Presque Isle Wilderness Waters Program

Aquatic Plant Management Plan – Papoose Lake

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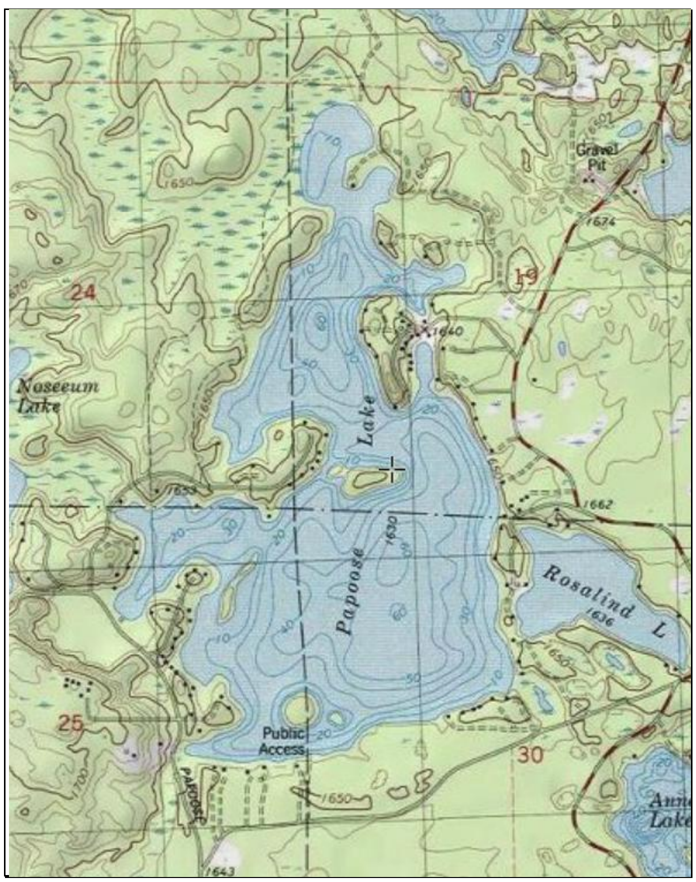

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This plan is a product of a WDNR Lake Planning Grant awarded to:

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WHITE WATER
ASSOCIATES, INC.

TABLE OF CONTENTS

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 the lakes as an ongoing endeavor that is integrated, coordinated, and administered by the Lakes Committee. This perspective reflects the appropriate range of geographic scales from which to approach lake stewardship: a "lake specific" focus that goes hand-in-hand with waterscape-wide awareness. Although this aquatic plant management plan (APMP) addresses Papoose Lake in Vilas County, Wisconsin, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to addressing introduction aquatic invasive species (AIS). The closely related ***Wilderness Waters Adaptive Management Plan*** (Stine et al., 2019) 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 capable of this kind of population boom. In some cases, even a native plant species can exhibit rampant growth and results in a population that is viewed by some as a recreational nuisance.

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 principal motivation for this plan lies in the first three objectives:

- ***Protection*** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;

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

- ***Maintenance*** - continuing the patterns of recreational use that have developed historically on and around a lake; and
- ***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 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, Appendix C contains a *Review of Papoose Lake Water Quality*, Appendix D contains the *Papoose Lake Shoreland and Shallows Habitat Monitoring Report*, and Appendix E contains the *Papoose Lake Aquatic Invasive Species Report* from 2018.

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 Township lakes lie on the state border. The location of the subject of this APM Plan (Papoose 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 Papoose Lake.

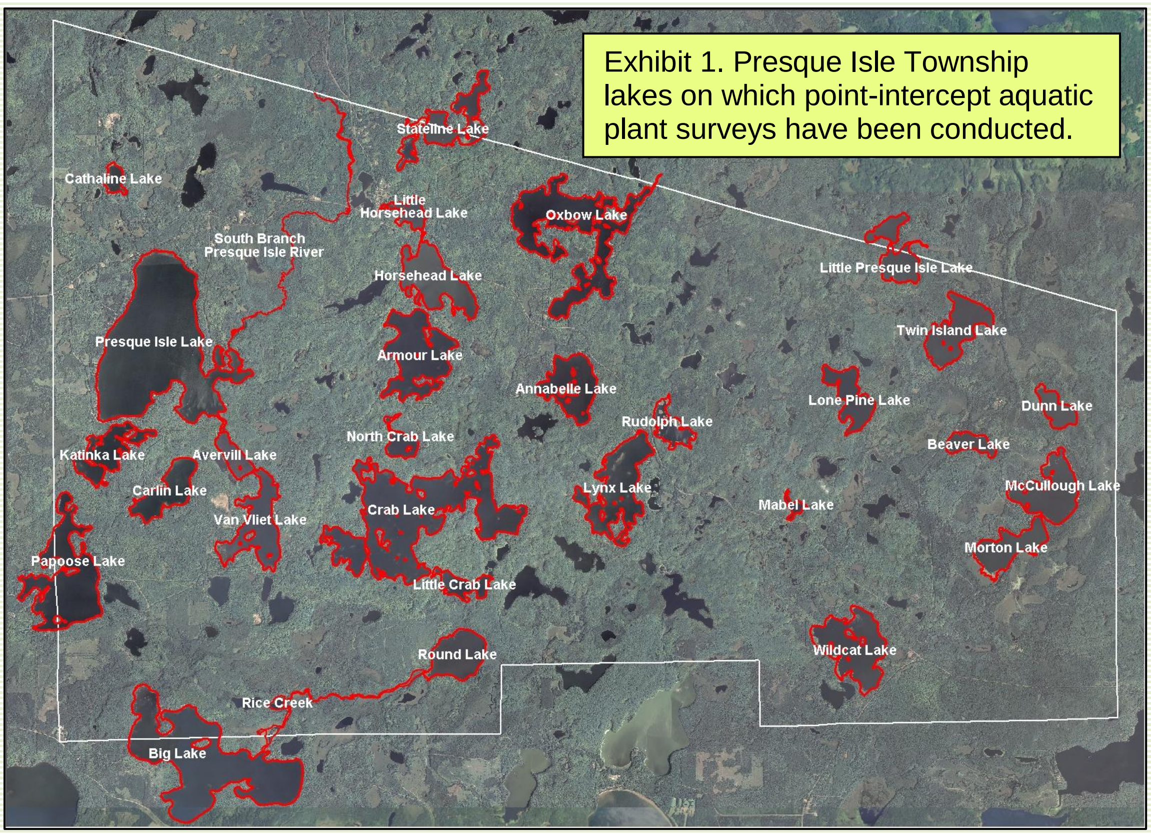


Exhibit 1. Presque Isle Township lakes on which point-intercept aquatic plant surveys have been conducted.

“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.”

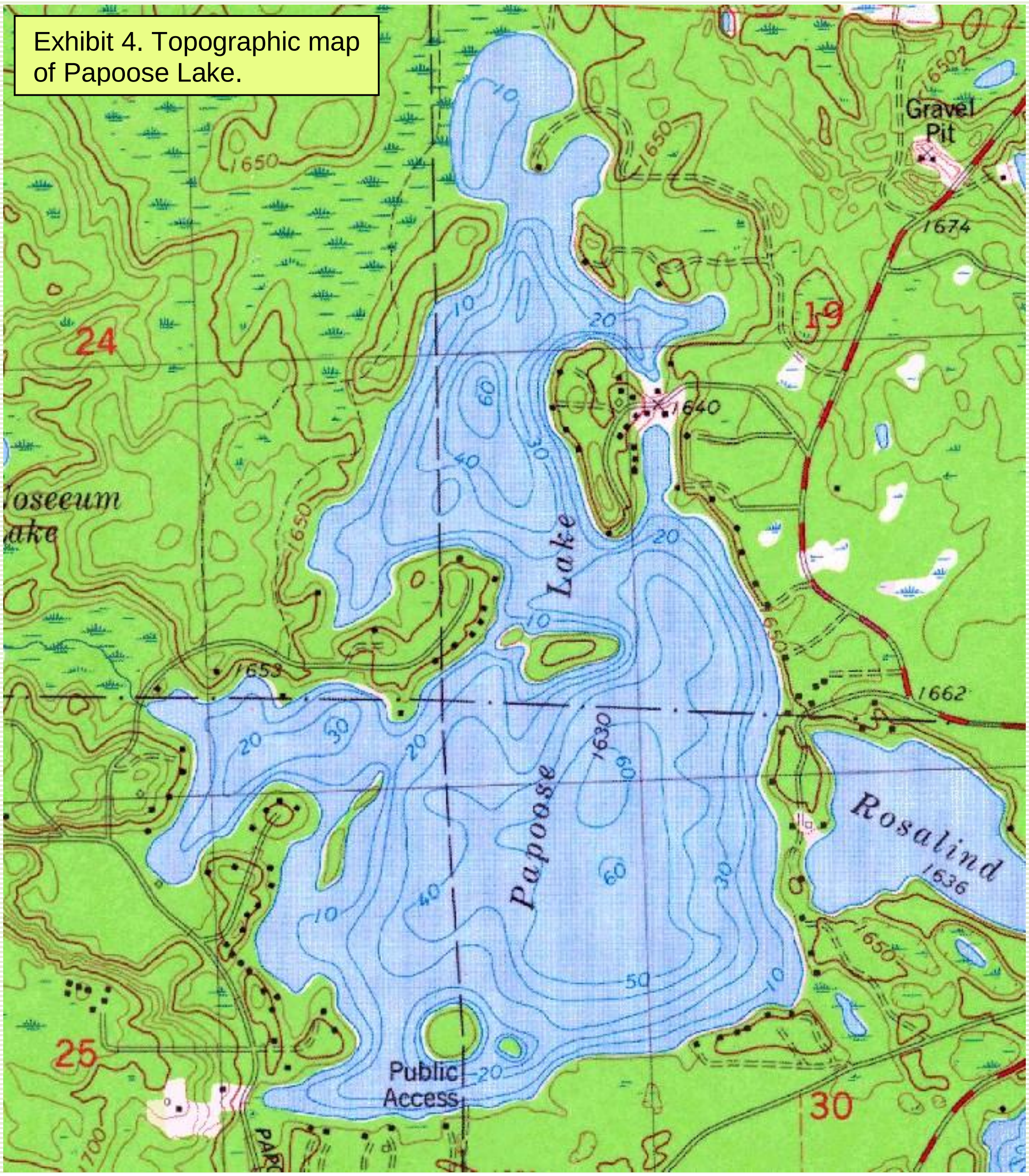
Exhibit 2. Aerial photo of Papoose Lake.

Descriptive parameters for Papoose Lake are in Exhibit 3. It is a groundwater drainage lake of about 422 acres and maximum depth of 65 feet. It has a shoreline development index of 2.7. 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. Of the lakes considered in the Wilderness Waters Program, the shoreline development index ranged from 1.4 to 2.8 (median value = 2.2).

Exhibit 3. Water Body Parameters	
Water Body Name	Papoose Lake
County	Vilas
Township/Range/Section	T43N-R06E-S19,S30
Water Body Identification Code	2328700
Lake Type	Spring Fed
Surface Area (acres)	422
Maximum Depth (feet)	65
Maximum Length (miles)	1.48
Maximum Width (miles)	0.92
Shoreline Length (miles)	7.91
Shoreline Development Index	2.7
Total Number of Piers (2019 aerial)	89
Number of Piers / Mile of Shoreline	11.25
Total Number of Homes (2019 aerial)	138
Number of Homes / Mile of Shoreline	17.4

Papoose Lake has a public access site on the lake's south end. We observe a total of 89 piers on the shoreline of Papoose Lake from a recent aerial photograph or about 11.25 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).

Exhibit 4. Topographic map of Papoose Lake.



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:

> ***Comprehensive aquatic plant surveys in 2008 and 2017 establish Papoose Lake has a healthy and diverse aquatic plant community that was documented by point-intercept aquatic plant surveys. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community. The purpose of this aquatic plant management plan is to maintain a balanced, high quality, and diverse native aquatic plant community in Papoose Lake.***

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 aquatic invasive species;***
> ***(3) Ecologically evaluate plant management options (including no action); and***
> ***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and recreating in a lake whose natural state includes an abundance of native aquatic 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 Papoose Lake stewards.

CHAPTER 4

Information and Analysis

Our efforts in the Wilderness Waters Program have compiled information about historical and current conditions of the Papoose 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. Papoose Lake is contained within the Papoose Creek Manitowish River Watershed (Exhibit 5). Exhibit 6 shows the watershed boundary for Papoose Lake.

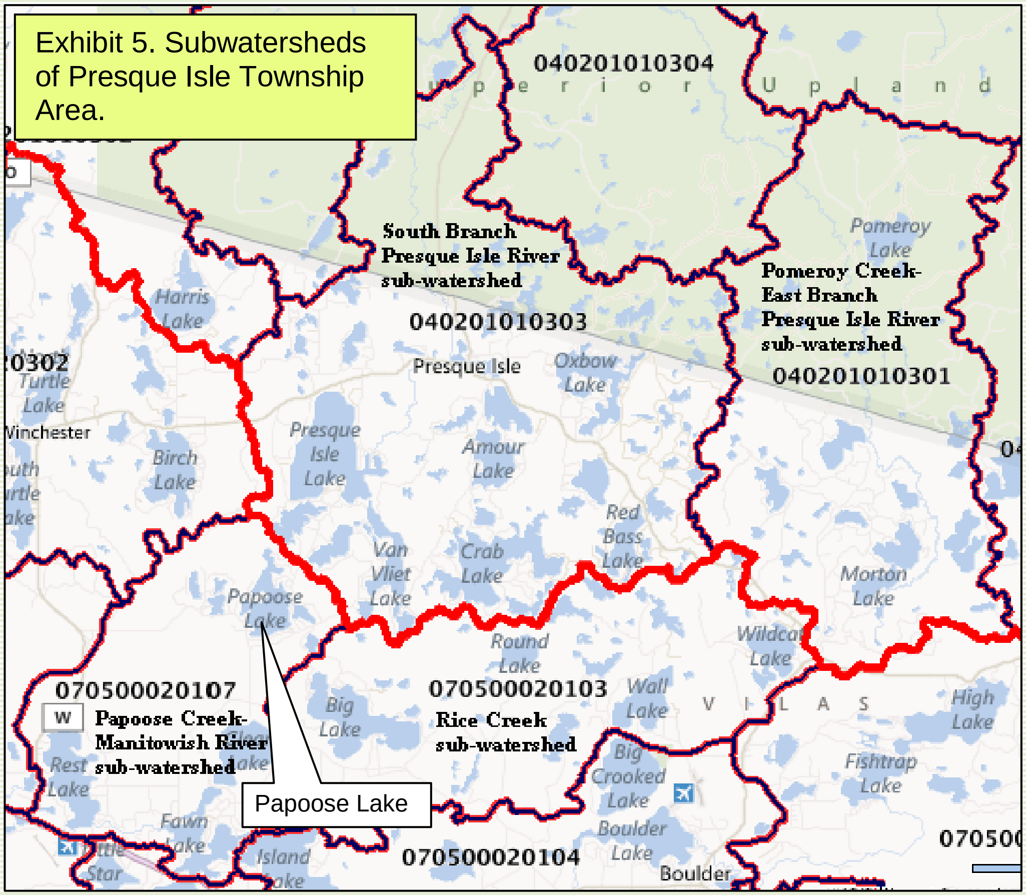


Exhibit 5. Subwatersheds of Presque Isle Township Area.

Sub-watersheds are delineated by dark lines and 12 digit HUC codes. North of the red line is the Great Lakes Basin (HUC# beginning 04), and south of the red line is the Upper Mississippi Basin (HUC# beginning 07).

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 7 and shows the relative elevations for the area with orange areas of the landscape being the highest elevations and greens and blues being the lowest elevations.

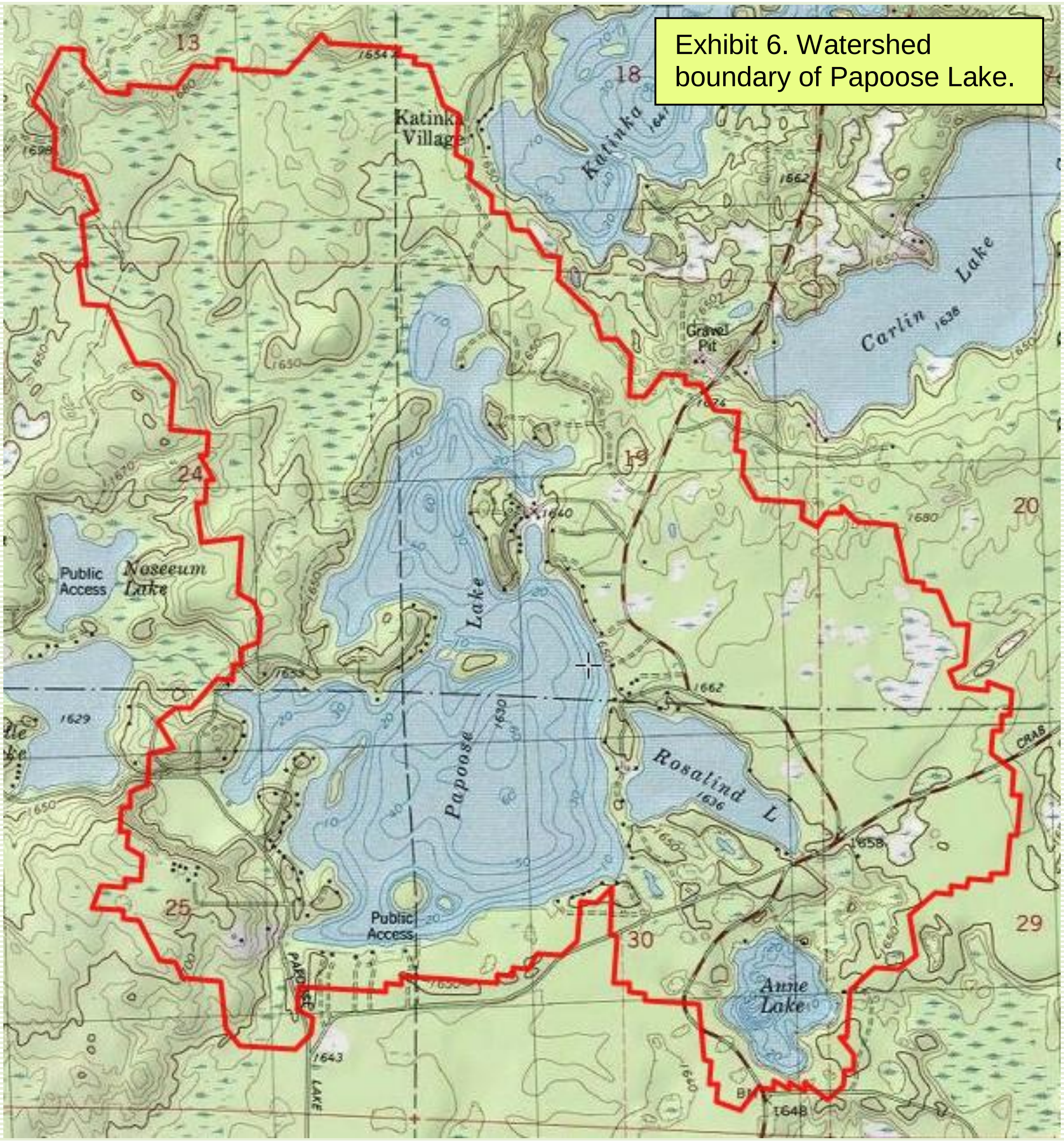


Exhibit 6. Watershed boundary of Papoose Lake.
Katinka Village
Katinka
Carlin Lake
Gravel Pit
Public Access
Noseeum Lake
Papoose Lake
Rosalind L
Public Access
Anne Lake
13
18
19
20
24
25
29
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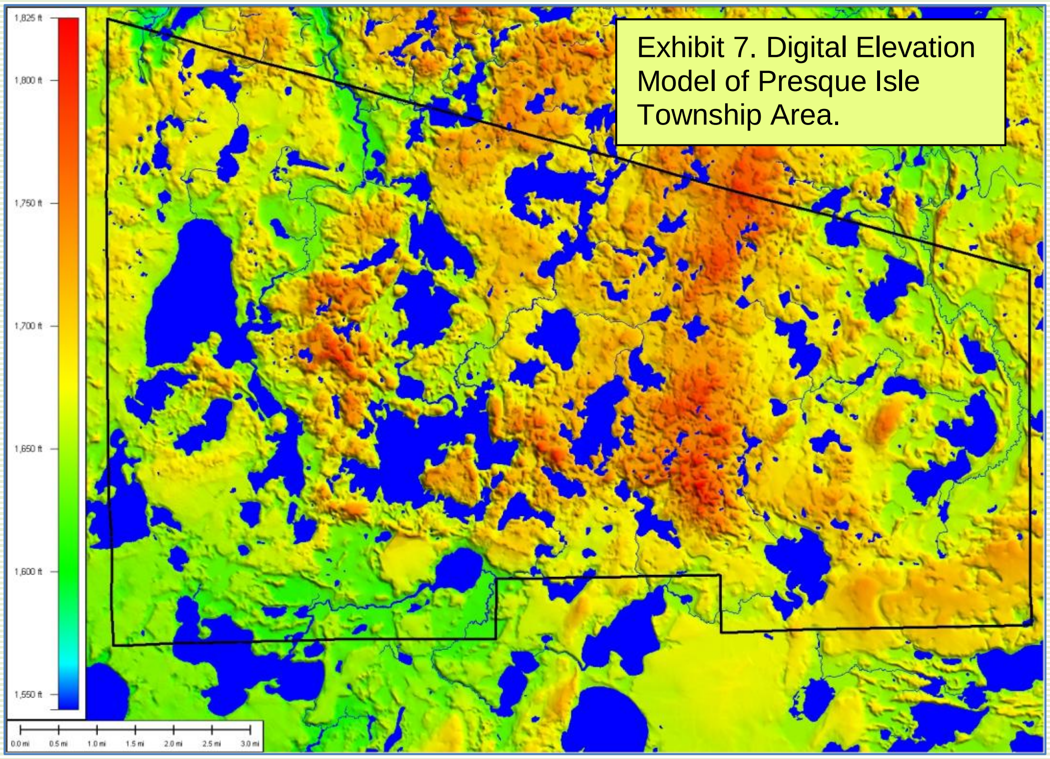


Exhibit 7. Digital Elevation Model of Presque Isle Township Area.

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 Papoose Lake watershed is 2,108 acres. It is identified in Exhibit 5 and bounded by the green, yellow and blue lines and also Exhibit 6. The cover types in the watershed are presented in Exhibit 8. Deciduous forest and surface water comprise the largest components. Soil group B is most prevalent, while group D is the second largest. Soil group B has a moderate infiltration capacity whereas D has very low infiltration capacity. The watershed to lake area ratio is 3.8:1. 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.

Exhibit 8. Cover Types and Soil Groups of the Papoose Lake Watershed.

Cover Type	Acres	Percent
Deciduous Forest	832.9	39.5
Emergent Wetlands (marsh)	33.8	1.6
Evergreen Forest	6.5	0.3
Grassland; Herbaceous	1.1	0.1
Mixed Forest	278.0	13.2
Open Space/Park	136.6	6.5
Open Water	554.4	26.3
Shrub; Scrub	29.8	1.4
Woody Wetlands (swamp)	253.3	11.2
Total	2108.3	100.00

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	0	0	**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	1883.7	89.3	**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	7.56	0.4	**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	217.1	10.3	**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)*

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 Papoose Lake. Over the years, no particular nuisance issues have demanded control action. It is our understanding that the plant survey conducted as part of the 2008 Wilderness Water Program was the first effort of its kind on this water body. A second aquatic plant survey was conducted in 2017. Findings from the 2017 survey are presented and discussed in the next section (Part 3) and compared to findings from 2008.

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. Cases such as these may warrant some kind of plant management. It should be noted, however, that altering aquatic plant communities through hand-pulling, mechanical harvest, herbicides, or other means is expensive (in time and/or money) and by no means permanent. Long-term outcomes of these manipulations are difficult to predict. In addition, permits are required in many cases of aquatic plant management.

Aquatic plant surveys have been conducted on Papoose Lake in 2008 and 2017. In each year, the survey was conducted using the WDNR point-intercept protocol. This formal survey assessed 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, we navigated to the points and used a rake mounted on a pole or rope to sample plants. Plants were identified, recorded, and eventually all data was entered into a dedicated spreadsheet for storage and data analysis. These systematic surveys provided baseline data about the lake and allow some analysis of change in the plant community over the time period of nine years.

An examination of changes in the aquatic plant community over nearly a decade is robust because the plant surveys were conducted using the same protocol. Future aquatic plant monitoring will allow additional analysis. 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 aquatic invasive plant species. 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 two surveys in Papoose Lake and compare the plant communities of 2008 and 2017. The supporting tables and figures for the aquatic plant survey are provided in Appendix B.

Species richness refers to the total number of species recorded. When considering the plant species recorded at sampling points only, species richness was higher in 2017 (18 species collected on the rake) when compared to 2008 (12 species collected on the rake) (see Exhibit 9 and Table 1). During the surveys, additional plant species observed but not collected at the sampling points are also documented. In 2017, a total of 22 species of aquatic plants were recorded in Papoose Lake at the sample points (four were not collected on the rake). Other species were observed from the boat at other places in the lake (not at sample points). If these species are also included in the richness tabulation, the overall number of species documented in 2017 was 31 (see Exhibit 9). Table 1 displays summary statistics for the 2008 and 2017 surveys. Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics for the 2017 survey.[2] In 2017, the number of species encountered at

[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)."*

any given sample point ranged from 0 to 6 and 24 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 2.29. The actual number of species encountered at each of the vegetated sites in 2017 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 in 2017 was 6.5 feet (Table 1 and Figure 3). Rooted vegetation was found at 55 of the 299 sample sites with depth ≤ the maximum depth of plant colonization (43.6% 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). Figures 5 presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2 and 3 provides information about the frequency of occurrence of the plant species recorded in the lake in 2017 and 2008, respectively. 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 in the 2017 survey are graphically displayed in descending order on Figure 6. This display shows that *Bidens beckii* (water marigold) had the highest relative frequency followed by *Potamogeton robbinsii* (fern pondweed). The lowest relative frequencies are at the far right of the graph. Figure 7 shows emergent and floating aquatic plant distribution in 2017. 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 plant species 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 Papoose Lake aquatic plants is 0.88 in 2017(Table 1) which indicates a highly diverse aquatic plant community. The value for 2008 (0.84) was very similar.

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 Papoose Lake FQI (28.4 in 2017) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Papoose Lake values are quite high compared to these statewide values. 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. Papoose 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. Papoose Lake data is consistent with that find. Finally, the Papoose Lake FQI (28.4) is slightly higher than the median value for the Northern Lakes and Forests lakes group (24.3). These findings support the contention that the Papoose Lake plant community is healthy and diverse.

We observed no aquatic plants in Papoose Lake that would be considered a nuisance-level population density/distribution. Our survey found no aquatic invasive plant species. We found no state or federally listed plant species. *Phalaris arundinacea* (reed canary grass) was noted on the boat survey at six locations. Reed canary grass is restricted in Wisconsin. *Iris sp*. was also noted on the boat survey but since it wasn't in bloom at the time, the species is uncertain. According to the WDNR AIS Viewer map, the non-native Yellow iris (*Iris pseudocorus*) was found on Papoose Lake in 2015 (at latitude/longitude 46.18820/-89.80392). This species can spread by seeds or vegetatively via fragments. Yellow iris forms dense clumps or mats that alter the hydrology of a lake and negatively impact native plant species (WDNR 2017). Yellow iris is a poisonous plant which also makes it harmful for wildlife species. The best way to differentiate yellow iris from the native northern blue flag iris is by observing flower color.

