The Lake Alice Stewardship Program Adaptive Management Plan (3rd Edition)

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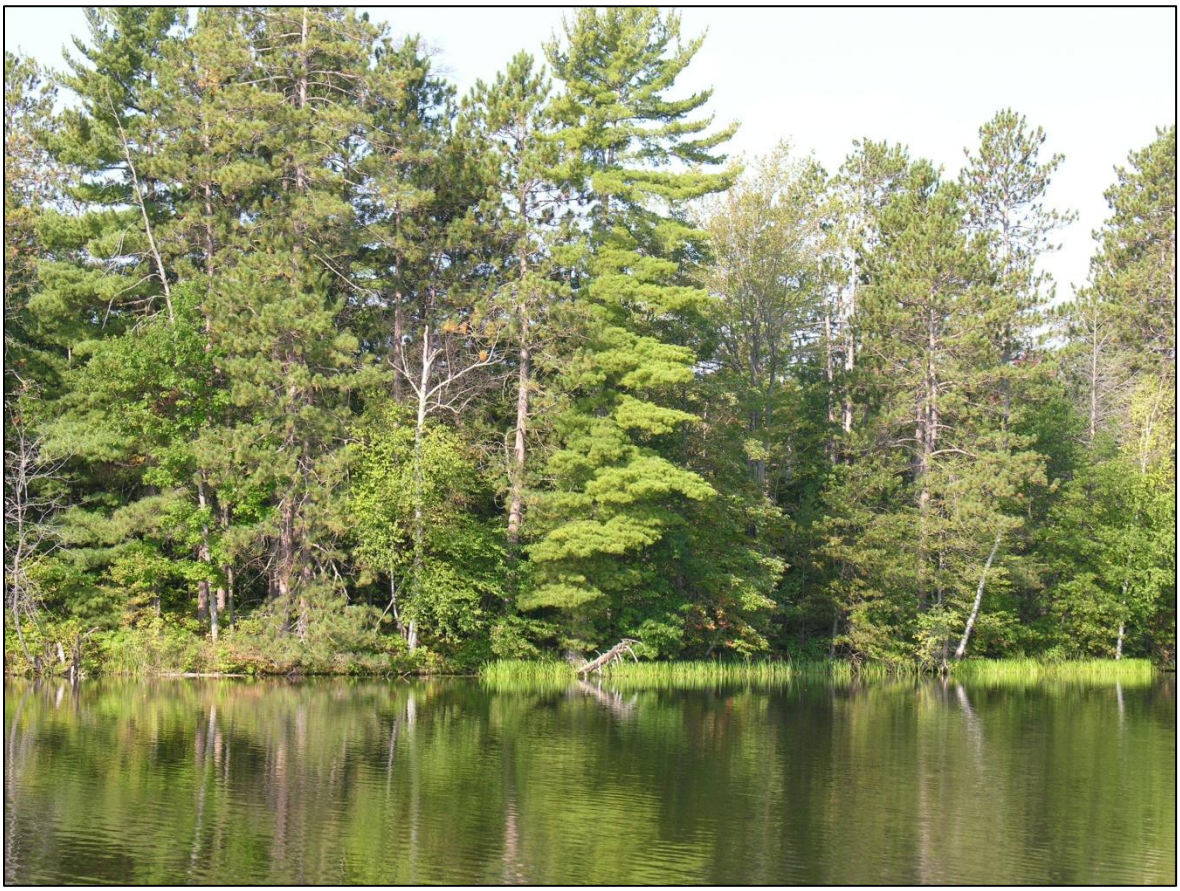

Lake Alice Shoreline 2009 (Dean Premo photo)

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The Lake Alice Stewardship Program Adaptive Management Plan (3rd Edition)

(Lincoln County, Wisconsin)

Includes information collected during:

- **Phase 1 – Information Inventory and Adaptive Lake Management Plan**
- **Phase 2 – Understanding the biota of Lake Alice and Aquatic Plant Management Plan**
- **Phase 3 – People, Plants, Animals, and Habitats**

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WHITE WATER ASSOCIATES, INC.

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CHAPTER 1

What Is the Lake Alice Stewardship Program?

The Lake Alice Stewardship Program is an ongoing endeavor composed of periodic phases that progress toward the overall vision of the Lake Alice Association – a healthy, sustainable Lake Alice. In Phase 1, participants learned about the lake and the landscape. In Phase 2, a principal task involved conducting an aquatic plant survey and creating an aquatic plant management plan. Phase 2 tasks also included frog and toad surveys and a volunteer angler journal. In Phase 3, we included people, plants, animals, and habitats in the investigation. In the Phase 3 products (including this Adaptive Management Plan and the Aquatic Plant Management Plan), we also report on activities conducted under two Early Detection Rapid Response Grants that were awarded the Lake Alice Association (one for Eurasian water-milfoil and one for curly-leaf pondweed). Success of future phases depends on a coalition of participants, each carrying out appropriate tasks and communicating needs and findings to other team members. It is appropriate that the Lake Alice Association (LAA) is the lead organization in this long-range endeavor.

This document integrates findings and activities of the three program phases now completed along with the information from the Eurasian water-milfoil and one for curly-leaf pondweed efforts. Like Phases 1 and 2, Phase 3 was the possible because of a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant awarded to LAA as well as two WDNR Early Detection Rapid Response Grants. White Water Associates, Inc. (White Water), an independent environmental laboratory and ecological consulting firm, has been contracted by LAA to carry out significant aspects of these projects. Phase 1 focused on an inventory of relevant information on Lake Alice and its surroundings and produced the first iteration of an Adaptive Lake Management Plan. Phase 2 addressed aquatic plants and other biota of Lake Alice and included preparation of an aquatic plant management plan. This 3rd Edition of the Adaptive Management Plan integrates all of the products of Phases 1 and 2 with the most recent findings and includes a second edition of the Aquatic Plant Management Plan. The vision of the Lake Alice Stewardship Program is to ensure the perpetuation of a healthy Lake Alice and its surrounding landscape ecosystem far into the future. Participants

believe that the tool by which to realize this vision is an adaptive management plan for the Lake Alice.

Project participants have embraced the concept of "adaptive management" in their approach to the Lake Alice Stewardship Program. Simply stated, adaptive management uses findings from planned monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive iterations of the comprehensive plan. The plan will therefore be a dynamic entity, successively evolving and improving to fit the needs of the Lake Alice watershed. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain. It follows that a practical management plan allows for ongoing adjustments in management designed to "adapt" to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management. It is the goal of the Lake Alice plan that future monitoring will focus on tangible indicators designed to measure progress toward specific program goals.

Including this introductory Chapter 1, this plan is organized in seven chapters. Chapter 2 describes the audience for the Lake Alice Adaptive Management Plan. Chapter 3 addresses why there should be a plan and discusses adaptive management and the underlying assumptions of the approach. Chapter 4 details how the plan was created, including the methodology used. Chapter 5 presents the findings from efforts to gather existing and new information about Lake Alice and its environs by providing summaries of information in fourteen subsections. Chapter 6 (What Goals Guide the Plan?) presents the desired future condition and goals established by the Lake Alice Association and the plan writers. Chapter 7 (What Objectives and Actions Move Us Toward the Goals?) offers a logical menu of practical management actions ready to be adopted and adapted by those interested in taking an active role in caring for Lake Alice and its surroundings. Ten Appendices complete this document. Appendix A contains literature cited. Appendix B presents the aquatic plant management plan. Appendix C includes a conductivity study that was completed on Lake Alice. Appendix D includes the results of a littoral zone and shoreland survey. Appendix E presents a volunteer based shoreland photo archive and assessment. Appendix F reports on the volunteer anglers' journal. Appendix G contains the frog and toad survey results. Appendix H is a review of water regulations and planning programs relevant to Lake Alice management. Appendix I is a human history of Lake Alice and Appendix J contains the results of a lake user survey.

CHAPTER 2

Who Is the Audience for the Lake Alice Plan?

The title of Chapter 3 poses the question: "Why have a Lake Alice Adaptive Management Plan?" The short answer is "Because we care!" We believe that people working together in the stewardship of this lake can make a difference. We can protect and restore a healthy ecosystem if we take a long-term, strategic approach. That approach is presented in this adaptive plan. It is an adaptive plan in the sense that it will grow and evolve. Implemented actions will be monitored. The plan will be evaluated. It will be reviewed and refined as years go by – as new generations take up their stewardship responsibility.

People who care about the Lake Alice Watershed are the audience for this plan. They will be the implementers and evaluators. They will be the reviewers and future plan writers. Many of them live in or near the watershed. These are the "grassroots" – the constituency most connected to Lake Alice and its surroundings. People who care are also those who live beyond the watershed boundaries. Some of these people visit Lake Alice for recreation and enjoyment. But the audience also includes foundations and other funding agencies, resource and regulatory agencies concerned with environmental quality, and other citizens that are working on their watersheds.

For those in the "grassroots" camp, this plan is intended to provide you with a practical approach to carrying out protection and restoration of Lake Alice. The plan does not have all the answers (it doesn't even have all the questions). It does not recommend every conceivable rehabilitation or protection action. But the plan does provide plenty with which to get started and it leaves room for ideas and contributions from others. Our recipe mixes a pinch of the theoretical with a cupful of the practical. Those of you who are "hands-on" have plenty to do.

The mixed audience of this plan challenges the authors to present a plan that is scientifically grounded and technically oriented, but at the same time accessible and understandable by the public who will in large part be responsible for its implementation. Although scientists are the primary authors of the plan, the writing is aimed at the public. We define terms where clarity is needed and cite other literature for those interested in the source of a statement, or in learning more about the topic. LAA has interacted with the plan writers

throughout the process. LAA has encouraged our practical approach so that applications of the plan are conspicuous.

We will end this chapter with our strongest management recommendation:

Approach lake and watershed management with humility.

Lake and watershed ecosystems are enormously complex. Our understanding of how they work is not complete. Our ability to predict outcomes from specific actions is uncertain. New discoveries are made every day that have important implications for future watershed management. We may never know all we need, but that fact can't stop us from starting work on Lake Alice today. The fact that ecosystems are inherently resilient is to our great advantage. They are able to rebound from disturbance and repair themselves from injury. In fact, some of today's best watershed managers state that "...successful restoration usually has less to do with skillful manipulation of ecosystems than it does with staying out of nature's way" (Williams et al 1997). This plan is intended to complement nature's own processes.

CHAPTER 3

Why Have a Lake Alice Adaptive Management Plan?

Why have a Lake Alice Adaptive Management Plan? The gut-level answer ("because we care") was offered in Chapter 2, but the question deserves more thoughtful reflection – the focus of this chapter. This requires consideration of environment, economy, history, and culture. This chapter also defines some important terms and presents the process and underlying assumptions.

Part 1 - Why Should We Care?

The health of a watershed and the health of local economies like those that exist in the Lake Alice Watershed are highly integrated. A sustainable economy depends on a healthy environment. In fact all social and economic benefits are based on the biological and physical properties of watersheds (Williams et al. 1997). In fact, our economy should be viewed as being nested inside our environment (Lanoo 1996).

This link between a healthy environment and the economy is true at several scales. For example, most property owners on Lake Alice have invested in an ecosystem. The reasons that they have purchased the property are typically linked to the quality of the environment. The economic value of their investment is linked to the health of lake and surroundings. If ecological health declines, so does the value of the property in dollars.

At a slightly larger scale, this same principal linking the environment and economy applies to municipalities. The Tomahawk community is caretaker of many ecosystems including Lake Alice. The long-term economic health of the municipality is tied to the health of Lake Alice and other lakes and streams in the area. At even larger scales yet, this applies to Lincoln County, to the State of Wisconsin, and so on.

The Lake Alice Association and this plan aspire to cultivate a deep connection to the lake and its surroundings. It is the people of the watershed that will make the management plan work. Lake and watershed stewardship must be a cultural imperative. In some ways, watershed restoration is about cultural restoration – rejuvenating citizens' civic responsibility to care for the environment in which they live. This is what Aldo Leopold referred to as "...the oldest task in human history: to live on a piece of land without spoiling it" (Leopold 1948).

People need to feel vital by working to improve, beautify, or build. Sometimes that need is expressed by gardening, caring for a lawn, or volunteering on civic projects. LAA and this plan endeavor to harness that energy and apply it to restoration and protection actions focused on Lake Alice and its landscape. Education, rehabilitation, and protection become outlets for this creative energy.

Why should you care about creating and implementing a practical watershed plan? Because we realize the economy and the economic options available to citizens in the watershed are tied to a healthy environment. Because we are all connected to the Lake Alice landscape in some way. Because we feel a civic responsibility to care for the lake. Because we can feel vital by doing meaningful work on the watershed. Because future generations depend on us to hand down a healthy Lake Alice ecosystem for them to enjoy and use.

The adaptive management plan will be successful if it allows and organizes meaningful stewardship work for Lake Alice. It needs to make provision for different kinds of approaches and different kinds of people who want to be part of the process. It has to be strategic and integrated so that various actions complement one another, and are consistent with the lake's natural processes. The plan should discourage management actions that work at cross-purposes or whose outcomes are undesirable.

Part 2 - What Is an Adaptive Management Plan?

An adaptive management process (Walters, 1986) is the most appropriate model to use in lake and watershed management. In adaptive management, a plan is made and implemented based on best available information and well-defined goals and objectives. Outcomes of management actions are monitored to ascertain whether they are effective in meeting stated goals and objectives. Based on this evaluation the plan is adapted (modified) in a process of continuous learning and refining.

Adaptive management concedes and confronts a truth that most resource managers are reluctant to acknowledge – uncertainty. Because natural systems are so diverse, so complex, and so variable, almost all management actions will have uncertain outcomes. An adaptive management approach essentially takes a position that says, "We will make our best attempt and get better as we go along. We'll listen to what the natural system tells us." In adaptive management monitoring is crucial. Adaptive management uses information from monitoring to continually evaluate and refine management practices. Monitoring measures the success of restoration or management. Well-designed monitoring should indicate how effectively

management measures are working and give us new insights into ecosystem structure and function. Monitoring should provide needed information to adapt management goals.

The Lake Alice Adaptive Management Plan can be implemented through five kinds of management actions: protection, rehabilitation, enhancement, education, and research. Research actions have a special subset called "monitoring actions" that serve all of the management actions. Each kind of action is summarized in the following bullets.

- Protection actions are used when high quality areas or ecosystem elements are identified and need to be safeguarded. Since numerous aspects of Lake Alice and its surroundings are quite pristine, a significant part of the Lake Alice adaptive management could fall under this kind of action. There are numerous forms that protection actions can take including protecting water quality, conservation easements, buffer zones to prevent runoff into the lake, and so on.
- Rehabilitation actions are those that manipulate site-specific elements of ecosystems in order to repair some past impact. Examples include planting lakeside natural vegetation in areas of erosion, placing fish structure where large woody material has been removed from the lake, or healing an area of active erosion. Individual rehabilitation actions contribute to overall lake and watershed restoration.
- Enhancement actions are intended to improve some function or value of the ecosystem. In some cases, these actions are meant to benefit human users of the lake (for example, enhancing recreation values by planting fish or creating new fish habitat).
- Education actions are those activities that serve to promote lake stewardship and inform landowners and visitors about natural ecosystems. These actions can include this report and management plan as an education piece. These actions also include the installation of interpretive points or incorporation of Lake Alice components in science classes of Tomahawk High School students. Every person that visits Lake Alice is an opportunity for education about healthy ecosystems.
- Research actions are employed to learn about the system being managed. Often we know very little about the plants, animals, habitats, ecosystems, and processes that our management actions are affecting. Research actions began at Lake Alice years ago with basic water quality measures and are ongoing today. Monitoring actions (a subset of research actions) are those that serve to evaluate the outcomes of protection, rehabilitation, enhancement, and education actions. Monitoring actions guide future management.

One word of caution is warranted. Our society typically thinks a long-term planning horizon is twelve months. Unfortunately, this is out of synchrony with the way an ecosystem functions. An ecological clock ticks off time in years, decades, centuries, and even millennia. Lake and watershed management and restoration must be viewed from this perspective. In fact, the final outcomes of some of the good work put in place today might not be apparent until a new generation of lake stewards is on the scene.

Part 3 - What Are the Plan's Underlying Assumptions?

As an adaptive plan, a basic assumption is that the management actions will change over time under the influence of many stakeholders. Through iterative refinement, the plan will more closely reflect the needs of the lake and the people who care about it. This plan has assumed a desired condition of sustainable lake health. The plan attempts to reflect the collective vision of the people and organizations that are concerned with the lake and the surroundings. LAA, Tomahawk High School students and faculty, Lincoln County Land Information and Conservation Department, the Wisconsin Department of Natural Resources, and the community of Tomahawk are among these stakeholders.

The Lincoln County (Wisconsin) Land Information and Conservation Department provides a wide variety of land information and related services including: natural resource and water quality protection information, geographic information, rural addressing, Public Land Survey System and surveying data, property ownership and tax assessment information and mapping products. This office can provide important assistance in during subsequent phases of the Lake Alice Stewardship Program.

At a larger geographic scale the WDNR published the Headwaters Basin Integrated Management Plan (2002) that provides a snapshot of current conditions of resources in the larger drainage basin that includes Lake Alice. The Plan outlines nineteen issues of concern to the basin, including control of exotic species, shoreline development, resource inventory and monitoring, habitat loss, user conflicts, and protection of endangered, special concern, or unique species. The Plan identifies Lake Alice is listed as "outstanding resource waters" and outlines the various offices and their authorities over the resources in the region.

The integrating feature of this lake management plan is Lake Alice and its surroundings. The plan assumes that proper planning in the beginning of the process will save time and money throughout the life of the program and that this can be accomplished by managing the causes rather than (or at least, in addition to) managing the symptoms of any impairments.

CHAPTER 4

How Was the Lake Alice Management Plan Made?

A team of consulting scientists (White Water) working with LAA, prepared this adaptive management plan. It has resulted from the efforts of three project phases. In this chapter, we describe the methods that were employed in each of the phases.

Part 1 – Phase 1 Methods

In the first project phase, the process began with a meeting between White Water scientists, LAA, and Tomahawk High School biological science teachers to share ideas about the planning process. Information gathering was conducted by each of these parties. Another 2009 meeting was held at the WDNR office in Rhinelander with White Water, LAA, and WDNR to obtain Lake Alice information and discuss specific approaches to information gathering. In Fall of 2009, a field trip was conducted on Lake Alice with members of the LAA, White Water scientist Dean Premo, Tomahawk High School (THS) teachers Todd Fredrickson and Jen Pfanerstill, and over forty THS juniors and seniors.

Existing information was the basis for the Phase 1 planning activity (as will be seen in the next two subsections, new information was collected in Phases 2 and 3). Existing information is found in many repositories and forms: anecdotal accounts of residents, resource agency reports and memos, municipal planning and zoning documents, scientific reports, old and new photographs, best guesses of knowledgeable people, and government land office records. Not all of the existing information is of equivalent value in the planning process. Some is not verifiable or the methods by which it was collected are unknown.

The methods that we used in Phase 1 followed closely the goals, objectives, and tasks that were described in the grant proposal submitted to the WDNR. The Phase 1 goals were to (1) inventory relevant information on Lake Alice and its watershed, (2) prepare an initial adaptive lake management plan, and (3) deliver educational elements that served to convey information about Lake Alice and the Stewardship Program. Early on in the project, nine objectives and associated tasks were established. In this section, we describe these objectives and tasks and the primary responsibility among project participants for specific tasks.

The first objective was to develop a strategy to perpetuate the quality of Lake Alice and its watershed ecosystem. Four tasks supported this objective: (A) articulate a general strategy in the form of a Lake Planning Grant proposal; (B) meet with project partners at beginning of program to identify and prioritize initial lake management needs and establish long-term goals; (C) meet with project partners at outset of Phase 1 project to develop agreed upon strategy and specific approach to Phase 1; and (D) assign specific tasks to project partners. These tasks were accomplished by a meeting held at the home of LAA Board President Glenn Mott (with representation by White Water, LAA, and THS), a second meeting at the Rhinelander WDNR office, and during numerous phone meetings. The effort was primarily carried out by LAA and White Water.

The second objective of Phase 1 was to gather, consolidate, assess, and manage information about fish and aquatic life and habitats of Lake Alice. Four tasks supported this objective: (A) collect and review historical information regarding the fishery resource in Lake Alice; (B) interview WDNR fisheries biologist regarding the fishery in Lake Alice, (C) collect and review existing information about other aquatic life in the lake; and (D) collect and review existing information about other aquatic and wetland habitats in Lake Alice. These tasks involved contacting various resource agency personnel in the WDNR and knowledgeable local residents. Information from disparate sources represents a large variety of quality and application, and this must be considered when deciding how or if to use a specific data set in management of the Lake. Tasks under the second objective were primarily carried out by White Water.

The third objective was to gather, consolidate, assess, and manage information about Lake Alice water quality and potential risks to water quality. Three tasks were applied to achieving this objective: (A) collect and review existing limnological information about Lake Alice, (B) analyze and summarize existing Lake Alice water quality data, and (C) prepare a water quality sampling regimen for Lake Alice. The relatively small amount of water quality data for Lake Alice came from WDNR lakes database. These data provide insight into lake water quality and are a useful starting point for adaptive lake management. Tasks under the second objective were primarily carried out by White Water.

The fourth objective was to gather, consolidate, assess, and manage information about the Lake Alice Watershed, especially those attributes relevant to lake health. This ambitious objective involved five tasks: (A) delineate the Lake Alice watershed area; (B) map land cover/use and soils of the watershed; (C) depict slopes through topographic maps and digital

elevation models to identify runoff patterns and environmentally "risky" areas in terms of contribution of non-point source (NPS) pollution to Lake Alice; and (D) determine existing institutional programs that affect lake quality. Tasks A, B, and C involved using existing layers of geographic information available from the WDNR and other sources and manipulating these data. Task D required an inventory of the programs within the region that address lake quality. White Water staff carried out tasks A, B, and C under this objective. LAA carried out Task D.

The fifth objective was to prepare a catalog of Lake Alice environmental, cultural, and aesthetic attributes with a qualitative evaluation of the quality and associated potential threats. This objective included four tasks: (A) list the Lake Alice attributes; (B) qualitatively evaluate each of the attributes; (C) identify and describe potential threats to the Lake Alice Attributes; and (D) conduct a site visit to Lake Alice as a reconnaissance of the attributes. Responsibility for these tasks was shared between LAA, THS, and White Water.

The sixth objective was to prepare a history of the Lake Alice area and the human community living there. This objective included three tasks: (A) conduct interviews of lake residents and others; (B) inventory existing written information about the Lake Alice community; and (C) prepare a written history that documents and consolidates findings. LAA had the responsibility for this objective and related tasks.

The seventh objective was to create an initial adaptive lake management plan for Lake Alice that would serve to ensure high quality lake management and would become a foundation for future iterations of the plan. This rather complex task was guided by two basic tasks: (A) develop adaptive management recommendations for Lake Alice using information gathered in previous objectives; and (B) prepare a practical written plan, grounded in science, that includes sections on implementation, monitoring, and adaptive management. White Water scientists carried out tasks under this objective.

Because other organizations are involved with water resources planning and management in northern Wisconsin, an eighth objective was established to integrate recommendations from existing plans (for example, Headwaters Basin Integrated Management Plan and/or County Land and Water Resources Management Plan) into the Lake Alice Plan. Two tasks supported this effort: (A) review existing basin plan and County Land and Water Resources Management Plan and draw information and recommendations from these (as appropriate) for use in the Lake Alice plan; and (B) prepare a written section of the

Lake Alice Plan that documents this review. Tasks under this objective were carried out by LAA and White Water.

The ninth objective had an education orientation intended to convey information about Lake Alice, LAA, WDNR Lakes Program, and resource stewardship. An intended outcome of this objective was to increase support and capacity of LAA through collaboration with THS faculty and students. Another intended outcome was to increase general community awareness of Lake Alice Stewardship and understanding of Lake Alice water quality and factors that affect lake health. Three tasks were outlined to achieve this objective: (A) provide technical assistance to THS faculty and students; (B) provide written education material about the project and about water quality aspects of Lake Alice that can be used for press releases and as handouts at lake association gatherings and other meetings; and (C) contribute information to the LAA website that highlights ongoing aspects of the Lake Alice Stewardship Program and the Phase 1 project. These tasks were shared between LAA, White Water, and THS.

Part 2 – Phase 2 Methods

As in Phase 1, the methods that we used in Phase 2 were associated with specific objectives and tasks that were outlined in the Phase 2 Planning Grant Proposal. The principal objectives in the second phase of the Lake Alice Stewardship Program were to (1) systematically investigate the aquatic plant community, (2) prepare an aquatic plant management plan, (3) prepare and implement a water quality sampling regimen, (4) initiate a volunteer amphibian monitoring program, and (5) develop and initiate a volunteer angler survey. We describe the methods associated with these objectives in this subsection.

The primary question that guided the field investigation of the Lake Alice aquatic plant community was "What is the composition, density, and geographic distribution of the aquatic plant community in the lake?" In the last few years, the WDNR has developed a new and rigorous aquatic plant survey approach. First, they realized that many citizens and lake groups requested permits every year to harvest or chemically treat nuisance plants, with no accounting of how successful they were. Second, the WDNR realized that they could get more information from their own routine plant sampling surveys by taking advantage of new technologies such as the Global Positioning System (GPS). In order to address both issues, the WDNR, with help from the Minnesota DNR, developed a new plant sampling survey system designed to systematically examine all parts of the lake. The protocol calls for using a rake

sampler to determine what species are present, where they occur, at what depths they are found, and in what kind of substrate. The spatially explicit information can be used to create a variety of ecologically based maps such as the location of an invasive plant, where the plants grow most densely, or how a species of special concern is distributed. The survey serves as a baseline for the future, and will be especially important should there be changes in the lake such as a water level or an invasion of an aquatic invasive plant species.

The WDNR launched the new plant survey protocol in 2005. After early experience, they revised the protocol to its current form. A lake group that creates an aquatic plant management plan, requests a permit to do large scale chemical treatment, or requests assistance from the WDNR with aquatic plant issues are asked to perform a plant survey following the new protocol.

This WDNR survey protocol is called a point-intercept sampling scheme because data is collected from all over the lake, instead of sampling along a few straight lines (called transects) laid out perpendicular to the shore (as was done by WDNR plant sampling crews prior to 2005). The first step is to lay an electronic grid (like a sheet of graph paper) over a map of the lake. This step is done by the WDNR's Integrated Science Services, who receives requests and determines the number of sampling points on this grid. This sampling density depends on the acreage of the lake, the depth contours of the lake, and the convolutions of the shoreline. There is a latitude and longitude associated with each point on the grid. The WDNR loaded these coordinates into spreadsheet file and conveyed it to White Water Associates. The White Water team loaded the coordinates into a global positioning (GPS) unit for use in the field.

The White Water field team, used the GPS unit, sampling rakes, and data sheets, to conduct the surveys. The sampling rake is a double-headed metal rake secured to a pole expandable to 15 feet. For deeper points, another double-headed rake weighted and attached to a rope was used. The boat driver used the GPS unit to navigate to each point. The navigator also called out the depth from and electronic depth finder so the sampler knew what sampling rake to use. At each point, the sampler used the rake-on-a-pole or the rake-on-a-rope to scrape the lake bottom and haul up the catch of aquatic plants. The sampler called out the depth and sediment type (muck, sand or rock), identified each plant caught on the rake, and gave each species an abundance rating of 1 (few plants), 2 (moderate amount), or 3 (plants overflowing the rake). The data recorder wrote down all the data and kept track of

what points still need to be sampled. Any non-native species were carefully identified and characterized.

The data allowed calculation of distribution metrics such as number of sites where a plant species is found, relative percent frequency of species occurrence, frequency of occurrence within vegetated areas, frequency of occurrence at all sites, and maximum depth at which plants are found. The data will also allow calculation of metrics such as total number of points sampled, total number of sites with vegetation, total number of sites shallower than maximum depth of plants, frequency of occurrence at sites shallower than maximum depth of plants, Simpson Diversity Index, maximum depth of plants (feet), average number of all species per site, average number of native species per site, and species richness.

An innovative component of the Phase 2 project was the development and initiation of two volunteer-based monitoring programs of vertebrate indicator animals: anurans (frogs and toads) and fish. Monitoring of each of these taxa can provide important information for lake and watershed management.

In the case of frog and toad surveys, a standard protocol was developed in communication with Mike Meyer (WDNR researcher). Several existing volunteer based monitoring programs provided important models and guidance for the program for monitoring amphibians in the Lake Alice watershed using volunteer monitors. More details of the methods used can be seen in the monitoring report in Appendix G.

For the volunteer-based angler survey, models from other regions of the U.S. provided guidance for developing the protocols. This activity will be done in concert with WDNR scientists and managers who provided several reviews of the data form. Volunteer derived fish data can augment fish data collected by WDNR fish studies on Lake Alice. An advantage of such data is it they come from on-going angling activity rather than periodic surveys (usually separated by several year intervals). Noteworthy occurrences (such as the discovery of an aquatic invasive species) or trends in fish sizes or numbers will be reflected in this volunteer data. As an example of the efficacy of this approach, a study reported in the American Fisheries Society Online Journals (Vol. 29, Issue 5) examined use of volunteer angler survey data for assessing length distribution and seasonal catch trends of trophy largemouth bass. Volunteer data were compared with agency collected data as a means to validate volunteer data and length distributions by inch-group. The study found no significant difference between survey methods, validating the fish length reported by volunteers. Additional detail regarding the protocol is provided in Appendix F.

Part 3 – Phase 3 Methods

The principal objectives in Phase 3 of the Lake Alice Stewardship Program were to:

- Gather/manage information about rare species;
- Carry out specific conductance study for purpose of determining nutrient sources;
- Investigate the wild rice population;
- Continue the frog/toad monitoring program;
- Continue the volunteer angler journal program;
- Develop and conduct a lake user survey;
- Deliver a workshop on the littoral zone and riparian area;
- Document the littoral and riparian area condition using digital photography;
- Qualitatively document the littoral and riparian areas;
- Quantitatively document the littoral and riparian areas;
- Revise the aquatic plant management plan based on new findings;
- Revise the Adaptive Management Plan to accommodate new findings;
- Contribute recommendations to Land &Water Resources Management Plan;
- Deliver an education program; and
- Conduct Aquatic Invasive Species (AIS) awareness and protection.

In addition to the principal Phase 3 objectives, were objectives for two Early Detection Rapid Response projects that are part of this adaptive management plan. The principal objectives in Curly-leaf Pondweed project were to:

- Investigate extent of Curly-leaf Pondweed in Lake Alice by field survey;
- Analyze the field data and prepare a map of the population distribution;
- Develop a realistic approach to Curly-leaf Pondweed in Lake Alice; and
- Report on findings in a revision to the Lake Alice aquatic plant management plan.

