
Pickerel/Crane Lakes Stewardship Program

Aquatic Plant Management Plan – Crane Lake

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CHAPTER 1

Introduction

The *Pickereel/Crane Lakes Stewardship Program* results from the efforts of Pickereel/Crane Protection & Rehabilitation District (PCPRD). The Pickereel/Crane Lakes Stewardship Program views lake stewardship as an ongoing endeavor that is integrated, coordinated, and administered by the PCPRD. The PCPRD takes a broad perspective that allows an appropriate range of geographic scales from which to approach lake stewardship. A discrete “lake specific” focus goes hand-in-hand with waterscape-wide awareness.

This aquatic plant management plan addresses Crane Lake in Forest County, Wisconsin. Despite this specificity, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related *Pickereel/Crane Lakes Adaptive Management Plan* (Premo et al. 2021) offers additional overarching waterscape level perspective that allows greater opportunity in water resource management and education.

A 2019 systematic survey of aquatic plants using the Wisconsin Department of Natural Resources (WDNR) “point-intercept” method formed 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 perspective is slowly changing. Many people still refer to an aquatic plant bed as 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 proliferate in a water body and negatively influence the community of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the invasive plant species capable of this kind of population boom. Fortunately, this kind of rampant growth of aquatic invasive plants does not always occur and a non-native plant can become part of a balanced native plant community. On occasion, even a native plant species can exhibit rampant growth and results in a population that is viewed by some as a recreational nuisance. The native Southern Naiad (*Najas guadalupensis*) has exhibited this kind of behavior in some northern Wisconsin Lakes.

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. In some lakes, even the presence of an aquatic invasive plant species is not a significantly negative phenomenon.

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. Actions taken to curtail a specific plant population (for example, herbicide use to treat Eurasian water-milfoil) will invariably impact other desirable native species. Rare plants, important habitat plants, or culturally significant plants (such as wild rice) should always be given careful consideration and protection.

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

This plan follows guidelines in *Aquatic Plant Management in Wisconsin*. The plan is an adaptive plan (Walters 1986) and as such will be modified as new information becomes

¹ <http://www4.uwsp.edu/cnr/uwexplakes/ecology/APM/APMguideFull2010.pdf>

available. The WDNR Guidance document outlines three objectives that may influence preparation of an aquatic plant management plan (APMP). Currently, the principal motivation for this plan lies in the first two objectives:

- **Protection** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- **Maintenance** - continuing the patterns of recreational use that have developed historically on and around a lake; and
- **Rehabilitation** - controlling imbalance in the plant community leading to the dominance of a few species, frequently associated with the introduction of invasive non-native species.

In preparation of this APMP, we have followed the first five steps in the seven-step plan outlined in the Guidance Document for developing an aquatic plant management plan:

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

Besides this introductory chapter, this plan is organized in six chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant survey. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Three appendices complete this document. Appendix 1 contains literature cited, Appendix 2 contains tables and figures for the aquatic plant survey, and Appendix 3 contains a *Review of Crane Lake Water Quality*.

CHAPTER 2

Study Area

Crane Lake is located in Forest County about seventeen miles north of Pickerel, Wisconsin. The water body identification code (WBIC) is 388500. Exhibit 1 is an aerial view of the Crane Lake landscape showing the surrounding lakes and a few other water features. This interconnected water landscape is a target for migrating and breeding waterfowl and other birds. Crane Lake has value and function in this larger landscape as well as its own watershed. An unnamed Creek flows into Crane Lake from the northeast and a drainage stream leaves the lake from the south and flows about one-quarter mile before entering Pickerel Lake. Pickerel Creek flows from Pickerel Lake and to the Wolf River.

Descriptive parameters for Crane Lake are in Exhibit 2. It is a drainage lake (meaning it has both an inlet and an outlet). Its sources of water include an un-named creek on the north side, surface water runoff, precipitation directly to the lake, and groundwater. Crane Lake has a surface area of about 355 acres and a maximum depth of 25 feet. The shoreline development index is 1.8. 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. Lakes with high shoreline development index values have relatively more productive littoral zone habitat.

Crane Lake has a ramp access located off Doemel Lane. We observed a total of 107 piers on the shoreline of Crane Lake or about 22.4 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibits 1 and 3). Although human development dominates, there is also high quality riparian forest and other habitat surrounding Crane Lake.

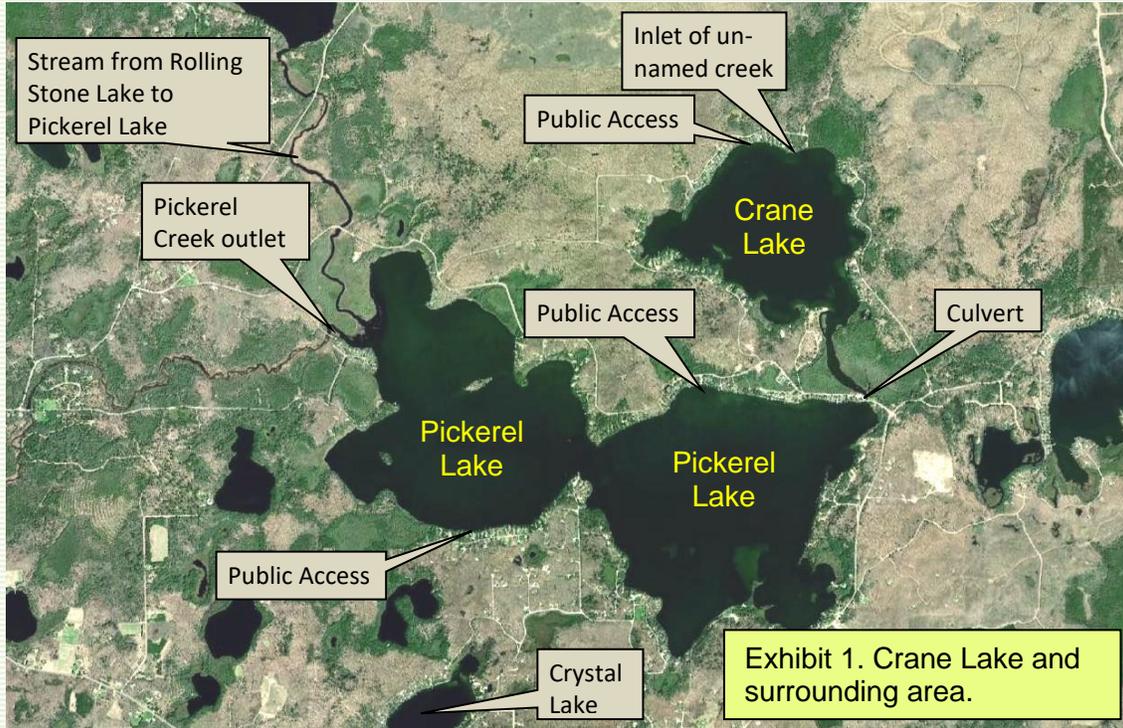
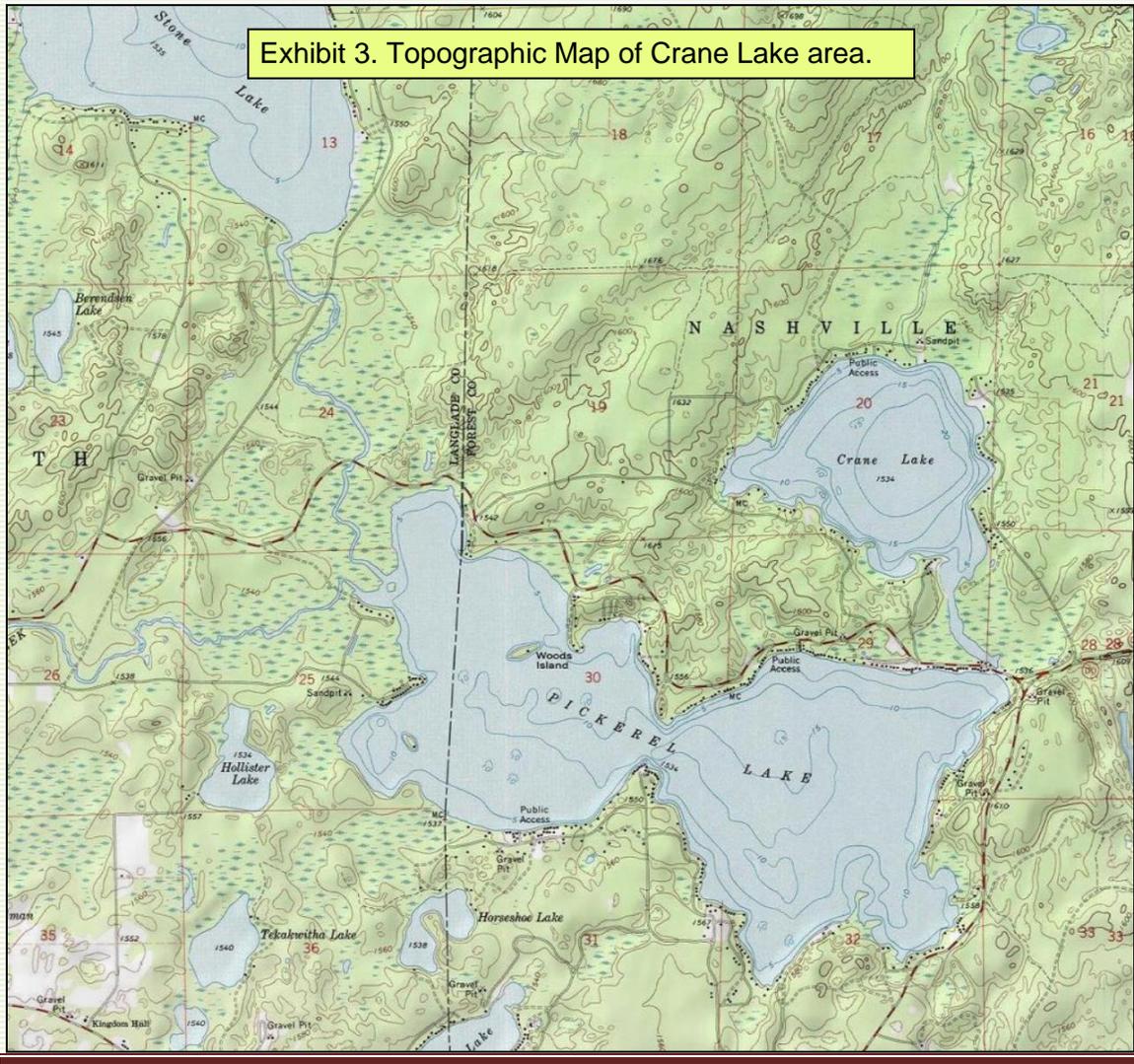


Exhibit 2. Water Body Parameters.

Water Body Name	Crane Lake
County	Forest
Township/Range/Section	T34N-R13E-S20
Water Body Identification Code	388500
Lake Type	Drainage
Surface Area (acres)	355
Maximum Depth (feet)	25
Maximum Length (miles)	1.02
Maximum Width (miles)	1.28
Shoreline Length (miles)	4.78
Shoreline Development Index	1.8
Total Number of Piers (Shoreline, 2019)	107
Number of Piers / Mile of Shoreline	22.4
Total Number of Homes (2021 aerial)	90
Number of Homes / Mile of Shoreline	18.8



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 for this plan:

Crane Lake has a healthy and diverse aquatic plant community as documented by a comprehensive aquatic plant survey. This plant community is essential to, and part of, a high quality aquatic ecosystem that has intrinsic value and benefits the human community with its recreational and aesthetic features. The purpose of this aquatic plant management plan is to maintain the aquatic plant community in a high quality state.

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

- (1) Monitor and protect the native aquatic plant community;*
- (2) Monitor existing AIS and prevent establishment of new non-native biota;*
- (3) Consider and evaluate the efficacy of active aquatic plant management; and*
- (4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that can alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and living with a lake whose natural healthy state includes areas with abundant 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 Crane Lake stewards.

CHAPTER 4

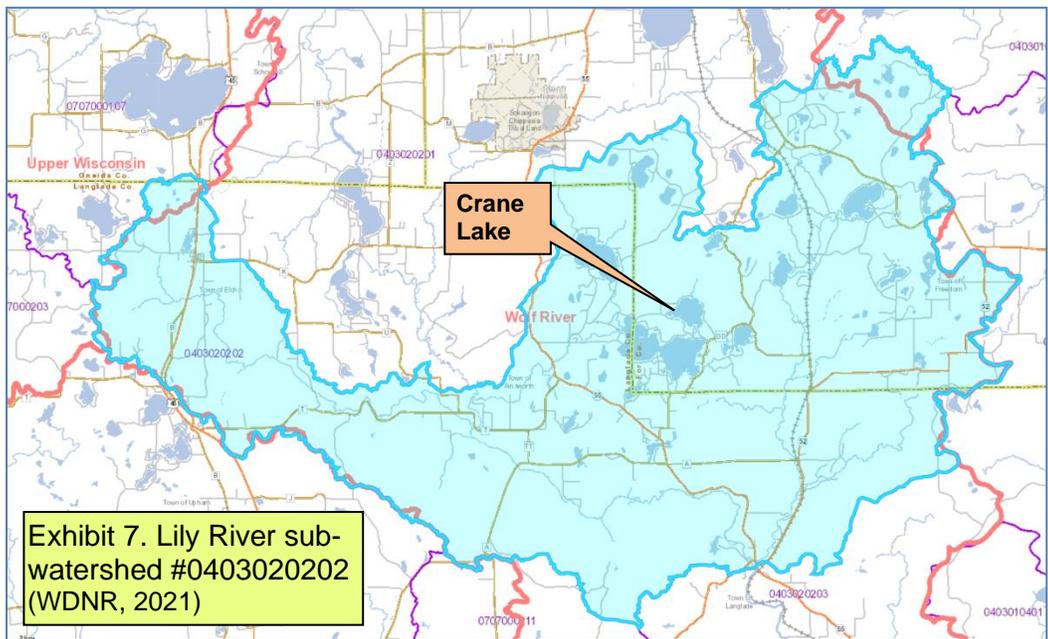
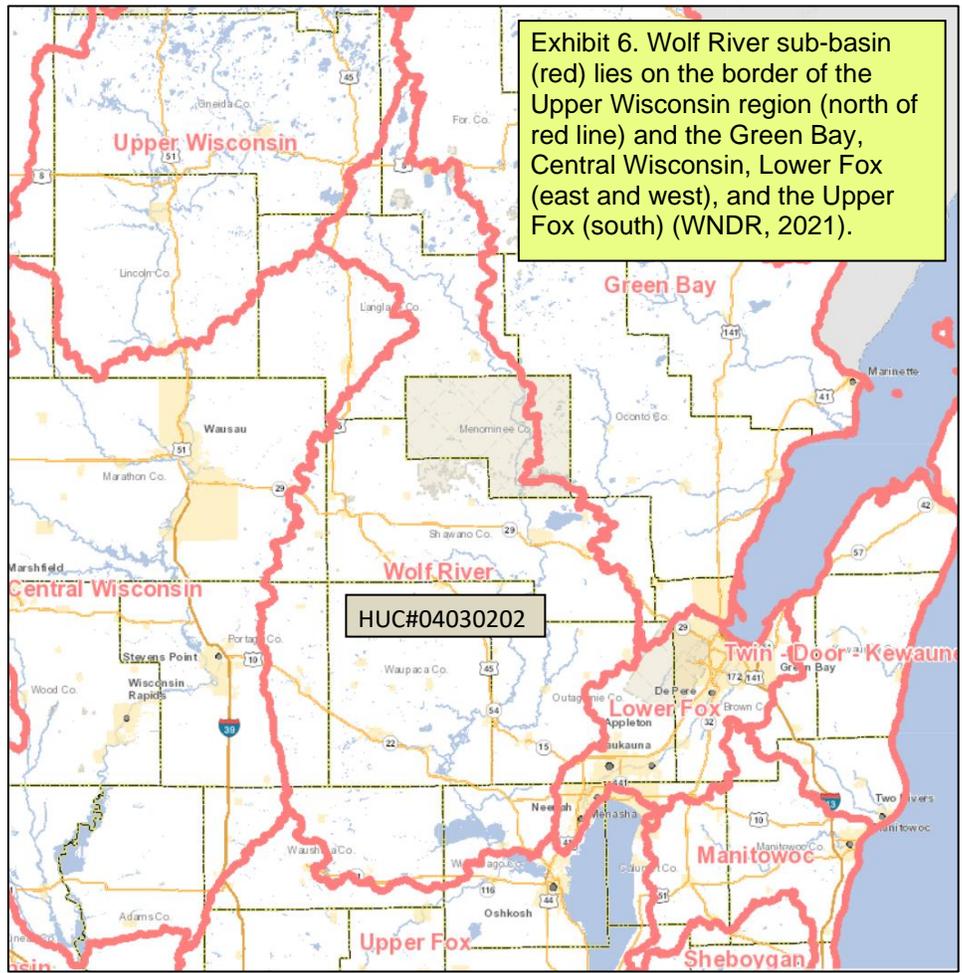
Information and Analysis

Our efforts in the Pickerel/Crane Lakes Stewardship Program have compiled information about historical and current conditions of the Crane Lake ecosystem and its surrounding watershed. Of particular importance to this aquatic plant management plan is the aquatic plant survey that was conducted in 2019 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” aquatic plant survey are presented in this chapter. The aquatic plant data along with other relevant Crane Lake information is 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

Crane Lake and its immediate watershed are very small components of a large-scale (continental) watershed landscape. The continental United States is divided into 18 watershed regions (Exhibit 4). Two watershed regions lie within Wisconsin: The Upper Mississippi and Great Lakes regions. Crane Lake is located in the Northwestern Great Lakes region. In turn, the Great Lakes region is made up of many sub-regions and smaller components referred to as “basins.” The Northwestern Lake Michigan sub-region (HUC#0403), and the Fox basin (HUC#040302) contain Crane Lake (Exhibit 5). Within the Fox basin is the Wolf sub-basin (HUC#0040302) (Exhibit 6), which can be further divided into watersheds and sub-watersheds. Crane Lake is located in the Lily River watershed (HUC#0403020202) (Exhibit 7). The watershed from which Crane Lake receives its surface water runoff is outlined in Exhibit 8 as the Pickerel Creek sub-watershed (HUC#040302020201).







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 Crane Lake watershed shown in Exhibit 8 is 4,361 acres. The cover types in the watershed are presented in Exhibit 9. Deciduous forest and woody wetlands cover types comprise the largest percentage of the watershed (about 80%). Surface water is nearly 11 percent of the watershed. Soil groups A, B, and C is present in the watershed. Soil groups B and C are about equally represented and together form over 90% of the acres in the watershed. Soil

group B has a moderate infiltration rate, while soil group C has very low infiltration capability. The watershed to lake area ratio is 12:1. 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 9. Cover Types and Soil Groups of the Crane Lake Watershed.			
Cover Type		Acres	Percent
Cropland generalized agriculture		0.00	0.00
Pasture/Hay		0.00	0.00
Barren Land		0.00	0.00
Shrub; Scrub		24.71	0.57
Grassland; Herbaceous		135.91	3.08
Open Space/Park		128.50	2.96
Deciduous Forest		2868.89	65.63
Evergreen Forest		2.47	0.04
Mixed Forest		49.42	1.10
High-intensity Residential		0.00	0.00
Medium-intensity Residential		0.00	0.01
Low-intensity Residential		2.47	0.04
Woody Wetland		644.94	14.78
Emergent Wetland		0.00	0.01
Water		504.09	11.55
Total		4361.40	99.8
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	261.93	6.8	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	1756.9	45.8	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	1818.7	47.4	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	0.00	0.00	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 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

On June 9-10, 2009 a survey was completed on Crane Lake by a lake consultant (Onterra, LLC) that focused on curly-leaf pondweed with no detection. In 2006, the Mole Lake Sokagon Chippewa Community conducted a point-intercept aquatic plant survey on Crane Lake. In 2009, a Onterra completed additional plant surveys and created aquatic plant community maps. Eurasian watermilfoil was found in the 2009 survey. White Water Associates conducted a point-intercept aquatic plant survey in 2019 and results are presented and discussed in the next section (Part 3) and compared to findings from 2006. In recent years, Crane Lake has also undergone some mechanical harvesting of native aquatic plants as a way to remedy perceived nuisance level (navigational) abundance.