Since the two aquatic plant surveys were conducted at Papoose Lake using the same protocol, comparisons are possible. Exhibit 9 presents a few salient parameters.

Exhibit 9. Comparison of Aquatic Plant Surveys Conducted on Papoose Lake.

	2008	**2017**
Survey Method	1076 point-intercept grid	1076 point-intercept grid
Species Richness (at sample points)	12	18
Species Richness (including visuals)	No data	22
Species Richness (including visuals and boat survey)	No data	31
Percent Coverage	15.32	43.64
Dominant Species	Large-leaf pondweed	Water marigold
Maximum Depth (ft) of Rooted Vegetation	17.0	6.5
FQI (Floristic Quality Index)	23.4	28.4
SDI (Simpson's Diversity Index)	0.84	0.88
Number of Native Species/Site	1.60	2.29

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 50% sand, 25% gravel, 20% rock, and 5% muck and that fish species present include musky, panfish, largemouth bass, smallmouth bass, northern pike and walleye. Papoose Lake has been stocked since 1991 to 2016 on Papoose Lake for Brown trout (1991), musky (1991, 1992, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, and 2016), and walleye (1991-1993, 1995, 2001, 2003, 2005, 2009, 2011, and 2013).

Part 5. Water Quality and Trophic Status

Papoose Lake is a 422 acre spring fed lake with a maximum depth of 422 feet. Existing water quality information includes data from the WDNR SWIMS database collected in 1984 and 1985 by Northern Lakes Monitoring; and Secchi depth data was collected from Citizen Lake Monitoring Network (CLMN) volunteers from 1991 to present. The water quality information is briefly summarized in this section, but more fully interpreted in Appendix C.

At times, temperature and dissolved oxygen showed stratification in Papoose Lake in the ice-free season. Water clarity was "good" and user perception of Papoose Lake aesthetic quality is generally beautiful, could not be better. Water color is low. The trophic state is oligotrophic. Water quality would be classified as "very good" with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae) is low. Nitrogen, chloride, sulfate, hardness, conductivity, calcium (borderline to suitable with respect to zebra mussel suitability), magnesium, sodium, and potassium are considered low. The pH of Papoose Lake is alkaline.

Part 6. Water Use

Papoose Lake has a public access site, and is used by riparian owners and their guests for a variety of recreational activities.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Papoose Lake. The near shore riparian area can be appreciated by viewing Exhibits 2 and 4. 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 recent aerial photography revealed 138 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.

As part of this grant, the riparian area and shallow water littoral zone was assessed. The WDNR has recently formulated a protocol called *Lake Shoreland and Shallows Habitat Monitoring* (WDNR 2016). It provides a standard methodology for surveying, assessing, and mapping habitat in lakeshore areas, including the riparian buffer, bank, and littoral zone (WDNR 2016). This information will be useful to local and regional resource managers, community stakeholders, and others interested in protecting and enhancing Wisconsin's lakes and rivers (WDNR 2016). A woody habitat survey was also conducted that locates large woody material in the littoral zone. A more detailed report can be found in Appendix D.

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. Loons have been monitored by a volunteer from 2008 to 2010. Data is available in SWIMS. Also of special importance would be monitoring for the presence of aquatic invasive animal species not presently found in Papoose Lake (spiny water flea, zebra mussel, rainbow smelt or common carp) and to monitor existing populations of AIS (rusty crayfish and yellow iris).

Papoose Lake is currently designated as a Priority Navigable Waterway (PNW) Musky area with a classification of A2, 2 (WDNR, 2019). Class A lakes that are category 2 average 1056 acres. Category 2 is classified that the musky population has some natural reproduction; however stocking occurs to supplement natural recruitment. Papoose Lake is also a PNW Walleye Area with a classification of stocking plus natural reproduction.

The Wisconsin Natural Heritage Inventory (NHI) lists the following plants and animals as rare or sensitive species and/or communities that are considered high-quality and significant natural features (Exhibit 10). They are found in the same town/range is Papoose Lake (NHI, 2013).

Exhibit 10. Rare Species and Communities located near Papoose Lake.			
Common Name	*Scientific Name*	*State Status*[3]	*Group Name*
Trumpeter swan	*Cygnus buccinators*	SC/M	Bird
Bald eagle	*Haliaeetus leucocephalus*	SC/P	Bird
A predaceous diving beetle	*Agabus wasastjernae*	SC/N	Beetle
Fairy slipper	*Calypso bulbosa*	THR	Plant
Downy willow-herb	*Epilobium strictum*	SC	Plant
Boreal rich fen		NA	Community
Emergent marsh-wild rice		NA	Community
Ephemeral pond		NA	Community
Lake-deep, soft, seepage		NA	Community
Lake-spring		NA	Community
Northern mesic forest		NA	Community
Northern wet forest		NA	Community
Northern wet-mesic forest		NA	Community
Poor fen		NA	Community

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, the Town Lakes Committee has represented the Papoose 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, mechanical harvesting or use of herbicides) are recommended by this current plan. The Town Lakes Committee has conducted a township wide lake users' survey that is presented in the overarching ***Wilderness Waters Adaptive Management Plan*** (Stine et al., 2019).

3 **END**=Endangered; **THR**=Threatened; **SC**=Special Concern; **SC/P**=fully protected; **SC/N**=no laws regulating use, possession or harvesting; **SC/H**=take regulated by establishment of open/closed seasons; **SC/FL**=federally protected as endangered or threatened; **SC/M**=fully protected by federal and state laws under Migratory Bird Act.

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) Ecologically evaluate plant management options (including no action); and
(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and recreating in a lake whose natural state includes an abundance of native aquatic plants.

Since Papoose Lake is a healthy and diverse ecosystem, we could simply recommend an alternative of "no action." In other words, Papoose Lake continues without any effort or intervention on part of Wilderness Waters Program and Town Lakes Committee. This ignores the fact, however, that the Wilderness Waters Program and Town Lakes Committee exists to care for and protect this special place. They are aware that Papoose Lake is vulnerable to forces that might diminish the quality of the lake ecosystem. The Papoose Lake Stewardship Program exists to understand and 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 lake 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). At this time, we recommend no direct manipulation of plant populations in Papoose Lake.

Recommended Actions for the Papoose 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 Town Lakes Committee oversee activity. ***Status:*** Planned for 2020.
Action #2: Monitor water quality in the lake. ***Objective***: Continue with collection and analysis of water quality parameters to detect trends in parameters such as nutrients, chlorophyll *a*, and water clarity. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity. ***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 Town Lakes Committee 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 Town Lakes Committee oversees activity and maintains data. ***Status:*** Ongoing.
Action #5: Monitor the populations of rusty crayfish in Papoose Lake. ***Objective***: Determine potential effects of this aquatic invasive animal. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity. ***Status:*** Planned for 2020.

Recommended Actions for the Papoose Lake APM Plan
Action #6: 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 Town Lakes Committee coordinate activity. ***Status:*** Planned for 2020.
Action #7: 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:*** Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR. ***Status:*** Anticipated in 2022.
Action #8: 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 Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR. ***Status:*** Ongoing.
Action #9: 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 and/or Town Lakes Committee oversees activity and reports instances of possible introductions of AIS. ***Status:*** Anticipated to begin in 2020.

Recommended Actions for the Papoose Lake APM Plan
Action #10: 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.
Action #11: 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 Lake Association and/or Town Lakes Committee oversee activity and assess effectiveness. ***Status:*** Ongoing.
Action #12: Monitor the lake watershed for yellow iris. ***Objective:*** Identify yellow iris populations before they reach a large size. ***Monitoring:*** The Lake Association and/or Town Lakes Committee oversee activity. ***Status:*** Anticipated in 2020.

Recommended Actions for the Papoose Lake APM Plan
Action #13: 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:*** Lake Association or Town Lakes Committee oversee activity and assess effectiveness. ***Status:*** Anticipated to begin in 2020.
Action #14: Consider conditions outlined in the *Shoreland and Shallows Habitat Monitoring Report* and implement protection or rehabilitation initiatives where appropriate. ***Objective:*** To maintain and restore high quality conditions of the riparian and shallow water habitat. ***Monitoring:*** Town Lakes Committee oversees activity and assesses effectiveness. ***Status:*** Anticipated to begin in 2020.
Action #15: For those who want to consider long-term protection of special areas, individual landowners should review information on the Northwoods Land Trust, a local land conservancy that serves northern Wisconsin (northwoodslandtrust.org). ***Objective:*** To conserve family lands (especially lake shorelands) for future generations. ***Monitoring:*** Town Lakes Committee stays apprised of properties within the Township that are participating in conservation of lands with the Northwoods Land Trust. ***Status:*** Ongoing.

Recommended Actions for the Papoose Lake APM Plan

Action #16: Identify and highlight high quality areas of littoral zone and riparian areas through review of aquatic plant and shoreland assessment data through various reports and online tools.

Objective: To (1) educate lake users on the value of these areas and the importance of good stewardship to their maintenance, (2) recognize landowners who implement good practices (e.g., large percentage of buffer area intact; three vegetative layers intact – herbaceous, shrubs, trees; areas of high native aquatic plant diversity and abundance), and (3) encourage landowners to implement good practices.

Monitoring: Town Lakes Committee and/or lake association promotes and oversees activity.

Status: Ongoing.

Action #17: Lake leaders should encourage and assist landowners to take on lake shore/shallow water improvement projects to rehabilitate areas identified through formal shoreland/shallow water assessments and/or lake user observations (sites might include areas of active erosion, channelized flow, point source pollution, imperious surfaces, and lawns) *Vilas County Land and Water Conservation* looks for partners in this endeavor and can provide planning and sponsorship of projects.

Objective: To rehabilitate specific areas of shoreland to improve natural functions and values.

Monitoring: Lake groups and lake leaders monitor and report progress to Town Lakes Committee.

Status: Ongoing.

Action #18: As part of an education program, encourage commitment from property owners to adopt practices that maintain/improve health of shoreland areas. In many cases, these are "practices" that mean less or no work (e.g., now mowing, no weed wacking, no leaf blowing, no removing large woody material).

Objective: To engage landowners in simple practices that improve/maintain health of the lake and shoreland.

Monitoring: Each landowner can monitor changes in the shoreland over time by simple means (e.g., annual mid-summer photographs or a catalog of plants and animals seen over time).

Status: Anticipated to begin in 2020.

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. The most recent WDNR grant to Wilderness Waters was an AIS Invasive Species Grant for Education, Prevention, and Planning on Papoose Lake. This grant focuses on aquatic invasive species, increasing the understanding of Papoose Lake, and enables Papoose Lake stakeholders to improve stewardship actions that address the lake. The project monitored Papoose Lake for AIS using WDNR protocol. A broader educational activity was delivered in the form of a floating workshop for Papoose Lake enthusiasts and focused on lake and riparian ecology while emphasizing the impacts that invasive species can have on these important ecosystems. Further discussion is found in Appendix E.

For riparian owners and users of a lake ecosystem, the discovery of AIS is an event 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 11 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.

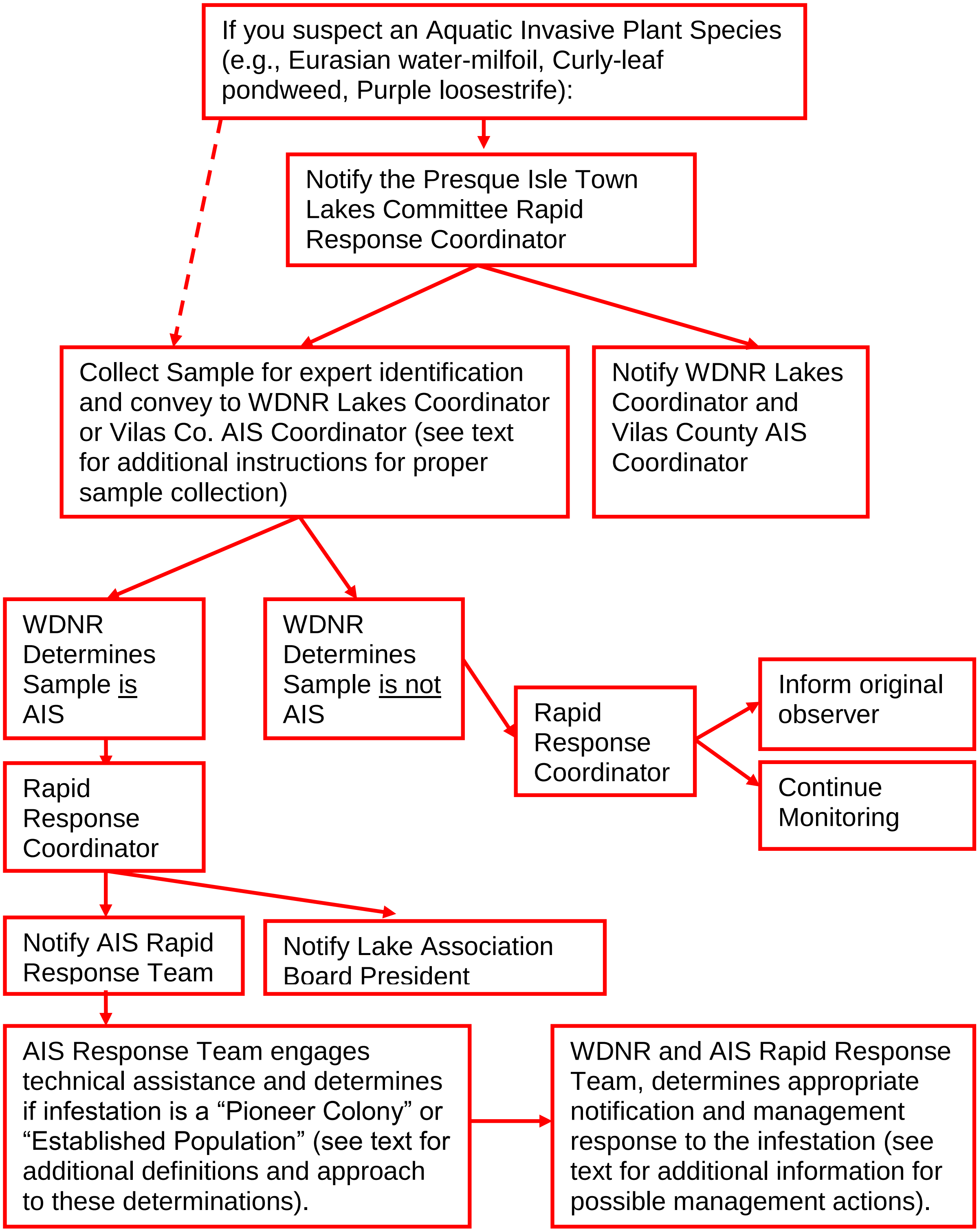
When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount 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) or the Vilas County AIS Coordinator (Al Wirt) 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, it is time to consult with the WDNR Lakes Coordinator 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, tribal contacts, chemical treatment contractors, and consultant(s).

Exhibit 11. Aquatic Invasive Plant Species Rapid Response



Appendix A
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Appendix B

Aquatic Plant Survey Tables and Figures

Table of Contents

Table 1. Summary statistics for the 2008 and 2017 point-intercept aquatic plant surveys for Papoose Lake.

Summary Statistic	Value 2008	Value 2017	Notes
Total number of sites on grid	1076	1076	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited		299	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation		24	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants		55	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	15.32	43.64	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.84	0.88	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.)	17	6.50	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope		16	
Number of sites sampled with rake on pole		132	
Average number of all species per site (shallower than max depth)	0.25	0.98	
Average number of all species per site (vegetated sites only)	1.60	2.29	
Average number of native species per site (shallower than max depth)	0.25	0.98	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	1.60	2.29	Total number of species collected including visual sightings.
Species Richness	12	18	
Species Richness (including visuals)		22	
Floristic Quality Index (FQI)	23.4	28.4	

Table 2. Plant species recorded and distribution statistics for the 2017 Papoose Lake aquatic plant survey.

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
Water marigold	*Bidens beckii* (formerly *Megalodonta*)	23.64	54.17	24.07	13	13	1
Fern pondweed	*Potamogeton robbinsii*	16.36	37.50	16.67	9	11	1.78
Common waterweed	*Elodea canadensis*	12.73	29.17	12.96	7	8	1.3
Ribbon-leaf pondweed	*Potamogeton epihydrus*	7.27	16.67	7.41	4	5	1
Muskgrasses	*Chara* sp.	3.64	8.33	3.70	2	2	1.5
Slender waterweed	*Elodea nuttallii*	3.64	8.33	3.70	2	2	1
Water star-grass	*Heteranthera dubia*	3.64	8.33	3.70	2	2	1
Wild celery	*Vallisneria americana*	3.64	8.33	3.70	2	2	1
Large-leaf pondweed	*Potamogeton amplifolius*	3.64	8.33	3.70	2	15	1
Northern water-milfoil	*Myriophyllum sibiricum*	3.64	8.33	3.70	2	4	1
Sparganium sp., floating	*Sparganium* sp., floating	3.64	8.33	3.70	2	3	1
Northern naiad	*Najas gracillima*	1.82	4.17	1.85	1	1	1
Blunt-leaf pondweed	*Potamogeton obtusifolius*	1.82	4.17	1.85	1	1	1
Common bladderwort	*Utricularia vulgaris*	1.82	4.17	1.85	1	1	1
Spatterdock	*Nuphar variegata*	1.82	4.17	1.85	1	11	1
Floating-leaf pondweed	*Potamogeton natans*	1.82	4.17	1.85	1	3	1
Alternate-flowered water-milfoil	*Myriophyllum alterniflorum*	1.82	4.17	1.85	1	2	1
Small pondweed	*Potamogeton pusillus*	1.82	4.17	1.85	1	2	1
White water lily	*Nymphaea odorata*				Visual	6	
Slender naiad	*Najas flexilis*				Visual	2	
Pickerelweed	*Pontederia cordata*				Visual	1	
Flat-stem pondweed	*Potamogeton zosteriformis*				Visual	1	

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.

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
Bottle brush sedge	*Carex comosa*				Boat Survey		
Three-way sedge	*Dulichium arundinaceum*				Boat Survey		
Creeping spikerush	*Eleocharis palustris*				Boat Survey		
Water horsetail	*Equisetum fluviatile*				Boat Survey		
Iris	*Iris* sp.				Boat Survey		
Reed canary grass	*Phalaris arundinacea*				Boat Survey		
Common arrowhead	*Sagittaria latifolia*				Boat Survey		
Common bur-reed	*Sparganium eurycarpum*				Boat Survey		
Cattail	*Typha* sp.				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.

Phalaris arundinacea is considered restricted invasive species.

Plant specimens were verified by Dr. Robert Freckmann, University of Wisconsin-Stevens Point, on 3/14/2018.

Table 3. Plant species recorded and distribution statistics for the 2008 Papoose Lake aquatic plant survey.

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	Average Rake Fullness
Large-leaf pondweed	*Potamogeton amplifolius*	6.07	39.62	24.71	21	1
Common waterweed	*Elodea canadensis*	4.62	30.19	18.82	16	2
Spatterdock	*Nuphar variegata*	4.34	28.30	17.65	15	1
Fern pondweed	*Potamogeton robbinsii*	3.47	22.64	14.12	12	2
Wild celery	*Vallisneria americana*	2.31	15.09	9.41	8	1
Northern water-milfoil	*Myriophyllum sibiricum*	1.16	7.55	4.71	4	1
Dwarf water-milfoil	*Myriophyllum tenellum*	0.58	3.77	2.35	2	1
Pickerelweed	*Pontederia cordata*	0.58	3.77	2.35	2	1
Ribbon-leaf pondweed	*Potamogeton epihydrus*	0.58	3.77	2.35	2	1
Creeping spikerush	*Eleocharis palustris*	0.29	1.89	1.18	1	1
White water lily	*Nymphaea odorata*	0.29	1.89	1.18	1	1
White-stem pondweed	*Potamogeton praelongus*	0.29	1.89	1.18	1	2

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.

Figure 1. Number of plant species recorded at Papoose Lake sample sites (2017).

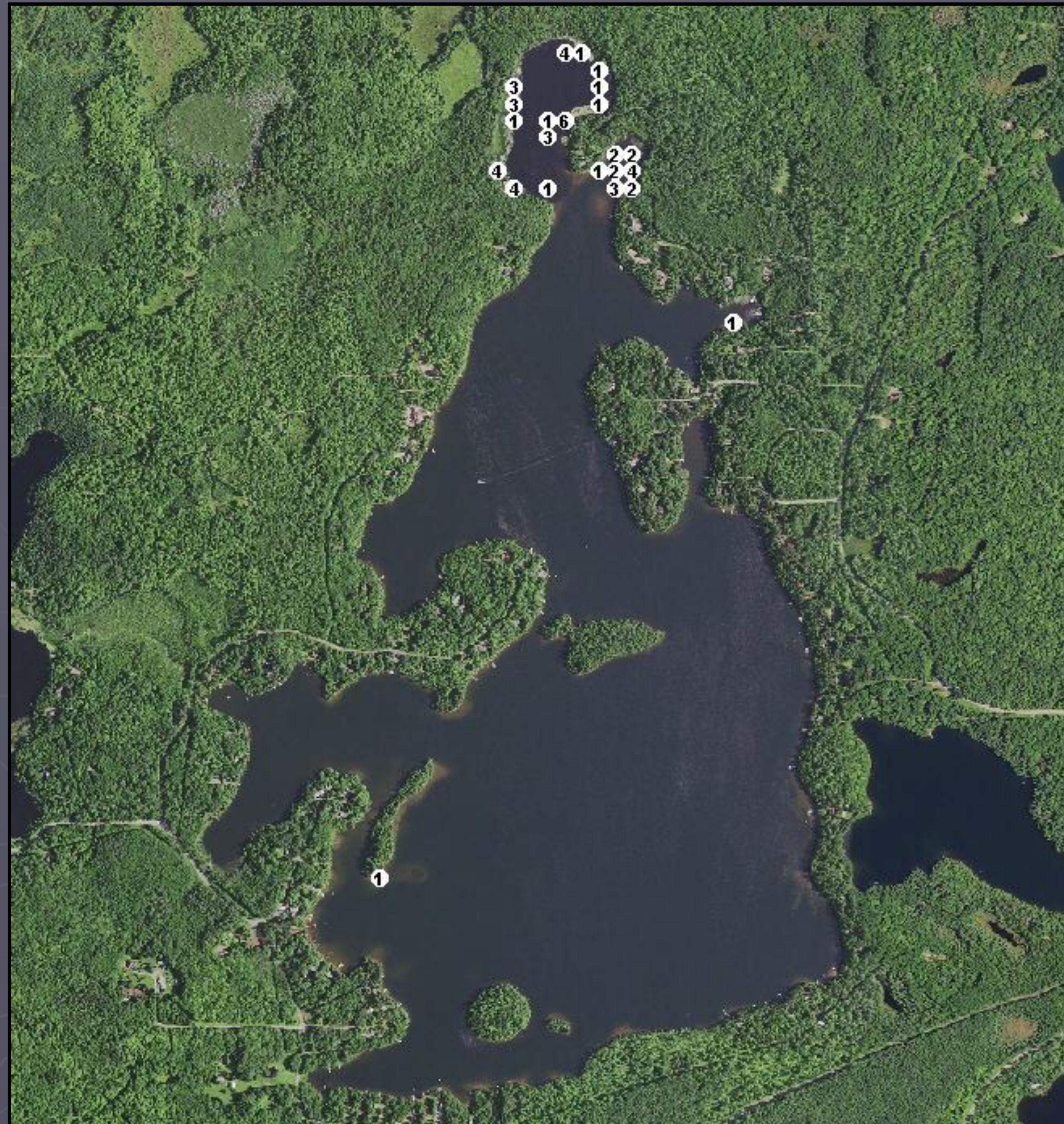
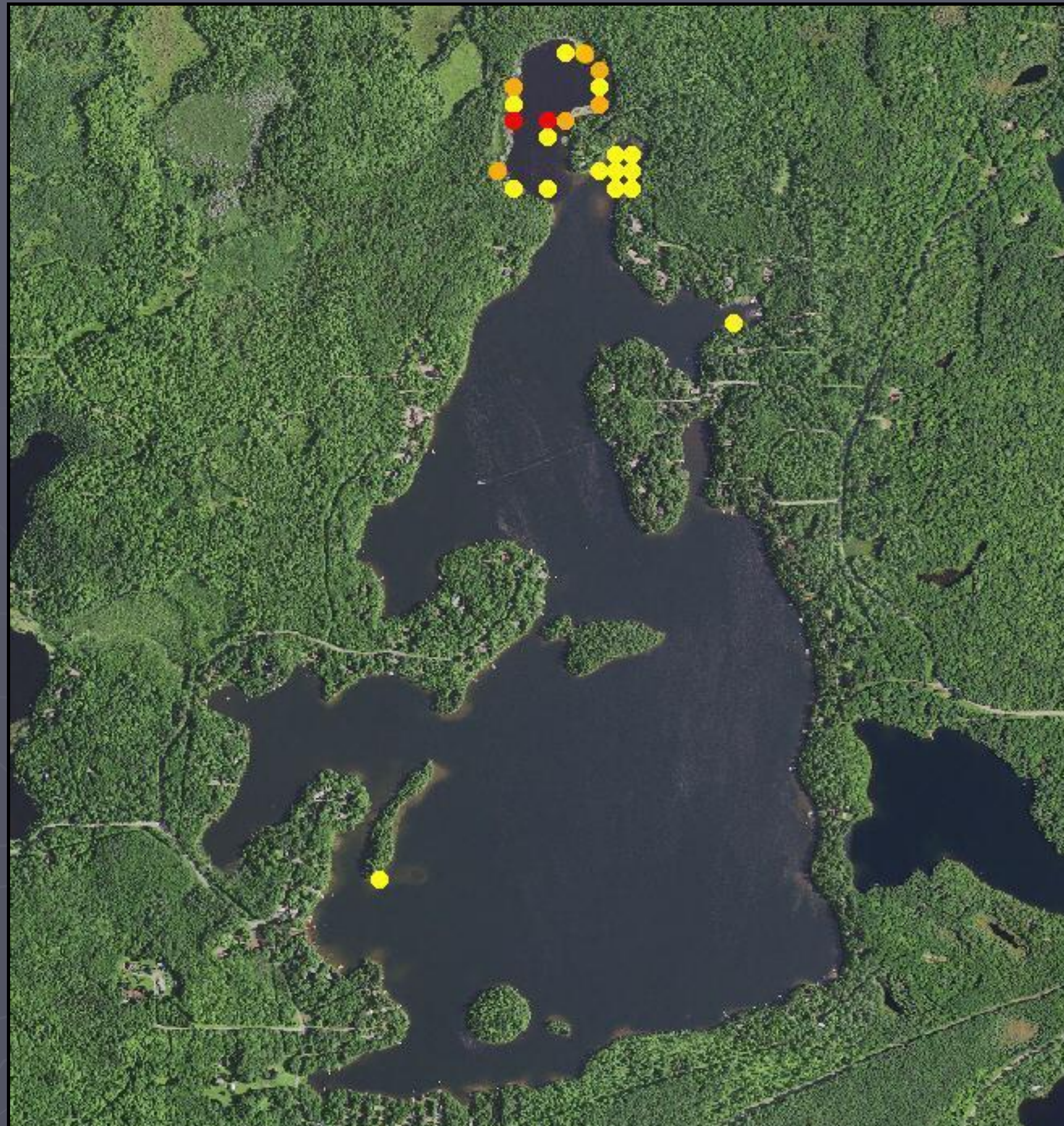


Figure 2. Rake fullness ratings for Papoose Lake sample sites (2017).