Finally, the principal objectives in Eurasian water-milfoil pondweed project were to:

- Conduct 2014 survey to locate and document EWM at site of the original find;
- Conduct a 2014 survey of the entire lake for Eurasian water-milfoil;
- In 2014, hand-pull Eurasian watermilfoil from the identified sites;
- Conduct early spring recon of known sites in 2015 and 2016;
- Hand-pull Eurasian water-milfoil plants in 2015 and 2016;
- Conduct 2015 meander search for Eurasian water-milfoil in Lake Alice;
- Conduct a 2016 aquatic plant survey and compare with data from 2010 survey;
- Update the aquatic plant management plan; and
- Conduct a plant workshop for Lake Alice stewards.

Rare species on Lake Alice are an indicator of a healthy environment. Part of the Phase 3 project included evaluation of Lake Alice use by common loons, bald eagles, and other rare species. This effort also included an assessment of habitat features appropriate to rare species.

Non-point source pollution sometimes influences the health of lakes and rivers. To determine if areas around Lake Alice contribute nutrients or other dissolved substances, we implemented a study using specific conductance as a way to screen shoreline areas. The data collected was analyzed and mapped for inclusion in the Adaptive Management Plan. More details of the methodology will be described in the respective Appendix.

Wild rice has long been part of the aquatic plant community of Lake Alice. Nevertheless, this culturally and ecologically significant plant is generally not appreciated by Lake Alice users. To investigate and describe the Lake Alice wild rice, we spoke with long-time lake users and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) Manoomin (wild rice) Biologist regarding changes in wild rice populations and the suitability of Lake Alice for wild rice. We also queried these sources about the environmental threats to which wild rice is subject.

In the case of the frog and toad survey and the volunteer anglers' journal we used the same methods as were applied in Phase 2.

The Phase 3 program endeavored to discover the observations and concerns of Lake Alice landowners and users. This was undertaken with a lake user survey that was developed in close consultation with the WDNR.

Emphasis was placed on the littoral zone and riparian area during Phase 3. Part of that undertaking was to prepare, promote, and deliver a half-day workshop on littoral zone and riparian area to Lake Alice users. Other education efforts were included in the Phase 3 project and the Eurasian water-milfoil project including written and verbal education material to lake volunteers, contributions to lake association newsletter and website, and a field trip for Tomahawk High School science students.

Continuing with the littoral zone and riparian area focus, we documented the existing conditions at Lake Alice through (1) geo-referenced digital photography of the entire shoreline, (2) qualitative documentation of shoreland conditions around the entire lake, and (3) quantitative documentation of the littoral zone and riparian areas at ten randomly selected physical-habitat stations around Lake Alice. In the quantitative effort, we used US Environmental Protection Agency and WDNR measurement protocols. Additional description of the methods used is contained in respective appendices where the results are presented.

All of the information gathered in the Phase 3 project and related Early Detection Rapid Response projects will be analyzed and interpreted in new editions of the Adaptive Management Plan and the Aquatic Plant Management Plan and cross-referenced.

Other resource management plans have importance to the Lake Alice planning efforts. The Lincoln County Land and Water Conservation Department maintains the Lincoln County Land and Water Resources Management Plan. As part of our efforts, we reviewed the plan and provided comments to the Land and Water Conservation Department.

Aquatic Invasive Species (AIS) awareness and protection was accomplished by the Lake Alice Association and White Water Associates by staffing boat landing(s) with CB/CW inspectors, soliciting lake steward volunteers to augment boat inspections for future years, reviewing documentation for known AIS in the lake system, conduct analysis of lake susceptibility to zebra and quagga mussels, incorporating AIS findings into education efforts, and recommending future AIS monitoring needs.

Our methods for the Curly-leaf Pondweed investigation included lake-wide field surveys targeting Curly-leaf Pondweed distribution at appropriate times of year in 2011, 2012, and 2013 to determine how the population changes over time. We documented Curly-leaf Pondweed distribution by using global positioning units (recording latitude and longitude) and recording observations on density. We entered and managed the geographic and population density information in geographic information system (GIS) database and prepared maps of distribution and density. Additional methods are described in the respective Appendix. Findings were discussed with the WDNR, Lake Alice Association, AIS coordinator. Findings are incorporated into the Aquatic Plant Management Plan.

Our methods for the Eurasian water-milfoil efforts included surveys targeting this species distribution in both the vicinity of the known sites (2014, 2015, and 2016) as well as meander searches in the entire lake (2014 and 2015). In 2016, we conducted a point-intercept aquatic plant survey of the entire lake following the protocol outlined under Phase 2 methods. These data will be compared to the previous point-intercept survey and included in the updated Aquatic Plant Management Plan. In 2014, 2015, and 2016 we conducted hand-pulling of Eurasian water-milfoil at known sites and documented these efforts. Outcomes are incorporated in the Aquatic Plant Management Plan.

CHAPTER 5

What is the State of Lake Alice and its Watershed?

An understanding of the history, features, and conditions of the Lake Alice and its landscape is the foundation for developing and implementing strategies that seek to protect and restore the biological health of the area. In Phase 1, we focused on existing information relating to the Lake Alice. In Phase 2, we collected new information about plants, animals, and water quality. In Phase 3 and associated projects, we continued collecting new information about the system. We have sought out the kind of information useful to devising the adaptive management plan for the lake. Future phases will collect and incorporate additional information about Lake Alice.

This chapter is intended to teach us about Lake Alice. What is the lake like? What is the surrounding landscape? What organisms live here? What is the human community? How healthy is the lake? How have humans contributed (or detracted) from that health? Do threats to watershed health exist? This chapter identifies and organizes information and reports on new findings

If you are new to Lake Alice and its surroundings, this chapter will make you familiar with features and conditions that exist here and provide some insight as to why things are the way they are. If you are a life-long resident of the Lake Alice area, you may be familiar with parts of the discussion in this chapter. You may have things to contribute or correct. This would be a welcome response. Become engaged! Improve the understanding of the watershed by adding your knowledge in future iterations of this plan.

We present Chapter 5 in fourteen Parts: the lake and watershed, aquatic plants, water quality, conductivity, littoral zone and riparian area, fisheries, wildlife, non-native species, relevant regulations and planning, special attributes, environmental threats, education, human history, and lake user survey. Some of the Parts reference appendices with individual reports or other documentation.

Part 1 – Lake Alice and the Surrounding Area

The Lake Alice Stewardship Program views Lake Alice as part of a larger landscape ecosystem (referred to as the Lake Alice Watershed). The watershed affects the lake and the lake influences the watershed in a tightly connected ecological system. To provide context for this report, this section describes Lake Alice and its surroundings.

Lake Alice is a 1,369 impoundment lake on the Wisconsin River. It is located immediately east of the town of Tomahawk in Lincoln County, Wisconsin. Despite its large surface area, Lake Alice is a fairly shallow lake and has a maximum depth of about 32 feet. Lake Alice can be best described as an "impoundment" in the Wisconsin River as its water level is controlled by King's Dam (operated by Tomahawk Power and Pulp and controlled by Wisconsin Valley Improvement Company). Exhibit 1 shows the Lake Alice area and identifies some major landmarks.

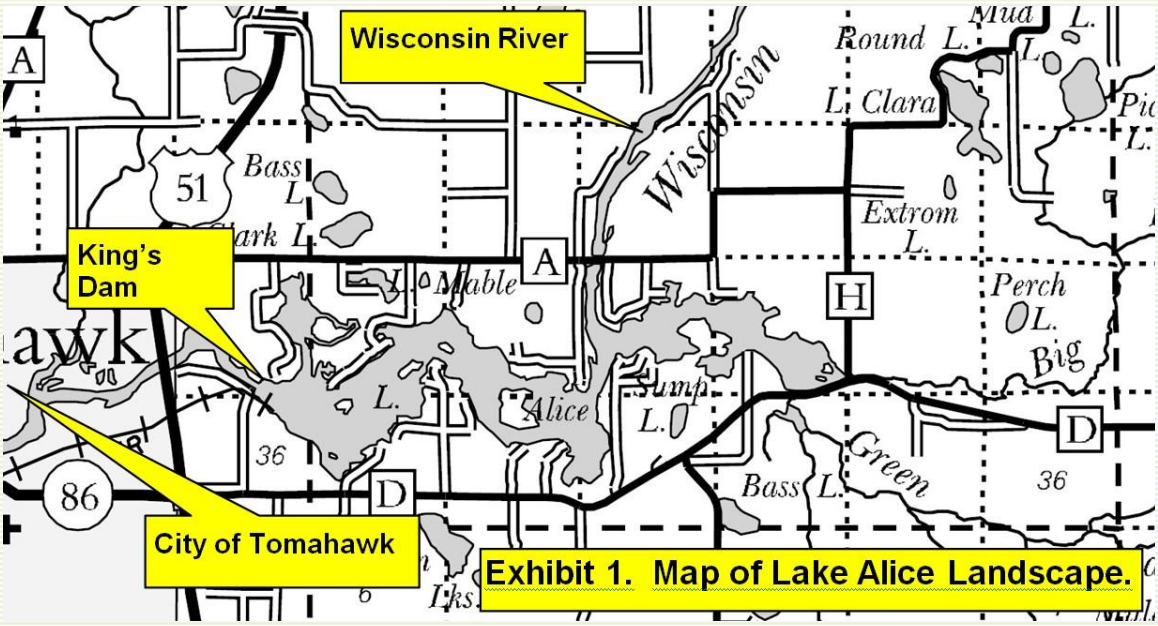


Exhibit 1. Map of Lake Alice Landscape.

Lake Alice is an important resource used by the public for a diversity of recreational pursuits. There are seven public access sites on Lake Alice with a total of forty-one parking spaces. A portage has been installed and maintained around King's Dam to facilitate canoe

and kayak enthusiasts in getting around the dam. There are twelve daily rental and one-hundred yearly rental campsites available around Lake Alice. Public access for fishing from shore is available at the ends of township roads and at several points along Hwy D and Echo Valley Road. Public access for shore fishing is also available on the King's Dam property (except in the immediate vicinity of the dam). Lincoln County owns several small islands on Lake Alice that are used for camping and waterfowl hunting. Up the river from Lake Alice, The State of Wisconsin owns 1,785 acres of land available for public use including hunting and fishing. Some of the land is only accessible by water route from public access sites on Lake Alice. Fishing tournaments are a fairly frequent occurrence on Lake Alice.

At a continental scale, Lake Alice is a part of the Upper Mississippi Water Resource Region (see Exhibit 2.) Waters that flow from Lake Alice eventually enter the Mississippi River and flow into the Gulf of Mexico.

Exhibit 2. United States Water Resource Regions (Source: USGS)

The Upper Mississippi Water Resource Region is further divided into sub-regions (Exhibit 3) and Lake Alice is in the northern part of Sub-region 0707. Exhibit 4 displays the next subdivision (accounting unit) and Lake Alice is in Accounting Unit 070700.

Exhibit 3. Water Resource Sub-regions of the Upper Mississippi Region (Source: USGS)

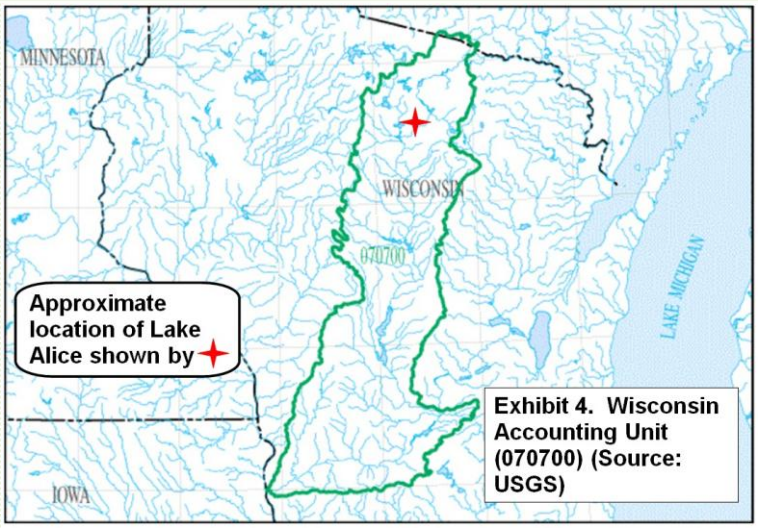


Exhibit 4. Wisconsin Accounting Unit (070700) (Source: USGS)

Exhibits 5 and 6 show further subdivisions and detail of the accounting unit and the location Lake Alice.

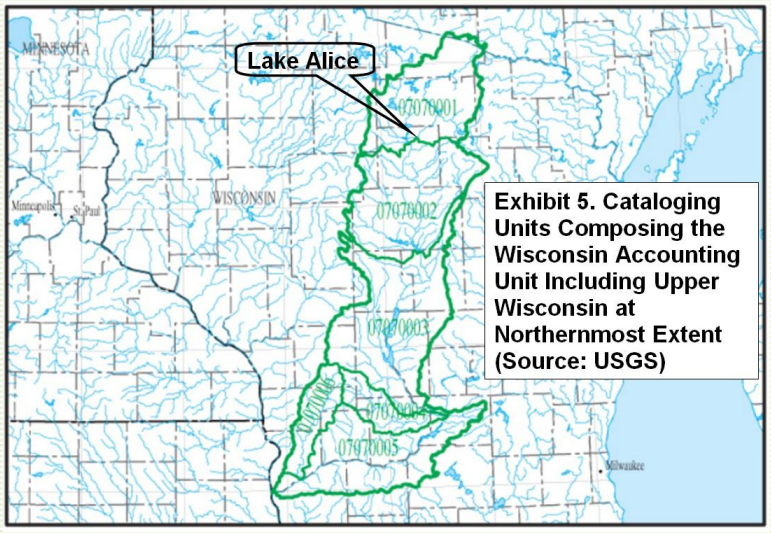


Exhibit 5. Cataloging Units Composing the Wisconsin Accounting Unit Including Upper Wisconsin at Northernmost Extent (Source: USGS)

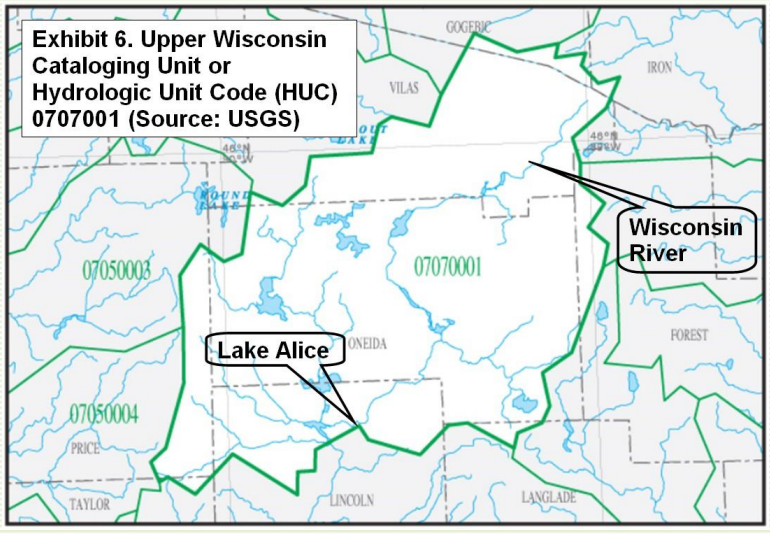


Exhibit 6. Upper Wisconsin Cataloging Unit or Hydrologic Unit Code (HUC) 0707001 (Source: USGS)

As part of this Phase 1 work, we delineated the total watershed for Lake Alice as that part of the watershed located upstream of King's Dam (near Tomahawk, Wisconsin). This is illustrated in Exhibit 7. This total watershed for Lake Alice extends up into Michigan's Upper Peninsula and includes over 1,200 square miles of surface area. All water runoff from the land and all of the streams in this region eventually feed into Lake Alice. Likewise, discharges from industry and waste water treatment plants potentially influence Lake Alice.

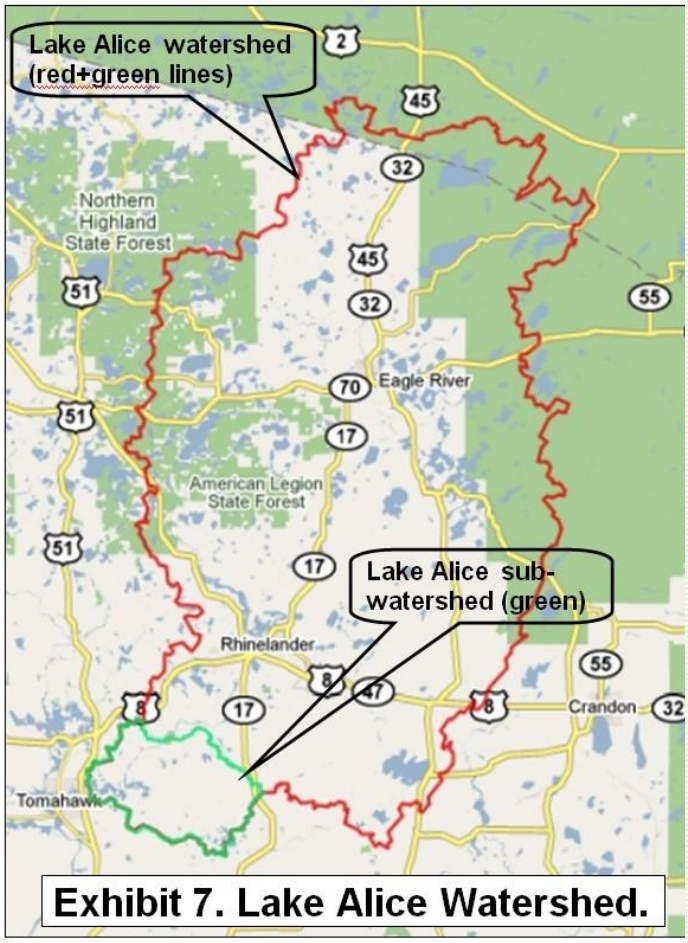
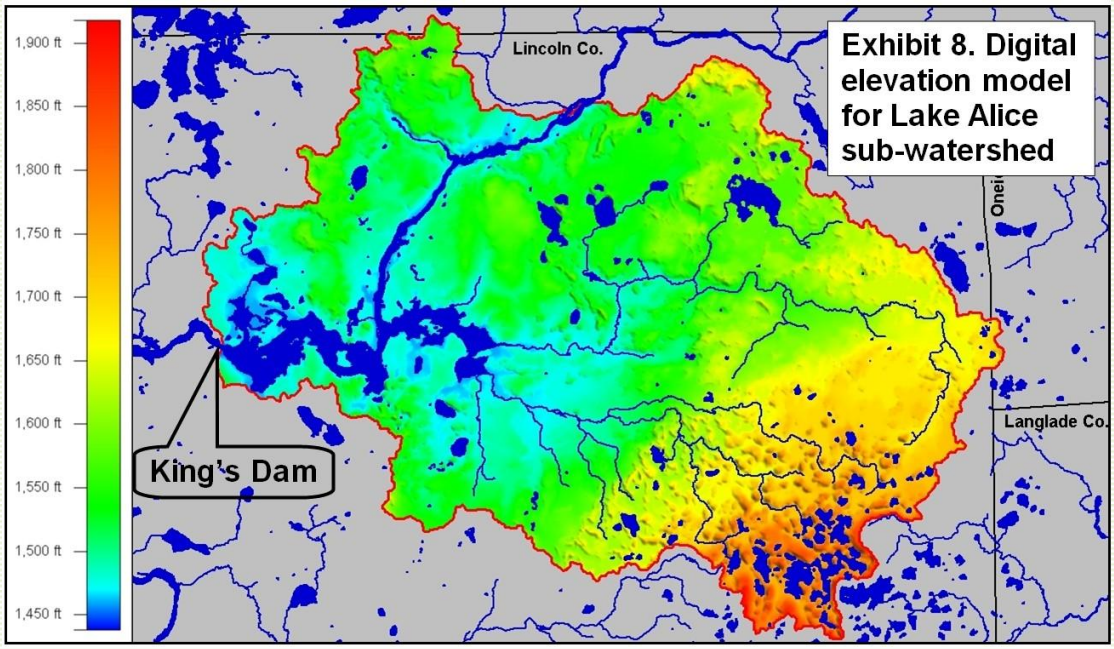


Exhibit 7. Lake Alice Watershed.

In order to have a more practical sized watershed with which to work in the Lake Alice Stewardship Program, we delineated a sub-watershed that extends from King's Dam up to the point where Trout Creek enters the Wisconsin River (approximately four river miles upstream of County Highway A. This sub-watershed is also illustrated in Exhibit 7. The Lake Alice sub-watershed is approximately seventy-four square miles (47,500 acres) and is located entirely within Lincoln County, Wisconsin.

The Lake Alice sub-watershed has relatively low topography, ranging only about 400 feet in elevation from high points in the landscape to the low point on Lake Alice. The southeastern part of the sub-watershed has the highest elevations. A digital elevation model is provided as Exhibit 8 and shows the relative elevations for the sub-watershed.



Both the total Lake Alice watershed and the Lake Alice sub-watershed are comprised of soils with good infiltration capacity. Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential.[1] The four Hydrologic Soils Groups are A, B, C and D and range from Group A soils with the smallest runoff potential to Group D soils with the greatest. 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. Group A soils consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission. Group B is silt loam or loam and has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. Rain water or snow melt water tends to be readily absorbed by Group A and Group B soils making the risk of erosion relatively low. Group C soils are sandy clay loam. They

[1] *Details of this classification can be found in 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.*

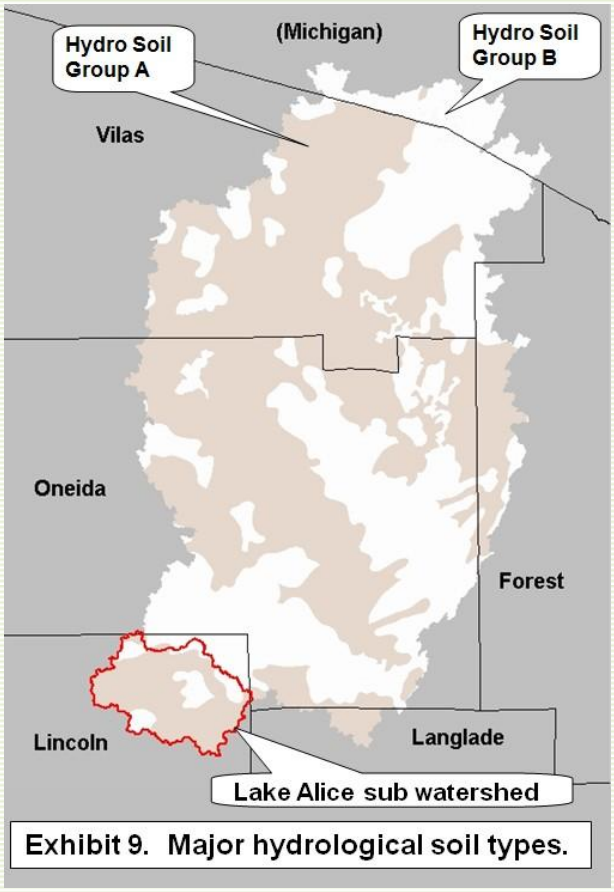


Exhibit 9. Major hydrological soil types.

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. Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. The Lake Alice watershed is comprised only of soils in Groups A and B (Exhibit 9).

The general land cover types in both the Lake Alice sub-watershed and the total Lake Alice watershed are quite similar. Exhibit 10 provides a summary by acres and percent surface area for both. The total watershed (nearly 800,000 acres) has a somewhat larger percentage of open water/wetland (about 40% of the surface area) than the sub-watershed (about 31% of the surface area). Agricultural land represents a fairly small portion of the watershed, but is somewhat higher in the Lake Alice sub-watershed. Forested land is at a greater proportion of the landscape in the Lake Alice sub-watershed than in the total watershed. Residential areas (both high density and low density) represent less than 5% of the landscape surface area in both total and sub-watersheds for Lake Alice. Exhibit 11 presents the land cover types in the Lake Alice sub-watershed.

Exhibit 10. Lake Alice Watershed General Cover Types				
	Total Watershed		Sub-Watershed	
	Acres	% Acres	Acres	% Acres
Water/Wetland	31,5437	39.86	14,570	30.67
Commercial	988	0.12	3	0.01
Agricultural	18,088	2.29	2,717	5.72
High Density Residential	4307	0.54	106	0.22
Low Density Residential	33,414	4.22	1,886	3.97
Grassland/Pasture	7,552	0.95	978	2.06
Forest	41,1134	51.95	27,240	57.35
Industrial	480	0.06	0	0.00
Total	**791,400**	**100.00**	**47,500**	**100.00**

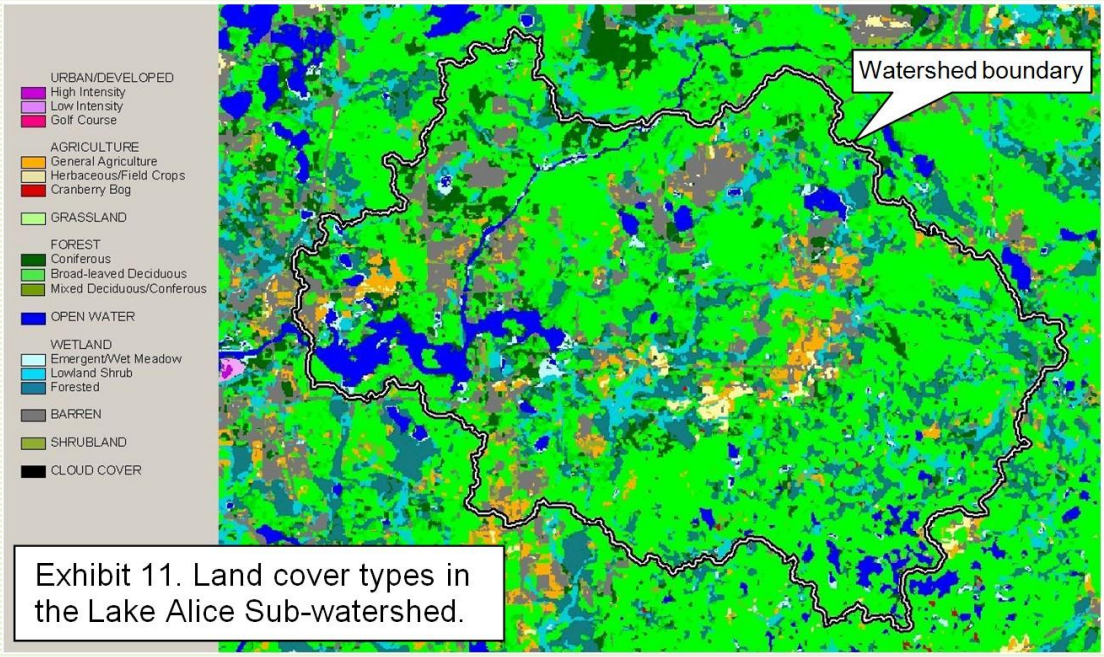


Exhibit 11. Land cover types in the Lake Alice Sub-watershed.

Part 2. Lake Alice Aquatic Plants and Aquatic Plant Management Plan

Until 2010, there had been no known formal surveys or studies of aquatic plants in Lake Alice. Nevertheless, a few anecdotal records regarding aquatic plants did exist.

In 1994, the WDNR (Jim Kreitlow, Water Quality Planner) identified algae in a sample taken from Lake Alice. This sample contained green algae (*Dichotomosiphon, Scendesmus quadricauda, Pandorina*, and *Golenkinia*) and diatoms (*Melosira granulate, Fragillaria, Gomphonema, Golenkinia*, and *Caloneis*).

Laura Herman (WDNR, Aquatic Plant Specialist) visited Lake Alice on at least two occasions to investigate specific aquatic plant concerns. She recorded aquatic plant species observed. In 1997, Herman visited the vicinity of Surewood Forest Campground pier area. She recorded burred, fine-leaf pondweed clasping leaf pondweed, coontail, large-leaf pondweed, vallisneria, and sagiteria. In 2001 at a site near Deer Run Road, Herman observed pickerelweed, white water lily, yellow water lily, fern pondweed, floating leaf pondweed, great bladderwort, coontail, and calla. All aquatic plants observed by Herman on these visits were native species.

Wild Rice is an important component of the Lake Alice ecosystem. The eastern component of Lake Alice is the principal population, especially the area referred to as Green Meadow Flowage. Other wild rice beds exist on the Wisconsin River immediately upstream of Lake Alice. The wild rice provides food and habitat for numerous species – both game and non-game. The wild rice beds on Lake Alice are harvested by rice gatherers. The Great Lakes Indian Fish and Wildlife Commission (GLFWC) regularly monitors the Lake Alice wild rice population. The APMP (Appendix B) provides more information on wild rice in Lake Alice.

In 2010, White Water scientists conducted a formal point-intercept aquatic plant survey on Lake Alice over the course of three days in mid-summer. We recorded a total of twenty-nine species of aquatic plants on Lake Alice. The aquatic plant community was diverse and had high floristic quality. During the 2010 aquatic plant survey, a previous record of the AIS Curly-leaf Pondweed (AIS) was confirmed. This species has been investigated further under a Early Detection Rapid Response grant and is reported in the APMP (Appendix B). In summer 2014, Eurasian water-milfoil was discovered in Lake Alice by AIS Coordinator John Preuss. Eurasian water-milfoil has been monitored and managed under a separate Early Detection Rapid Response grant. This effort included a second point-intercept aquatic plant survey on Lake Alice (conducted in 2016). Twenty-four species of plants were recorded

during the 2016 survey. The aquatic plant management plan (Appendix B) was updated in order to integrate the new information on the Lake Alice aquatic plant community.

Part 3. Lake Alice Water Quality

A limited set of Lake Alice data (Exhibit 13) was available from the WDNR Self-Help Monitoring Program database. Sechhi transparencies, Chlorophyll "a", and total phosphorus all indicate that Lake Alice should be classified as "eutrophic." The Carlson's Trophic State Index (TSI)[2] also indicates an enriched lake. Eutrophic lakes (Exhibit 14) typically have high nutrients, are highly productive, and support large biomass (all plants and animals in the lake). Eutrophic lakes host high densities of aquatic plants and are prone to algal blooms. Many can experience dissolved oxygen depletion. In fact, the Wisconsin Department of Natural Resources places Lake Alice on the 303(d) list for low dissolved oxygen levels caused by sediment oxygen demand.