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 in the form of 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 can diminish the native plant community and the related habitat. At times, even a native plant species can reach high population levels and interfere with certain kinds of human recreation. Cases such as these may elicit calls for 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 and collateral damage to non-target plant species can be significant. In addition, permits are required in many cases of aquatic plant management.

Aquatic plant surveys were conducted on Crane Lake in 2006 and 2019. In each year, the survey used the WDNR point-intercept protocol. This formal survey assessed the plant species composition on a grid of 401 points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, we navigated to the points and used a rake to sample plants. Plants were identified, recorded, and all data were 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 thirteen years.

The PCPRD conducted a lake user survey and results are presented in the *Adaptive Management Plan* (Premo et al. 2021). One survey question asked, “*During the years you’ve been familiar with Crane Lake, what changes have you seen in aquatic plants (including algae)?*” Seventeen of the respondents said that there are more aquatic plants than in the past. Thirty-five of the respondents said there was more algae blooms and twenty said there was no change. The majority of the respondents felt that aquatic plant management is needed. These responses reflect interest and concern regarding aquatic plants. Responses demonstrate the need to scientifically document changes in the plant community and identify possible areas for educational outreach.

An examination of changes in the aquatic plant community over more than 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 AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section, we provide a report of the aquatic plant findings for Crane Lake and compare the plant communities of 2006 and 2019. 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 plant species recorded at sampling points only, species richness in 2006 was 17 (that is, 17 species collected on the rake). The richness documented in 2019 was 21 (species collected on the rake, see Tables 1 and 3). During the surveys, additional plant species observed but not collected at the sampling points are also documented. In 2019, a total of 25 species of aquatic plants were recorded in Crane Lake at the sample points but an additional 15 species were seen near shore on the boat survey, indicating a diverse plant community. Table 1 displays summary statistics for the 2019 survey. Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics for the 2019 survey.² Table 3 compares data from 2006 and 2019 surveys. In 2019, the number of species encountered at any given sample point ranged from 0 to 5 and 178 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 2.32. The actual number of species encountered at each of the vegetated sites is graphically displayed on Figure 1. Plant density is estimated by a “rake fullness” metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figure 2. The 2019 rake average total rake fullness for vegetated sites was 1.5. This is not a number that indicates a high plant density lake. A direct comparison to the same factor is not possible for the 2006 survey because a “total rake density” value was not recorded by the plant survey team.

The maximum depth of plant colonization was 16.5 feet in 2019 (Table 1 and Figure 3). Rooted vegetation was found at 178 of the 237 sample sites with depth \leq the maximum depth of plant colonization (75.11% 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 provides information about the frequency of occurrence of the plant species recorded in the lake in 2019. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites \leq 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

² If you more are interested in learning 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).”

with a rake in 2006 and 2019 are graphically displayed on Figure 6. This display shows that *Lemna trisulca* (star duckweed) had the highest relative frequency followed *Ceratophyllum demersum* (Coontail) in 2019. In 2006, *Ceratophyllum demersum* (Coontail) had the highest relative frequency followed by *Lemna trisulca* (star duckweed). The relative frequencies of species for the 2006 plant community are remarkably similar to those documented in 2019. The minor differences are attributable to natural fluctuations of the individual populations and indicate a dynamic and healthy plant community. Figure 7 displays sampling sites with emergent and floating aquatic plants. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8-13.

“Species richness” is the term given to the total number of species in a given area. For example, the total number of plant species in a lake would be its plant species richness. Generally speaking, a high species richness means high biodiversity and this is considered a healthy and desirable condition in an ecosystem. But species richness 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 Crane Lake aquatic plants was 0.83 in 2006 and 0.82 in 2019 (Table 3) indicating a diverse aquatic and stable plant community over time.

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 Crane Lake FQI (23.8 in 2006 and 26.2 in 2019) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Crane Lake values are much higher than 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. Stateline 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. Crane Lake data is much higher than that median value. Finally, the Crane Lake FQI is higher than the median value for the Northern Lakes and Forests lakes group (24.3). These findings support the contention that the Crane Lake plant community is healthy and diverse.

We observed no aquatic plants in Crane Lake that would be considered a nuisance-level population density/distribution. Eurasian water-milfoil (*Myriophyllum spicatum*) was observed in the aquatic plant survey on Crane Lake along with the narrow-leaved cattail (*Typha angustifolia*) and purple loosestrife (*Lythrum salicaria*) on the boat survey. These aquatic invasive species are considered *restricted* invasive species in Wisconsin. They were confirmed by Dr. Freckmann at the University of Wisconsin-Stevens Point herbarium in 2020. We found no state or federally listed plant species.

Eurasian water-milfoil is not abundant or widespread plant in Crane Lake. It was collected on the rake at two sites. If visual sightings in the vicinity of the sample sites are also included, it was recorded at 5 sites. For the most part, Eurasian water-milfoil was collected or observed with other native aquatic vegetation. The littoral zone for Crane Lake (the area where rooted aquatic vegetation exists or potentially exists) represented about 60% of the surface area of the lake in 2019. The 2019 littoral zone is effectively illustrated in Figure 4 by the distribution of circles (site less than or equal to maximum depth of plant colonization). It forms a variable band around the lake's margin. The robust native plant community in the littoral zone deters dispersal of Eurasian water-milfoil to other parts of the lake and protects against establishment of other aquatic invasive plant species. In addition, this littoral zone is extremely critical to the lake's ability to produce fish and attract the type of wildlife (e.g., blue heron, bald eagles and common loons) that are valued by lake users.

It should be emphasized that the statistics presented in Table 3 indicate very little change in the Crane Lake plant community over the 13 year period. It is a diverse and healthy plant community that is an asset to the entire lake ecosystem.

Part 4. Fish Community

Fish surveys and stockings have been conducted on Crane Lake for years. A walleye spawning rock reef project was installed in 2019. For more fisheries information, see Appendix H of the *Pickereel/Crane Lakes Adaptive Management Plan*. The WDNR Lake Pages website (<http://dnr.wi.gov/lakes/lakepages/>) indicates that fish species present include bluegill, largemouth bass, yellow bullhead, walleye, northern pike, yellow perch, and black crappie.

Part 5. Water Quality and Trophic Status

Crane Lake is a 355 acre drainage lake with a max depth of 25 feet. Existing water quality data was retrieved from the WDNR SWIMS database from 2003 to 2020. Water quality information is briefly summarized in this section, but more fully interpreted in Appendix 3.

Temperature and dissolved oxygen samples showed stratification in Crane Lake. Water clarity was considered “poor”, with a 2020 average Secchi reading of 6 ft. The trophic state is mildly eutrophic. Water quality would be classified as “good” with respect to phosphorus concentrations. The 2019 pH of Crane Lake (8.81 SU) was alkaline.

Part 6. Water Use

Crane Lake has a public ramp access site located on the north shoreline of the lake (see Exhibit 1).

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Crane Lake. The Crane Lake riparian area can be appreciated by viewing aerial photography (Exhibit 1) and the topographic map in Exhibit 3. The lake is generally surrounded by forested habitat. Extensive wetland areas exist at the north end of the lake (along the un-named creek that flows into the lake and at the south end of the lake in association with the outlet creek). An upland mixed conifer and deciduous forest predominates the remainder of the nearby riparian area of Crane Lake. Recent aerial photography reveals 90 houses on the lake concentrated principally along the north and west shores. The east and south shores of the lake are less developed with houses. 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.

The WDNR, in 2016, 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 Zones (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). Part of the shallow water habitat survey includes documenting woody habitat. A more detailed report can be found in Appendix F of the *Pickereel/Crane Lakes Adaptive Management Plan*.

Part 8. Wildlife

Loon and bald eagle studies have been conducted by the WDNR and volunteers as part of programs such as Loon Watch. In May of 2010 seven non-territorial loons and one loon pair were noted. In April of 2011 one loon pair and two loon chicks were documented. In 2018, the WDNR monitored bald eagle nests Forest County and it had 32 nests and Langlade had 16 nests (WDNR, 2018).

In the future, it would be desirable to monitor indicator species of wildlife such as bald eagles and osprey on Crane Lake. Also, of special importance would be monitoring the populations of aquatic invasive animal species that already exist in the lake (banded mystery snail and Chinese mystery snail). Finally, it is essential to monitor Crane Lake for the presence of new aquatic invasive animal species (for example, spiny water flea and zebra mussels).

Part 9. Stakeholders

At this point in the plant management planning process, the PCPRD has represented Crane Lake stakeholders. Additional interested citizens are invited to participate as the plan is refined and updated in order to broaden input and encourage participation in stewardship. Some Crane Lake users have expressed concerns regarding aquatic plant populations that interfere with specific recreational activities. Plant management may be a consideration for Crane Lake in the future, but warrants careful consideration. Using a lake-user survey, the PCPRD solicited input from Crane Lake residents and users to understand the knowledge base, educational needs, concerns, and desires. Results of the lake user survey are presented in the *Pickereel/Crane Lakes Adaptive Management Plan* (Premo et al. 2021).

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) Monitor existing AIS and prevent establishment of new non-native biota;*
- (3) Consider and evaluate the efficacy of active aquatic plant management; and*
- (4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that can alter the plant community, minimizing physical removal of native riparian and littoral zone plants, and living with a lake whose natural healthy state includes areas with abundant aquatic plants.*

Crane Lake is a healthy and diverse ecosystem. This is an enviable position from which to conduct lake stewardship. It is possible that Crane Lake could continue as a healthy lake without any effort or intervention on part of lake stewards. Nevertheless, there are threats to the quality of the lake and Pickerel/Crane Lakes Stewardship Program and the PCPRD endeavor to minimize those threats. We outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

At this time, we recommend no large scale direct manipulation of plant populations in Crane Lake. As we have outlined, Eurasian water-milfoil (EWM) is present in the plant community, but at a very small population size. We advise that this population should be managed by hand-pulling with use of a long handled rake or by snorkeling. The population should be monitored spring, summer, and fall by trained volunteers or a professional consultant. Algae abundance may interfere with snorkeling at certain times of the year. The ecological risks associated with chemical treatment or mechanical harvesting outweigh possible short-term reduction in the Eurasian water-milfoil population. If the PCPRD feels strongly that some action should be undertaken Diver Assisted Suction Harvesting (DASH) could be considered, but should be accompanied by a specific monitoring protocol to determine whether the outcomes warrant expenditures.

Even with the presence of Eurasian water-milfoil, the Crane Lake plant community is diverse and balanced. Some Crane Lake stakeholders, however, have expressed desire to remove

aquatic plants from the lake. So that the PCPRD can address stakeholder concerns from a basis of solid information, we summarize categories of plant management in the following paragraphs. It should be stated that from the standpoint of a healthy Crane Lake, no plant management actions are required. Plant management intended to improve specific human recreational activities or a desired aesthetic stem from diverse personal opinions not ecological benefits. For this reason, it is difficult to arrive at consensus as to plant management approaches. Some actions are expensive. No plant management actions result in a permanent “fix” (periodic re-treatments are always needed). All plant management activities have negative and unpredictable environmental impacts. **Because native aquatic vegetation is unavoidably impacted, any plant management activity renders the lake more susceptible to aquatic invasive plant species that have evolved to exploit disturbed habitat.** In the following paragraphs, we summarize plant management actions. We do not provide costs for these approaches as costs vary depending on the specifics of a project and the associated challenges of the project and a specific environment. Costs can also change significantly over the lifetime of a lake management plan, rendering estimates provided in 2021 of little value in 2022 or beyond.

Manual Removal involves methods such as cutting, raking or hand-removal. These methods do not require permits from the WDNR (with some exceptions when using powered mechanisms for removal). According to WDNR Natural Resource Chapter 109, “Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured along the shoreline provided that any piers, boatlifts, swim rafts and other recreational and water use devices are located within that 30-foot wide zone and may not be in a new area or additional to an area where plants are controlled by another method” (Wisconsin State Leg. Ref. Bureau). Manual removal is more cost-effective when used in small areas. However, these methods are labor intensive and require re-treating areas. Cutting and/or removal of plants can disturb fish spawning, stir up sediments and most importantly, open the door for invasive species to replace native plant communities.

Mechanical Harvesting is often compared to mowing and bagging a lawn. Harvesters range in size, therefore costs can be variable. After harvesting is complete, all plant material must be transported to a landfill or compost site. Work requires WDNR permitting. Like all treatments, multiple applications are likely required. While harvesting is more selective in which plants are managed, some research indicates that there is little or no reduction in plant density.

Chemical (Herbicide) Treatments are typically used to treat invasive species and not native plant communities. They are potentially hazardous to both the applicator and the environment, so specialized training and experience is recommended. WDNR permitting is

required. Many herbicides are not selective and require multiple retreatments-sometimes multiple treatments in one season. Chemical treatments, if applied improperly, may lead to target plant resistance. For example, an aquatic invasive plant species population that is treated with an herbicide tends to select for the resistant individuals and thereafter require increasingly more herbicide or more frequent treatments. Herbicides occasionally even stimulate plants to grow more rapidly. Chemical treatment is generally not recommended or permitted if rare or culturally important species are potentially affected.

Water Drawdown is a technique used primarily as a method to control invasive species not native plants. It is typically only used in impoundments where water levels are manipulated by a dam. A water drawdown on Crane Lake would be technically infeasible. This method also requires permits from the WDNR. This method can have detrimental effects on the native fish, aquatic wildlife, and surrounding wetlands. Because this method involves exposing the lake bed, there is a high chance of invasive species taking advantage of available disturbed habitat.

Dredging involves removal of any material from lake or streambed (such as muck, sand, gravel, silt, and organic material). Dredging is considered by some to be an action that significantly alters a lake. This technique is sometimes used to treat invasive plants, not native plant communities. It requires permitting from the WDNR and possibly other federal agencies. Dredging can have significant impacts on fish and wildlife, can disturb sediments and release toxic substances and nutrients that cause algal blooms, and most importantly, leave the lake bed susceptible to invasive species.

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

Recommended Actions for the Crane Lake APM Plan

Action #1: Formally adopt the Aquatic Plant Management Plan.

Objective: To provide foundation for long-term native plant community conservation, existing AIS monitoring and management, and to respond to new AIS introductions.

Monitoring: The PCPRD oversees activity and maintains the plan.

Status: Planned for 2021.

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 PCPRD oversees activity and maintains data.

Status: Ongoing.

Action #3: Monitor Crane Lake shoreline for areas of erosion and excessive terrestrial/wetland vegetation clearing.

Objective: To inform riparian owners of improvements to shoreline stability and health and identify areas where shoreline would benefit from restoration.

Monitoring: The PCPRD oversees activity and maintains data.

Status: Begin in 2021.

Action #4: Monitor the lake for existing and new aquatic invasive plant species.

Objective: To understand the lake's biotic community, provide for early detection of new AIS, and tracking status of existing populations of aquatic invasive plant species.

Monitoring: The PCPRD oversees activity (hiring professional consultant as needed) and maintains data.

Status: To begin in 2021.

Action #5: Monitor the lake for aquatic invasive animal species.

Objective: To understand the lake's biotic community, provide for early detection of new AIS and continue monitoring any existing populations of AIS.

Monitoring: The PCPRD oversees activity (hiring professional consultant as needed) and maintains data.

Status: To begin in 2021.

Recommended Actions for the Crane Lake APM Plan

Action #6: Form an Aquatic Invasive Species Rapid Response Team (see Chapter 6 of this APMP).

Objective: To be prepared for AIS discovery and efficient response.

Monitoring: The PCPRD coordinates activity.

Status: Planned for 2021.

Action #7: Conduct quantitative plant survey every five years using WDNR Point-Intercept Methodology.

Objective: To watch for changes in species diversity, floristic quality, plant abundance, and plant distribution and to check for the occurrence of non-native, invasive plant species (including the existing population of Eurasian water-milfoil).

Monitoring: The PCPRD oversees and maintains data; copies to WDNR.

Status: Anticipated in 2024.

Action #8: Monitor the lake watershed for purple loosestrife.

Objective: Identify and manage purple loosestrife populations before they reach large size.

Monitoring: The PCPRD oversees activity.

Status: Anticipated in 2021 and annually.

Action #9: Conduct 2021 monitoring of Eurasian water-milfoil population and, based on results, conduct manual management actions (rake or hand-pulling with possible use of snorkel or SCUBA).

Objective: Identify 2021 location(s) and colony sizes of Eurasian water-milfoil and remove as much as possible to curtail expansion of population.

Monitoring: The PCPRD oversees activity with professional consultant assistance.

Status: Anticipated in 2021 and annually.

Action #10: Investigate eligibility for WDNR grant for managing Eurasian water-milfoil (Early Detection Rapid Response).

Objective: To have funds for professional assistance in monitoring and managing the small population of Eurasian water-milfoil and keep it from further spread or expansion.

Monitoring: PCPRD or consultant makes inquiry and prepares grant application.

Status: Anticipated in 2021.

Recommended Actions for the Crane Lake APM Plan

Action #11: 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: PCPRD oversees and maintains data; copies to WDNR.

Status: Ongoing; next time in 2024.

Action #12: 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/uwexplakes/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 PCPRD oversees activity and reports instances of possible introductions of AIS.

Status: Anticipated to begin in 2021.

Action #13: Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development. Implement best management practices on Crane Lake shorelines where needed.

Objective: To protect native aquatic plants, water quality, and riparian habitat.

Monitoring: Overseen by the PCPRD. Conducted by lake residents and other stakeholders.

Status: Ongoing.

Action #14: Promote adherence to, and enforcement of, ordinances.

Objective: To minimize recreational and development impacts on the aquatic plant community and shoreline habitats, and promote safe boating.

Monitoring: PCPRD oversees activity and assesses effectiveness.

Status: Ongoing.

Recommended Actions for the Crane Lake APM Plan

Action #15: Create an education plan for the property owners and other stakeholders that will address issues of healthy 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: PCPRD oversees activity and assesses effectiveness.

Status: Anticipated to begin in 2021.

Action #16: Develop and implement an approach for systematic citizen monitoring of filamentous algae over the course of the summer season and continue for a period of 5 years.

Objective: To understand trends in seasonal and annual abundance and collect information as to nuisance status and increase awareness of possible causes.

Monitoring: PCPRD oversees activity

Status: Anticipated to begin in 2021.

Action #17: 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: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2021.

