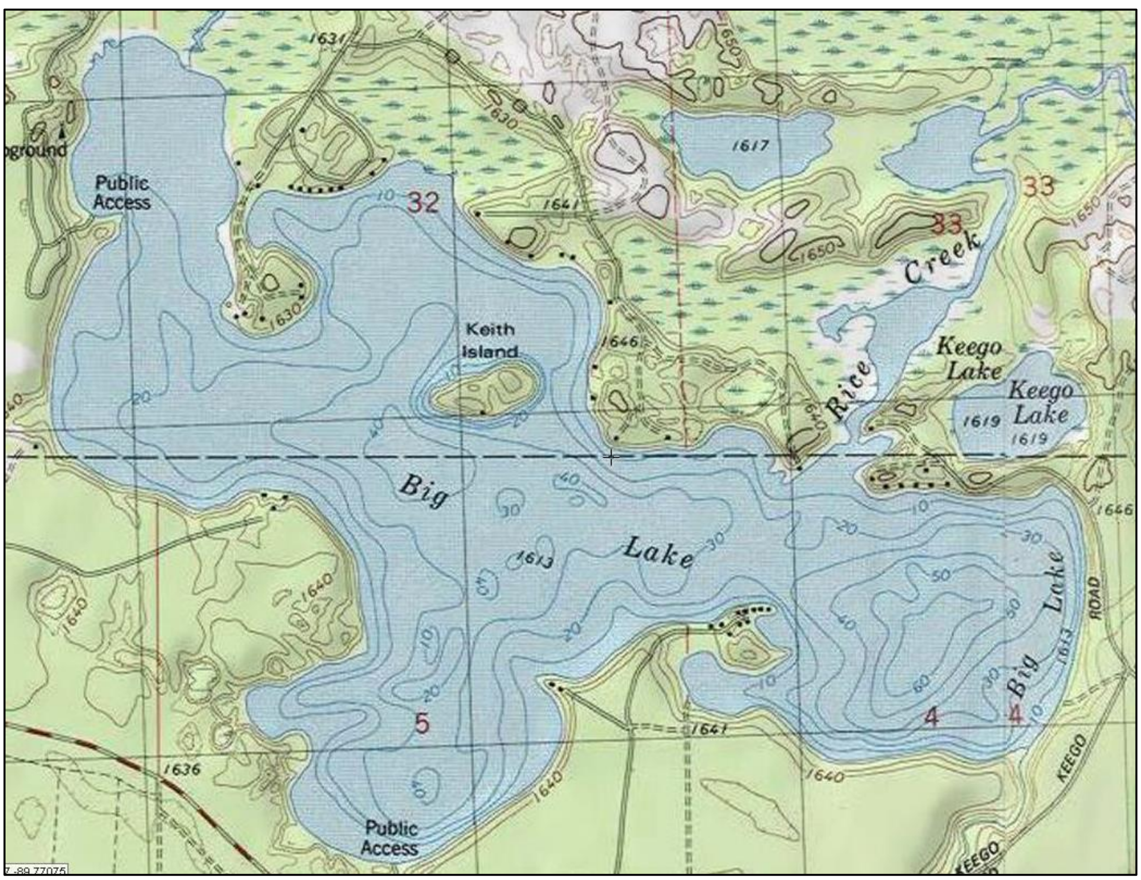

Date: December 2015

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This plan is a product of WDNR Lake Planning Grant (LPL-1504-13) awarded to:

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Cite as: *Premo, Dean, Angie Stine, Caitlin Clarke and Kent Premo. 2015. Presque Isle Wilderness Waters Program: Big Lake Aquatic Plant Management Plan. White Water Associates, Inc.*

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CHAPTER 1

Introduction

The ***Presque Isle Wilderness Waters Program*** results from the efforts of the Presque Isle Town Lakes Committee, an organization that has been active since 2005. The Lakes Committee views stewardship of lakes as an ongoing endeavor that is integrated, coordinated, and administered by the Lakes Committee. This broader perspective accommodates the appropriate range of geographic scales from which to approach lake stewardship: a discrete "lake specific" focus that goes hand-in-hand with waterscape-wide awareness.

This aquatic plant management plan addresses Big Lake. Despite this specificity, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related ***Wilderness Waters Adaptive Management Plan*** (Premo et al., 2015) provides additional overarching waterscape level examination that allows greater opportunity and efficiency in water resource management and education.

A systematic survey of aquatic plants using the Wisconsin Department of Natural Resources (WDNR) "point-intercept" method was an important underpinning of this aquatic plant management plan. An analysis of the plant data along with water quality and other lake information allowed the preparation of the plan.

Aquatic plants rarely get the respect they merit, although this is slowly changing. We still call an aquatic plant bed a "weed bed." Many aquatic plants have "weed" in their names (e.g., duckweed, pondweed, or musky weed). Likely this term was borrowed from "seaweed" and not intended as derogatory, but in today's use, "weed" connotes an unwanted, aggressively growing plant. Such is not the case for the vast majority of aquatic plants. In fact, aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for animal life. Invertebrates, including crustaceans and insects, live on or within this "aquatic forest." Fish find food and shelter within aquatic plant beds. Waterfowl eat parts of plants directly as well as feed on invertebrates associated with the plants. Muskrats eat aquatic plants and particularly love cattails and bulrushes. Otter and mink hunt invertebrates and small vertebrates within the shelter of submergent and emergent beds. In shallow water, great blue herons find fishes among the plants.

In lakes that receive an excess of nutrients (particularly from fertilizers or leaking septic tanks), plant growth can become too lush or dominated by only a few species. As these abundant plants die, their decomposition can depress dissolved oxygen levels and diminish suitability for fish. Algae can respond rapidly to nutrient influxes and create nuisance conditions. These phenomena can cause humans to view all aquatic plants in a negative light.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, private ponds and water gardens may come to dominate a water body to the exclusion of a healthy diversity of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the better known examples of these so-called aquatic invasive plant species.

For most lakes, native aquatic plants are an overwhelmingly positive attribute, greatly enhancing the aesthetics of the lake and providing good opportunities for fishing, boating, swimming, snorkeling, sight-seeing, and hunting.

When it comes to aquatic plant management, it is useful to heed the mantra of the medical profession: "First, do no harm." It is both a social and scientific convention that aquatic plant management is more effective and beneficial when a lake is considered as an entire and integrated ecosystem. Anyone involved in aquatic plant management should be aware that a permit may be required to remove, add, or control aquatic plants. In addition, anyone using Wisconsin's lakes must comply with the "Boat Launch Law" that addresses transport of aquatic plants on boat trailers and other equipment. A good review of the laws, permits, and regulations that affect management and behavior surrounding aquatic plants can be found in the WDNR guidelines called ***Aquatic Plant Management in Wisconsin***.[1]

In preparing this plan, we followed guidelines in ***Aquatic Plant Management in Wisconsin***. The resulting plan is an adaptive plan (Walters, 1986). Simply put, it will be modified as new information becomes available. The WDNR Guidance document outlines three objectives that may influence preparation of an aquatic plant management plan. Currently, the motivation for this plan lies in the first two objectives:

- ***Protection*** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- ***Maintenance*** - continuing the patterns of recreational use that have developed historically on and around a lake; and

[1] *http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/APMguideFull2010.pdf*

- ***Rehabilitation*** - controlling an imbalance in the aquatic plant community leading to the dominance of a few plant species, frequently associated with the introduction of invasive non-native species.

During projects with the WDNR Planning Grant Program and through past efforts, Town Lakes Committee has followed the first five steps in the seven-step plan outlined in the Guidance Document for developing an aquatic plant management plan:

1. Goal setting – Getting the effort organized, identifying problems to be addressed, and agreeing on the goals;
2. Inventory – Collecting baseline information to define the past and existing conditions;
3. Analysis – Synthesizing the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints, and setting directions to achieving the goals;
4. Alternatives – Listing possible management alternatives and evaluating their strengths, weaknesses and general feasibility;
5. Recommendations – Prioritizing and selecting preferred management options, setting objectives, drafting the plan;
6. Implementation – Formally adopting the plan, lining up funding, and scheduling activities for taking action to achieve the goals;
7. Monitor & Modify – Developing a mechanism for tracking activities and adjusting the plan as it evolves.

Besides this introductory chapter, this plan is organized in six Chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant survey. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Three appendices complete this document. Appendix A contains literature cited, Appendix B contains tables and figures for the aquatic plant survey, and Appendix C contains a *Review of Big Lake Water Quality*.

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CHAPTER 2

Study Area

Presque Isle Township is one of the northern-most townships in Vilas County, Wisconsin. Presque Isle Township's northern border is shared with the State of Michigan. In fact some of the Presque Isle Township lakes lie on the state border. The location of the subject of this APM Plan (Big Lake) is shown in Exhibit 1 along with other lakes in Presque Isle Township that have had point-intercept aquatic plant surveys conducted. Exhibit 2 is an aerial view of Big Lake.

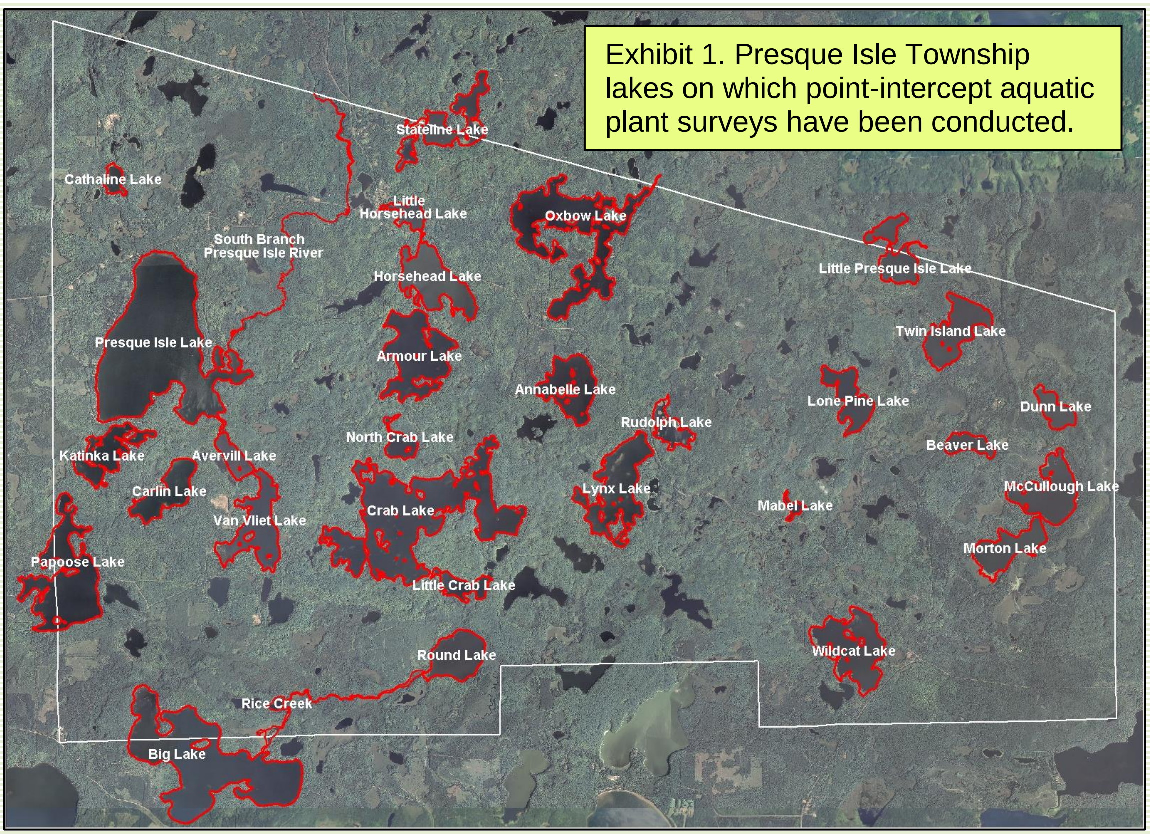


Exhibit 1. Presque Isle Township lakes on which point-intercept aquatic plant surveys have been conducted.

“Almost an island” is the literal translation of the French phrase “Presque Isle.” Early French missionaries, perhaps disoriented by the preponderance of water in this north central Wisconsin landscape applied the name, “Presque Isle” to describe an area where the water seemed to dominate the land. The French visitors and Native Americans certainly recognized this landscape as special. Modern ecologists and recreationist share this view. The region that includes the Township of Presque Isle, Wisconsin is an ecological landscape marvelously rich in surface waters. Aerial photography reveals a concentration of lakes and streams that is unique in North America. Presque Isle Township has eighty-four lakes. The Presque Isle area could as easily be termed a “waterscape” as a “landscape.”

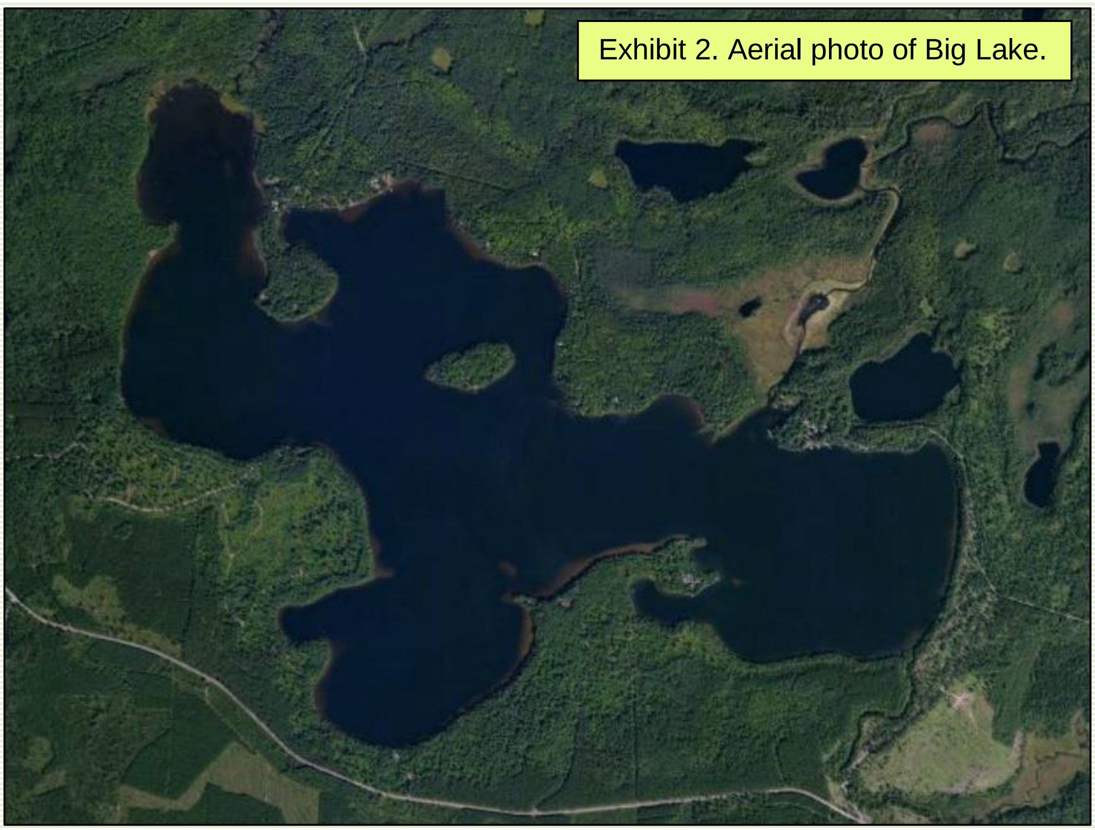


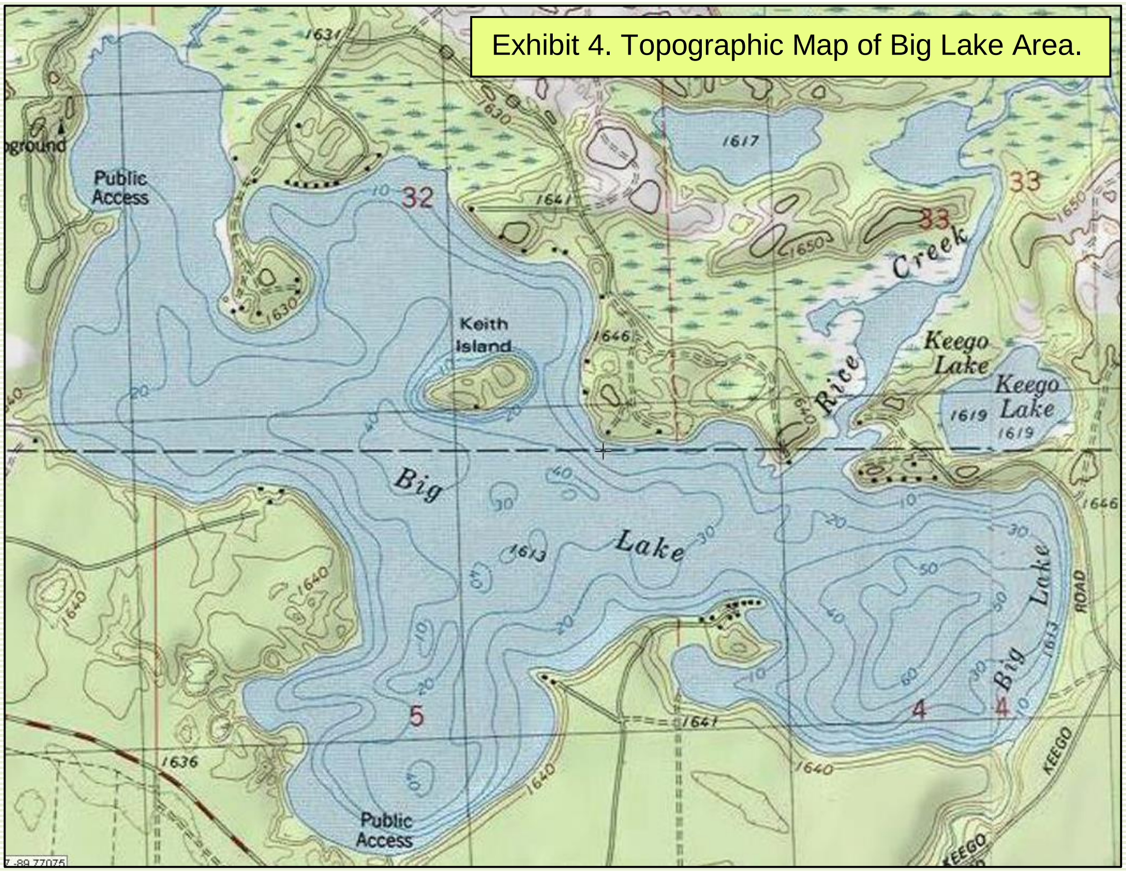
Exhibit 2. Aerial photo of Big Lake.

Descriptive parameters for Big Lake are in Exhibit 3. It is a drainage lake of about 835 acres and maximum depth of 61 feet. The shoreline development index values for twenty-nine of the Wilderness Waters Program lakes surveyed from 2007 to 2014 ranged from 1.2 to 4.2 (average = 2.1). Big Lake's shoreline development index is slightly higher than the average (2.4). The shoreline development index is a quantitative expression derived from the shape of the lake. It is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake would have an index of 1. Increasing irregularity of shoreline development in the form of bays and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI's exceeding 5. A higher shoreline development index indicates that a lake has relatively more productive littoral zone habitat.

Exhibit 3. Water Body Parameters	
Water Body Name	Big
County	Vilas
Township/Range/Section	T43N-R6E-S 31, 32, 33 and T42-R6E-S 4, 5, 6
Water Body Identification Code	2963800
Lake Type	Drainage
Surface Area (acres)	835
Maximum Depth (feet)	61
Maximum Length (miles)	1.3
Maximum Width (miles)	1.4
Shoreline Length (miles)	9.6
Shoreline Development Index	2.4
Total Number of Piers (2013 aerial)	36
Number of Piers / Mile of Shoreline	3.8
Total Number of Homes (2013 aerial)	38
Number of Homes / Mile of Shoreline	4.0

Big Lake has two public access sites. We observe a total of 36 piers on the shoreline of Big Lake from a 2013 aerial photograph or about 4.0 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).

Exhibit 4. Topographic Map of Big Lake Area.



CHAPTER 3

Purpose and Goal Statements

This plan approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose and goals for this plan:

> ***Big Lake has a native aquatic plant community that was documented by a point-intercept aquatic plant survey. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community with its recreational and aesthetic features. The purpose of this aquatic plant management plan is to maintain the aquatic plant community in its present high quality state.***

Supporting this purpose, the goals of this aquatic plant management plan are:

> ***(1) Monitor and protect the native aquatic plant community;***
> ***(2) Prevent establishment of AIS and nuisance levels of native plants;***
> ***(3) Promote and interpret APM efforts; and***
> ***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.***

The purpose and goals are the foundation for the aquatic plant management plan presented in this document. They inform the objectives and actions outlined in Chapter 5 and are the principal motivation of Big Lake stewards.