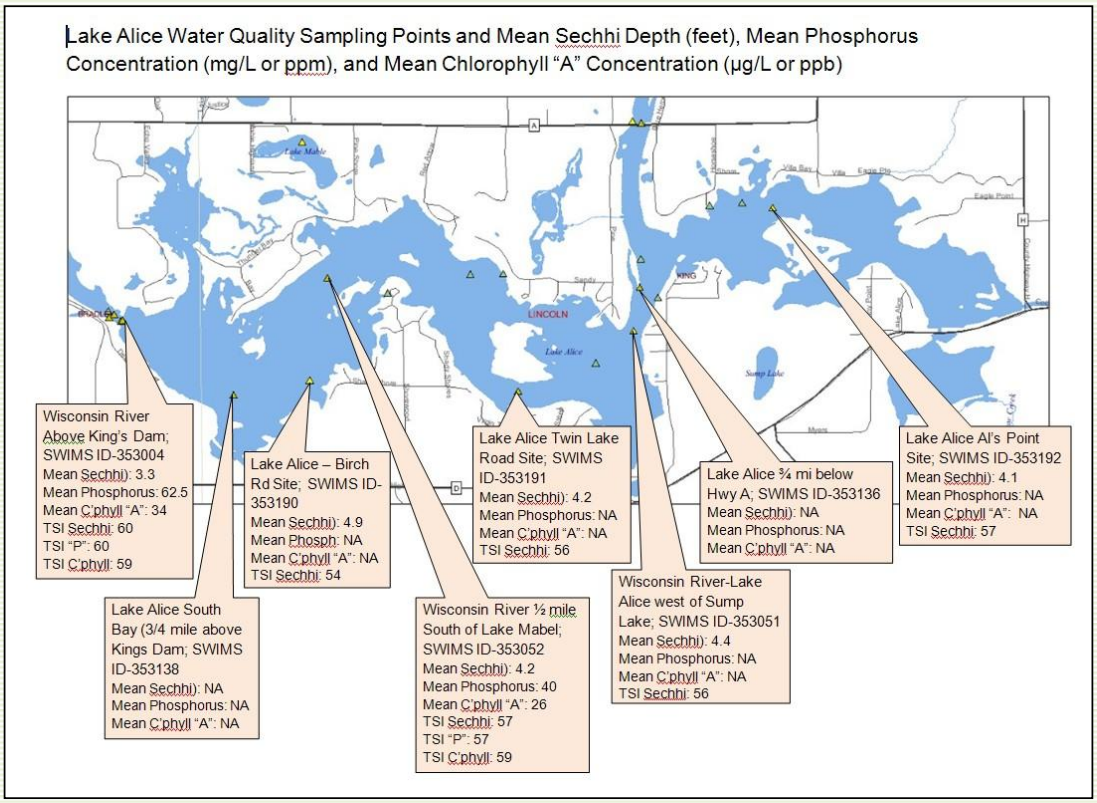
On July 25, 2014, White Water Associates staff collected Lake Alice water quality samples at Station ID#10042173. This is the Citizens Lake Monitoring site for Lake Alice (latitude/longitude: 45.4804, -89.6653). These samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis of chlorophyll "a" (22.8 ug/liter) and total phosphorus (49.1 ug/liter). Both of these values indicate eutrophic conditions. On the same date, a water sample was collected to analyze calcium for the purpose of determining susceptibility of Lake Alice to zebra mussel colonization. The calcium concentration was 9.4 mg/liter.

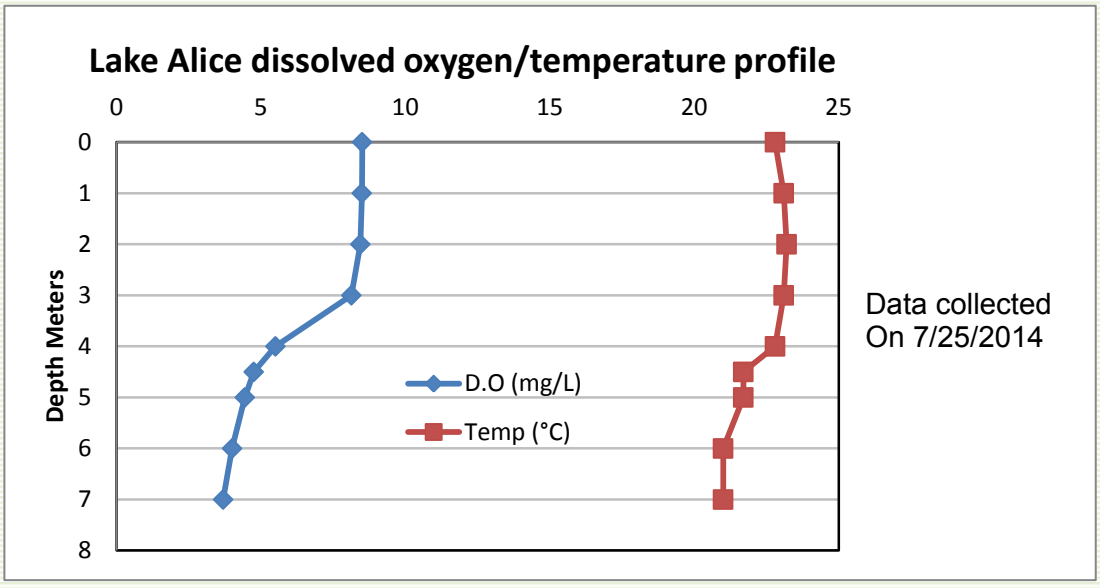
During the July 25, 2014 sampling event, White Water Associates staff conducted a dissolved oxygen and temperature profile of Lake Alice. This data is graphically displayed in the bottom figure of Exhibit 13.

In 2014 and 2015, Lake Alice mean Secchi depth for July and August was four feet. This is consistent with previous summer readings.

[2] *TSI is determined using a mathematical formula and values for Secchi disk depth, phosphorus concentration, and Chlororphyll "a" concentration. TSI values range from 0 to 100, with lakes that are less fertile having lower TSI values. TSI values that are >50 are considered eutrophic.*

Exhibit 13: Lake Alice Water Quality Monitoring.





The shoreline development index is a quantitative expression derived from the shape of a 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 embayments 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. The Shoreline development index for Lake Alice is 5.2. This high number indicates that the lake has a large area of potentially productive littoral zone habitat (shallow water habitat). This translates as good habitat for fish species and other aquatic animals present in the Lake Alice ecosystem.

Exhibit 14: Trophic Status

Trophic state *of a lake is an indicator of water quality. Lakes are typically divided into three categories of trophic state: oligotrophic, eutrophic, and mesotrophic.*

Oligotrophic *lakes are clear, deep, and free of weeds or large algal blooms. They are low in nutrients and do not support large fish populations, but they can develop a food web capable of sustaining a desirable fishery.*

Eutrophic *lakes are high in nutrients and support large biomass (plants and animals). They are usually either weedy or subject to large algal blooms or both. Eutrophic lakes can support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill.*

Mesotrophic *lakes are intermediate between the oligotrophic and eutrophic. The deepest levels become devoid of oxygen in late summer and limit coldwater fish. Anoxic conditions at the water-sediment interface causes phosphorus to be released from the sediments.*

Over long periods of time, lakes go through natural aging from oligotrophic through mesotrophic to eutrophic. As part of this process, they begin to fill in. This aging process can be sped up by introductions of sediments and nutrients. (Shaw et al. 2002).

Part 4. Conductivity Study

Conductivity is the measure of the water's ability to conduct an electric current (Shaw et al., 2004). It depends on ions (such as chloride, calcium, potassium or iron) in the water. The more ions present, the higher the conductivity. A lake's natural conductivity is influenced by the geology and soils in the watershed. Minerals that leach from the bedrock and soils that enter the lake through runoff and contribute to conductivity. Human activities also affect lake water conductivity. When elevated or increasing conductivity is observed in a lake, it can be due to human activity such as road salting, faulty septic systems, urban runoff, or agricultural

runoff. New construction that alters runoff patterns and exposes new soil and bedrock areas can also contribute to elevated conductivity. We designed and implemented a conductivity study in Lake Alice to look for potential sources of non-point source pollution. The report from the investigation is presented in Appendix C.

Part 5. Littoral Zone and Riparian Area

The littoral zone is a critical part in maintaining a healthy lake ecosystem. This zone can be generally defined as the area nearest to a lake's shore in which it is usually shallowest, warmest and where sufficient sunlight to sustain rooted aquatic plants can penetrate to the bottom. These factors usually allow for aquatic plant growth. Aquatic plants provide habitat for invertebrates and fish in lakes, provide a food source for wildlife species, dampen the impact of waves, and absorb nutrients that would otherwise be used by algae. Bottom substrates also play an important role in the littoral zone. Substrates can include bedrock, cobble, sand, muck and woody material. These substrates provide habitat for invertebrates, amphibians, crustaceans and fish.

Riparian zones make up the area where aquatic ecosystems converge with terrestrial ecosystems. It is one of the most structurally diverse and naturally dynamic ecosystems making it sensitive to environmental and human-cause changes. Like the littoral zone, the riparian zone provides shelter and food sources for wildlife, and improves water quality by retarding runoff, reducing erosion and absorbing pollutants. The importance of riparian areas is codified through protection by a Wisconsin Administrative Code that requires at least 35 feet of land inland from the ordinary high water mark (OHW) be a vegetative buffer (State of Wisconsin Legislature).

In a national assessment of lakes, the United States Environmental Protection Agency (USEPA) evaluated hundreds of lakes across the United States assessing water quality, recreational suitability, and ecological integrity (USEPA, 2009). Important findings of that assessment included (1) poor lakeshore habitat (riparian vegetation) is the number one stressor of lake ecosystems nation-wide and (2) poor shallow water (littoral zone) habitat is the number two stressor. For the lake steward, by managing for sound lakeshores (both littoral and riparian components), we can make a difference in lake biological integrity (lake health). This means both development standards (e.g., NR115 and county shoreland ordinances) as well as best management practices (e.g., leave wood in place and minimize clearing of aquatic

vegetation). See results of the EPA Littoral and Shoreline Surveys conducted for Lake Alice in Appendix D.

In 2014, LAA volunteers conducted a qualitative assessment and photographic documentation of the shorelines of Lake Alice. This information has been integrated and made available as a CD-ROM deliverable of this project. A summary of the qualitative results is provided in Appendix E.

Part 6. Lake Alice Fisheries

In Phase 1 of the program we reviewed existing information about Lake Alice and interviewed WDNR fisheries biologist to glean additional information. In Phases 2 and 3, we designed and implemented a volunteer anglers' journal as way of gathering information about Lake Alice fisheries that is complimentary to the periodic WDNR fish surveys on the lake. Outcomes from both of these undertakings are presented in this section.

On July 16, 2009, Dean Premo (White Water Associates) interviewed Dave Seibel (Fisheries Biologist for Lincoln County, WDNR) regarding the Lake Alice fishery. A list of questions was sent to Seibel several days prior to the phone interview. The following is an account of the conversation prepared by Dean Premo, with supplemental information on stocking and fish survey coming as data provided by Dave Seibel. Dave Seibel reviewed a draft of this account.

Question: Please describe a general overview of the Lake Alice historical fishery.

The Wisconsin River has historically been a good walleye fishery and prior to industrialization was a great fishery. Paper mills, dams, and the associated pollution and environmental effects degraded the river system greatly. This degradation continued until the Clean Water Act (1978) when a turn-around began that continues today. In the decades prior the Clean Water Act, the Wisconsin River (including that part of it in the vicinity of Lake Alice) was heavily polluted. Fisherman reported that the fish flesh gave off a terrible odor when it was cooked. The Wisconsin River provides quite a success story for the Clean Water Act. Once again, the Wisconsin River has healthy water and a great fishery.

Historically, the Wisconsin River, including the Lake Alice area, has been managed primarily for walleye. Other fish were managed in order of their perceived importance to the fishery. These fish species included muskellunge, northern pike, smallmouth bass, largemouth bass, bluegills, crappie, and yellow perch.

Lake Alice has been a good natural fishery since its creation. WDNR stocking records (summarized in Exhibit 15) date back to the late 1930s and show a large variety of fish that were introduced to Lake Alice. Stocking began in 1938 with introduction of 3,000 adult bluegills, 3,000 adult crappies, and 50,000 walleye fingerlings. Interestingly, it would be twenty-five years before walleye were again stocked when in 1963, 22,740 fingerlings were planted. Another ten thousand fingerlings were stocked in 1969 just prior to a fourteen year period (1969-1983) when no fish were introduced to Lake Alice due to high mercury levels in fish. Starting in 1983 walleye became the major focus of fish introduction into Lake Alice with over 400,000 being planted from 1983 to 2000.

Exhibit 15: Historical record of fish stocking in Lake Alice.

Species	Number	Comments
Walleye	450,000	Stocked in 1938, 1963, 1969, 1983, 1986, 1990, 1992, 1994, 1996, and 1998 as fingerlings. Stocked in 1994, 1999, and 2000 as six to nine inch fish.
Northern pike	375,000	Stocked annually 1940 through 1946 as fry.
Largemouth bass	38,186	Stocked 1941, 1944-1946, 1950, and 1952 as fingerlings.
Muskellunge	29,000	Stocked in 1948, 1951, 1953, 1954, 1955, 1956, 1957, 1959, 1960, 1961, 1962, 1965, and 1989 as fingerlings. Stocked in 1994 and 1997 as eight to fifteen inch fish.
Channel catfish	18,000	Stocked in 1989, 1990, and 1991 as six to eight inch fish.
Smallmouth bass	6,000	Stocked only one time in 1941 as fingerlings.
Bluegill	4,100	Stocked in 1938 and 1939 (adults) and 1939 (fingerlings).
Crappie	3,000	Stocked in 1939 as adults.
Yellow perch	250	Stocked in 1939 as fingerlings.

Channel catfish (not native to this part of the Wisconsin River) were introduced to Lake Alice in 1989, 1990, and 1991. Two were recorded during a 2003 WDNR fish survey (likely from original stocking). No fish of any species has been stocked in Lake Alice since 2000.

Question: How does this historical fishery compare with the current Lake Alice fishery?

The current Lake Alice fishery is similar to the historic fishery although the water quality is currently much higher than it was between time of industrialization and 1978 (Clean Water Act was enacted). The current fishery is very good and self-sustaining. No fish have been stocked for about ten years. Lake Alice is one of the better fisheries in the vicinity. It displays good populations of all fish species (game and panfish). A healthy distribution of fish sizes (including large fish) exists within each of the species in the community.

This self-sustaining condition is a very desirable condition and a goal of the WDNR for Lake Alice. Based in good quality habitat and high water quality, a self-sustaining fish community offers not only recreation and food to human users, but provides important food and other habitat requirements for many animals.

It is important for the lake stewards and recreationists to understand the value of a healthy self-sustaining fishery. Resource agencies cannot create fish communities as well as nature can if the right habitat and water quality is present. Fishery biologists within the WDNR have become more knowledgeable about the ecosystem effects of stocking fishes in a system of naturally reproducing populations and have become aware of negative consequences. Disease communication, diminishment of gene pool, and introduction of exotic species are all serious considerations. Any future stocking will consider the risks as well as the potential values.

Question: What are the overall management goals for the fish community in Lake Alice?

The WDNR envisions Lake Alice management priorities with respect to fish species to continue with the way it has been in the past. The greatest management attention will directed to walleye. Muskellunge, northern pike, smallmouth bass, largemouth bass, and panfish (listed in order of approximate management importance) will also be part of the overall management scheme. Panfish in the Lake Alice system include bluegill, crappie, bullhead, yellow perch, and pumpkinseed. The WDNR's goals are directed toward a balanced community of native predator and prey species. The agency will seek to achieve this through self-sustaining populations and use of creel limits, size limits, and fishing season dates as well as habitat improvement when appropriate. Redhorse, suckers, and trout perch are also critical members of the fish community and must be present if the system is to be considered healthy.

Question: What are specific goals for individual species within the Lake Alice community?

The WDNR manages to maintain self-sustaining naturally reproducing species and balanced populations in the system. For walleye the WDNR hopes to maintain adult populations above 3 adults per acre (this is the average for northern Wisconsin). For muskellunge, they will try to maintain adult pop above 0.2/acre (again, an average for northern Wisconsin). They are in the process of assessing populations of other fish species in the system and will set goals accordingly. The WDNR tends to survey Lake Alice fish populations fairly infrequently (it is a large and expensive undertaking). Surveys were conducted in 1977, 1982, and 2003. It will be ten or twelve years before another one is done on Lake Alice (the WDNR's goal is to survey on ten to twelve year intervals). Assessing whether population goals are being met is thus a fairly long term endeavor. Wisconsin River impoundments tend to have high predator densities. This serves to keep the prey densities in check (lower numbers, but high quality bluegills and perch). Three tools are available to the WDNR to achieve their fish management goals: (1) preserve and protect habitat, (2) protecting and improving water quality, and (3) establishing appropriate fishing regulations (fishing seasons, size limits, and bag limits). In 2009, the fishing season for walleye, northern pike, smallmouth bass, and largemouth bass in the Lake Alice system changed from a continuous year-round open season to being closed after the first Sunday in March through the first Friday in May to align with most inland lakes in the state.

Question: How would you rank the quality of fish habitat in Lake Alice?

Great fish habitat exists in Lake Alice. There is a large quantity of standing timber (literally, acres of trees sticking out at the water line). There is a lot of shallow water habitat with diverse and abundant native aquatic plants. There seems to be a good balance of deep water and shallow water habitat, but this attribute is not well studied or understood or even documented on maps. Spawning habitat is present and of good quality for the fish species of management interest in Lake Alice. There are good gravel areas in Lake Alice for smallmouth bass and other fish spawning habitat. Some of the walleye population spawns in the lake while a good many walleyes travel from the lake up the Wisconsin River for spawning.

Question: Are their habitat components or other Lake Alice attributes that require restoration or other management attention?

Perhaps first and foremost is to protect against introduction of aquatic invasive species (AIS). The healthy and diverse native aquatic plant community is the best defense against AIS establishment, but education of boaters and monitoring at boat launches is important in a popular water body like Lake Alice. The entire eastern bay of Lake Alice (often known as the

"Pine Creek Flowage," where Pine Creek enters the system) forms a crucial habitat complex. The northerly extending bay off of the King's Dam Reservoir zone of the lake (near the county club) is also an important shallow, well-vegetated habitat.

The large woody material in Lake Alice is a critical part of the fish habitat and should be maintained. Under low water conditions (drawdowns for dam repair) there is a temptation to cut down some of the standing timber and remove stumps, but this would be detrimental to fish habitat. Any areas with standing submerged timber should be protected. After assessment of the Lake Alice shoreline habitat and documentation of habitat need, it is possible that dropping trees from the shoreline into the littoral zone would create beneficial habitat.

In so far as possible, the large privately owned islands and other undeveloped islands are important to preserve and maintain as high quality habitat for Lake Alice.

Question: Are non-native fish present in Lake Alice?

No non-native fish are known to be present in Lake Alice (other than the introduced channel catfish that were previously mentioned). Common carp and white bass are not present. None of the Great Lakes AIS fish are present. Rusty crayfish is present, but apparently not creating a big problem with aquatic plants. Smallmouth bass and rock bass are important controllers of this AIS crayfish.

In Phases 2 and 3 of the Lake Alice Stewardship Program we established a means by which anglers could collect meaningful fisheries data. Members of the Lake Alice Association and White Water scientist Dean Premo worked closely with the WDNR to develop the Volunteer Angler's Journal. The goal of the journal (and the resulting data) is to augment the discrete periodic WDNR fish surveys (including Fyke nets, electroshocking, and creel surveys) with continuously collected and annually reported fishing data from systematically recorded angler journals. The material in Appendix F describes the protocol thoroughly and presents individual journal entries from 2010 and summary of results from Phase 3.

Part 7. Lake Alice Wildlife

Because of it habitat quality and fishery, Lake Alice is home to rare species of vertebrate animals such as bald eagles and common loons. Both species nest at Lake Alice. Standing dead timber (submerged during the original flooding of Lake Alice) makes areas of the lake fairly secluded because it hinders boat traffic from entry and high speed boating. This maintains quiet areas for these relatively shy species. Ospreys are also present.

The common loon (*Gavia immer*) has one of the most distinct plumages of North American birds. It is a large bird with spotted black and white body, and a black/iridescent green head. The loon has many distinct calls for guarding territories, communicating with other loons, and warding of threats. Loons spend most of their life in the water. Unlike most birds, loons have solid bones allowing them to dive as deep as 250 feet in search of food (MNDNR, 2013). They are good swimmers because their legs are located far back on their body. On the other hand, this makes walking on land is difficult. Because of their awkwardness on land, nests are built close to shore (Cornell). Loon nests are made of grasses, rushes, and twigs. Loons are also territorial birds. A smaller lake (5-50ha) can accommodate one pair of breeding loons, while larger lakes may have more than one pair, with each pair occupying a bay or different section of the lake (Loon Pres. Comm., 2013).

LoonWatch, a program of the Sigurd Olson Environmental Institute, has hundreds of volunteers monitoring loon nests and territories in Wisconsin. In 2010, volunteers observed approximately 3,373 adult loons and 805 chicks on Wisconsin lakes (LoonWatch, 2012). Diana Kasbaum has monitored for loons on Lake Alice and has entered information into the WDNR SWIMS database. In 2010, Kasbuam recorded the first arrival of loons as May 1. In the same year they were no longer seen on the lake after October 30. Five loons used Lake Alice during fall migration in 2010. During summer month of 2010, there were three occasional use non-resident loons, one non-territorial loon in residence, three territorial loon pairs in residence, and two loon pairs that nested and hatched chicks. Three loon chicks hatched for the entire lake and survived up to 4 and 8 weeks noted in the SWIMS database.

The bald eagle (*Haliaeetus leucocephalus*) is listed as a Special Concern species in Wisconsin, and is federally protected by the Bald & Golden Eagle Act (WDNR, Sept 2013). Bald eagles live near water and eat small animals, preferring fish. They are believed to mate for life. Eagles create their nests in tall trees, using sticks and other debris. Eagle territories can be 1 to 2 square miles. In Wisconsin, bald eagle nest and territory surveys are conducted by plane. In 2012, there were 1,337 known bald eagle nest territories occupied by breeding adults (NHI, 2013b). This was an increase of 50 pairs from 2011 (NHI, 2013b).

Lake Alice has 4 known nests in 3 known territories (Ron Eckstein, email). The Wisconsin Natural Heritage Inventory (NHI) assesses the rarity of species by using State and Global ranks. The State and Global ranks of bald eagle are described as: "Apparently secure in Wisconsin, with many occurrences (breeding and non-breeding)," and "Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery."

Small wetland ponds exist in several places in close proximity to Lake Alice and these rather rare habitats provide habitats for amphibians, reptiles, birds, and mammals. These habitats often go unnoticed but they contribute enormously to the biodiversity of the landscape. These wetlands are some of the first habitats to produce insects in the spring of the year making them important stopover places for birds migrating north. The abundant forests and wetlands that are part of the Lake Alice area provide habitat for fisher, otter, mink, black bear, gray fox, red fox, coyotes, muskrats, beaver, and white tailed deer. Other rare species and communities found in the same township(s) as Lake Alice are listed in Exhibit 16.

Rare Species and Communities located near Lake Alice (NHI, 2013a)

Common Name	*Scientific Name*	*State Status*[1]	*Group Name*
Bald eagle	*Haliaeetus leucocephalus*	SC/P	Bird
Wood turtle	*Glyptemys insculpta*	THR	Turtle
Woodland jumping mouse	*Napaeozapus insignis*	SC/N	Mammal
Little brown bat	*Myotis lucifugus*	THR	Mammal
Missouri rock-cress	*Arabis missouriensis*	SC	Plant
Autumnal water-starwort	*Callitriche hermaphroditica*	SC	Plant
Algae-like pondweed	*Potamogeton confervoides*	THR	Plant
Northeastern bladderwort	*Utricularia resupinata*	SC	Plant
Lake-cress	*Armoracia lacustris*	END	Plant
Pale beardtongue	*Penstemon pallidus*	SC	Plant
Hooker's orchid	*Platanthera hookeri*	SC	Plant
Vasey's pondweed	*Potamogeton vaseyi*	SC	Plant
Emergent marsh		NA	Community
Ephemeral pond		NA	Community
Floodplain forest		NA	Community
Lake-shallow, soft, seepage		NA	Community
Lake-deep, soft, drainage		NA	Community
Muskeg		NA	Community
Northern mesic forest		NA	Community
Northern dry-mesic forest		NA	Community
Open bog		NA	Community
Stream-slow, soft warm		NA	Community

[1] **END**=Endangered; **THR**=Threatened; **SC**=Special Concern; **SC/P**=fully protected; **SC/N**=no laws regulating use, possession or harvesting; **SC/H**=take regulated by establishment of open/closed seasons; **SC/FL**=federally protected as endangered or threatened, but not so designated by DNR; **SC/M**=fully protected by federal and state laws under Migratory Bird Act (WDNR, Aug 2013).

In 1992, the WDNR conducted a survey of freshwater mussels in the King's Hydrolectric Project including Lake Alice (Heath 1992). This work was done to evaluate hydroelectric project operations on benthos (aquatic animals living on the bottom of the river/lake) and to determine presence/absence of endangered or threatened species. Thirteen mussel species were recorded in Wisconsin River immediately upstream of Lake Alice (see Exhibit 17) including three state special concern species (*Anodonta imbecillis*, *Lasmigona, compressa*, and *Alasmidonta marginata*). None of these species were found in Lake Alice. The WDNR report concluded that the river reach in the vicinity of King's Dam showed much lower species richness (diversity) and presumed this to be due to historic adverse water quality. The report further concluded that the presence of dams on the Wisconsin River has fragmented the riverine habitat and prevented reoccupation by several mussel species now missing into areas with improved water quality. WDNR recommended reintroduction of nine presently absent mussel species in the King's Dam Project.

Exhibit 17: Mussels of the Wisconsin River upstream of Lake Alice

Species Name
Anodonta imbecillis
Anodonta grandis grandis
Anodontoides ferussacianus
Alasmidonta marginata
Lasmigona complanata
Lasmigona compressa
Lasmigona costata
Amblema plicata
Fusconaia flava
Actinonaias ligamentina carinata
Ligumia recta
Lampsilis siliqoidea
Lampsilis ventricosa

One component of Phase 2 of the Lake Alice Stewardship Program was to establish a volunteer frog and toad survey of habitats in the Lake Alice watershed. The survey continued in Phase 3. The decline of amphibian populations in many areas in North America has prompted monitoring of local frog and toad populations. Many states (including Wisconsin) have developed frog and toad survey protocols for this purpose. We followed the Wisconsin Frog and Toad Survey Manual for site selection and field methodology and surveyed 15 sites in 2010. This was an audio survey, conducted at night, for calling male frogs and toads. Appendix G presents the methodology, locations and descriptions of field sites, and results from the 2010, 2013, and 2014 surveys.

Part 8. Lake Alice Non-Native Species

There are several know aquatic invasive species (AIS) in Lake Alice. These include curly-leaf pondweed (*Potamogeton crispus*), Eurasian water-milfoil (*Myriophyllum spicatum*), yellow iris (*Iris pseudacorus*), purple loosestrife (*Lythrum salicaria*), and rusty crayfish (*Orconectes rusticus*).

A 1992 report by Gregory Hoffman (WBIS) was the first mention of curly-leaf pondweed in Lake Alice (source of this report: WDNR). White Water Associates' 2010 aquatic plant survey confirmed this plant species was present and follow up work has determined the extent of the population (see the Aquatic Plant Management Plan, Appendix B). Curly-leaf pondweed is originally native to Eurasia. It has been in North America for over a century and is now present in nearly every state in the U.S. and almost every county in Wisconsin. In some lakes, curly-leaf pondweed coexists with native plants without causing big problems. It provides shelter for small fish and invertebrates that are important as fish food. Curly-leaf pondweed can, however, become the dominant plant in a lake and cause problems with early summer recreation because of dense plant beds. It dies back by mid-summer resulting in release of phosphorus from the decaying plant material. Algal blooms can result from the availability of this nutrient.

Eurasian water-milfoil was not observed in Lake Alice until July 19, 2014 when Lincoln County AIS coordinator discovered a small colony of this aquatic invasive species. Eurasian water-milfoil exhibit aggressive growth in some settings and can form dense mats, preventing light from reaching other native plants and interfering with boating and other recreational activities. In some settings, Eurasian water-milfoil can behave as simply a part of the plant community and not proliferate. Eurasian water-milfoil reproduces by buds, rhizomes and by mechanical fragmentation (such as being chopped up by boat engine propellers). The boating traffic on Lake Alice increases the chances for this species to disperse through fragmentation. An early detection/rapid response grant has allowed additional study on the distribution of Eurasian water-milfoil in Lake Alice and some hand-pulling management of this species (see the Aquatic Plant Management Plan, Appendix B).

Starting in 2014, purple loosestrife has been reported from several locations around Lake Alice. According to active LAA member Fred Brach, initially a few scattered purple loosestrife plants were dug out, but about three dozen plants were found on the corner of Highways D and H that were too large and widespread to remove. In 2015 LAA with assistance from John Preuss (AIS Coordinator) undertook a project to grow the herbivorous

beetle that has been effective in biological control of purple loosestrife. In this endeavor, LAA teamed with students from the Tomahawk High School.

Yellow iris has been opportunistically observed in few locations on Lake Alice by White Water Associates staff and was documented at five locations during the 2016 point-intercept aquatic plant survey ("boat survey" records). No systematic study that focuses on its distribution around the lake has been conducted. The yellow iris is native to parts of Europe, North Africa and the Mediterranean region and was introduced to the United States. The species produces many seeds that can disperse by floating. The yellow iris can also spread vegetatively via rhizomes and rhizome fragments. All parts of the plant are poisonous, which results in lowered wildlife food sources in areas where it dominates (USFS 2006). The yellow iris is currently listed as a restricted invasive species in Wisconsin (WDNR 2017). This species should be monitored on Lake Alice and a decision made as to possible management.

There is a 2002 report to WDNR (reporter unknown) of rusty crayfish in Lake Alice. It is not known to have had detrimental impact. No follow up surveys or studies have occurred for this aquatic invasive species.

Channel catfish were introduced to Lake Alice by the WDNR in 1989, 1990, and 1991. Two adult catfish were recorded during a 2003 WDNR fish survey and assumed to be from the original plantings. The fish is not apparently reproducing in Lake Alice. Common carp and white bass have not been found in the Lake Alice system.

Evidence for the presence of two other aquatic invasive animals (spiny waterfleas and zebra mussels) has been monitored in Lake Alice. Plankton tows in 2006, 2008 (two dates), 2010 (three dates), 2012, 2013, and 2014 revealed no evidence of either species. Additionally, zebra mussels have been surveyed using plate samplers by Tomahawk Pulp & Paper in 2000 and 2001. None have been documented.