Recommended Actions for the Crane Lake APM Plan

Action #18: Lake leaders should encourage and assist landowners to take on shoreland and 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) Forest County Land and Water Conservation Department looks for partners in this endeavor and can provide planning and sponsorship of projects. Funding for eligible projects is available from WDNR. Example projects on active lake stewards' properties would serve as valuable demonstration projects and encourage others to participate.

Objective: For high quality areas, maintain this condition through protection. For degraded areas, rehabilitate specific shoreland areas to improve natural functions and values.

Monitoring: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2022.

Action #19: Provide Forest County with all shoreline addresses and have them cross reference with their mailing database of "yellow cards" to lakeshore owners.

Objective: To evaluate septic compliance of lakeshore owners and eventually improve compliance in order to reduce nutrient inputs to the lake.

Monitoring: PCPRD conducts and oversees activity.

Status: Anticipated to begin in 2021.

Action #20: 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: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2021.

Recommended Actions for the Crane Lake APM Plan

Action #21: Determine source(s) of excess phosphorus in the lake.

Objective: To (1) better understand the nutrient dynamics in the lake, (2) educate landowners riparian contribution of nutrients to the lake, and (3) develop strategies to reduce excess nutrients in the lake.

Monitoring: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2021.

Action #22: Meet with Town of Nashville to discuss current culvert and road conditions and how they may relate to water quality and lake health.

Objective: To engage public partners in efforts to restore and maintain lake water quality and health.

Monitoring: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2021.

Action #23: Meet with Mole Lake Fisheries (Mike Preul) to discuss opportunities regarding wild rice propagation in the lake.

Objective: To understand benefits of wild rice to the lake ecosystem and explore possibility of wild rice propagation.

Monitoring: PCPRD promotes and oversees activity.

Status: Anticipated to begin in 2021.

Action #24: Promote and improve the Crane/Pickerel Lakes website as a source of information to lake users (including lake studies, opportunities for volunteering, and ongoing projects).

Objective: To take advantage of this efficient resource for distribution of information and education on the lake.

Monitoring: PCPRD promotes and oversees activity.

Status: Ongoing.

CHAPTER 6

Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. Some source lakes are close to Crane Lake. There is an increasing likelihood of accidental introduction of AIS through conveyance of life stages by boats, trailers, and other vectors. It is important for the Crane Lake stakeholders and other lake stewards to be prepared for the contingency of aquatic invasive plant species colonization in Crane Lake.

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

Exhibit 14 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 take digital photo(s) of the plant in the setting where it was found (if possible, try to capture details such as flowers, leaf shape, leaf and stem arrangement, and fruits and include a common object in the photo for scale).

Next, the observer or team coordinator should collect an entire plant specimen including roots, stems, and flowers (if present). If plants are numerous, collect several. The sample should be placed in a sealable bag with a damp paper towel. Place a label in the bag written in pencil

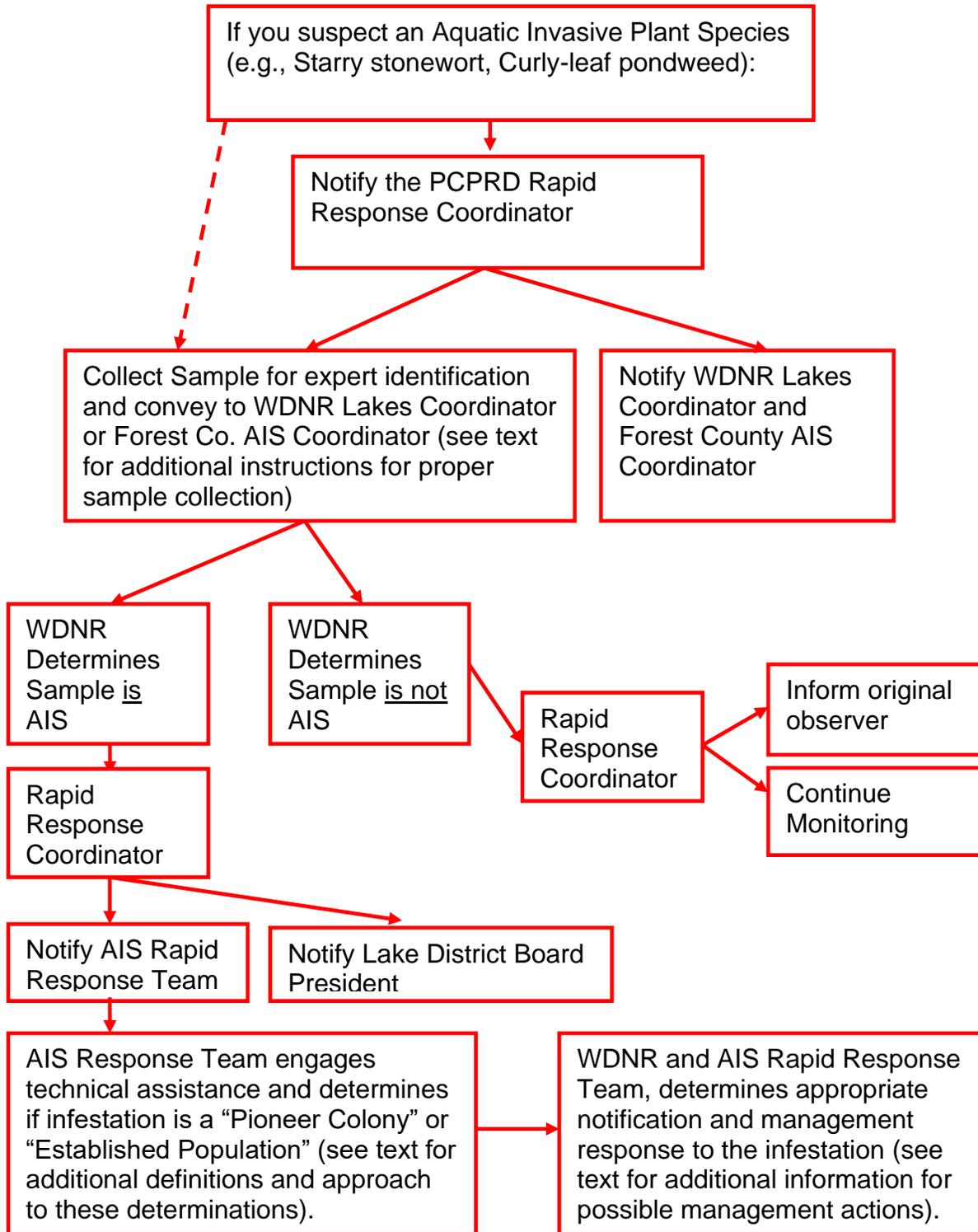
with date, time, collector's name, lake name, location, town, and county. Attach a lake map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Lakes Management Coordinator (Scott Van Egeren) or the Forest County AIS Coordinator (Alan Wirt) as soon as possible (at least within four 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 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 or Lake District Presidents (or other points of contact), local WDNR warden, local government official(s), other experts, chemical treatment contractors, and consultant(s).

Exhibit 13. Aquatic Invasive Plant Species Rapid Response





Appendix 1
Literature Cited

Literature Cited

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Appendix 2

Aquatic Plant Survey Tables and Figures

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Table 1. Summary statistics for the 2019 point-intercept aquatic plant surveys for Crane Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	401	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	313	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	178	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	237	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	75.11	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.82	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	16.50	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	69	
Number of sites sampled with rake on pole	200	
Average number of all species per site (shallower than max depth)	1.75	
Average number of all species per site (vegetated sites only)	2.33	
Average number of native species per site (shallower than max depth)	1.74	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	2.32	Total number of species collected including visual sightings.
Species Richness	21	
Species Richness (including visuals)	25	
Floristic Quality Index (FQI)	26.2	

Table 2. Plant species recorded and distribution statistics for the 2019 Crane 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
Forked duckweed	<i>Leman trisulca</i>	51.48	68.54	29.40	122	127	1.07
Coontail	<i>Ceratophyllum demersum</i>	45.57	60.67	26.02	108	119	1.43
Muckgrasses	<i>Chara sp.</i>	19.41	25.84	11.08	46	49	1.76
Flat-stem pondweed	<i>Potamogeton zosteriformis</i>	15.61	20.79	8.92	37	56	1.00
Northern water-milfoil	<i>Myriophyllum sibiricum</i>	6.75	8.99	3.86	16	28	1.19
Wild celery	<i>Vallisneria Americana</i>	6.33	8.43	3.61	15	26	1.07
Water star-grass	<i>Heteranthera dubia</i>	4.22	5.62	2.41	10	11	1.10
Small pondweed	<i>Potamogeton pusillus</i>	4.22	5.62	2.41	10	10	1.00
Common waterweed	<i>Elodea Canadensis</i>	3.80	5.06	2.17	9	11	1.00
White-stem pondweed	<i>Potamogeton preaelongus</i>	3.80	5.06	2.17	9	19	1.00
Sago pondweed	<i>Stuckenia pectinata</i>	3.38	4.49	1.93	8	12	1.63
Fern pondweed	<i>Potamogeton robbinsii</i>	2.53	3.37	1.45	6	9	1.00
Fries' pondweed	<i>Potamogeton friesii</i>	1.69	2.25	0.96	4	6	1.00
Clasping-leaf pondweed	<i>Potamogeton richardsonii</i>	1.69	2.25	0.96	4	10	1.00
White water lily	<i>Nymphaea odorata</i>	1.27	1.69	0.72	3	22	1.00
Eurasian water-milfoil	<i>Myriophyllum spicatum</i>	0.84	1.12	0.48	2	5	1.00
Spatterdock	<i>Nuphar variegata</i>	0.84	1.12	0.48	2	14	1.00
Small duckweed	<i>Lemna minor</i>	0.42	0.56	0.24	1	5	1.00
Slender naiad	<i>Najas flexilis</i>	0.42	0.56	0.24	1	3	1.00
Stiff pondweed	<i>Potamogeton strictifolius</i>	0.42	0.56	0.24	1	1	1.00
Common bur-reed	<i>Sparganium eurycarpum</i>	0.42	0.56	0.24	1	5	1.00
Swamp loosestrife	<i>Decodon verticuillatus</i>				Visual	4	
Water smartweed	<i>Persicaria amphibium</i>				Visual	1	
Floating-leaf pondweed	<i>Potamogeton natans</i>				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
Large duckweed	<i>Spirodela polyrhiza</i>				Visual	1	
Crowned beggarticks	<i>Bidens trichosperma</i>				Boat Survey		
Water arum	<i>Calla palustris</i>				Boat Survey		
Marsh bellflower	<i>Campanula aparinoides</i>				Boat Survey		
Bottlebrush sedge	<i>Carex comosa</i>				Boat Survey		
Upright sedge	<i>Carex stricta</i>				Boat Survey		
Bulblet-bearing water hemlock	<i>Cicuta bulbifera</i>				Boat Survey		
Water net (green algae)	<i>Hydrodictyon reticulatum</i>				Boat Survey		
	<i>Iris sp.</i>				Boat Survey		
Purple loosestrife	<i>Lythrum salicaria</i>				Boat Survey		
Dock	<i>Rumex sp.</i>				Boat Survey		
Hardstem bulrush	<i>Schoenoplectus acutus</i>				Boat Survey		
Softstem bulrush	<i>Schoenoplectus tabernaemontani</i>				Boat Survey		
Narrow-leaved cattail	<i>Typha angustifolia</i>				Boat Survey		
Broad-leaved cattail	<i>Typha latifolia</i>				Boat Survey		
	<i>Filamentous algae</i>				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.

Dr. Freckmann (U.W. Stevens Point: Herbarium) confirmed the voucher specimens January 2020.

***Myriophyllum spicatum*, *Lythrum salicaria* and *Typha angustifolia* are “Restricted” species in Wisconsin.**

Table 3. Comparison of summary statistics for 2006 and 2019 point-intercept aquatic plant surveys in Crane Lake.

Summary Statistic	2006	2019
Total number of sites on grid	401	401
Total number of sites visited	336	313
Total number of sites with vegetation	190	178
Total number of sites shallower than maximum depth of plants	282	237
Frequency of occurrence at sites shallower than maximum depth of plants	67.38	75.11
Simpson Diversity Index	0.83	0.82
Maximum depth of plants (ft.)	22.00	16.50
Number of sites sampled with rake on rope	336	69
Number of sites sampled with rake on pole	0	200
Average number of all species per site (shallower than max depth)		1.75
Average number of all species per site (vegetated sites only)	2.45	2.33
Average number of native species per site (shallower than max depth)	1.61	1.74
Average number of native species per site (vegetated sites only)	2.45	2.32
Species Richness	17	21
Species Richness (including visuals)	18	25
Floristic Quality Index (FQI)	23.8	26.2

Figure 1. Number of plant species recorded at Crane Lake sample sites (2019).

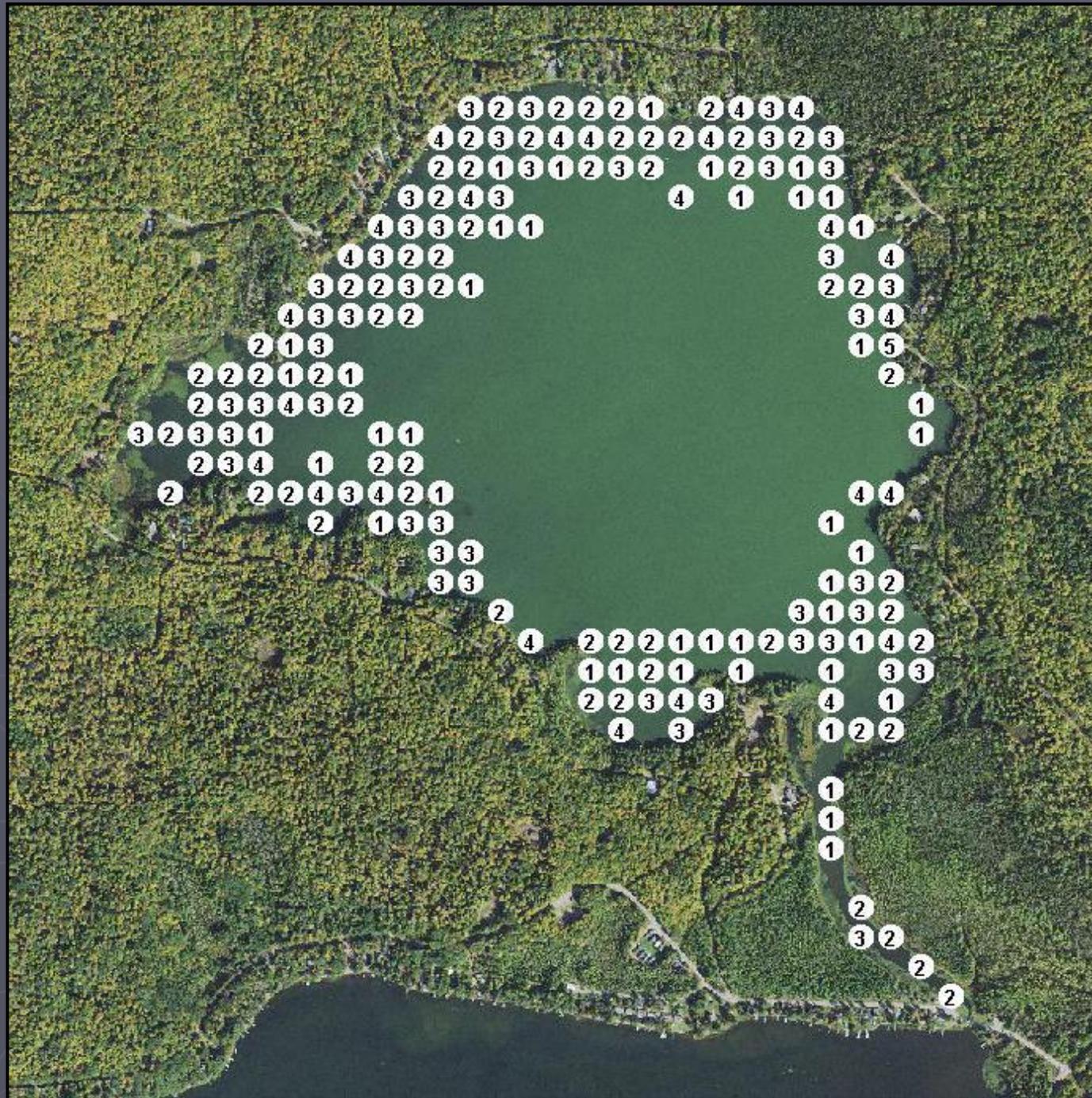


Figure 2. Rake fullness ratings for Crane Lake sample sites (2019).