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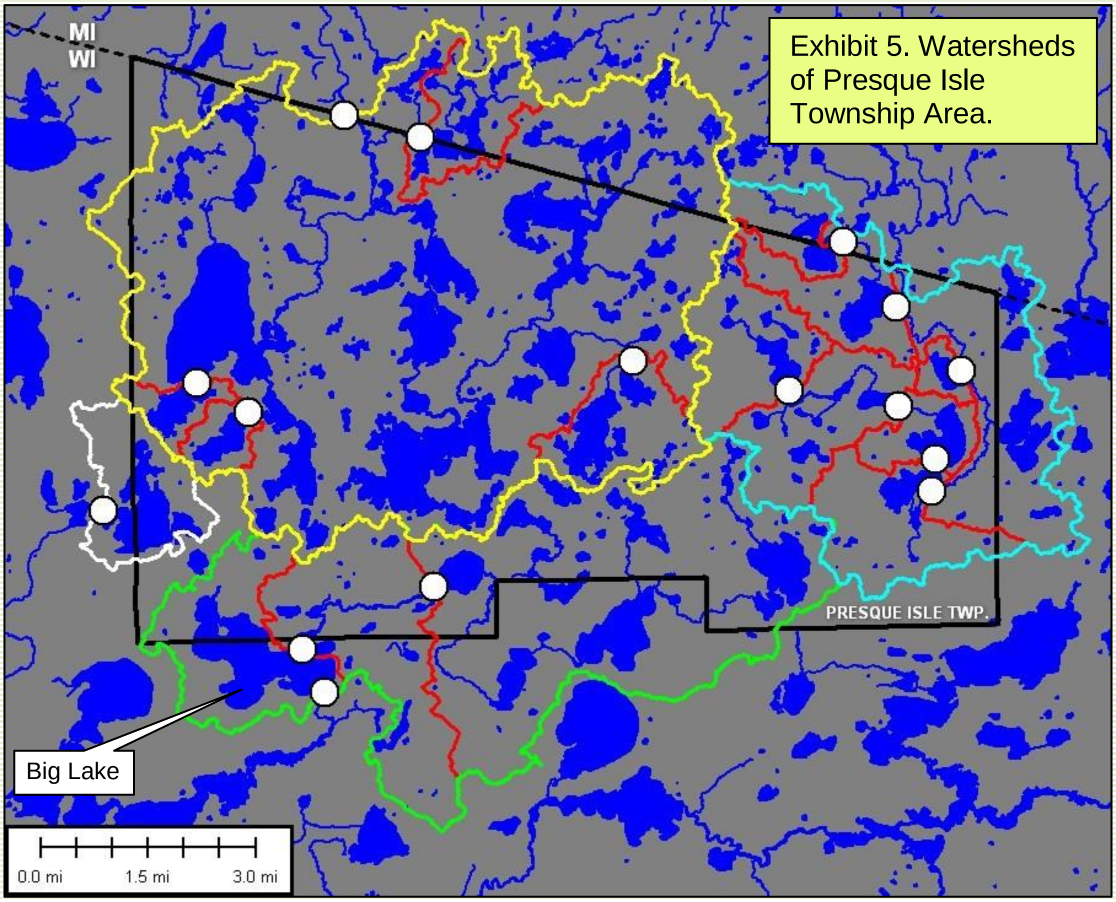
CHAPTER 4

Information and Analysis

Our efforts in the Wilderness Waters Program have compiled information about historical and current conditions of the Big Lake ecosystem and its surrounding watershed. Of particular importance to this aquatic plant management plan is the aquatic plant survey that was conducted using the ***WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry*** (Hauxwell et al., 2010). The results of this comprehensive "point-intercept" survey along with relevant components of other information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

Part 1. Watershed

The Presque Isle Township waterscape sits on a large-scale watershed divide. Some of the water drains north through the Presque Isle River system and eventually enters Lake Superior. Some of the water drains into the Wisconsin River system to the Mississippi River and to the Gulf of Mexico. In fact there are two federal hydrologic sub-basins (designated by 8-digit HUC codes) that include Presque Isle Township. The Black-Presque Isle Rivers sub-basin (HUC#04020101) drains north to Lake Superior and the Flambeau River sub-basin (HUC#0705002) drains southwesterly to the Mississippi River. The Black-Presque Isle Rivers sub-basin contains two federal hydrologic sub-watersheds within Presque Isle Township: the South Branch Presque Isle River sub-watershed (HUC#040201010303) and the Pomeroy Creek-East Branch Presque Isle River sub-watershed (HUC#040201010301). The Flambeau River sub-basin contains one sub-watershed within Presque Isle Township: the Rice Creek sub-watershed (HUC#07050020103). Exhibit 5 illustrates these watersheds and the watersheds of the water bodies subject to the Wilderness Waters Program studies. Big Lake is contained within the Rice Creek sub-watershed.



Description: Portions of 3 federal hydrologic sub-watersheds are illustrated: (1) S.Br. Presque Isle River (bounded by yellow), (2) Pomeroy Cr-E.Br. Presque Isle River (bounded by blue and yellow), and (3) Rice Cr. (bounded by green, yellow, and blue). Also shown are the smaller watersheds of individual water bodies subject to the Wilderness Waters studies (bounded by red and, in the case of Papoose Lake, bounded by white). White dots show outlet points for the smaller watersheds.

The elevation in Presque Isle Township ranges from around 1,550 feet above sea level to 1,750 feet above sea level. A digital elevation model is provided as Exhibit 6 and shows the relative elevations for the area with red and orange areas of the landscape being the highest elevations and greens and blues being the lowest elevations.

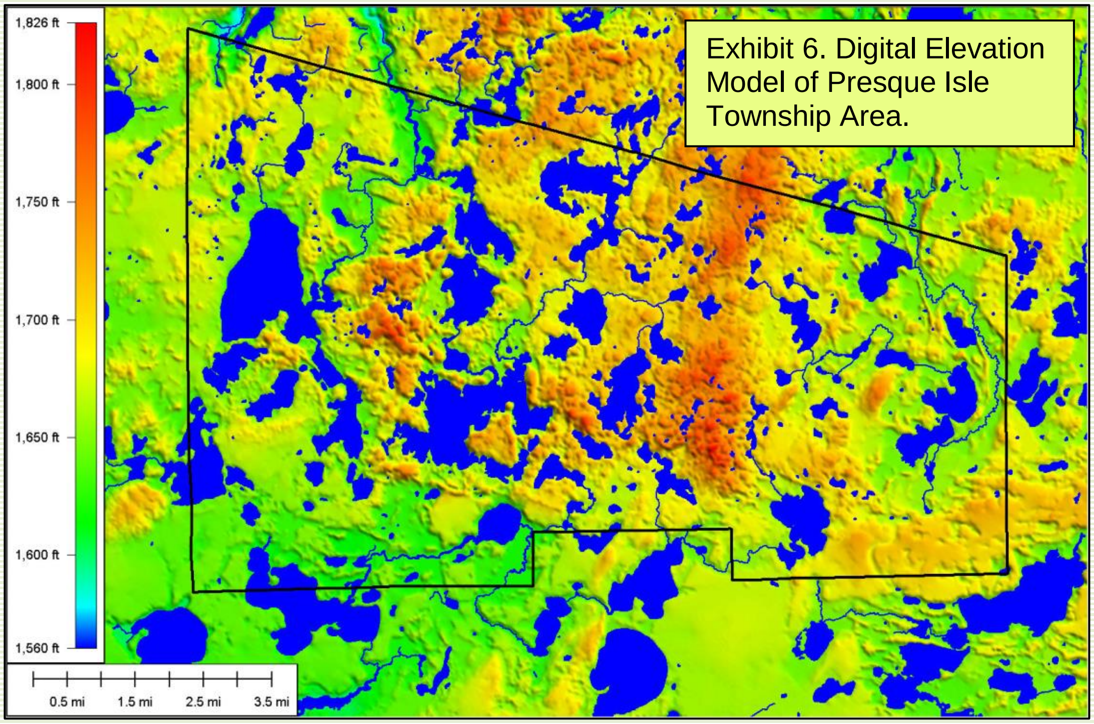


Exhibit 6. Digital Elevation Model of Presque Isle Township Area.

The watershed (drainage basin) is all of the land and water areas that drain toward a particular river or lake. A water body is greatly influenced by its watershed. Watershed size, topography, geology, land use, soil fertility and erodibility, and vegetation are all factors that influence water quality. The Big Lake watershed is about 16,400 acres. The type of land cover (for example, forest, grassland, row crops, or human development) is also an important variable in determining amounts and kinds of materials (like nutrients and sediment) that are carried off the land and into the water. Certain kinds of agriculture (tilled row crops) and urban areas (with their impervious surfaces) have a tendency to give up sediments and nutrients to runoff. In contrast, native vegetation (forests, wetlands, and grasslands), tend to slow runoff of water and nutrients, allowing the soil to absorb them. The cover types in Big Lake's watershed are presented in Exhibit 7.

Exhibit 7. Cover Types and Soil Groups of the Big Lake Watershed.		
Cover Type	Acres	Percent
Agriculture	0	0
Commercial	1.0	0.01
Forest	9604.8	58.47
Grass/Pasture	33.9	0.21
High-density Residential	2.7	0.02
Low-density Residential	755.9	4.60
Water	6027.8	36.70
Total	16426.0	100.0

Soil Group	Acres	Percent	**Hydrologic Soil Groups** - Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups* based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A has the smallest runoff potential and D the greatest.
A	4526.6	27.6	**Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
B	6805.4	41.4	**Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	0	0	**Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	5094.0	31.0	**Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

*(*USDA, Natural Resources Conservation Service, 1986)*

Forest and surface water comprise the largest components. Soil groups A, B and D are present in the watershed. Soil group A makes up approximately 28% of the watershed, while groups B and D make up 41% and 31% respectively. Soil group A has a high infiltration capacity whereas D has very low infiltration capacity. The watershed to lake area ratio is 20:1. Water quality often decreases with an increasing ratio of watershed area to lake area. As the watershed to lake area increases there are more sources and amounts of runoff. In larger watersheds, runoff water can leach more minerals and nutrients and carry them to the lake. The runoff to a lake (such as after a rainstorm or snowmelt) differs greatly among land uses. Forest cover is the most protective as it exports much less soil (through erosion) and nutrients (such as phosphorus and nitrogen) to the lake than agricultural or urban land use.

Part 2. Aquatic Plant Management History

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Big Lake. Over the years, no particular nuisance issues have demanded control action. In 2007, an aquatic plant survey was conducted on Big Lake, and again in the summer of 2013. Findings from the 2007 and 2013 surveys are discussed in the next section (Part 3).

Part 3. Aquatic Plant Community Description

Why do lakes need aquatic plants? In many ways, they are underwater forests. Aquatic plants provide vertical and horizontal structure in the lake just like the many forms and variety of trees do in a forest. Imagine how diminished a forest's biodiversity becomes in the advent of a clear-cut. Similarly, a lake's biodiversity in large part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many submerged plants provide food for waterfowl and habitat for insects on which some waterfowl feed. Aquatic plants further benefit lakes by producing oxygen and absorbing nutrients (phosphorus and nitrogen) from runoff. Aquatic plants also protect shorelines and lake bottoms by dampening wave action and stabilizing sediments.

The distribution of plants within a lake is generally limited by light availability, which is, in turn, controlled by water clarity. Aquatic biologists often estimate the depth to which rooted aquatic plants can exist as about two times the average Secchi clarity depth. For example, if the average Secchi depth is eight feet then it is fairly accurate to estimate that rooted plants might exist in water as deep as sixteen feet. At depths greater than that (in our hypothetical example), light is insufficient for rooted plants to grow. In addition to available light, the type of substrate influences the distribution of rooted aquatic plants. Plants are more likely to be found in muddy or soft sediments containing organic matter, and less likely to occur where the substrate is sand, gravel, or rock. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline lakes and some prefer more acidic lakes. The presence of nutrients like phosphorous and nitrogen also influence plant community composition.

As mentioned earlier, non-native invasive plant species can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even a native plant species can reach nuisance levels with respect to certain kinds of human recreation. These cases may warrant some kind of plant management.

Aquatic plant surveys have been conducted on Big Lake by aquatic plant specialists in 2007 and in 2013. In each of these surveys, WDNR point-intercept protocol and methodology was followed. This formal survey assesses the plant species composition on a grid of several hundred points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, scientists navigate to the points and use a rake mounted on a pole or rope to sample plants. Plants are identified, recorded and put into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake.

Because Big Lake has been surveyed twice, we are able to identify differences in the plant community that have resulted over the course of the six year interval. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section (Part 3) we provide a report of the findings of the 2013 point-intercept aquatic plant survey, and provide a summary of the aquatic plant survey conducted in 2007. Supporting tables and figures for the aquatic plant surveys are provided in Appendix B. Table 3 provides a comparison of statistics from both survey years.

Species richness refers to the total number of species recorded. In 2013, we recorded 28 species of aquatic plants. Of these, 24 were collected at sampling sites and the others were observed from the boat. Table 1 displays summary statistics for the survey. Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics.[2] The number of species encountered at any given sample point ranged from 0 to 8 and 74 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 2.89. The actual number of species encountered at each

[2] *If you are interested in learning more about the plant species found in the lake, visit the University of Wisconsin Steven Point Freckmann Herbarium website at: http://wisplants.uwsp.edu/ or obtain a copy of "Through the Looking Glass (A Field Guide to the Aquatic Plants in Wisconsin)."*

of the vegetated sites is graphically displayed on Figure 1. Plant density is estimated by a "rake fullness" metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figure 2.

The maximum depth of plant colonization is 16 feet (Table 1 and Figure 3). Rooted vegetation was found at 74 of the 195 sample sites with depth ≤ the maximum depth of plant colonization (37.95% of sites). These sites are displayed as a black dot within a circle on Figure 4. This indicates that although availability of appropriate depth may limit the distribution of plants, it is not the only habitat factor involved. Substrate is another feature that influences plant distribution (e.g., soft substrate often harbors more plants than hard substrate). Figure 5 presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2 provides information about the frequency of occurrence of the plant species recorded in the lake. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites ≤ the maximum depth of rooted vegetation. This frequency metric is standardized as a "relative frequency" (also shown in Table 2) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake are graphically displayed in descending order on Figure 6. This display shows that coontail (*Ceratophyllum demersum)* had the highest relative frequency followed by wild celery (*Vallisneria americana*). The lowest relative frequencies are at the far right of the graph. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8-18.

Species richness (total number of plants recorded at the lake) is a measure of species diversity, but it doesn't tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (in other words, richness is 10). In the first pond each of the ten species populations is comprised of 100 individuals. In the second pond, Species #1 has a population of 991 individuals and each of the other nine species is represented by one individual plant. Intuitively, we would say that first pond is more diverse because there is more "even" distribution of individual species. The "Simpson Diversity Index" takes into account both richness and evenness in estimating diversity. It is based on a plant's relative frequency in a lake. The closer the Simpson Diversity Index is to 1, the more diverse the plant community. The Simpson Diversity Index for Big Lake aquatic plants is 0.90 (Table 1) which indicates a highly diverse aquatic plant community.

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols, 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake's plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake. Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environments (relatively unaltered from presettlement conditions). The coefficients range from 0 to 10, with 10 being assigned to those species most sensitive to disturbance. As more environmental disturbance occurs, the less conservative species become more prevalent.

Nichols (1999) analyzed aquatic plant community data from 554 Wisconsin Lakes to ascertain geographic (ecoregional) characteristics of the FQI metric. This is useful for considering how the Big Lake FQI (27.7) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Big Lake values are high compared to these statewide values. With regard to the Presque Isle Township lakes, the minimum FQI value is 17.1 (Armour Lake), the maximum is 39.8 (Morton Lake), and the average FQI value is 29.5. Compared to other lakes in Presque Isle Township, Big Lake's FQI is slightly below average (27.7). Nichols (1999) determined that there are four ecoregional-lake types groups in Wisconsin: (1) Northern Lakes and Forests lakes, (2) Northern Lakes and Forests flowages, (3) North Central Hardwoods and Southeastern Till Plain lakes and flowages, and (4) Driftless Area and Mississippi River Backwater lakes. Big Lake is located in the Northern Lakes and Forests lakes group. Nichols (1999) found species numbers for the Northern Lakes and Forests lakes group had a median value of 13. Big Lake data is consistent with that find. Finally, the Big Lake FQI (27.7) is higher than the median value for the Northern Lakes and Forests lake group (24.3). These findings support the contention that the Big Lake plant community is healthy and diverse.

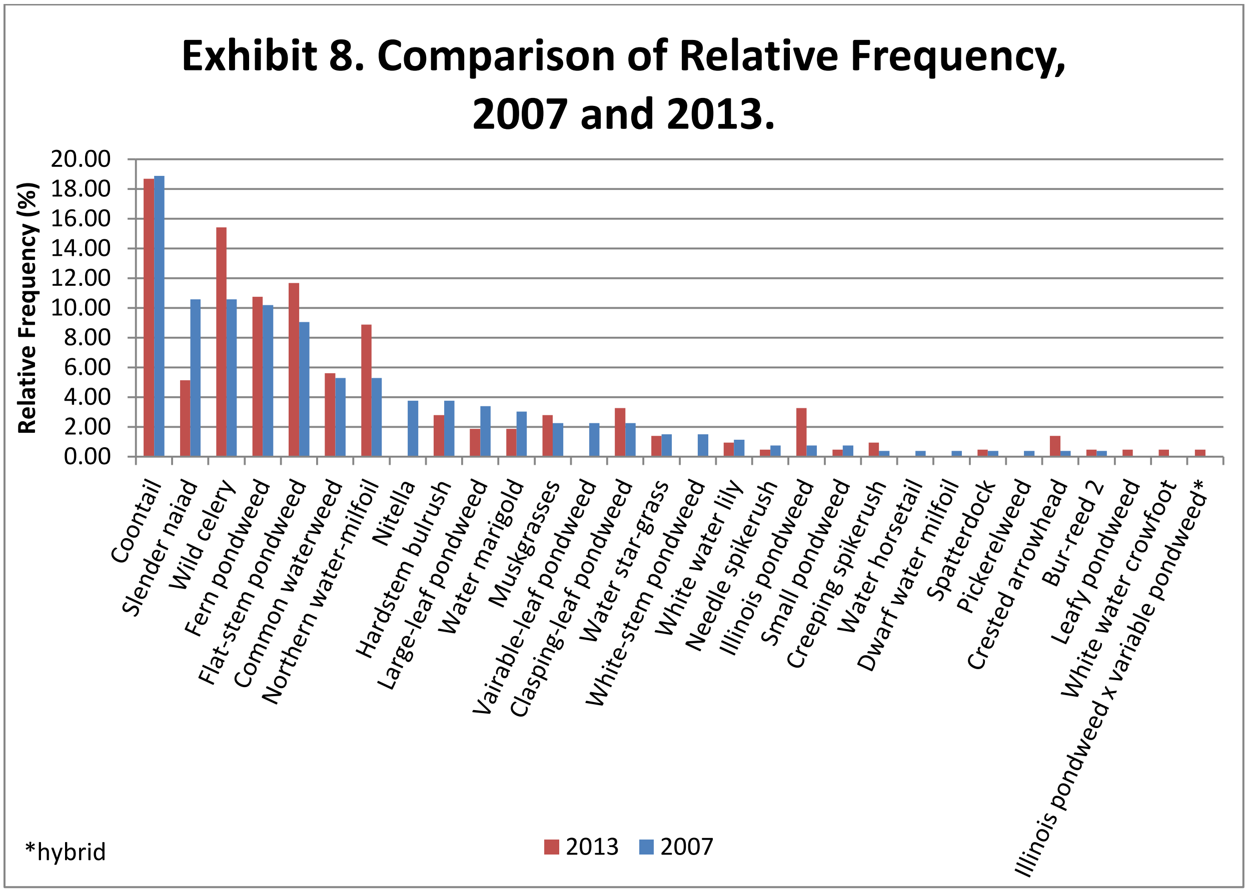
In 2013, we observed no aquatic plants in Big Lake that would be considered a nuisance-level population density/distribution. There was however, a small population of narrow-leaved cattail (*Typha angustifolia)* observed along the northeast shoreline. *Typha angustifolia* is classified as a *Restricted* invasive species by the WDNR. A *Restricted* species is one that has already been established in the state and causes or has the potential to cause significant environmental or economic harm or harm to human health (WDNR, 2012).

We found no state or federally listed species, however, Northern wild rice (*Zizania palustris*) was visually observed at five sites. Wild rice is an important food source for many waterfowl and animals. It also has cultural significance to the Anishinaabe (Chippewa or Ojibwa), who call it *manoomin* (GLIFWC, *Wild Rice* brochure).

In 2007, Big Lake had an average 2.52 species per site[3]. This number is slightly less than the average species per site in 2013 (2.89). The maximum depth of plants was 20 feet in 2007, which is slightly deeper than in 2013 (16 feet). The frequency of occurrence of plants at sites shallower than the maximum depth of plants was 31.72% in 2007, and in 2013, it was 37.95% which indicates that more sites had vegetation in 2013 than did in 2007. Coontail (*Ceratophyllum demersum)* and slender naiad (*Najas flexilis)* had the highest relative frequencies in 2007. The relative frequency of coontail was nearly the same in 2013 as it was in 2007. Slender naiad's relative frequency decreased by half since 2007, while wild celery's relative frequency increased, making it the second most common species in 2013. The Simpson Diversity Index, which takes into account both richness and evenness in estimating diversity, was 0.91 in 2007, meaning the lake had a highly diverse aquatic plant community. In 2013, the SDI was 0.90, which indicates the diversity of the plant community has not dramatically changed. In 2007, the FQI was 33.1; significantly higher than state and regional averages, and higher than the FQI from the 2013 survey (27.7). This decrease in FQI is likely due to a decrease (or absence) of species that have higher *coefficients of conservatism*, or an increase in species with low *C* values. A comparison of 2007 and 2013 aquatic plant statistics can be viewed in Table 3 of Appendix B.

Exhibit 8 displays the relative frequencies of plants found in 2007 and 2013. We can see that coontail was the most common plant species in both years. We also see that the lake's even distribution of plant species appear similar in both years, which is evident from the nearly equal SDI values.

[3] The 2007 aquatic plant statistics included filamentous algae, which, according to WDNR protocol, should not be included. Because of this, species number, average species per site, SDI and relative frequencies will vary.



Part 4. Fish Community

It was beyond the scope of the current Wilderness Waters project to characterize the fish community and fish habitat of this water body. The WDNR Lake Pages website (http://dnr.wi.gov/lakes/lakepages/) indicates that the bottom is comprised of 60% sand, 15% gravel, 10% rock, and 15% muck and that fish species present include musky, panfish, largemouth bass, smallmouth bass, northern pike and walleye.

Part 5. Water Quality and Trophic Status

Big Lake is an 835 acre drainage lake with a maximum depth of 61 feet. Existing water quality data was retrieved from the Wisconsin DNR SWIMS database from 1984 to 2013. In May, 2003 baseline monitoring was performed by the WDNR. Secchi disk measurements were collected by Citizen Lake Monitoring Network (CLMN) volunteers from 1991 to 2013. The water quality information is briefly summarized in this section, but more fully interpreted in Appendix C.

Temperature and dissolved oxygen showed stratification in Big Lake in the ice-free season. Water clarity is considered “good.” Water color is generally low. The trophic state is mesotrophic. Water quality can be classified as “good” with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae), nitrogen, chloride, sulfate, calcium, magnesium, sodium, and potassium are considered low. The pH of Big Lake is alkaline.

Part 6. Water Use

Big Lake has two public access sites and is used by riparian owners and recreationists for a variety of activities. The majority of land surrounding Big Lake is owned by the State of Wisconsin.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Big Lake. The near shore riparian area can be appreciated by viewing Exhibits 2 and 4. These images give the impression that the lake is lightly developed with a fairly intact forested riparian zone that extends for hundreds of feet back from the lake. The forest is a mixture of coniferous and deciduous trees and shrubs. Our review of 2013 aerial photography reveals 38 houses on the lake. This intact riparian area provides numerous important functions and values to the lake. It effectively filters runoff to the lake. It provides excellent habitat for birds and mammals. Trees that fall into the lake from the riparian zone contribute important habitat elements to the lake. Educating riparian owners as to the value of riparian areas is important to the maintenance of these critical areas.

Part 8. Wildlife

A study of wildlife was beyond the scope of the current study, but would be valuable to study and interpret in future iterations of the plan. This would be especially true of wetland and water oriented wildlife such as frogs, waterfowl, fish-eating birds, aquatic and semi-aquatic mammals, and invertebrate animals. In the future, it would be desirable to monitor indicator species of wildlife such as common loons, bald eagles, and osprey. Also of special importance would be monitoring the populations of aquatic invasive animal species that already exist in the lake (rusty crayfish, banded mystery snail, and Chinese mystery snail). Finally, it is essential to monitor Big Lake for the presence of new aquatic invasive animal species (for example, spiny water flea, zebra mussels, rainbow smelt, etc.).

Big Lake is currently designated as a *priority Navigable Water (PNW)* (WI Admin. Code, 2014). Priority Navigable Waters meet any of these standards: navigable waterways, or portions thereof, that are considered ORW/ERW or trout streams; lakes less than 50 acres in size; tributaries and rivers connecting to inland lakes containing naturally-reproducing lake sturgeon populations; waters with self-sustaining walleye populations in ceded territories; waters with self-sustaining musky populations; or perennial tributaries to trout streams (WI Admin. Code, 2014). Big Lake is considered a PNW with self-sustaining musky and walleye populations.