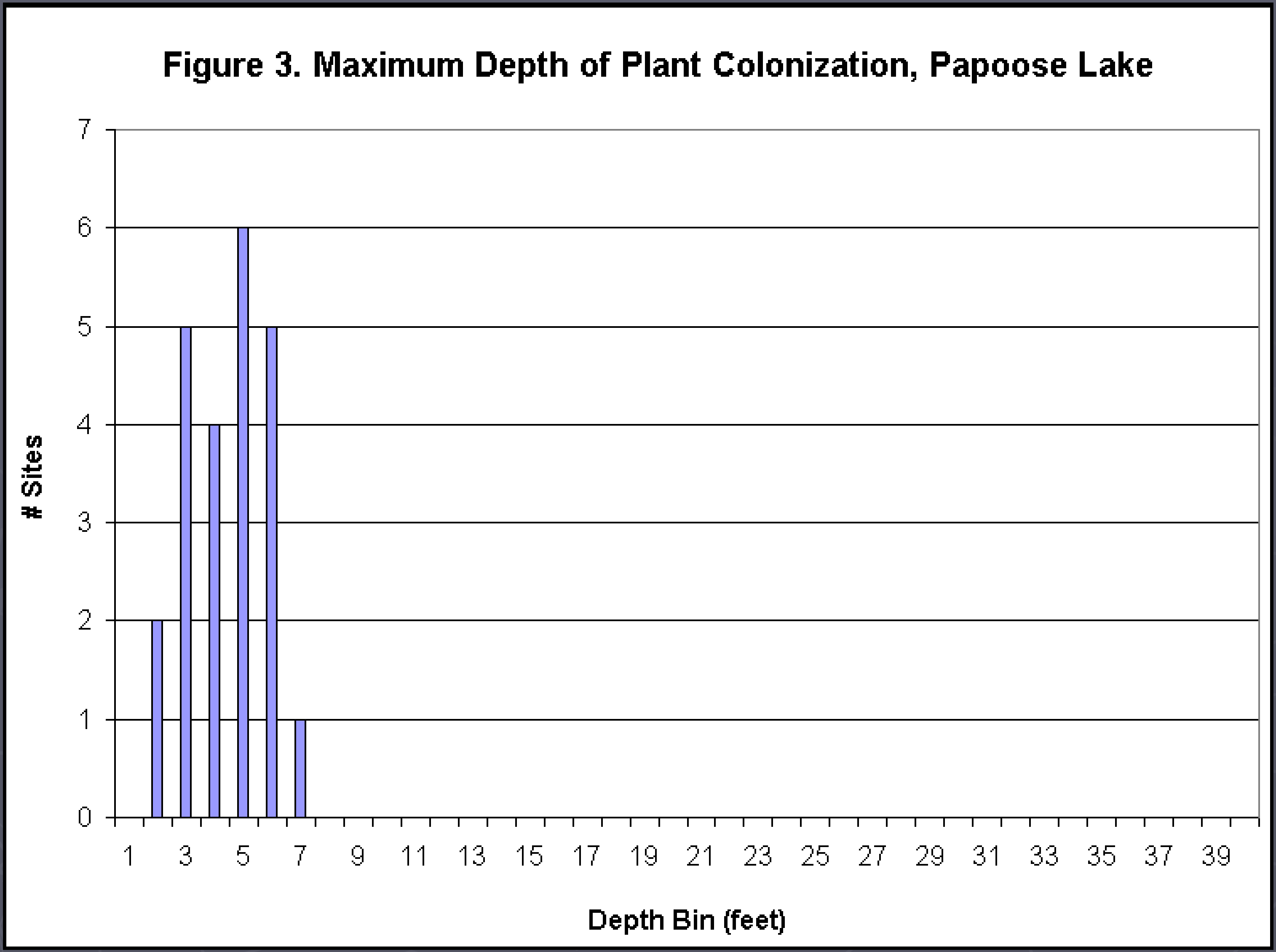


Figure 3. Maximum Depth of Plant Colonization, Papoose Lake
Sites
0
1
2
3
4
5
6
7
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Depth Bin (feet)

Figure 4. Papoose Lake sampling sites less than or equal to maximum depth of rooted vegetation (2017).

Figure 5. Papoose Lake substrate encountered at point-intercept plant sampling sites (2017).

Figure 6. Papoose Lake aquatic plant occurrences for 2017 point-intercept survey data.

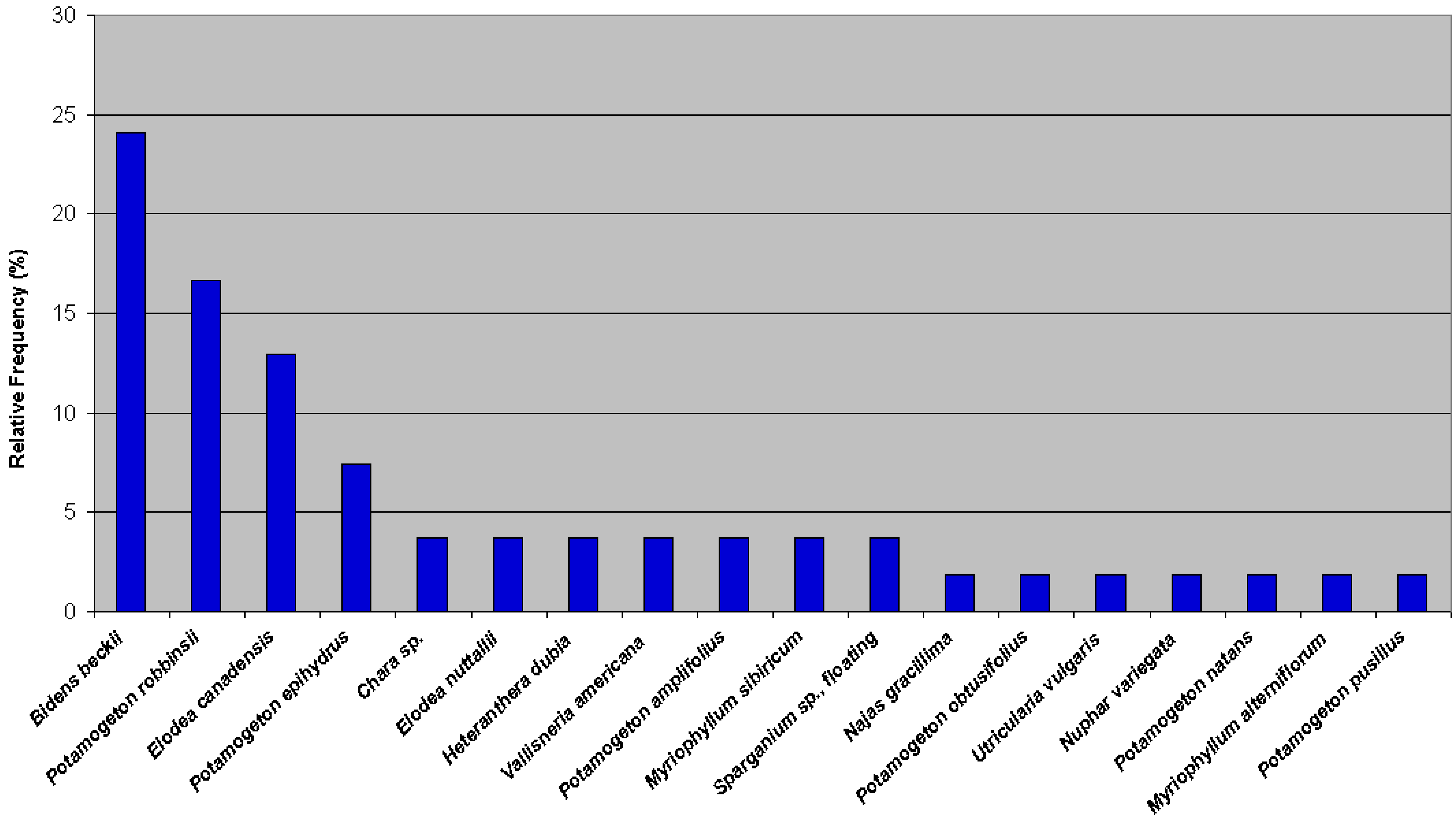


Figure 7. Papoose Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2017).

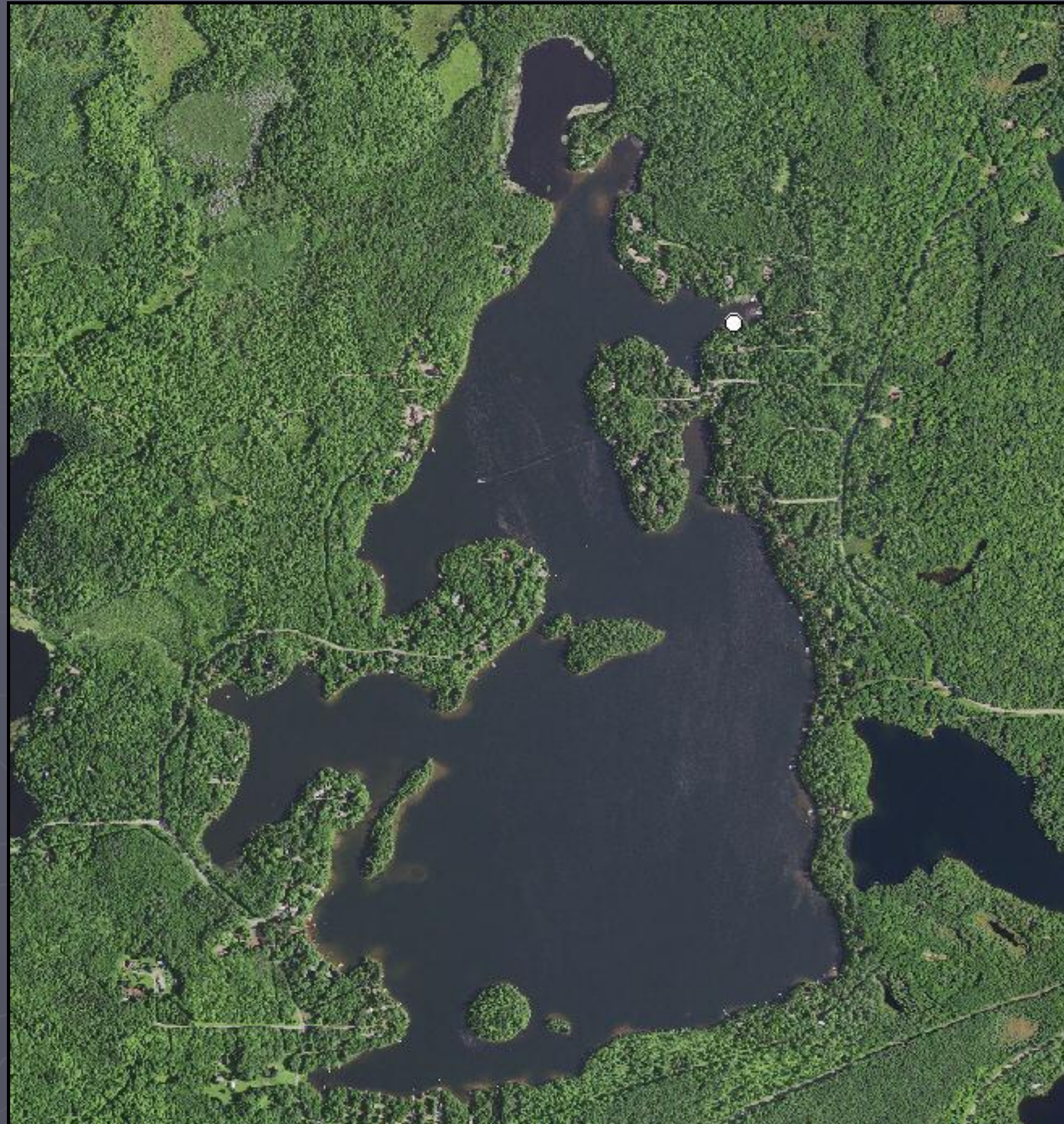


Figure 8. Distribution of plant species, Papoose Lake (2017).

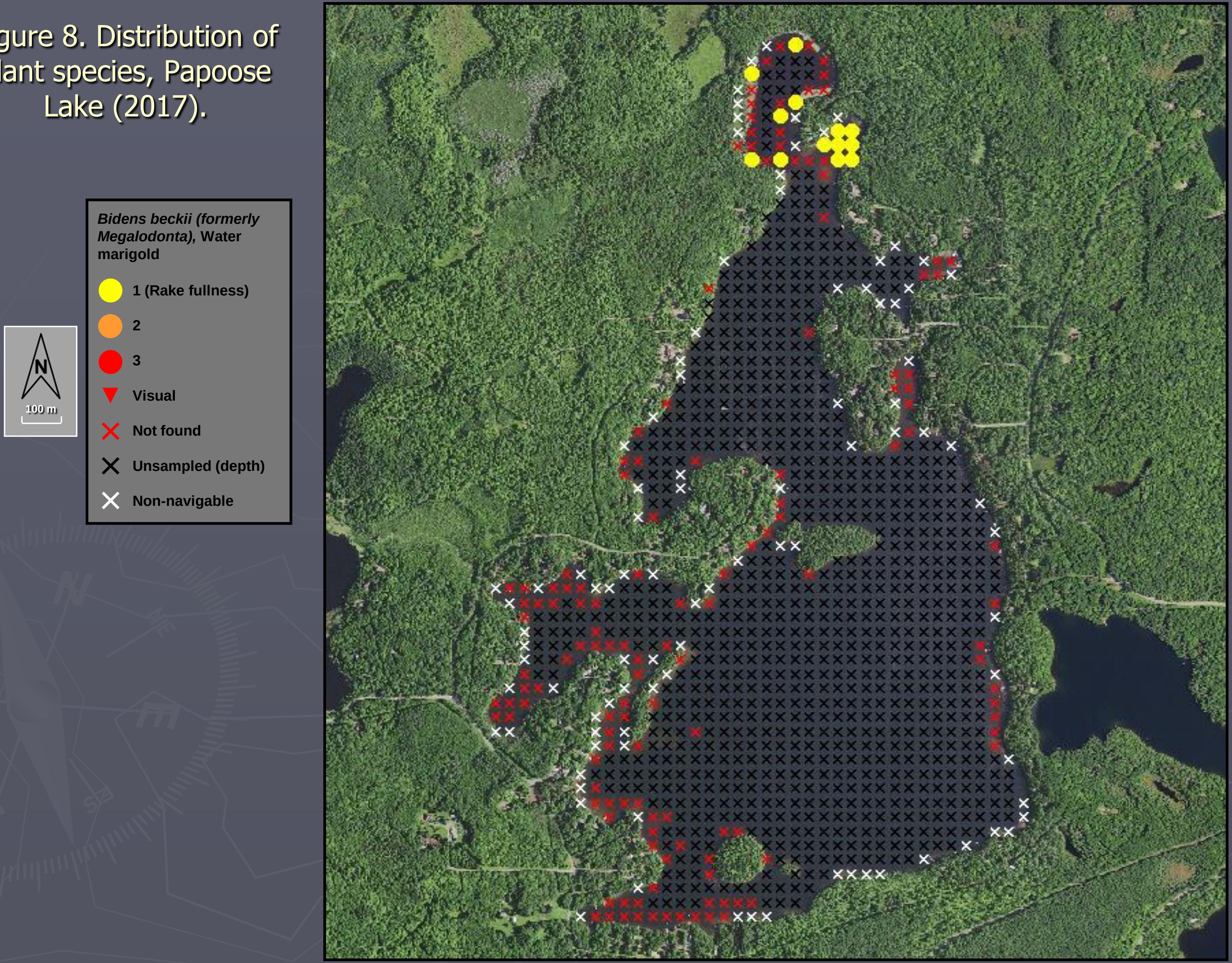


Figure 9. Distribution of plant species, Papoose Lake (2017).

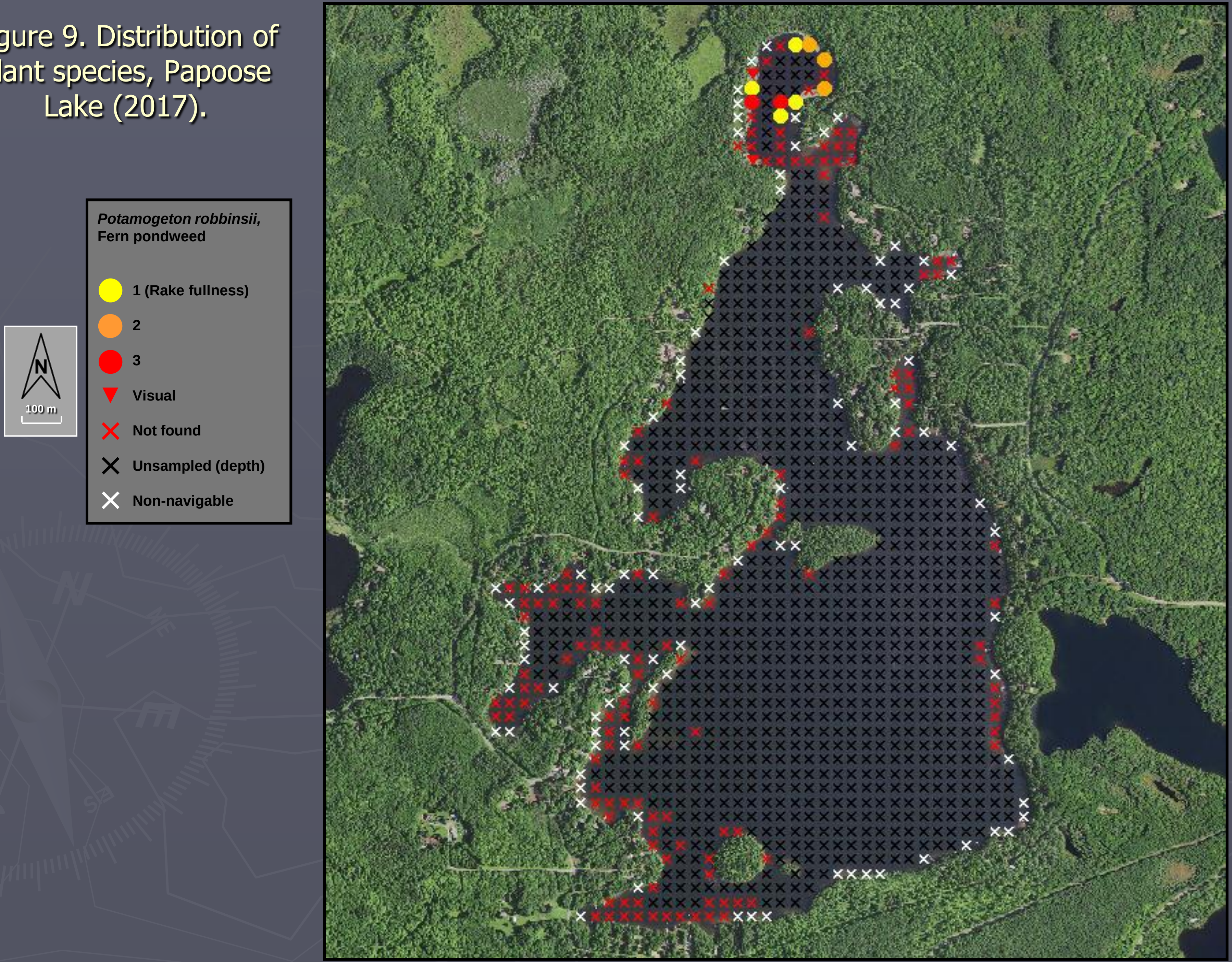


Figure 10. Distribution of plant species, Papoose Lake (2017).

Figure 11. Distribution of plant species, Papoose Lake (2017).

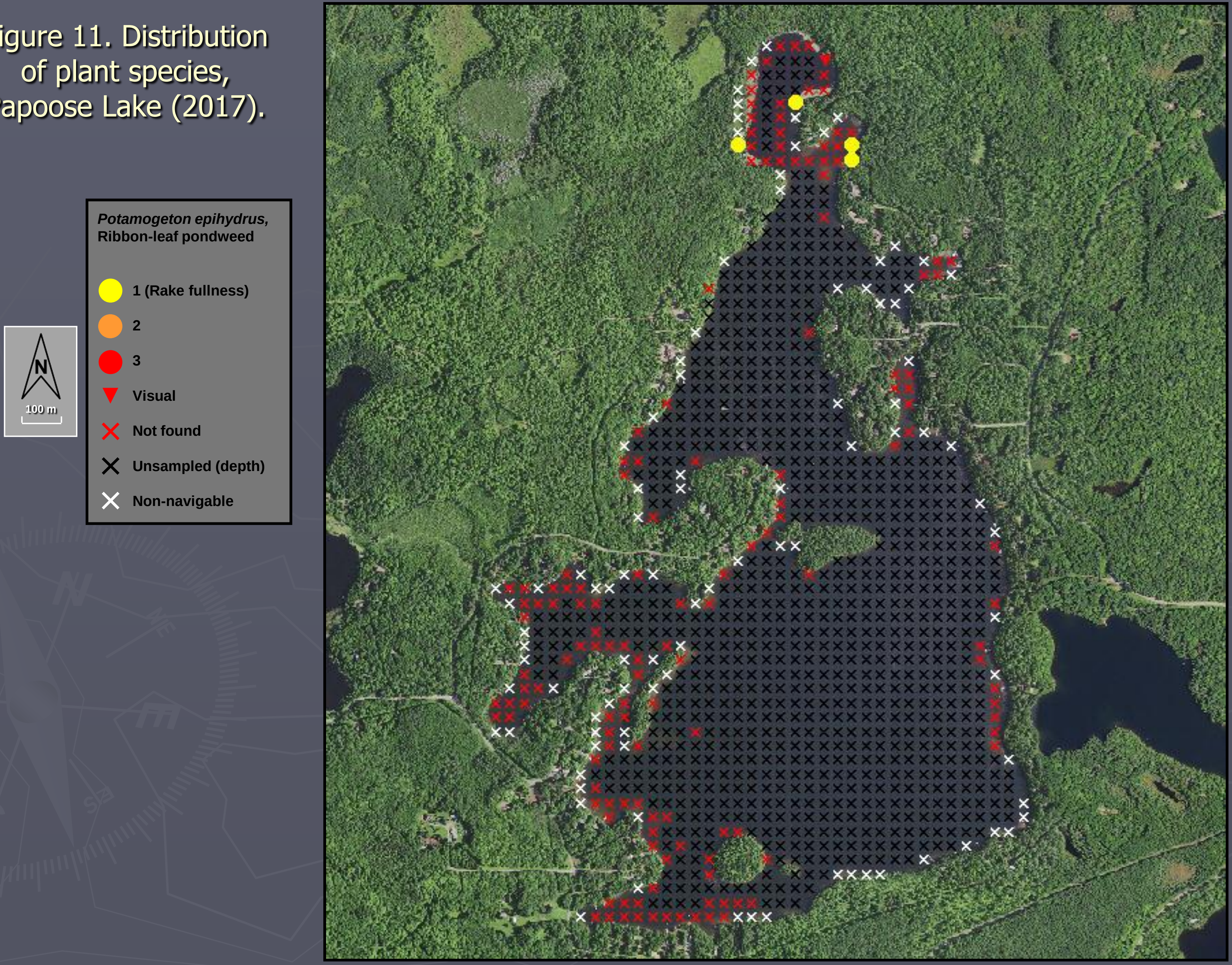


Figure 12. Distribution of plant species, Papoose Lake (2017).

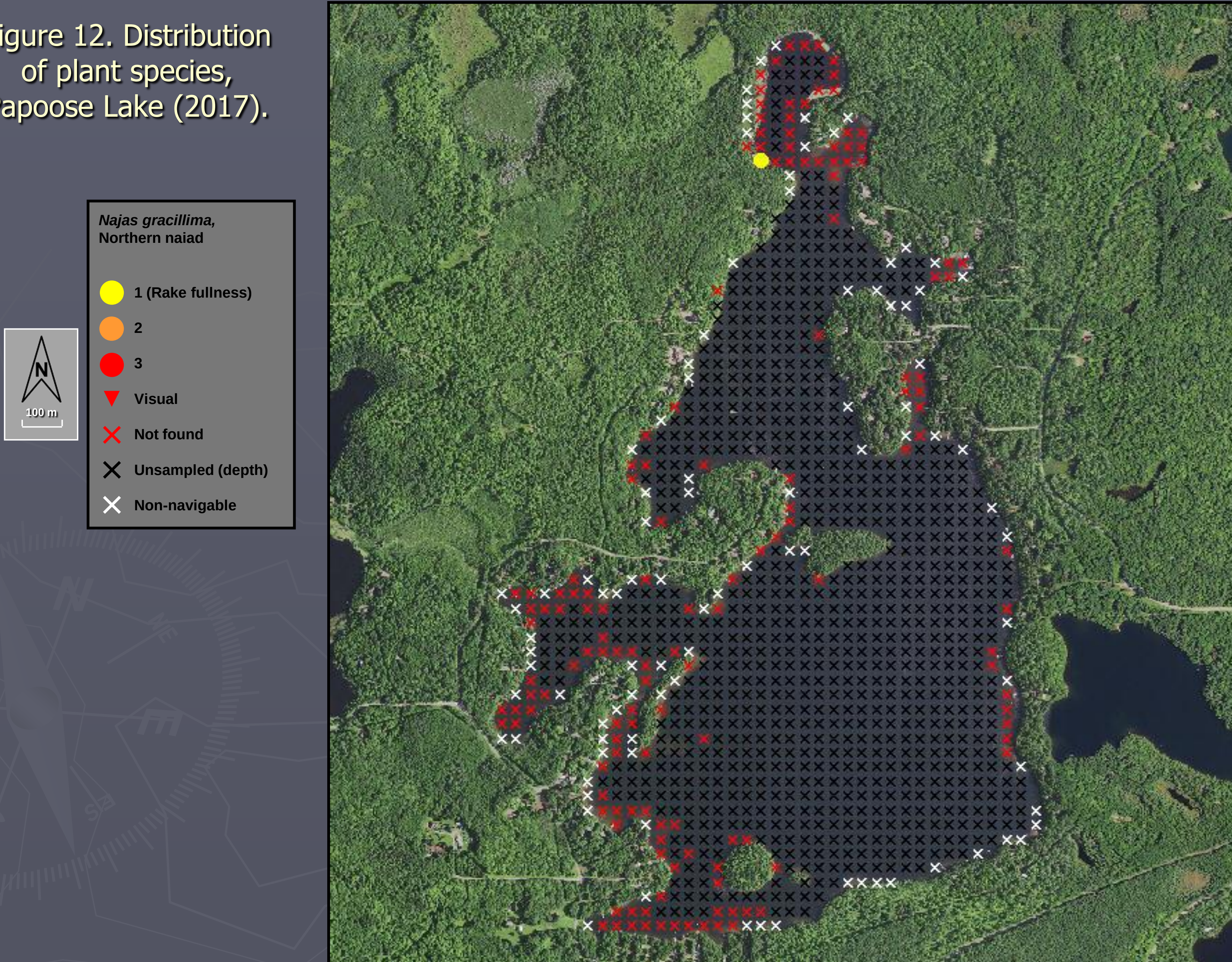


Figure 13. Distribution of plant species, Papoose Lake (2017).