**Rake fullness
(all species)**

- 1
- 2
- 3

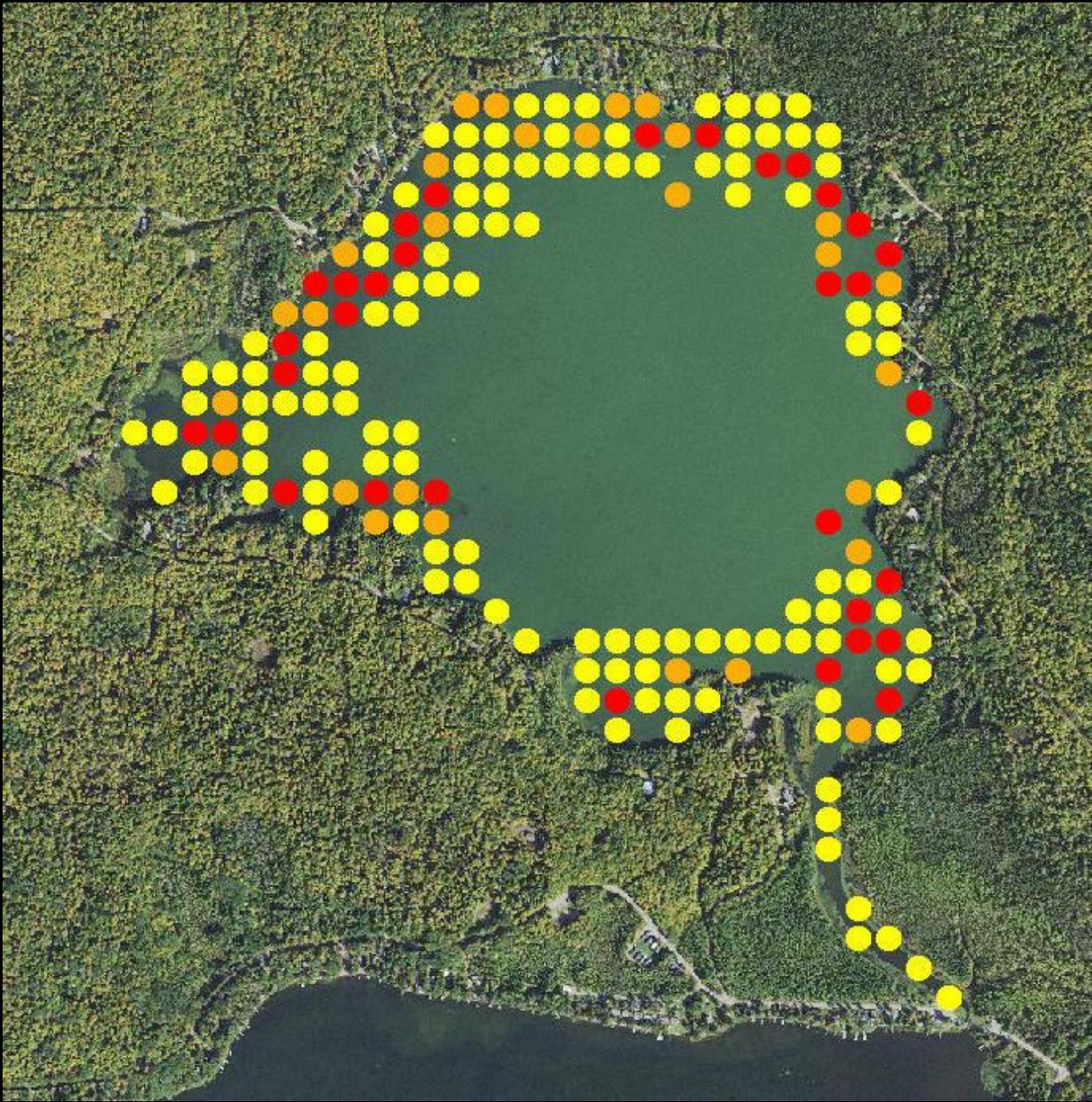


Figure 3. Maximum Depth of Plant Colonization, Crane Lake, 2019

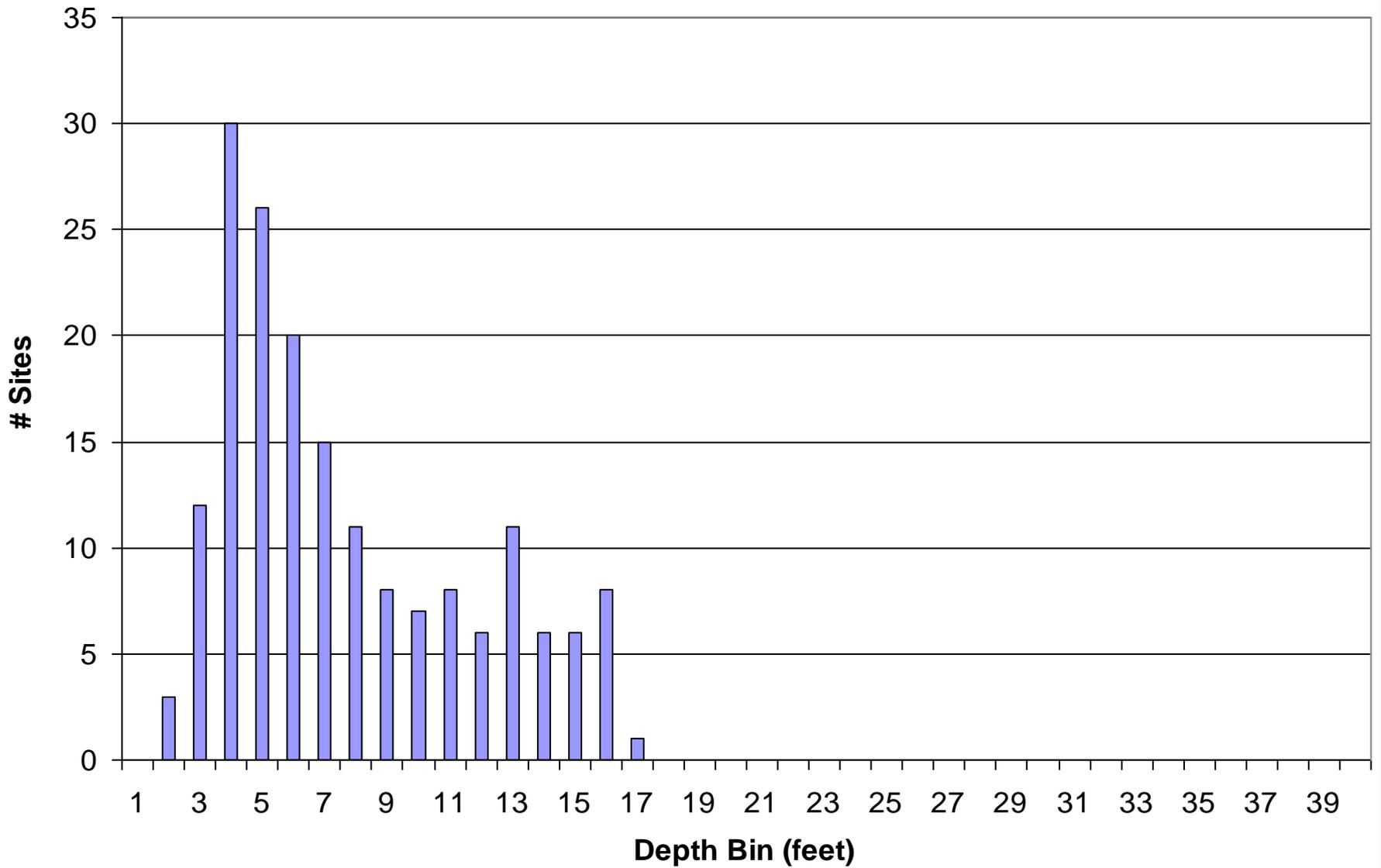


Figure 4. Crane Lake sampling sites less than or equal to maximum depth of rooted vegetation (2019).



- Site less than or equal to maximum depth of plant colonization (MDC).
- Plant find(s) at site less than or equal to MDC.

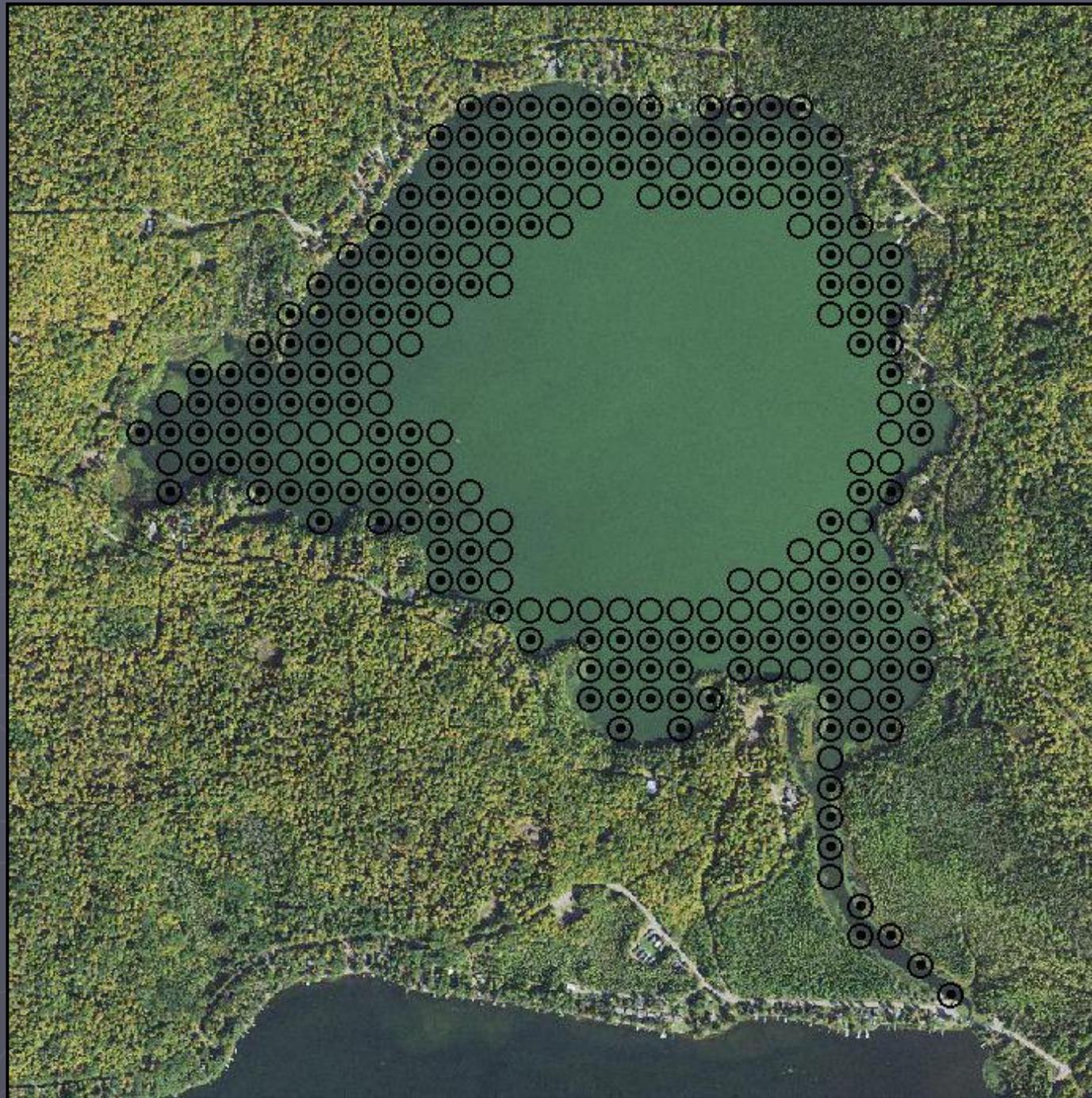


Figure 5. Crane Lake substrate encountered at point-intercept plant sampling sites (2019).

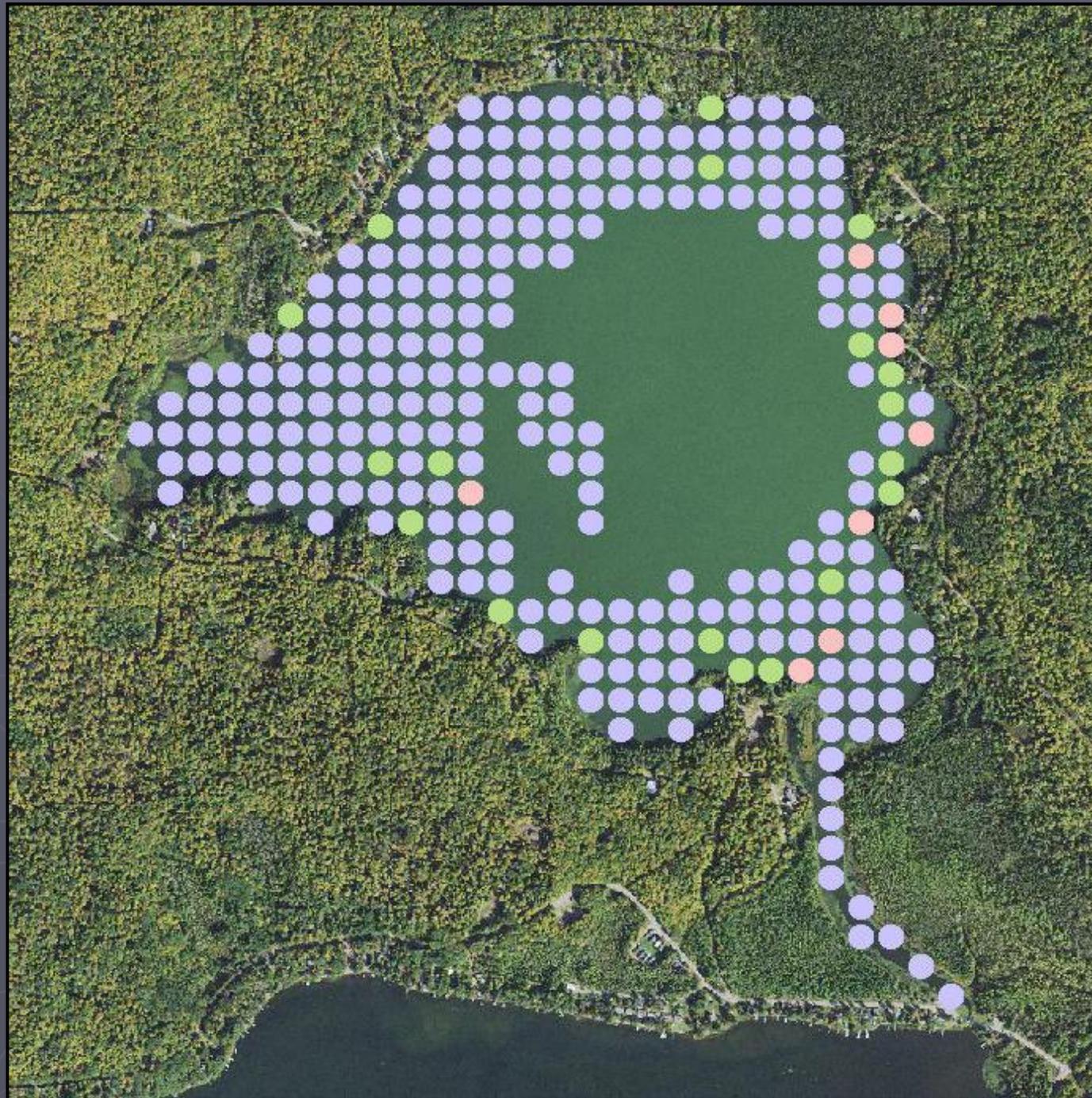


Figure 6. Crane Lake, Plant Finds in 2006 and 2019.

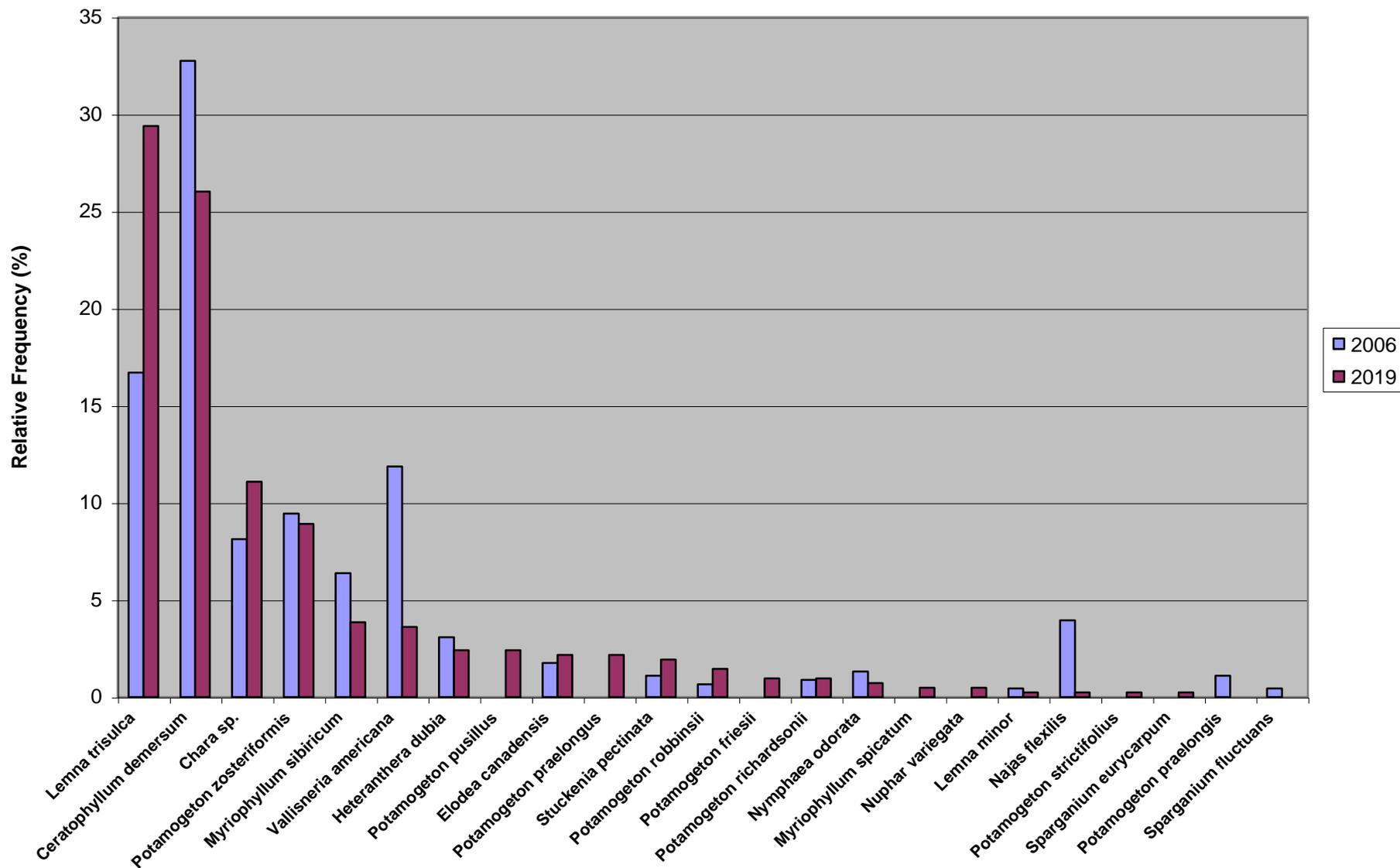


Figure 7. Crane Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2019).



Figure 8. Distribution of plant species, Crane Lake (2019).

Lemna trisulca,
Forked duckweed

● 1 (Rake fullness)

● 2

● 3

▼ Visual

✗ Not found

✗ Unsampled (depth)

✗ Non-navigable

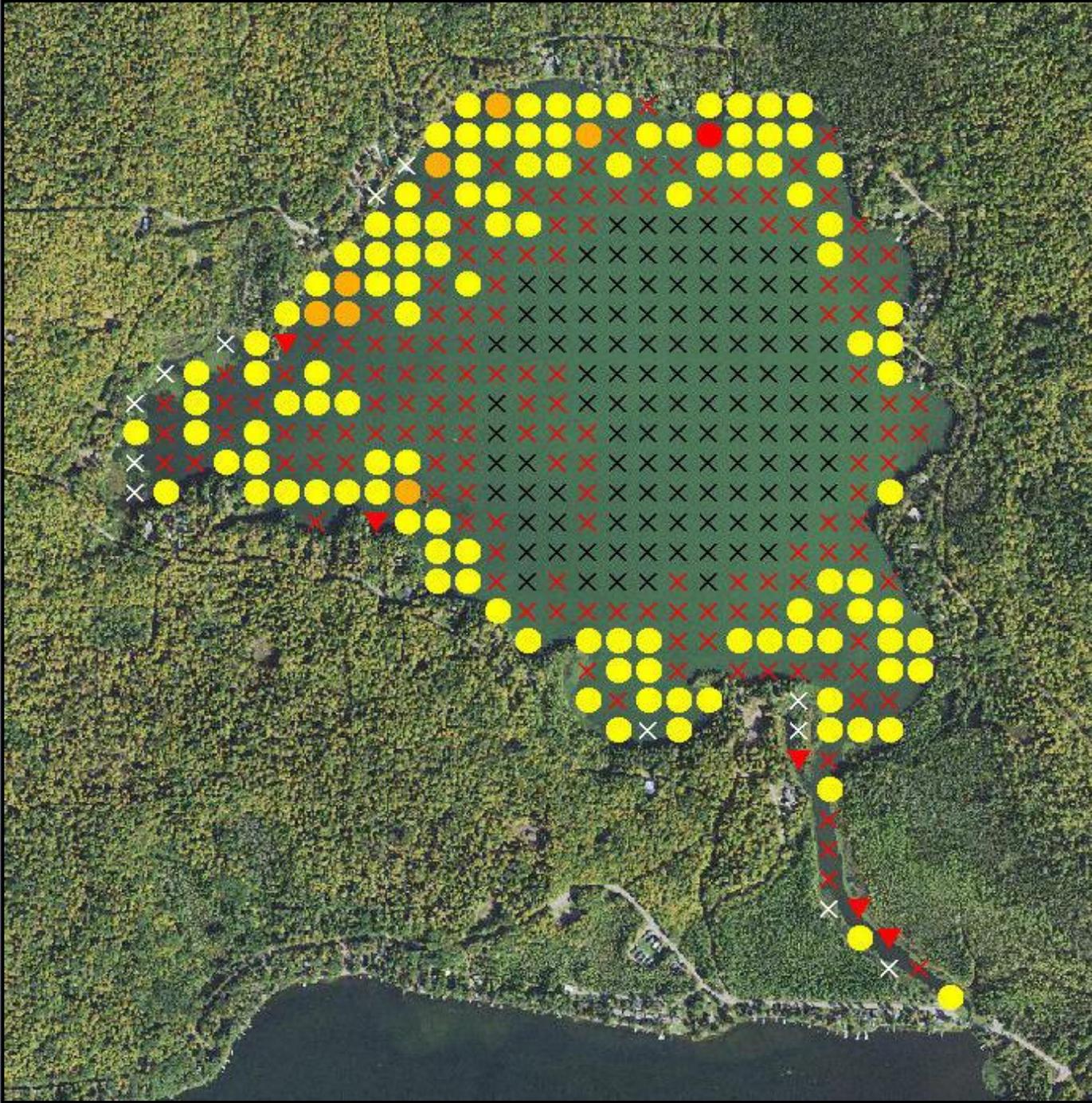


Figure 9. Distribution of plant species, Crane Lake (2019).