Until recently (2015), zebra mussels have not been recorded in any lakes in Lincoln County (WDNR, 2012). In 2015, however, zebra mussels were discovered in Lake Nokomis in northern Lincoln County (about 5 miles from Lake Alice). Other than Oneida County (in which part of Lake Nokomis occurs), other neighboring Wisconsin counties have not yet reported zebra mussel in their waters. Lakes in Wisconsin and Michigan that do have zebra mussel populations are located more than 70 miles from Lake Alice. However, the Wisconsin River, in Portage and Wood Counties, has populations of zebra mussels. At this point in time the most likely avenue for zebra mussels to be transferred to Lake Alice would be through boats or other equipment transferred by humans.

Many water quality factors can augment or inhibit the growth and reproduction of zebra mussels. Calcium and pH levels are the most significant water quality constituents that help predict if zebra mussels can survive in a given lake. Calcium is crucial to zebra mussel survival because it is used at every stage of the life cycle (ANS Task Force). This is why calcium is considered a limiting factor for establishment of zebra mussel populations in inland lakes. According to *The Practical Manual for Zebra Mussel Monitoring and Control*, lakes with calcium ranges from 5-6 mg/L allow for no shell growth, 10-11 mg/L allows for poor growth, 25-26 mg/L allows for moderate growth, and greater than 35 mg/L allows for good growth (Claudi and Mackie, 1994). Important calcium thresholds for zebra mussels are as follows: survival (3 mg/L), shell growth (7 mg/L), reproduction (12 mg/L), and massive infestations (25 mg/L) (Claudi and Mackie, 1994). As stated earlier, Lake Alice's calcium concentration was 9.4 mg/L in 2014. This would indicate that there would not be sufficient calcium for zebra mussels to reproduce in Lake Alice.

Zebra mussels also have a distinct pH tolerance level. According to Claudi and Mackie, lakes with pH ranges from 0-6.8 allow for no shell growth, 6.9-7.4 allows for poor growth, 7.5-7.8 allows for moderate growth, and greater than 7.9 allows for good growth (1994). Important pH thresholds for zebra mussels are as follows: survival of adults begins near 6.5, survival of veligers begins near 6.9, the incipient lethal level (level at which 50 percent of a population cannot survive—also known as LD50) for veligers is near 7.4, and levels of infestation begin near 8.0 (Claudi and Mackie, 1994). In 1996, the pH of Lake Alice was 7.6, and in 1997 it was 6.8. These levels indicate that zebra mussels could not grow in Lake Alice; however, new data should be collected.

It is difficult to predict Lake Alice's susceptibility. The pH implies that zebra mussels could not survive, but levels may have changed since 1997. Calcium level indicates that Lake Alice is not very suitable for zebra mussels. According to the University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention, Lake Alice is considered "Borderline Suitable" for zebra mussels (UW-Madison).

Part 9. Relevant Regulations and Planning

Federal, State, County, and local ordinances and regulations have influence on the health and management of Lake Alice. These are summarized in Appendix H. Also include in Appendix H is a letter to the Lincoln County Land Information and Conservation Department that conveys a review of the Lincoln County Land & Water Resource Management Plan.

Part 10. Lake Alice Special Attributes

Because of its large size, Lake Alice is often divided into five zones for purposes of discussion and navigation. The five zones are illustrated in Exhibit 18. Members of the Lake Alice Association identified and compiled information about special attributes of Lake Alice. These are outlined in this part along with aerial photos that illustrate the locations of the described features (numbers in the text correspond with location numbers on aerial photos (Exhibits 19-23). Other features are likely to be added in future versions of the Lake Alice plan.

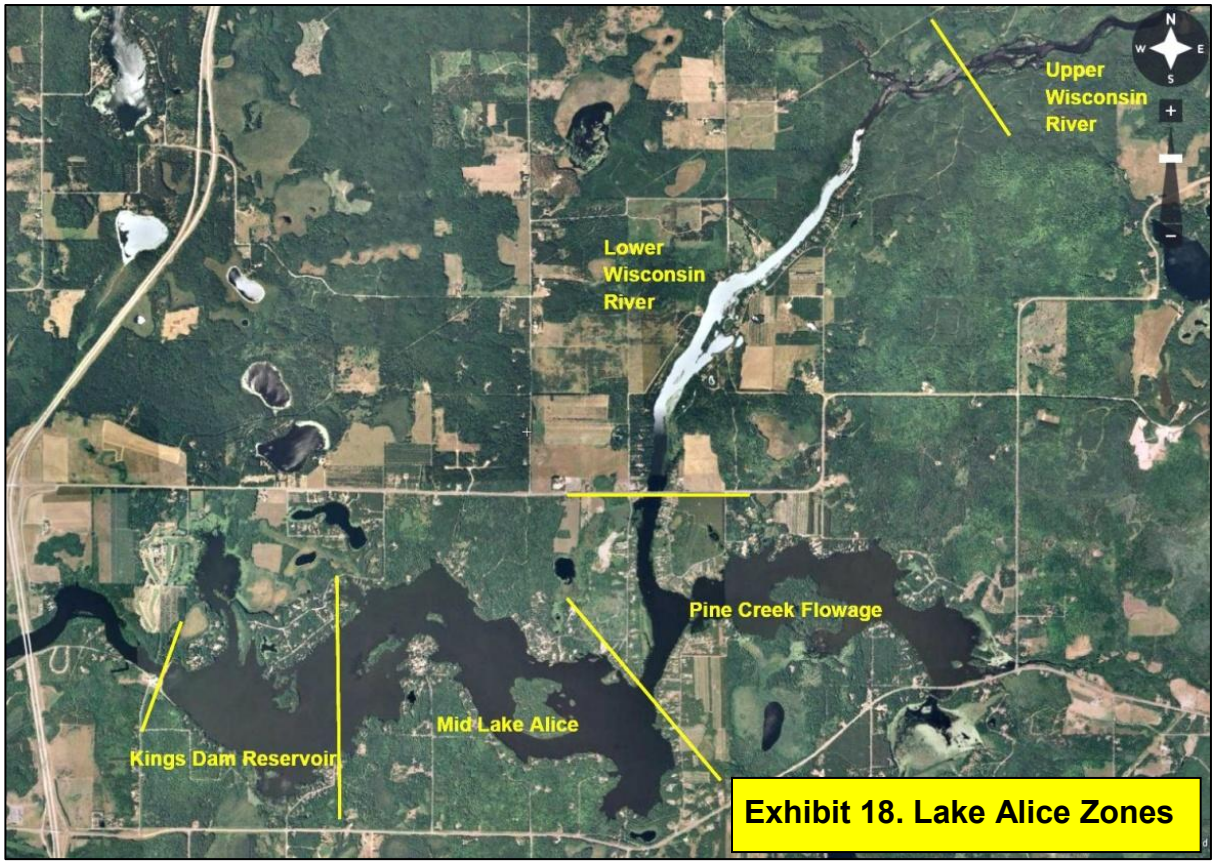


Exhibit 18. Lake Alice Zones

KING'S DAM (1, Exhibit 19) is owned and operated by the Tomahawk Power Company. The dam was built in 1910 creating Lake Alice, a 1,369 acre reservoir. Board members have obtained newspaper accounts and articles about the building of the dam, how Lake Alice got its name, description of the Pulp mill by the dam (Pulp Lake was a suggested name) and of the King family, who lived in this area. This information is contained in Appendix B). The river channel is the deepest from the dam to Generator Island.

Exhibit 19. King's Dam Reservoir Attributes

GENERATOR ISLAND (2, Exhibit 19) is a privately owned island with high quality natural shoreline. Many of Lake Alice's islands are privately owned and, like Generator Island, are not overly developed. These provide refuge for birds, excellent shorelines and littoral zones for fish habitat, and an aesthetically attractive natural setting away from a comparatively more developed shoreline. This island and others like it are considered very high quality features of Lake Alice.

EDGEWATER GOLF COURSE & BAY (3, Exhibit 19) is a large open landscape feature situated in the northern most part of the King's Dam section of Lake Alice. It borders a large shallow bay with excellent native vegetation beds (submergent, floating, and emergent varieties). This area provides great resting and nesting habitat for waterfowl. Fish habitat is also outstanding. The hunting and fishing recreational values of this area are very high. The bay is susceptible to algae blooms (the shallow, clear water and nutrient rich runoff from the surrounding land contribute to this predisposition). A proposed condo development included plans to dredge the shallow bay for a dock/marina. This project was abandoned and critical spawning areas were spared damage. Alice Lake Association President Glen Mott, defined the Lake Association's position as "encouraging responsible development, but discouraging ill conceived projects that threaten fragile areas, as this one."

ACTIVE EAGLE NESTS such as the one indicated in Exhibit 19 (at number 4) occur on several places on Lake Alice. This is a clear indicator of the health environment that Lake Alice represents. Bald eagles are relatively rare animals, but are frequently observed at Lake Alice.

PINE ISLAND (5, Exhibit 19) is a privately owned island with a high quality natural shoreline at the mouth of a bay on the southern shore of the King's Dam section of Lake Alice. The bay has a high density of large woody material in the form of stumps from timber flooded at the time Lake Alice was created by damming the Wisconsin River. The structure is good for ducks and has high quality bluegill spawning habitat.

OLD RAILROAD TRACKS (6, Exhibit 19) can be seen along the southern shore of the King's Dam section of Lake Alice. This is an historic feature of Lake Alice. Lake Alice Association board member, Neal Pietenpol obtained an historical video describing how Tomahawk's founder, William Bradley, engineered and used this rail as part of his vision of commercial development of logging along with the harnessing and "taming" of the Wisconsin River through impoundments. Lake Alice was one such impoundment that was originally created as part of a commercial enterprise.

THUNDER BAY (7, Exhibit 19) is a secluded narrow bay North of Generator Island. It is provides good cover for waterfowl and spawning habitat for fish.

LONG ISLAND (8, Exhibit 20) and ***GRASS ISLAND*** (9, Exhibit 20) are located in Mid-Lake Alice and provide resting areas for waterfowl and spawning areas for fish that are protected from the heavily used river channel.

PINE SHORE BAY (10, Exhibit 20) is a highly developed area of Mid-Lake Alice.

SPRING POND (11, Exhibit 20) is a high quality spring fed pond that likely existed prior to the creation of Lake Alice. Its water level reflects surrounding water table and often has a different water level than Lake Alice. When Lake Alice water level was lowered for dam maintenance, the pond level remained the same. The drought conditions experience in the past five years has caused a lowering of water in the pond. This pond stays clear even when the lake is experiencing an algal bloom. It has a diverse community of native aquatic plants. This permanent open water wetland forms habitat for numerous species of invertebrate and vertebrate animals. The mosquito population in this pond is low indicating a healthy pond ecosystem with invertebrate and vertebrate predators that keep mosquitoes in check. Many snapping and painted turtles use the pond. Leopard frogs, spring peepers, gray treefrogs, green

frogs, and bull frogs use the pond. Migrating waterfowl and songbirds use the pond and the surroundings as stop-over habitat. Other similar ponds exist in the Lake Alice watershed.

KRULL ISLAND (12, Exhibit 20) is a fifty-four acre undeveloped island, flanked to the east by a large submerged stump field. Considered as very high quality habitat, this island provides aesthetic value to the lake and habitat for numerous terrestrial species. The undeveloped shoreline provides good fish habitat. The Lake Alice Association has investigated purchasing this island from the current owner, to preserve its unique ecological and aesthetic values.

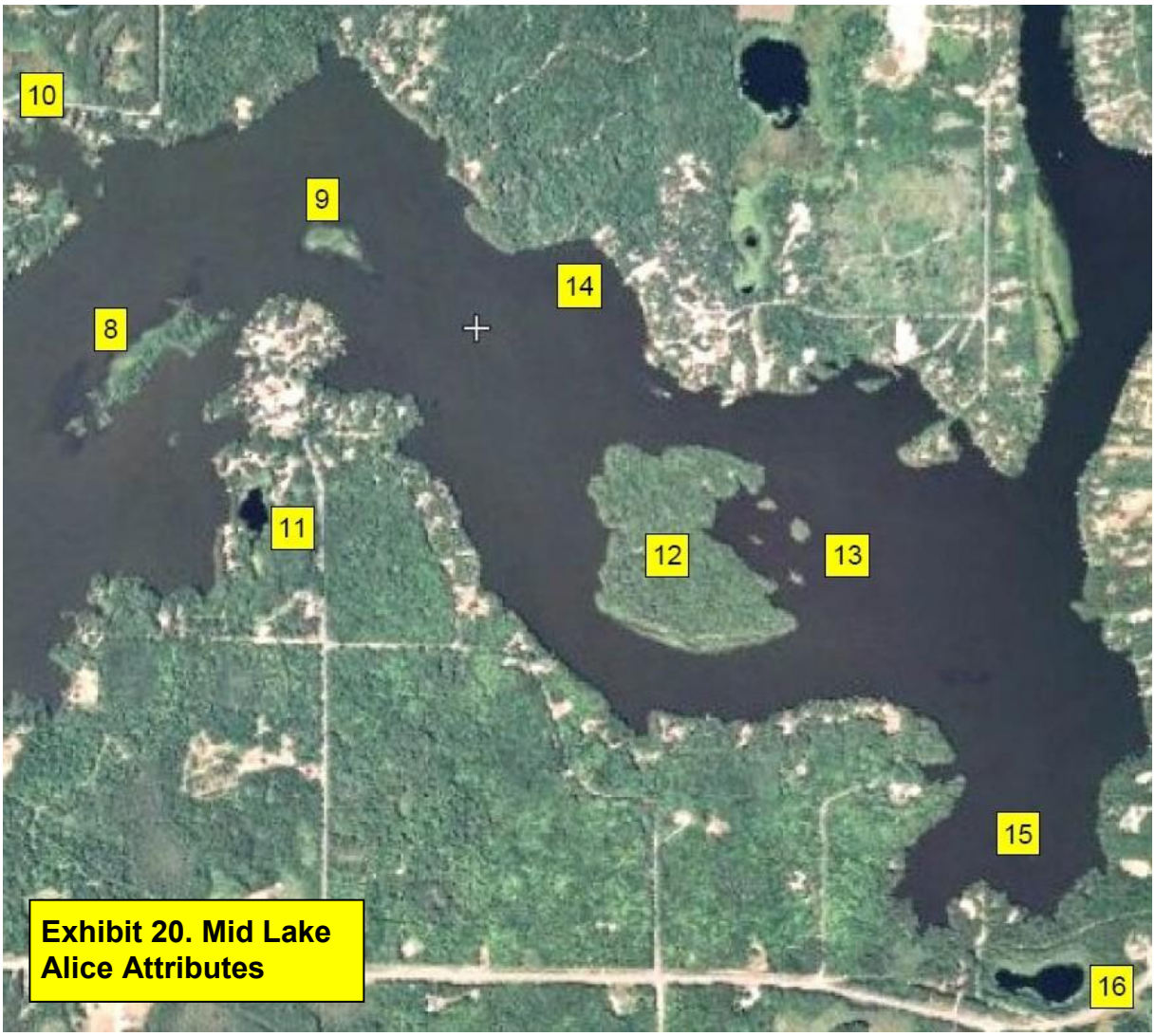


Exhibit 20. Mid Lake Alice Attributes

FIVE ISLANDS (13, Exhibit 20) located on east side of Krull Island provide a wilderness-like setting, that is popular with campers and boaters, as a scenic recreational destination. A wide variety of fish, turtles, and birds use the island. These islands are

considered high quality and provide an enchanting and tranquil refuge directly across the river channel from one of the most heavily used portions of Lake Alice.

RESORT ALLEY (14, Exhibit 20) is located on the north shore of Mid-Lake Alice with Old Red Arrow Lodge (currently closed), Surewood Forest Campgrounds and, and Pine Point Resort. This area hosts many vacationers and experiences a high volume of water recreation in the summer months. Tourist sites, seasonal cottages, and resort cabins once lined Lake Alice's shoreline. Many of the resorts are now condominium developments . Seasonal cottages are being replaced by year-round homes. Lake Alice still experiences heavy recreational use by fishermen, water skiers, sight-seeing pontoons boats, jet skiers, and (more recently) kayak and canoe enthusiasts. This heavy recreational use is a testament to the beauty and quality of Lake Alice, but at the same time poses some risks to the ecosystem.

LOKA BAY (15, Exhibit 20) is a high quality feature located in the southeast part of Mid-Lake Alice. This is a large and generally shallow bay filled with the old stumps from the originally flooded timber and a variety of aquatic plants. It forms a good wood duck breeding area and is a popular year round fishing area. Loka Bay offers spectacular sunset views from the Anglers Avenue side. Stump filled bays, like Loka Bay, provide important habitat for fish and waterfowl. Stump fields are also a refuge for fishermen because the stumps form water hazards that dissuade intrusion of water skiers and high speed watercraft.

POMMERN POND (16, Exhibit 20) is located in between Highway D and the southern tip of Loka Bay on Mid-Lake Alice. It is visible from Highway D. This small pond is probably spring fed and its connection to Lake Alice water levels is unknown. This high quality feature provides great habitat for turtles and amphibians. Beaver and water-related birds (like blue herons and belted kingfishers) use Pommern Pond as important habitat.

A narrow ***FINGER-LIKE BAY*** (17, Exhibit 21) is fronted by a long island (called "Indian Island") on the western portion of the Pine Creek Flowage part of Lake Alice. This area attracts numbers of common loons, common mergansers, hooded mergansers, mallards, and Canada geese in the spring as ice breaks up. The bay has shallow areas with diverse and abundant aquatic plants. Wild rice beds grow on shallow flats that drop off into the deeper channel and holes. The wild rice forms a great habitat resource for waterfowl and fishes. This part of Lake Alice has been called a "wide spot in the river" because it appears to be an extension of Wisconsin River as it flows down from the Highway A bridge. It forms the crossroads of Lake Alice as it provides access from the King's Dam Reservoir and Mid-Lake Alice sections to the five mile run up the Wisconsin River and to the Pine Creek Flowage

portion of Lake Alice. Anglers Avenue runs northward along the east bank to a public boat landing in a bay created by Weggie's Point. This bay is shallow and could be a potential site for invasive species coming into the lake from boat trailers. Eagles are often seen on the island off Weggie's Point (located to the east and across the river from the finger-like bay). Once the heavy boat traffic starts many of the early avian arrivals, like common loons, relocate to nest, but blue herons frequent the shallows in summer. Lake Alice has a lot of boat landings relative to its size. This means great access, but also brings up litter issues, especially in spring after ice fishing. Invasive species are commonly introduced by boat trailers and boat landings in shallow bays can become contaminated. Eurasian water-milfoil has become established in local lakes and poses a threat to Lake Alice.

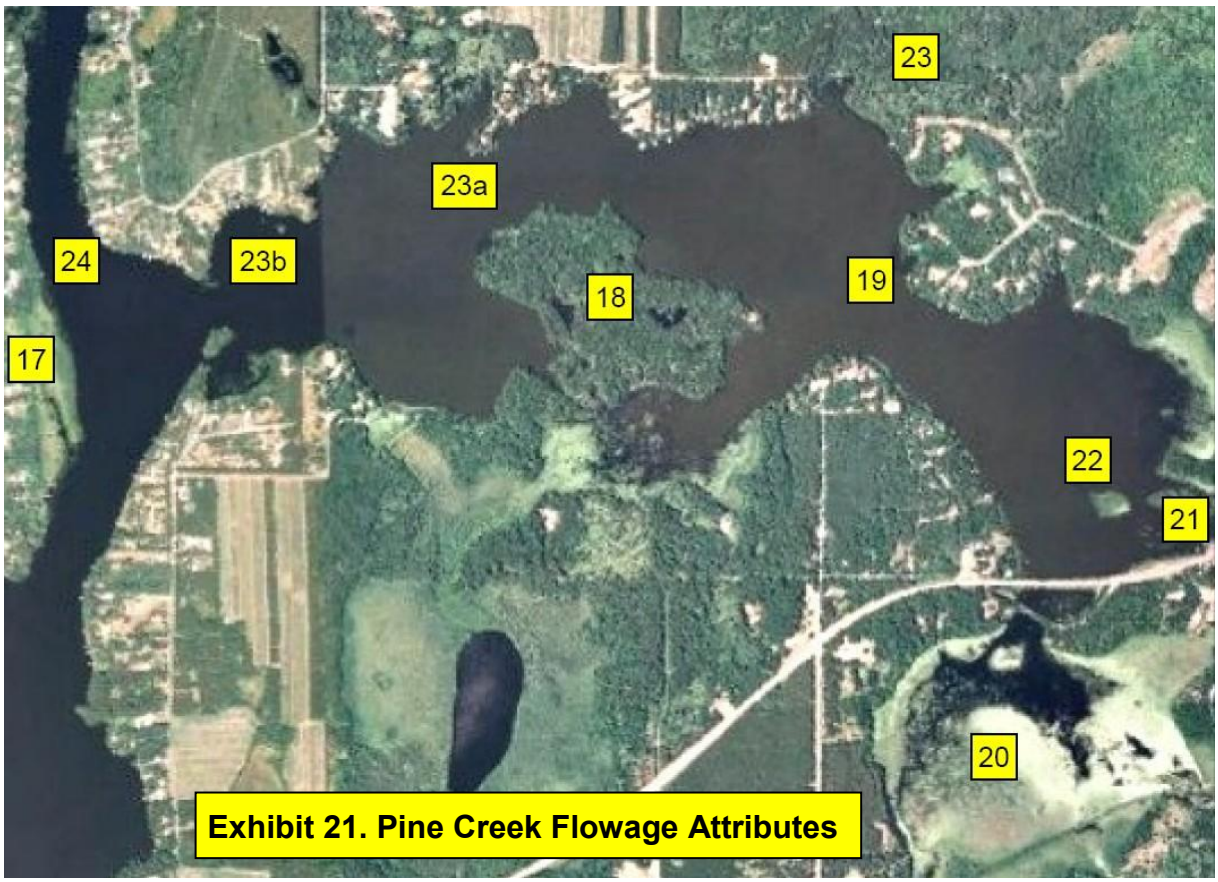


Exhibit 21. Pine Creek Flowage Attributes

BRIDGE ISLAND (18, Exhibit 21) is Lake Alice's largest island and is dominated by natural vegetation. Only one small residence is on the island which is connected to the southern shore of the Pine Creek Flowage section of Lake Alice by a narrow bridge. The entire shoreline of the island is natural providing high quality littoral zone habitat. The island

is flanked on the east by a large submerged stump field, a popular fishing area. To the southwest of the island is shallow Turtle Bay, a great spot for turtles, amphibian, spawning fishes (especially bluegills). The bay to the west of the island also contains many submerged stumps and a convoluted shoreline with small bays filled with water lilies. This large island acts a screen from much of the heavier boat traffic of the lake. In the "stump fields," fishermen and nature observers have a refuge, while water skiers and general traffic have "fast lane" the entire length of the lake by following the old river channel (caution must always be given to "floaters" that higher spring waters launch from the shorelines out into the main lake). The submerged stumps still exist after one hundred years under the waters of Lake Alice. Their longevity may be related to the relative stability of Lake Alice's water level. The constant water level maintains the quality of the lake, but also makes it a magnet for heavy fishing and recreational pressure. The relatively constant water level is a high quality attribute of Lake Alice.

SUNNY POINT (immediately south of 19, Exhibit 21) and EAGLE POINT (immediately east of 19) are prominent features of the Pine Creek Flowage part of Lake Alice. A fair amount of development exists on both points.

GREEN MEADOW LAKE (20, Exhibit 21) is a very high quality and unique feature of Lake Alice. It is approximately a one hundred acre lake with an average depth of about four feet. It is created by three trout stream tributaries, including Green Meadow Creek. Approximately 90% of the shoreline is undeveloped. It is separated from Lake Alice proper by two low bridges. The more southern bridge divides Green Meadow Lake from Lake Alice from a regulatory standpoint where Green Meadow Lake has a different set of non-river flowage regulations.

Green Meadow Lake is a major waterfowl resting area for migrating birds and local nesting species. It provides great spawning habitat for several fish species, including northern pike, yellow perch, largemouth bass, bluegills, and crappie. The south and west shorelines of the lake harbors large fields of wild rice that are attractive to waterfowl and provide good substrate for aquatic insects and hiding areas for small fishes. Muskrats, river otter, mink, fisher, red fox, white tailed deer, beaver, and black bear have been in or around the lake. A diverse fauna of frogs use the lake as well as many painted and snapping turtles. Major hatches of dragonflies and damselflies occur throughout the summer months. Like Lake Alice, the water level in Green Meadow remains relatively constant over the annual cycle.

In recent years, some concerns have been raised regarding Green Meadow Lake. Some observers report increasing density of aquatic vegetation over the past several years with previously well defined creek channels disappearing. In past two years, a new type of alga (large spherical colonies) has appeared in the water. In the past few years, few fish have remained in the lake after early January. It is not known whether this indicates low oxygen concentration. The access to Green Meadow is restricted by the low, privately owned bridge (abandoned by the county years ago). Concern exists of increased access to the lake if the bridge is removed.

PINE CREEK (21, Exhibit 21) is the coldest spring-fed trout stream in Lincoln County. It empties into a shallow bay in the far eastern part of the Pine Creek Flowage. This bay is often full of aquatic vegetation and provides good fish habitat.

EAGLE NEST ISLAND (22, Exhibit 21) contains the most easily viewed eagle's nest on the lake.

UNNAMED TRIBUTARY (23, Exhibit 21) to Lake Alice may even be a vestige of the original channel for Pine Creek (prior to when Lake Alice was created).

AL'S POINT (23a, Exhibit 21) is a prominence along the north shore of the Pine Creek Flowage. Water transparency measurements have been obtained using a Secchi disk out in front of Al's Point.

HORSESHOE BOAT LANDING (23b, Exhibit 21) marks the western extent of a section of "old" development along shoreline the north shore of the Pine Creek Flowage. This section extends back to the Unnamed Tributary (23) and is characterized by fairly dense human development.

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NO-WAKE ZONE (24, Exhibit 22) extends both north and south of the Highway A Bridge. This area of Lake Alice receives a high density of watercraft traffic. The bridge itself forms nesting habitat for swallows whose mud nests can be observed when boating underneath the bridge. Boat landings exist on both sides of the bridge allowing easy access up and downstream of the bridge. Wild rice beds are present along the river in this area. An unnamed body of water and extensive wetland enters Lake Alice from the west side of the river just downstream of the Highway A Bridge. This wetland provides high quality habitat, but little is known about the area.

Exhibit 22. Lower Wisconsin River Attributes

Upstream of the Highway A Bridge, the Wisconsin River, forms a wonderful part of the Lake Alice watershed. Boaters from Lake Alice and navigate for five miles upstream. A few cottages exist along the east bank of the river but disappear about two miles upstream (25, Exhibit 22) of the Highway A Bridge. ***SPRING CREEK*** (26, Exhibit 22) enters the river from the west side in an area of meanders and small islands. Further upstream, ***TROUT CREEK*** (28, Exhibit 23) enters the river at the downstream end of a rapids section of river and opposite the historic ***MENARD'S ISLAND*** (27, Exhibit 23). Menard's Island is a very popular boating destination. Larger watercraft coming upstream from Lake Alice cannot navigate upstream of Menard's Island. This section of river, owever,

receives a great deal of canoe and kayak traffic that navigates from access points upstream of Menard's Island.

All along the river are important spawning habits for walleye, smallmouth bass and northern pike. Beaver, river otter, mink, muskrat, and many water-associated birds use this section of the river as habitat. Large tracts of shoreline along this section of river are now owned by the State of Wisconsin and under WDNR management. This portion of the Wisconsin River is a very high quality attribute of the Lake Alice watershed ecosystem.

The final part of this chapter discusses some of the environmental threats to the attributes of Lake Alice and surroundings.

Part 11. Environmental Threats to Lake Alice

As outlined in the previous part, the Lake Alice watershed ecosystem has numerous attributes of high ecological and aesthetic significance. These attributes are what makes Lake Alice a unique and special place. Nevertheless, these attributes are at risk of degradation from environmental threats. We outline some of these threats in this part of the Lake Alice plan.

Recreational pressure – Lake Alice is a well-known and much-used fishing lake for people from near and far. It is a popular recreation and vacation destination and has received publicity outside of Wisconsin. An expanding base of admirers has resulted in increasing recreational pressures. During the recent draught years in Wisconsin, many bodies of water have experienced greatly reduced water levels (often limiting navigability). Because of the King's Dam hydroelectric facility operating parameters, Lake Alice levels have remained constant even during these draught years. Many boaters and fishermen accustomed to using other water bodies have focused their attention on Lake Alice. For many years, Lake Alice had a year-round open season for many game fishes (see Exhibit 24 for more on this). Boats running up river at excessive speeds resulted in resident complaints about shore erosion, as well as concerns about disturbing loon and other

Exhibit 24: Fishing Season

"Spring run" has always been a Wisconsin River fishing tradition and this was also the case for Lake Alice and the Wisconsin River upstream of the lake. Some feel that heavy fishing pressure (both legal and illegal) on spawning game fish, depleted fish in numbers and size for rest of season. Unregistered bass tournaments have been another relatively unknown source of pressure on the Lake Alice fishery. These threats to the Lake Alice fishery led to direct involvement by the Lake Alice Association and others concerned about Lake Alice. The Association went through a series of meetings with local and regional WDNR, Conservation Congress representatives, and concerned citizens about the resource management of Lake Alice. Under consideration was a slot size for walleyes, future comprehensive fish surveys, and fishing seasons. This effort resulted in a 2009 change in the fishing season for walleye, northern pike, smallmouth bass, and largemouth bass in the Lake Alice system. The season changed from a continuous year-round open season to being closed after the first Sunday in March through the first Friday in May to align with most inland lakes in Wisconsin.

nesting birds. The numerous access points to Lake Alice are convenient for the public, but increases fishing and other recreation pressure. These access sites are also points of littering and likely portals for introduction of aquatic invasive species.

Development pressure – Lake Alice has some areas of fairly high residential development as well as development in the form of resorts, road ways (impervious surfaces), and a golf course. In contrast, Lake Alice also has large areas with predominantly natural vegetation and broad and diverse riparian areas. In some areas of the lake, old-style lawns, cropped short and in close proximity to the shore indicate a need for some educational effort to inform residents about more ecologically friendly waterfront vegetation. Likewise, development of artificial beaches diminishes the habitat quality for invertebrates and fish. The riparian wetlands and small ponds are also vulnerable to development and human "grooming" since their great ecological values are often overlooked.