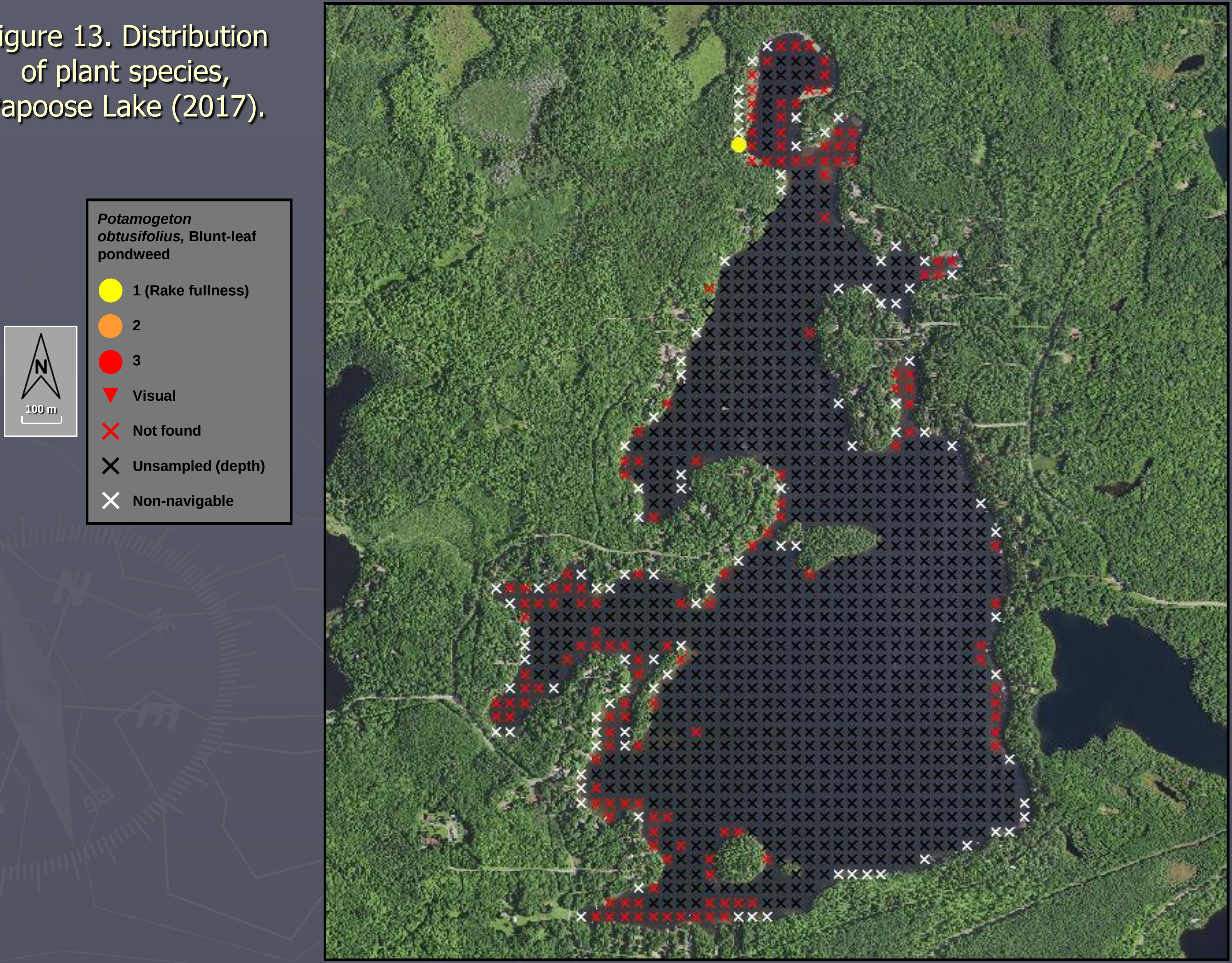


Figure 14. Distribution of plant species, Papoose Lake (2017).

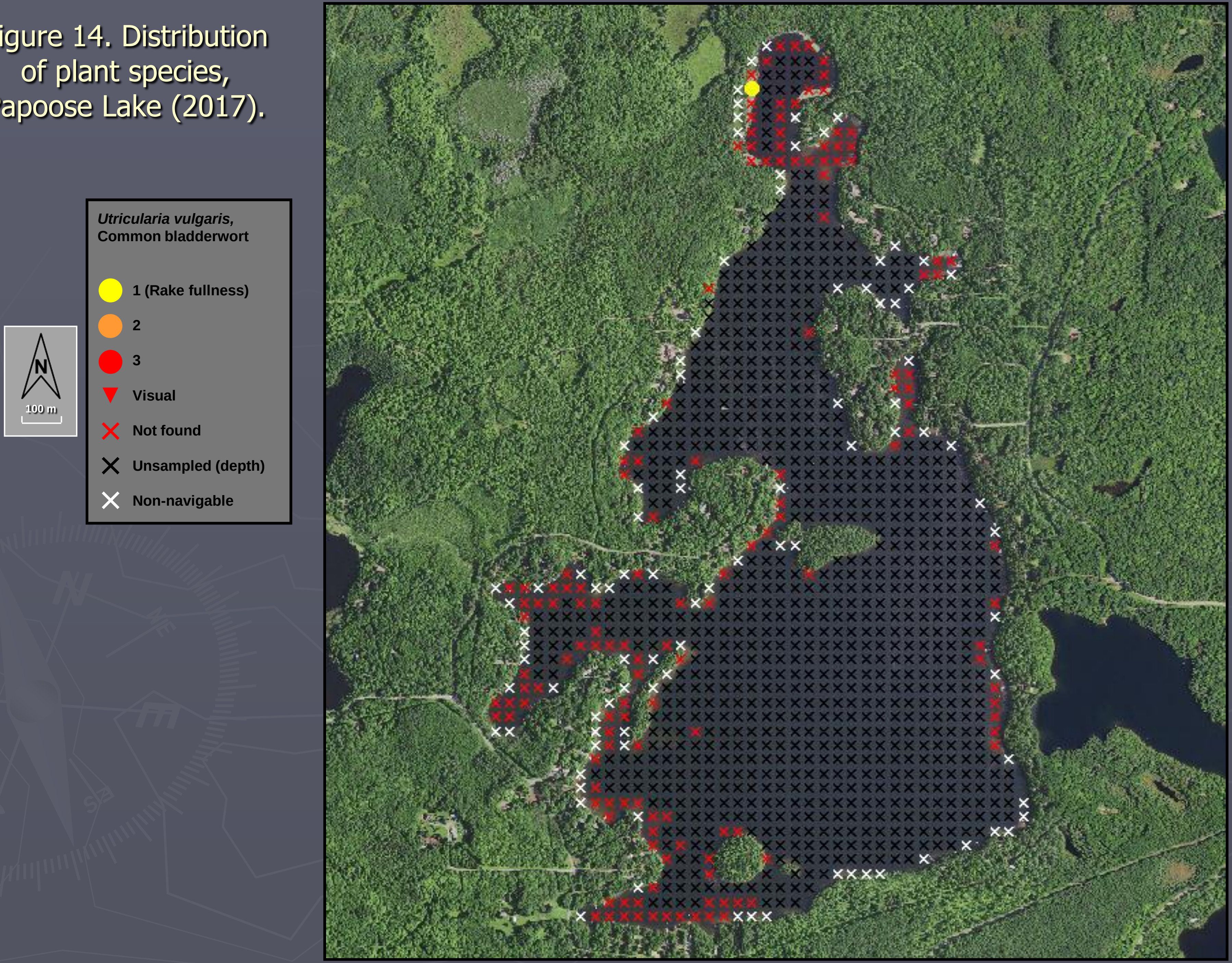


Figure 15. Distribution of plant species, Papoose Lake (2017).

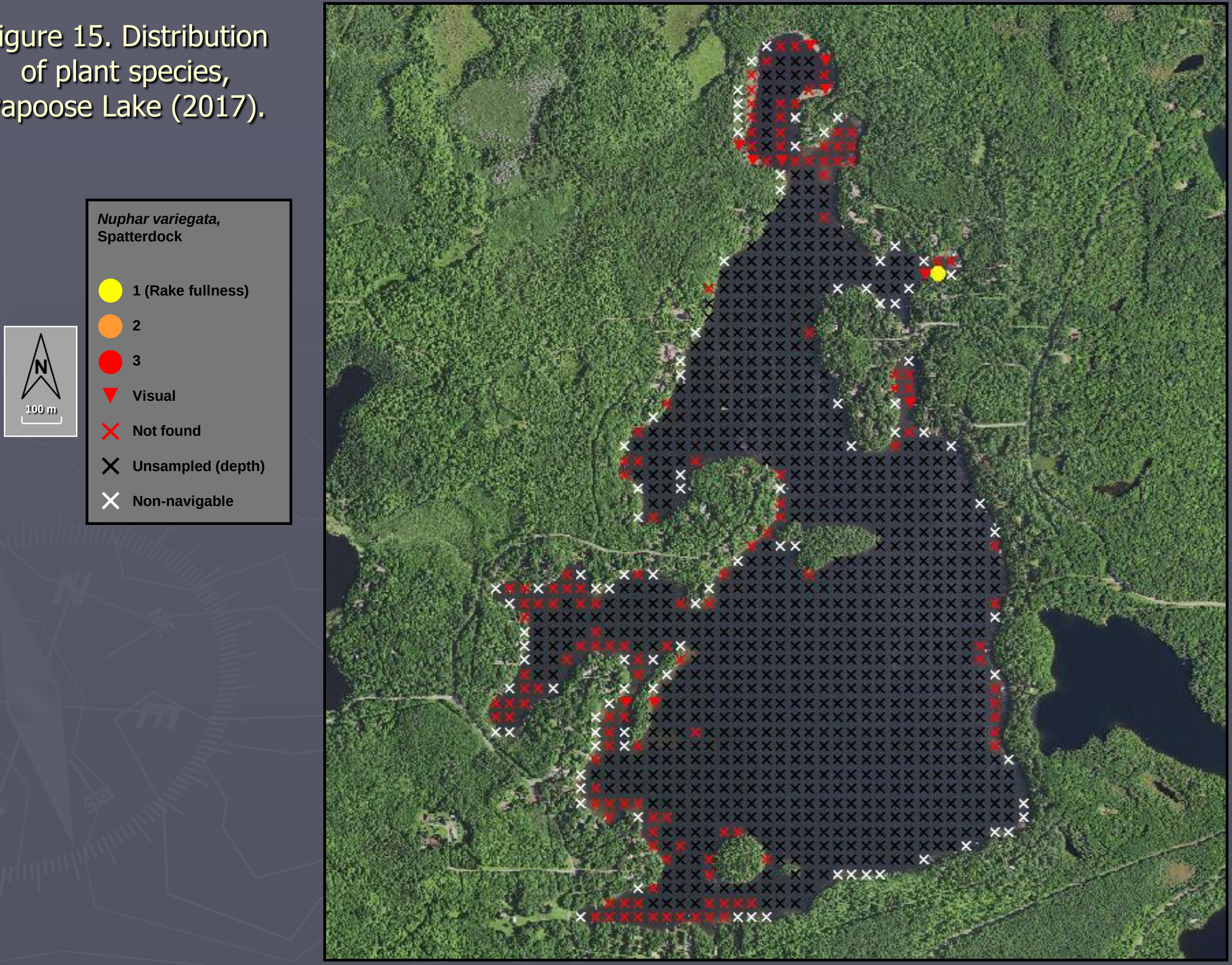


Figure 16. Distribution of plant species, Papoose Lake (2017).

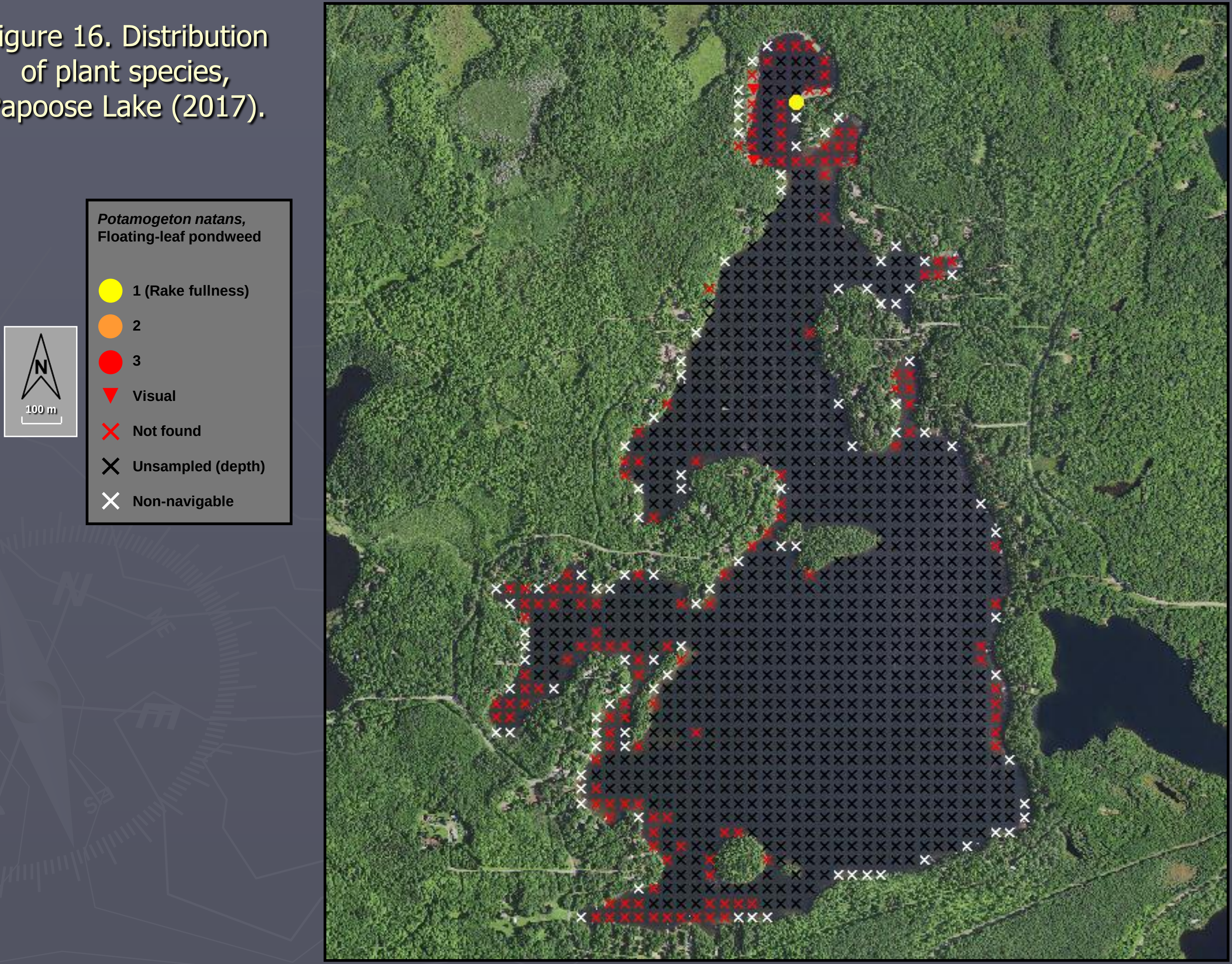


Figure 17. Distribution of plant species, Papoose Lake (2017).

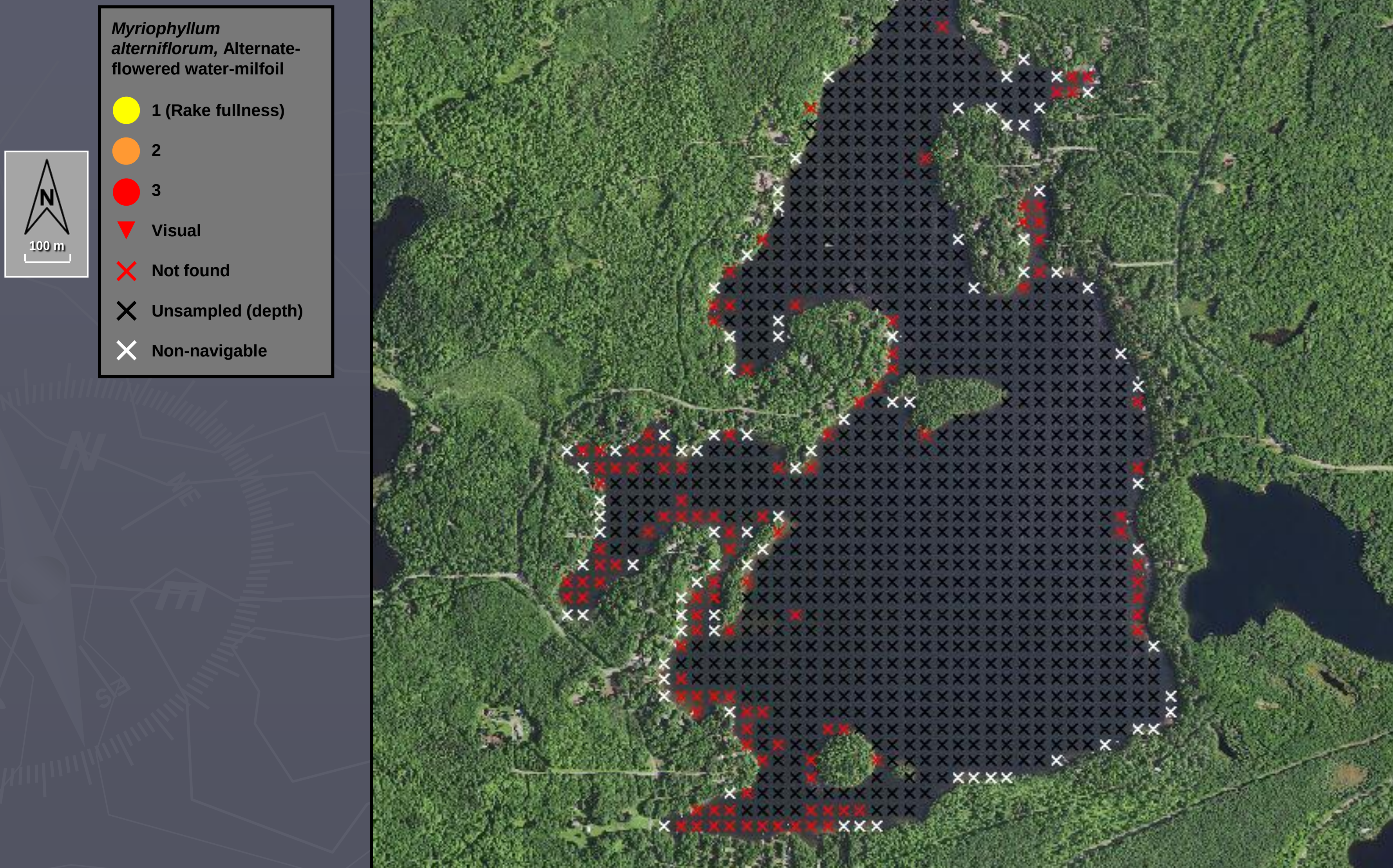
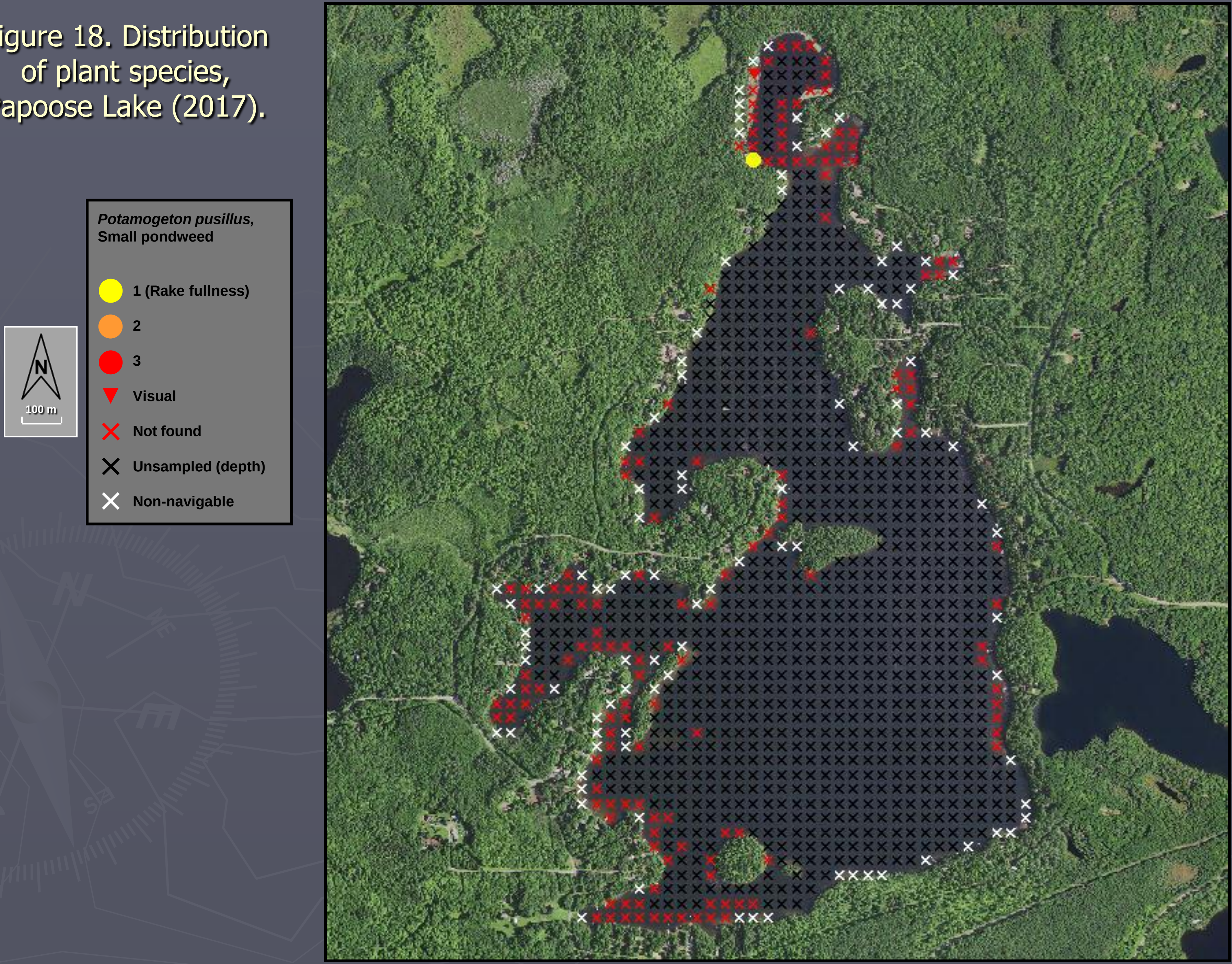


Figure 18. Distribution of plant species, Papoose Lake (2017).



Scale for Papoose Lake sample sites (2017)

Appendix C

Review of Papoose Lake Water Quality

Appendix C

Review of Papoose Lake Water Quality

Table of Contents

Review of Papoose Lake Water Quality

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

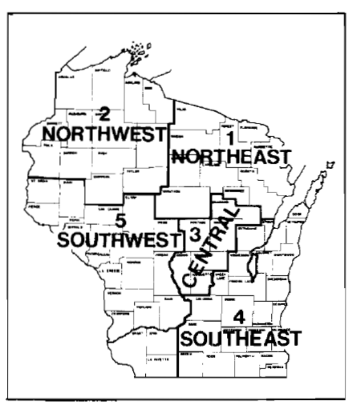
Introduction

Papoose Lake is located in Vilas County, Wisconsin. It is a 422 acre spring fed lake with a maximum depth of 65 feet. The Waterbody Identification Code (WBIC) is 2328700. The purpose of this review is to assemble and interpret water quality data for Papoose Lake in order to establish a baseline against which future water quality monitoring can be compared. Water quality data were retrieved from the Wisconsin DNR SWIMS database since 1984. In October, 1985 an unknown sampler measured many water quality parameters which are included in this report. Secchi disk measurements were collected by Citizen Lake Monitoring Network (CLMN) volunteers from 1991 to present. Chlorophyll *a* and total phosphorus were also collected in 1995 to present by CLMN volunteers.

Comparison of Papoose Lake with other datasets

Lillie and Mason's *Limnological Characteristics of Wisconsin Lakes* (1983) is an excellent resource for evaluating and comparing water quality measures from lakes in northern Wisconsin. For their treatment, Wisconsin is divided into five regions. Vilas County lakes are in the Northeast Region (Figure 1). Water quality measures from a lake of interest can be compared to other lakes within the region using this resource.

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. Figures 2 through 7 indicate the changes in water temperature from 1985 to 2017. In April and May, the temperature stayed consistent from the surface to the bottom (Figure 2 and 3). The summer temperature levels show stratification. In June, the lake stratified between 12-20 feet (Figure 4). In July, the lake usually stratified between 10 and 20 feet (Figure 5). In August, surface temperatures were lower and the water stratified between 20 to 25 feet (Figure 6). In September and October the temperature profiles are mixed (Figure 7).

Figure 2. Papoose Lake temperature profiles, April.

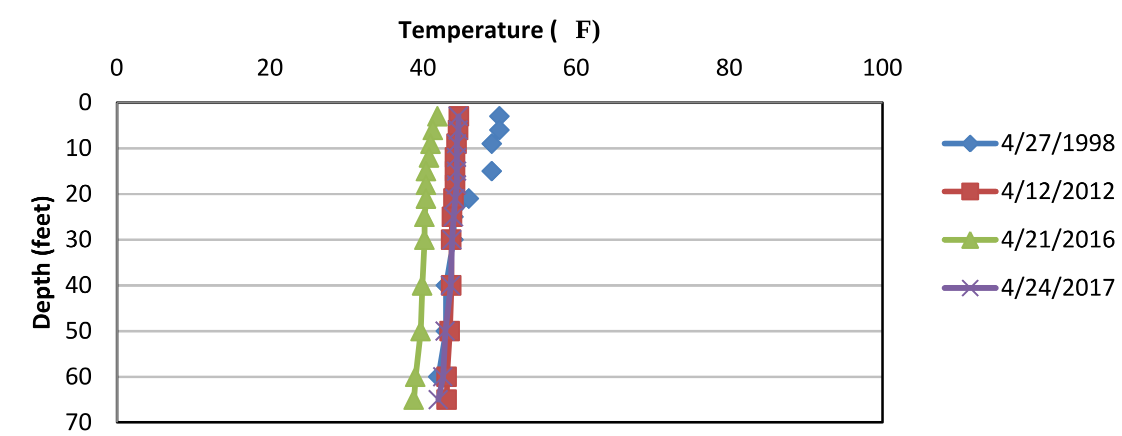
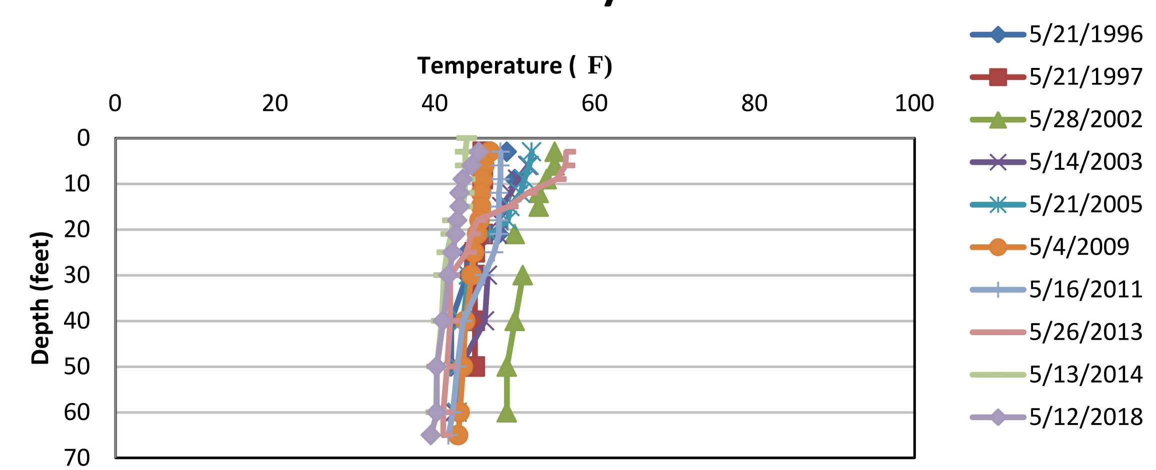


Figure 3. Papoose Lake temperature profiles, May.