Ceratophyllum demersum,
Coontail

● 1 (Rake fullness)

● 2

● 3

▼ Visual

✕ Not found

✕ Unsampled (depth)

✕ Non-navigable

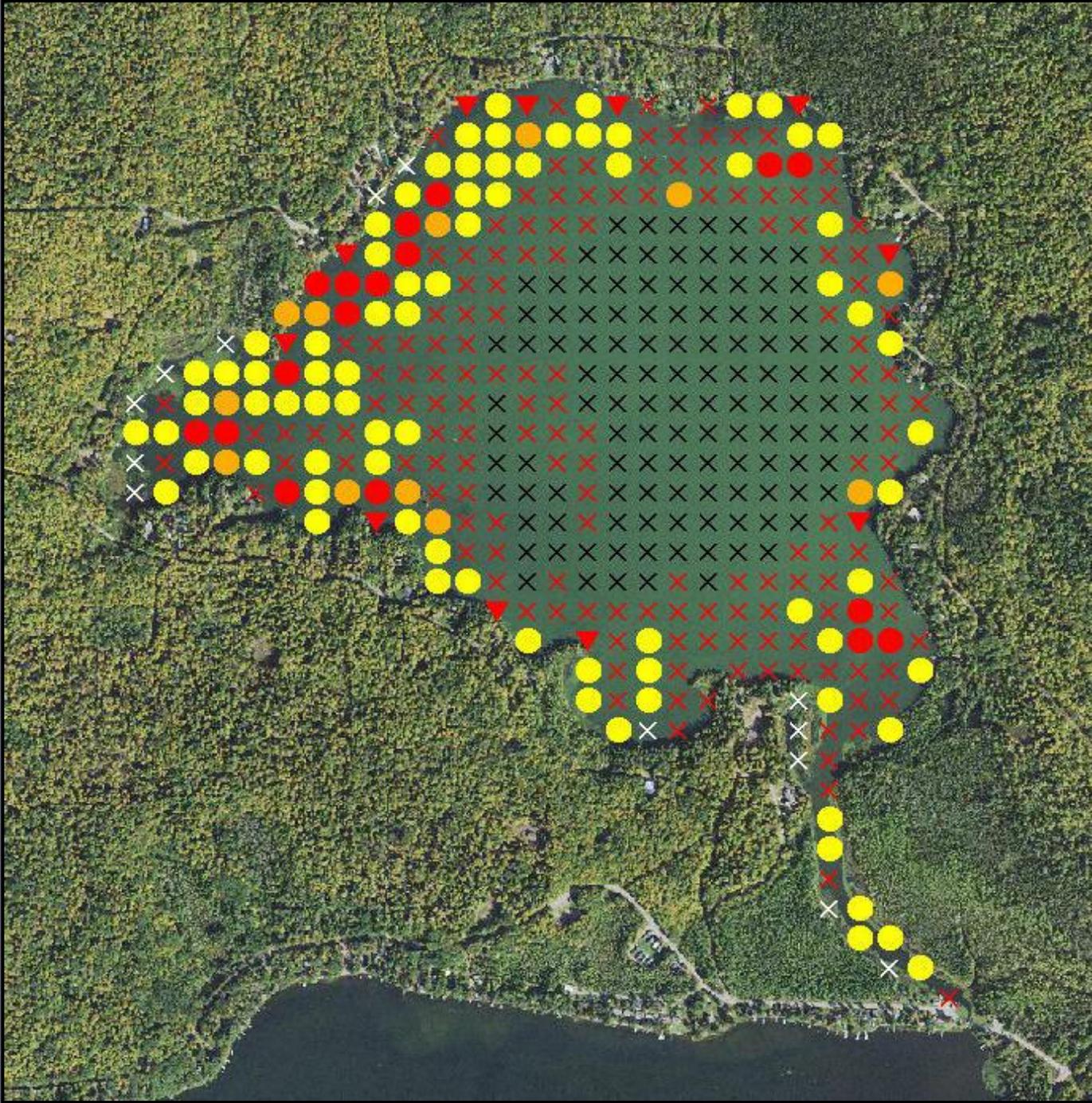


Figure 10. Distribution of plant species, Crane Lake (2019).



Chara sp.,
Muskgrasses

-  1 (Rake fullness)
-  2
-  3
-  Visual
-  Not found
-  Unsampled (depth)
-  Non-navigable

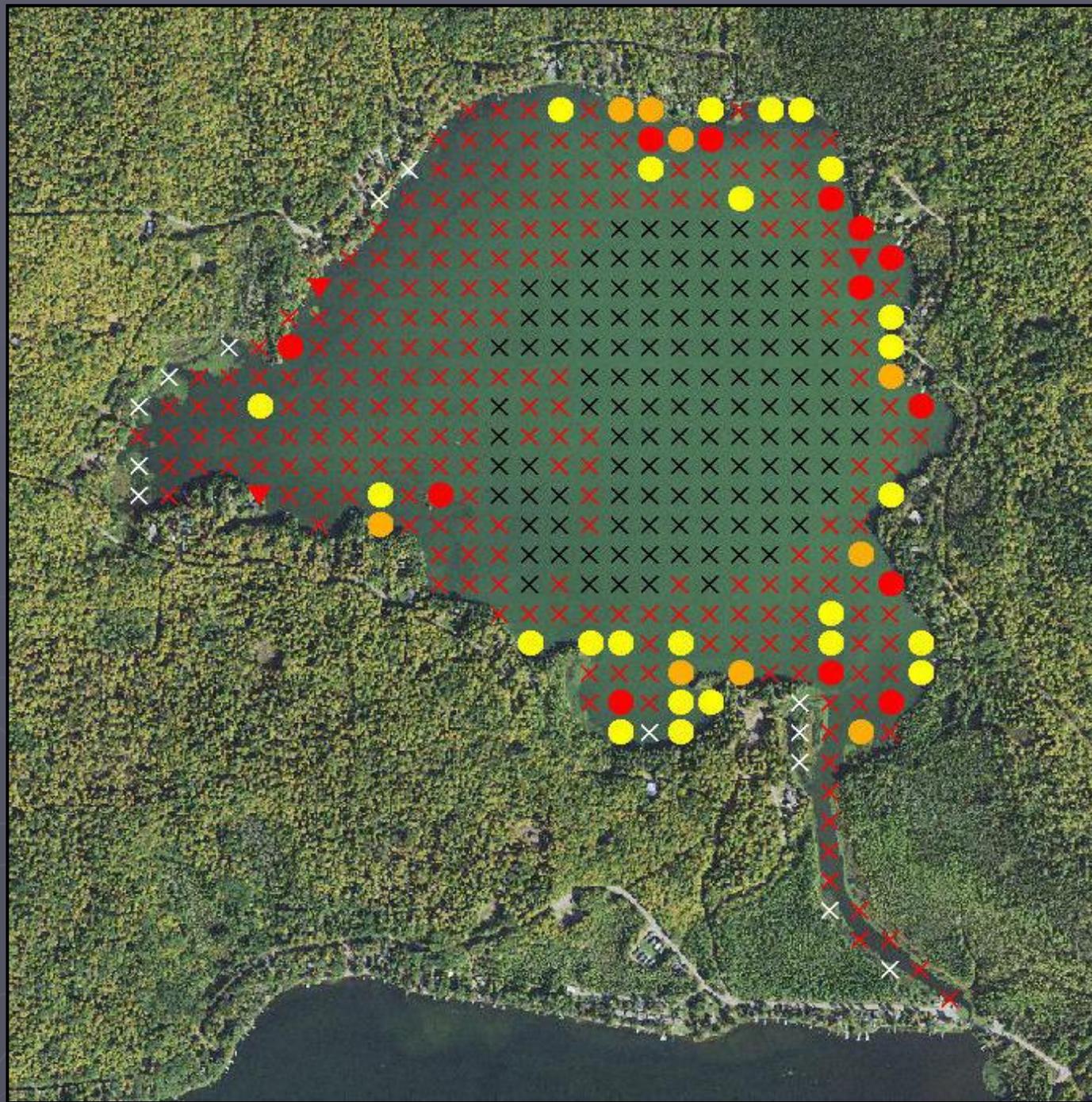


Figure 11. Distribution of plant species, Crane Lake (2019).



Potamogeton zosteriformis,
Flat-stem pondweed

-  1 (Rake fullness)
-  2
-  3
-  Visual
-  Not found
-  Unsampld (depth)
-  Non-navigable

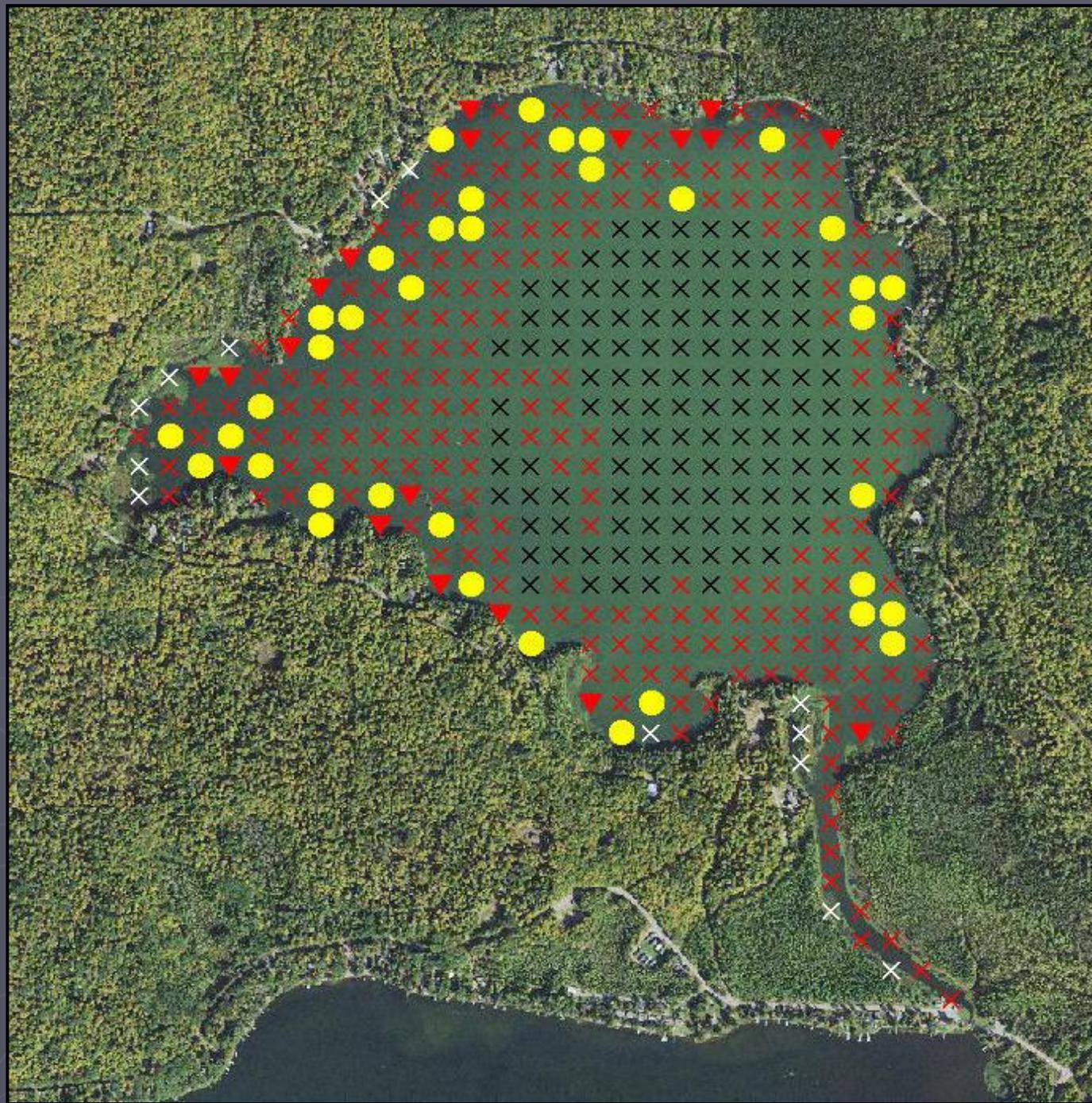


Figure 12. Distribution of plant species, Crane Lake (2019).



Myriophyllum sibiricum,
Northern water-milfoil

-  1 (Rake fullness)
-  2
-  3
-  Visual
-  Not found
-  Unsampld (depth)
-  Non-navigable

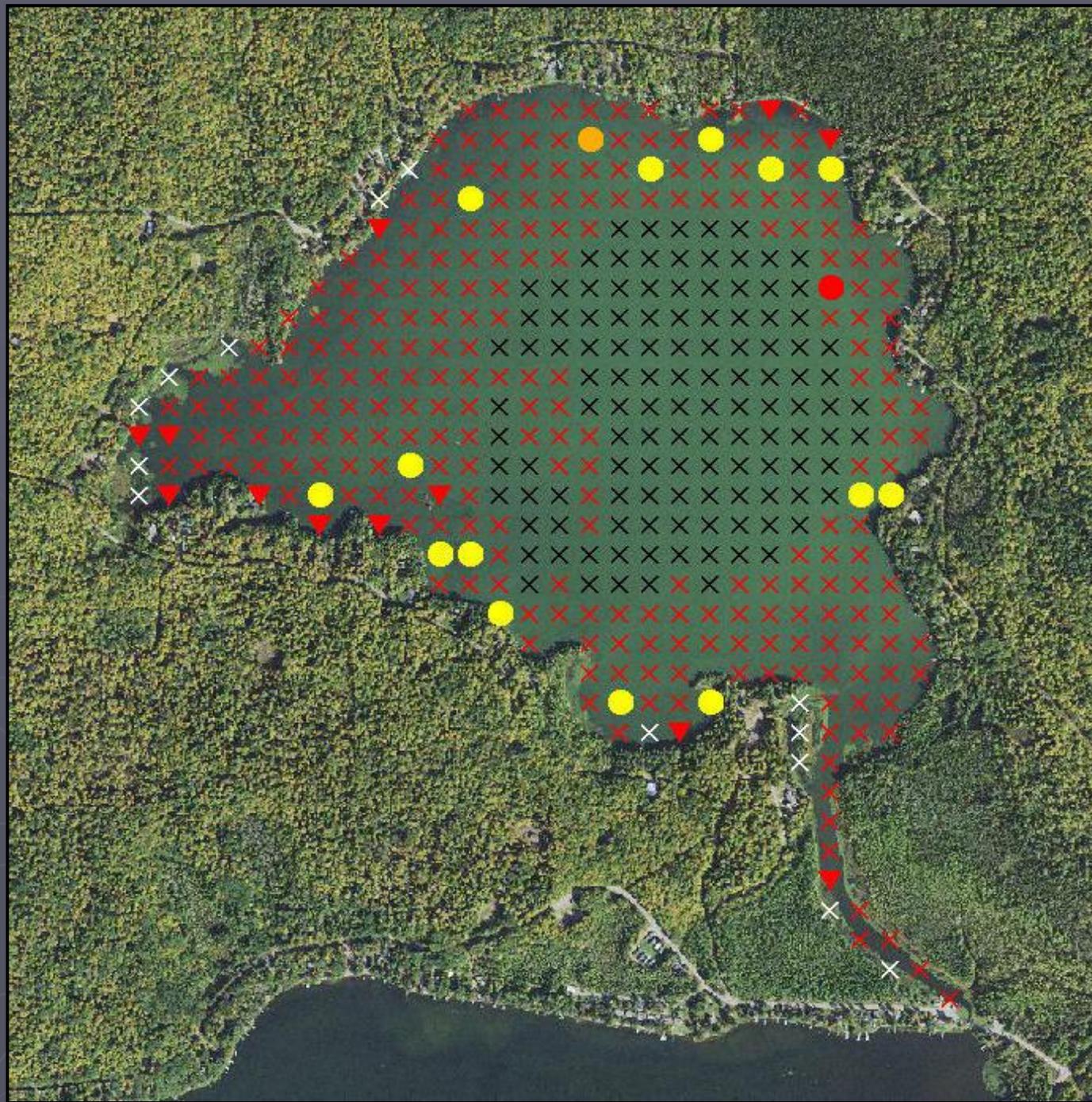
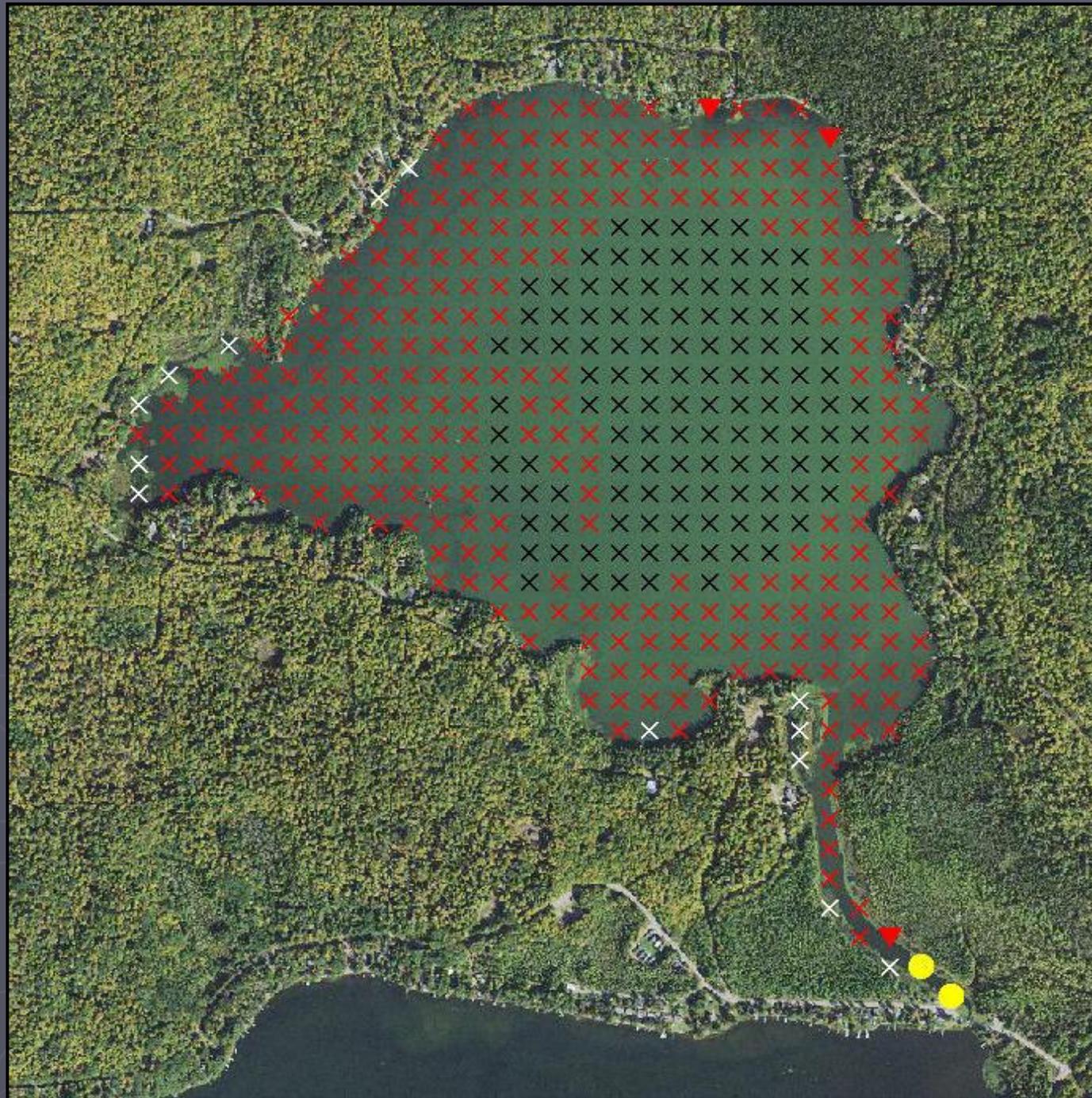


Figure 13. Distribution of plant species, Crane Lake (2019).