Integrity and Maintenance of King's Dam – Maintaining a hydroelectric facility must be cost-effective in order to continue long term. King's Dam is one-hundred years old and requires frequent and costly upkeep. The periodic relicensing process (overseen by the Federal Energy Regulatory Commission) is also expensive. It is conceivable that at some point a decision would be made to decommission King's Dam resulting in dramatic outcomes for Lake Alice. It is important for the Lake Alice Association and others concerned with a healthy Lake Alice, to remain in communication with King's Dam owner in order to understand the long term plans.

Water quality inputs – The water quality and aquatic ecosystem functioning of Lake Alice is affected by all inputs of water (groundwater, precipitation, streams, and overland runoff). All of these sources have potential to carry pollutants of various kinds to Lake Alice. Fortunately, the water contributions to Lake Alice have become cleaner in years since the Clean Water Act (1978) greatly reduced point-source pollution in the Wisconsin River. Nevertheless, catastrophic spills (from tanker trucks and other carriers) and combined sewer overflows (when wastewater treatment plants are overwhelmed with stormwater runoff) pose a threat to the water quality of Lake Alice. Non-point source pollution (see next paragraph) remains an important threat to Lake Alice water quality.

Non-point source pollution – Surface runoff from the land, roadways, parking lots and other surfaces flows into Lake Alice and to the streams (including the Wisconsin River) that contribute water to Lake Alice. This runoff carries with it sediment, nutrients (for example, from fertilizers) and contaminants (for example, herbicides) that can have detrimental effects on the Lake Alice ecosystem. Known as non-point source pollution (because it does not emanate from a discrete point like an effluent pipe from a paper mill), this kind of runoff can come from lawns, golf courses, agricultural fields, clearcuts, and impervious surfaces (for example, roads and paved parking lots). Sometimes the impact is physical, such as sediment covering gravel spawning areas. Sometimes it is chemical such as excess phosphorus from lawn fertilizers that might invoke an algal bloom. This type of pollution can be best controlled through education and protection of riparian buffers (natural vegetation near the waterways that absorb the pollutants before they reach the water).

Invasive aquatic species – Non native plant and animal species have become a grave concern for aquatic, wetland, and terrestrial ecosystems. Lake Alice has been relatively fortunate so far to avoid serious establishments of these destructive organisms. Nevertheless, the threat remains an important concern especially given the numerous public access sites and the high volume of boat traffic (aquatic invasive species often hitchhike to new bodies of water via boats, trailers, and bait containers). The Wisconsin River upstream of Lake Alice is itself a potential source of invasive aquatic organisms for Lake Alice. When it comes to non-native aquatic plant invaders, the best defense against establishment is a healthy community of native plants. Although no formal plant surveys have been done in Lake Alice, a diverse native plant community presently exists. Effective education and diligent monitoring are important factors in avoiding establishment of aquatic invasive species.

Riparian ecosystem integrity – Healthy riparian areas (the naturally vegetated land near the water) provide numerous important functions and values to Lake Alice. For example, they serve as habitat, filter out non-point source pollution, and protect against erosion. Educating riparian owners around Lake Alice as to the importance of riparian areas is important to the maintenance of these critical areas.

Littoral zone ecosystem quality – Much of the productivity of a lake comes from the shallow water areas known as the littoral zone. This is where plants grow, invertebrates live, fishes

spawn, and aquatic birds and mammals spend much of their time. The presence of good aquatic vegetation, diverse substrate, and dead woody material (logs and branches) is crucial to this littoral zone ecosystem. Sometimes the human temptation is to "clean up" these areas, but in fact this process diminishes the habitat quality greatly. Lake Alice is fortunate to have an abundance of good quality littoral zone habitat, but it can be degraded quickly. It is important to educate landowners and others about how to protect the littoral zone from degradation. Piers and swimming areas impact the littoral zone as well, but can coexist with a quality shallow water habitat if kept to a reasonable level. A rather special feature in Lake Alice is the stump fields (dead standing timber that remains submerged in various areas of the lake). Although these are sometimes located in deeper water the habitat they provide is similar to the woody material found in littoral zones. These areas deserve special consideration in the management of Lake Alice.

Habitat degradation of nearby aquatic and wetland habitats (ponds, streams) – The wetland habitats, streams, small lakes, and ponds in the vicinity of Lake Alice all contribute to the high quality of the lake. These smaller ecosystems can be overlooked in terms of their importance and therefore deserve some special attention. One of the first protective measures to take is to identify where these features are and characterize their size and ecological composition. This informs future protection and restoration efforts.

Part 12. Environmental Education

The Lake Alice Stewardship Program endeavors to provide education to Lake Alice users and others through a variety of avenues (workshops, outdoor activities, website, and newsletter).

In September of 2009, over forty Tomahawk High School (THS) biological science students participated with their teachers, LAA members, and Dr. Dean Premo from (White Water Associates) in a field trip on Lake Alice (see Exhibit 25). Key features of the lake were viewed and interpreted. Shoreline assessments were conducted. Water quality sampling was demonstrated. Students documented the outing with notes and digital photography. Back at school, students interpreted notes from the field and organized multi-media presentations of their experiences.

On July 25, 2014 Dean Premo and Angie Stine (both with White Water Associates) met up with Lake Alice Association members to conduct a floating workshop. Two pontoons

boats were used as the classroom platforms. Premo began the workshop discussing the importance of the riparian and littoral zones. The next topic was how an aquatic plant point-intercept survey is conducted. Stine pulled a few aquatic plants with the rake and described the differences in them and educated the members how to identify them. The last stop was to conduct some water quality sampling using an integrated sampler. Chlorophyll a, total phosphorus and calcium were going to be analyzed from the sample. A dissolved oxygen and temperature profile was also conducted. A Secchi depth was recorded to determine the clarity of the water. The importance of conducting water quality over time to see if there are any trends was discussed.

Exhibit 25: A New Generation

The Lake Alice Association believes that the long term health of Lake Alice will be ensured if young people become involved with the process of stewardship. To initiate that process, the LAA organized and hosted a school field trip. In September of 2009, over forty THS biological science students participated with their teachers, LAA members, and Dr. Dean Premo from (White Water Associates) in a field trip on Lake Alice. Key features of the lake were viewed and interpreted. Shoreline assessments were conducted. Water quality sampling was demonstrated. Students documented the outing with notes and digital photography. Back at school, students interpreted notes from the field and organized multi-media presentations of their experiences.

On a pleasant September 2009 day, eight pontoon boats ferried students around Lake Alice (Dean Premo photo)

On May 16, 2016 Angie Stine, met at LAA member Glenn Mott's home to take out students from the Tomahawk High School. THS teacher Brianna Schield accompanied them the students. Glenn Mott and another LAA member provided pontoon boats. Stine began the session by describing the various WDNR grants Lake Alice had received. The first stop was along a shoreline to discuss the riparian area and littoral zone and its importance to the quality of the water and wildlife. The second stop for the students was to discuss the aquatic plant survey and also to use the rake to collect some plants and have the students use the reference books to identify

them (with assistance from Stine). The third stop was to explain some water quality sampling, including demonstration of a dissolved oxygen and temperature profile. Stine showed the students how to use the Secchi disk to measure water transparency and demonstrated collecting a water sample using the Kemmer sampler. The final stop was to show the students Eurasian-water milfoil and curly-leaf pondweed and discuss the importance of Clean, Drain, and Dry and also to stay away from areas of EWM and CLP when boating so that the plants do not further spread. Purple loosestrife, rusty crayfish, and yellow iris were also discussed along with other AIS. Stine ended the boat tour by explaining the importance of Lake Alice discussing the wildlife, wild rice, scenery, pleasure, fishing, boating, and hunting. A lunch was served at Mott's home following the floating workshop.

Information regarding the progress of the Grants was conveyed to LAA members to place in newsletters. All of past newsletters can be found on the Lake Alice Association Website. In addition, White Water staff has supplied articles for the newsletters including:

- January 2013 Vol. 15: Article from Dean Premo about curly-leaf pondweed;
- May 2013 Vo. 15 NO 2: Lake User Survey information and promotion (the front page was included and they stated they could find the survey on the website);
- May 2014 Vol 16 No 2: Insert from Dean Premo and Angie Stine summarizing the progress of Lake Alice studies;
- January 2015 Vol. 17, No. 1: Mention of EWM being found and a Rapid Response Grant made available by WDNR;
- June 2015 Vol. 17, No. 1: Description of the Lake Alice Stewardship Program – Time line of Phase I, II, III, CLP, and EWM Early Detection and Rapid Response. Write up by Dean Premo about the Early Detection and Rapid Response Grant. Also photos by Angie Stine of EWM explaining hand-pulling the EWM and also a photo of Purple Loosestrife;
- January 2016 Vo. 18, No. 1: Article by Fred about purple loosestrife; and
- January 2017 Vo. 19, NO. 1: Eurasian water-milfoil article written by Fred Brach describing the 2014 and 2015 EWM hand-pulling.

The LAA hosts an annual event (Winter in Wonderland Fishing Tournament) that promotes Lake Alice and its environment. This is both an important information distribution venue and fundraiser for the LAA.

Part 13. Human History

The human history of Lake Alice is one hundred years old in 2010 since Lake Alice was created by impounding the Wisconsin River in 1910. Humans are now and have always been an important influence in the watershed. This management plan recognizes that condition.

In the not too distant past, the Lake Alice landscape was molded and influenced by natural disturbances such as fires, blowdowns, floods, beaver, insect outbreaks, and climate. Today's landscape is the obvious result of the combined interaction of human and natural processes, with humans nowadays serving as the most significant agents of change. The LAA has prepared a history of Lake Alice and this is included in its entirety in Appendix B.

In recent years, the Lake Alice Association has organized around a common concern for the long-term care of Lake Alice. This has begun a very hopeful chapter in the history of Lake Alice. The LAA has actively become involved with all aspects of Lake Alice resources and with educating those that live near and use the lake. Perhaps most importantly for the future, the LAA has developed a relationship with Tomahawk High School biological science teachers and students in order to enlist a new generation of lake stewards (see Exhibit 25).

Part 14. Lake Alice User Survey

As part of the Phase 3 program, a Lake User Survey was developed for Lake Alice. The survey is included in Appendix J. The Lake User Survey was posted on the LAA website and promoted in the LAA newsletter. An email version of the survey was also produced and distributed. There were eight responders to the survey. These are include as Appendix J.

CHAPTER 6

What Goals Guide the Lake Alice Management Plan?

"Protect the Best and Restore the Rest" has become the credo of successful watershed managers across the country. This simple phrase acknowledges that watershed management is more than identifying the worst areas and trying to rehabilitate them. It recognizes that of equal or greater importance is identifying those areas that are of high or moderate quality in the watershed and establishing mechanisms to maintain that quality. "Protect the Best and Restore the Rest" also implies the importance of identifying imminent threats to watershed health and working to eliminate them. This simple principal is founded on the restoration ecology fact that the most certain way to successfully restore the structure and function of part of a broken watershed ecosystem is to rely on intact areas of the watershed to serve as the donors of healthy "parts" (such as aquatic insect species or good quality water). "Protecting the Best" allows us to "Restore the Rest" more effectively and economically. But, protecting the best is prerequisite.

The primary goal of the Lake Alice Stewardship Program is to perpetuate the quality of Lake Alice and its watershed ecosystem into the future. Sometimes this will mean protecting what is good about the lake and its surroundings and sometimes it may mean restoring some feature that has been degraded. Restoration is reestablishment of the structure and function of an ecosystem including its natural diversity (Cairns 1988; National Research Council 1992). It implies rehabilitating and protecting sufficient components of the ecosystem so that it functions in a more or less natural way, provides habitat for native plants and animals, and supports reasonable human uses.

The Lake Alice Adaptive Management Plan offers several supporting goals. In an adaptive plan, new goals can be adopted as the plan evolves. We conclude this chapter by presenting these goals organized under topical headings.

Restoration – Apply rehabilitation, protection, and education actions under the direction of specific objectives to identified specific areas in the Lake Alice watershed.

Research – Gather information that is useful in planning and monitoring restoration actions and devising education programs.

Monitoring – Establish a monitoring system in the Lake Alice Watershed that will provide data that reveals the quality of the system and establishes methods to evaluate the effectiveness of management efforts.

Cultural Climate – Encourage a cultural and political atmosphere that allows and promotes good watershed stewardship including cooperation between citizens, businesses, public agencies, and municipalities.

Sustainable Economy – Foster an environment that promotes a sustainable economy, provides a diversity of economic options for the residents of the watershed, and does not diminish opportunities for future generations of watershed residents.

Recreation – Promote a sustainable recreation in Lake Alice where all citizens (now and in the future) can enjoy the opportunities of the natural and human-sustained environment while respecting the environment and the rights of fellow citizens.

Program Maintenance – Foster a stewardship culture that engages people to donate time, talent, and money sufficient to support the implementation and periodic update of the Lake Alice plan.

In the final chapter of this Adaptive Management Plan, we present possible objectives and actions that will serve to move toward these goals. This is not an exhaustive treatment, but part of an ongoing refinement and update of activities, integrated with monitoring so that adaptive management can take place in subsequent years.

CHAPTER 7

What Objectives and Actions Move Us Toward Those Goals?

The Lake Alice watershed is healthy, diverse, and productive. Our challenge through this adaptive management plan is to perpetuate that condition into the future. The challenge will be met by a capable set of program partners that are prepared to devote themselves to Lake Alice stewardship. These partners include the members of the Lake Alice Association, biological science faculty and students of Tomahawk High School, the ecological scientists of White Water Associates, Inc., and the WDNR.

Abraham Lincoln is attributed with the following wisdom: "If I had an hour to cut down a tree, I'd spend the first 45 minutes sharpening my ax." Planning and preparation are important for any task, but especially when working with a system as complex as a lake or watershed. The vision and goals described in the previous chapter provide the basis for developing objectives and actions to achieve the desired future for the Lake Alice Watershed. In keeping with the spirit of an adaptive management plan, we present several actions and associated objectives that can be undertaken as human and financial resources allow in subsequent phases of the program. Desired outcomes of each action are also stated. The actions, objectives, and outcomes each need to be further developed so that appropriate methodology and accurate estimates of required effort can be described. The plan is flexible and allows the insertion of new actions at any point along the path of lake management.

Action (Research): Conduct temperature and dissolved oxygen profiles over the annual cycle in various parts of Lake Alice.
Objective: To develop a better understanding of available and usable fish habitat.
Outcome: LAA oversees activity and maintains data. Data to be shared with WDNR.
Status: Planned for future implementation (pending funding).

Action (Education): Work with WDNR to understand and manage the Lake Alice fishery.
Objective: To support scientific and effective restoration of a quality Lake Alice fishery.
Outcome: Document meetings and other contacts made to the WDNR and others.
Status: Planned for future implementation (pending funding).

Action (Education): The Lake Alice Association should become a project partner in the WDNR's Wisconsin River Basin Water Quality Improvement Project (for an overview, see: http://dnr.wi.gov/topic/TMDLs/documents/WisconsinRiver/WQIPTMDL.pdf).
Objective: For the LAA to become better informed on the water quality of the Wisconsin River and how it influences Lake Alice.
Outcome: Improved water quality of the Wisconsin River, its reservoirs, and tributaries.
Status: Planned for future implementation.

Action (Research): Assess rusty crayfish presence, distribution, and population in Lake Alice.
Objective: To understand the potential impact represented by this aquatic invasive species.
Outcome: A written report should document findings.
Status: Planned for future implementation (pending funding).

Action (Research): Continue frog and toad surveys on Lake Alice and associated wetlands.
Objective: To understand the abundance and diversity of this sensitive group of organisms and monitor long-term health of the Lake Alice environment.
Outcome: A report should document the findings.
Status: Action included in Phase 1 plan. This activity was begun in 2010 and is ongoing as interest and funding allows.

Action (Education): Establish kiosks or other structure at the public boat launches that provide information on the threats of aquatic invasive species introductions to Lake Alice and outline how such introductions can be minimized.
Objective: Prevent new introductions of aquatic invasive species to Lake Alice and minimize transfer of Lake Alice AIS to other water bodies.
Outcome: Creates more informed and responsible recreational users of Lake Alice. Lake Alice Association should document that the kiosks are maintained with educational material.
Status: This is an ongoing activity.

Action (Research): Conduct point-intercept survey for aquatic plants in Lake Alice in 2021.
Objective: To understand the diversity and abundance of native and non-native aquatic plants in Lake Alice and document and interpret changes in the aquatic plant community.
Outcome: Data archived by Lake Alice Association and submitted to the WDNR.

Status: Planned for future implementation (pending funding). This action was carried out in 2010 and 2016 with results reported in the an aquatic plant management plan.

Action (Research): Conduct periodic assessments of Lake Alice for aquatic invasive plants.
Objective: To provide an early warning of introductions of aquatic invasive species to allow rehabilitation actions to occur when populations are still small.
Outcome: Document the number and timing of surveys and maintain record of findings.
Status: This is an ongoing activity with more specific guidance provided in the aquatic plant management plan.

Action (Research): In consultation with WDNR, expand the volunteer water sampling program in Lake Alice to include total phosphorus, chlorophyll "a", dissolved oxygen, and temperature.
Objective: To understand trophic status and fluxes in Lake Alice.
Outcome: Samples and data delivered to Wisconsin State Lab of Hygiene and WDNR.
Status: Planned for future implementation (pending funding).

Action (Protection): Continue to pursue protection mechanisms for Krull Island (including outright purchase, conservation easements, and local land conservancies).
Objective: Ensure long term integrity of this high quality habitat and aesthetic resource.
Outcome: Continue to update LAA members through website and newsletters.
Status: This is an ongoing activity.

Action (Research): Identify, map, and characterize important wetlands (including open water ponds) within the Lake Alice watershed. Assess quality and threats for each wetland.
Objective: Protect and monitor the health of important wetlands that influence Lake Alice.
Outcome: Written report documents findings and recommends follow-up monitoring.
Status: Planned for future implementation (pending funding).

Action (Research): Document the state of development of the Lake Alice Shoreline using aerial and digital photography (include a count of number of piers along the shoreline).
Objective: Create baseline for shoreline development against which to monitor future change.
Outcome: The findings are documented in this adaptive management plan.

Status: Completed in Phase 3.

Action (Research): Monitor common loon nesting success on Lake Alice.
Objective: To determine presence and reproductive success of common loons.
Outcome: Reports should document annual nesting success and historic trends.
Status: This is an ongoing activity.

Action (Research): Monitor bald eagle nesting and success on Lake Alice.
Objective: To determine presence and reproductive success of bald eagles.
Outcome: Reports should document annual nesting success and historic trends.
Status: This is an ongoing activity.

Action (Education): Establish an award or recognition of riparian owners that preserve or rehabilitate "natural shoreline" habitat on their property. This could be recognized in LAA newsletter along with an article about the ecological benefits of natural shorelines.
Objective: To encourage good shoreline stewardship by riparian owners and improve the riparian area quality of Lake Alice.
Outcome: Monitor by general awareness of landowners and changes in shoreline maintenance behaviors.
Status: Planned for future implementation.

Action (Education): Conduct periodic field trips for Tomahawk High School biological science students and teachers.
Objective: To foster an interest in Lake Alice in the next generation lake stewards.
Outcome: Student involvement in adaptive management actions on Lake Alice.
Status: Planned for future implementation (pending funding).

Action (Education): Create periodic updates of the adaptive management plan.
Objective: To incorporate most up-to-date information regard Lake Alice and application of best stewardship practices.
Outcome: Up-to-date management plan is available for ongoing implementation and stewardship of Lake Alice.
Status: This document is the third version of the adaptive management plan.

Action (Protection): Adopt and implement the Aquatic Plant Management Plan prepared as result of Phase 3 efforts.

Objective: To protect and maintain a high quality aquatic plant community in Lake Alice (including wild rice), reduce opportunities for introduction of aquatic invasive plant species, and manage/monitor the populations of curly-leaf pondweed and Eurasian water-milfoil that presently occur in Lake Alice.

Outcome: A healthy, diverse Lake Alice aquatic plant community and a human community that is actively engaged in monitoring and protecting native aquatic plants.

Status: The aquatic plant management plan is intended for adoption in 2017.

Action (Education): Conduct a formal lake users' survey.

Objective: To gather information about Lake Alice users' knowledge base, concerns, and goals for Lake Alice. The formal survey would also serve as an educational vehicle to inform lake users about the Lake Alice Association, the Adaptive Management Plan, and the Aquatic Plant Management Plan.

Outcome: A knowledgeable population of Lake Alice users and a better informed Lake Alice Association that can apply new information and tools to Lake Alice management.

Status: There was no response from Lake Alice users to the web-based distribution of the survey in Phase 3. This action planned for future implementation (pending funding).

Future phases of the Lake Alice Stewardship Program will build on the foundation established in earlier program phases. Additional aspects of the Lake Alice watershed ecosystem will be explored. For example, future phases will address watershed wetlands, more thorough aquatic and riparian vegetation assessment and mapping, survey of lake users on conditions of Lake Alice, and education of lake users on topics such as the importance of the riparian zone to lake health. Future phases will include revisions to the lake management plan and actions that support adaptive management.

Lake Alice and its watershed serve its human residents well. But, in order for future generations to enjoy all that the watershed can provide, this adaptive plan should be embraced, developed, and implemented. It may seem slow at first, but considerable momentum already exists because of the hard work that has already occurred. The Lake Alice

Watershed has begun this next millennium with a well-prepared and duly concerned human population ready to take up stewardship responsibility.

Appendix A
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Appendix B
Aquatic Plant Management Plan

The Lake Alice Stewardship Program

Aquatic Plant Management Plan (2nd Edition)

Prepared for:

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Aquatic vegetation on Lake Alice (Dean Premo photo)

Date: May 2, 2017

The Lake Alice Stewardship Program

Aquatic Plant Management Plan (2nd Edition)

Includes information collected during:

- **Phase 1 – Information Inventory and Adaptive Lake Management Plan**
- **Phase 2 – Understanding the biota of Lake Alice and Aquatic Plant Management Plan**
- **Phase 3 – People, Plants, Animals, and Habitats**

This document is a product of a WDNR Lake Planning Grant and Early Detection Rapid Response Grants awarded to:

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WHITE WATER ASSOCIATES, INC.

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CHAPTER 1 Introduction

The Lake Alice Stewardship Program is as an ongoing endeavor composed of phases that progress toward the overall vision. An important aspect of this stewardship is consideration of the aquatic plant community. The first systematic survey of aquatic plants in Lake Alice took place in 2010. The 2010 survey used the Wisconsin Department of Natural Resources (WDNR) "point-intercept" method. With that plant data, the Lake Alice Association and its consultant (White Water Associates) prepared an Aquatic Plant Management Plan for Lake Alice (Premo and Premo 2011). A second Lake Alice point-intercept aquatic plant survey took place in 2016. This second survey allows us to examine whether the plant community has changed in and evaluate its current state of health. This information has allowed the preparation of this 2nd Edition of the Aquatic Plant Management Plan for Lake Alice.

Aquatic plants rarely get the respect they deserve, although this is slowly changing. Still, in common parlance, an aquatic plant bed is a "weed bed." Many aquatic species incorporate "weed" in their names. Consider duckweed, pondweed, musky weed, and waterweed, to name a few. Likely this appellation was borrowed from "seaweed" and not meant to be derogatory, but in today's language, "weed" connotes an unwanted plant, often exhibiting rampant growth. Such is not the case for the vast majority of plants in aquatic ecosystems.

Aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for a plethora of animal life. Aquatic invertebrates, including many species of crustaceans and insects, live on or within this veritable "aquatic forest" of plants. Many species of fish find food and shelter within aquatic plant beds. Some species of waterfowl eat parts of plants directly as well as feed on the abundant invertebrate life associated with the plants. Muskrats eat a variety of aquatic plants with a particular affinity for cattails and bulrushes. Otter and mink hunt invertebrates and small vertebrates within the shelter of submergent and emergent beds. Great blue and green herons find small fishes among the plants in this same shallow water.

In lakes that receive an overabundance of nutrients (from fertilizers, leaking septic systems, or particularly large watersheds), plant growth can become too lush, or dominated by only a few species that respond more rapidly to extra nutrients. As these abundant plants die, their decomposition can result in low oxygen levels that are injurious to fish populations. Algal blooms, responding rapidly to nutrient influxes, can create foul odors. In short, this process of accelerated lake eutrophication can give aquatic plants a bad name.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, may come to dominate a water body to the exclusion of a healthy diversity of native species. Eurasian watermilfoil and curly-leaf pondweed are two of the better known examples of these so-called ***aquatic invasive species*** (***AIS***).

For most lakes like Lake Alice, aquatic plants are a positive attribute, greatly enhancing the aesthetics of the lake and providing opportunities for good fishing, good hunting, good boating, and good snorkeling. Lake Alice does not currently have a nuisance level of aquatic plants. It has a healthy and fairly diverse community of native plants. The aquatic invasive plants, although worthy of diligent monitoring, have not proliferated to nuisance levels. Members of the Lake Alice Association want to maintain a high quality condition of the plant community.

In preparing this plan, we have followed the guidelines prepared by the WDNR called Aquatic Plant Management in Wisconsin. This is an adaptive plan (Walters 1986). That is, it will be modified as additional information about the Lake Alice aquatic plant community and its management becomes available.

The WDNR Guidance document outlines three objectives that may lead to preparation of an aquatic plant management plan:

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

Currently, the Lake Alice Association's motivation lies in the first two objectives. Lake Alice is a tremendous resource with good water quality and a diverse and interesting

community of aquatic plants. It also has a strong recreational history and current human use that has caused only moderate degradation to the ecosystem.

The Lake Alice Association has followed the seven-step plan outlined in the Guidance Document for developing this second edition of its an aquatic plant management plan. The seven steps are as follows:

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.

This document presents the 2nd Edition of the Lake Alice Aquatic Plant Management Plan. It resulted from a draft plan prepared by White Water Associates and submitted to the Lake Alice Association for review and comment. Besides this introductory chapter, this plan is organized in five additional Chapters. Chapter 2 describes the study area. Chapter 3 states the purpose and goals for the Lake Alice Aquatic Plant Management Plan. Chapter 4 references the lake information inventory that has been ongoing in Lake Alice including newly collected data (particularly, results of the aquatic plant surveys conducted in 2010 and 2016 and additional monitoring of aquatic invasive plant species). Chapter 5 provides recommendations for objections and actions that support the overall goals and establish the stewardship component of aquatic plant management plan. Finally, Chapter 6 outlines a contingency plan for rapid response to aquatic invasive plant species should they appear in Lake Alice. Two appendices complete this document. Appendix A contains literature cited in this document and Appendix B contains tables and figures.

CHAPTER 2 Study Area

Lake Alice is a 1,369 impoundment lake on the Wisconsin River. It is located immediately east of the town of Tomahawk in Lincoln County, Wisconsin. Despite its large surface area, Lake Alice is a fairly shallow lake and has a maximum depth of about 32 feet. Lake Alice can be best described as an "impoundment" in the Wisconsin River as its water level is controlled by King's Dam (operated by Tomahawk Power and Pulp and controlled by Wisconsin Valley Improvement Company). Exhibit 1 shows the Lake Alice area and identifies some major landmarks. The Lake Alice Adaptive Management Plan describes the landscape surrounding Lake Alice more thoroughly.

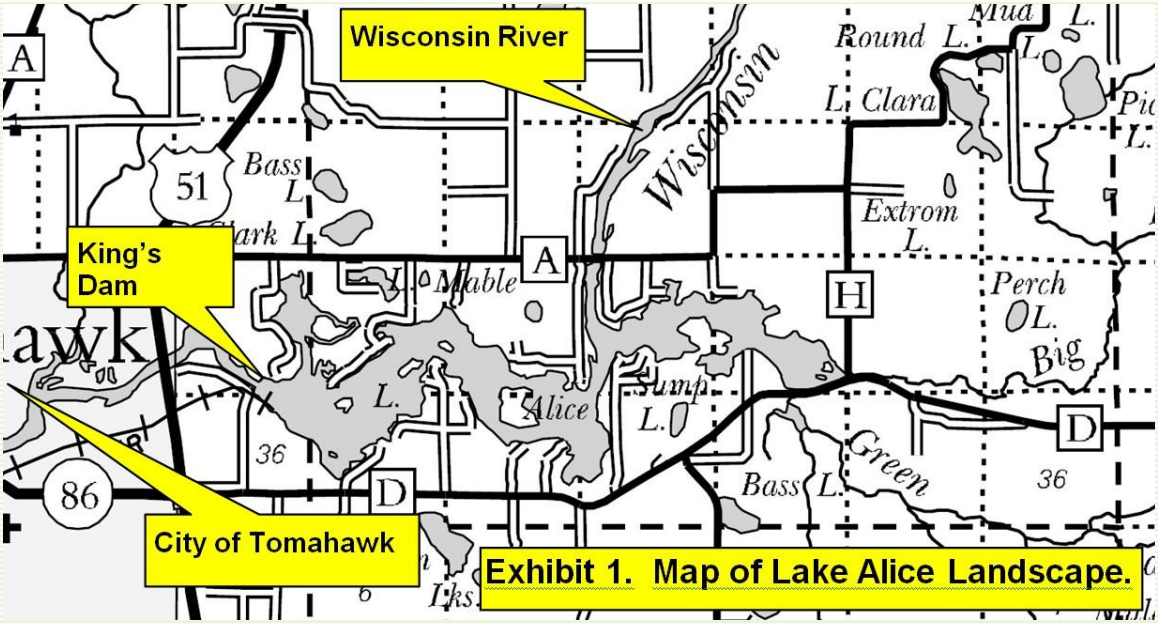


Exhibit 1. Map of Lake Alice Landscape.

CHAPTER 3

Purpose and Goal Statements

The Lake Alice Association approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose and for the Lake Alice Aquatic Plant Management Plan:

> ***Lake Alice has a healthy and diverse aquatic plant community that has been well-documented by a point-intercept surveys in 2010 and 2016. This plant community is essential to, and part of, a high quality lake ecosystem that serves the human community with its recreational and aesthetic features. The Lake Alice Association aspires to maintain the Lake Alice aquatic plant community in its present high quality state.***

Supporting this purpose, we offer this goal statement:

> ***It is the goal of the Lake Alice Association to maintain a healthy Lake Alice ecosystem by (1) monitoring the native plant community and existing aquatic invasive plant populations, (2) guarding against establishment of additional aquatic invasive species (AIS), and (3) monitoring and educating Lake Alice recreationists and riparian owners.***

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

CHAPTER 4 Information and Analysis

Our efforts in Phases 1, 2, and 3 of the Lake Alice Stewardship Program have compiled extensive information about historical and current conditions of the Lake Alice ecosystem and its surrounding watershed. This information has been organized and presented in the 3rd Edition of the Lake Alice Adaptive Management Plan (to which this Aquatic Plant Management Plan is appended) and submitted to the WDNR as part of our obligation under the Lake Planning and Early Detection-Rapid Response Grants. Of particular importance to this aquatic plant management plan are the aquatic plant surveys that were conducted in 2010 and 2016 using the ***WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry***. The results of this comprehensive "point-intercept" survey along with specific information gathered on Eurasian water-milfoil and curly-leaf pondweed *under separate Early Detection-Rapid Response grants), and relevant components of other Lake Alice information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

Part 1 – Watershed

The Lake Alice Stewardship Program views Lake Alice as part of a larger landscape ecosystem (referred to as the Lake Alice Watershed). At a continental scale, Lake Alice is a part of the Upper Mississippi Water Resource Region. Waters that flow from Lake Alice eventually enter the Mississippi River and flow into the Gulf of Mexico.