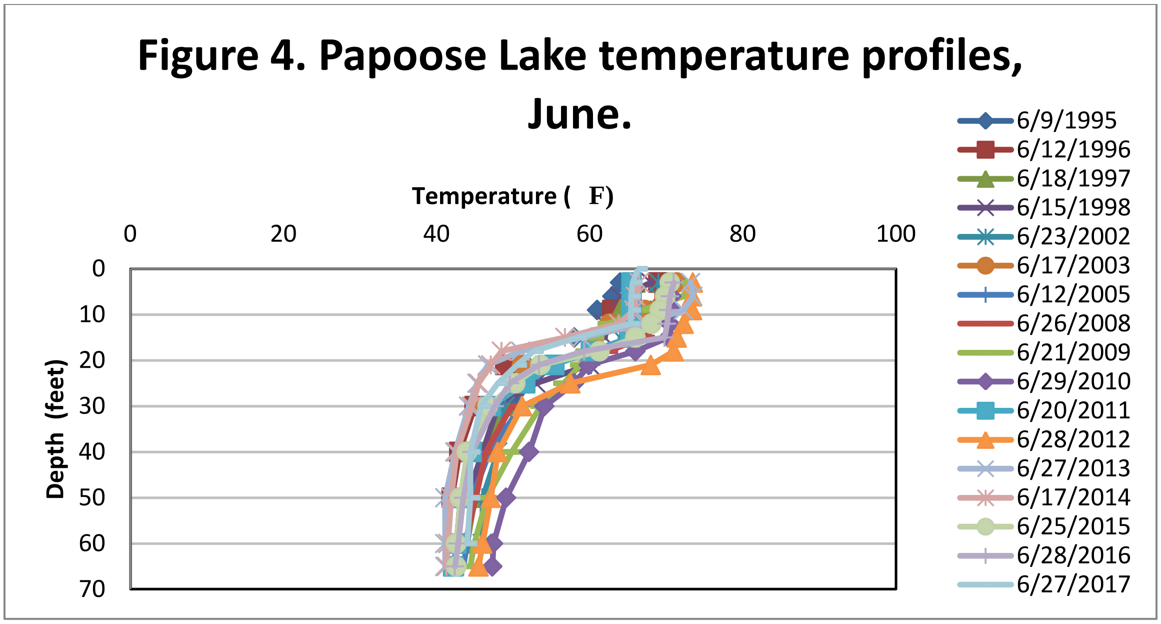


Figure 4. Papoose Lake temperature profiles, June.
Temperature (F)
0
20
40
60
80
100
Depth (feet)
0
10
20
30
40
50
60
70
6/9/1995
6/12/1996
6/18/1997
6/15/1998
6/23/2002
6/17/2003
6/12/2005
6/26/2008
6/21/2009
6/29/2010
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6/17/2014
6/25/2015
6/28/2016
6/27/2017

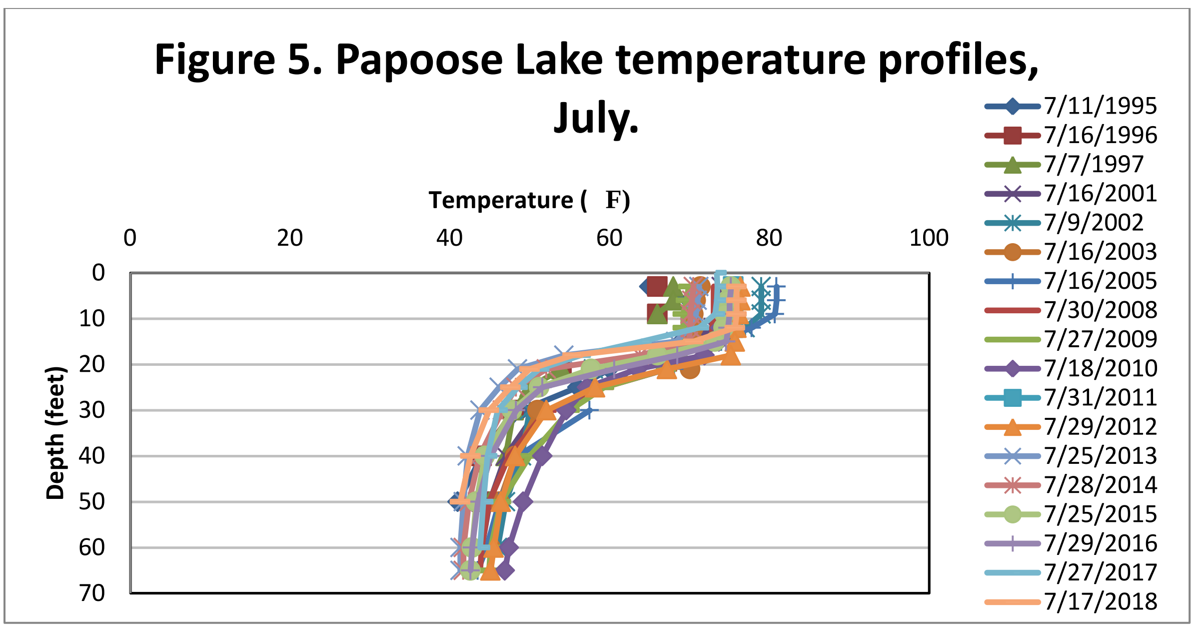


Figure 5. Papoose Lake temperature profiles, July.
Temperature (F)
0
20
40
60
80
100
Depth (feet)
0
10
20
30
40
50
60
70
7/11/1995
7/16/1996
7/7/1997
7/16/2001
7/9/2002
7/16/2003
7/16/2005
7/30/2008
7/27/2009
7/18/2010
7/31/2011
7/29/2012
7/25/2013
7/28/2014
7/25/2015
7/29/2016
7/27/2017
7/17/2018

Figure 6. Papoose Lake temperature profiles, August.

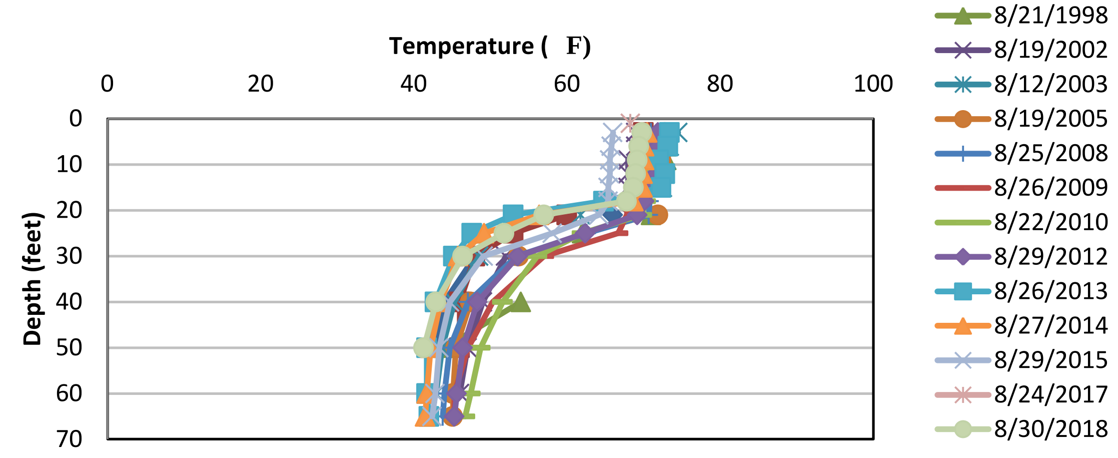
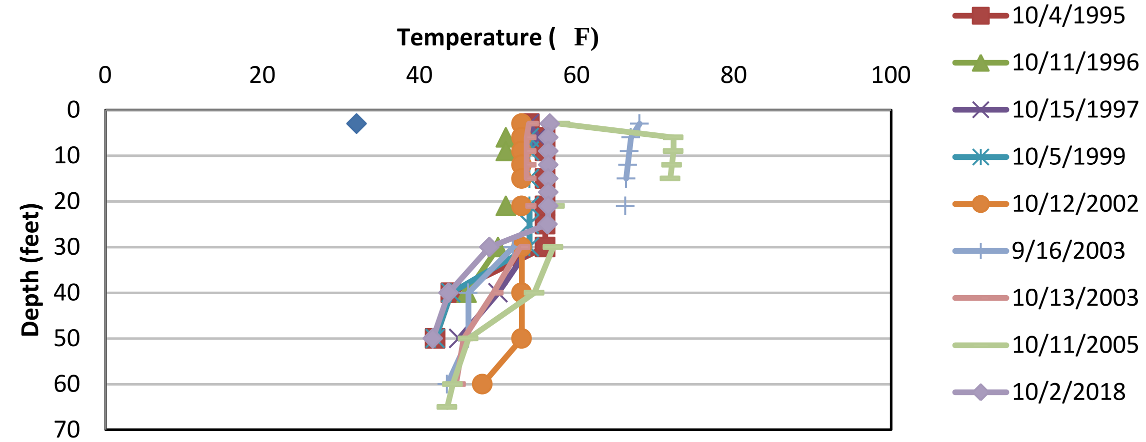
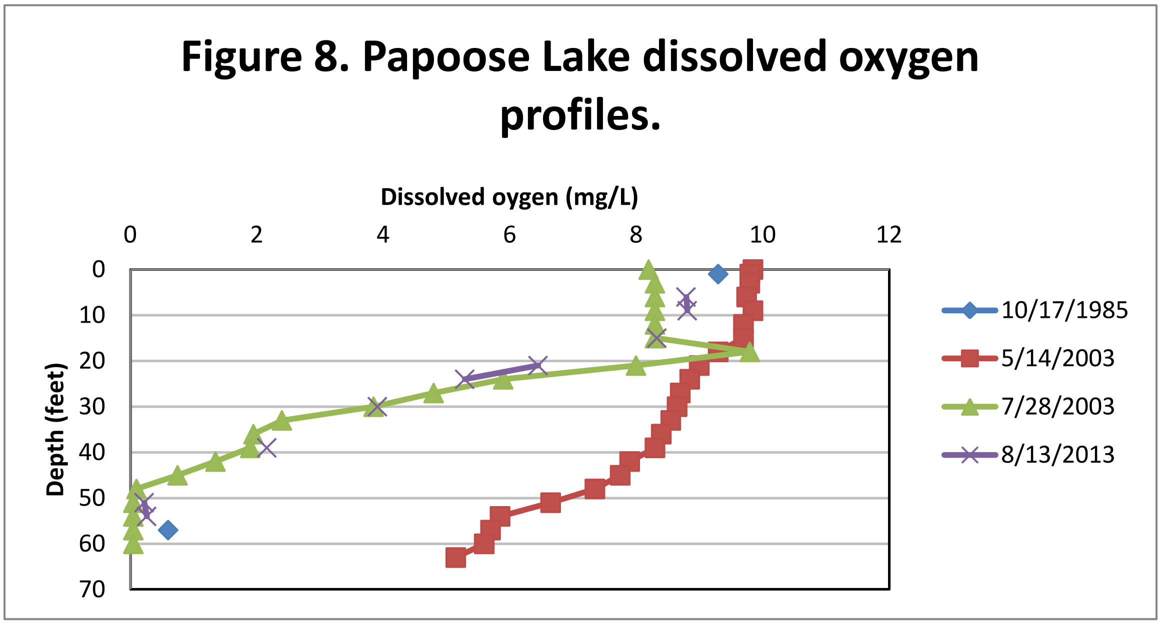


Figure 7. Papoose Lake temperature profiles, September and October.



Dissolved Oxygen

The dissolved oxygen 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 D.O. is dependent on the water temperature, atmospheric pressure, and biological activity. D.O. 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. D.O. levels were 10 mg/L at the surface on 5/14/2003. In July and August, 2013 the D.O. levels were 8-9 mg/L at the surface and at approximately 18 feet the D.O. levels drop off (Figure 8).

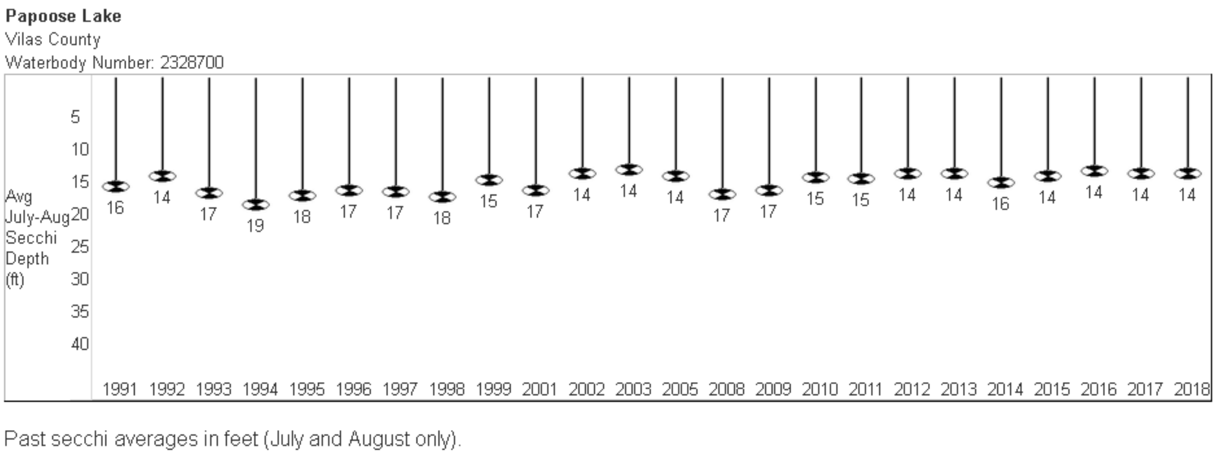


Water Clarity

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. The depth at which the disk disappears is noted and then the disk is slowly brought up to where it is just visible again and the depth noted. The mean value between these two measures is recorded as the Secchi depth.

Figure 9 shows the July and August mean Secchi depths from 1991 to 2018. According to Table 1, Papoose Lake's most recent Secchi reading is considered "good" with respect to water clarity. The shallowest Secchi depth was 11.8 feet in 2018, and the deepest reading was at 21 feet in 2008 (Figure 10).

Figure 9. Papoose Lake Secchi depth averages (July and August only).



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

(WDNR, 2019)

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 10. Papoose Lake's July and August Secchi Data: Mean, Min, Max, and Secchi Count (1991-2018).

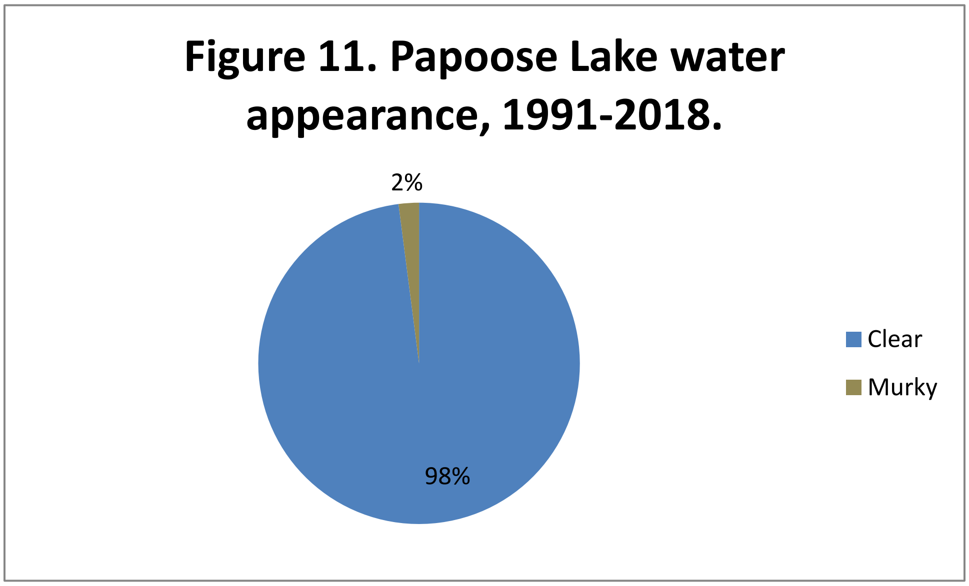
Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1991	16.25	14	17.75	3
1992	14.5	14	15	2
1993	17.25	13	19.75	3
1994	19	18	20	5
1995	17.65	15	20	5
1996	16.87	16	17.75	5
1997	16.94	16	18	4
1998	17.88	17	19	4
1999	15.17	15	15.5	3
2001	16.75	16.75	16.75	1
2002	14.25	13	15.5	2
2003	13.5	11.5	16	3
2005	14.5	13	16	2
2008	17.38	13	21	4
2009	16.75	16.75	16.75	2
2010	14.75	14	15.5	2
2011	15	15	15	1
2012	14.25	13	15.5	2
2013	14.25	14	14.5	2
2014	15.5	14	17	2
2015	14.5	14	15	2
2016	13.75	13.75	13.75	1
2017	14.25	13.5	15	2
2018	14.29	11.8	15.6	4

Report Generated: 01/14/2019

(WDNR, 2019)

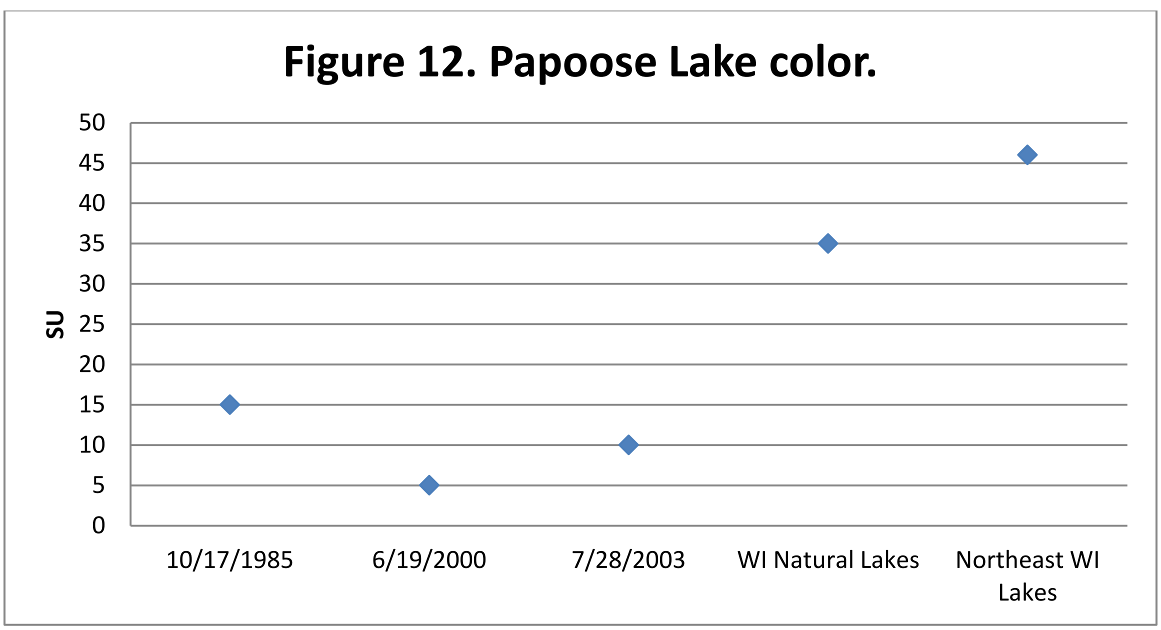
Turbidity

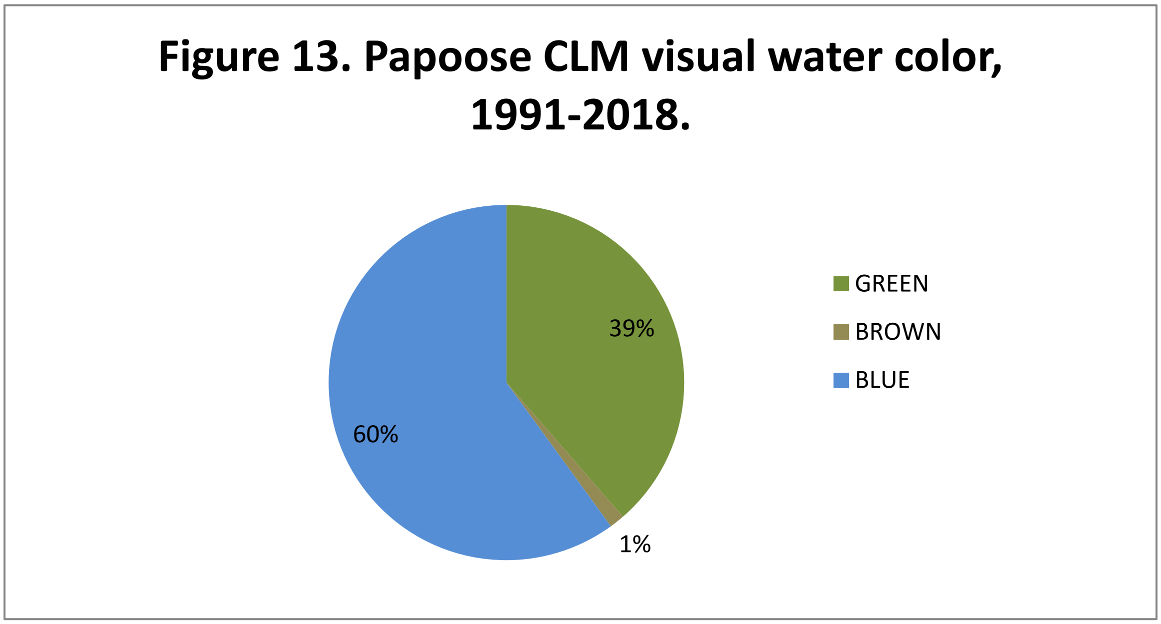
Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth to which light can penetrate. This affects the depth at which plants can grow. 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. Papoose Lake turbidity has not been tested, and should be included in future water quality sampling. While checking Secchi depth, the CLMN volunteers also rate the water clarity and describe the water as "clear" or "murky." From 1991 to 2018, 98% of volunteers rated the water as "clear" (Figure 11).



Water Color

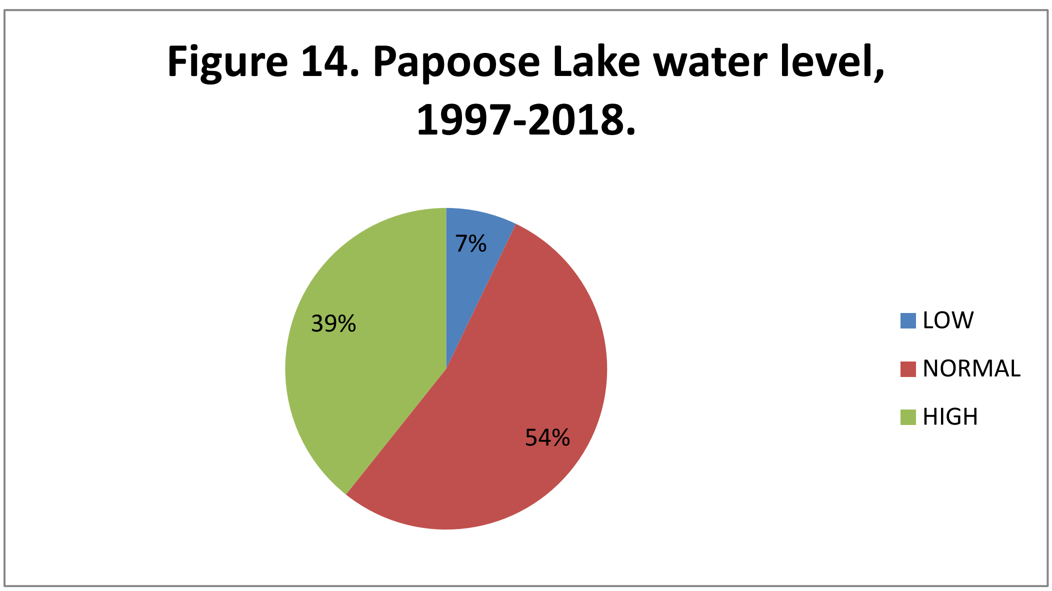
Color of lake water is related to the type and amount of dissolved organic chemicals. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant 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. Papoose Lake was analyzed for color levels and is shown in Figure 12. CLMN volunteers also recorded their perceptions of water color in Papoose Lake. Since 1991, 60% of volunteers indicated the water appeared "blue" in color (Figure 13).





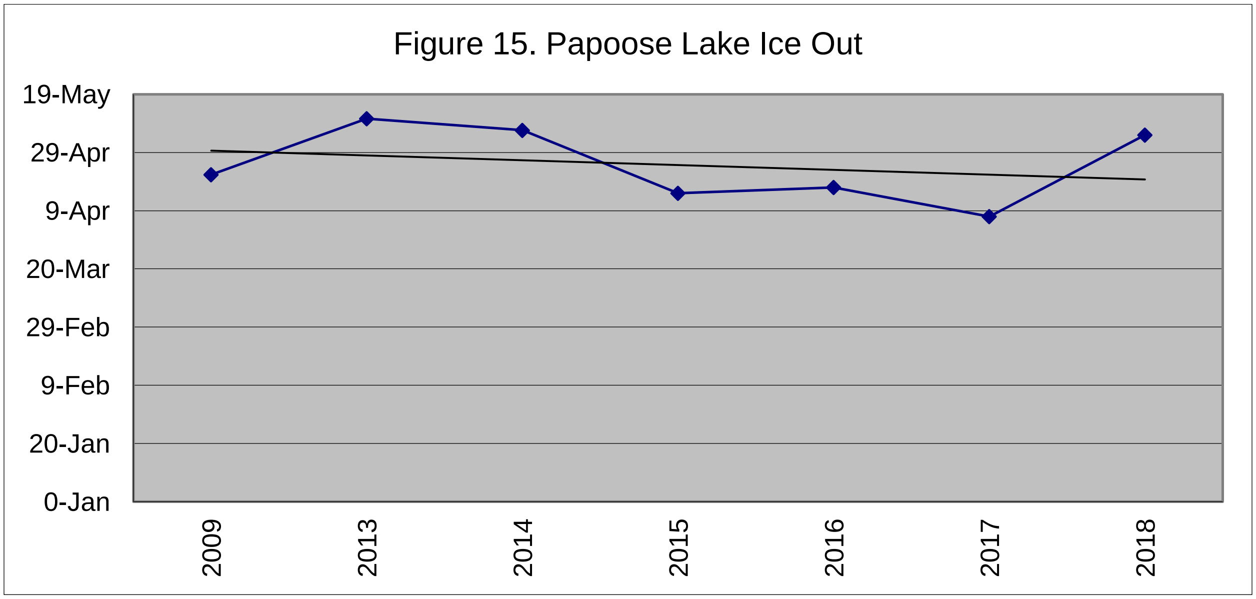
Water Level

When CLMN volunteers collect Secchi depth readings, they also record the lake level as "low," "normal," or "high." Figure 14 show that 54% of volunteers viewed Papoose Lake as having "normal" water levels.