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, the Town Lakes Committee has represented the Big Lake stakeholders. Additional stakeholders and interested citizens are invited to participate as the plan is refined and updated in order to broaden input, build consensus, and encourage participation in stewardship. No contentious direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan.

CHAPTER 5

Recommendations, Actions, and Objectives

In this chapter we provide recommendations for specific objectives and associated actions to support the APM Plan's goals stated in Chapter 3 and re-stated here for convenient reference:

(1) Monitor and protect the native aquatic plant community;

(2) Prevent establishment of AIS and nuisance levels of native plants;

(3) Promote and interpret APM efforts; and

(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.

Since Big Lake is a healthy ecosystem, we could simply recommend an alternative of "no action." In other words, Big Lake continues without any effort or intervention on part of lake stewards. Nevertheless, we consider the "no action" alternative imprudent. Many forces threaten the quality of the lake and Wilderness Waters Program and Town Lakes Committee feels a great responsibility to minimize the threats. We therefore outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

The actions are presented in tabular form. Each "action" consists of a set of four statements: (1) a declarative "action" statement that specifies the action (2) a statement of the "objective" that the action serves, (3) a "monitoring" statement that specifies the party responsible for carrying out the action and maintaining data, and (4) a "status" statement that suggests a timeline/calendar and indicates status (not yet started, ongoing, or completed).

Recommended Actions for the Big Lake APM Plan
Action #1: Formally adopt the Aquatic Plant Management Plan. ***Objective:*** To provide foundation for long-term native plant community conservation and stewardship and to be prepared for response to AIS introductions. ***Monitoring:*** The Lake Association and the Presque Isle Town Lakes Committee (PITLC) oversee activity and maintains the plan. ***Status:*** Planned for 2015.
Action #2: Monitor water quality. ***Objective***: Continue with collection and analysis of water quality parameters to detect trends. Expand monitoring to include parameters for which little information exists (see Appendix C for individual parameters). ***Monitoring:*** The Lake Association or the PITLC oversees activity and maintains data. ***Status:*** Ongoing.
Action #3: Monitor the lake for aquatic invasive plant species. ***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS. ***Monitoring:*** The Lake Association or the PITLC oversees activity and maintains data. ***Status:*** Ongoing.
Action #4: Monitor the lake for aquatic invasive animal species. ***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS. ***Monitoring:*** The Lake Association or the PITLC oversees activity and maintains data. ***Status:*** Ongoing.
Action #5: Form an Aquatic Invasive Species Rapid Response Team and interface with the Town Lakes Committee AIS Rapid Response Coordinator. ***Objective:*** To be prepared for AIS discovery and efficient response. ***Monitoring:*** The Lake Association and/or the PITLC coordinate activity. ***Status:*** Planned for 2015.

Recommended Actions for the Big Lake APM Plan
Action #6: Conduct quantitative plant survey every five years using WDNR Point-Intercept Methodology. ***Objective:*** To watch for changes in native species diversity, floristic quality, plant abundance, and plant distribution and to check for the occurrence of non-native, invasive plant species. ***Monitoring:*** The PITLC oversees and maintains data; copies to WDNR. ***Status:*** Anticipated in 2018.
Action #7: Periodically update the APM plan approximately every five years or as needed to reflect new plant information from plant surveys and monitoring. ***Objective:*** To have current information and management science included in the plan. ***Monitoring:*** Lake Association and/or PITLC oversees and maintains data; copies to WDNR. ***Status:*** Ongoing.
Action #8: Develop a Citizen Lake Monitoring Network to monitor for invasive species and develop strategies including education and monitoring activities (see http://www.uwsp.edu/cnr/uwexlakes/clmn for additional ideas). ***Objective:*** To create a trained volunteer corps to monitor aquatic invasive species and to educate recreational users regarding AIS. ***Monitoring:*** The Lake Association oversees activity and reports instances of possible introductions of AIS. ***Status:*** Anticipated to begin in 2015.
Action #9: Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development. ***Objective:*** To protect native aquatic plants, water quality, and riparian habitat. ***Monitoring:*** Lake residents and other stakeholders. ***Status:*** Ongoing.

Recommended Actions for the Big Lake APM Plan
Action #10: Promote adherence to, and enforcement of, the Town of Presque Isle's 200 foot no-wake ordinances (from shoreline and islands). ***Objective:*** To minimize recreational impacts on the aquatic plant community and shoreline habitats, and promote safe boating. ***Monitoring:*** The PITLC oversees activity and assesses effectiveness. ***Status:*** Ongoing.
Action #11: Create an education plan for the property owners and other stakeholders that will address issues concerning aquatic and riparian plant communities. ***Objective:*** To educate stakeholders about issues and topics that affect the lake's aquatic and riparian plant communities, including topics such as: (1) the importance of the aquatic plant community; (2) no or minimal mechanical removal of plants along the shoreline is desirable and that any plant removal should conform to Wisconsin regulations; (3) the value of a natural shoreline in protecting the aquatic plant community and lake health; (4) nutrient sources to the lake and the role excess nutrients play in degradation of the aquatic plant community; (5) the importance of reducing or eliminating use of fertilizers on lake front property; (6) the importance of minimizing transfer of AIS to the lake by having dedicated watercraft and cleaning boats that visit the lake. ***Monitoring:*** The PITLC oversees activity and assesses effectiveness. ***Status:*** Anticipated to begin in 2015.
Action #12: Monitor the lake watershed for purple loosestrife. ***Objective:*** Identify purple loosestrife populations before they reach large size. ***Monitoring:*** The Lake Association and/or Town Lakes Committee oversees activity. ***Status:*** Anticipated in 2015.
Action #13: Monitor the population of narrow-leaved cattail (*Typha angustifolia*) observed during the 2013 aquatic plant survey. ***Objective:*** Determine whether management of this is warranted or feasible at this site. ***Monitoring:*** The Lake Association and/or Town Lakes Committee oversees activity. ***Status:*** Anticipated in 2015.

CHAPTER 6

Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. Some infested lakes are quite close to Presque Isle Township. There is an increasing likelihood of accidental introduction of AIS to Presque Isle Township Lakes through conveyance of life stages by boats, trailers, and other vectors. It is important for the Town Lakes Committee and other lake stewards to be prepared for the contingency of aquatic invasive plant species colonization in a Presque Isle Township water body.

For riparian owners and users of a lake ecosystem, the discovery of AIS invokes a sense of tragedy that elicits an immediate desire to "fix the problem." Although strong emotions may be evoked by such a discovery, a deliberate and systematic approach is required to appropriately and effectively address the situation. An aquatic plant management plan (one including a contingency plan for AIS) is the best tool by which the process can be navigated. In fact the APM plan is a requirement in Wisconsin for some kinds of aquatic plant management actions. One of the actions outlined in the previous chapter was to establish an Aquatic Invasive Species Rapid Response Team. This team and its coordinator are integral to the management process. It is important for this team to be multi-dimensional (or at least have quick access to the expertise that may be required). AIS invade not just a single lake, but an entire region since the new infestation is an outpost from which the AIS can more easily colonize other nearby water bodies. For this reason it is strategic for the Rapid Response Team to include representation from regional stakeholders.

Exhibit 9 provides a flowchart outlining an appropriate rapid response to the suspected discovery of an aquatic invasive plant species. The response will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. In the remainder of this chapter we further describe the approach.

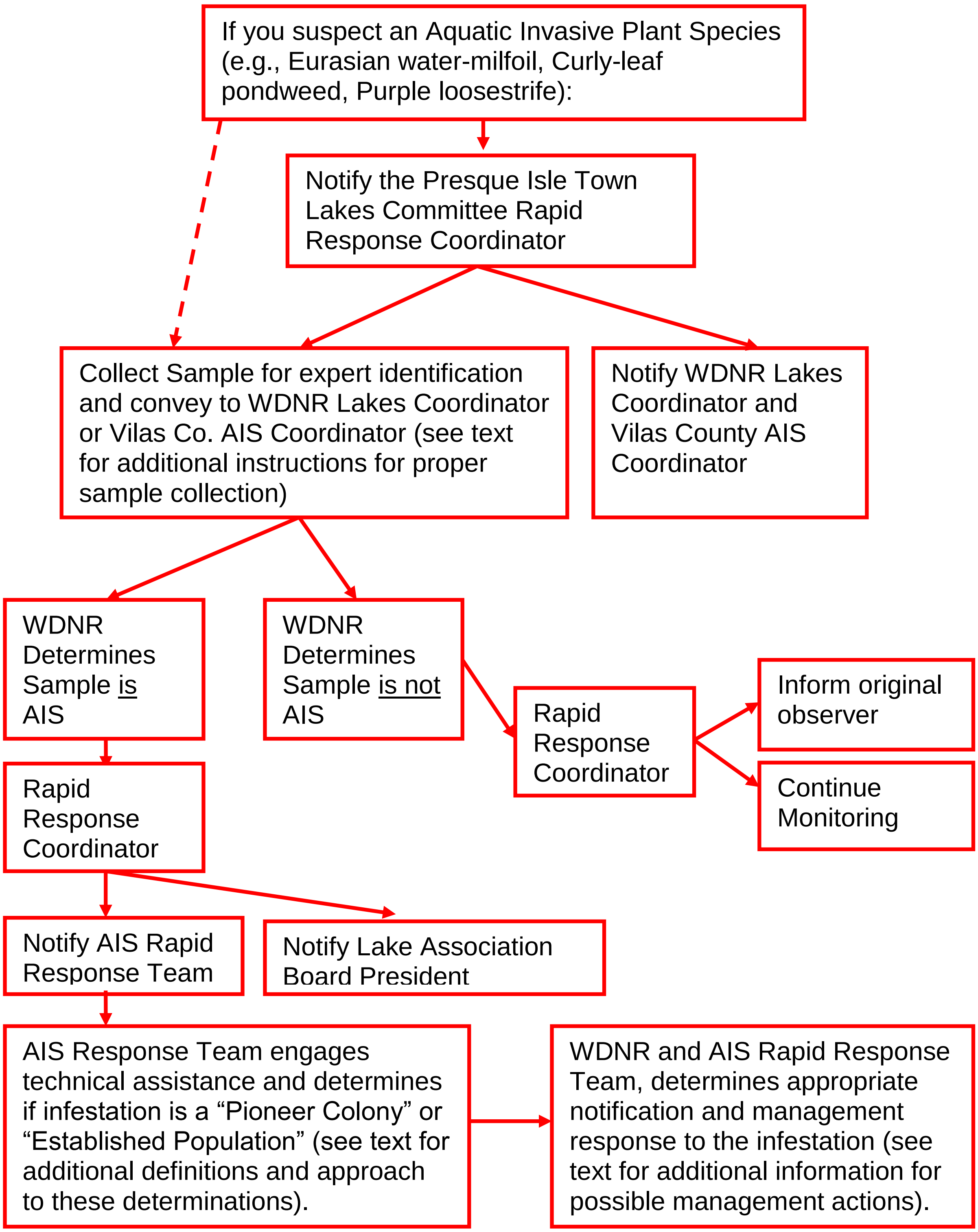
When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount of water to keep it moist. Place a label in the bag written in pencil with date, time, collector's name, lake name, location, town, and county. Attach a lake map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Water Resource Management Specialist (Kevin Gauthier in Woodruff), the Vilas County AIS Coordinator (Cathy Higley) or the WDNR Lakes Coordinator as soon as possible (at least within three days). The WDNR or their botanical expert(s) will determine the species and confirm whether or not it is an aquatic invasive plant species.

If the suspect specimen is determined to be an invasive plant species, the next step is to determine the extent and density of the population since the management response will vary accordingly. The Rapid Response Team should conduct (or have its consultant conduct) a survey to define the colony's perimeter and estimate density. If less than five acres (or <5% of the lake surface area), it is designated a "Pioneer Colony." If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population." Once the infestation is characterized, "at risk" areas should also be determined and marked on a map. For example, nearby boat landing sites and areas of high boat traffic should be indicated.

When "pioneer" or "established" status has been determined, the WDNR Lakes Coordinator should be consulted in order to determine appropriate notifications and management responses to the infestation. Determining whether hand-pulling or chemical treatment will be used is an important and early decision. Necessary notifications of landowners, governmental officials, and recreationists (at boat landings) will be determined. Whether the population's perimeter needs to be marked with buoys will be decided by the WDNR. Funding sources will be identified and consultants and contractors will be contacted where necessary. The WDNR will determine if a further baseline plant survey is required (depending on type of treatment). A post treatment monitoring plan will be discussed and established to determine the efficacy of the selected treatment.

Once the Rapid Response Team is organized, one of its first tasks is to develop a list of contacts and associated contact information (phone numbers and email addresses). At a minimum, this contact list should include: the Rapid Response Coordinator, members of the Rapid Response Team, County AIS Coordinator, WDNR Lakes Management Coordinator, Lake Association Presidents (or other points of contact), local WDNR warden, local government official(s), other experts, chemical treatment contractors, and consultant(s).

Exhibit 9. Aquatic Invasive Plant Species Rapid Response



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WHITE WATER ASSOCIATES, INC.

Appendix A
Literature Cited

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White Water Associates, Inc.

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Appendix B

Aquatic Plant Survey Tables and Figures

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WHITE WATER
ASSOCIATES, INC.

Table 1. Summary statistics for the 2013 point-intercept aquatic plant surveys for Big Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	685	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	350	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	74	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	195	Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	37.95	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.90	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	16.00	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	66	
Number of sites sampled with rake on pole	178	
Average number of all species per site (shallower than max depth)	1.10	
Average number of all species per site (vegetated sites only)	2.89	
Average number of native species per site (shallower than max depth)	1.10	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	2.89	Total number of species collected including visual sightings.
Species Richness	24	
Species Richness (including visuals)	28	
Floristic Quality Index (FQI)	27.7	

Table 2. Plant species recorded and distribution statistics for the 2013 Big Lake aquatic plant survey[1].

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Coontail	*Ceratophyllum demersum*	20.51	54.05	18.69	40	41	1.43
Wild celery	*Vallisneria americana*	16.92	44.59	15.42	33	33	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	12.82	33.78	11.68	25	32	1.08
Fern pondweed	*Potamogeton robbinsii*	11.79	31.08	10.75	23	23	1.26
Northern water-milfoil	*Myriophyllum sibiricum*	9.74	25.68	8.88	19	21	1.00
Common waterweed	*Elodea canadensis*	9.15	16.22	5.61	12	12	1.00
Slender naiad	*Najas flexilis*	5.64	14.86	5.14	11	11	1.00
Illinois pondweed	*Potamogeton illinoensis*	3.59	9.46	3.27	7	8	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	3.59	9.46	3.27	7	11	1.00
Muskgrasses	*Chara* sp.	3.08	8.11	2.80	6	6	1.00
Hardstem bulrush	*Schoenoplectus acutus*	3.08	8.11	2.80	6	13	1.00
Water marigold	*Bidens beckii* (formerly *Megalodonta*)	20.5	5.41	1.87	4	4	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	20.5	5.41	1.87	4	5	1.00
Water star-grass	*Heteranthera dubia*	1.54	4.05	1.40	3	3	1.00
Crested arrowhead	*Sagittaria cristata*	1.54	4.05	1.40	3	3	1.00
Creeping spikerush	*Eleocharis palustris*	1.03	2.70	0.93	2	4	1.00
White water lily	*Nymphaea odorata*	1.03	2.70	0.93	2	12	1.00
Needle spikerush	*Eleocharis acicularis*	0.51	1.35	0.47	1	1	1.00
Spatterdock	*Nuphar variegata*	0.51	1.35	0.47	1	3	1.00
Leafy pondweed	*Potamogeton foliosus*	0.51	1.35	0.47	1	1	1.00
Small pondweed	*Potamogeton pusillus*	0.51	1.35	0.47	1	1	1.00
White water crowfoot	*Ranunculus aquatilis*	0.51	1.35	0.47	1	1	1.00
Bur-reed 2	*Sparganium* sp. 2	0.51	1.35	0.47	1	1	1.00
Illinois pondweed x variable pondweed	*Potamogeton illinoensis* x *P. gramineus*	0.51	1.35	0.47	1	1	1.00

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

[1] Specimens of each species were collected, pressed and identification was confirmed by Dr. Robert Freckmann, University of Wisconsin-Stevens Point, on 2/28/2014.

Table 2. Continued.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Northern wild rice	*Zizania palustris*				Visual	5	
Pickerelweed	*Pontederia cordata*				Visual	2	
Large duckweed	*Spirodela polyrhiza*				Visual	1	
Common bladderwort	*Utricularia vulgaris*				Visual	1	
Broad-leaved cattail	*Typha latifolia*				Boat Survey		
Northwest Territory sedge	*Carex utriculata*				Boat Survey		
Water horsetail	*Equisetum fluviatile*				Boat Survey		
Bur-reed 1	*Sparganium* sp. 1				Boat Survey		
Swamp loosestrife	*Decodon verticillatus*				Boat Survey		
Narrow-leaved cattail	*Typha angustifolia*				Boat Survey		

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Typha angustifolia is considered a **Restricted** species in Wisconsin.

Table 3. Comparison of summary statistics for 2007 and 2013 point-intercept aquatic plant surveys in Big Lake.

Summary Statistic	2007[1]	2013
Total number of sites on grid	685	685
Total number of sites visited		350
Total number of sites with vegetation		74
Total number of sites shallower than maximum depth of plants		195
Frequency of occurrence at sites shallower than maximum depth of plants	31.72	37.95
Simpson Diversity Index	0.91	0.90
Maximum depth of plants (ft.)	20.00	16.00
Number of sites sampled with rake on rope		66
Number of sites sampled with rake on pole		178
Average number of all species per site (shallower than max depth)	0.79	1.10
Average number of all species per site (vegetated sites only)	2.52	2.89
Average number of native species per site (shallower than max depth)	0.79	1.10
Average number of native species per site (vegetated sites only)	2.52	2.89
Species Richness	28	24
Species Richness (including visuals)		28
Floristic Quality Index (FQI)	33.1	27.7

[1] The 2007 aquatic plant statistics included filamentous algae, which, according to WDNR protocol, should not be included. Because of this, statistics will vary.

Figure 1. Number of plant species recorded at Big Lake sample sites (2013).

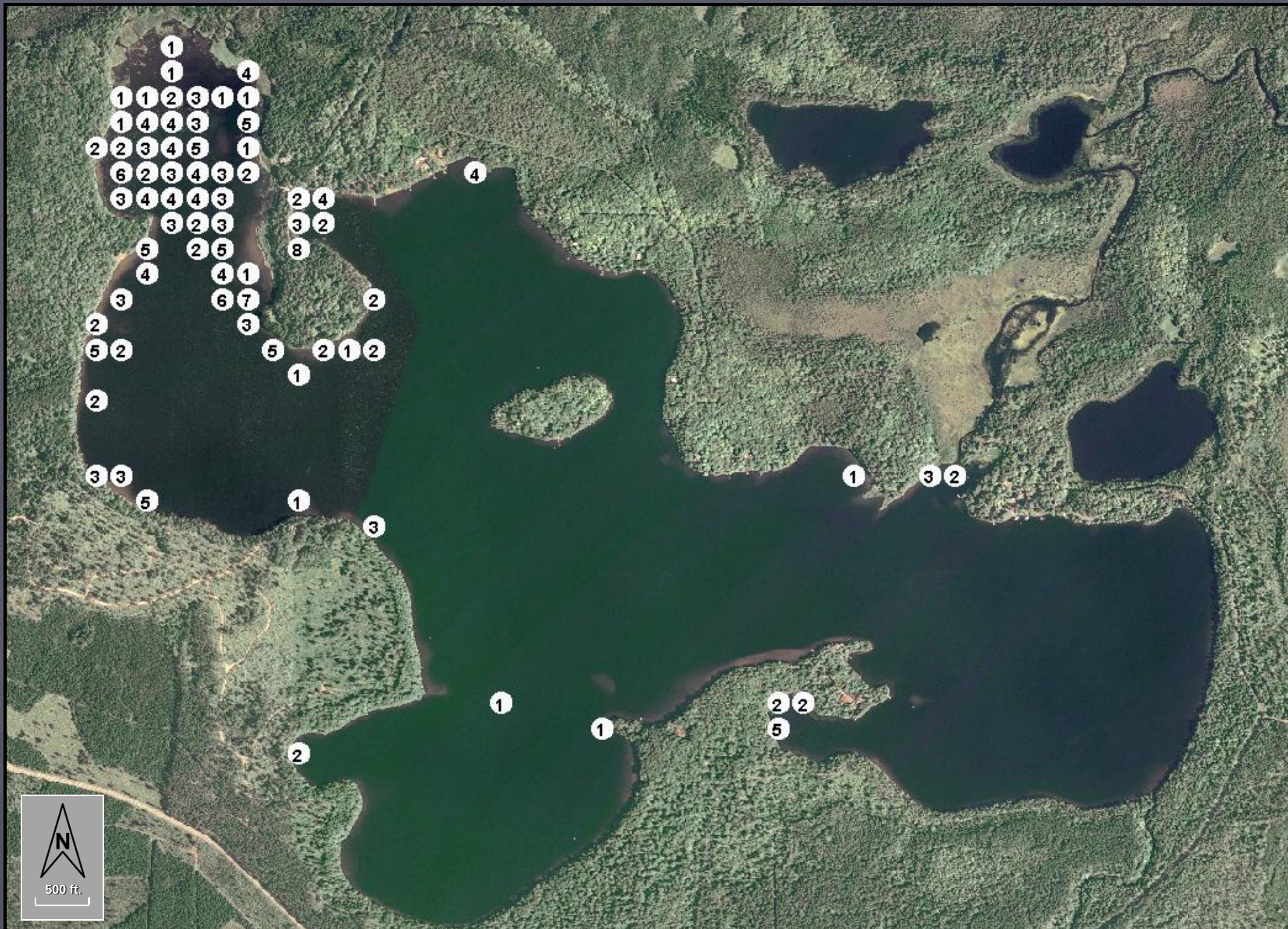


Figure 2. Rake fullness ratings for Big Lake sample sites (2013).