As part of the Phase I work of the Lake Alice Stewardship Program, we delineated the total watershed for Lake Alice as that part of the watershed located upstream of King's Dam (near Tomahawk, Wisconsin). This is illustrated in Exhibit 2. This total watershed for Lake Alice extends up into Michigan's Upper Peninsula and includes over 1,200 square miles of surface area. All water runoff from the land and all of the streams in this region eventually flows to Lake Alice. Likewise, discharges from industry and waste water treatment plants within this watershed potentially influence Lake Alice.

In order to have a more practical sized watershed with which to work, we delineated a sub-watershed that extends from King's Dam up to the point where Trout Creek enters the Wisconsin River (approximately four river miles upstream of County Highway A). This sub-watershed is also illustrated in Exhibit 2. The Lake Alice sub-watershed is approximately seventy-four square miles (47,500 acres) and is located entirely within Lincoln County, Wisconsin.

Exhibit 2. Lake Alice Watershed

The Lake Alice sub-watershed has relatively low topography, ranging only about 400 feet in elevation from high points in the landscape to the low point on Lake Alice. The southeastern part of the sub-watershed has the highest elevations. A digital elevation model is provided as Exhibit 3 and shows the relative elevations for the sub-watershed.

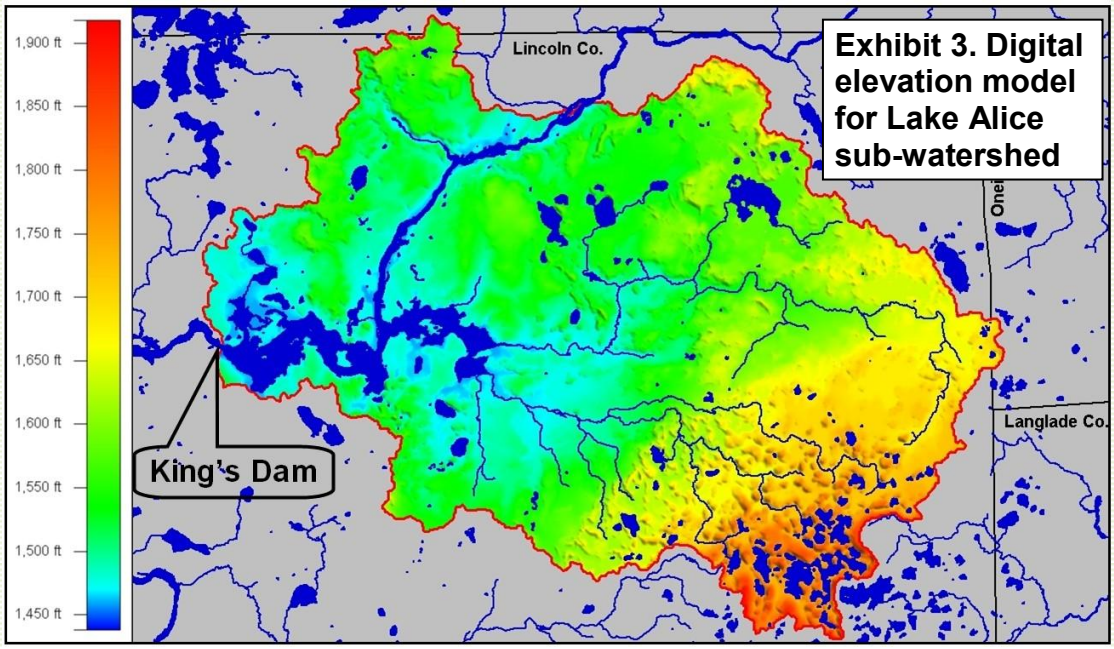


Exhibit 3. Digital elevation model for Lake Alice sub-watershed

Both the total Lake Alice watershed and the Lake Alice sub-watershed are comprised of soils with good infiltration capacity. The general land cover types in both the Lake Alice sub-watershed and the total Lake Alice watershed are quite similar. The land cover types in the sub-watershed include forest (57% of surface area), water and wetland (31%), agriculture (6%), low density residential (4%), and grassland-pasture (2%).

Part 2. Aquatic Plant Management History

Prior to 2014 when hand-pulling of Eurasian watermilfoil took place, no targeted plant management activity had ever taken place in Lake Alice. No nuisance plant issues or aquatic invasive plants have required control action. Although curly-leaf pondweed was confirmed in Lake Alice by the 2010 aquatic plant survey, its population size and distribution has not

warranted targeted plant control actions. The curly-leaf pondweed population in Lake Alice has been the subject of investigation under an Early Detection-Rapid Response grant and is reported in Appendix 4. In 2014, Eurasian water-milfoil was discovered in Lake Alice. Monitoring of this population and hand-pulling of individual plants has been conducted during 2014, 2015, and 2016 under a separate Early Detection-Rapid Response grant. A report on Lake Alice Eurasian water-milfoil is presented in Appendix 4. It is the hope of the Lake Alice Association and the intent of actions recommended in this plan that large-scale plant management remains unnecessary for this beautiful Wisconsin water body.

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 clearcut. Similarly, a lake's biodiversity in part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many aquatic 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. The fairly low water clarity in Lake Alice does not allow rooted aquatic plants in deep water (in fact, the maximum depth of rooted vegetation determined in our 2010 and 2015 surveys were seven and eleven feet, respectively). 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 or gravel. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline conditions and some prefer more acidic water.

As mentioned earlier, AIS can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even native plants can reach nuisance levels with respect to certain kinds of human recreation.

Prior to the first formal point-intercept aquatic plant survey conducted in 2010, we are aware of no formal surveys or studies of aquatic plants on Lake Alice. A few records regarding aquatic plants in Lake Alice do exist. These are described Adaptive Management Plan and summarized here. Laura Herman (WDNR) visited Lake Alice on two occasions. In 1997, Herman visited the vicinity of Surewood Forest Campground pier area. She recorded burreed, fine-leaf pondweed, clasping leaf pondweed, coontail, large-leaf pondweed, *Vallisneria*, and *Sagiteria*. In 2001 at a site near Deer Run Road, Herman observed pickerelweed, white water lily, yellow water lily, fern pondweed, floating leaf pondweed, great bladderwort, coontail, and *Calla*. In 1994, the WDNR (Jim Kreitlow, WDNR) identified algae in a sample taken from Lake Alice. This sample contained green algae (*Dichotomosiphon, Scendesmus quadricauda, Pandorina*, and *Golenkinia*) and diatoms (*Melosira granulate, Fragillaria, Gomphonema, Golenkinia*, and *Caloneis*).

Wild Rice is an important component of the Lake Alice ecosystem. The principal rice population is contained in the eastern component of Lake Alice contains, especially the area referred to as Green Meadow Flowage (where Green Meadow creek enters Lake Alice). Additional wild rice beds occur in the part of Lake Alice where the Wisconsin River enters. Appendix 3 provides additional detail on wild rice in Lake Alice.

White Water Associates has conducted two WDNR point-intercept aquatic plant surveys on Lake Alice (2010 and 2016). These formal surveys assessed the plant species composition on a grid of 878 points distributed evenly over Lake Alice. Using latitude-longitude coordinates and a handheld GPS unit, biologists navigated to the points and used a rake mounted on a pole or rope to sample plants. These were identified and recorded and input into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake. Future monitoring can identify and track changes in the plant community. In fact, having these data allow us to compare the plant community of 2010 with the plant community of 2016. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section (Part 5) we report the findings of the 2010 and 2016 point-intercept surveys. The supporting tables and figures are provided in Appendix 2.

Table 1 displays summary statistics for the 2010 and 2016 surveys. Tables 2 and 3 provide lists of the species encountered, including common and scientific name along with summarizing statistics for the 2010 and 2016, respectively. We recorded a total of twenty-nine species of aquatic plants in 2010 and thirty-four species in 2016. The total number of species is referred to as "richness," thus the species richness for Lake Alice in 2010 was 29. The number of species encountered at any given sample point ranged from 0 to 10, but only 66 sample points were found to have aquatic vegetation present in 2010 (68 in 2016). The actual number of species encountered at each of the vegetated sites is graphically displayed on Figures 1 (2010) and 14 (2016). Plant density is estimated by a three category "rake fullness" metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figures 2 (2010) and 15 (2016).

We determined the maximum depth of plant colonization was 7 feet in 2010 (see Figure 3 and Table 1) and eleven feet in 2016 (Figure 16 and Table 1). Rooted vegetation was found at 66 of the 211 sample sites with depth ≤7 feet (31.6% of the sites) in 2010 and 68 of 394 sites with depth ≤11 feet in 2016 (17.3%). These sites are displayed on Figures 4 and 17 for each year. 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. A comparison of Figures 4 and 5 (for the 2010 survey) and Figures 17 and 18 (for the 2016 survey) reveals that many of the sites with suitable depth but no plants had sandy substrate that likely did not provide suitable anchoring substrate and/or nutrients for plants.

Tables 2 and 3 provide information about the frequency of occurrence of the plant species encountered in Lake Alice in 2010 and 2016, respectively. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites ≤ the maximum depth of rooted vegetation. This frequency metric is standardized as a "relative frequency" (also shown in Tables 2 and 3) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake at sampling sites are graphically displayed in descending order on Figures 6 (2010) and 19 (2016). These graphs show a healthy distribution of aquatic plants in Lake Alice with several species being quite common (those on the left side of the graphs) and others being relatively rare (those on the right side of the graphs). Comparison of the 2010 and 2016 data further

shows remarkably little change in the plant community structure. This kind of stability is in part a result of the diversity of species represented in Lake Alice. To illustrate this stability with a few specific cases, consider the two most commonly encountered species in both surveys (slender waterweed and coontail). Coontail was found at 26 sites in 2010 and 22 sites in 2016. Slender waterweed was found at 31 sites in 2010 and 22 in 2016. Likewise, another fairly common species, fern pondweed, was found at 18 sites in 2010 and 16 sites in 2016. Among the least commonly encountered species are two aquatic invasive plant species: curly-leaf pondweed and Eurasian water-milfoil. Curly-leaf pondweed was documented at only a single point-intercept point in 2010 and 2016. Eurasian watermilfoil was not documented at all in the 2010 survey and found at three sites in 2016. As examples of individual species distributions we show occurrence of some of the most frequently and least frequently encountered plant species in Figures 8-13 and 21-27.

Species richness (total number of plants recorded at the lake) is a measure of species diversity, but it doesn't tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (richness is 10). In the first pond each of the ten species populations in comprised of 100 individuals. In the second pond, Species #1 has a population of 901 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 eveness in estimating diversity. The Simpson Diversity Index for the Lake Alice plant community was 0.91 in 2010 (Table 1) which indicates a diverse aquatic plant community (the maximum possible value in 1.0). The 2016 value (0.90) demonstrates an unchanged diversity with the plant community.

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake's plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake. Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environment (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 Lake Alice FQI (30.1 in 2010 and 31.8 in 2016) compares to other lakes and regions. The statewide medians for number of species, average conservatism value, and FQI are 13, 6, and 22.2, respectively. On a statewide basis, Lake Alice compares favorably to these values (in 2010, Lake Alice's native species count was 28 and it mean conservatism was 5.7). Nichols (1999) determined that there are four ecoregional-lake types groups in Wisconsin: (1) Northern Lakes and Forests lakes, (2) Northern Lakes and Forests flowages, (3) North Central Hardwoods and Southeastern Till Plain lakes and flowages, and (4) Driftless Area and Mississippi River Backwater lakes. Lake Alice is located in the Northern Lakes and Forests flowages group. Nichols (1999) found species numbers for the Northern Lakes and Forests flowages group were the highest of any of the four groups with a median value of 24. Lake Alice data is consistent with that find. The Lake Alice mean average conservatism (5.7) is also similar to Nichols (1999) findings for the median value for the Northern Lakes and Forests flowages group (6.2). Finally, the Lake Alice FQI (in both years) was somewhat higher than the median value for the Northern Lakes and Forests flowages group (28.3). These findings support the contention that the Lake Alice plant community is healthy and diverse.

In both the 2010 and 2016 aquatic plant surveys, we observed no aquatic plant species that would be considered a nuisance-level population density/distribution. Our surveys, however, did document the aquatic invasive plant species curly-leaf pondweed (*Potamogeton crispus*) in 2010 and 2016 and Eurasian water-milfoil in 2016. In addition, purple loosestrife (*Lythrum salicaria*) and yellow iris (*Iris pseudacorus*) have been observed on and near Lake Alice. The purple loosestrife is being treated with beetles. We recommend further monitoring for both the yellow iris and the purple loosestrife.

In 2011, 2012, and 2013, White Water Associates characterized the population density and distribution of curly-leaf pondweed in Lake Alice. During this period of time, the curly-leaf pondweed was restricted to the eastern part of Lake Alice and did not appreciably change in its area of coverage from one year to the next (159 acres in 2011, 170 acres in 2012, and 172 acres in 2013). From 2011 to 2012, the relative density in the curly-leaf pondweed beds along the northern and eastern shore increased from moderate to high density. No changes in

density were documented between 2012 and 2013. Appendix 4 provides illustrative maps and additional description of the curly-leaf pondweed population in Lake Alice.

During the same year that Eurasian water-milfoil was first documented in Lake Alice, White Water Associates staff characterized its distribution and began hand-pulling in an area of approximately 6 acres near Generator Island. A 1 acre area within that polygon had the most dense Eurasian water-milfoil. In 2014, 56 pounds (wet weight) was removed in a single bout. About 18 pounds were removed in two bouts in 2015. Three bouts in 2016 removed a total of 1,145 pounds of Eurasian water-milfoil. The 2016 point-intercept survey revealed two new areas where Eurasian water milfoil was present: (1) about 0.3 mile due east of Generator Island population and (2) about 0.3 mile south of Generator Island population. Appendix 5 provides maps and additional documentation for the monitoring and removal project.

The Lake Alice Association and its consultant (White Water Associates) have proceeded cautiously with respect to the presence of curly-leaf pondweed and Eurasian water-milfoil. As AIS, they warrant concern and watchful monitoring as to their distribution and population growth with the lake. No mechanical or chemical management has been employed for either species. In the case of Eurasian water-milfoil, hand-pulling has been implemented for the existing population. The most effective and natural defense against these AIS in this setting is the diverse community of native plants the currently exists in Lake Alice.

The WDNR's evaluation of years of Wisconsin data on the behavior of Eurasian water-milfoil populations and the use of herbicides to control these populations lends validation to the cautious approach adopted by the Lake Alice Association. In many instances, Eurasian water-milfoil does not "take over" a lake but seems to integrate as part of the existing plant community. Chemical treatments are costly, not 100% effective, and cause collateral damage to other plants and associated aquatic life (Nault 2016). The long-term effects of herbicides on the aquatic ecosystem are uncertain and unknown.

Part 4. Fish Community

The Lake Alice Adaptive Management Plan summarizes the Lake Alice fish community. Lake Alice is one of the better fisheries in the area and includes walleye, largemouth bass, smallmouth bass, northern pike, muskellunge, bluegill, black crappie, and yellow perch. The WDNR indicates it displays good populations of all fish present. A healthy distribution of fish sizes also exists. No non-native fish species are known to be present, except for Channel Catfish which were introduced by the WDNR (see Part 8).

Part 5. Water Quality and Trophic Status

According to the WDNR, the hydrologic lake type for Lake Alice is a "drainage lake" and its waterbody type is "flowage." A limited set of Lake Alice data is available from the WDNR Self-Help Monitoring Program database. Sechhi transparencies, Chlorophyll "a", and total phosphorus all indicate that Lake Alice should be classified as "eutrophic" (Shaw *et al.* 2002). The Carlson's Trophic State Index also indicates an enriched lake. Eutrophic lakes typically have high nutrients, high productivity, and support large biomass of plants and animals. Eutrophic lakes host high densities of aquatic plants and are prone to algal blooms. Many experience dissolved oxygen depletion. Secchi depth for Lake Alice averages around four feet. During the summer of 2010, White Water scientists collected Lake Alice water for analysis. The resulting data support the conclusion that Lake Alice is a eutrophic lake.

The shoreline development index (the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake) for Lake Alice is 5.2. This high number indicates that the lake has a large area of potentially productive littoral zone habitat (shallow water habitat). This translates as potentially good habitat for aquatic plants, fish species, and other aquatic animals present in the Lake Alice ecosystem.

Part 6. Water Use

Lake Alice is an important resource used by the public for recreation. There are seven public access sites with a total of forty-one parking spaces. A portage has been installed and maintained around King's Dam to facilitate canoe and kayak enthusiasts in getting around the dam. There are twelve daily rental and one-hundred yearly rental campsites available around Lake Alice. Public access for fishing from shore is available at the ends of township roads and at several points along Hwy D and Echo Valley Road. Public access for shore fishing is also available on the King's Dam property (except in the immediate vicinity of the dam). Lincoln County owns several small islands on Lake Alice that are used for camping and waterfowl hunting. Up the river from Lake Alice, The State of Wisconsin owns 1,785 acres of land available for public use including hunting and fishing. Some of the land is only accessible by water route from public access sites on Lake Alice. Fishing tournaments are a fairly frequent occurrence on Lake Alice. In recent years, the Lake Alice Association (LAA) has organized around a common concern for the long-term care of Lake Alice. This has begun a very hopeful chapter in the history of Lake Alice. The LAA has actively become involved with all aspects of Lake Alice resources and with educating those that live near and use the lake.

Part 7. Riparian Area

The Lake Alice Adaptive Management Plan describes the extensive and diverse riparian area that encompasses the lake. Lake Alice has about 27 miles of shoreline and associated riparian area (about 5.4 miles of this shoreline results from islands). Healthy riparian areas provide numerous important functions and values to Lake Alice. Educating riparian owners around Lake Alice as to the value of riparian areas is important to the maintenance of these critical areas.

Part 8. Wildlife

The Lake Alice Adaptive Management Plan characterizes the wildlife in the vicinity of Lake Alice. In 2010, 2013, and 2014, the Lake Alice Association conducted a frog/toad surveys on wetlands in the vicinity of Lake Alice and the results are reported in the Adaptive Management Plan.

There is a 2002 report to WDNR (reporter unknown) of rusty crayfish in Lake Alice. It is not known to have had detrimental impact. No follow up surveys or studies have occurred for this AIS.

Two other aquatic invaders, spiny waterfleas and zebra mussels, have been surveyed in Lake Alice, but have not been documented. The Lake Alice Adaptive Management Plan provides details of these efforts.

Channel catfish were introduced to Lake Alice by the WDNR in 1989, 1990, and 1991. Two adult catfish were recorded during a 2003 WDNR fish survey and assumed to be from the original plantings. The fish is not apparently reproducing in Lake Alice. Common carp and white bass have not been found in the Lake Alice system.

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, the Lake Alice Association has represented the population of Lake Alice stakeholders. In the future, additional stakeholders and interested citizens will be invited to participate as the plan is refined in order to broaden input. No controversial direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan.

CHAPTER 5 Recommendations

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

> ***It is the goal of the Lake Alice Association to maintain a healthy Lake Alice ecosystem by (1) monitoring the native plant community and existing aquatic invasive plant populations, (2) guarding against establishment of additional aquatic invasive species (AIS), and (3) monitoring and educating Lake Alice recreationists and riparian owners.***

Lake Alice is a healthy and diverse ecosystem. Nevertheless, many forces threaten the quality of the lake and the Lake Alice Association feels a great responsibility to minimize the threats. In this section, we outline a set of actions and related management objectives that will actively engage Lake Alice stewards in the process of lake stewardship.

The actions are presented in tabular form. Each "action" consists of a set of four statements: (1) a declarative "action" statement the 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 (e.g., not yet started, ongoing, or completed).

Recommended Actions for the Lake Alice Aquatic Plant Management Plan
Action: Monitor Lake Alice water quality.
Objective: Continue with collection and analysis of Lake Alice water quality parameters to detect trends in parameters such as nutrients, chlorophyll "a", and water clarity.
Monitoring: The Lake Alice Association oversees activity and maintains data.
Status: Ongoing.

Recommended Actions for the Lake Alice Aquatic Plant Management Plan
Action: Conduct a qualitative near-shore habitat inventory of Lake Alice. ***Objective:*** To characterize, assess, & photograph the near-shore habitat (including plants, level of disturbance, amount of natural shoreline, and impacted areas). ***Monitoring:*** The Lake Alice Association oversees activity and maintains data. ***Status:*** Completed as part of Phase 3.
Action: Adopt the Aquatic Plant Management Plan, 2nd Edition. ***Objective:*** To provide foundation for long-term native plant community conservation and stewardship and to be prepared for response to AIS introductions. ***Monitoring:*** The Lake Alice Association oversees activity and maintains plan. ***Status:*** Planned for 2017.
Action: Form an Aquatic Invasive Species Rapid Response Team (see Chapter 7) ***Objective:*** To be prepared for AIS discovery and efficient response. ***Monitoring:*** The Lake Alice Association coordinates activity. ***Status:*** Planned for 2017.
Action: Conduct quantitative plant survey every five years using P-I Methodology. ***Objective:*** To watch for changes in native species diversity, floristic quality, plant abundance, and plant distribution and check for the occurrence of aquatic invasive plants. ***Monitoring:*** Lake Alice Association oversees and maintains data; copies to WDNR. ***Status:*** Anticipated in 2021.
Action: Request WNDR conduct "Sensitive Area Designation Assessment" on Lake Alice. ***Objective:*** Identify and protect sensitive and special habitat areas and conservancy areas in the Lake Alice ecosystem. ***Monitoring:*** Lake Alice Association oversees and develops further actions if necessary. ***Status:*** Anticipated to make request to WDNR in 2018.

Recommended Actions for the Lake Alice Aquatic Plant Management Plan

Action: Develop a Citizen Lake Monitoring Network to monitor for invasive species on Lake Alice and develop strategies including education and monitoring activities (see http://www.uwsp.edu/cnr/uwexlakes/clmn for additional ideas).

Objective: To create a trained volunteer corps to monitor aquatic invasive species and to educate recreational users regarding AIS and special features of Lake Alice

Monitoring: The Lake Alice Association oversees activity and records instances of possible or actual introductions of aquatic invasives.

Status: Anticipated to begin in 2018.

Action: Continue the "Clean Boats, Clean Waters" program in a form that will engage and enlist volunteers.

Objective: To monitor recreational watercraft traffic as it comes in and out of the lake checking for possible introduction of AIS on boats, engines, and trailers and to educate recreational users regarding AIS and special features of Lake Alice.

Monitoring: The Lake Alice Association oversees activity and records instances of possible or actual introductions of aquatic invasives.

Status: Ongoing

Action: Create an education plan for the Lake Alice Association members and other Lake Alice stakeholders that will address issues of healthy aquatic and riparian plant communities.

Objective: To educate Lake Alice 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; (4) nutrient sources to Lake Alice 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;

Monitoring: Lake Alice Association oversees activity and assesses effectiveness.

Status: Ongoing.

Recommended Actions for the Lake Alice Aquatic Plant Management Plan
Action: Identify, photograph, and describe areas of Lake Alice riparian area and shoreline that might be candidates for rehabilitation or restoration. ***Objective:*** To inventory and describe areas of Lake Alice riparian area and shoreline and plan possible rehabilitation or restoration actions. ***Monitoring:*** The Lake Alice Association oversees activity and maintains data. ***Status:*** Progress toward this goal was made in Phase 3 with shoreland evaluation and photographic documentation.
Action: Manage and increase Lake Alice Stakeholders Mailing List. ***Objective:*** To increase ability to communicate with Lake Alice riparian owners and other stakeholders. To be used in delivering education materials and fostering lake stewardship and volunteerism. ***Monitoring:*** The Lake Alice Association oversees activity and maintains data. ***Status:*** Ongoing
Action: Investigate the extent of the Curly-leaf Pondweed population in Lake Alice. ***Objective:*** To understand the size and distribution of the population and determine appropriate management response(s) to this AIS species in Lake Alice. ***Monitoring:*** The Lake Alice Association oversees activity and maintains data. ***Status:*** Reported in this APMP and ongoing monitoring..
Action: Participate in the Mable Lake Association lake stewardship program. ***Objective:*** To provide guidance to Mable Lake Association as it addresses lake management issues, including a newly discovered AIS population (Eurasian watermilfoil) in Mable Lake (located just ¼ mile north of Lake Alice). ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Completed.

Recommended Actions for the Lake Alice Aquatic Plant Management Plan
Action: Work with Edgewater Golf Course to create a better buffer zone. ***Objective:*** Provide protection against runoff of nutrients into this Lake Alice bay and to convey information to the public about the importance of buffer zones along lakes. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Anticipated in 2018.
Action: Monitor the Lake Alice watershed for purple loosestrife. ***Objective:*** Identify purple loosestrife populations for treatment with beetles. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Ongoing.
Action: Continue biological control of purple loosestrife colonies in vicinity of Lake Alice. ***Objective:*** Reduce size and vigor of existing and bew purple loosestrife colonies. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Ongoing.
Action: Monitor Lake Alice shoreland for yellow iris. ***Objective:*** Identify locations and colony sizes for purposes of control actions. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** 2018.
Action: Monitor Lake Alice population of Eurasian water-milfoil. ***Objective:*** To understand the size and distribution of the population. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Ongoing.
Action: Continue hand-pulling Lake Alice population of Eurasian water-milfoil. ***Objective:*** To keep population in check and minimize dispersal. ***Monitoring:*** The Lake Alice Association oversees activity. ***Status:*** Pending additional funding for this activity.

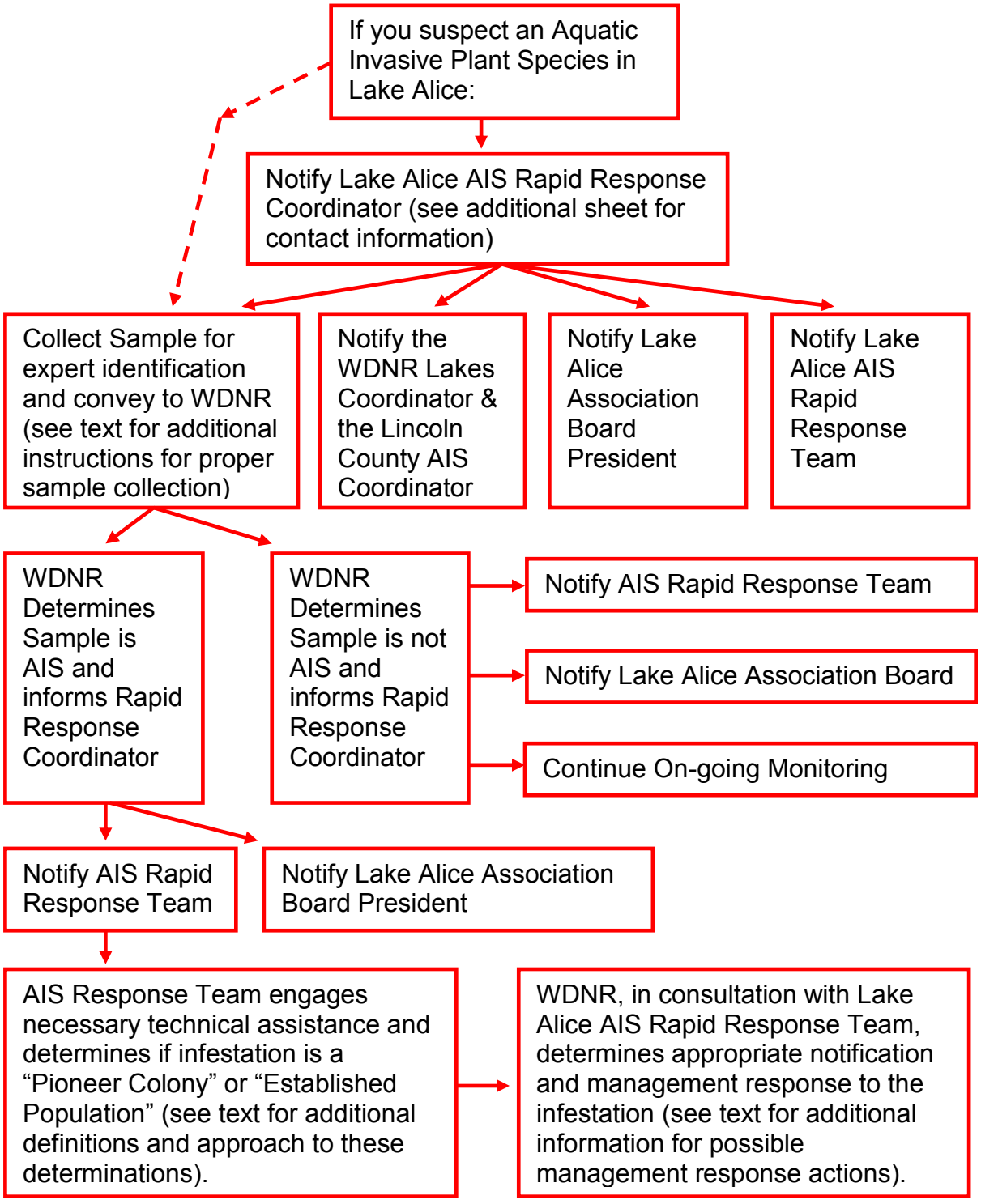
CHAPTER 6 Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. There is likelihood of accidental introduction of AIS to Lake Alice through conveyance of life stages by boats, trailers, and other vectors. It is important for the Lake Alice Association to be prepared for the contingency of an aquatic invasive plant species introduction to the lake. This final chapter of the aquatic plant management plan outlines the contingency plan for rapid response to AIS in Lake Alice.

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 is a systematic tool by which the process can be navigated. One of the actions outlined in the previous chapter is to establish an ***Aquatic Invasive Species Rapid Response Team***. This team and its coordinator are integral to the management process. It is beneficial 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 4 (next page) provides a flowchart for 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.