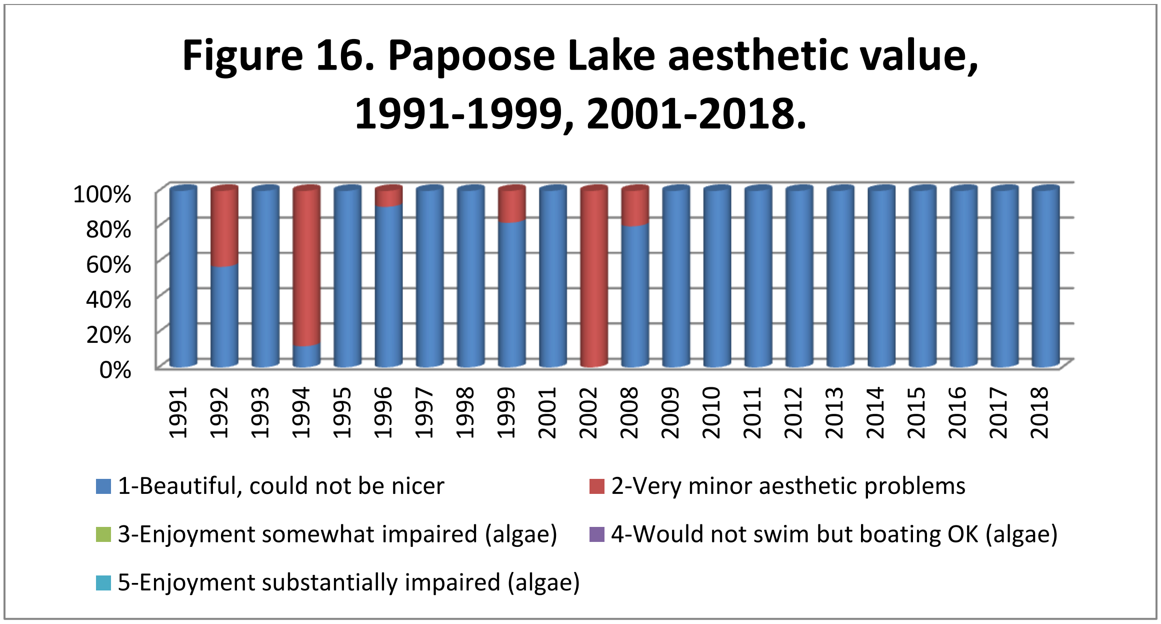
Ice Off

Figure 15 displays the seven years the CLMN documented ice off dates.



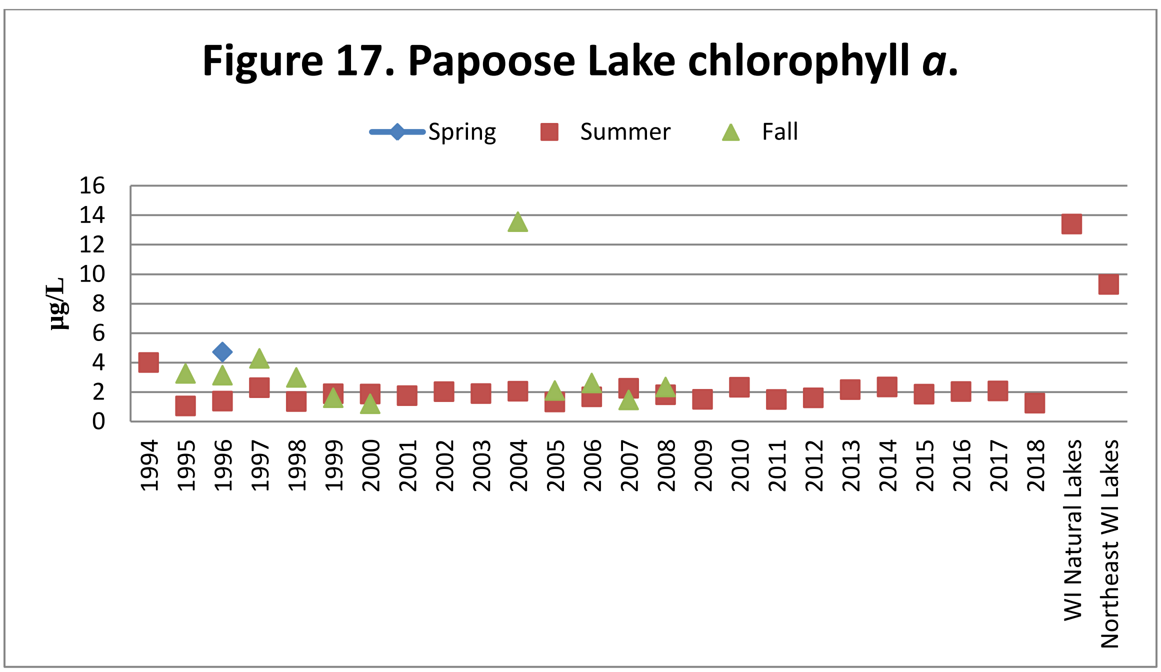
User Perceptions

CLMN volunteers also 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 the Secchi depth decreases, the rating of the lake's physical appearance also decreases. These perceptions of recreational suitability are displayed by year in Figure 16. In 1991, 1993, 1995, 1997-88, 2001, 2009-2018, 100% of CLMN volunteers recorded Papoose Lake to be "beautiful, could not be nicer." In 2002, 100% of volunteers said there were "very minor aesthetic problems." The values varied in all other years.



Chlorophyll *a*

Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is 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* values were below nuisance levels and well below the average levels for Wisconsin natural lakes (Figure 17). In Papoose Lake, the average of all the year's chlorophyll *a* values remain below the average for northeast WI lakes and the average for WI natural lakes.



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).

Papoose Lake's average total phosphorus (Figure 18) is below the average for northeast WI lakes and the average for WI natural lakes. This value can be considered "very good" with respect to total phosphorus (Figure 19).

Figure 18. Papoose Lake total phosphorus.

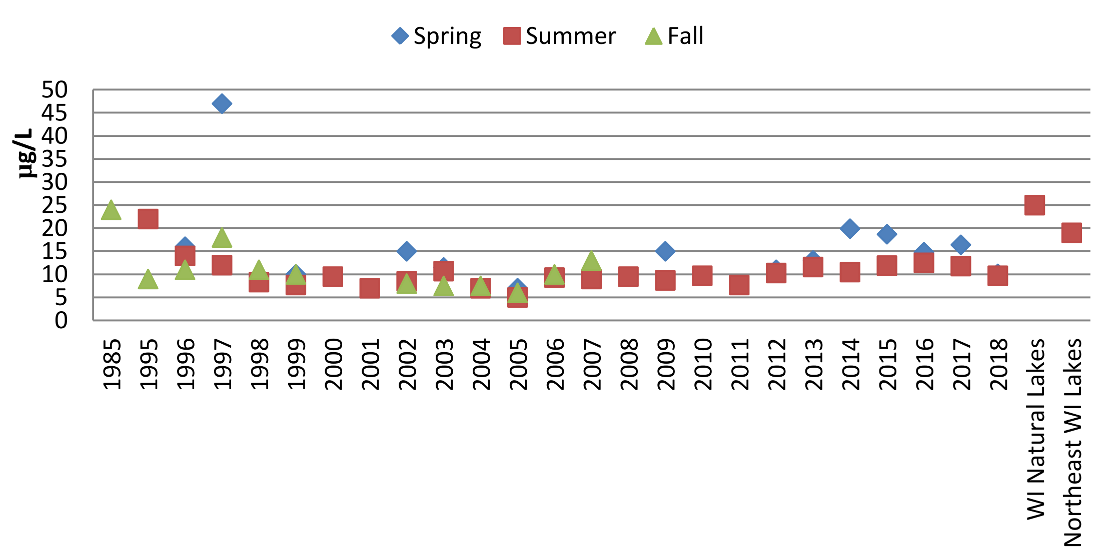
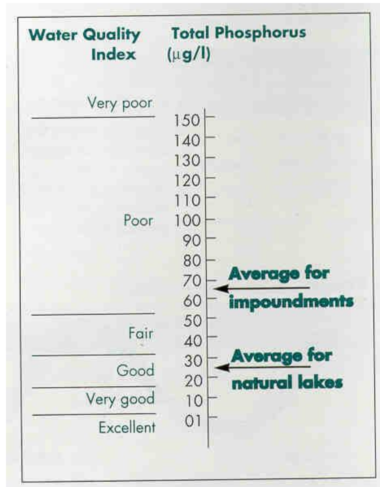


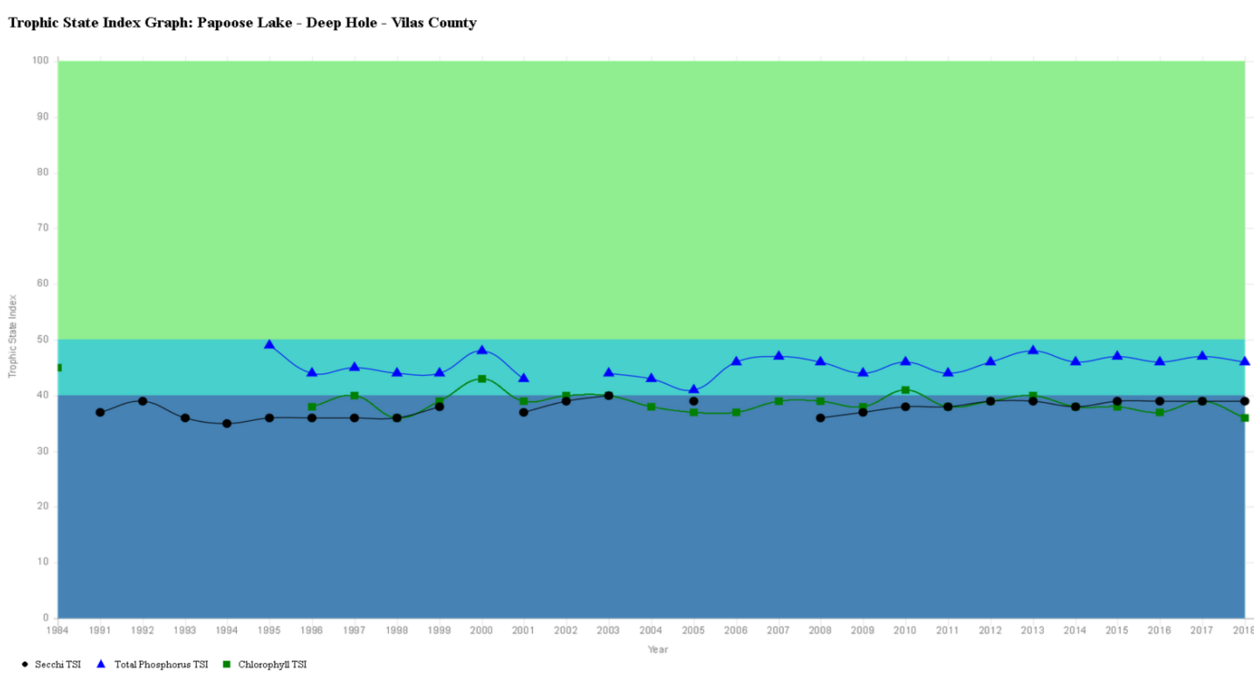
Figure 19. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).



Trophic State

Trophic state is another indicator of water quality (Carlson, 1977). Lakes are typically 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, chlorophyll *a*, and total phosphorus (Figure 20). Papoose Lake is classified as "oligotrophic" (Table 2).

Figure 20. Papoose Lake, (1984-2018).



(WDNR, 2019)

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, 2019)

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. 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). Papoose Lake was analyzed for total Kjeldahl nitrogen on 10/17/1985 (0.4 mg/L) and 7/28/2013 (0.31 mg/L); for nitrate-nitrite 10/17/1985 (0.02 mg/L) and 7/28/2013 (not detected), and for ammonium on 10/17/1985 (0.02 mg/L).

Chloride

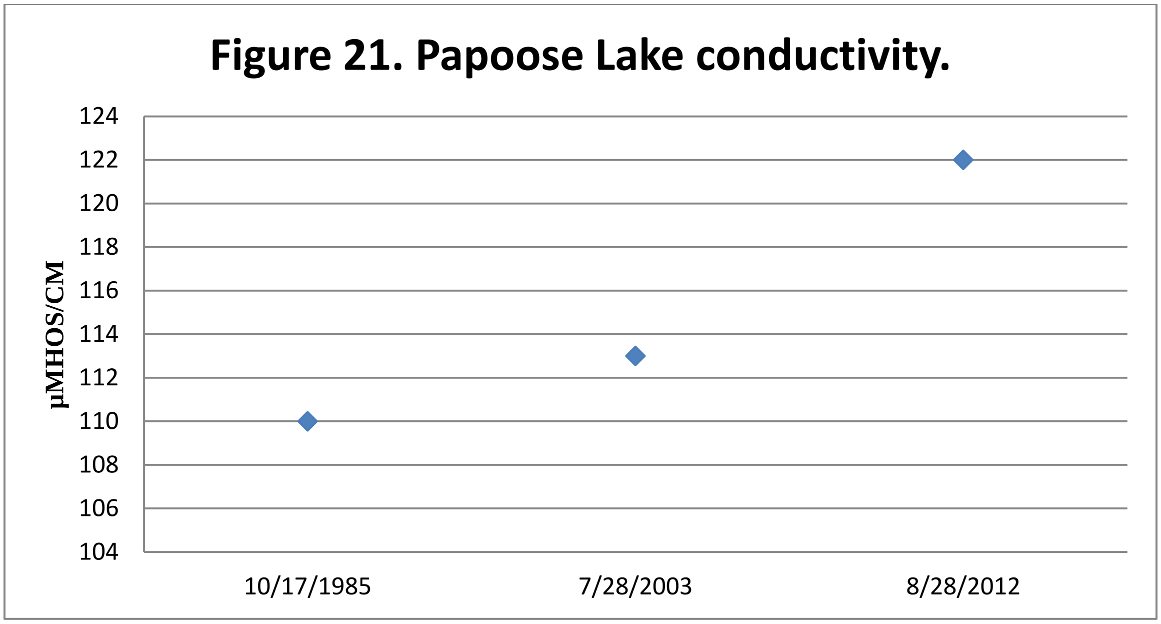
The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Chloride concentrations in Papoose Lake were well below the generalized distribution gradient of chloride found in surface waters in Wisconsin. Only trace amounts of chloride were found in Papoose Lake, at 1.4 and 1.7 mg/L in 10/17/1985.

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). There was one sample taken for sulfate on 10/17/1985 (3.1 mg/L) indicating that sulfate concentrations were low.

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). Papoose Lake conductivity is shown in Figure 21.



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. The pH of Papoose Lake is shown in Figure 22 indicating that the lake was neutral to slightly alkaline.

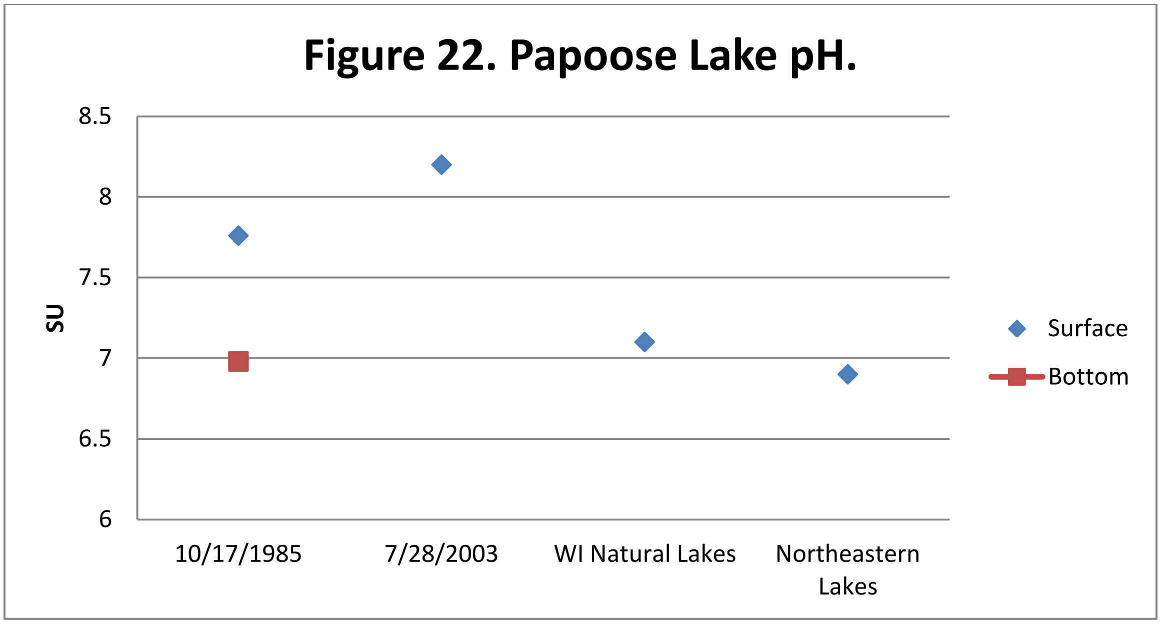


Table 4 shows the effects pH levels less than 6.5 can have on fish. Papoose Lake is slightly alkaline, which is above a level that would affect any fish species. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be harmful. In low pH waters, zinc, and 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. The alkalinity of Papoose Lake was 51 mg/L on 7/28/2003. This most recent alkalinity level categorizes Papoose Lake as "not sensitive to acid rain" (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 ($CaCO_3$). The total hardness of Papoose Lake, 53.93 mg/L on 10/17/1985, can be categorized as "soft" water (Table 6).

Table 6. Categorization of hardness (mg/L of calcium carbonate ($CaCO_3$)) (from 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. Papoose Lake has a calcium level of 15 and 18 mg/L (10/17/1985) and 16.8 mg/L (7/29/2003). Although this value is below 20 mg/L, outside influences (chemical or biological) could allow for zebra mussels may survive if introduced. Magnesium was 4 mg/L (10/17/1985) and 3.7 mg/L (7/28/2003) in Papoose Lake, which are lower than other lakes in the region.

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). Sodium (1 mg/L) and potassium (1 mg/L) were measured on 10/17/1985 both indicated low values.

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. Papoose Lake DOC was 6.92 mg/L on 6/17/2014.

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. Silica was analyzed on 10/17/1985 with a value of 5.6 and 12 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, phosphorus will not dissolve back into the water column as readily. Aluminum was measured on 10/17/1985 with a value of 25 µg/L.

Iron

Iron also forms sediment particles that 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. Iron data is unknown for Papoose Lake, so further water quality sampling should include this parameter.

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 Papoose 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 Papoose 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." Because total suspended solids data is unknown for Papoose Lake, future water quality sampling should include measurement of this parameter.

Aquatic Invasive Species

There are two invasive species found in Papoose Lake: rusty crayfish (found in 1975) and the Yellow iris (2015). White Water Associates biologist conducted a WDNR AIS Early Detection Survey on 5/23/2018 and found only the rusty crayfish. A detailed report is found in Appendix E.

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, 2014). 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, 2014). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2015). It is also illegal to release crayfish into a water body without a permit (WDNR, 2015).

The yellow iris (*Iris pseudacorus)* is a perennial aquatic plant native to Europe, western Asia and North Africa. It was first introduced to North America in the 1800s as an ornamental plant. Over time, the plant has spread too many wetlands and proliferated to the detriment of native plants and animals. Yellow iris is present in numerous Michigan and Wisconsin lake margins. The Yellow iris can reduce habitat needed by fish and waterfowl (Thomas,1980). A future survey, when the Yellow iris is in bloom, would be beneficial to determine what strategies could be used to help control this plant.

The University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention program classifies Papoose Lake as "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 efforts have not taken place on, Papoose Lake and they should consider applying for a grant to start this program.

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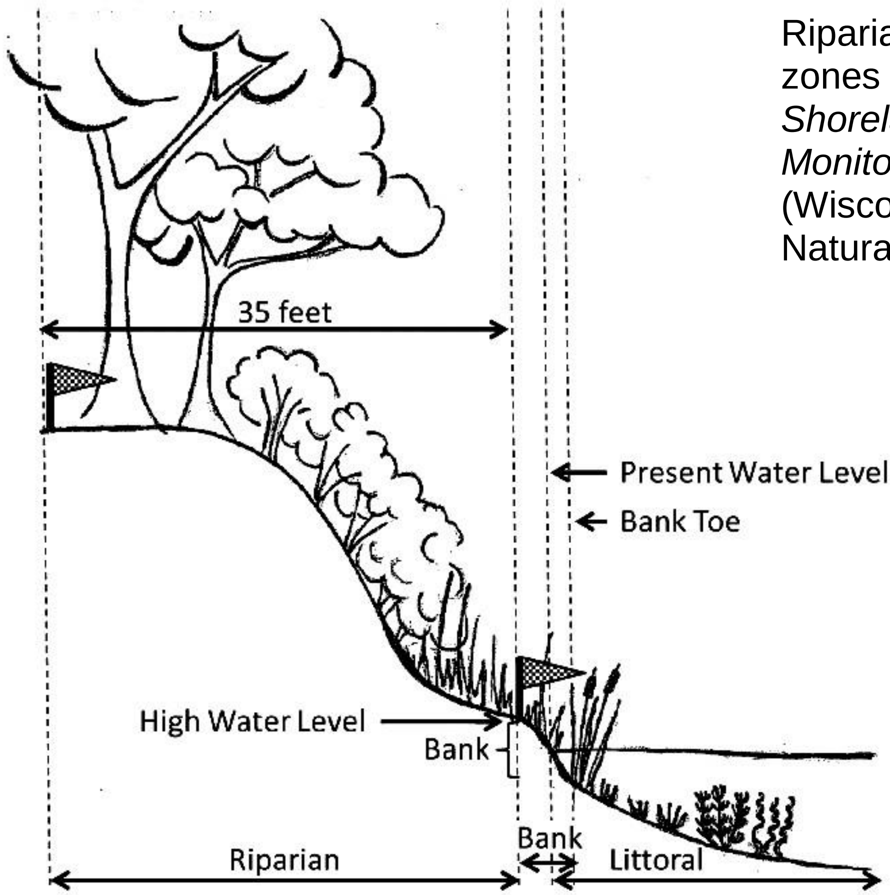
Appendix D

Papoose Lake Shoreland and Shallows Habitat Monitoring Report

Papoose Lake (Vilas County, Wisconsin)

Shoreland and Shallows Habitat Monitoring Report



Riparian, bank, and littoral zones covered by the *Shoreland & Shallows Habitat Monitoring Field Protocol* (Wisconsin Department of Natural Resources 2016)

White Water Associates, Inc.

Date: March 2019

INTRODUCTION

White Water Associates, Inc. is retained by the Presque Isle Town Lakes Committee (PITLC) as a consultant for the *Presque Isle Wilderness Waters Program.* A recent Wisconsin Department of Natural Resources (WDNR) lake planning grant to the PITLC included an assessment of the shoreland area and shallows habitat for Papoose Lake (Vilas County, Wisconsin). The assessment was conducted using the *Lake Shoreland and Shallows Habitat Monitoring Field Protocol* (WDNR 2016)[1]. This protocol provides a standard methodology for surveying, assessing, and mapping habitat in lakeshore areas, including the riparian buffer, bank, and littoral zone (WDNR 2016). This information will be useful to local and regional resource managers, community stakeholders, and others interested in protecting and enhancing Wisconsin's lakes and rivers (WDNR 2016).

METHODS

There are three principal components to the shoreland and shallows habitat monitoring: (1) obtain georeferenced photos of the entire lake shoreline area, (2) assess the riparian, bank, and littoral habitat by ownership parcel, and (3) count and map all pieces of large woody material in water less than 2 feet deep. In this section, we describe each of these components.

The photographic component of the monitoring documented shoreland habitat conditions around the lake at the time of the survey. Results may be referred to in future years (WDNR 2016). Digital photos were taken with the intent to slightly overlap, thus capturing the entire shoreline. The survey crew used the boat to circumnavigate the lake at a distance of approximately 50 feet perpendicular from shore where conditions permitted. This standardized relative position on the lake allowed the photos to include the water's edge and understory vegetation 35 feet inland. A digital camera with an internal GPS was used to capture the photos. Exhibit 1 provides an example photograph. In the laboratory, photos were processed, georeferenced, and provided as part of the data package to the WDNR.

[1] Wisconsin Department of Natural Resources. May 27, 2016. *Draft Lake Shoreland & Shallows Habitat Monitoring Field Protocol.* WDNR 2016.

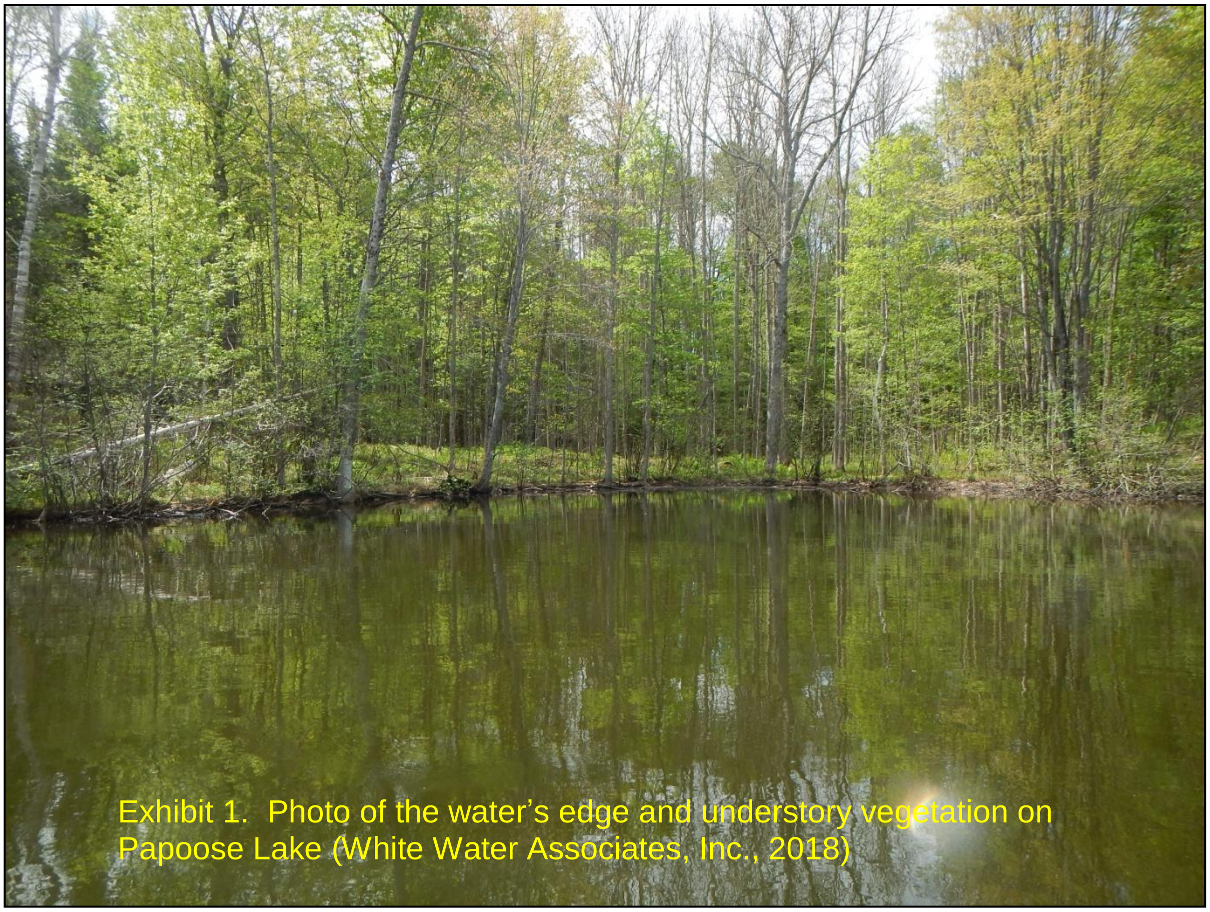


Exhibit 1. Photo of the water's edge and understory vegetation on Papoose Lake (White Water Associates, Inc., 2018)

The shoreline habitat assessment was conducted for every ownership parcel on the lake. To facilitate this effort, parcel data was obtained March 2017 via the Wisconsin Statewide Parcel Map, which can be found at https://maps.sco.wisc.edu/Parcels/. Parcel IDs and shoreline lengths were derived from these spatial data files. Parcel IDs and parcel lines, together with a "riparian buffer" line at 35 feet from the shoreline, were layered onto aerial photography maps saved as a georeferenced image file viewed on the Avenza Maps application on an Apple® iPad Pro 9.7 equipped with GPS for offline navigation. The GPS function of the iPad allowed the survey crew to know their position relative to the shoreline and specific parcels. Data sheets were prepared that included parcel ID numbers and frontage feet of each parcel (an example data sheet is shown in Exhibit 2). Exhibit 2 also shows the categories that were documented for each parcel. Back in the laboratory, data recorded on field data sheets were input to a Microsoft Office Excel spreadsheet and later conveyed to the WDNR as part of the data package to be included in a publicly available database.