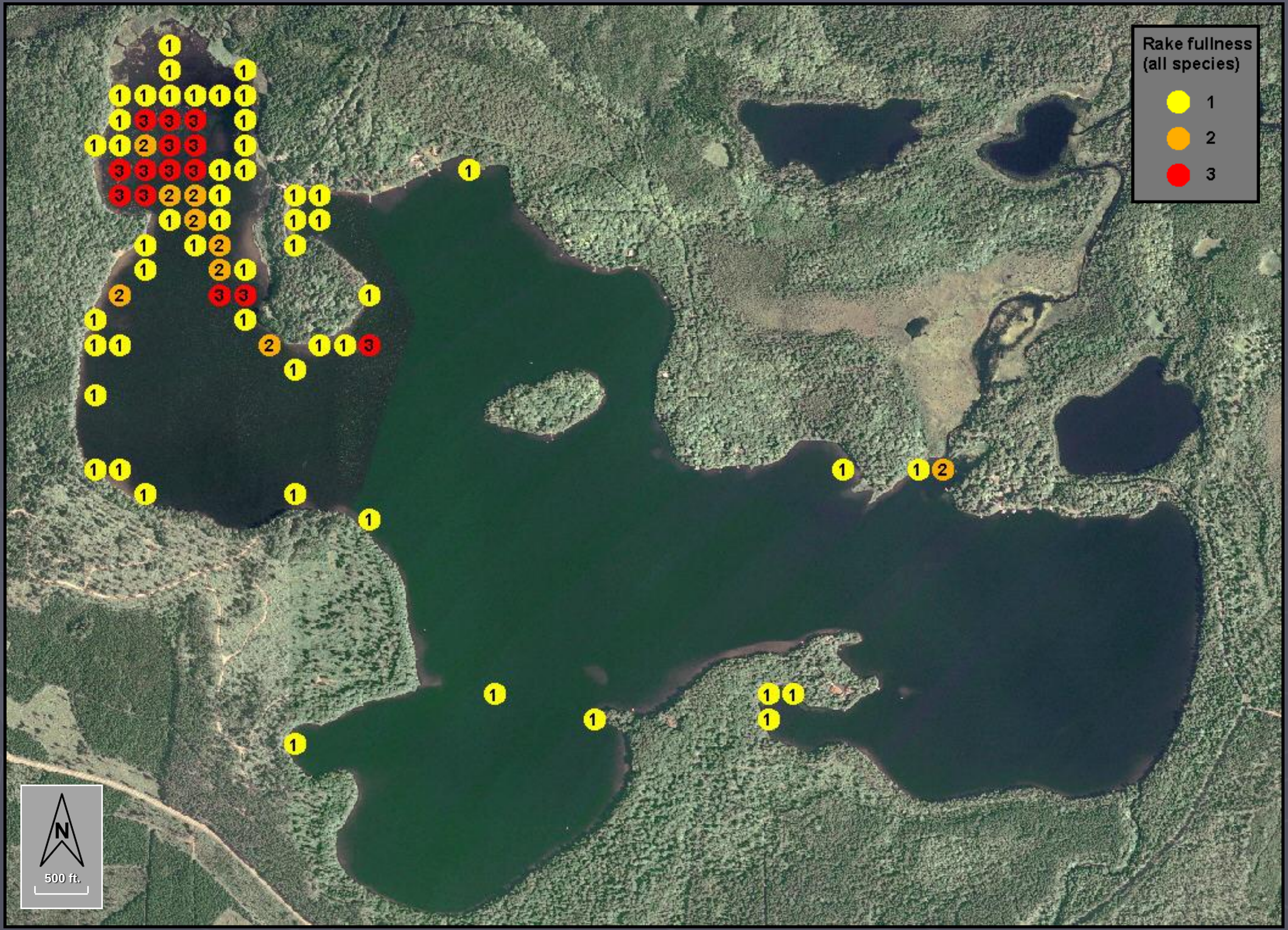


Figure 3. Maximum Depth of Plant Colonization in Big Lake.

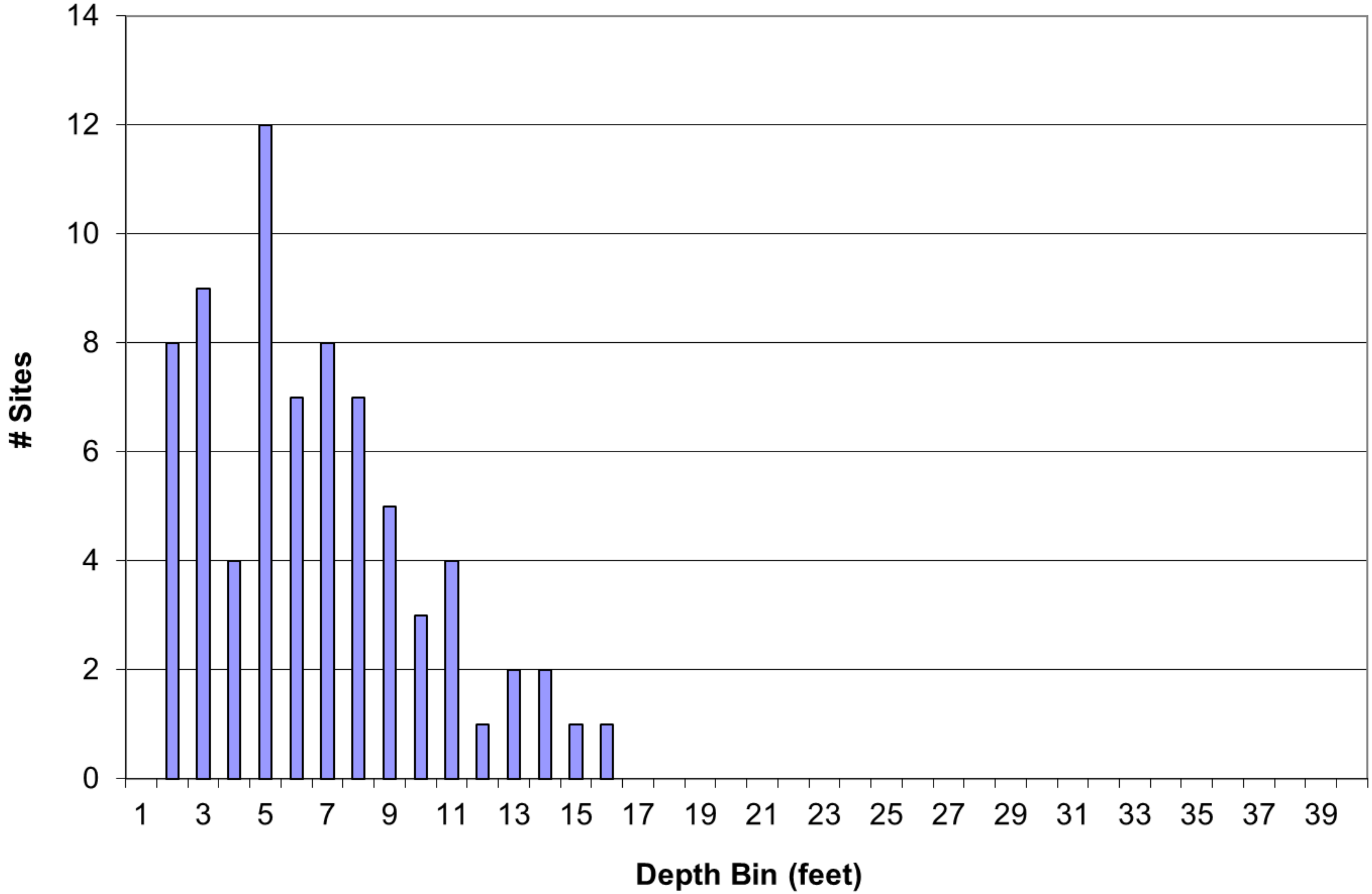


Figure 4. Big Lake sampling sites less than or equal to maximum depth of rooted vegetation (2013).

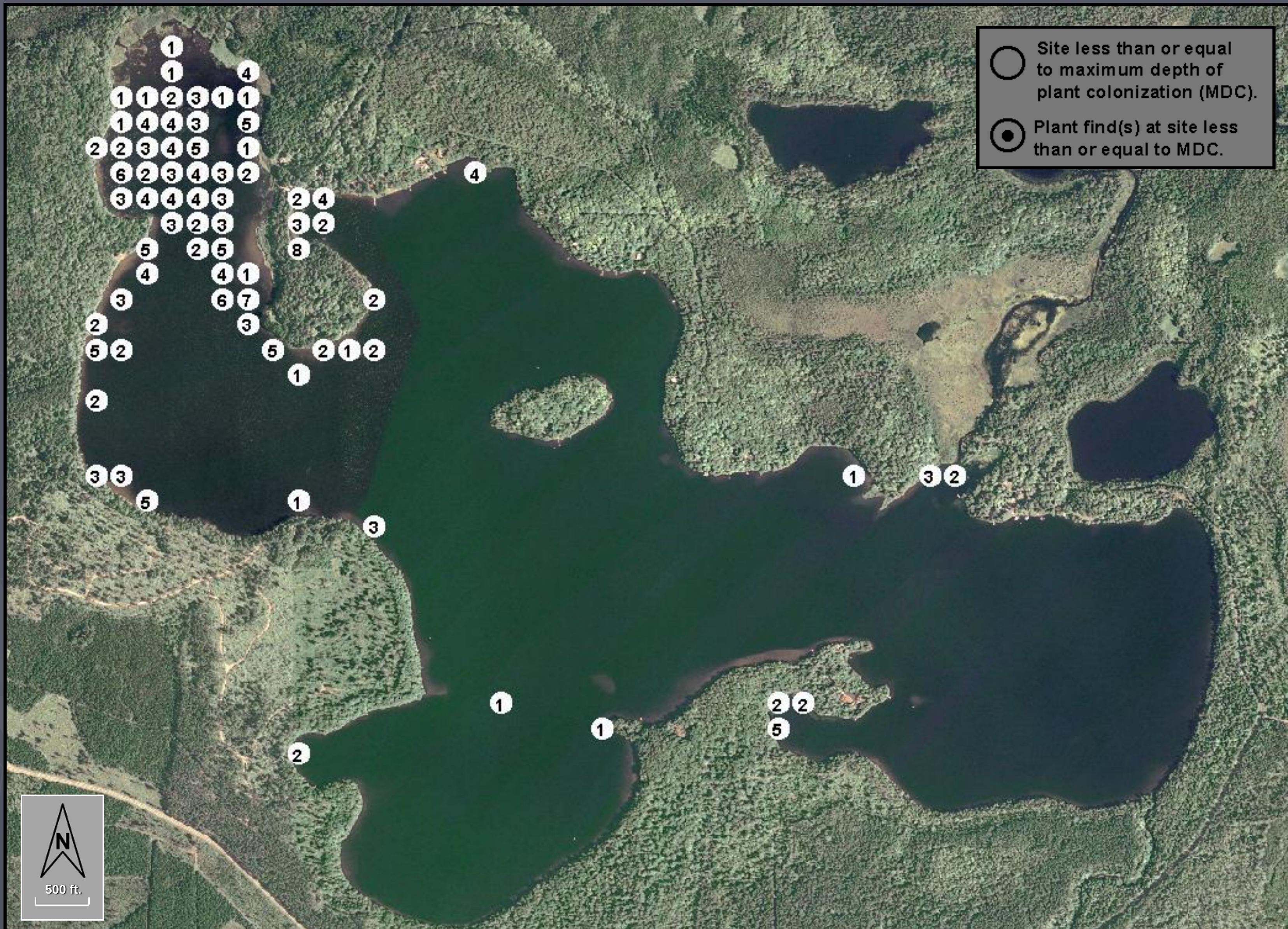


Figure 5. Big Lake substrate encountered at point-intercept plant sampling sites (2013).

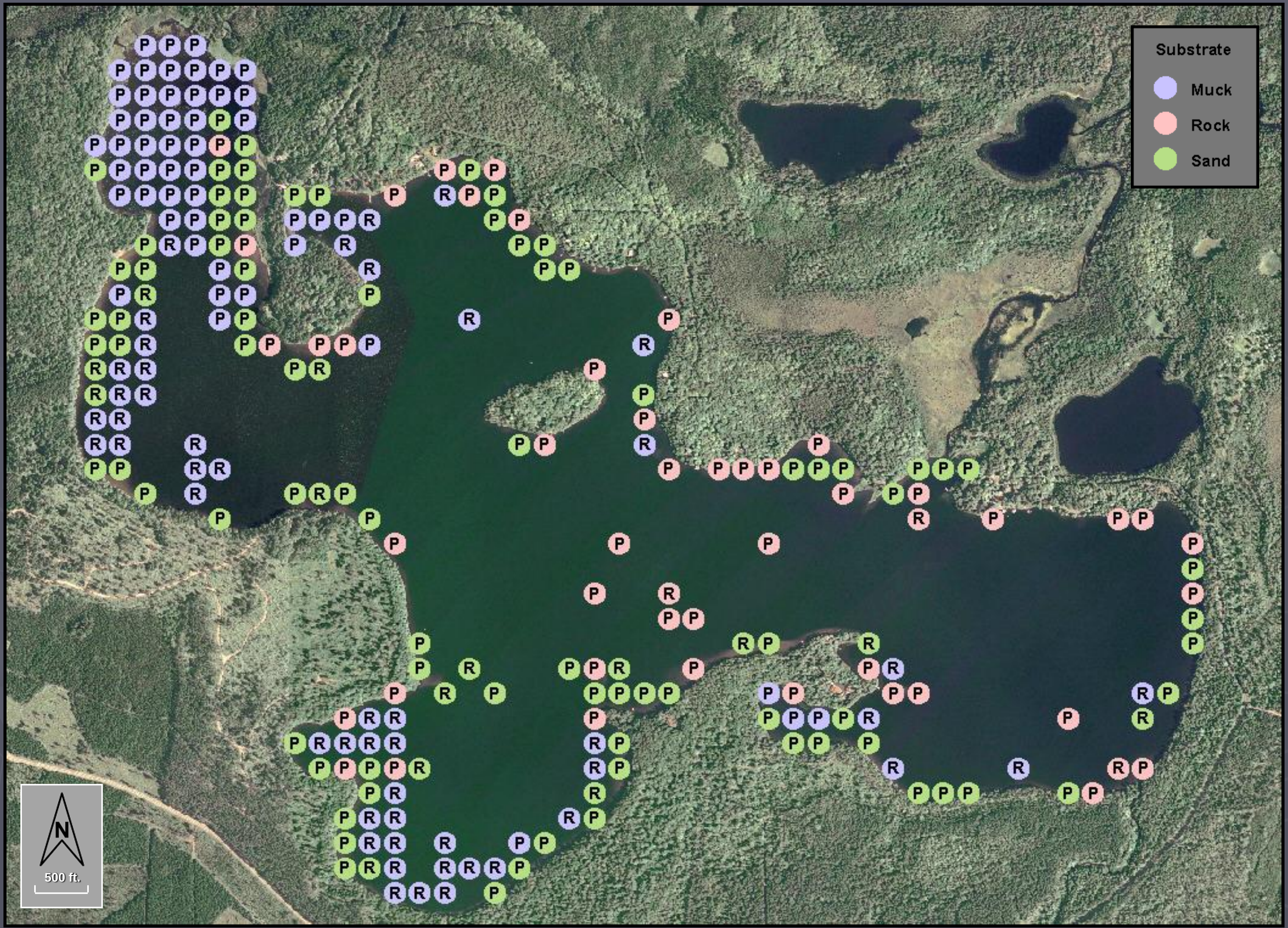


Figure 6. Big Lake aquatic plant occurrences for 2013 point-intercept survey data.

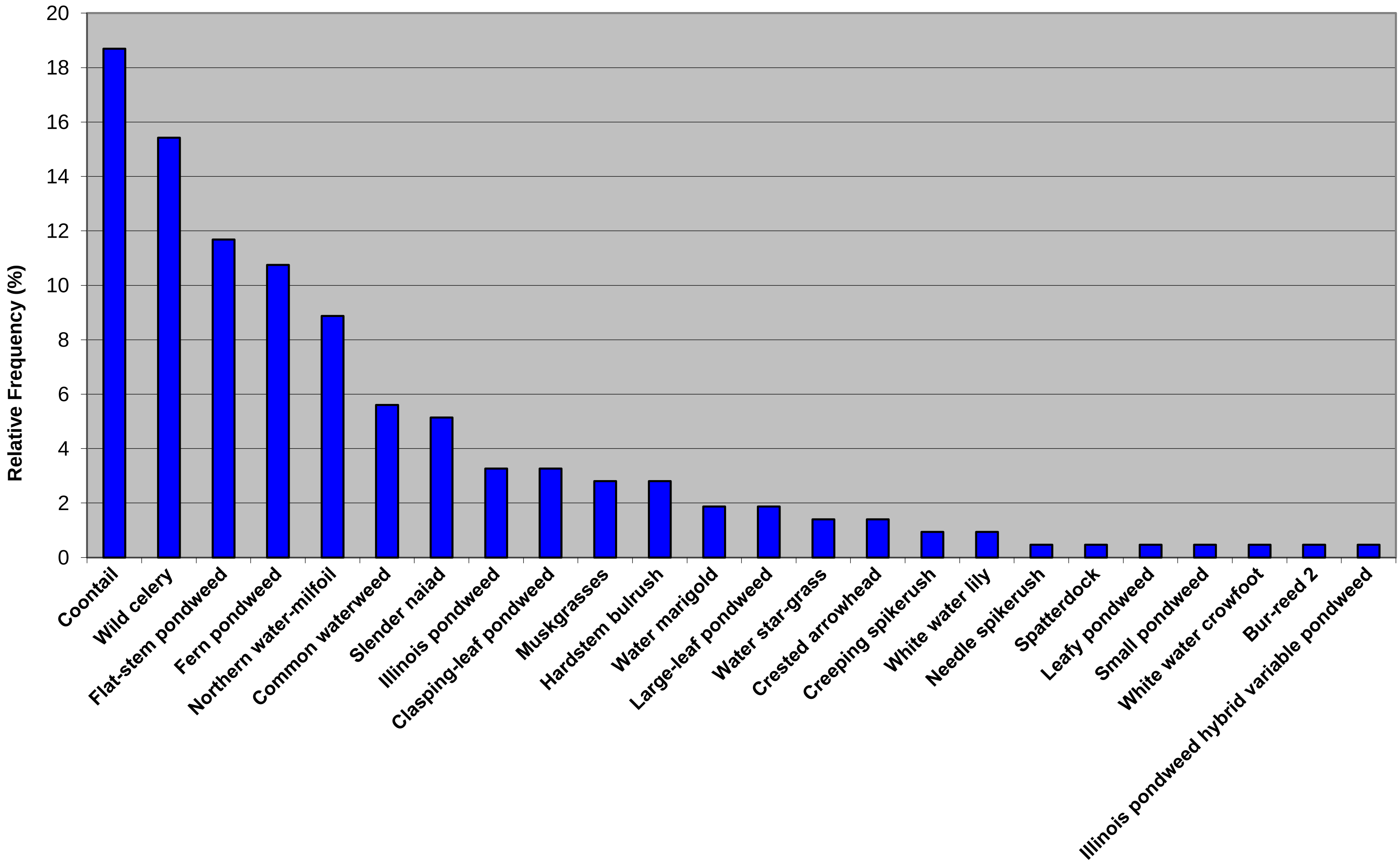


Figure 7. Big Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2013).

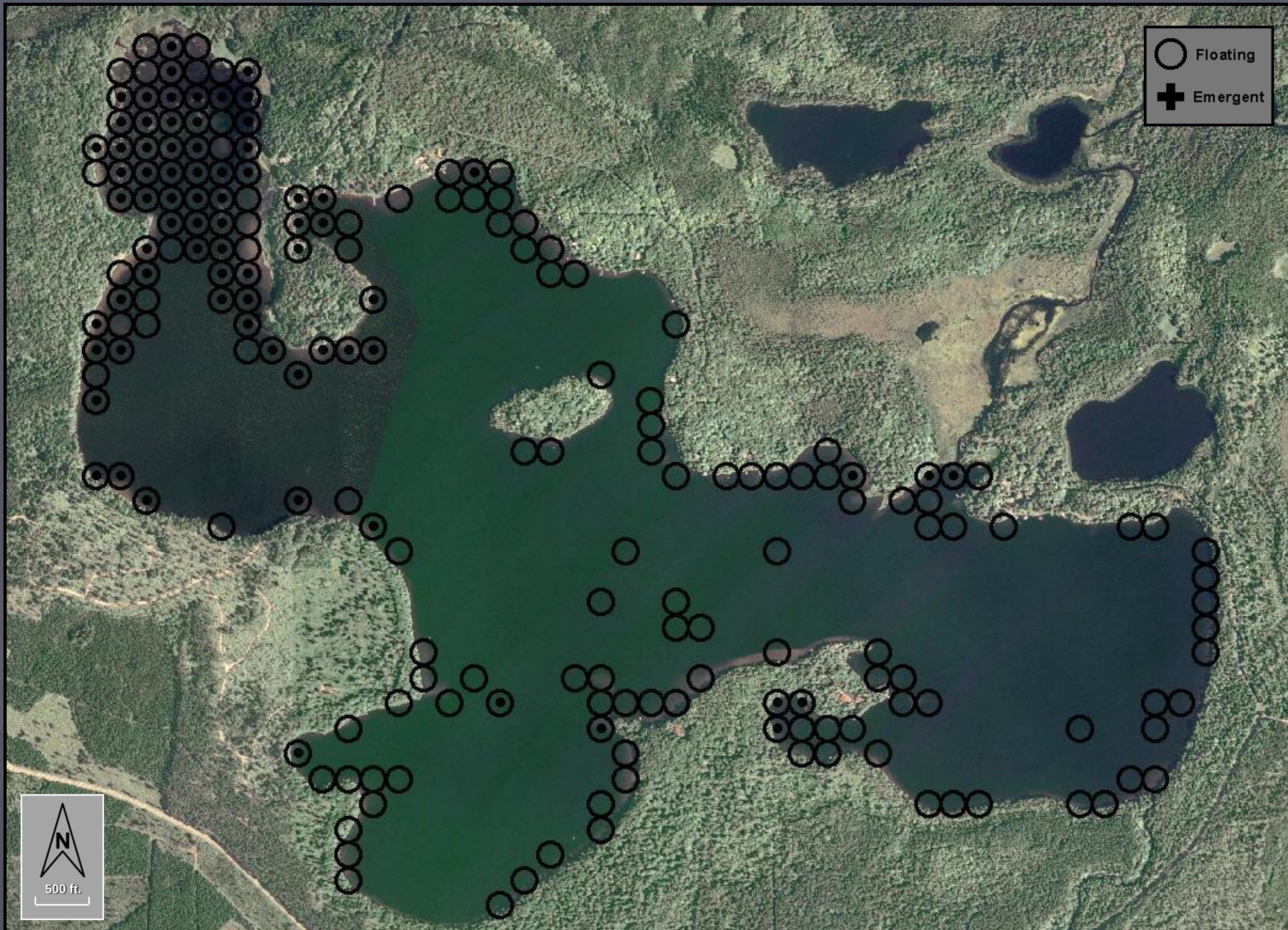


Figure 8. Distribution of plant species, Big Lake (2013).