Exhibit 4. Lake Alice Aquatic Invasive Plant Species Rapid Response



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

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. 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 should be contacted where necessary. The WDNR will determine if further baseline plant survey is required. 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 Alice Association President, local WDNR warden, local government official(s), other experts, chemical treatment contractors, and consultant(s).

Appendix 1
Literature Cited

LITERATURE CITED

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Appendix 2
Tables and Figures

Table 1. Summary statistics for 2010 and 2016 Lake Alice point-intercept aquatic plant surveys.

Summary Statistic	2010 Value	2016 Value	Notes
Total number of sites on grid	878	878	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	679	712	Total number of sites where boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	66	68	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	211	394	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	31.6	17.26	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.91	0.90	An 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.)	7.00	11.00	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	46	23	
Number of sites sampled with rake on pole	254	432	
Average number of all species per site (shallower than max depth)	0.84	0.34	
Average number of all species per site (vegetated sites only)	2.68	1.96	
Average number of native species per site (shallower than max depth)	0.83	0.33	
Average number of native species per site (vegetated sites only)	2.67	1.93	
Species Richness	23	27	Total number of species collected at sample points. Does not include visual sightings.
Species Richness (including visuals)	29	34	Total number of species collected including visual sightings.
Floristic Quality Index (FQI)	30.1	31.8	An assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions.

Table 2. Plant species recorded and distribution statistics for the 2010 Lake Alice 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
Slender waterweed	*Elodea nuttallii*	14.69	46.97	17.51	31	32	1.06
Coontail	*Ceratophyllum demersum*	12.32	39.39	14.69	26	33	1.38
Fern pondweed	*Potamogeton robbinsii*	8.53	27.27	10.17	18	19	1.22
Flat-stem pondweed	*Potamogeton zosteriformis*	8.53	27.27	10.17	18	30	1.00
Wild celery	*Vallisneria americana*	7.11	22.73	8.47	15	22	1.07
Whorled water-milfoil	*Myriophyllum verticillatum*	4.74	15.15	5.65	10	23	1.00
Slender naiad	*Najas flexilis*	3.32	10.61	3.95	7	7	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	3.32	10.61	3.95	7	9	1.00
Small duckweed	*Lemna minor*	2.84	9.09	3.39	6	11	1.00
Forked duckweed	*Lemna trisulca*	1.90	6.06	2.26	4	4	1.00
Nitella	*Nitella* sp.	1.90	6.06	2.26	4	4	1.00
Spatterdock	*Nuphar variegata*	1.90	6.06	2.26	4	17	1.00
White water lily	*Nymphaea odorata*	1.90	6.06	2.26	4	25	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	1.90	6.06	2.26	4	10	1.00
Small pondweed	*Potamogeton pusillus*	1.90	6.06	2.26	4	4	1.00
Water marigold	*Bidens beckii* (formerly *Megalodonta*)	1.42	4.55	1.69	3	5	1.00
Water star-grass	*Heteranthera dubia*	1.42	4.55	1.69	3	7	1.00
Watershield	*Brasenia schreberi*	0.95	3.03	1.13	2	5	1.00
White-stem pondweed	*Potamogeton praelongus*	0.95	3.03	1.13	2	4	1.00
Spiral-fruited pondweed	*Potamogeton spirillus*	0.95	3.03	1.13	2	2	1.00
Curly-leaf pondweed	*Potamogeton crispus*	0.47	1.52	0.56	1	1	1.00
Floating-leaf pondweed	*Potamogeton natans*	0.47	1.52	0.56	1	3	1.00
Short-stemmed bur-reed	*Sparganium emersum*	0.47	1.52	0.56	1	7	1.00

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

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
Pickerelweed	*Pontederia cordata*				Visual	5	
Cattail	*Typha* sp.				Visual	3	
Common bladderwort	*Utricularia vulgaris*				Visual	3	
Southern wild rice	*Zizania aquatica*				Visual	3	
Creeping spikerush	*Eleocharis palustris*				Visual	1	
Hardstem bulrush	*Schoenoplectus acutus*				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 3. Plant species recorded and distribution statistics for the 2016 Lake Alice 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
Coontail	*Ceratophyllum demersum*	5.58	32.35	16.54	22	43	1.09
Slender waterweed	*Elodea nuttallii*	5.58	32.35	16.54	22	23	1.09
Wild celery	*Vallisneria americana*	4.31	25.00	12.78	17	30	1.00
Fern pondweed	*Potamogeton robbinsii*	4.06	23.53	12.03	16	21	1.13
Small pondweed	*Potamogeton pusillus*	2.03	11.76	6.02	8	11	1.00
Slender naiad	*Najas flexilis*	1.27	7.35	3.76	5	8	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	1.27	7.35	3.76	5	26	1.00
White water lily	*Nymphaea odorata*	1.02	5.88	3.01	4	37	1.00
Eurasian water milfoil*	*Myriophyllum spicatum*	0.76	4.41	2.26	3	15	1.67
Water marigold	*Bidens beckii (formerly Megalodonta)*	0.76	4.41	2.26	3	4	1.00
Nitella	*Nitella sp.*	0.76	4.41	2.26	3	3	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	0.76	4.41	2.26	3	15	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	0.76	4.41	2.26	3	14	1.00
Common bladderwort	*Utricularia vulgaris*	0.76	4.41	2.26	3	6	1.00
Whorled water-milfoil	*Myriophyllum verticillatum*	0.51	2.94	1.50	2	10	1.00
Ribbon-leaf pondweed	*Potamogeton epihydrus*	0.51	2.94	1.50	2	8	1.00
White-stem pondweed	*Potamogeton praelongus*	0.51	2.94	1.50	2	6	1.00
Curly-leaf pondweed*	*Potamogeton crispus*	0.25	1.47	0.75	1	10	1.00
Watershield	*Brasenia schreberi*	0.25	1.47	0.75	1	5	1.00
Brook grass	*Catabrosa aquatica*	0.25	1.47	0.75	1	2	1.00
Common waterweed	*Elodea canadensis*	0.25	1.47	0.75	1	1	3.00
Small duckweed	*Lemna minor*	0.25	1.47	0.75	1	10	1.00
Spatterdock	*Nuphar variegata*	0.25	1.47	0.75	1	29	1.00
Berchtold's pondweed	*Potamogeton berchtoldii*	0.25	1.47	0.75	1	5	1.00
Bur-reed	*Sparganium sp.*	0.25	1.47	0.75	1	16	1.00
Large duckweed	*Spirodela polyrhiza*	0.25	1.47	0.75	1	16	1.00
Northern wild rice	*Zizania palustris*	0.25	1.47	0.75	1	4	1.00

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

Table 3. 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
Floating-leaf bur-reed	*Sparganium fluctuans*				Visual	5	
Pickerelweed	*Pontederia cordata*				Visual	4	
Floating-leaf pondweed	*Potamogeton natans*				Visual	4	
Water star-grass	*Heteranthera dubia*				Visual	1	
Forked duckweed	*Lemna trisulca*				Visual	1	
Spotted pondweed	*Potamogeton pulcher*				Visual	1	
Hardstem bulrush	*Schoenoplectus acutus*				Visual	1	
Broad-leaved cattail	*Typha latifolia*				Boat Survey		
Three-way sedge	*Dulichium arundinaceum*				Boat Survey		
Needle spikerush	*Eleocharis palustris*				Boat Survey		
Iris	*Iris sp.*				Boat Survey		
Yellow iris	*Iris pseudocorus*				Boat Survey		
Sessile-fruited arrowhead	*Sagittaria rigida*				Boat Survey		
Reed canary grass	*Phalaris arundinaea*				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.

Figure 1. Number of plant species recorded at Lake Alice sample sites (2010).

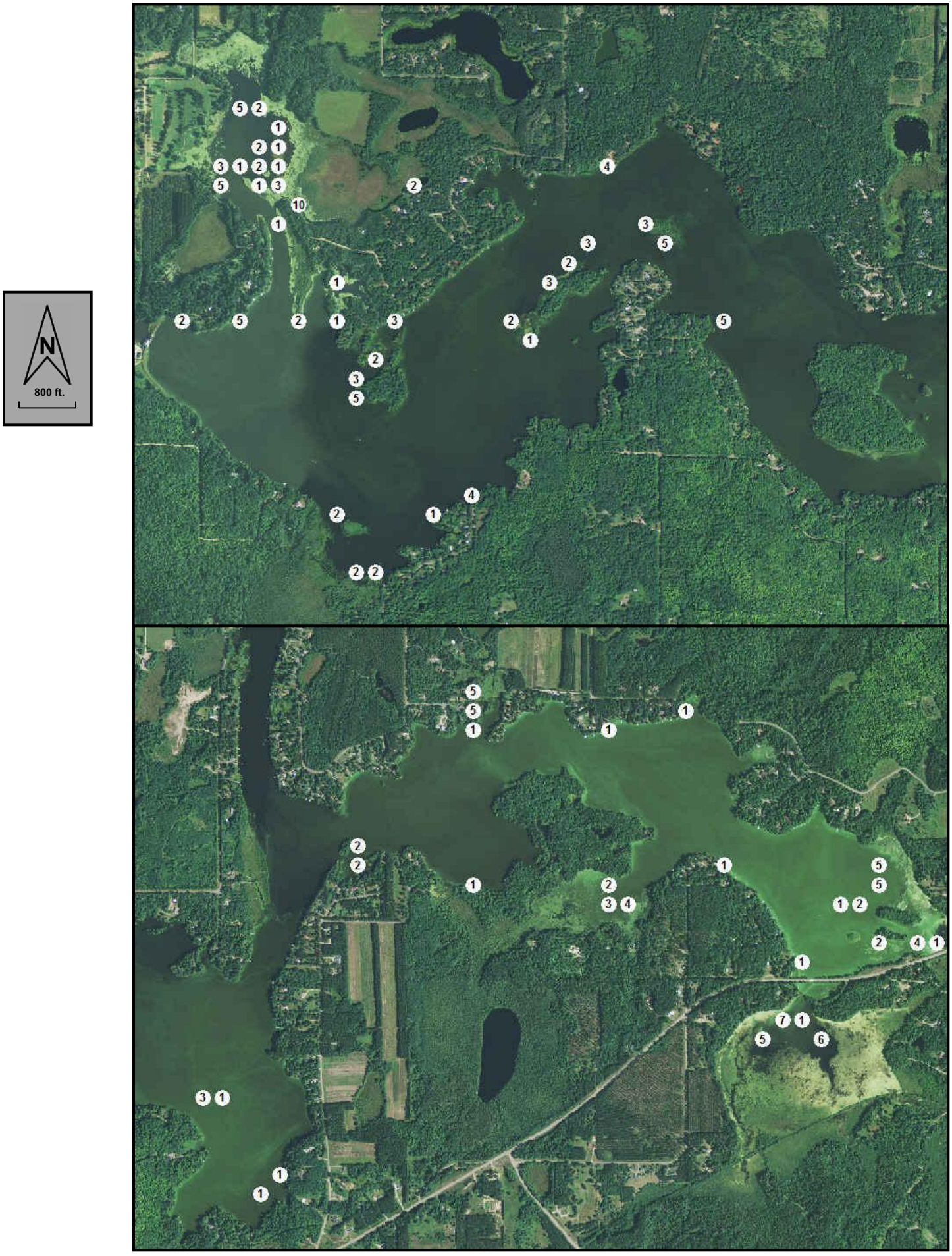


Figure 2. Rake fullness ratings for Lake Alice sample sites (2010).

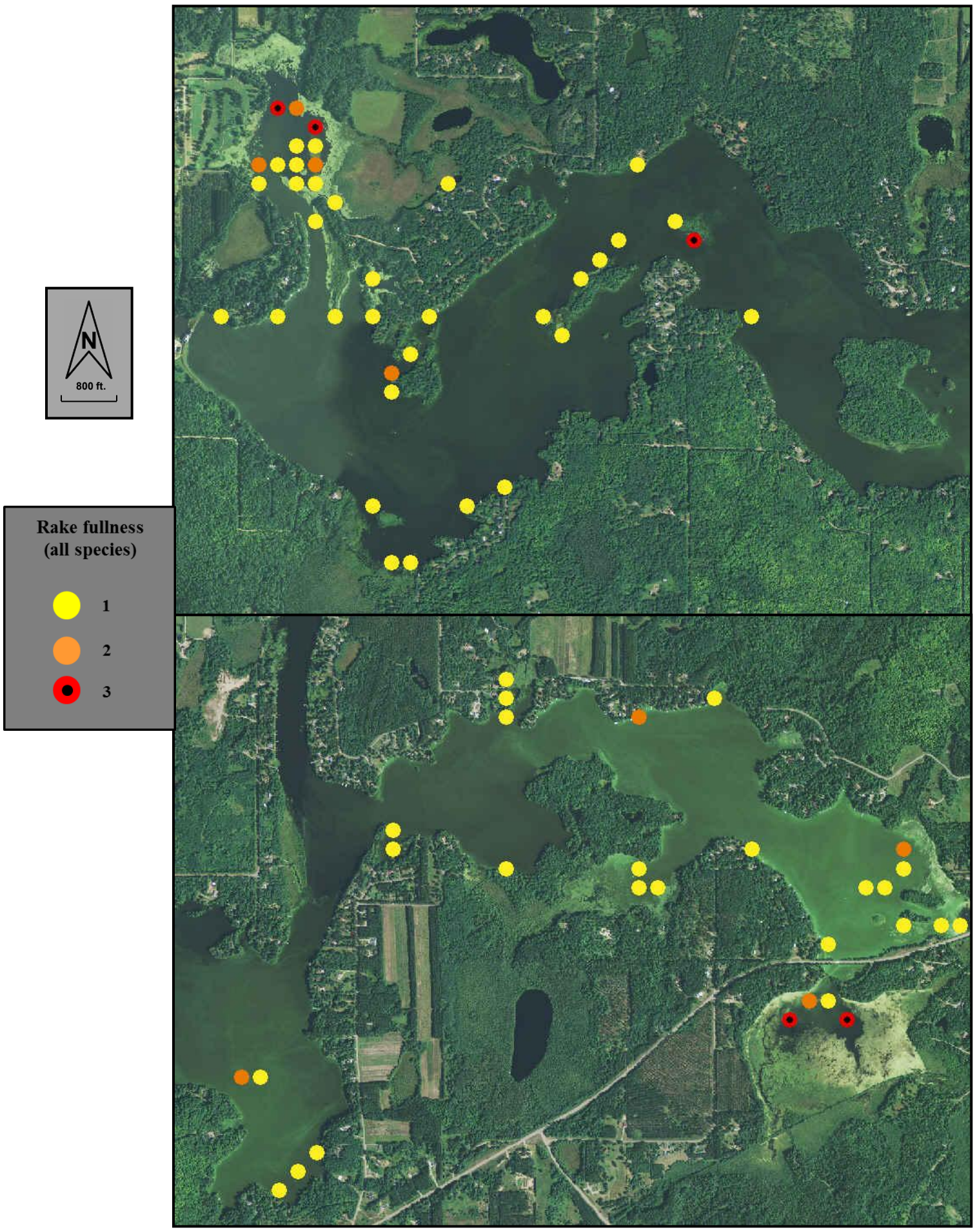


Figure 3. Maximum Depth of Plant Colonization in Lake Alice (2010).

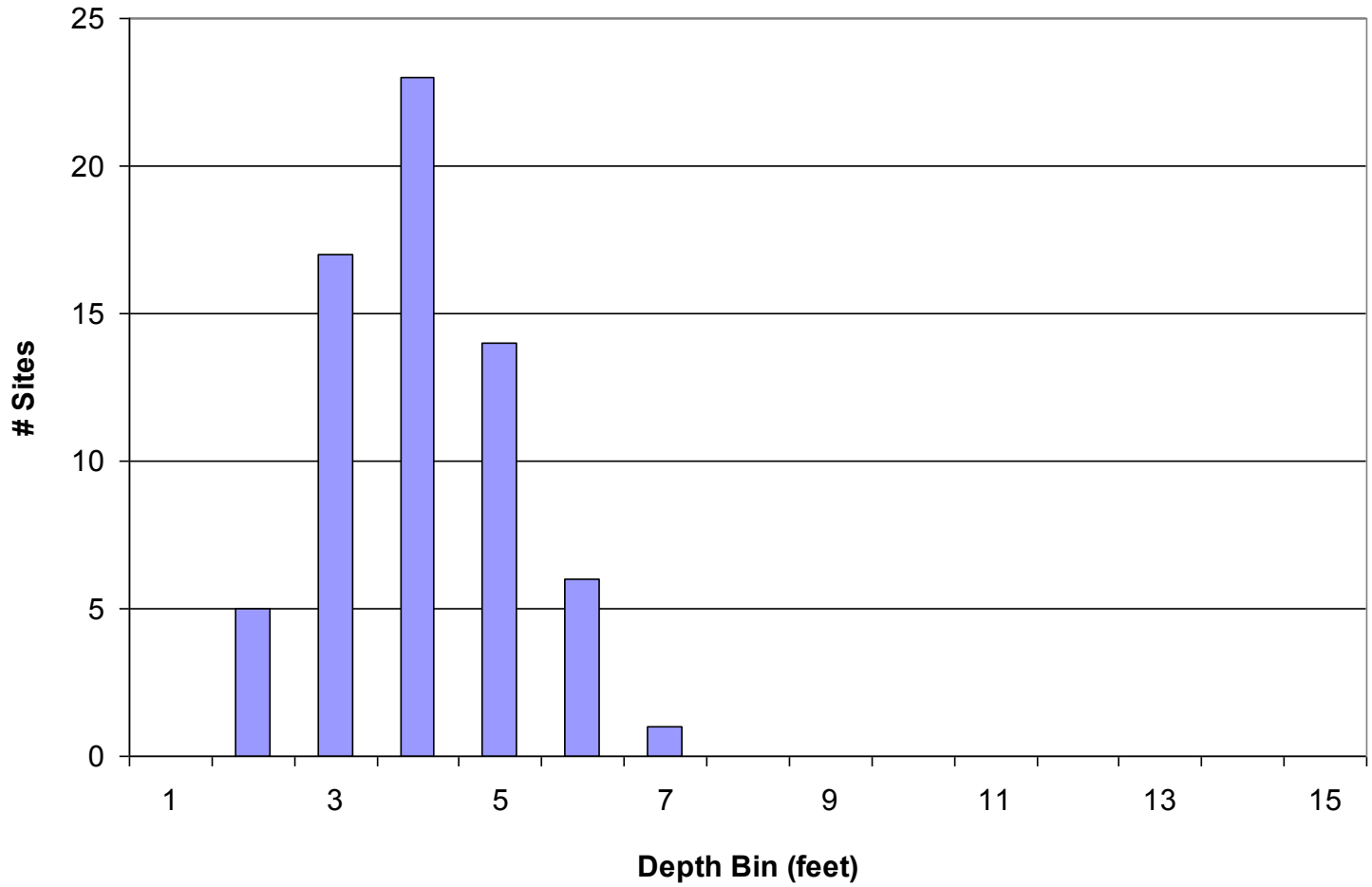


Figure 4. Lake Alice sample sites less than or equal to maximum depth of rooted vegetation (2010).

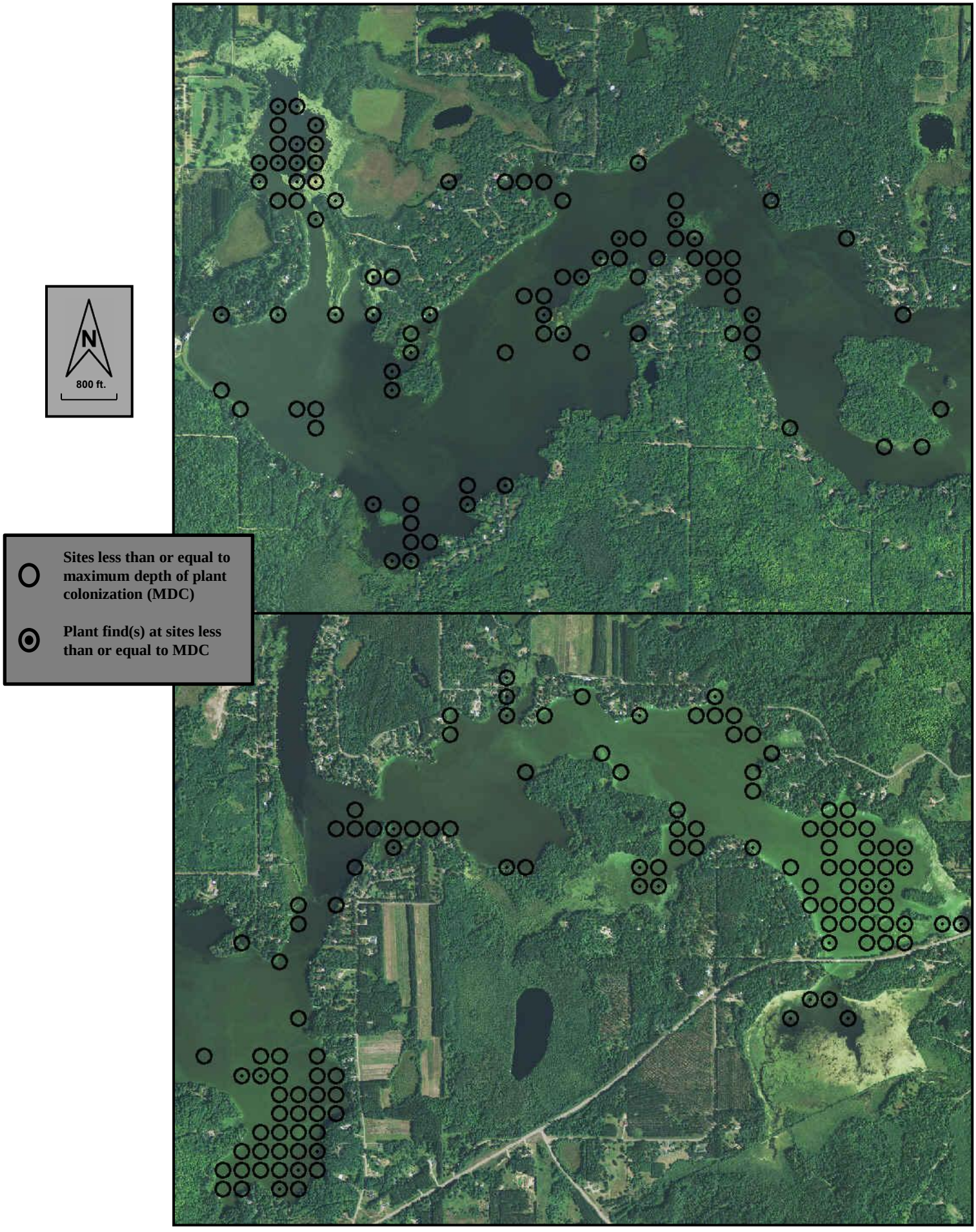


Figure 5. Lake Alice substrate encountered at sampling sites (2010).

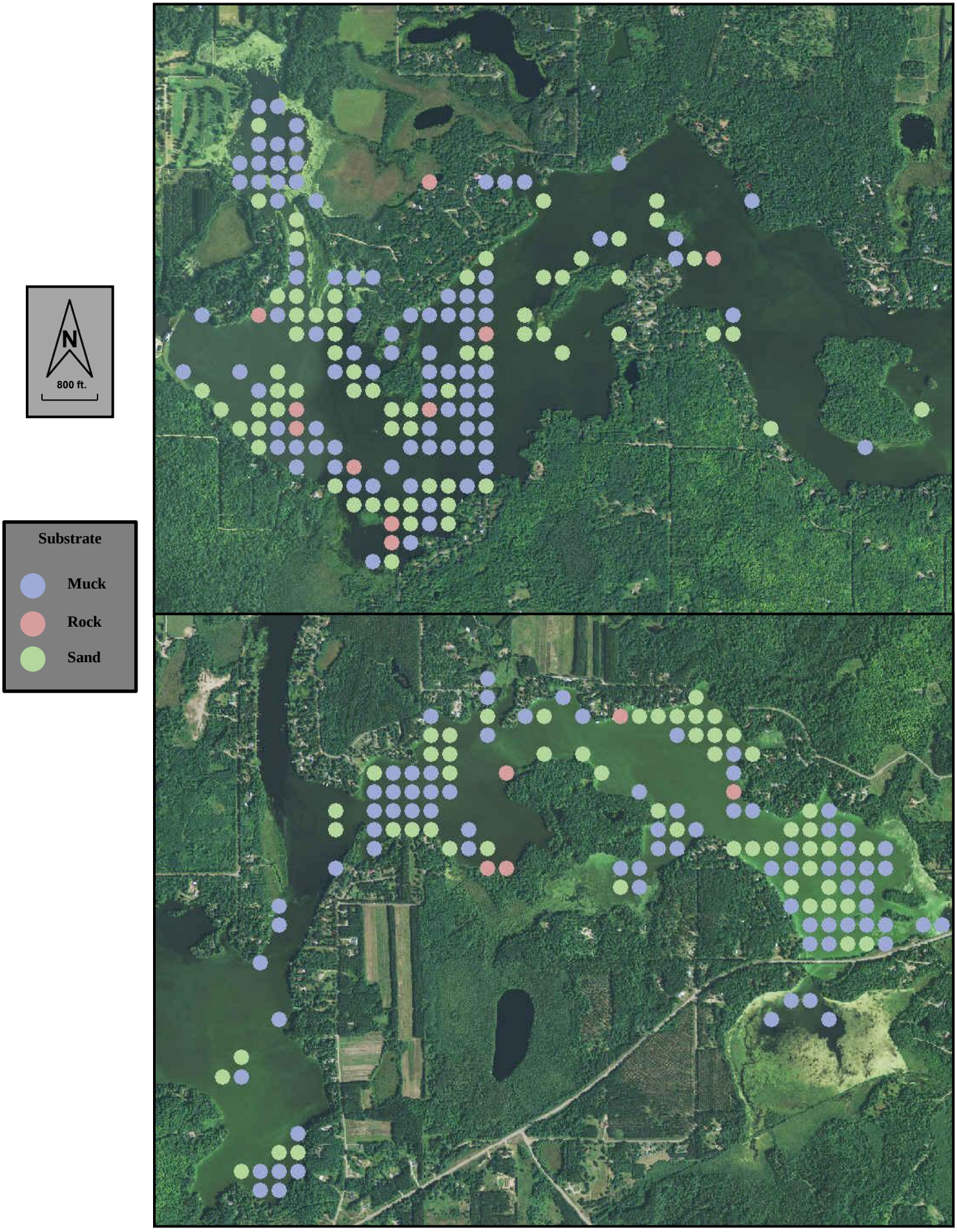


Figure 6. Lake Alice aquatic plant occurrences for 2010 point-intercept survey data.

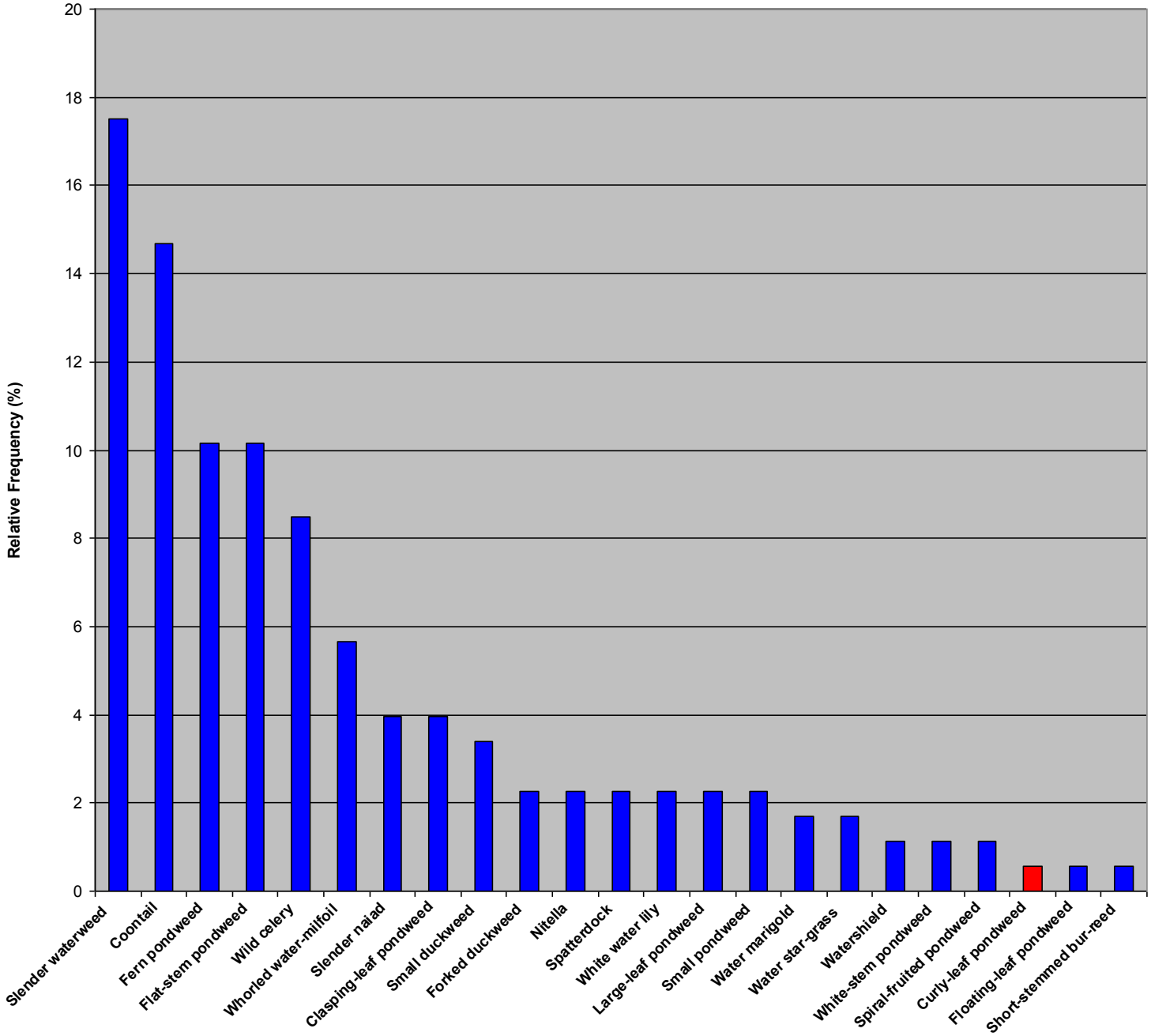


Figure 7. Lake Alice sampling sites with emergent and floating aquatic plants (2010).