The woody habitat component of the assessment was conducted on a separate circumnavigation of the lake. Before starting, a Secchi depth was measured. The protocol specifies that if the Secchi depth is less than two feet, no woody habitat survey will be conducted due to poor visibility (WDNR 2016). In addition to the Secchi depth, lake water level was documented relative to the lake's *high water level* (HWL). As the lake was circumnavigated, large wood was enumerated. The protocol defines "large wood" as wood greater than 4 inches in diameter somewhere along its length and at least 5 feet long. Eligible large wood was that which was located between the high water level and the 2 foot depth contour and the large wood section must be in the water or below the high water level. Tree "branchiness" ranking was recorded as "0" (no branches), "1" (few branches), or "2" (tree trunk with full crown). Additional details on eligible large wood are provided in the protocol document (WDNR 2016). A GPS was used to document each eligible piece of large wood. A datasheet entry corresponded to each large wood piece. An example datasheet is provided as Exhibit 3.

FINDINGS

The data and photos for the assessment of shoreland area and shallows habitat for Papoose Lake have been delivered to the WDNR. Any user can view the results in the Wisconsin Department of Natural Resources Lakes and AIS Mapping Tool found at: https://dnr.wi.gov/lakes/viewer/ . In this section we summarize a few of the data and provide some example maps that illustrate the findings from the assessment.

The assessment was conducted on May 23, 2018. At the time of the survey there were 158 ownership parcels on Papoose Lake. The shoreline perimeter of Papoose Lake is 7.91 miles. Exhibit 4 summarizes some of the Papoose Lake data. Exhibits 5 through 13 provide maps of findings on Papoose Lake. Any interested party can access the data in the database and create maps of this type or maps specific to detailed areas of shoreland and shallow water habitat.

In general, the assessment shows the shoreland and shallow water habitat of Papoose Lake to be of high quality. There is excellent tree canopy coverage as well as shrub and herbaceous coverage. That being said, there is evidence of human influence in the riparian buffer zone and bank zone. The number of large wood pieces per mile of shoreline is moderate to somewhat low.

LAKE STRATEGY

Papoose Lake is a high quality lake with good shallow water habitat and intact riparian area. Lake stewardship could primarily be directed toward protection of the current conditions and monitoring to detect changes over time. Although Papoose Lake is in a mostly natural state, there are many parcels that could undertake some restoration to ameliorate possible runoff and erosion issues. These areas can be identified by investigating the 2018 monitoring data in maps and tables in this report as well as in the WDNR database (link given previously). The Healthy Lakes program in Wisconsin provides simple, practical, and inexpensive best practices that improve habitat and water quality on lakeshore property (see https://healthylakeswi.com/ for additional information and guidance on funding projects). Papoose Lake large woody habitat could be augmented with the "fish sticks" best practice.

Habitat Assessment Data Sheet (one per parcel)

Date ______________ Lake name ____________________________ WBIC___________

Parcel ID__________________ Observers____

RIPARIAN BUFFER ZONE

Percent Cover — Percent

Canopy ☐ (0-100)

Shrub ☐ Herbaceous ☐

Shrub/Herbaceous ☐

Impervious surface ☐

Manicured lawn ☐ sum=100

Agriculture ☐

Other (e.g. duff, soil, mulch) ☐

description:_________________________

Human Structures — Number

Buildings ☐

Boats on shore ☐

Fire pits ☐

Other ☐

description:_________________________

Runoff Concerns in Riparian or Entire Parcel	Present in Riparian	Present out of Riparian
Point source	☐	☐
Channelized water flow/gully	☐	☐
Stair/trail/road to lake	☐	☐
Lawn/soil sloping to lake	☐	☐
Bare soil	☐	☐
Sand/silt deposits	☐	☐
Other	☐	☐

description:_________________________

Notes:

BANK ZONE	Length (ft)
Vertical sea wall	
Rip rap	
Other erosion control structures	
Artificial beach	
Bank erosion > 1 ft face	
Bank erosion < 1 ft face	

LITTORAL ZONE

Human Structures	Number
Piers	
Boat lifts	
Swim rafts/water trampolines	
Boathouses (over water)	
Marinas	
Other	

description:_______________________

Aquatic Plants	Present
Emergents	☐
Floating	☐
Plant Removal	☐

If Applicable (low water level):

EXPOSED LAKE BED ZONE

Plants	Present
Canopy	☐
Shrubs	☐
Herbaceous	☐
Disturbed	
Plants (mowed or removed)	☐
Sediment (tilled or dug)	☐

Exhibit 2. Example habitat assessment data sheet.

Exhibit 3. Coarse woody habitat inventory data sheet.

Date ______________ Lake name ___________________________ WBIC___________

Observers____

Present water level is ☐ Below ☐ At ☐ Above the High Water Level Secchi depth ______ ft

ID	Branch	Touch Shore	In Water	ID	Branch	Touch Shore	In Water	ID	Branch	Touch Shore	In Water	ID	Branch	Touch Shore	In Water
1				26				51				76			
2				27				52				77			
3				28				53				78			
4				29				54				79			
5				30				55				80			
6				31				56				81			
7				32				57				82			
8				33				58				83			
9				34				59				84			
10				35				60				85			
11				36				61				86			
12				37				62				87			
13				38				63				88			
14				39				64				89			
15				40				65				90			
16				41				66				91			
17				42				67				92			
18				43				68				93			
19				44				69				94			
20				45				70				95			
21				46				71				96			
22				47				72				97			
23				48				73				98			
24				49				74				99			
25				50				75				100			

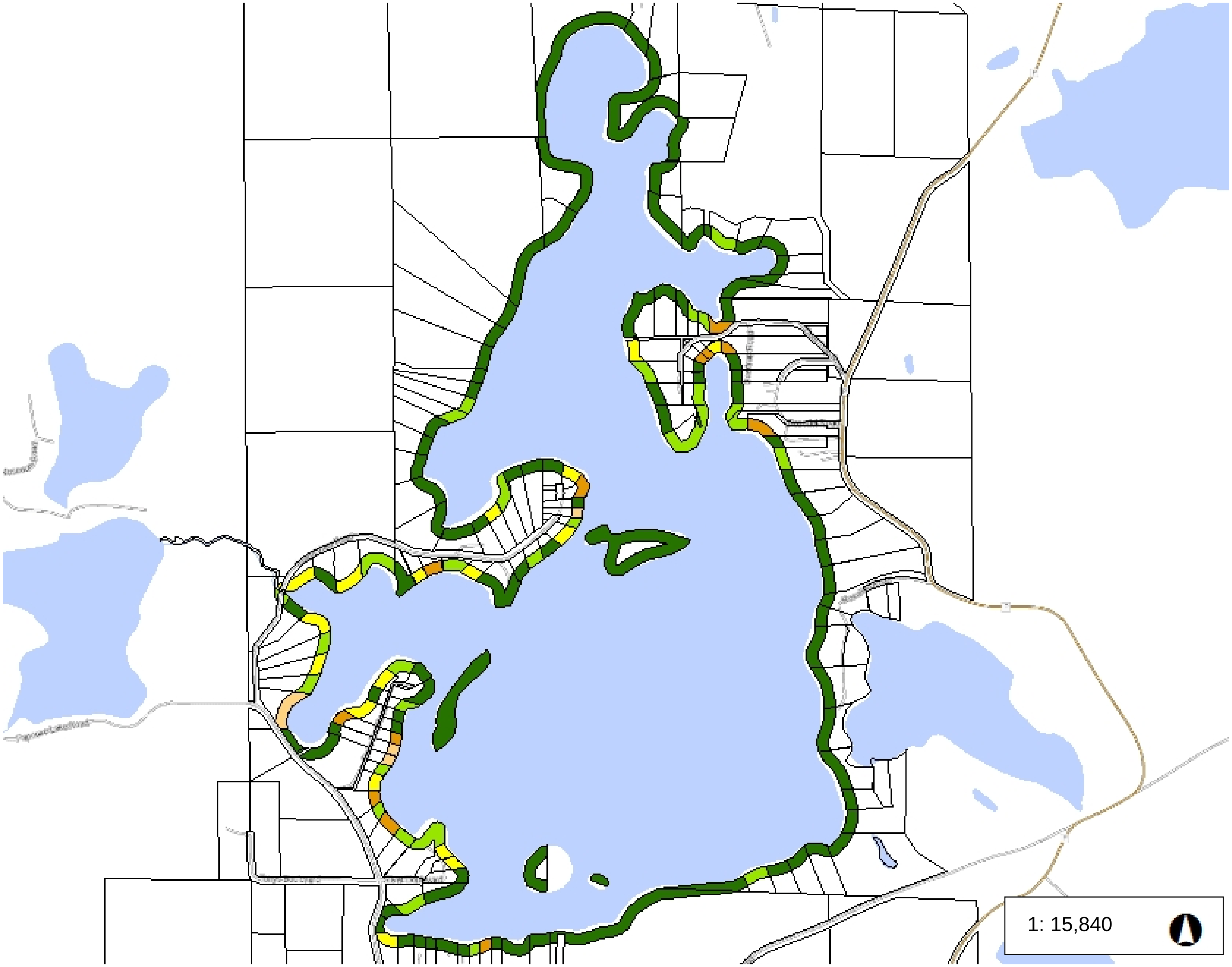
Branch: 0 = no branches, 1 = a few branches, 2 = full tree crown

Touch Shore: 0 = entirely below High Water Level (HWL), 1 = crosses HWL

In Water: 0 = less than 5 ft of log is currently underwater, 1 = at least 5 ft of log is currently underwater

Exhibit 4. Summary of shoreland and shallow water habitat for Papoose Lake.		
Date of Survey: May 23, 2018	Miles of shoreline: 7.91	
Number of ownership parcels: 158	Mean parcel frontage feet: 264	
Riparian Buffer Zone	# of parcels	% of parcels
Impervious surfaces	79	50%
Manicured lawn	79	50%
Agriculture	0	0%
Other (duff, soil, mulch)	134	85%
Human structures (buildings, boats on shore, fire pit, other)	119	75%
Runoff concerns on the parcel (e.g., point source; channelized water flow; stair, trail, or road to lake; lawn or soil sloping to lake; bare soil; sand/silt deposits)	116	73%
Bank Zone	# of parcels	% of parcels
Concerns in the bank zone (e.g., vertical sea wall, rip rap, other erosion control structures, artificial beach, active erosion)	41	26%
Littoral Zone	# of parcels	% of parcels
Human structures in littoral zone (e.g., piers, boat lifts, swim rafts, water trampolines, boat houses over water, marinas, other)	121	77%
Emergent and/or floating aquatic plants	15	9%
Evidence of aquatic plant removal	0	0%
Large Wood Habitat		
Total Number of large wood pieces	442	
Number of large wood pieces per mile of shoreline	55.9	

Exhibit 5. Papoose Lake Riparian Coverage - % Canopy - 2018



Legend

Percent Canopy
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

Shoreland Parcels
County Boundary
Municipality
State Boundaries
County Boundaries

Major Roads
- Interstate Highway
- State Highway
- US Highway

County and Local Roads
- County HWY
- Local Road

Railroads
Tribal Lands
Rivers and Streams
Intermittent Streams
Open Water
Great Lakes

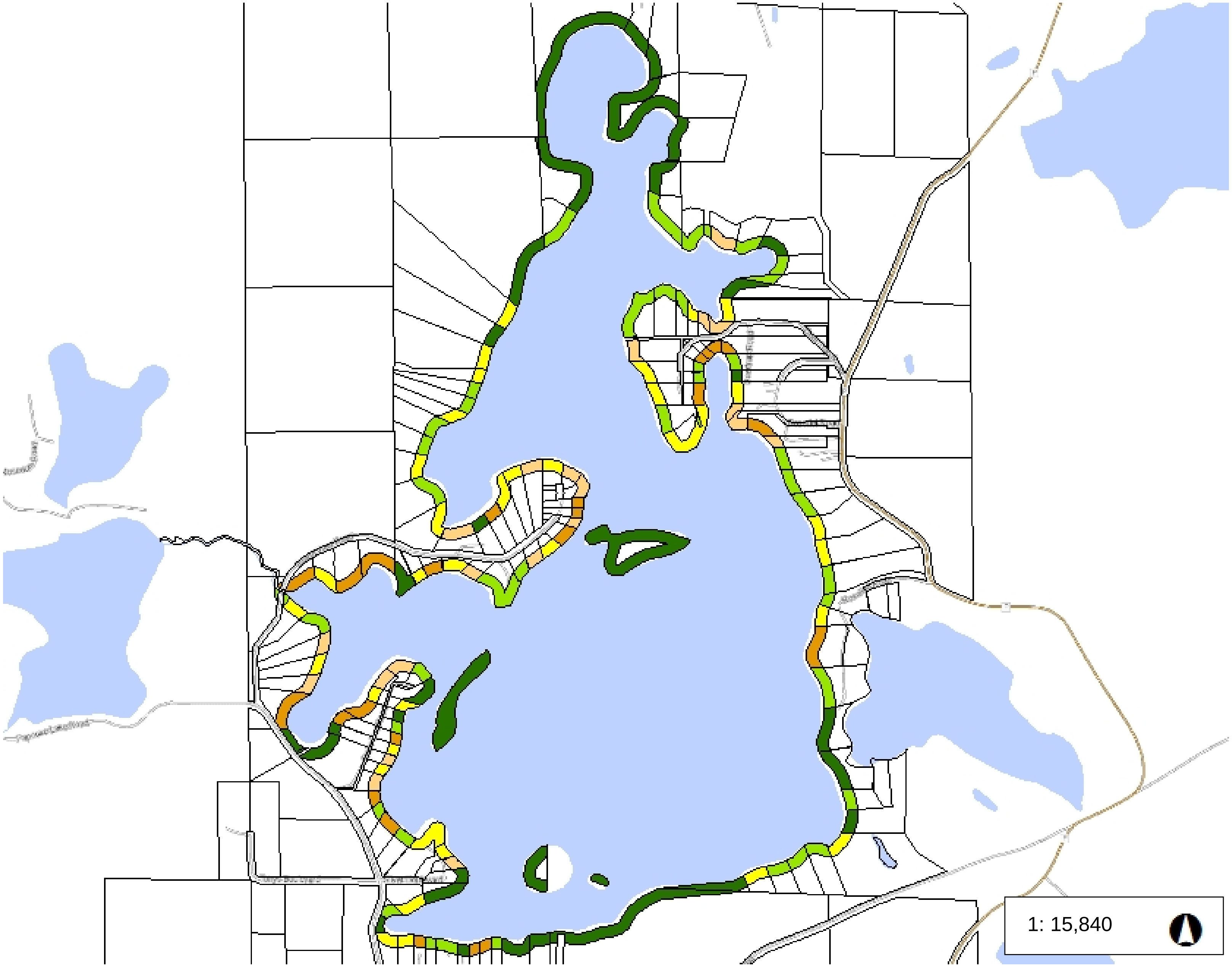
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

Exhibit 6. Papoose Lake Riparian Coverage - % Shrub Herbaceous - 2018



Legend

Percent Shrub Herbaceous

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries

Major Roads

- Interstate Highway
- State Highway
- US Highway

County and Local Roads

- County HWY
- Local Road

- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

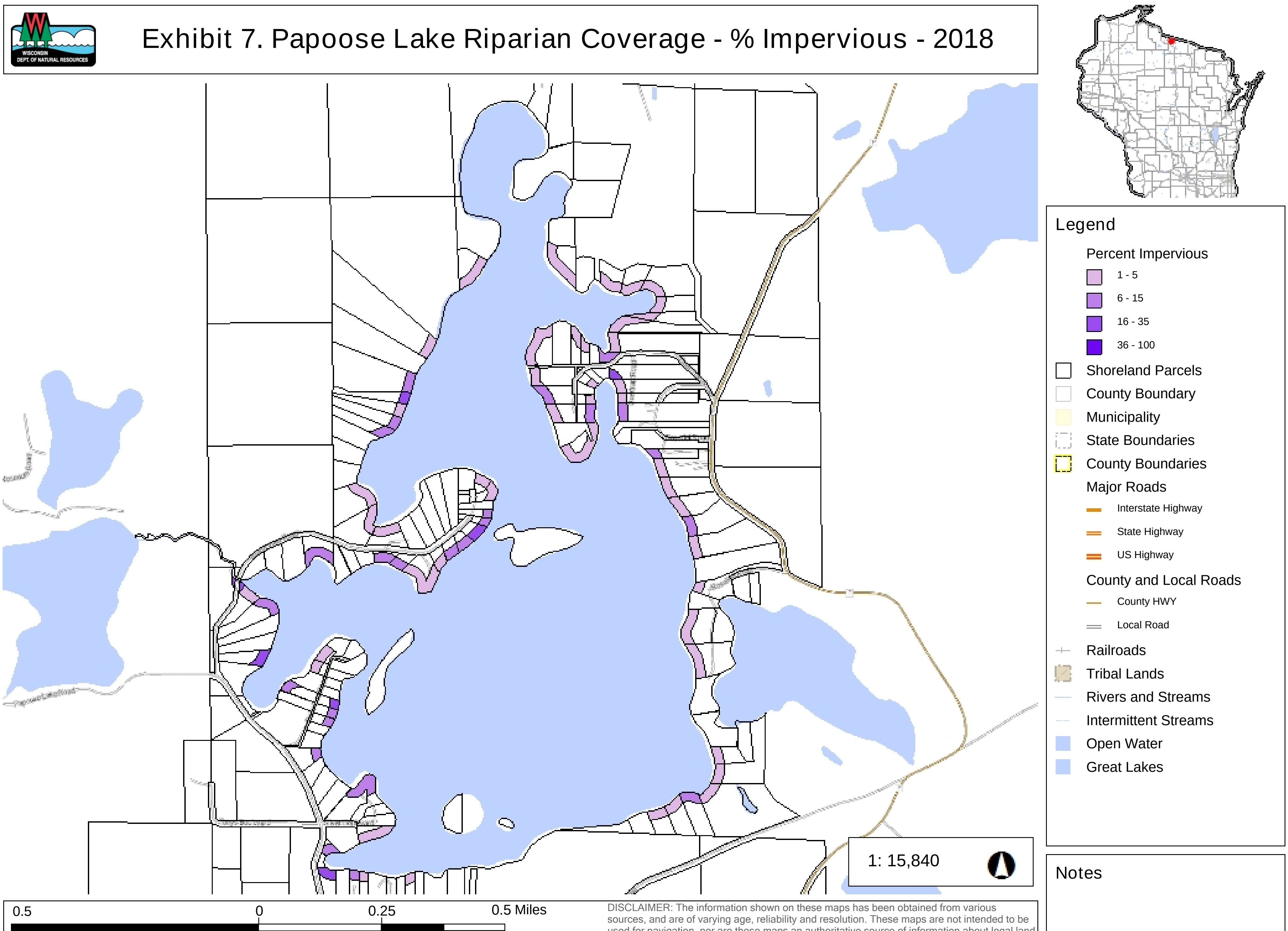
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

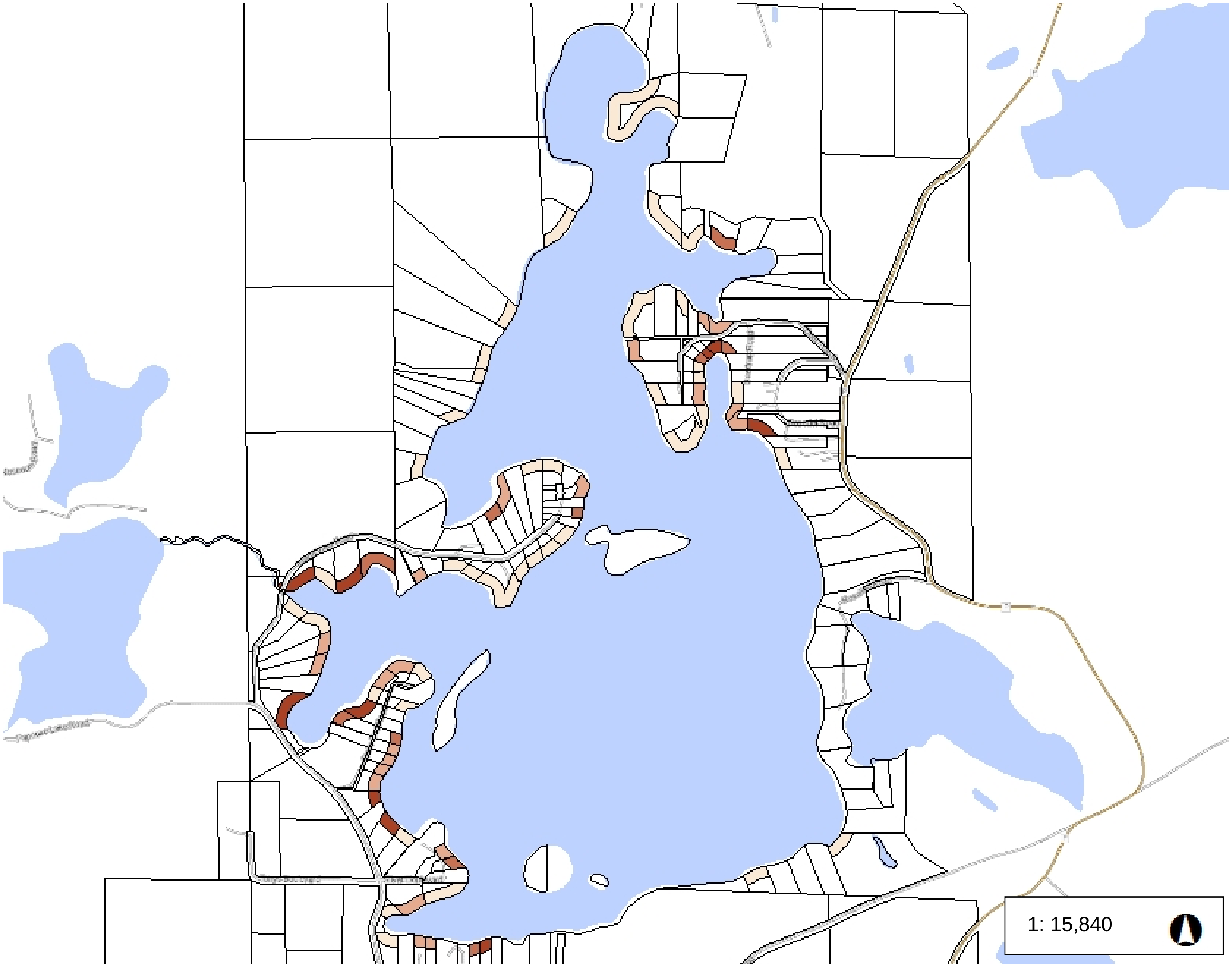
NAD_1983_HARN_Wisconsin_TM

Exhibit 7. Papoose Lake Riparian Coverage - % Impervious - 2018



DISCLAIMER: The information shown on these maps has been obtained from various sources, and are of varying age, reliability and resolution. These maps are not intended to be used for navigation, nor are these maps an authoritative source of information about legal land ownership or public access. No warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on this map. For more information, see the DNR Legal Notices web page: http://dnr.wi.gov/legal/

Exhibit 8. Papoose Lake Riparian Coverage - % Manicured Lawn - 2018



Legend

Percent Manicured Lawn
- 1 - 25
- 26 - 50
- 51 - 75
- 76 - 100

Shoreland Parcels

County Boundary

Municipality

State Boundaries

County Boundaries

Major Roads
- Interstate Highway
- State Highway
- US Highway

County and Local Roads
- County HWY
- Local Road

Railroads

Tribal Lands

Rivers and Streams

Intermittent Streams

Open Water

Great Lakes

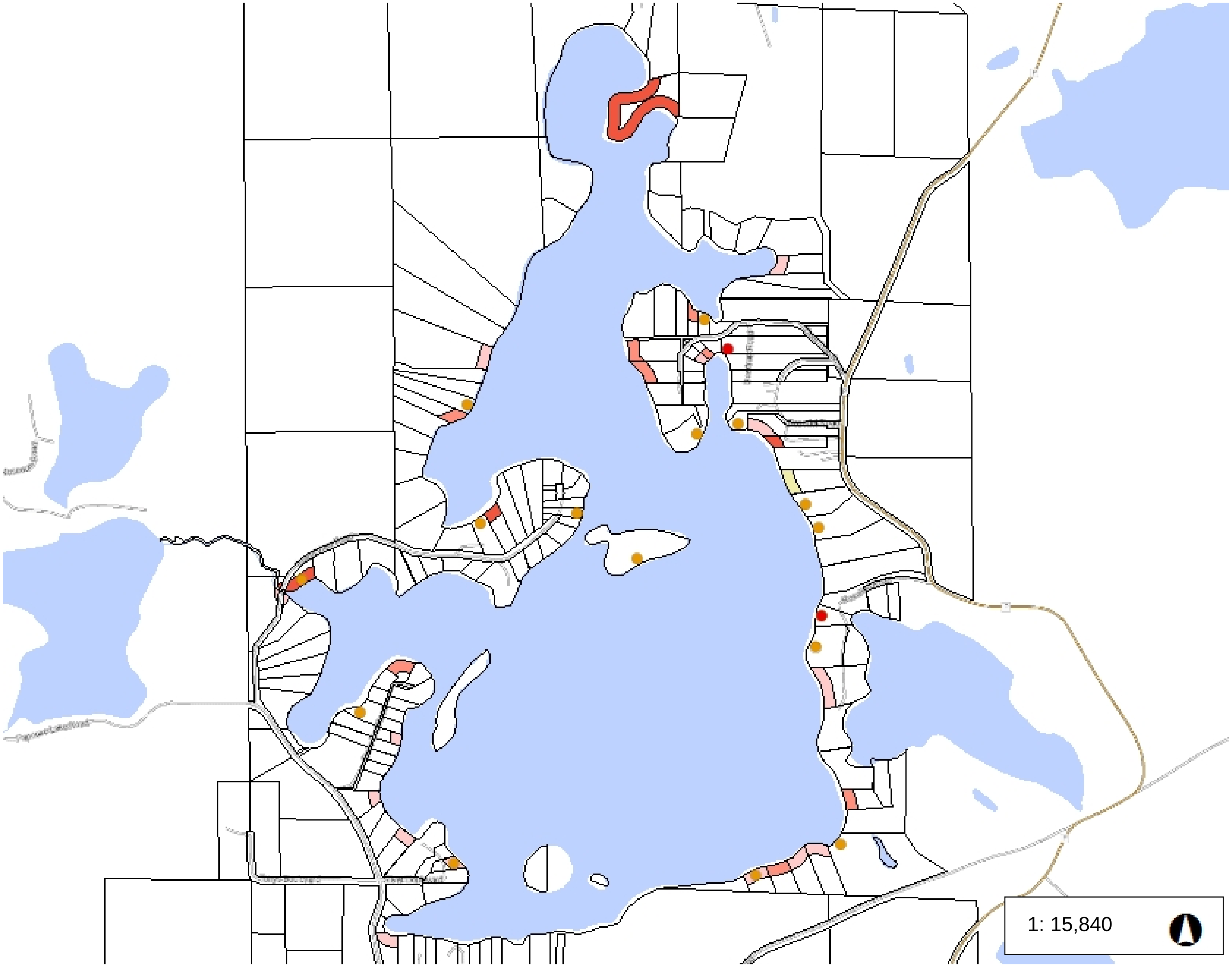
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