Myriophyllum spicatum,
Eurasian water milfoil

- 1 (Rake fullness)
- 2
- 3
- ▼ Visual
- ✕ Not found
- ✕ Unsampled (depth)
- ✕ Non-navigable



Appendix 3
Review of Crane Lake Water Quality

Note: This document is available as Appendix C of the
Pickereel/Crane Lakes Adaptive Management Plan
(starts on following page)

Appendix C

Review of Crane Lake Water Quality

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Review of Crane Lake Water Quality

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

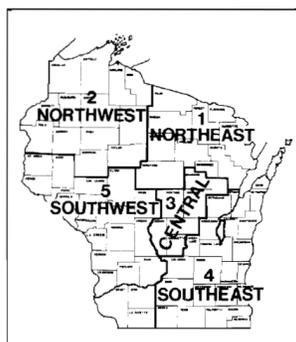
Introduction

Crane Lake is located in Forest County, Wisconsin. It is a 355-acre spring fed lake with a maximum depth of 25 feet. The Waterbody Identification Code (WBIC) is 388500. The purpose of this review is to assemble and interpret water quality data for Crane 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 (WDNR, 2021a) from 2013 to present. Secchi disk measurements have been collected by Citizen Lake Monitoring Network (CLMN) volunteers from 1990-2020. Chlorophyll *a* and total phosphorus were collected since 2002, by CLMN volunteers.

Comparison of Crane 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. Forest 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. Figure 2 present water temperature profiles for March and April. These samples show very little stratification. In May and June (Figure 3 and 4), the temperature profiles show some slight stratification from surface to bottom. In July, temperature profiles show definite stratification (Figure 5). During this time, the lake usually stratified between 15 and 20

feet. In August there is slight stratification (Figure 6). In September, October, and November (Figure 7), temperature profiles showed little stratification and show the same temperature throughout.

Figure 2. Crane Lake temperature profiles, March and April.

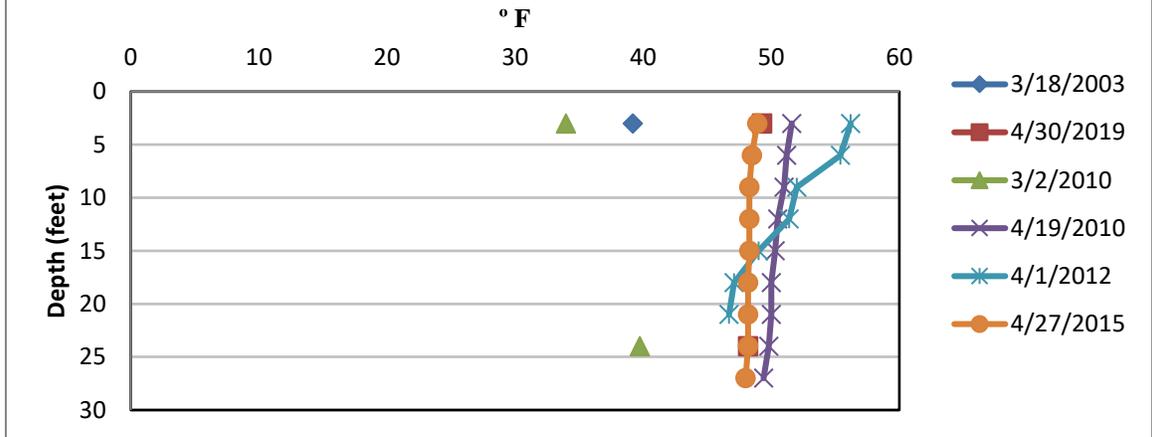


Figure 3. Crane Lake temperature profiles, May.

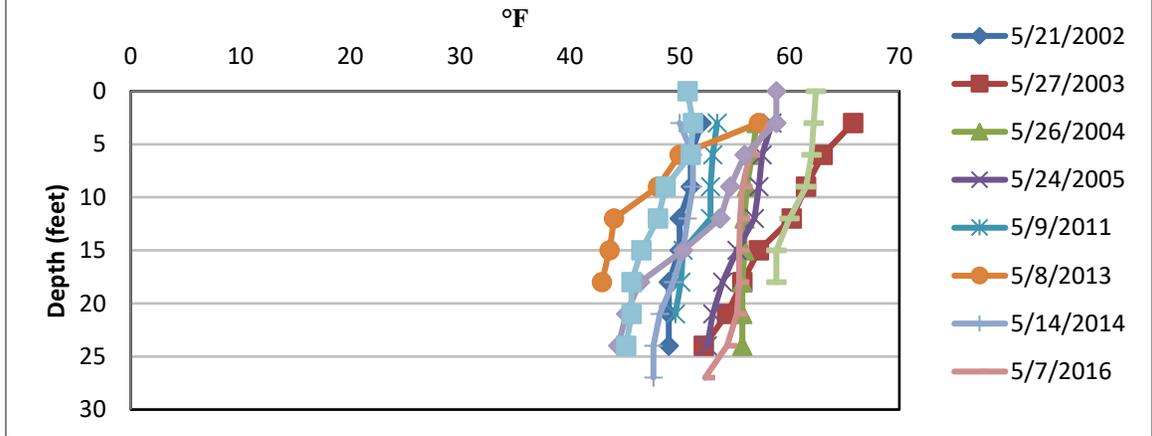


Figure 4. Crane Lake temperature profiles, June.

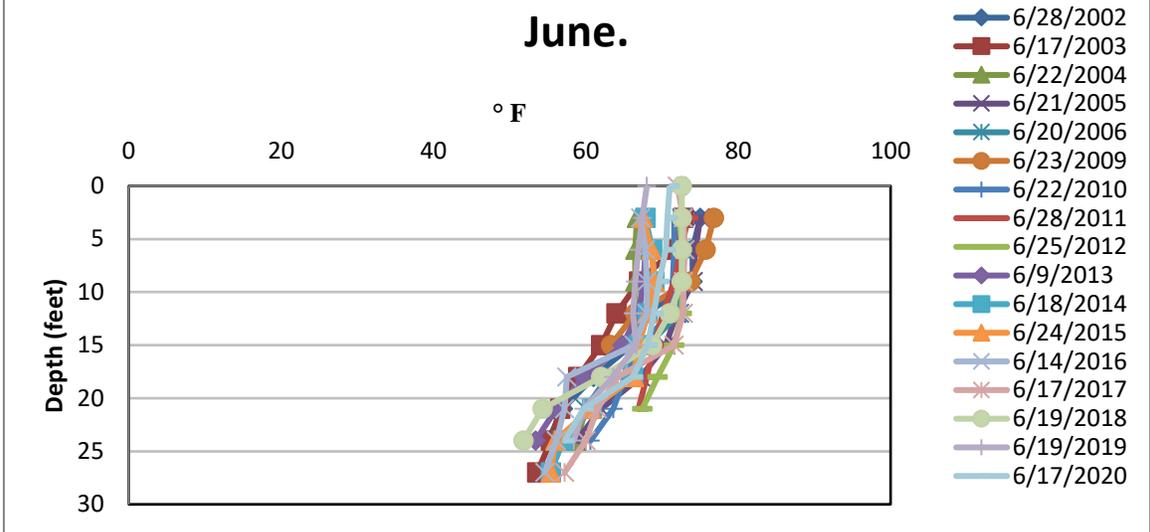


Figure 5. Crane Lake temperature profiles, July.

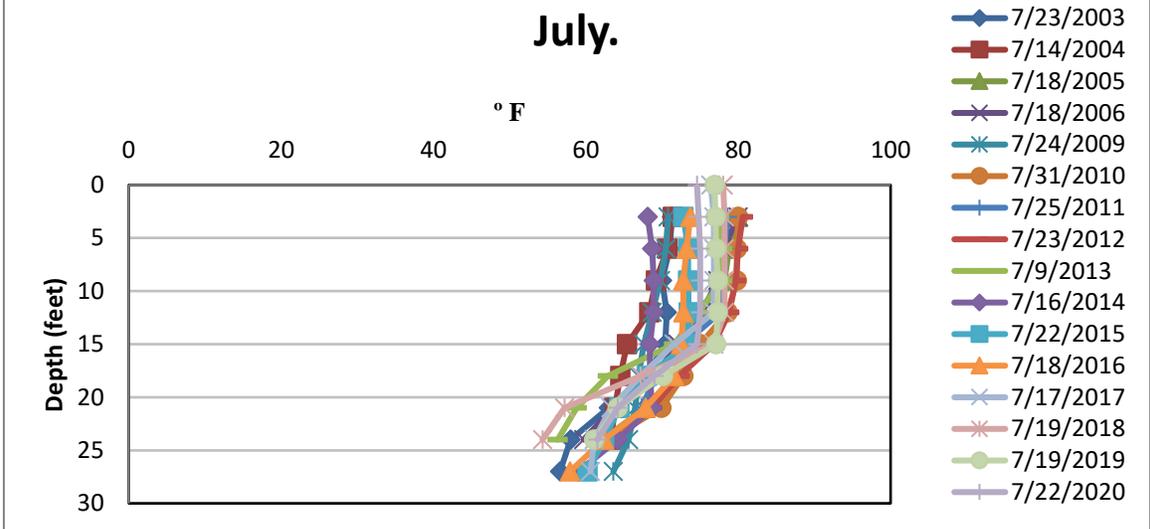


Figure 6. Crane Lake temperature profiles, August.

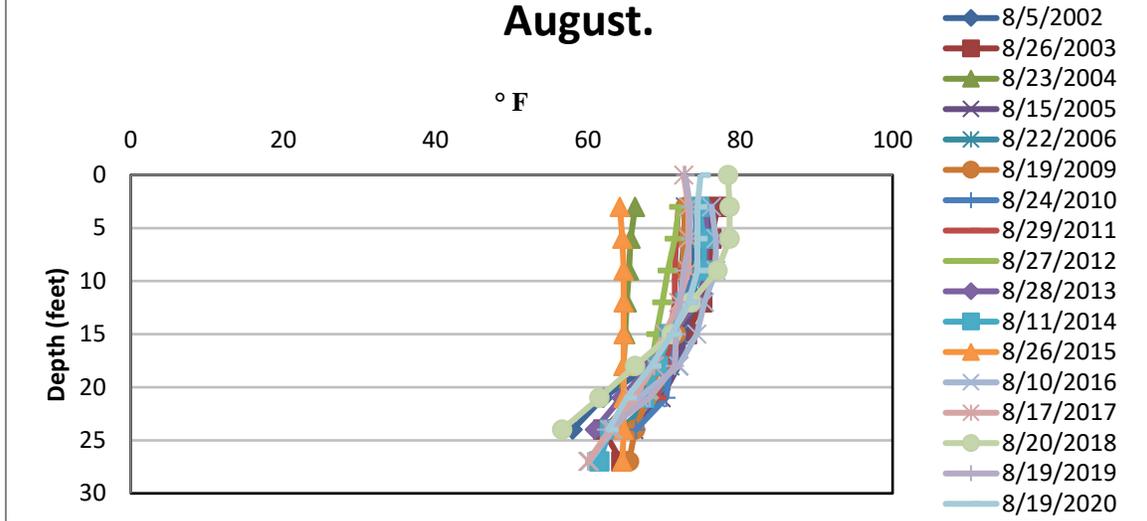
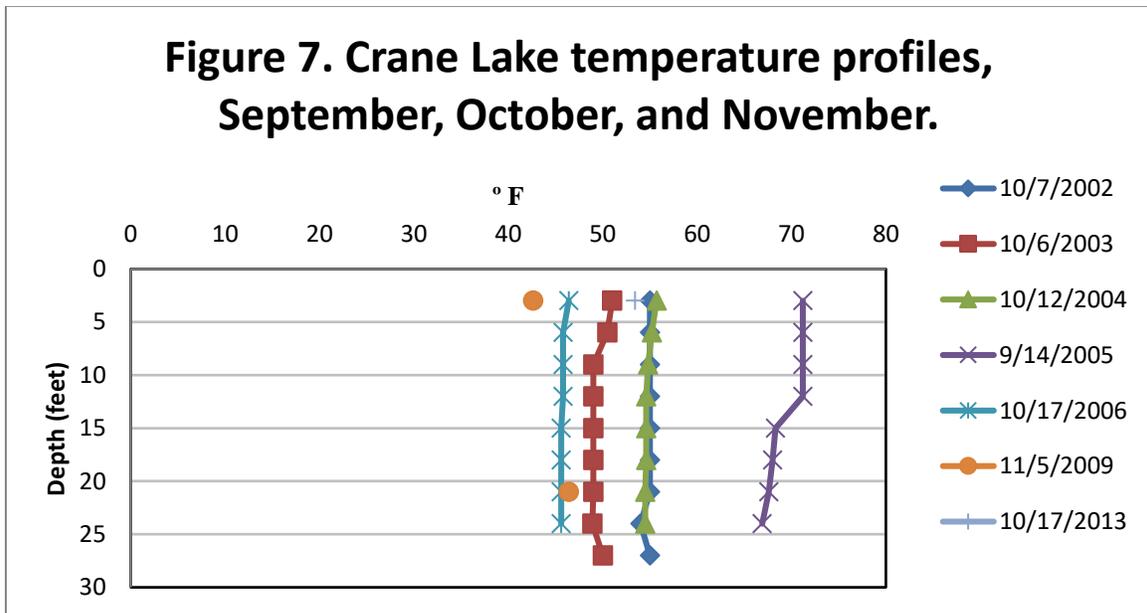


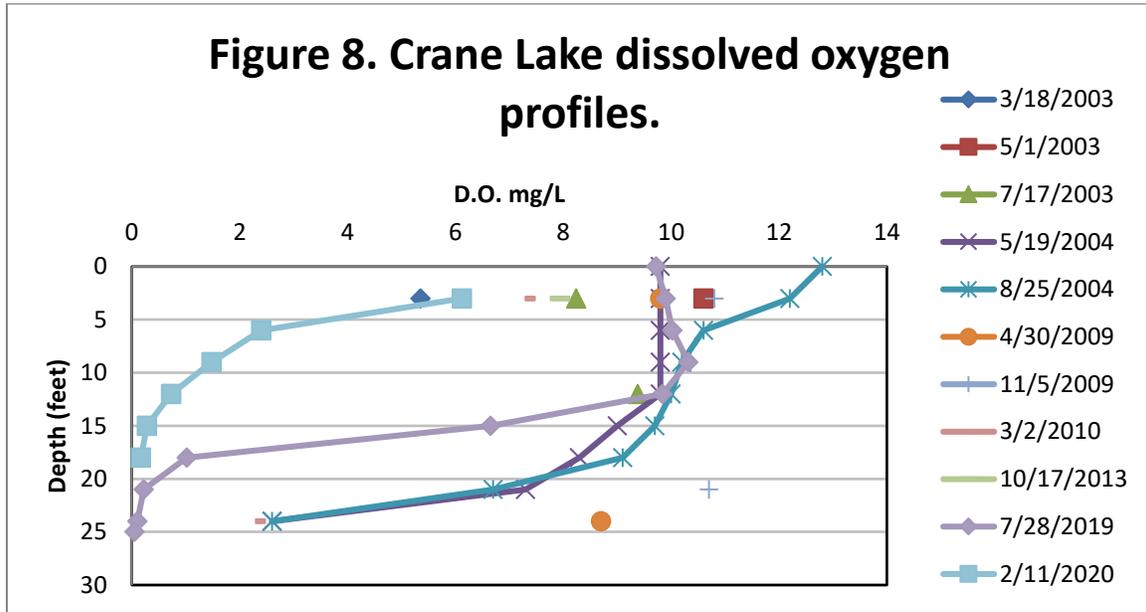
Figure 7. Crane Lake temperature profiles, September, October, and November.



Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis, but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of D.O. available in a lake, particularly in the deeper parts of a lake, is critical to overall health. Crane Lake D.O. profiles are

displayed in Figure 8. D.O. levels were between 5.36 and 12.8 mg/L from March to October at the surface (Figures 8).

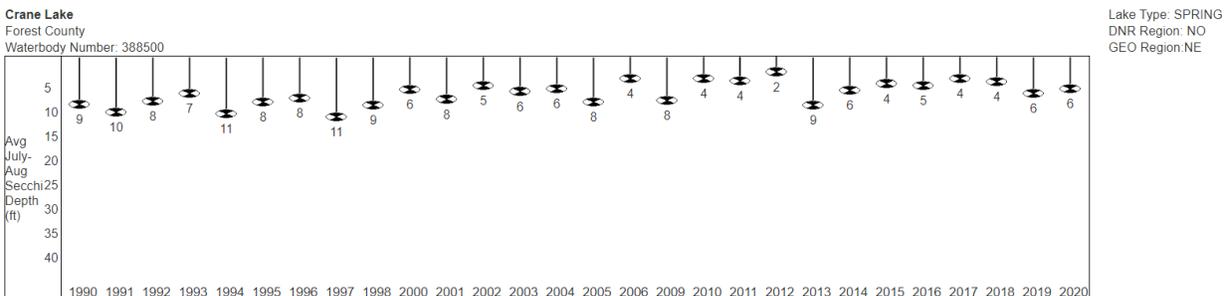


Water Clarity

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 displays the July and August mean Secchi depths from 1990 to 1998 and 2000 to 2006, 2009 to 2020. Crane Lake’s most recent Secchi depth categorizes it as “poor” with respect to water clarity (Table 1). The shallowest mean Secchi depth was 2.25 feet in 2012, and the deepest mean reading was at 11.37 feet in 1992 (Figure 10).