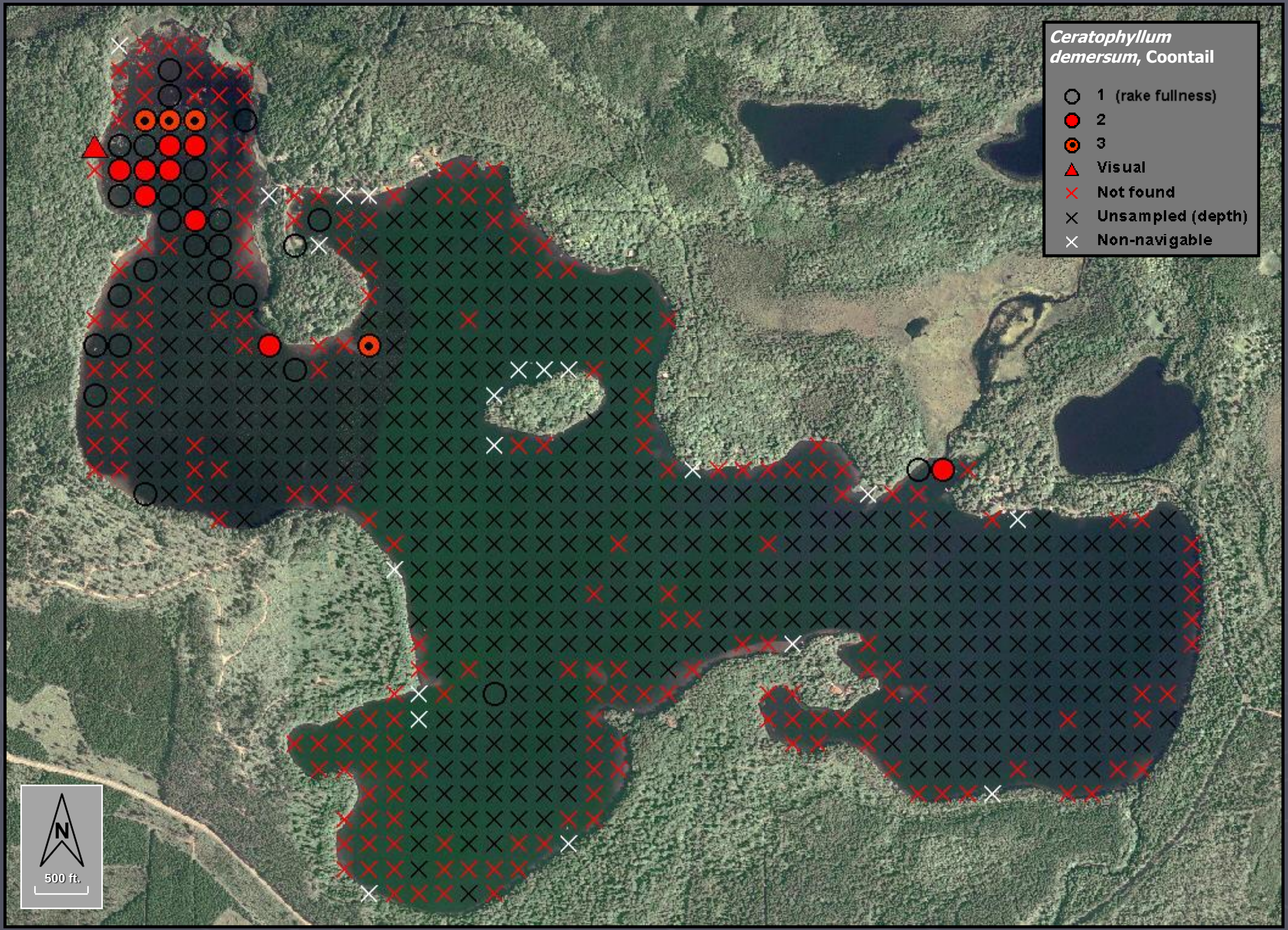


Figure 9. Distribution of plant species, Big Lake (2013).

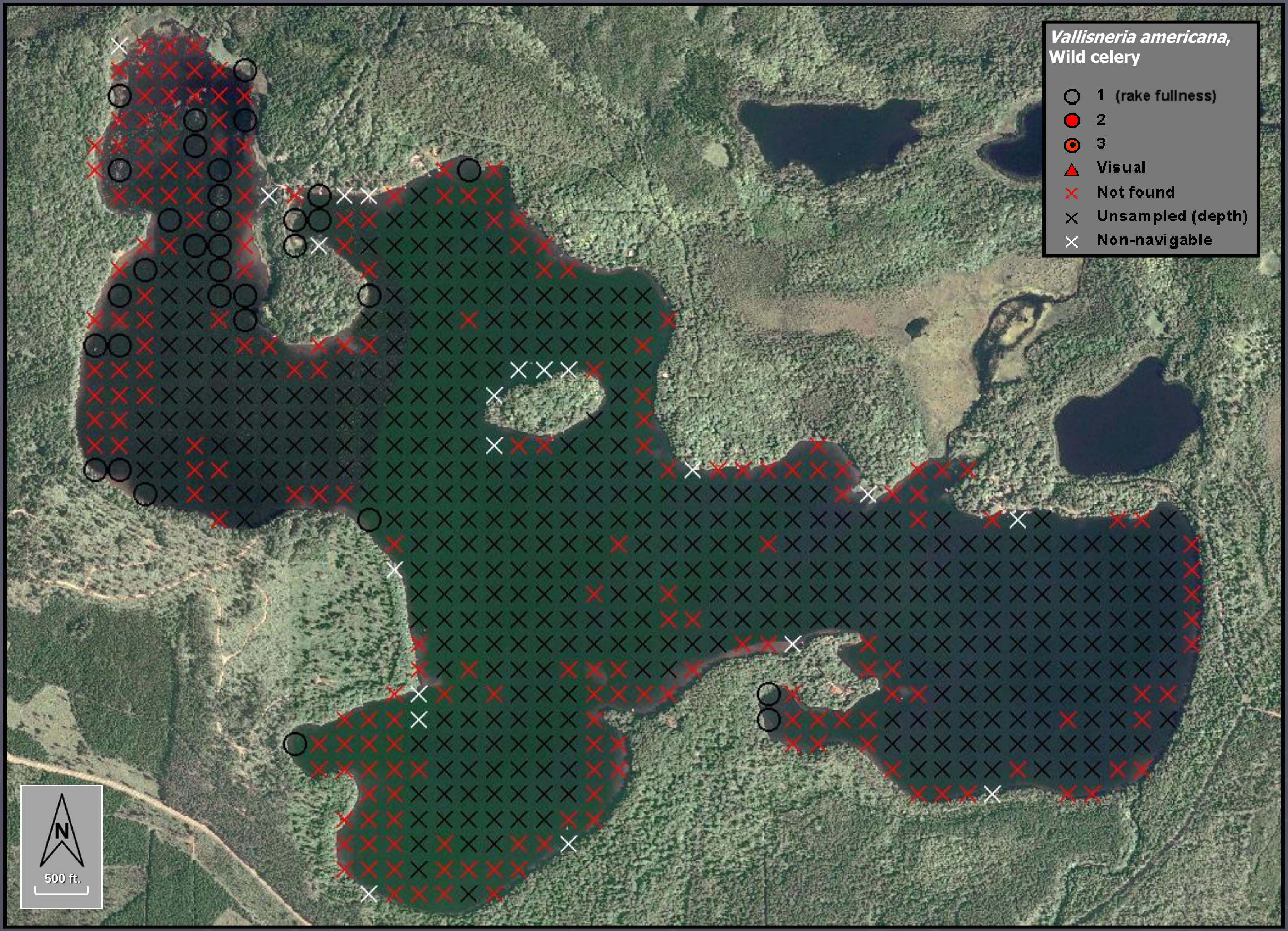


Figure 10. Distribution of plant species, Big Lake (2013).

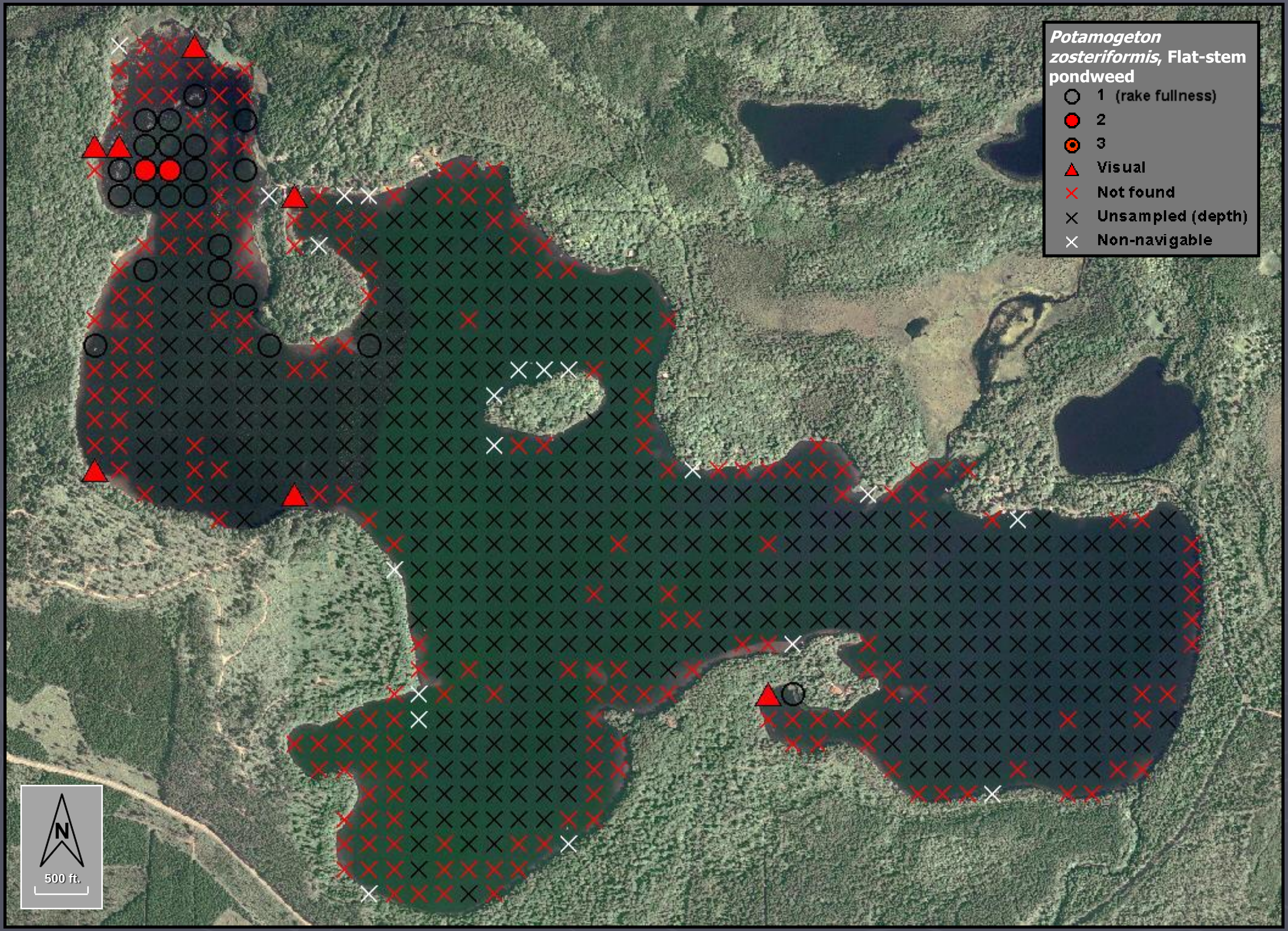


Figure 11. Distribution of plant species, Big Lake (2013).

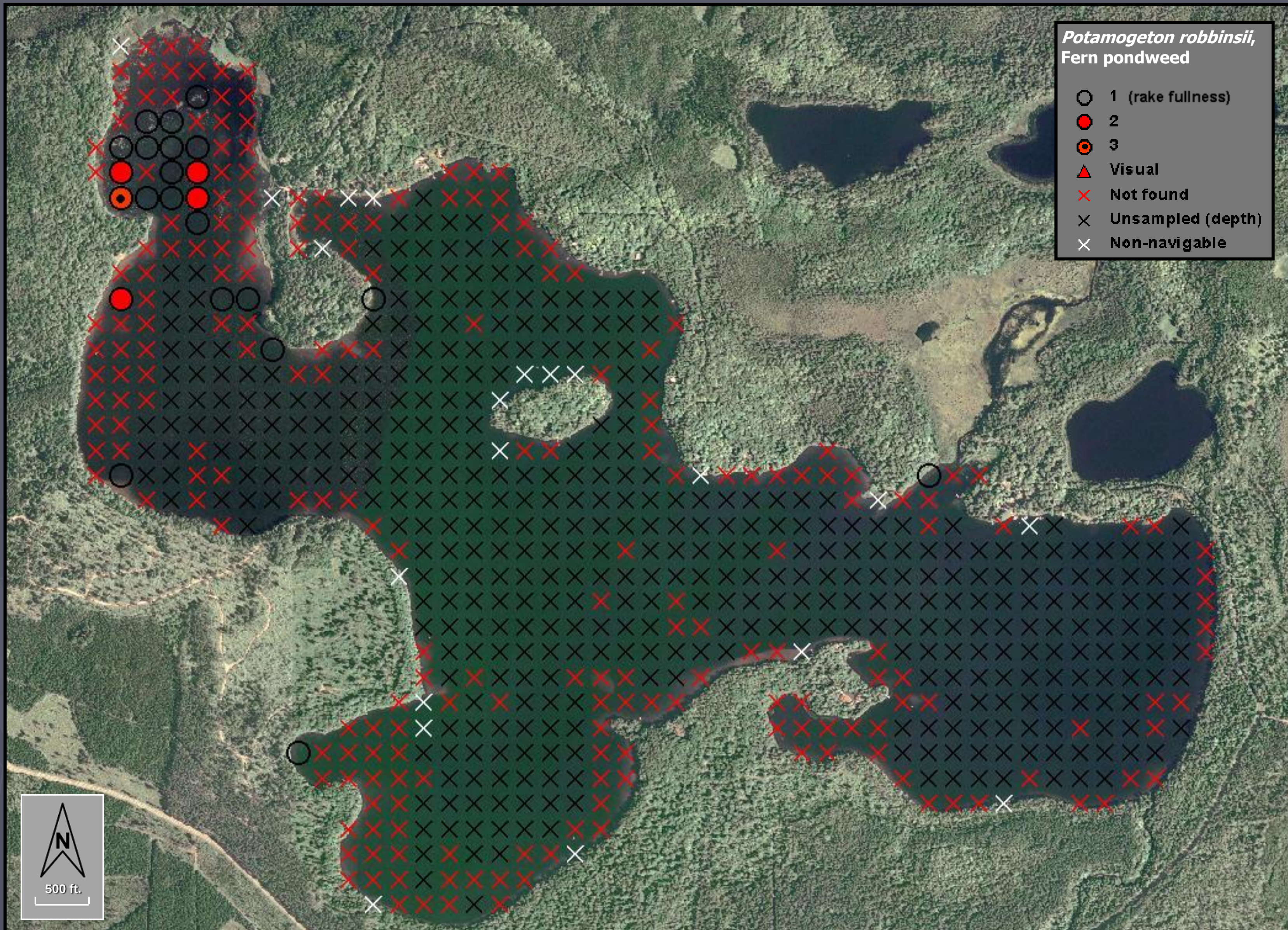


Figure 12. Distribution of plant species, Big Lake (2013).

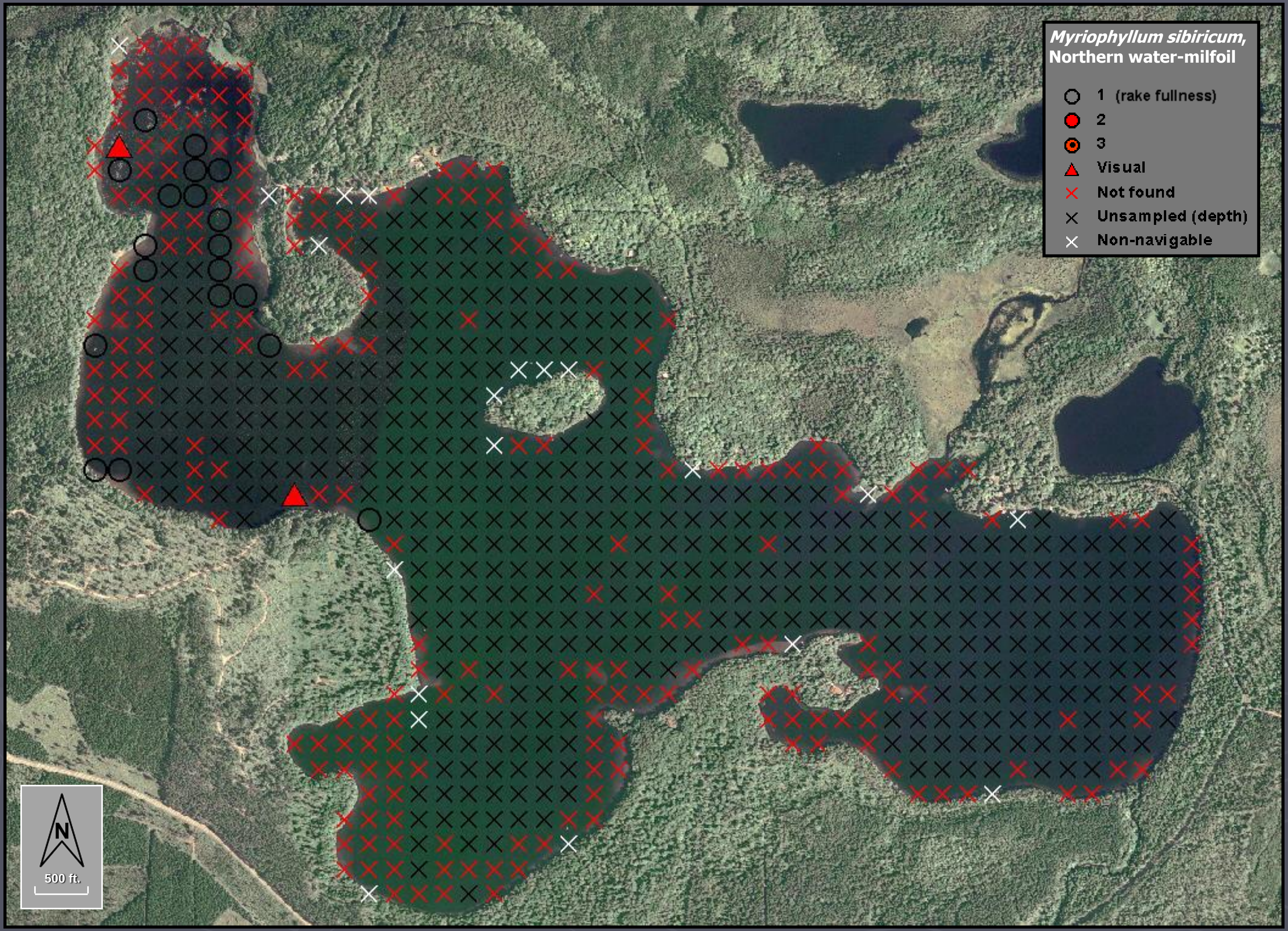


Figure 13. Distribution of plant species, Big Lake (2013).

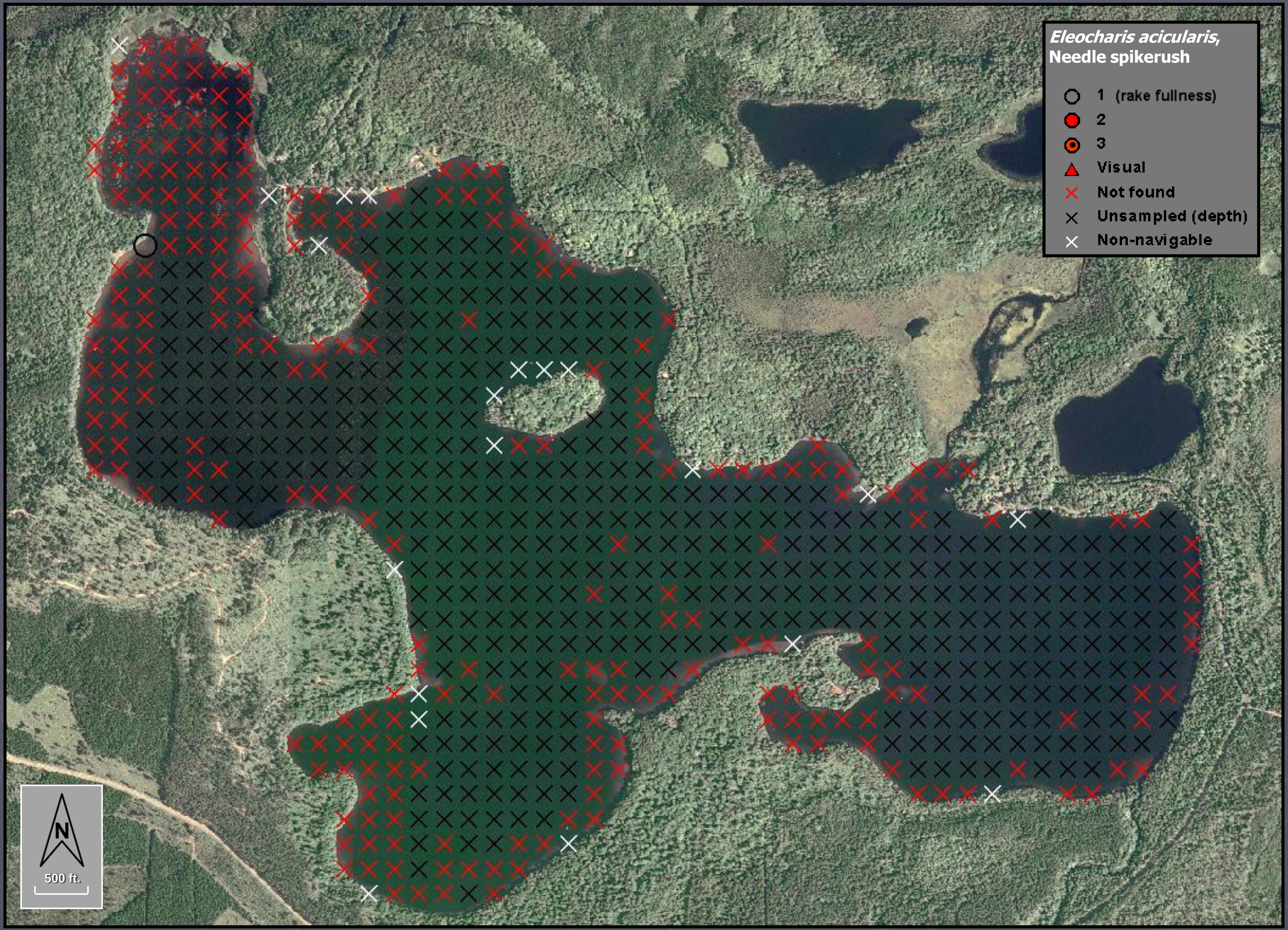


Figure 14. Distribution of plant species, Big Lake (2013).