Exhibit 9. Papoose Lake Bank Erosion and Modifications - 2018



Legend

- Bank Erosion >1ft
- Bank Erosion <1ft

Vertical Sea Wall
- 1 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200 + ft

Rip Rap
- 1 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

Other Bank Modifications
- 10 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

Artificial Beach
- 0 - 50 ft
- 51 - 100 ft
- 101 - 200 ft
- 200+ ft

Shoreland Parcels
County Boundary
Municipality
State Boundaries

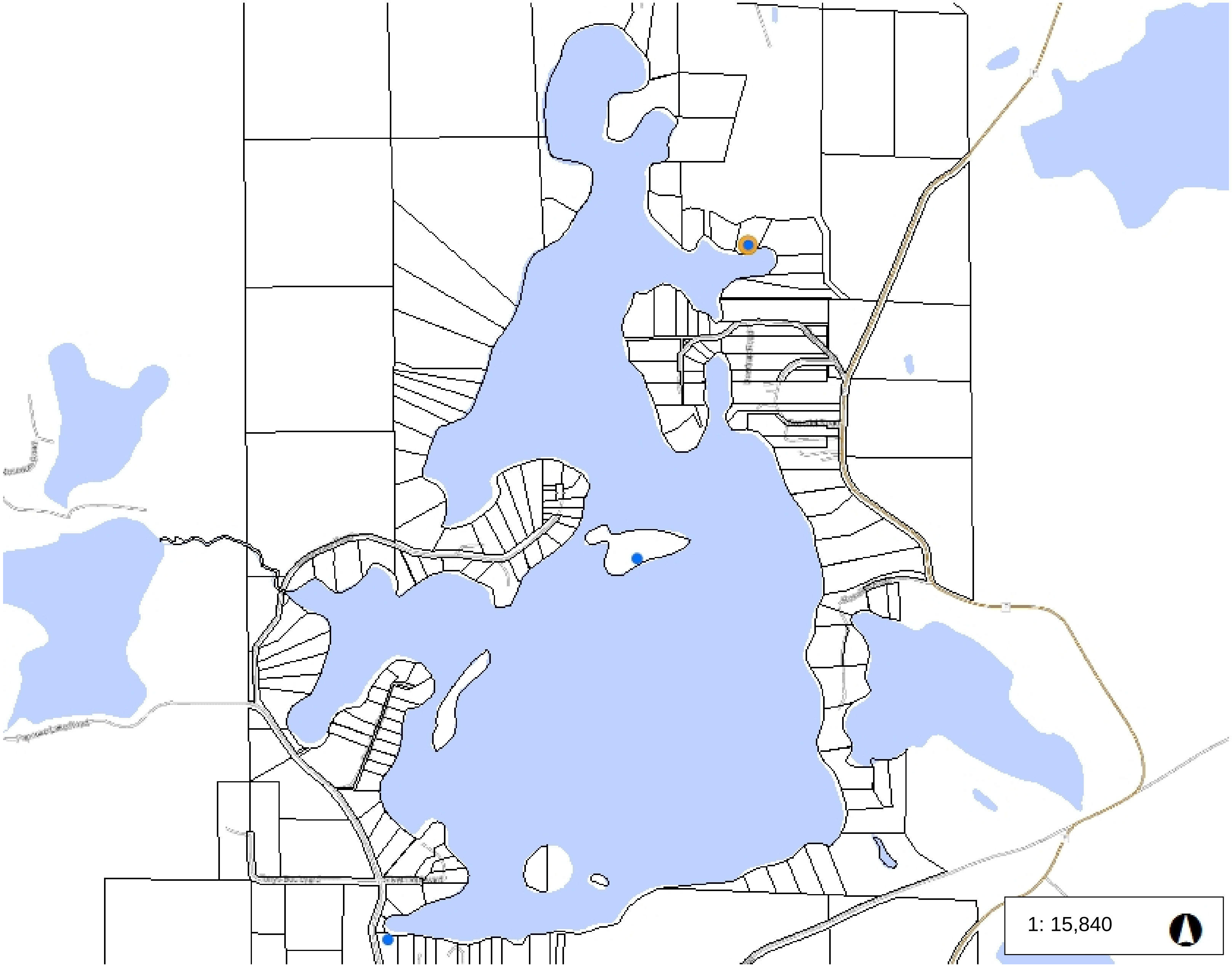
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

Exhibit 10. Papoose Lake Runoff Concerns - 2018



Legend

- Channelized Flow
- Point Source
- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries
- Major Roads
  - Interstate Highway
  - State Highway
  - US Highway
- County and Local Roads
  - County HWY
  - Local Road
- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

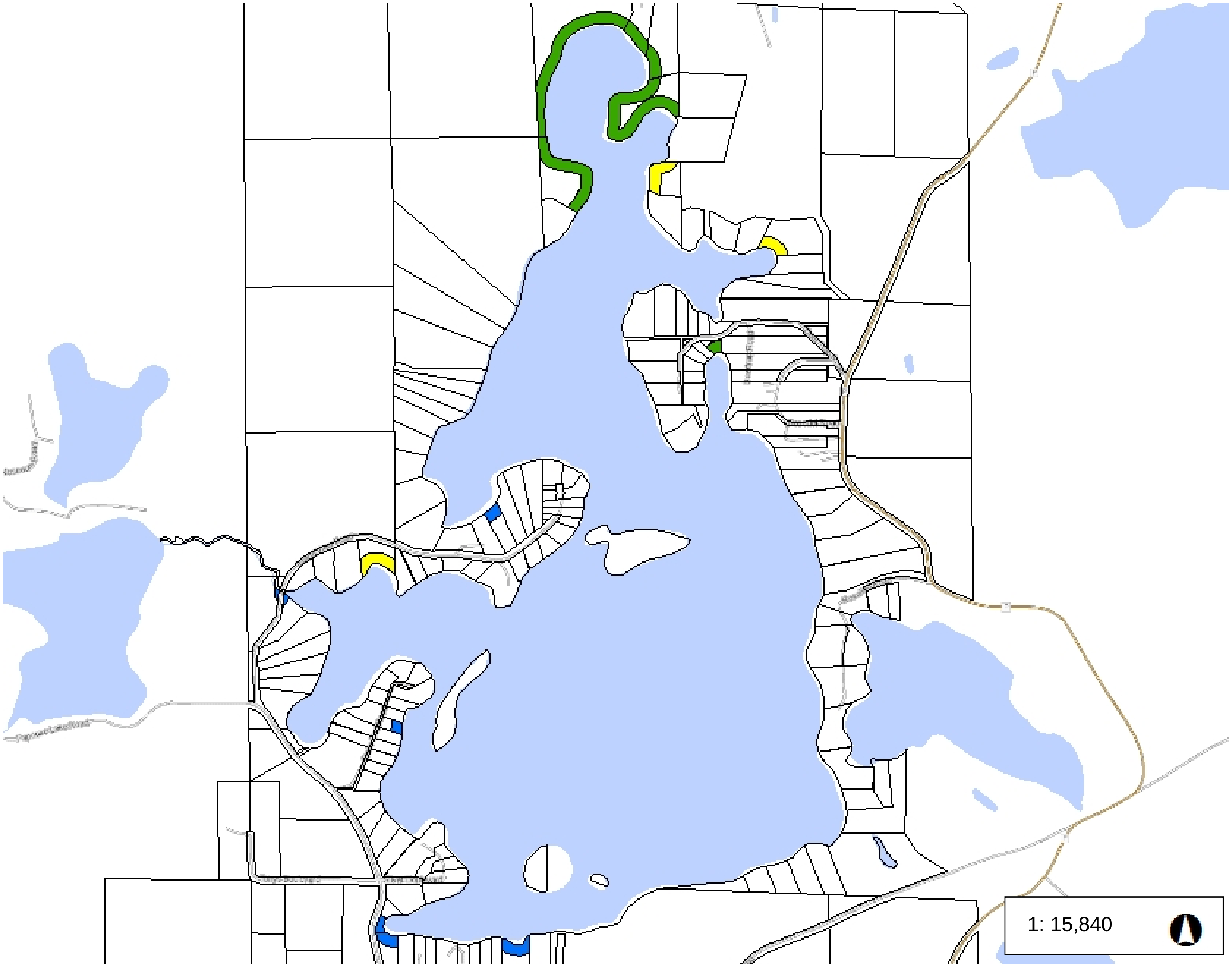
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

Exhibit 11. Papoose Lake Littoral Zone - Aquatic Plants - 2018



Legend

- Aquatic Plant Removal
- Floating & Emergent Plants
- Emergent Plants
- Floating Plants
- Shoreland Parcels
- County Boundary
- Municipality
- State Boundaries
- County Boundaries
- Major Roads
  - Interstate Highway
  - State Highway
  - US Highway
- County and Local Roads
  - County HWY
  - Local Road
- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Open Water
- Great Lakes

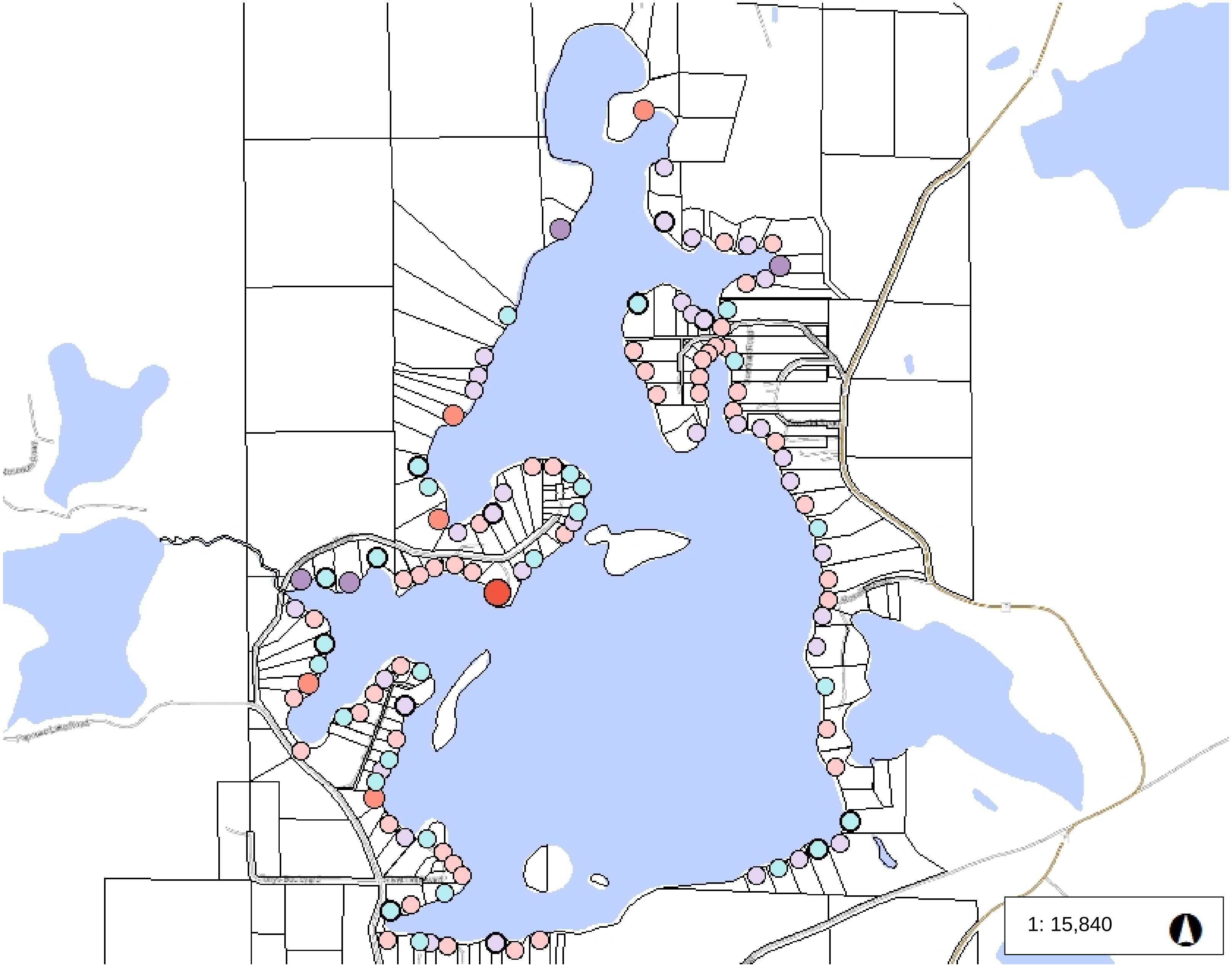
1: 15,840

Notes

0.5 0 0.25 0.5 Miles

NAD_1983_HARN_Wisconsin_TM

Exhibit 12. Papoose Lake Littoral Zone - Human Structures - 2018



Legend

Swim Rafts
- 1
- 2
- 3 - 5
- 6+

Boat Lifts
- 1
- 2
- 3 - 5
- 6+

Piers
- 1
- 2
- 3 - 5
- 6+

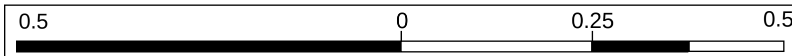
Boat Houses
- 1
- 2
- 3 - 5
- 6+

Marinas
- 1
- 2
- 3 - 5
- 6+

Shoreland Parcels

1: 15,840

Notes



NAD_1983_HARN_Wisconsin_TM

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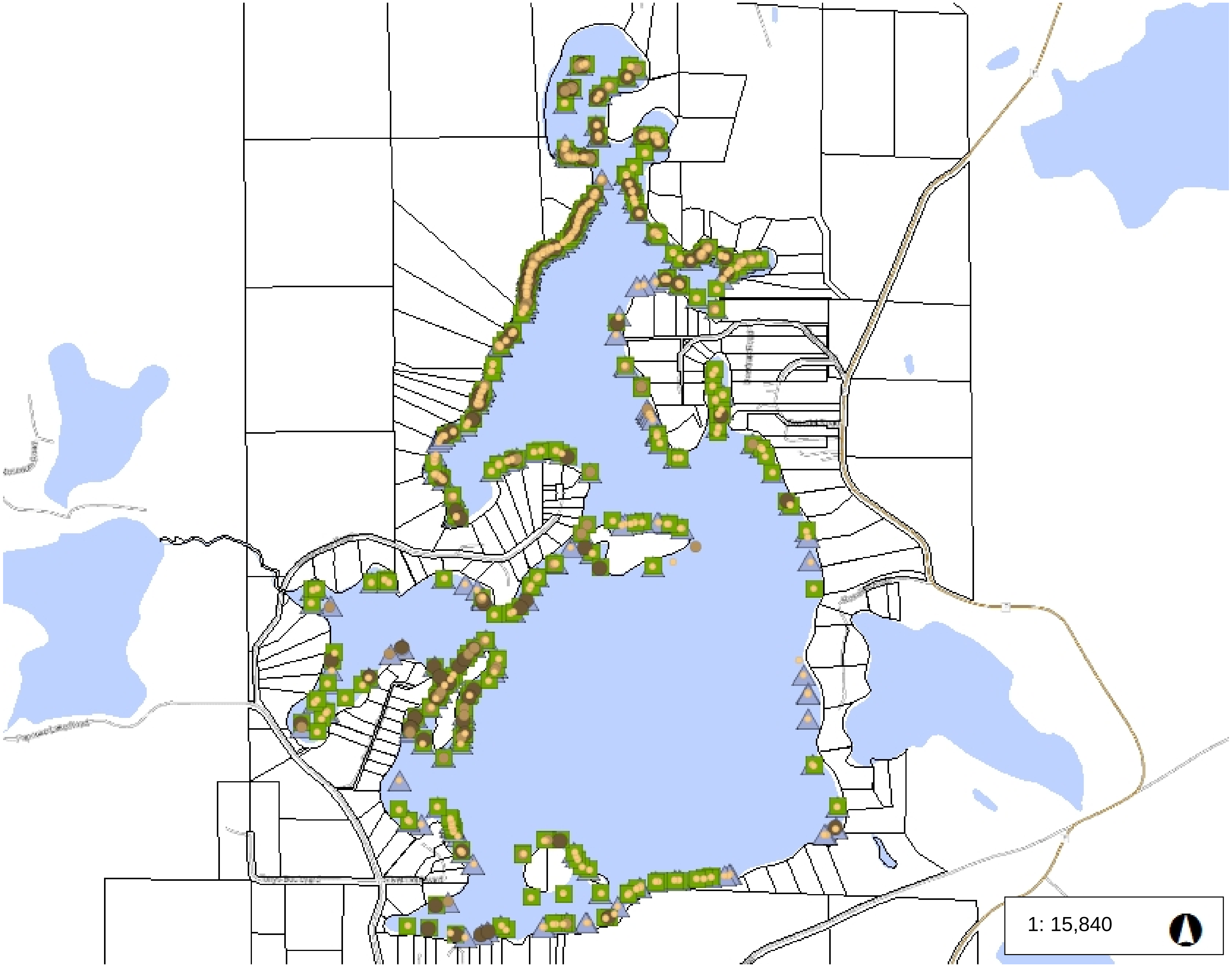
Exhibit 13. Papoose Lake Woody Habitat - 2018



Legend

WH Branchiness
- No branches
- Few branches
- Full tree crown

WH Touching Shore
WH In Water
Shoreland Parcels
County Boundary
Municipality
State Boundaries
County Boundaries

Major Roads
- Interstate Highway
- State Highway
- US Highway

County and Local Roads
- County HWY
- Local Road

Railroads
Tribal Lands
Rivers and Streams
Intermittent Streams
Open Water
Great Lakes

1: 15,840

Notes

0.5 0 0.25 0.5 Miles

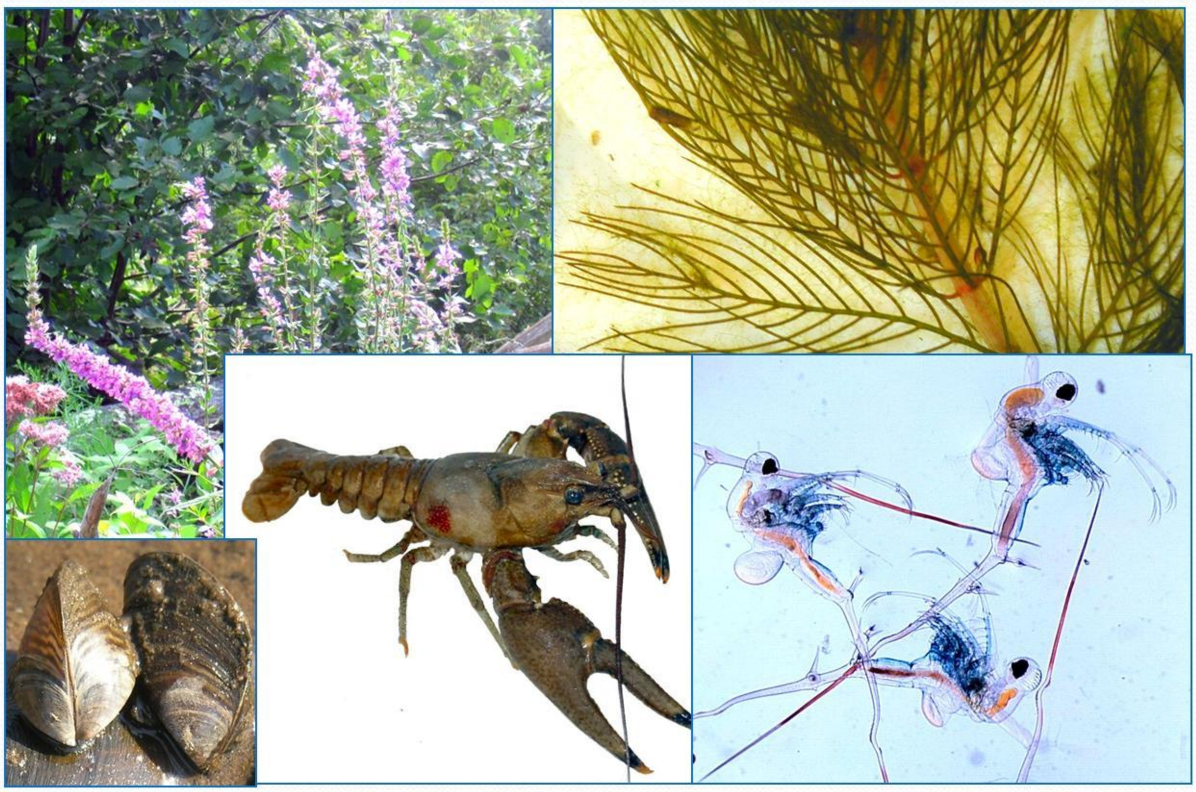
NAD_1983_HARN_Wisconsin_TM

Appendix E

Papoose Lake Aquatic Invasive Species Report

Papoose Lake (Vilas County, Wisconsin)

Aquatic Invasive Species Report



WHITE WATER ASSOCIATES, INC.

Date: 2019

INTRODUCTION

White Water Associates, Inc. has been retained by Wilderness Waters through a Large Scale Planning Grant on Papoose Lake (Vilas County, Wisconsin). Some tasks for this grant focused on aquatic invasive species. It is intended to increase the understanding of AIS as well as native species in Papoose Lake, and prepares the Papoose Lake stakeholders to undertake and continue stewardship actions that serve lake health. A portion of this project monitored Papoose Lake for AIS using Wisconsin Department of Natural Resources (WDNR) protocol. This approach assesses the lake as to its vulnerability to AIS and documents aquatic invasive plant species as detected. Findings from the survey were entered into the SWIMS database. A broader educational activity was delivered in the form of a *floating workshop* for Papoose Lake enthusiasts and interpreted and discusses lake health, riparian ecology, and the impacts that invasive species can have on these important ecosystems.

AQUATIC INVASIVE SPECIES EARLY DETECTION MONITORING

In order to determine if other aquatic invasive species (AIS) were present in study areas, biologists followed the *Aquatic Invasive Species Early Detection Monitoring Standard Operating Procedure* (WDNR, 2014). This procedure outlines several types of monitoring techniques, including: boat landing searches, sample site searches, targeted searches, waterflea tows and/or a Ponar dredge, and a meander search. The Papoose Lake Survey took place May 23, 2018.

Five sites around the lake shoreline were searched along with a meander search in between sites. The public boat landing was searched by wading in the riparian area. The landing was surveyed for 30 minutes, covering 200 feet of shoreline. The other four shoreline sites were randomly selected and are identified in Map 1 and Table 1. Snorkeling was not used to search for AIS due to the high water clarity and the cool water temperature. A long rake was used to collect any suspicious aquatic plants for closer inspection and identification. A D-net was used to collect invertebrate animals to look for AIS. Any invasive species observed were recorded. In the event of a new AIS record, specimens are collected for verification. The only invasive that was found was the rusty crayfish which was already established in Papoose Lake.

Spiny water fleas are an aquatic invasive zooplankton species that is found in a few lakes in Wisconsin. They can be monitored by way of plankton tow nets or by an examination of sediment for dead waterflea exoskeleton fragments. In Papoose Lake, a Ponar dredge was used to collect a sediment sample in the middle of the lake (Map 1 and Table 2). The sample was brought back to the lab and filtered to look for spiny water flea spines under magnification. No AIS were found.

Meander surveys found no additional invasive species.

Table 1. AIS Survey on Papoose Lake 5/23/2018.			
Site	**Latitude**	**Longitude**	**Species found**
1	46.18201	-89.807783	Rusty crayfish
2	46.183517	-89.795367	None
3	46.1948333	-89.802867	None
4	46.184750	-89.813583	Rusty crayfish
5 BL	46.176417	-89.803700	Rusty crayfish

Table 2. Spiny Water Flea Dredge for Sediment Sample from Papoose Lake			
Date: 5/23/2018	**GPS Coordinates**		**Depth of plankton sample (feet)**
Dredge Site	46.8085	-89.79815	40

Two known AIS are established in Papoose Lake; the rusty crayfish and the Yellow Iris (2015). The Yellow Iris is a very aggressive invasive species and capable of quickly overtaking native vegetation and altering shoreline/wetland habitat depended on by wildlife. Because it is poisonous, it generally does not provide a food source for wildlife. We did not see the Yellow Iris during this survey due to the plant not being in bloom. An appropriate time to survey this plant is the middle to end of June when it is in flower. It is very hard to distinguish between the native Northern Blue Flag Iris and the Yellow Iris when they are not in bloom.

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, 2014). 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, 2014). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2015). It is also illegal to release crayfish into a water body without a permit (WDNR, 2015).

The Wisconsin DNR has a very informative website that educates on invasive species. The Papoose Lake stakeholders are the ones that frequent the lake and play a big role in protecting the lake. Stopping the spread of AIS and early detection is important is important when it comes to invasives. Please feel free to take the time to browse through the many links provided: https://dnr.wi.gov/topic/Invasives/.

FLOATING WORKSHOP

A floating workshop for Papoose Lake enthusiasts was conducted by White Water Associates, Dr. Dean Premo, describing lake and riparian ecology while emphasizing the impacts that invasive species can have on these important ecosystems. The workshop took place on Papoose Lake on August 14, 2018 using pontoon boats. Highlights were the basic ecology of a lake, what can be monitored in a lake (discussed the historic aquatic plant surveys, shoreline survey, and macroinvertebrates), demonstration of Secchi disk, what is a littoral zone and the riparian area, stressors to a lake, aquatic invasive species, recommendations for good stewardship in the littoral and riparian area. The lake steward participants were invited to ask questions and bring up points of discussion regarding their concerns for the lake.

Literature Cited

Gunderson, Jeff. 2014. *Rusty Crayfish: A Nasty Invader*. Minnesota Sea Grant. Retrieved 2017. <http://www.seagrant.umn.edu/ais/rustycrayfish_invader>

Wisconsin Department of Natural Resources. 2014. *Aquatic Invasive Species Early Detection Monitoring Standard Operating Procedure*. Retrieved 2017. <http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=99459630>

Wisconsin Department of Natural Resources. 2015. *Rusty Crayfish*. Retrieved 2017. <http://dnr.wi.gov/lakes/invasives/AISDetail.aspx?roiseq=22588740>