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



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

(WDNR, 2021)

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. Crane Lake’s July and August Secchi Data: Mean, Min, Max, and Secchi Count (1990 -1998, 2000-2006, 2009-2020) (WDNR, 2021).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1990	8.83	6.25	11	3
1991	10.39	5.75	15.25	11
1992	8.1	7	10	5
1993	6.53	4.25	9	13
1994	10.8	7	18.75	11
1995	8.32	3.5	11.5	11
1996	7.55	5.5	11	14
1997	11.32	7	16	11
1998	9	6.75	11	3
2000	5.75	4.25	8	3
2001	7.88	4	10.6	4
2002	5.08	3.25	6	3
2003	6.13	4.25	8	2
2004	5.58	3	9.75	3
2005	8.38	3	13.75	2
2006	3.5	3	4	2
2009	8	6	9	3
2010	3.5	3	4	2
2011	4	3	5	2
2012	2.25	1	3.5	2
2013	9	7	11	2
2014	6	5	7	2
2015	4.5	4	5	2
2016	5	3	7	2
2017	3.5	3	4	2
2018	4.25	2.5	6	2
2019	6.5	3	10	4
2020	5.5	4	7	2

Report Generated: 01/14/2021

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 the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms. Crane Lake turbidity has not been tested, and should be included in future water quality sampling.

While checking Secchi depth, CLMN volunteers also rate the water clarity and describe the water as “clear” or “murky.” In the years that were sampled (1995-2016) Crane Lake had a water column appearance of “clear” 99% of the time.

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. Crane Lake color has been analyzed in 2004 and 2019 (Figure 11). CLMN also recorded their perceptions of water color in Crane Lake. Volunteers indicated the water appeared “blue” 52% of the time, “green” 45% of the time, and 3% of the time they indicated the water appeared “brown” in color (Figure 12).

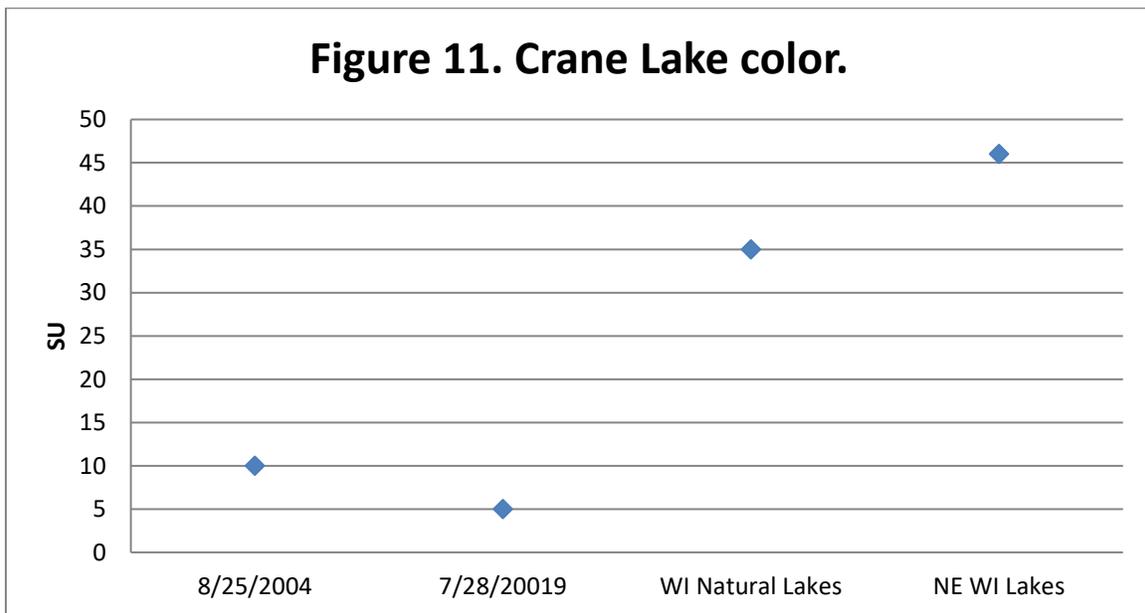
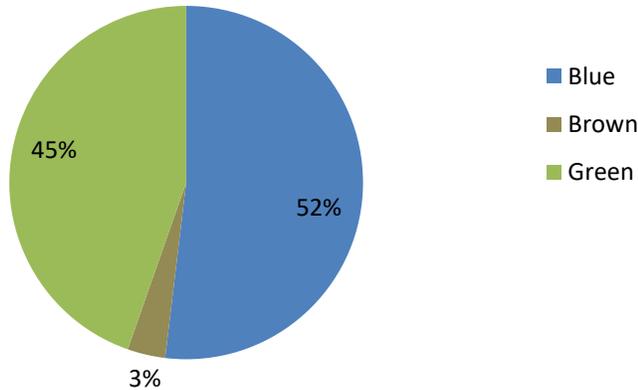


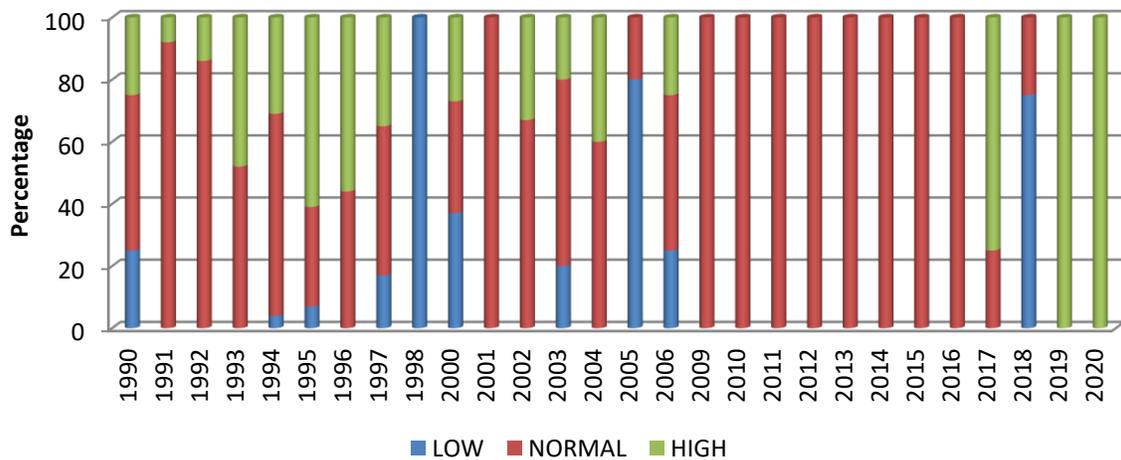
Figure 12. Crane Lake water color appearance, 1990-1998, 2000-2020.



Water Level

When CLMN volunteers collect Secchi depth readings, they also record the lake level as “high,” “normal,” or “low.” Figure 13 indicates that in 2019 and 2020 the water level in Crane Lake appeared “high.”

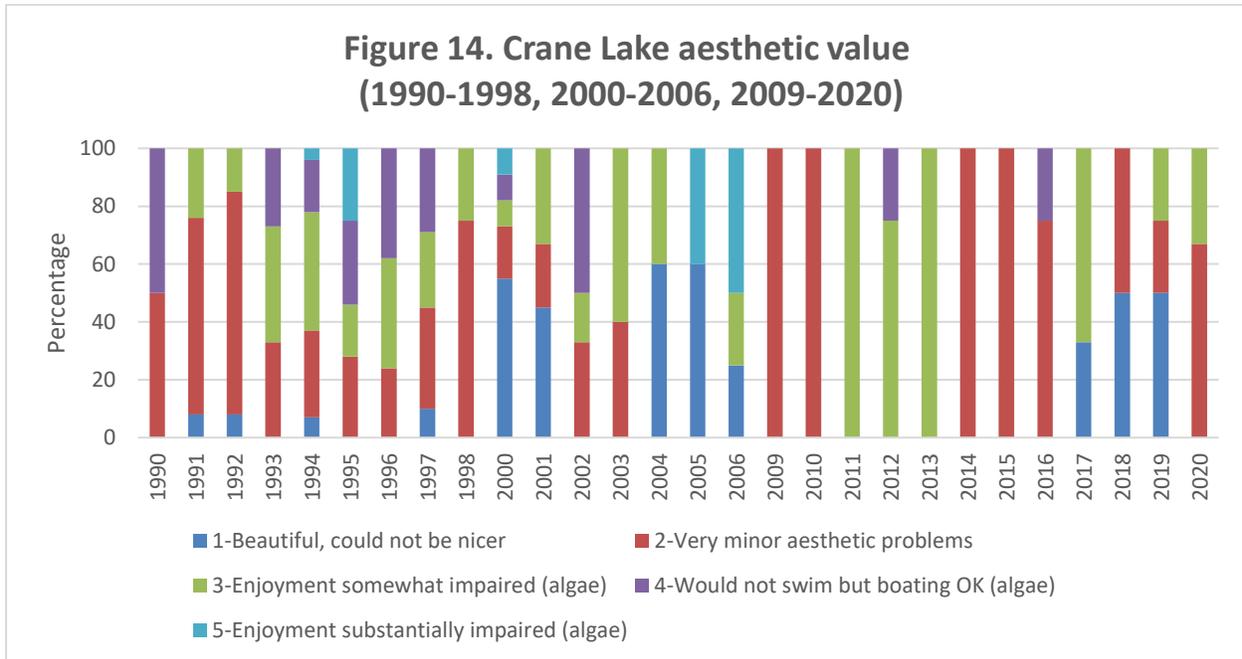
Figure 13. Crane Lake lake level.



User Perceptions

The CLMN 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

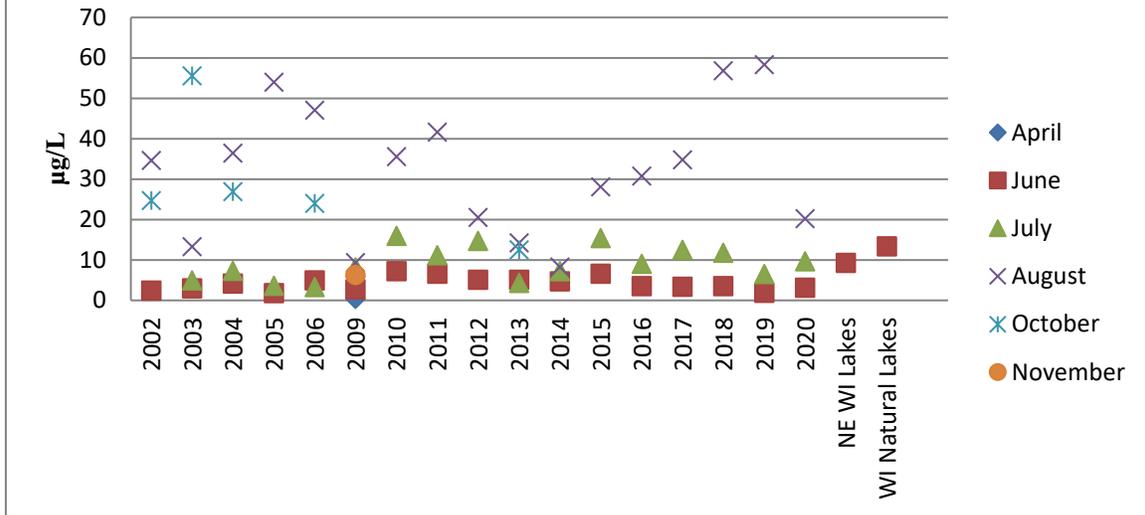
lake user would experience the lake at that time. When interpreting the transparency data, we see that when the Secchi depth decreases, the rating of the lake’s physical appearance also decreases. These perceptions of recreational suitability are displayed by year in Figure 14. In 2014 and 2015, 100% of CLMN volunteers recorded Crane Lake to have “very minor aesthetic problems.”



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 15). Crane Lake is considered an impaired water (303d) due to one or more pollutants and associated quality impacts. The water was listed for excess algal growth in 2014. Assessments in 2016, 2018, and 2020 confirm the algal impairment (WDNRc, 2021). During the aquatic plant survey in 2019 we noted net algae on the rake in many locations along with filamentous algae.

Figure 15. Crane Lake chlorophyll *a*.



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).

Crane Lake total phosphorus values were considered “fair” to “good,” (Figure 16) and are comparable to the region and state values in some years but were above for a few years (Figure17). Ortho phosphorus had no detection on 3/18/2003, 5/1/2003, 7/17/2003, 4/30/2009, and 10/17/20013. March 2, 2010 there was a 0.003 mg/l value at 3 feet and 0.007 mg/L at 24 feet.

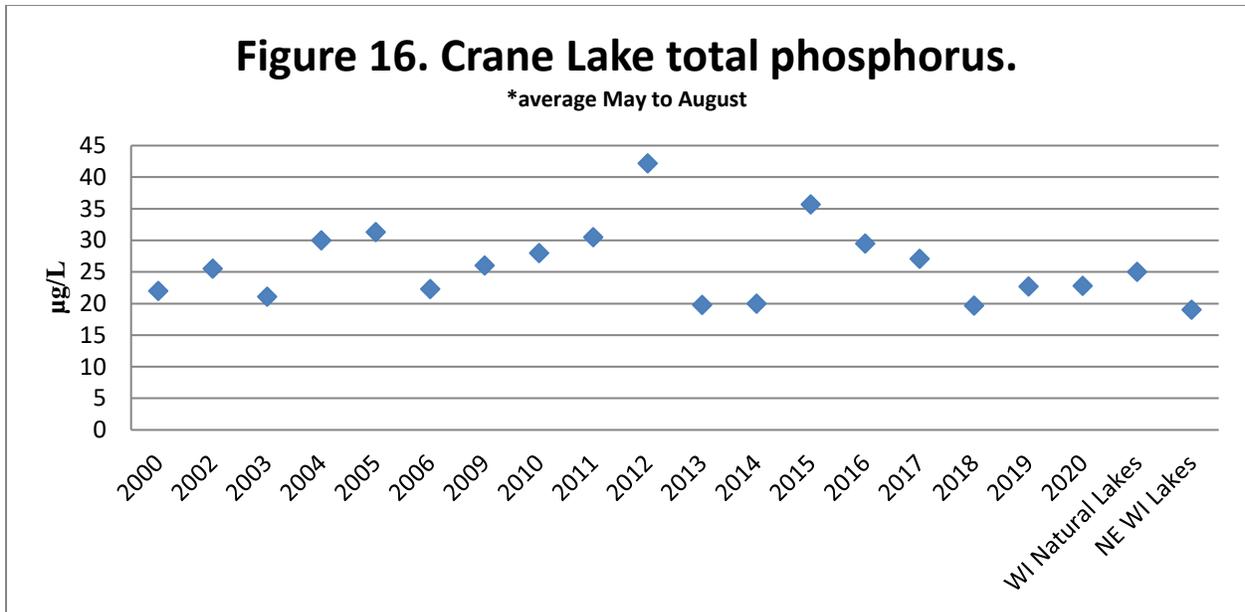
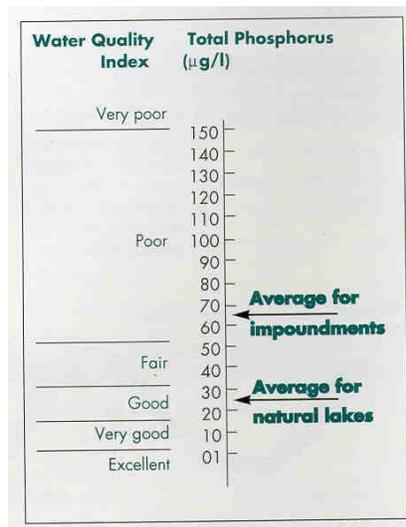


Figure 17. Total phosphorus concentrations for Wisconsin’s natural lakes and impoundments (Shaw et al., 2004).



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 only Secchi measurements, chlorophyll *a*, and total phosphorus collected from the CLMN. Figure 18, classifying Crane Lake as “mildly eutrophic” (Table 2).

Figure 18. Crane Lake Trophic State Index, (1989-2020). (WDNR, 2021)

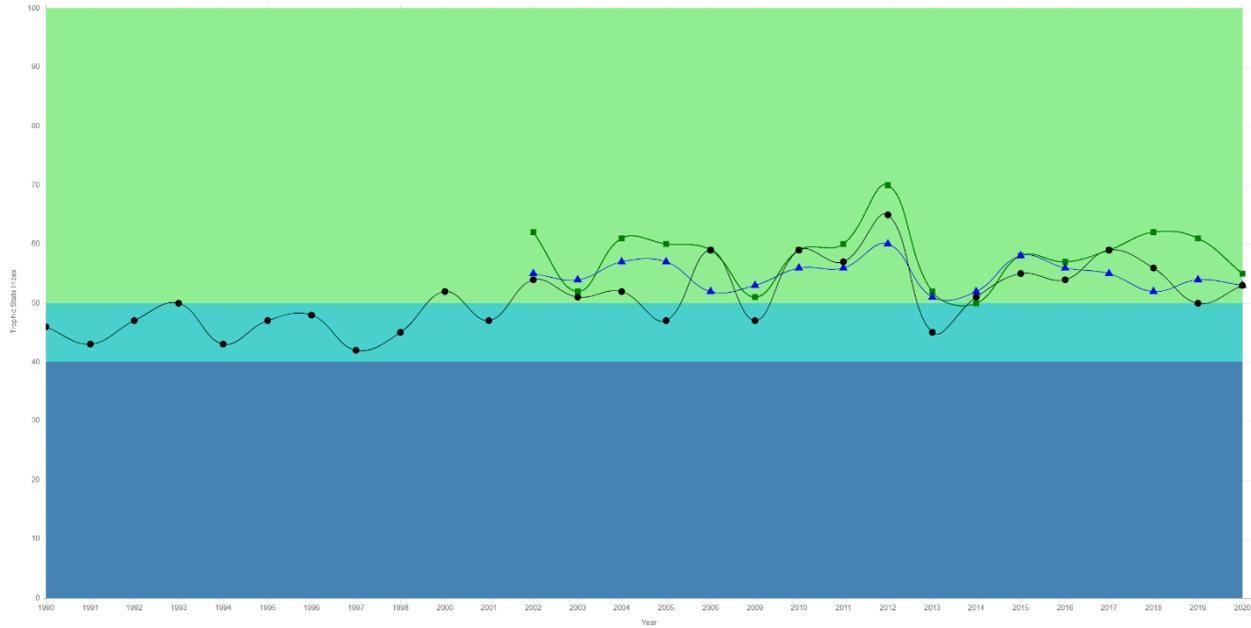


Table 2. Trophic State Index.	
30-40	Oligotrophic: clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	Mesotrophic: moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and 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, 2019b)

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 $\mu\text{g/L}$	Chlorophyll <i>a</i> $\mu\text{g/L}$	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 is 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 ammonia, nitrate, and nitrite, derived from human activities, can stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, macrophytes), 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). Crane Lake nitrate/nitrite nitrogen has been tested with no detection on 5/1/2003, 8/25/2004, 4/30/2009, 6/23/2009, 7/24/2009, 8/19/2009, 11/5/2009, 3/2/2010, and 7/28/2019 at 3 feet. April 30, 2009 there was a value of 0.029 mg/L at 23 feet and on March 2, 2010 a value of 0.035 mg/L at 24 feet. Figure 19 displays total Kjeldahl nitrogen and Figure 20 displays ammonium.