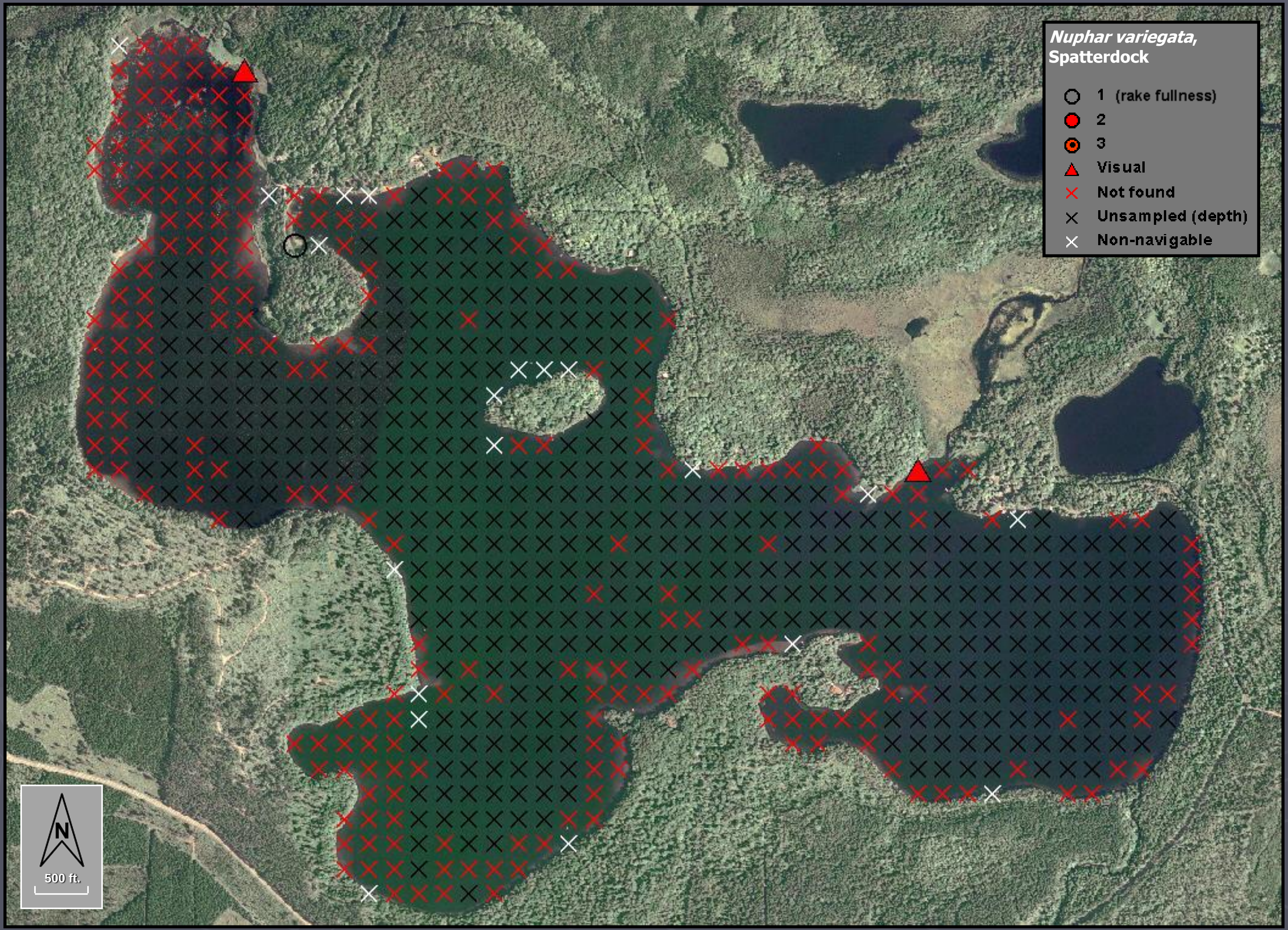


Figure 15. Distribution of plant species, Big Lake (2013).

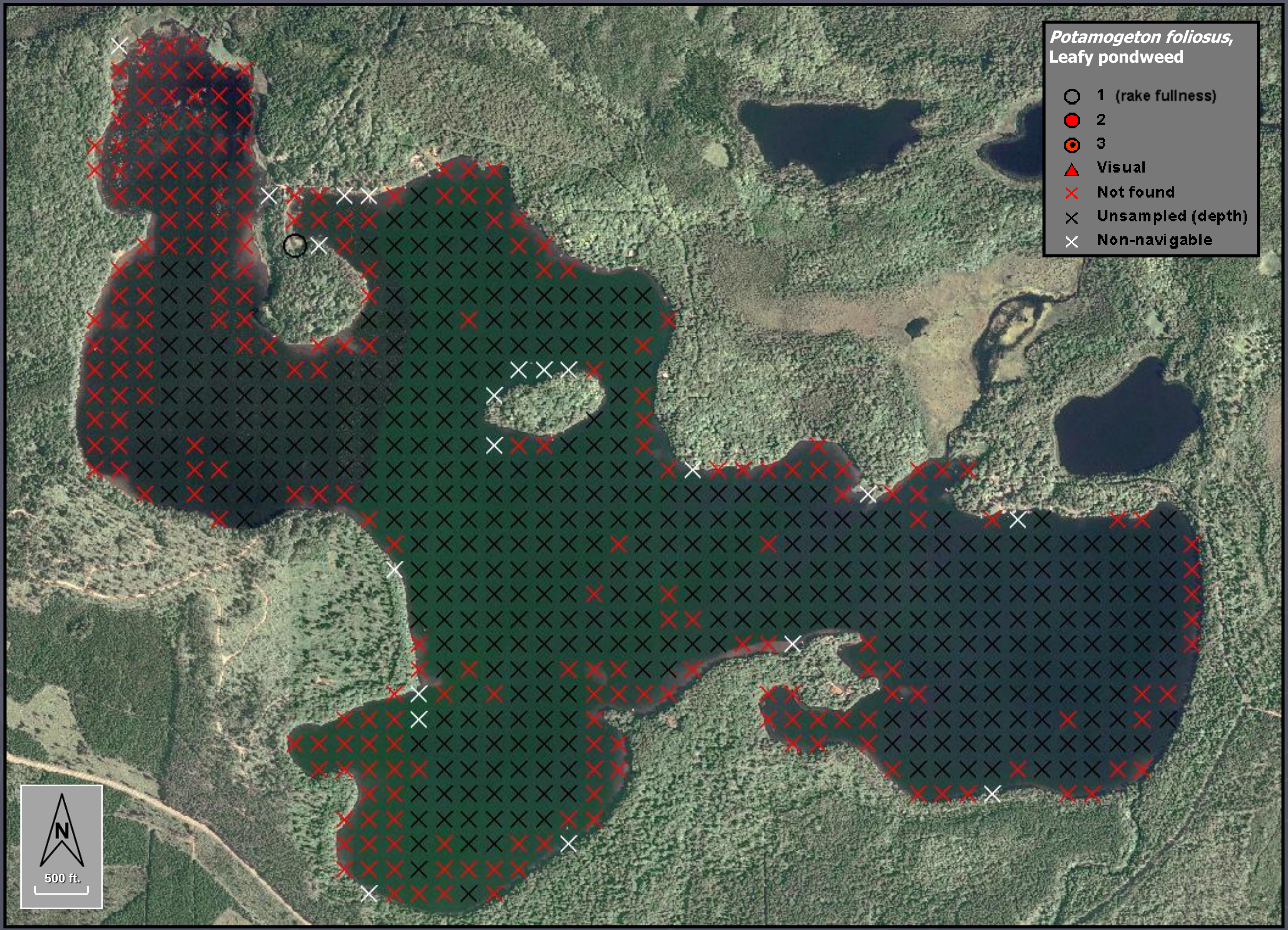


Figure 16. Distribution of plant species, Big Lake (2013).

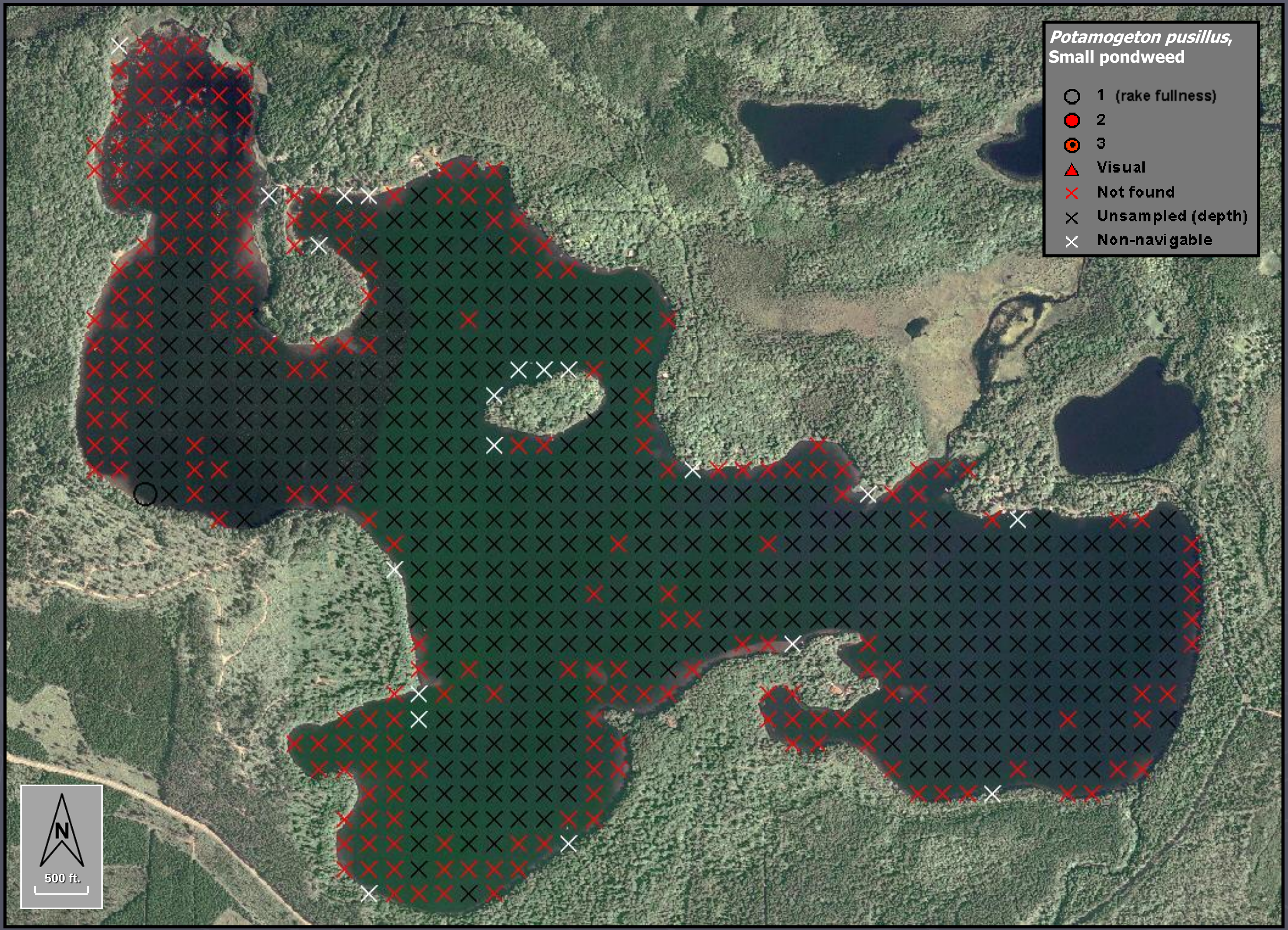


Figure 17. Distribution of plant species, Big Lake (2013).

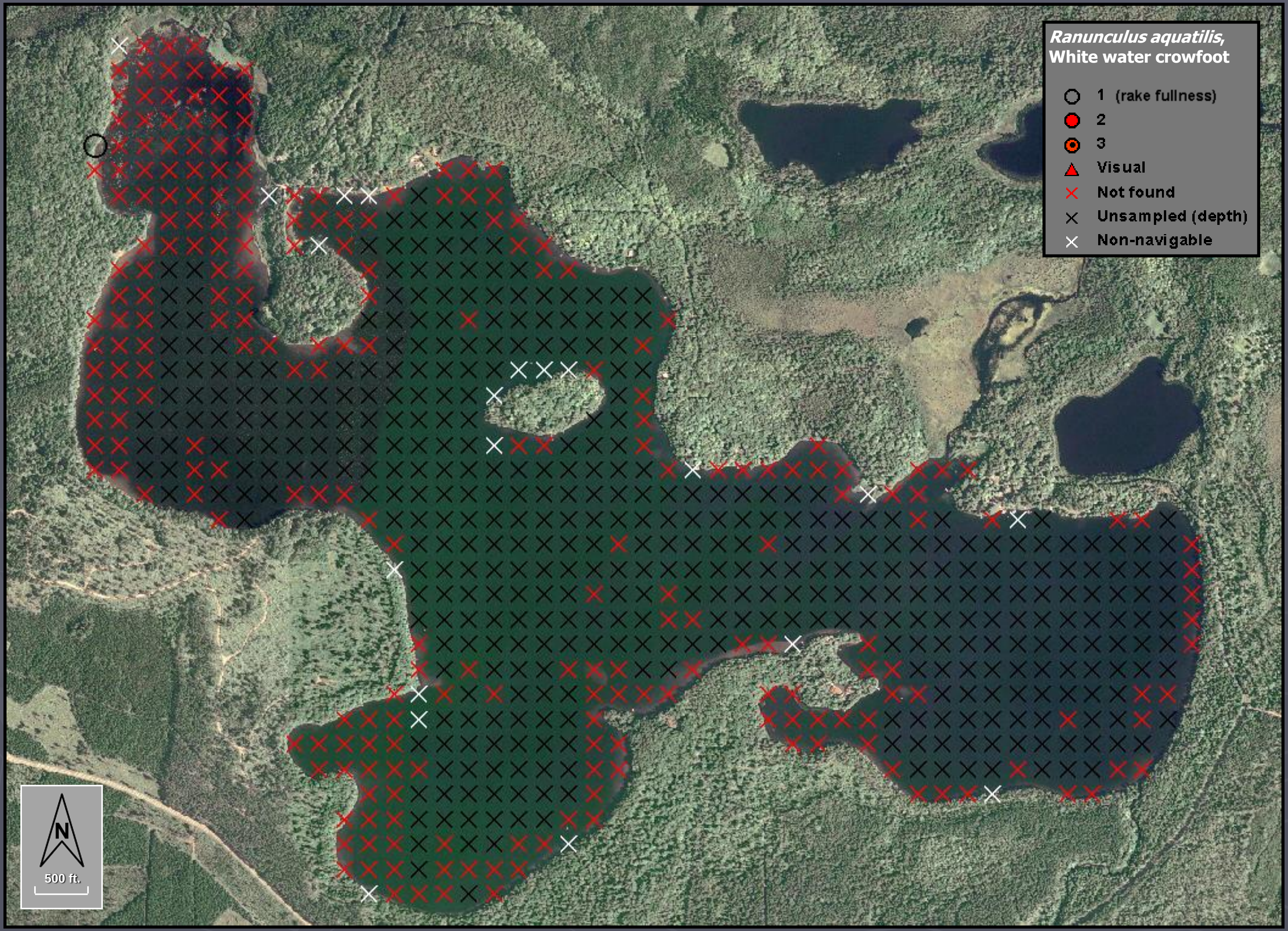
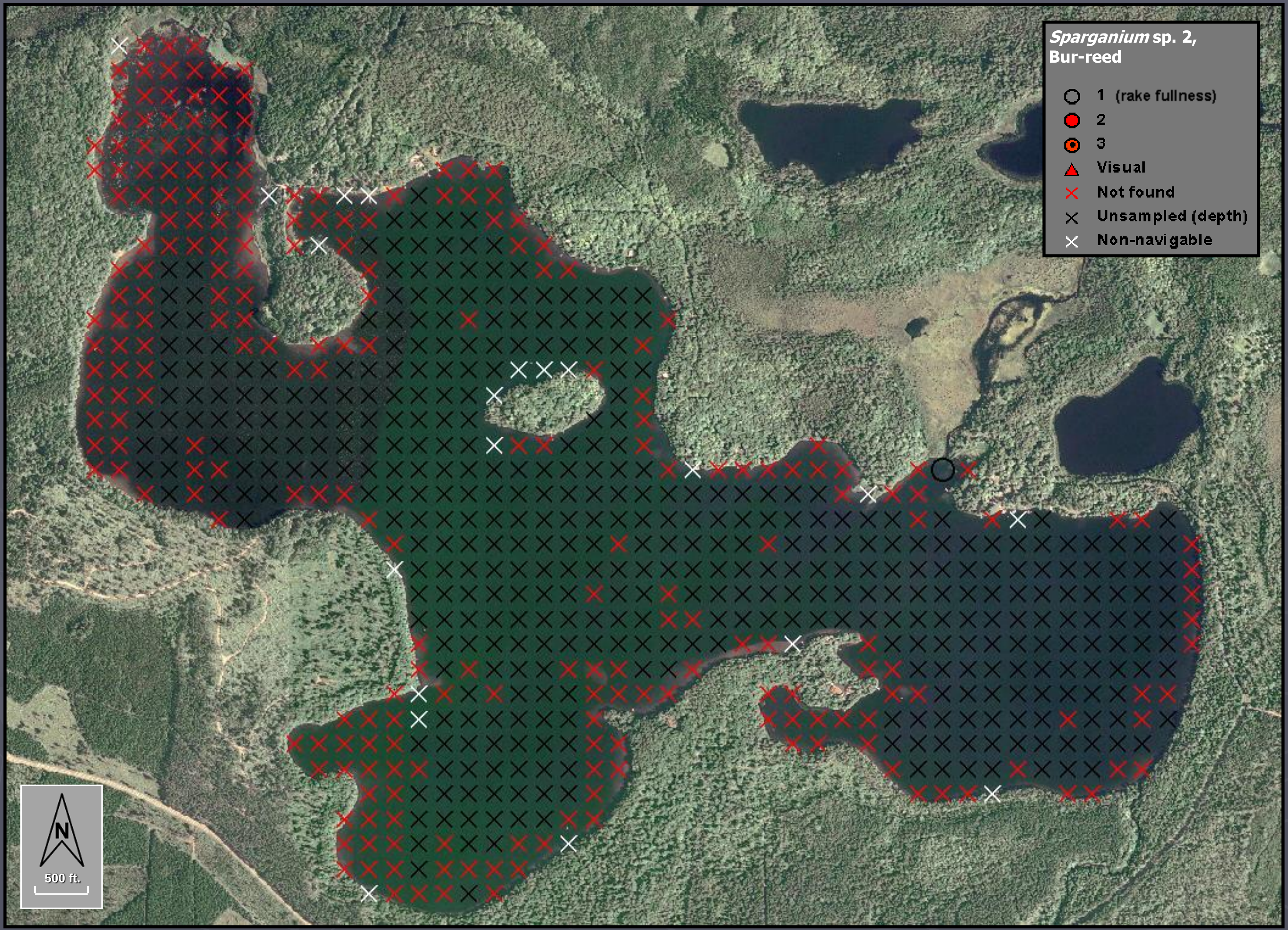


Figure 18. Distribution of plant species, Big Lake (2013).



Appendix C

Review of Lake Water Quality

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Review of Big Lake Water Quality

Prepared by Angie Stine, B.S., and Caitlin Clarke, B.S., White Water Associates, Inc.

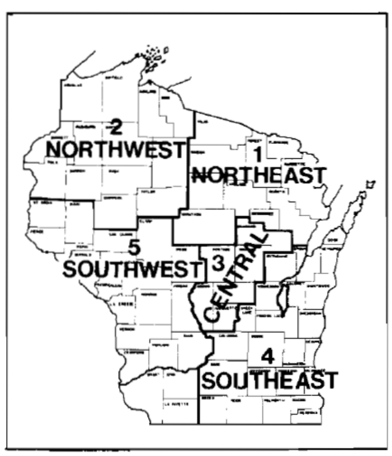
Introduction

Big Lake is located in Vilas County, Wisconsin. It is an 835 acre drainage lake with a maximum depth of 61 feet. The Waterbody Identification Code (WBIC) is 2334700. The purpose of this study is to develop baseline data. Our goal is to collect existing water quality data to give us a starting point, and continue to monitor Big Lake for a comparison of environmental and human changes. Water quality data was retrieved from the Wisconsin DNR SWIMS from 1984 to 2013. In May, 2003 baseline monitoring was performed by the WDNR. Secchi disk measurements were collected by Citizen Lake Monitoring Network (CLMN) volunteers from 1991 to 2013. Chlorophyll *a* and total phosphorus were also collected in October, 1985; May, 2003 and August, 2003 by CLMN volunteers.

Comparison of Big Lake with other datasets

Lillie and Mason's *Limnological Characteristics of Wisconsin Lakes* (1983) is a great source to compare lakes within our region to a subset of lakes that have been sampled in Wisconsin. Wisconsin is divided into five regions of sampling lakes. Vilas County lakes are in the Northeast Region (Figure 1) and were among 243 lakes randomly selected and analyzed for water quality.

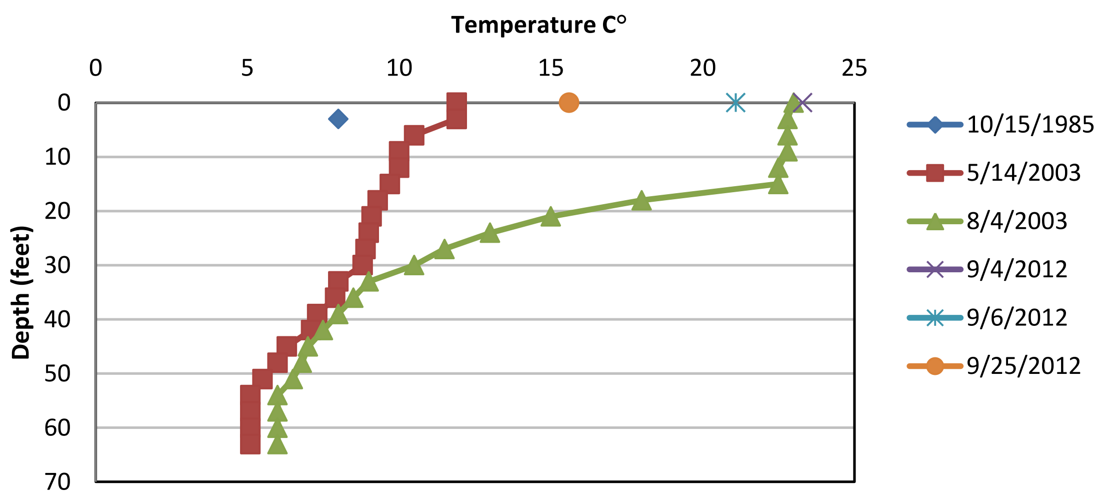
Figure 1. Wisconsin regions in terms of water quality.



Temperature

Measuring the temperature of a lake at different depths will determine the influence it has on the physical, biological, and chemical aspects of the lake. Lake water temperature influences the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen (D.O.) concentration. Temperature can also affect the distribution of fish species throughout a lake. Figure 2 indicates the changes in water temperature from various months and years sampled from 1985, 2003, and 2012. In May, the temperatures began to stratify from surface to bottom. The August, 2003 temperatures show stratification beginning at 18 feet. Water temperatures dropped considerably from September 4 to September 9, 2012. For more information about the influence of lake stratification on a lake's water quality and biota, please refer to *Understanding Lake Data* (Shaw et al., 2004).

Figure 2. Big Lake temperature profile.



Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis, but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of dissolved oxygen available in a lake, particularly in the deeper parts of a lake, is critical to overall health. In October, 1985 a D.O. sample of 9.2 mg/L was recorded at 3 feet. D.O. levels were 10.1 mg/L at the surface in May, 2003 and decreased to 4.6 at 48 feet deep (Figure 3). In August, 2003 the surface D.O. level was 8 mg/L, and at 24 feet it decreased 0.1 mg/L (Figure 4). In August 2007 the surface D.O. was 8.29 mg/L and 0.34 mg/L at the bottom and the lake stratified between 51-66 feet (Figure 5).

Figure 3. Big Lake dissolved oxygen and temperature profile, May, 2003.

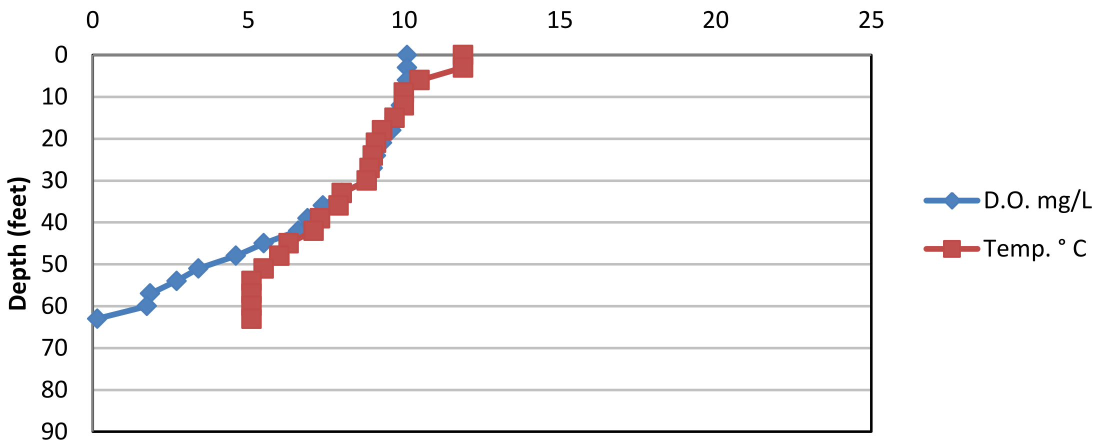
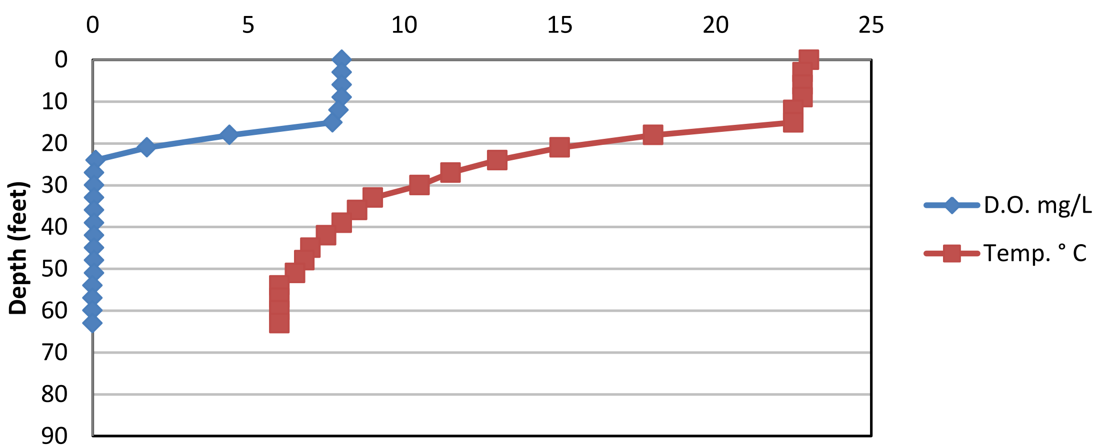
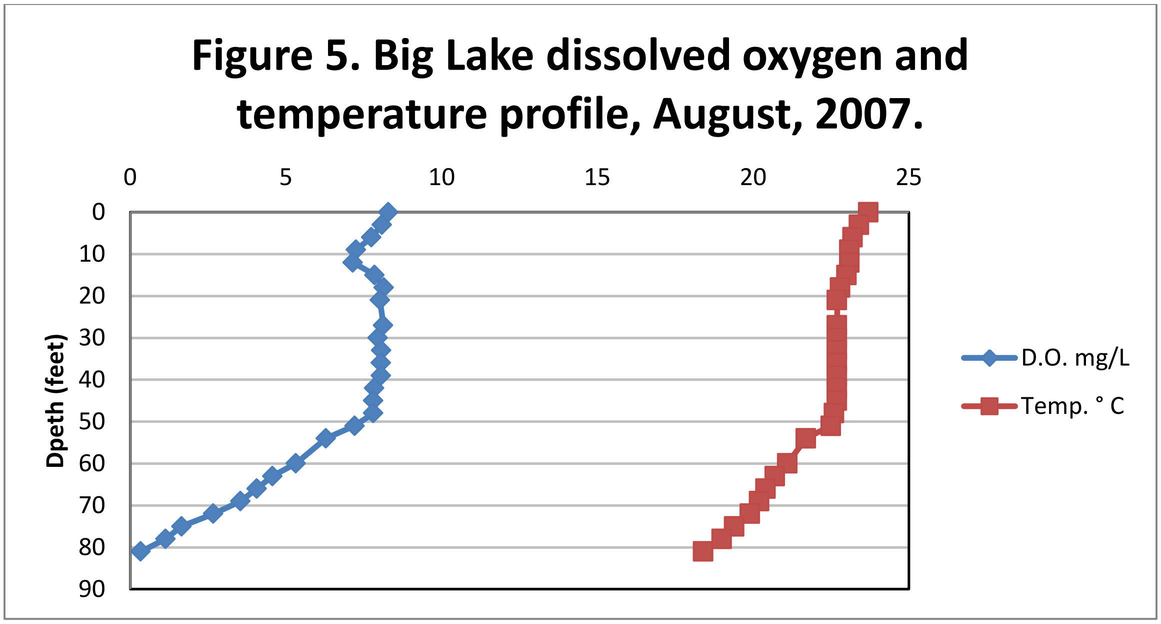


Figure 4. Big Lake dissolved oxygen and temperature profile, August, 2003.





Water Clarity

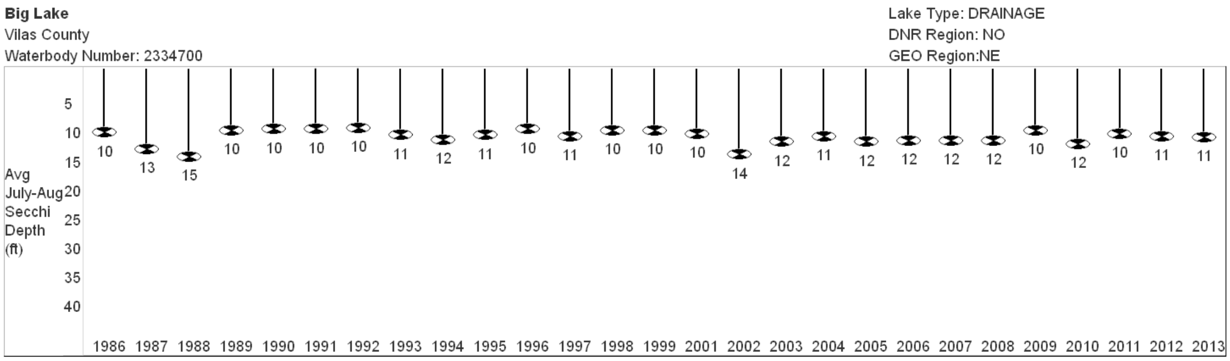
Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity gives an indication of the overall water quality in a lake. Water clarity is typically measured using a Secchi disk (black and white disk) that is lowered into the water column on a tether. In simple terms, the depth at which the disk is no longer visible is recorded as the Secchi depth.

Figure 6 shows the July and August mean Secchi depths from 1986 to 2013. The shallowest mean Secchi depth was 9.5 feet in 1992, and the deepest average depth was 14.6 feet in 1988 (Figure 7). According to Table 1, the 2012 average Secchi depth classifies Big Lake as "good," with respect to water clarity.

Table 1. Water clarity index (Shaw et al., 2004).

Water clarity	Secchi depth (ft.)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Figure 6. Big Lake Secchi depth averages (July and August only).



Past secchi averages in feet (July and August only).

(WDNR, 2013)

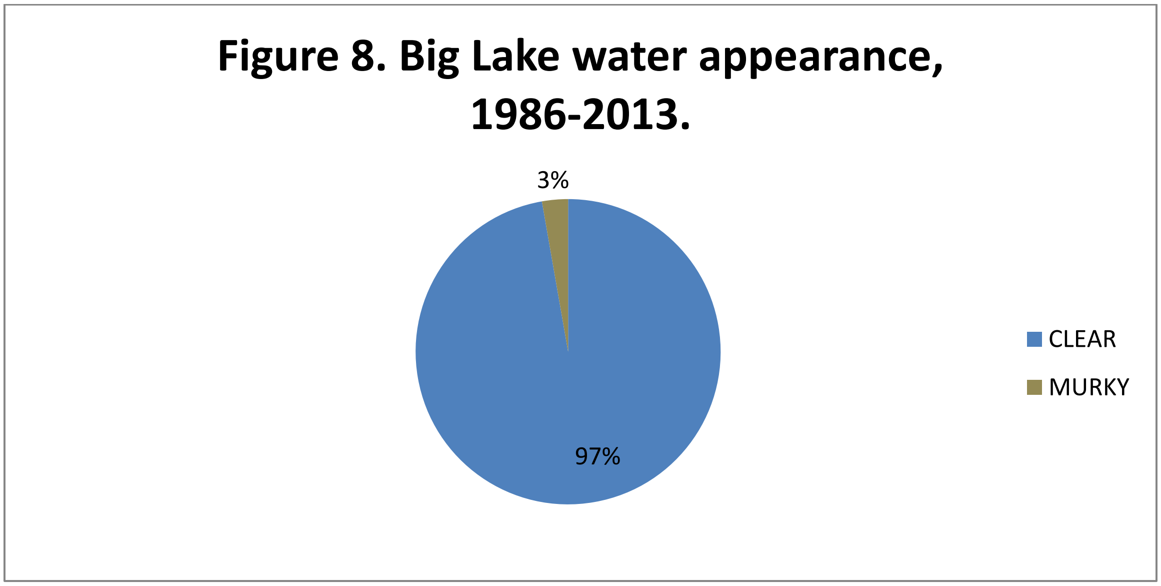
Figure 7. Big Lake's July and August Secchi Data: Mean, Min, Max, and Secchi Count (1986-2013).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1986	10.4	7.5	13.5	7
1987	13.2	11.5	14.5	6
1988	14.6	12	17.5	6
1989	9.9	8.5	11.25	8
1990	9.8	9	11	7
1991	9.7	8.5	10.5	8
1992	9.5	8.5	11	7
1993	10.8	9	13	6
1994	11.5	10.5	13	5
1995	10.8	8.5	12	4
1996	9.8	9	10.5	4
1997	10.9	10.25	11.5	4
1998	9.9	9.25	10.5	4
1999	10	8	11.5	4
2001	10.5	10	11	2
2002	14.1	13.75	14.5	2
2003	12	10.8	12.5	6
2004	10.9	8.8	13	2
2005	12	10.8	13	5
2006	11.7	10.6	12.8	2
2007	11.8	9	13.3	4
2008	11.8	8.8	13.7	3
2009	10	8.5	11.5	2
2010	12.3	10.25	17	4
2011	10.5	9.9	11	2
2012	10.9	10	12.5	5
2013	11.2	9.25	12.5	5

(WDNR, 2013)

Turbidity

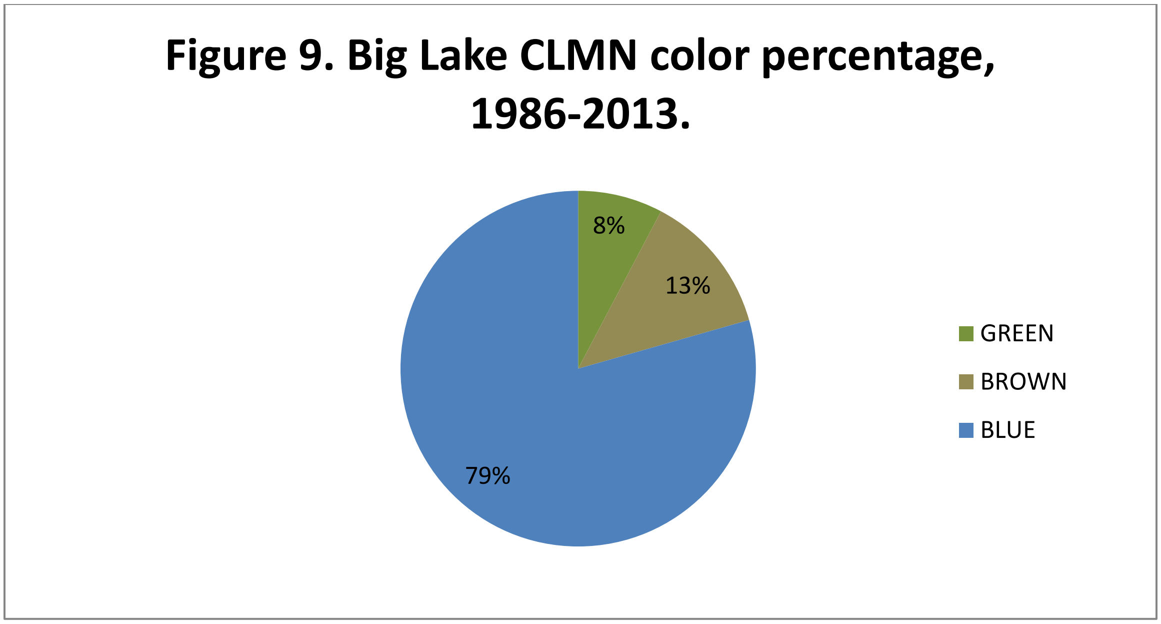
Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms. Big Lake turbidity has not been tested, and should be included in future water quality sampling. While checking Secchi depth, CLMN volunteers also rated water clarity and describe the water as “clear” or “murky.” From 1986 to 2013, 97% of volunteers rated Big Lake to have “clear” water (Figure 8).



Water Color

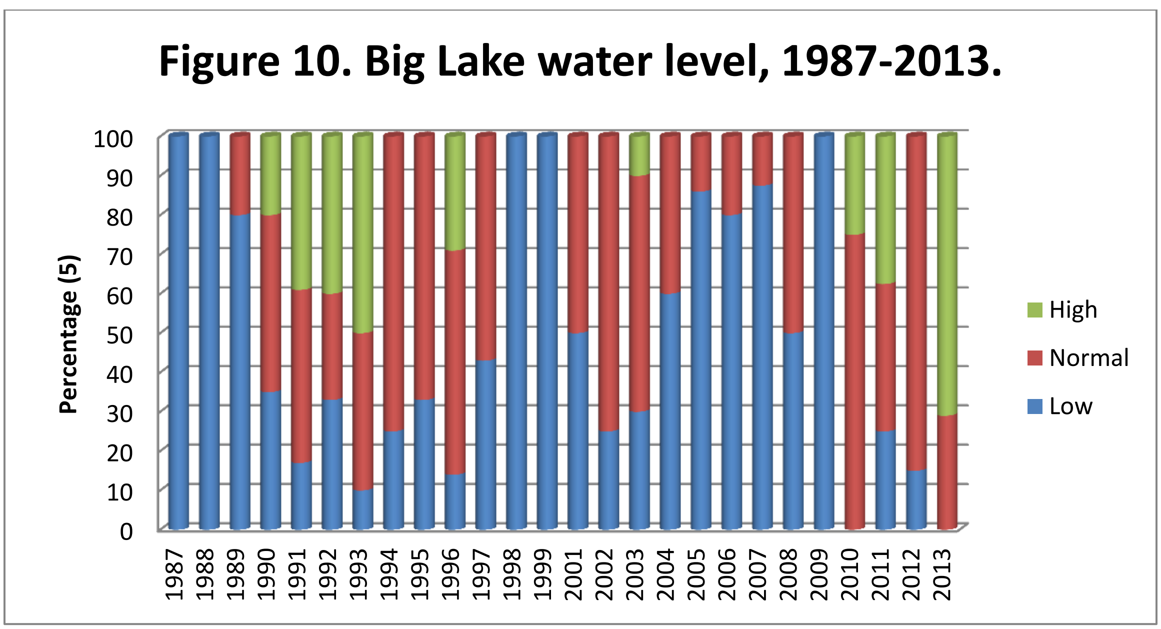
Color of lake water is related to the type and amount of dissolved organic chemicals. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant material in the watershed (Shaw et al., 2004). Units of color are determined from the platinum-cobalt scale and are therefore recorded as Pt-Co units. Shaw states that a water color between 0 and 40 Pt-Co units is low. In October, 1985 Big Lake had a color value of 20 Pt-Co. In August, 2003 the color level was also 20 Pt-Co.

The CLMN have also recorded their perceptions of water color in Big Lake. Since 1990, 78% of volunteers indicated the water appeared “blue,” 14% indicated the water appeared “brown” and 8% indicated it appeared “green” (Figure 9).



Water Level

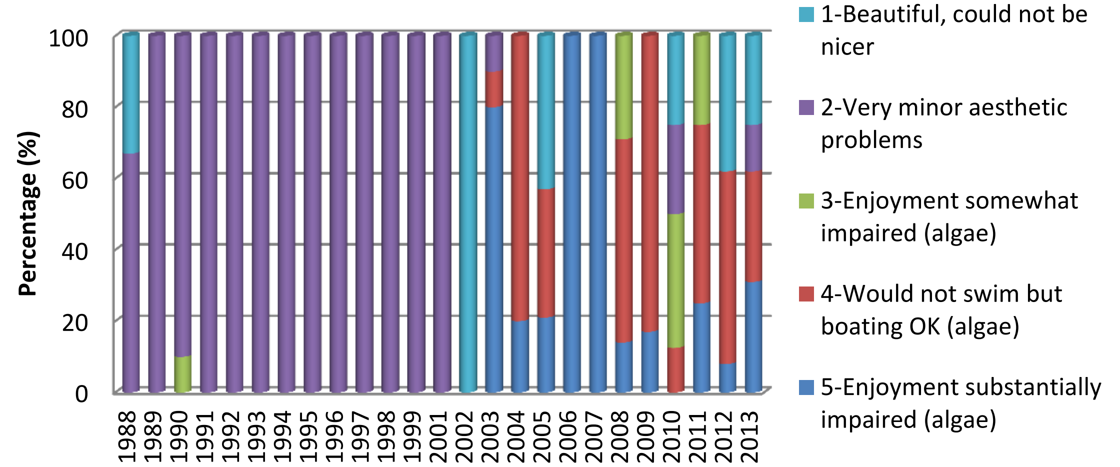
When CLMN volunteers collect Secchi depth readings, they also record the lake level as “high,” “normal,” or “low” (Figure 10). In 1987, 1988, 1998, 1999 and 2009 the water level in Big Lake was considered “low.” In 1993, half of the volunteers viewed Big Lake water levels as “high.” In 2013 the water level was viewed as “high” the majority of the time.



User Perceptions

When Secchi depth readings are collected, the CLMN record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting the transparency data, we see that when Secchi depth decreases, the rating of the lake's physical appearance also decreases. These perceptions of recreational suitability are displayed in Figure 11. From 1988 to 2001, the majority of volunteers viewed Big Lake as having "very minor aesthetic problems." In 2002, 100% of the volunteers recorded the lake to be "beautiful, could not be nicer", there was also a Secchi of 14 which was the clearest since 1989. Unfortunately, in 2006 and 2007, 100% of volunteers said their "enjoyment was substantially impaired (algae)." In 2004, 2008, 2009, 2011 and 2012 over half of the volunteers said they "would not swim, but boating OK (algae)." In 2013 the majority of the time volunteers stated they "would not swim but boating OK (algae) or "enjoyment substantially impaired (algae)."

Figure 11. Big Lake aesthetic value, 1988-2013.



Chlorophyll *a*

Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is therefore an indicator of the amount of algae. Chlorophyll *a* concentrations greater than 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance. Chlorophyll *a* was analyzed in Big Lake in August, 1984 (6 µg/L) and in August, 2003 (6.06 µg/L). Chlorophyll *a* values in Big Lake were below nuisance levels and well below the average levels for Wisconsin natural lakes. It would be beneficial to monitor chlorophyll *a* to determine any trends in Big Lake.

Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and plant growth. If phosphorus levels are high, excessive aquatic plant growth can occur.

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw et al., 2004). Phosphorus provokes complex reactions in lakes. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus dissolves in the water and directly influences plant growth (Shaw et al., 2004). Its concentration varies in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake's nutrient status than soluble reactive phosphorus because its levels remain more stable (Shaw et al., 2004). Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments suspended in lake water. Ideally, soluble reactive phosphorus concentrations should be 10 µg/L or less at spring turnover to prevent summer algae blooms (Shaw et al., 2004). A concentration of total phosphorus below 20 µg/L for lakes should be maintained to prevent nuisance algal blooms (Shaw et al., 2004).

Big Lake total phosphorus ranged from 27 µg/L to 14 µg/L, with an average of 21 µg/L (Figure 12). According to Figure 13, the average total phosphorus for Big Lake classifies it as "good." A better understanding of Big Lake's phosphorus levels would need more routine sampling to determine any trends in the lake.

Figure 12. Big Lake total phosphorus.

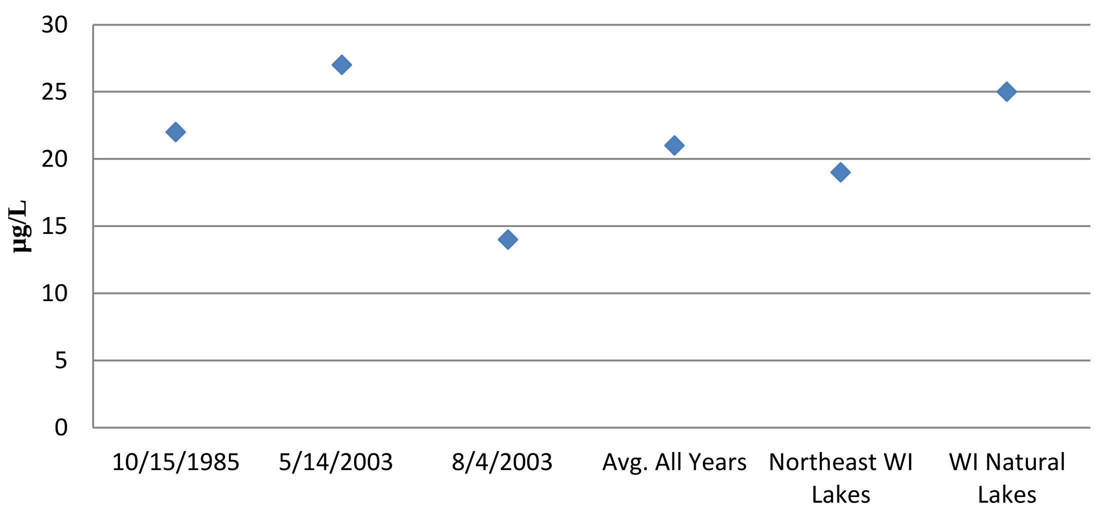
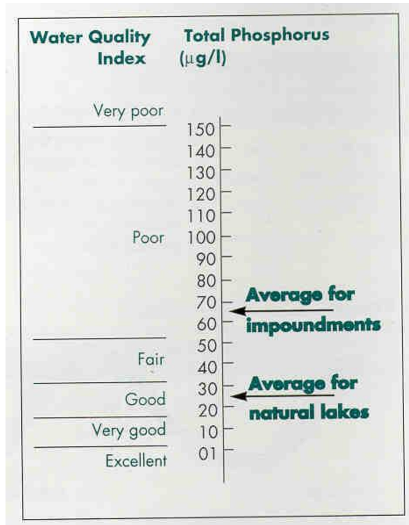


Figure 13. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).