Figure 19. Crane Lake total Kjeldahl nitrogen.

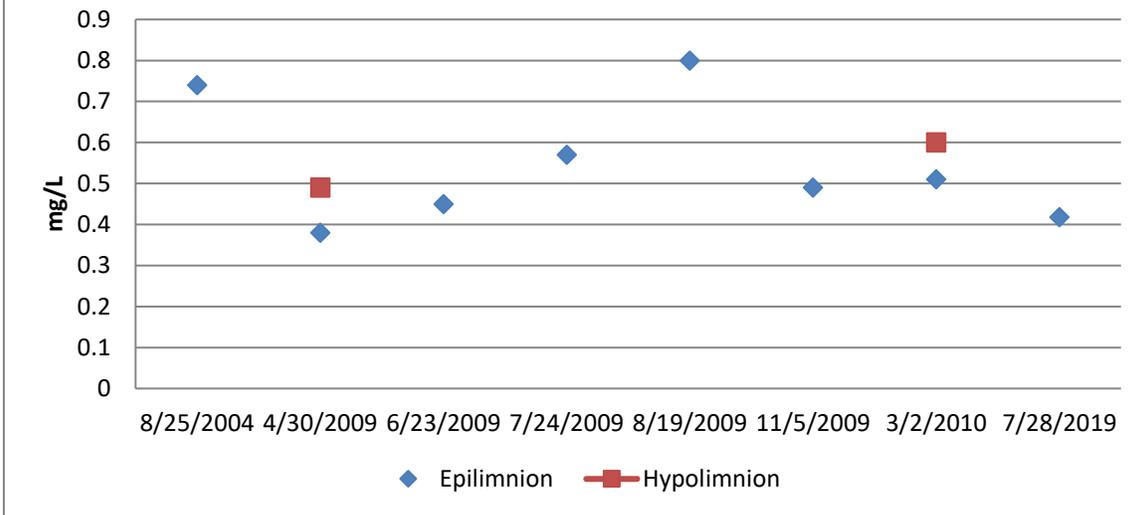
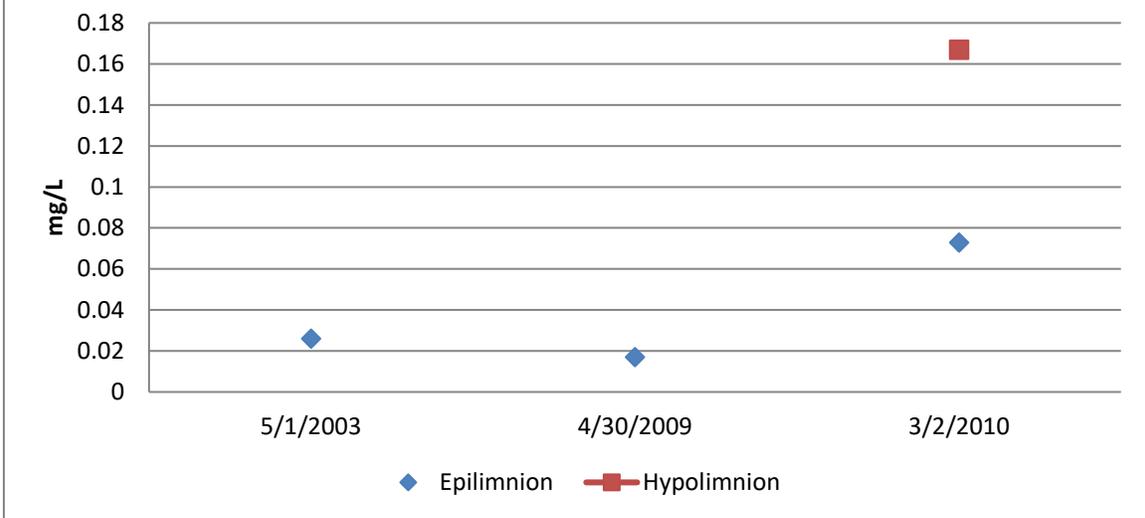


Figure 20. Crane Lake ammonia.



Chloride

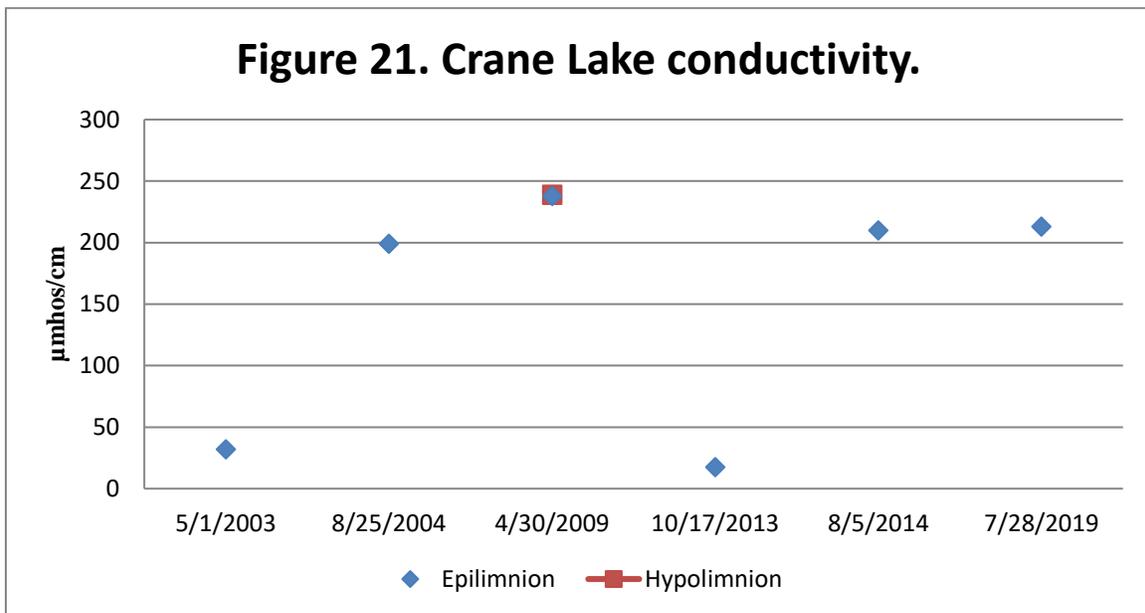
The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Crane Lake chloride was analyzed on 7/28/2019 with a 1.81 mg/L. For Northeast Wisconsin Lakes the mean for chloride is 2 mg/L and 4 mg/L for Wisconsin Natural Lakes.

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). Crane Lake sulfate was analyzed on 7/28/2019 with a 3.62 mg/L.

Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter ($\mu\text{mhos/cm}$) 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). Crane Lake conductivity values are displayed 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. 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. Crane Lake pH values are shown in Figure 22 and ranged from 7.16 to 8.67 SU.

Table 4 shows the effects pH levels less than 6.5 can have on fish. Crane Lake is close to neutral in the one sample taken of pH. While moderately low pH does not usually harm fish, the metals that become

soluble under low pH can be important. In low pH waters, aluminum, zinc, and mercury concentrations increase if they are present in lake sediment or watershed solids (Shaw et al., 2004).

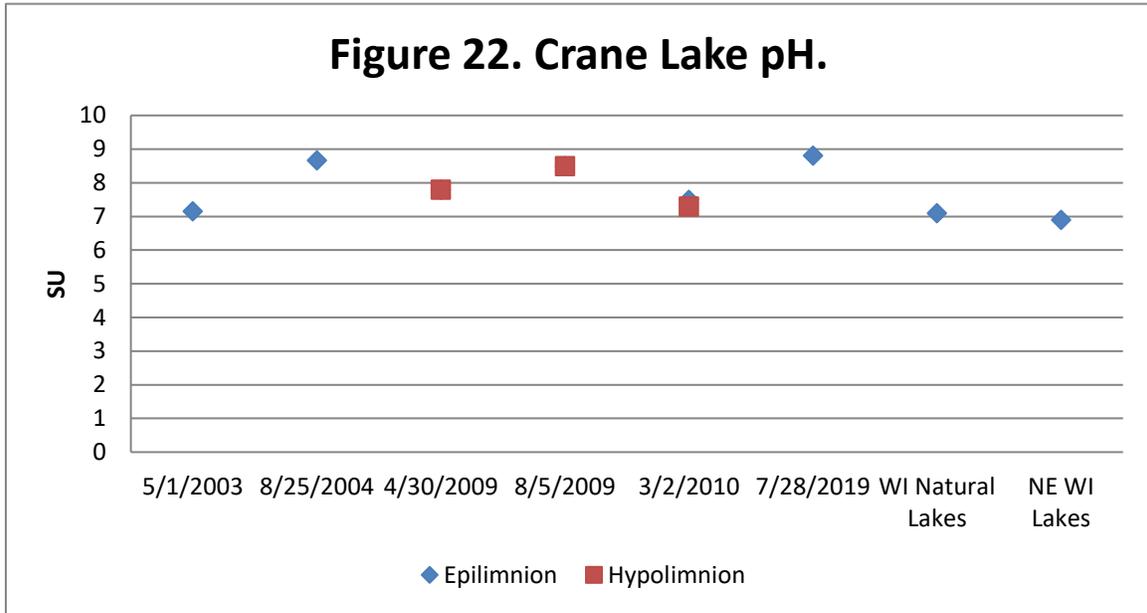


Table 4. Effects of acidity on fish species (Olszyk, 1980).

<i>Water pH</i>	<i>Effects</i>
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. Crane Lake alkalinity is shown in Figure 23. This level categorizes Crane Lake as “non-sensitive” to acid rain (Table 5).

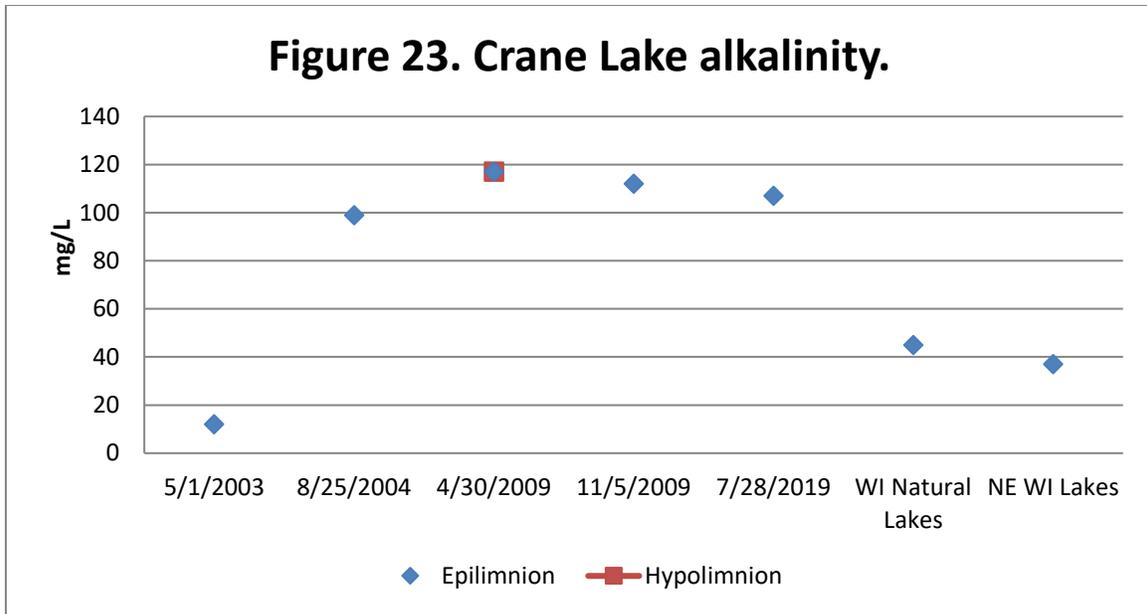


Table 5. Sensitivity of Lakes to Acid Rain (Shaw et al., 2004).

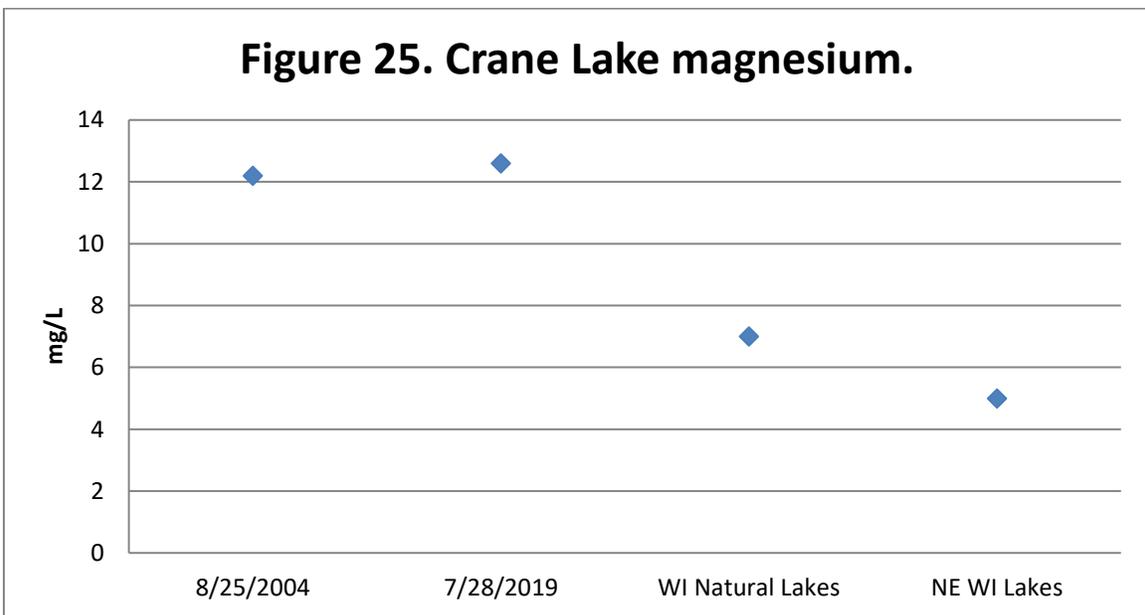
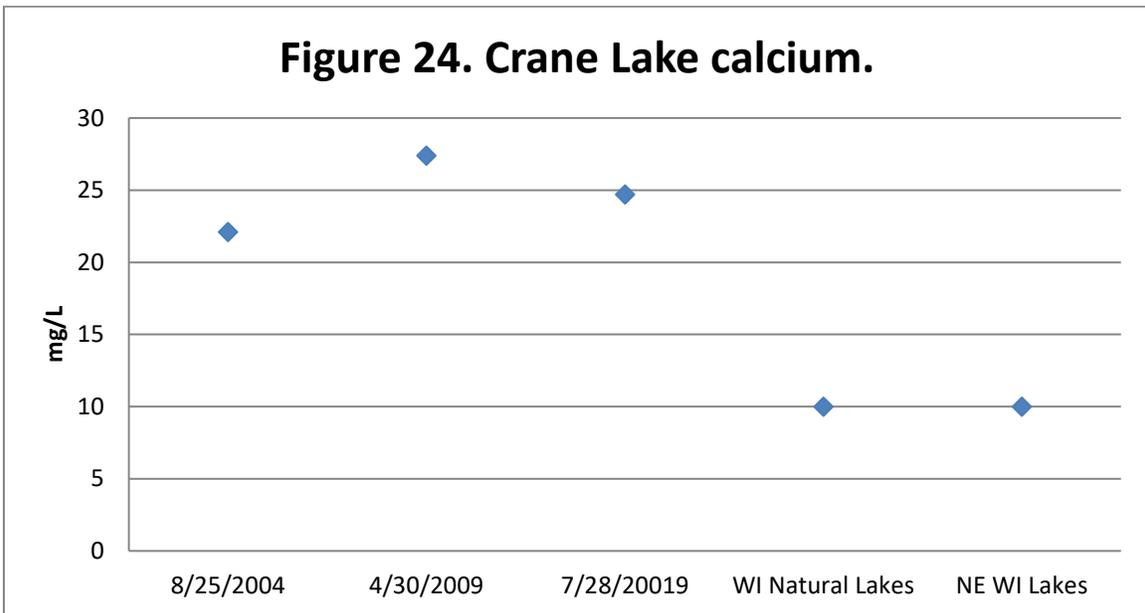
<i>Sensitivity to acid rain</i>	<i>Alkalinity value (mg/L or ppm CaCO₃)</i>
High	0-2
Moderate	2-10
Low	10-25
Non-sensitive	>25

Hardness

Hardness levels in a lake are affected by the soil minerals, bedrock type, 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 (CaCO₃). Crane Lake hardness was tested in 7/28/2019 with a value of 114 mg/L.

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. Crane Lake calcium levels are shown in Figure 24. Calcium was 22 to 27 mg/L indicating that Crane Lake is “suitable” for zebra mussels if they were introduced. Magnesium levels (Figure 25) are high for Crane Lake in comparison to Wisconsin natural lakes and Northeast Wisconsin lakes mean.



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). Crane Lake sodium was tested on 7/28/2019 with a value of 1.86 mg/L. Potassium was also tested on the same date with values of 0.581 mg/L.

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. In general, organic carbon compounds are a result of decomposition processes from dead organic matter such as plants. When water contacts high 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. Crane Lake DOC has not been tested, and should be included in future water quality sampling.

Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. Generally, lakes that are fed by groundwater have higher levels of silica. Crane Lake silica has not been tested, and should be included in future water quality sampling.

Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. Crane Lake aluminum has not been tested, and should be included in future water quality sampling.

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. Crane Lake iron has not been tested, and should be included in future water quality sampling.

Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining

problems. Manganese data is unknown for Crane 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. There was a Phase-I Diagnostic & Feasibility Study conducted in 1990 to evaluate the sediment in Crane and Pickerel Lakes see Eilers and Bernert, 1992 for the detailed report.

Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by bottom-feeding fish. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can in turn affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” Total suspended solids data was sampled in 4/30/2009 at 3 feet (no detection) and 23 feet (no detection). TSS was also sampled 11/5/2009 at 3 feet (3 mg/l) and at 22 feet (2 mg/L). On 3/2/2010 there was no detection at 3 and 24 feet.

Ice Out and Ice On

Ice out was documented once and occurred 4/26/2019.

Aquatic Invasive Species

The aquatic invasive species found in Crane Lake are the banded (2011) and Chinese (2014) mystery snails, Eurasian watermilfoil (EWM) (2011) and the hybrid milfoil (2009). Looking in the SWIMS database a DNR AIS zebra mussel and spiny waterflea tow was conducted 8/24/2009, 9/6/2009, 8/17/2010, 8/5/2014, and 5/31/2019 with no finds. On 8/5/2014 a baseline AIS monitoring was conducted by the DRN. The Chinese and banded mystery snail were found along with EWM and the hybrid. There was a note of purple loosestrife found on the road. On 5/31/2019, a White Water Associates biologist along with a volunteer from Crane Lake conducted an AIS Early Detection Monitoring Survey and found the banded mystery and Chinese mystery snail. A more detailed report can be found in Appendix E.

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 occurred in 2013. There were 54 boats inspected, 112 people contacted, and 54 hours spent (WDNR, 2021b)

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