Trophic State

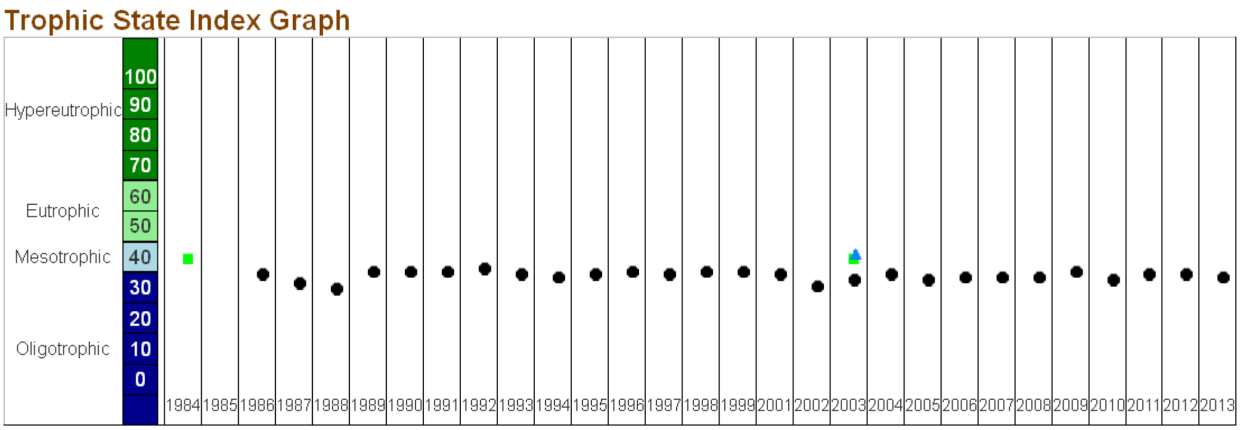
Trophic state is another indicator of water quality (Carlson, 1977). Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic, and eutrophic. These categories reflect a lake's nutrient and clarity levels (Shaw et al., 2004).

Trophic State Index (TSI) was calculated by the WDNR using Secchi measurements (1986-2013), chlorophyll *a* (1984 and 2003), and total phosphorus (2003) collected from the CLMN. The July and August average Secchi TSI (43.5), chlorophyll *a* TSI (51.7) and total phosphorus TSI (48) (Figure 14) classify Big Lake as "mesotrophic" (Table 2).

Table 2. Trophic State Index.	
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

(WDNR, 2013)

Figure 14. Big Lake Trophic State Index (1984-2013).



Monitoring Station: Big Lake (T42 R06 S04) - Deep Hole, Vilas County
Past Summer (July-August) Trophic State Index (TSI) averages.

● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

(WDNR, 2013)

Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to make the determination are: total phosphorus (important for algae growth), chlorophyll *a* concentration (a measure of the amount of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 3).

Table 3. Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values (Shaw et al., 2004).

Trophic class	Total phosphorus µg/L	Chlorophyll *a* µg/L	Secchi Disk (ft.)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for aquatic plant and algae growth (Shaw et al., 2004). Human activities on the landscape greatly influence the amount of nitrogen in a lake. Nitrogen may come from lawn fertilizer, septic systems near the lake, or from agricultural activities in the watershed. Nitrogen may enter a lake from surface runoff or groundwater sources.

Nitrogen exists in lakes in several forms. Big Lake was analyzed for total Kjeldahl nitrogen (0.6 and 1.8 mg/L in October, 1985 and 0.39 mg/L in August, 2003), ammonium (0.06 and 1.5 in October, 1985), and nitrate-nitrite (0.02 mg/L in October, 1985 and not detected in August, 2003). Nitrogen is a major component of all organic (plant and animal) matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen if present (Shaw et al., 2004). All inorganic forms of nitrogen can be used by aquatic plants and algae (Shaw et al., 2004). If these inorganic forms of nitrogen exceed 0.3 mg/L (as N) in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2004). Elevated concentrations of ammonium, nitrate, and nitrite, derived from human activities, can stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, marcrophytes), contributing to the widespread phenomenon of the cultural (human-made) eutrophication of aquatic ecosystems (Camargo et al., 2007). The nutrient enrichment can cause important ecological effects on aquatic communities, since the overproduction of organic matter, and its subsequent decomposition, usually lead to low dissolved oxygen concentrations in bottom waters, and sediments of eutrophic and hypereutrophic aquatic ecosystems with low turnover rates (Camargo et al., 2007).

Chloride

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Big Lake chloride levels were 0.9 and 1.3 mg/L in October, 1985. Chloride in Big Lake was well below the generalized distribution gradient in Wisconsin surface waters.

Sulfate

Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in Vilas County (Lillie and Mason, 1983). Big Lake was sampled for sulfate in October, 1985 and had a value of 3 and 9 mg/L.

Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter (µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Usually, values are approximately two times the water hardness, unless the water is receiving high concentrations of human-induced contaminants (Shaw et al., 2004). Big Lake conductivity levels were sampled in October, 1985 and had a conductance of 110 and 150 µmhos/cm, and in August, 2003 had a value of 121 µmhos/cm.

pH

The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is considered neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid, bog lakes to 8.4 in hard water, marl lakes (Shaw et al., 2004). Natural rainfall in Wisconsin averages a pH of 5.6. Some minerals become available under low pH (especially aluminum, zinc, and mercury) and can inhibit fish reproduction and/or survival. Mercury and aluminum are not only toxic to many kinds of wildlife, but also to humans (especially those that eat tainted fish). The pH scale is logarithmic, so every 1.0 unit change in pH increases the acidity tenfold. Water with a pH of 6 is 10 times more acidic than water with pH of 7. A lake's pH level is important for the release of potentially harmful substances and affects plant growth, fish reproduction and survival. A lake with neutral or slightly alkaline pH is a good lake for fish and plant survival. In October, 1985, the pH of Big Lake was 7.69, and in August, 2003 it was 8.22, indicating that the lake was alkaline.

Table 4 shows the effects pH levels less than 6.5 will have on fish. Since Big Lake is alkaline, it is unlikely the pH would have negative effects any fish species. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be important. In low pH waters, aluminum, zinc, and mercury concentrations increase if they are present in lake sediment or watershed solids (Shaw et al., 2004).

Table 4. Effects of acidity on fish species (Olszyk, 1980).

Water pH	*Effects*
6.5	Walleye spawning inhibited
5.8	Lake trout spawning inhibited
5.5	Smallmouth bass disappear
5.2	Walleye & lake trout disappear
5	Spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	Perch spawning inhibited
3.5	Perch disappear
3	Toxic to all fish

Alkalinity

Alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. Acid rain has long been a problem with lakes that have low alkalinity levels and high potential sources of acid deposition. Alkalinity was analyzed in August, 2003 and had a value of 56 mg/L. Based on this value, Big Lake is not sensitive to acid rain, although new samples should be collected (Table 5).

Table 5. Sensitivity of Lakes to Acid Rain (Shaw et al., 2004).

Sensitivity to acid rain	*Alkalinity value (mg/L or ppm $CaCO_3$)*
High	0-2
Moderate	2-10
Low	10-25
Non-sensitive	>25

Hardness

Hardness levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). One method of evaluating hardness is to test for calcium carbonate ($CaCO_3$). Big Lake hardness was 58.9 and 61.4 mg/L in October, 1985. Table 6 suggests Big Lake has "soft" to "moderately hard" water.

Table 6. Categorization of hardness (mg/L of calcium carbonate ($CaCO_3$)) (Shaw et al., 2004).

Soft water	0-60
Moderately hard water	61-120
Hard water	121-180
Very hard water	>180

Calcium and Magnesium Hardness

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate and carbonate. These compounds are usually found with two hardness ions: calcium and magnesium (Shaw et al., 2004). Calcium is the most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed (Shaw et al., 2004). Aquatic organisms such as native mussels use calcium in their shells. The aquatic invasive zebra mussel tends to need calcium levels greater than 20 mg/L to maintain shell growth. Big Lake had a calcium level of 17 and 18 mg/L in October, 1985, and 16.5 mg/L in August, 2003, which is an indication that zebra mussels could flourish. Magnesium was sampled in October, 1985 and was 4 mg/L.

Sodium and Potassium

Sodium and potassium are possible indicators of human pollution in a lake, since naturally occurring levels of these ions in soils and water are very low. Sodium is often associated with chloride and gets into lakes from road salting, fertilizations, and human and animal waste (Shaw et al., 2004). Potassium is the key component of commonly-used potash fertilizer, and is abundant in animal waste. Both of these elements are held by soils to a greater extent than is chloride or nitrate; therefore, they are not as useful as indicators of pollution impacts (Shaw et al., 2004). Although not normally toxic themselves, they provide a strong indication of possible contamination by more damaging compounds (Shaw et al., 2004). Big Lake sodium (1 mg/L) and potassium (1 mg/L) were sampled in October, 1985.

Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is a food supplement, supporting growth of microorganisms, and plays an important role in global carbon cycle through the microbial loop (Kirchman et al., 1991). In general, organic carbon compounds are a result of decomposition processes from dead organic matter such as plants. When water contacts highly organic soils, these components can drain into rivers and lakes as DOC. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability. Baseflow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. Big Lake DOC has not been tested, and should be included in future water quality sampling.

Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. Generally lakes that are fed by groundwater have higher levels of silica. Big Lake was analyzed for silica in October, 1985 and had values of 8.9 and 14 mg/L.

Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. Big Lake aluminum was sampled in August, 2003 and had a value of 25 µg/L.

Iron

Iron also forms sediment particles that bind with and store phosphorus when dissolved oxygen is present. When oxygen concentration gets low (for example, in winter or in the deep water near sediments) the iron and phosphorus dissolve in water. This phosphorus is available for algal blooms. Big Lake iron levels have not been tested, and should be included in future water quality sampling.

Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining problems. Manganese data is unknown for Big Lake, so future water quality sampling should include this parameter.

Sediment

Lake bottom sediments are sometimes analyzed for chemical constituents that they contain. This is especially true for potentially toxic metals such as mercury, chromium, selenium, and others. Lake sediments also tend to record past events as particulates settle down and become part of the sediment. Biological clues for the historic conditions in the lake can be gleaned from sediment samples. Examples include analysis of pollen or diatoms that might help understand past climate or trophic states in the lake. Sediment data was not collected for Big Lake, and future sampling should include this parameter.

Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by bottom-feeding fish. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can in turn affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” Total suspended solids data is unknown for Big Lake, so future water quality sampling should include this parameter.

Aquatic Invasive Species

There are three invasive species found in Big Lake: banded mystery snail (found in 2010), Chinese mystery snail (2005) and rusty crayfish (1961).

Banded mystery snails are native to northeastern United States down to Florida, the Gulf of Mexico, and some states along the Mississippi River. Records show that an amateur conchologist (scientist of sea shells and the animals that inhabit them) intentionally released banded mystery snails into the Hudson River, which led to its dispersal throughout the Great Lakes area (Kipp et al., 2013b). There is no known negative impact caused by the snails in the Great Lake region (Kipp et al., 2013b). Banded mystery snails have also been found in Lynx Lake (2007), Rice Creek, Oxbow Lake (2005), and Wildcat Lake (2005).

Chinese mystery snail was originally from Southeast Asia and Eastern Russia and was likely released to the Great Lakes from an aquarium between 1931 and 1942 (Kipp et al., 2013a). The snail does not seem to have a significant impact on native species, but its ecological and anthropological threat comes from its potential to transmit parasites and diseases (Kipp et al., 2013a). It is illegal to introduce the Chinese mystery snail into Wisconsin waters. Chinese mystery snails have also been discovered in Lynx Lake (2007), Round Lake (2005), and Wildcat Lake (2005).

Rusty crayfish are native to parts of Ohio, Tennessee, Kentucky and Indiana, and were likely introduced to Wisconsin waters by fishermen using the crayfish as bait (Gunderson, 2008). Rusty crayfish negatively affect other native crayfish species, cause destruction to aquatic plant beds, reduce fish populations by eating eggs, and cause shoreland owners recreational problems (Gunderson, 2008). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2012). It is also illegal to release crayfish into a water body without a permit (WDNR, 2012). Rusty crayfish have also been found in Averill Lake (2003), Crab Lake (2009), McCullough Lake (2003), Papoose Lake (2003), Presque Isle Lake (2003), Rice Creek, Round Lake (1998), Stateline Lake (2011) and Van Vliet Lake (2003).

The University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention program classifies Big Lake as "Borderline Suitable" for zebra mussels, based on calcium and conductivity levels found in the lake (UW-Madison).

Clean Boats, Clean Waters (CBCW) is a program that inspects boats for aquatic invasive species and in the process educates the public on how to help stop the spread of these species. Clean Boats, Clean Waters inspected 8 boats in 2008 and 3 boats in 2010 and 2011 and then 281 in 2013 (Figure 15). It would be beneficial for Big Lake to continue the CBCW program. Figure 16 indicates that the people contacted were visiting other lakes within 5 days of using Big Lake 57% of the time. High percentages of boaters are taking actions to stop the spread of invasives and 100% are aware of the laws (Figure 17).

Figure 15. Big Lake (Hwy K Access) Clean Boats Clean Waters data (WDNR, 2014).

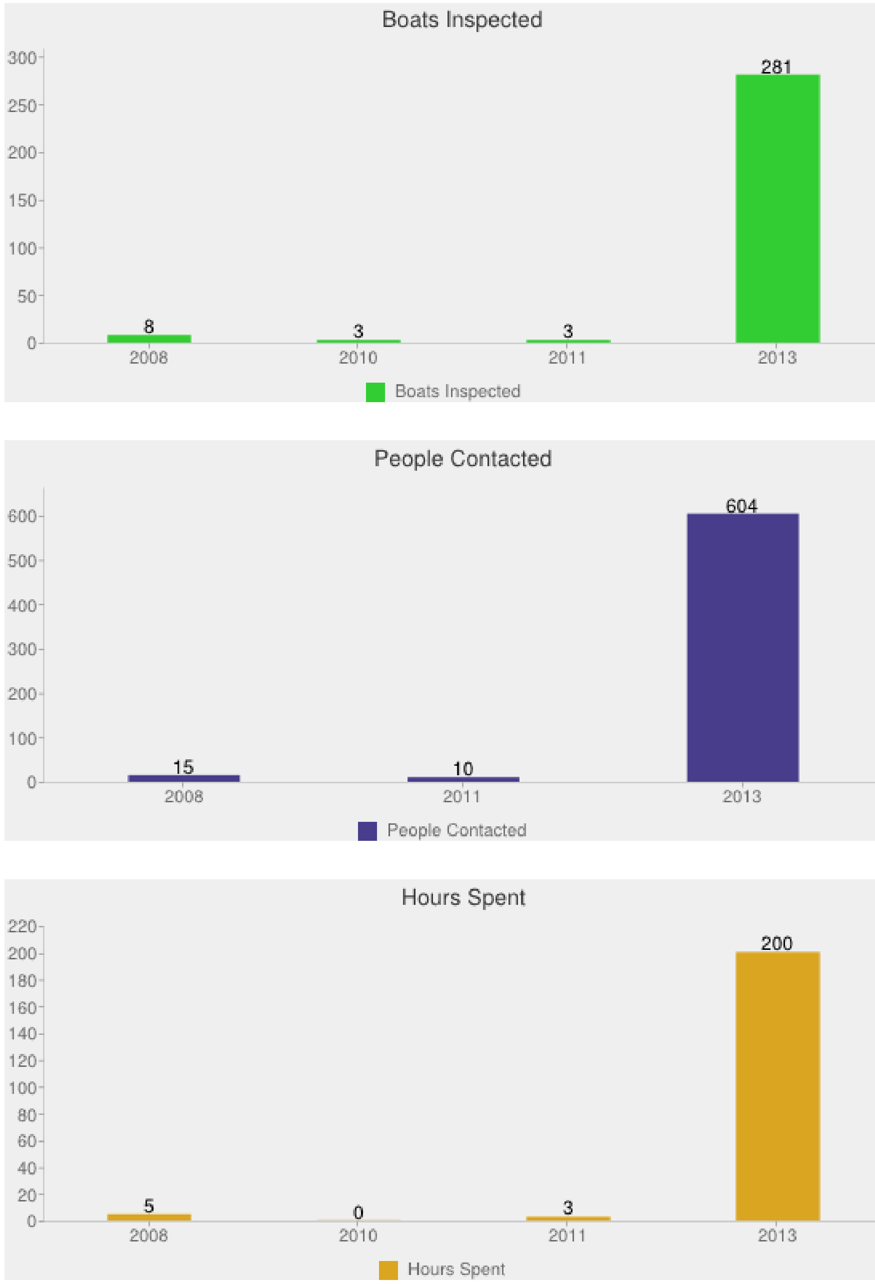
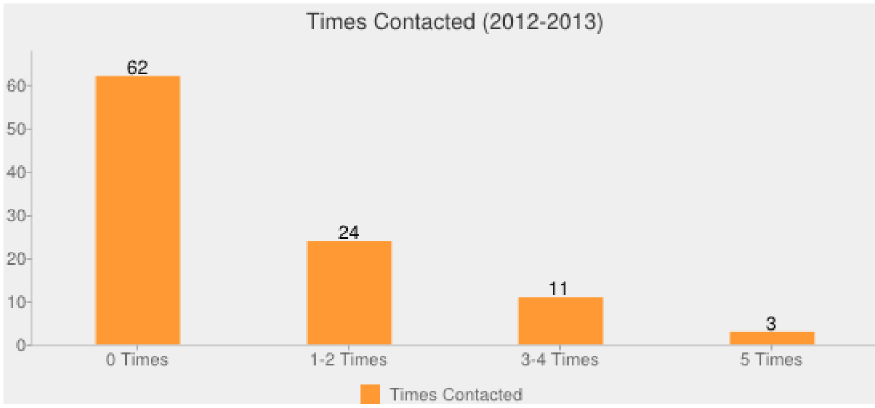
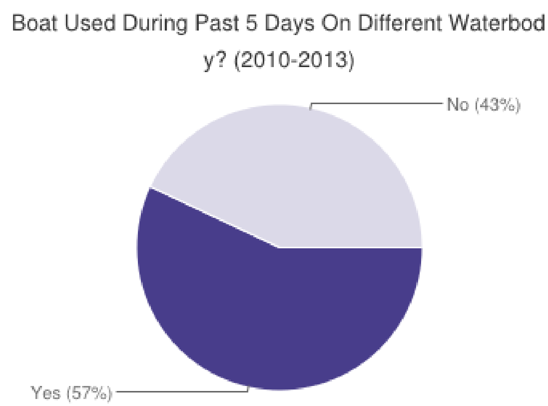


Figure 16. Big Lake (Hwy K Access) Clean Boats Clean Waters data (WDNR, 2014).





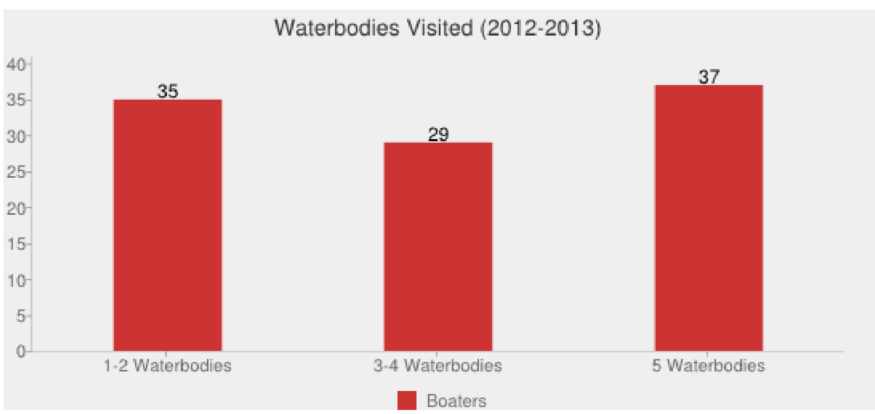
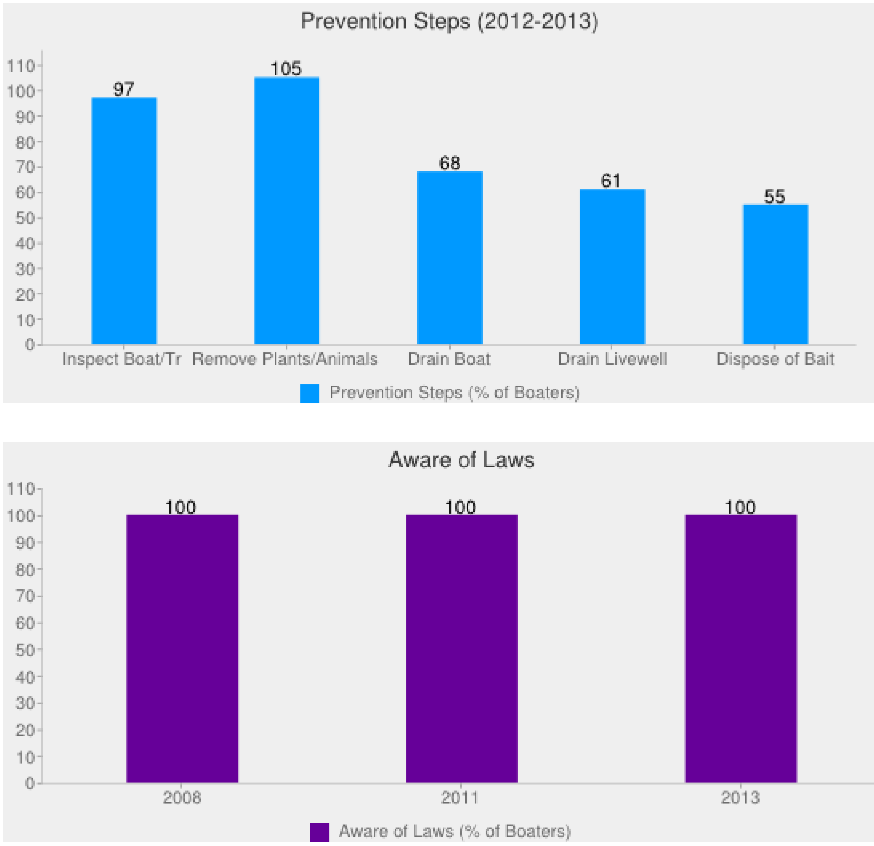


Figure 17. Big Lake (Hwy K Access) Clean Boats Clean Waters data (WDNR, 2014).



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