Figure 8: Distribution of Elodea nuttallii (Slender waterweed), Lake Alice, 2010

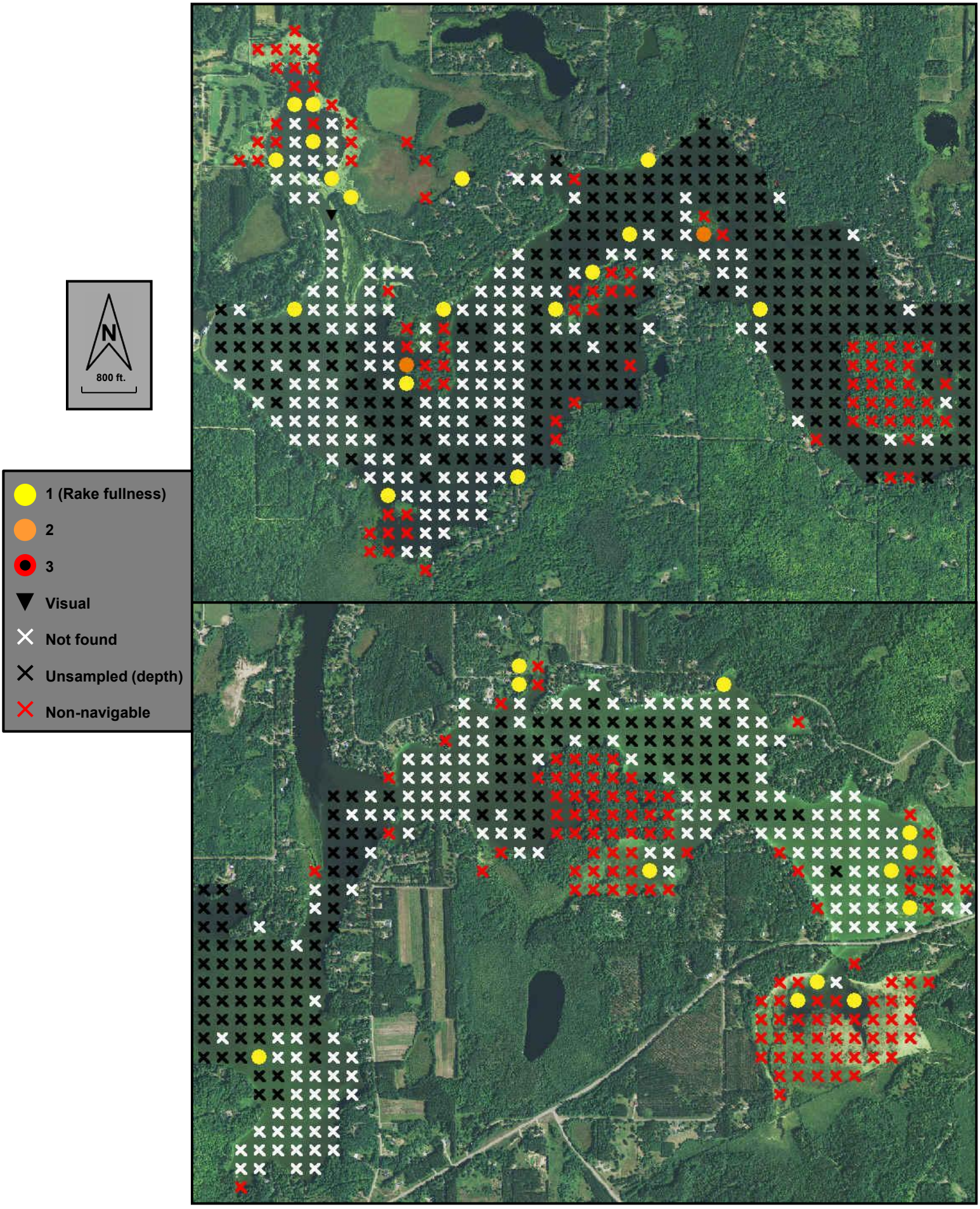


Figure 9: Distribution of Ceratophyllum demersum (Coontail), Lake Alice, 2010

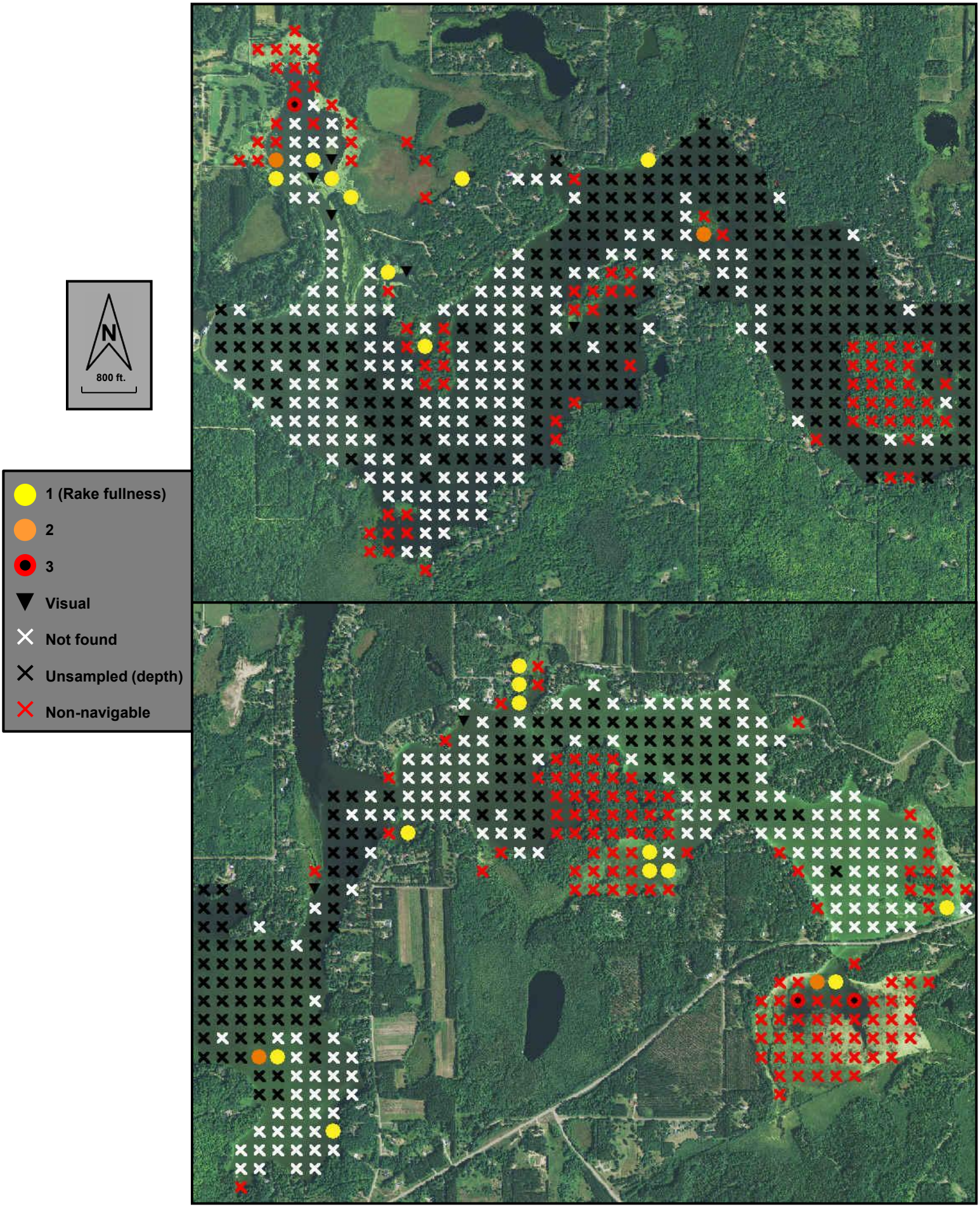


Figure 10: Distribution of Potamogeton robbinsii (Fern pondweed), Lake Alice, 2010

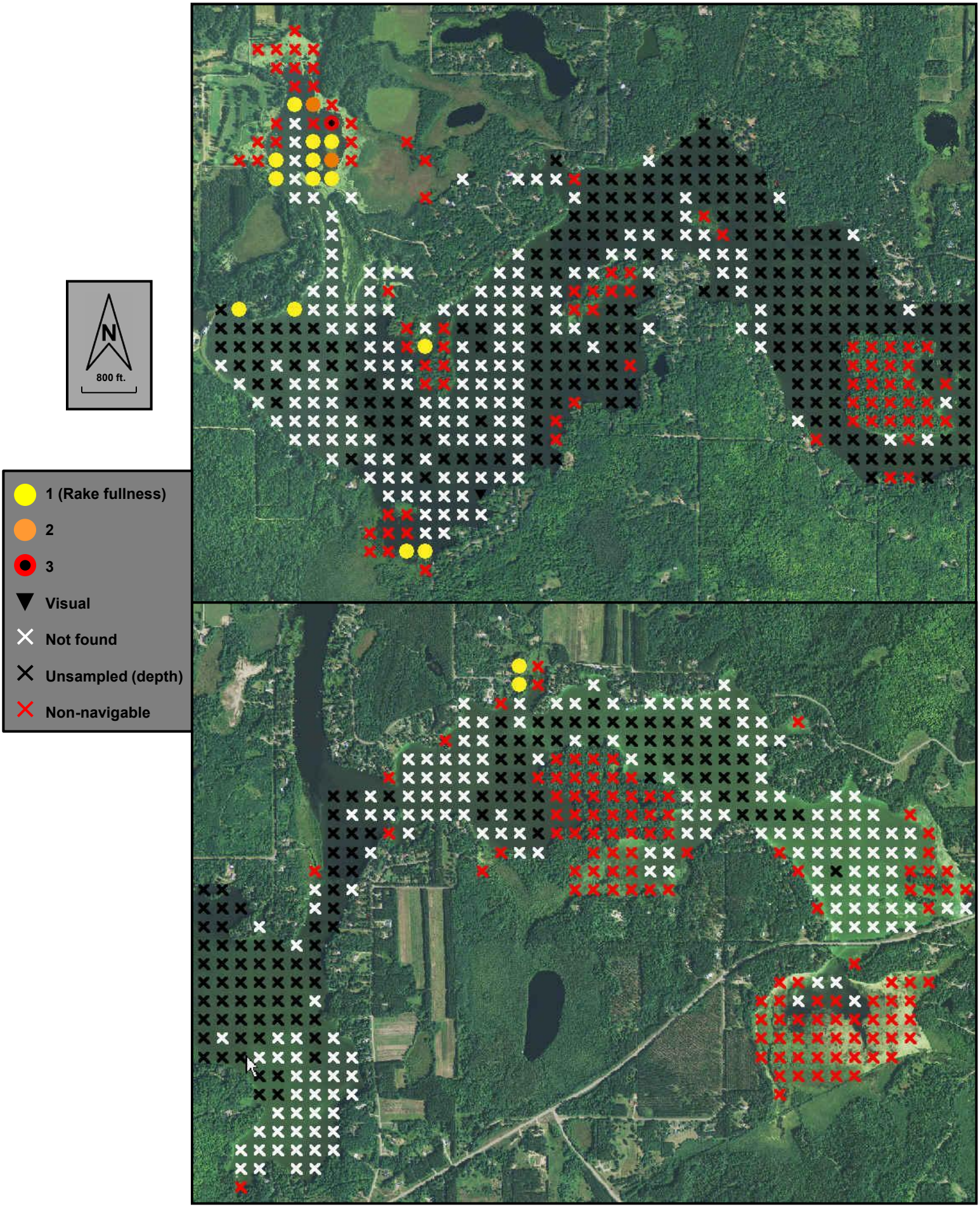


Figure 11: Distribution of Potamogeton zosteriformis (Flat-stem pondweed), Lake Alice, 2010

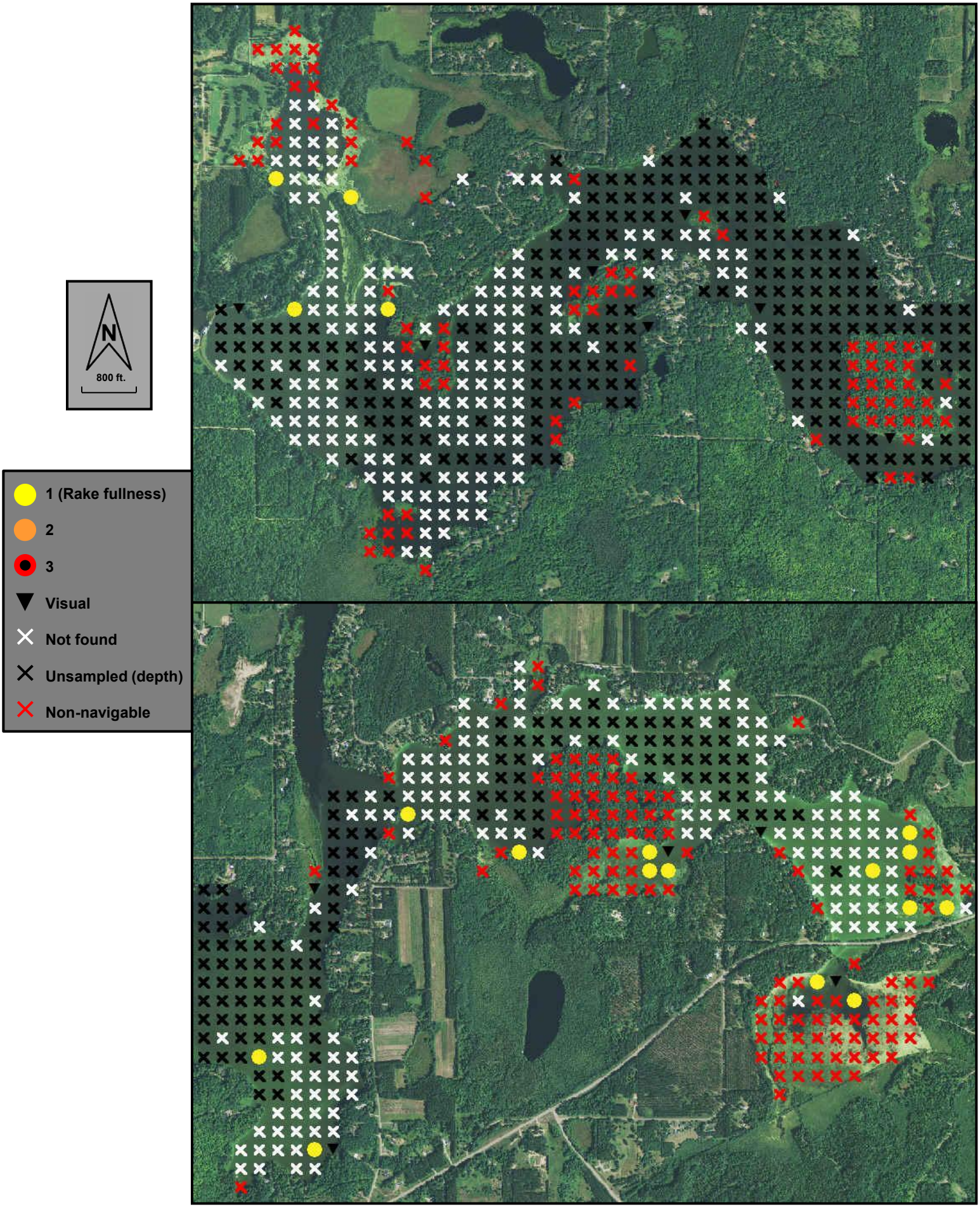


Figure 12: Distribution of Potamogeton praelongus (White-stem pondweed), Lake Alice, 2010

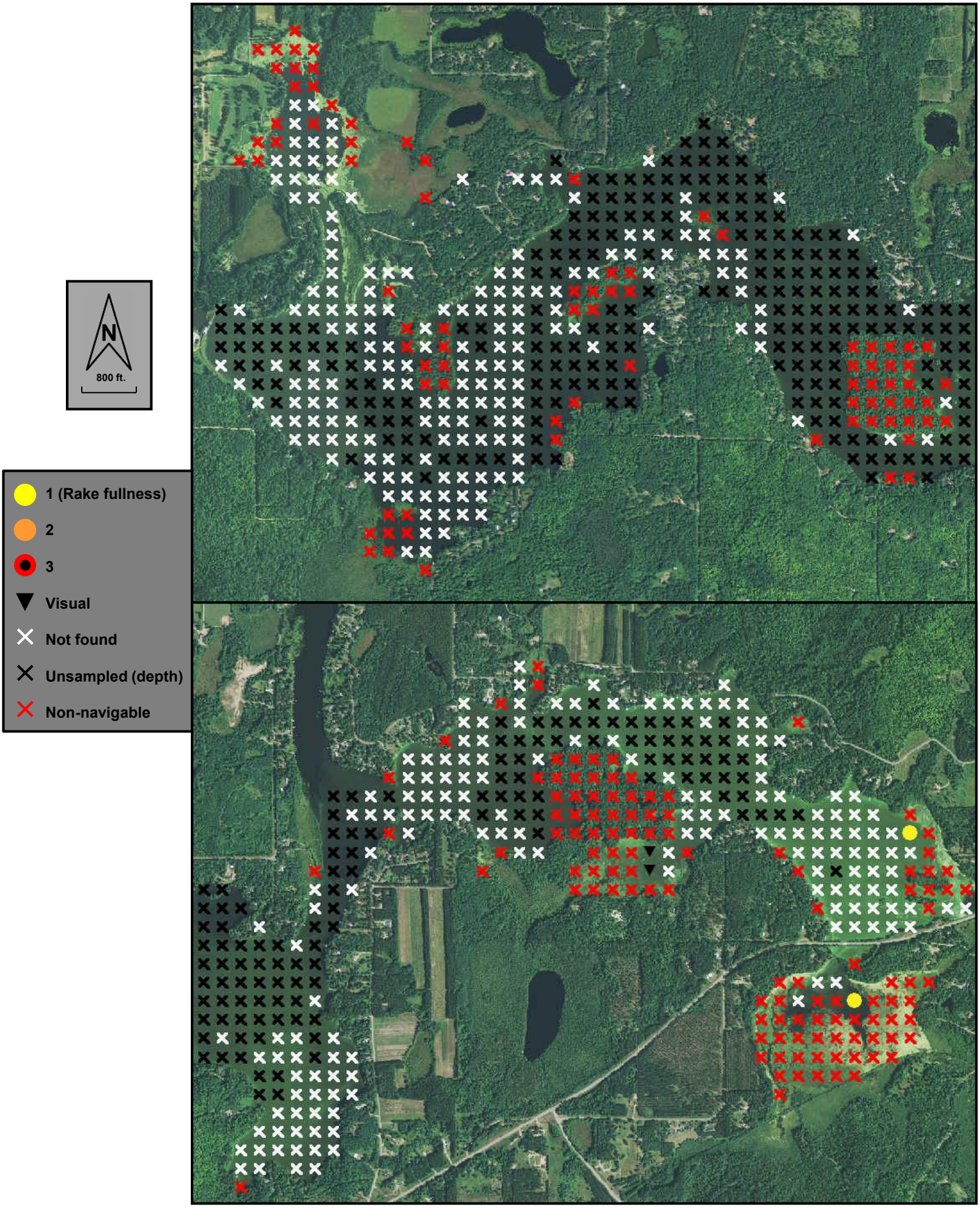


Figure 13: Distribution of Potamogeton crispus (Curly-leaf pondweed), Lake Alice, 2010

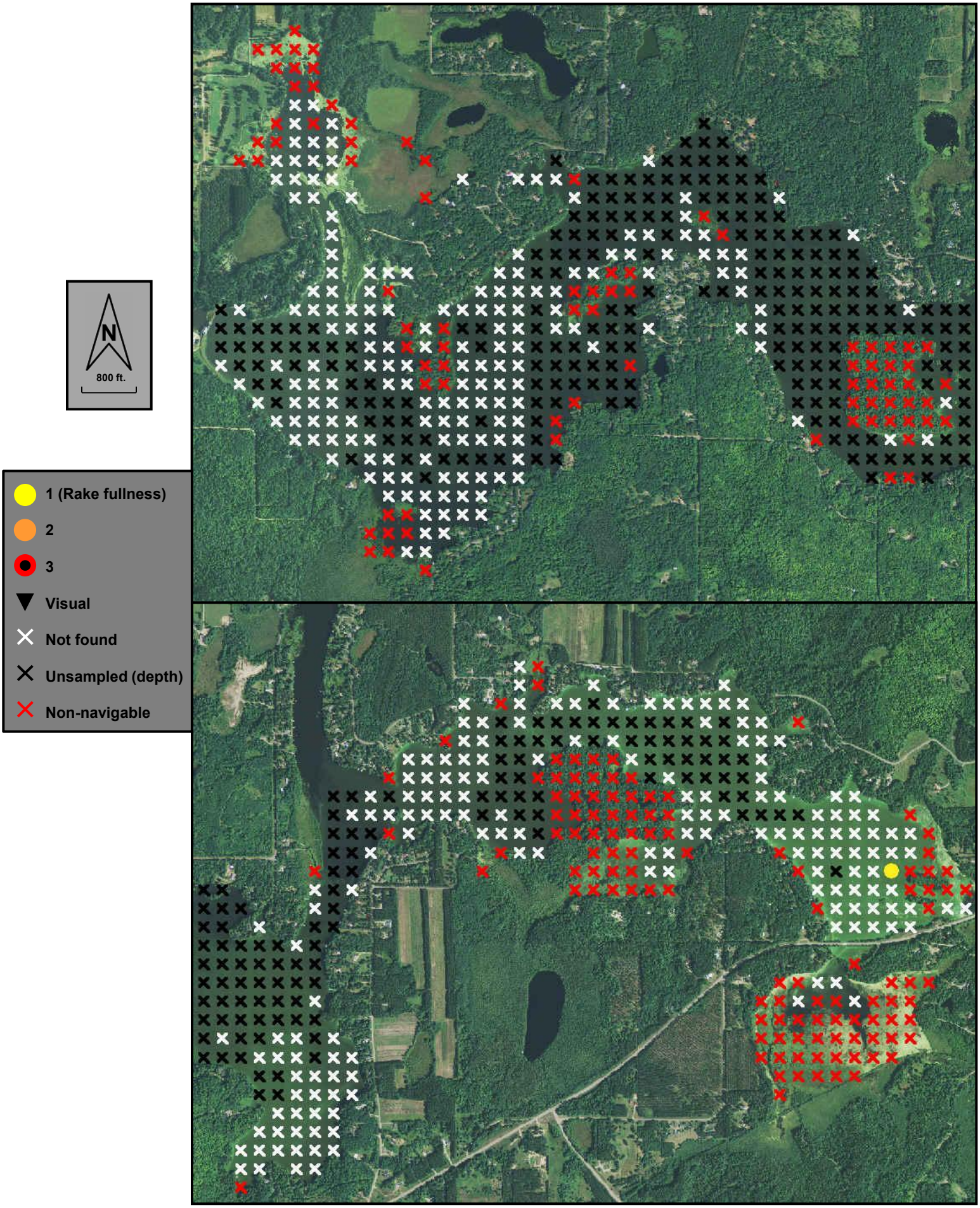


Figure 14. Number of plant species recorded at Lake Alice sample sites (2016).

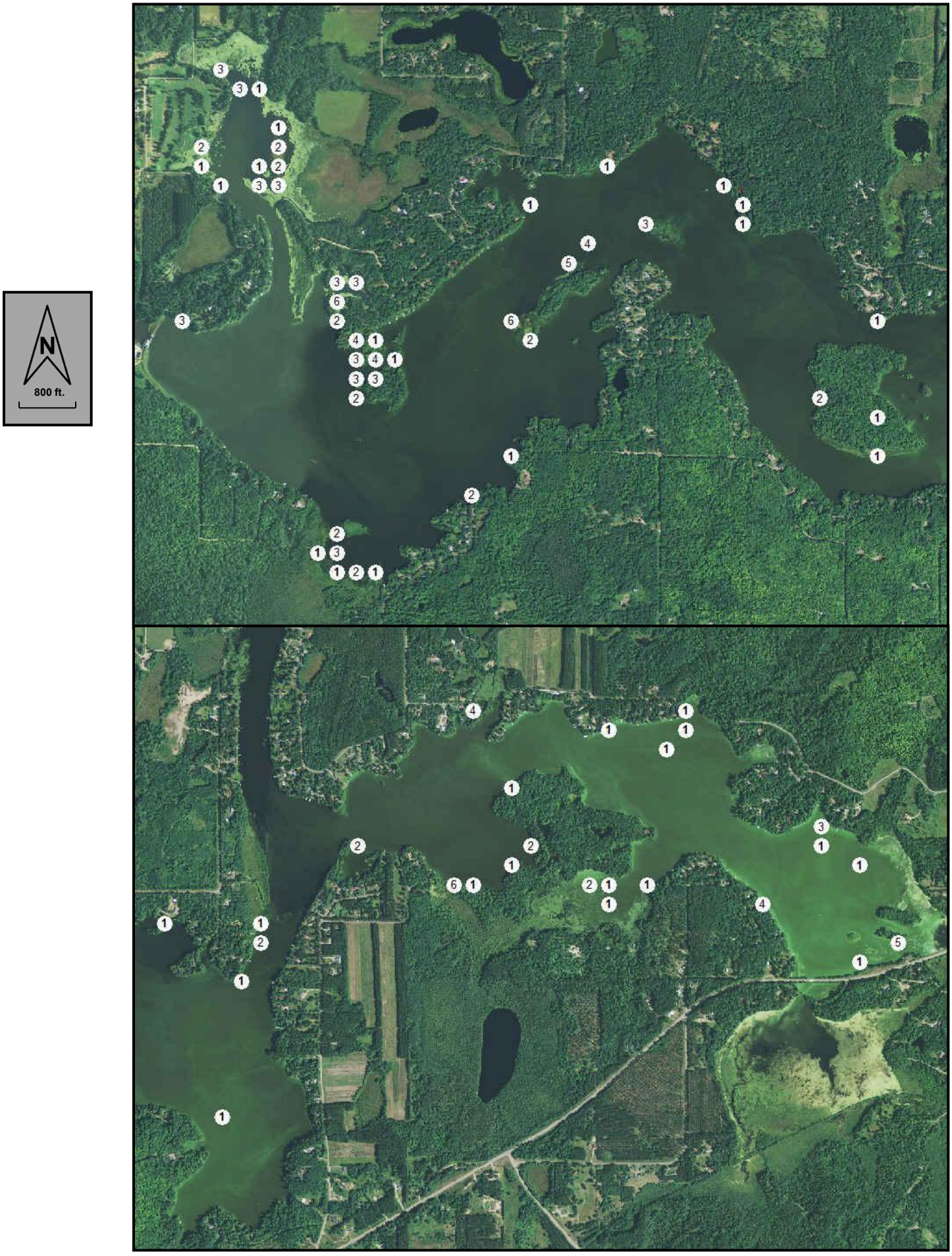


Figure 15. Rake fullness ratings for Lake Alice sample sites (2016).

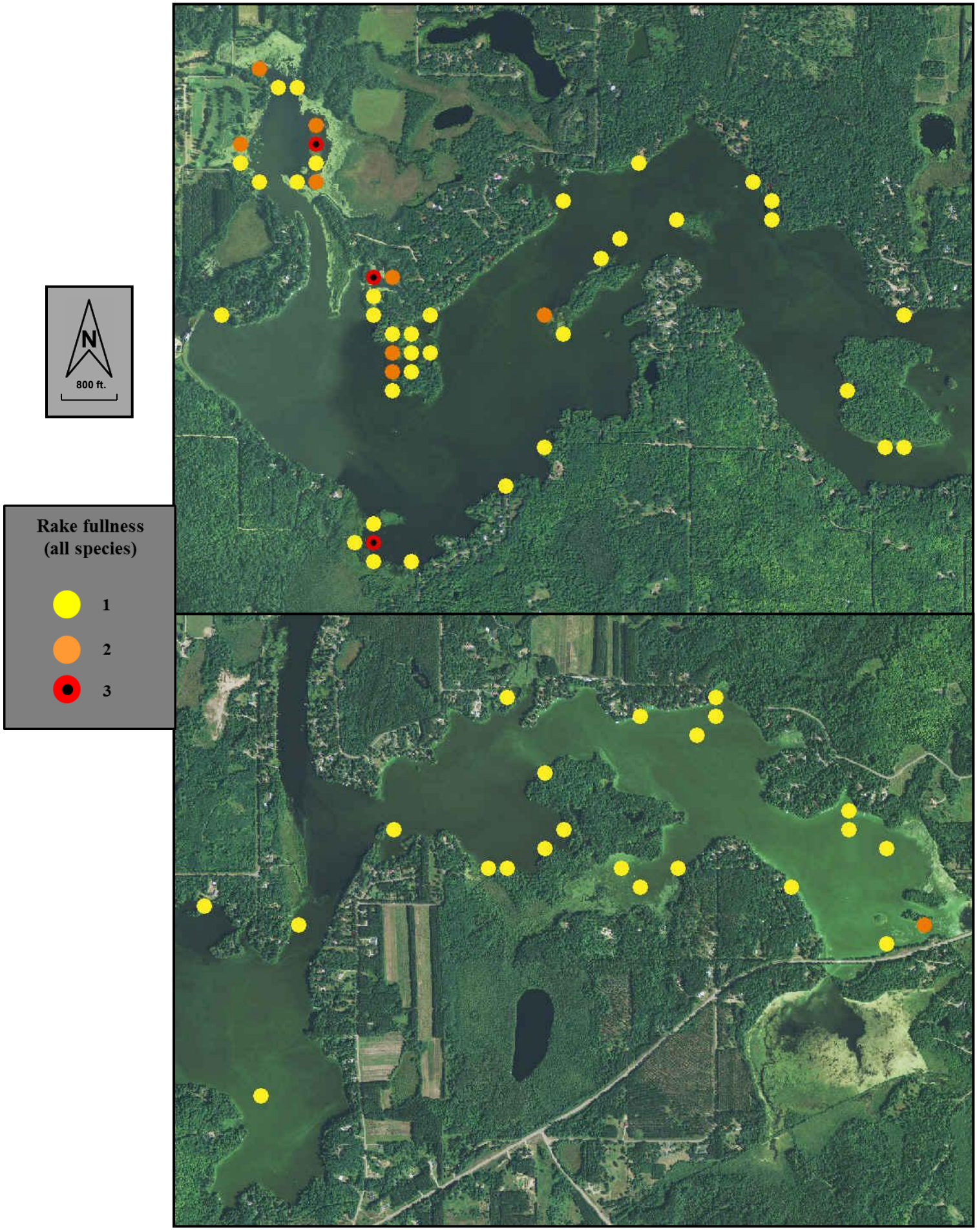


Figure 16. Maximum Depth of Plant Colonization in Lake Alice (2016).

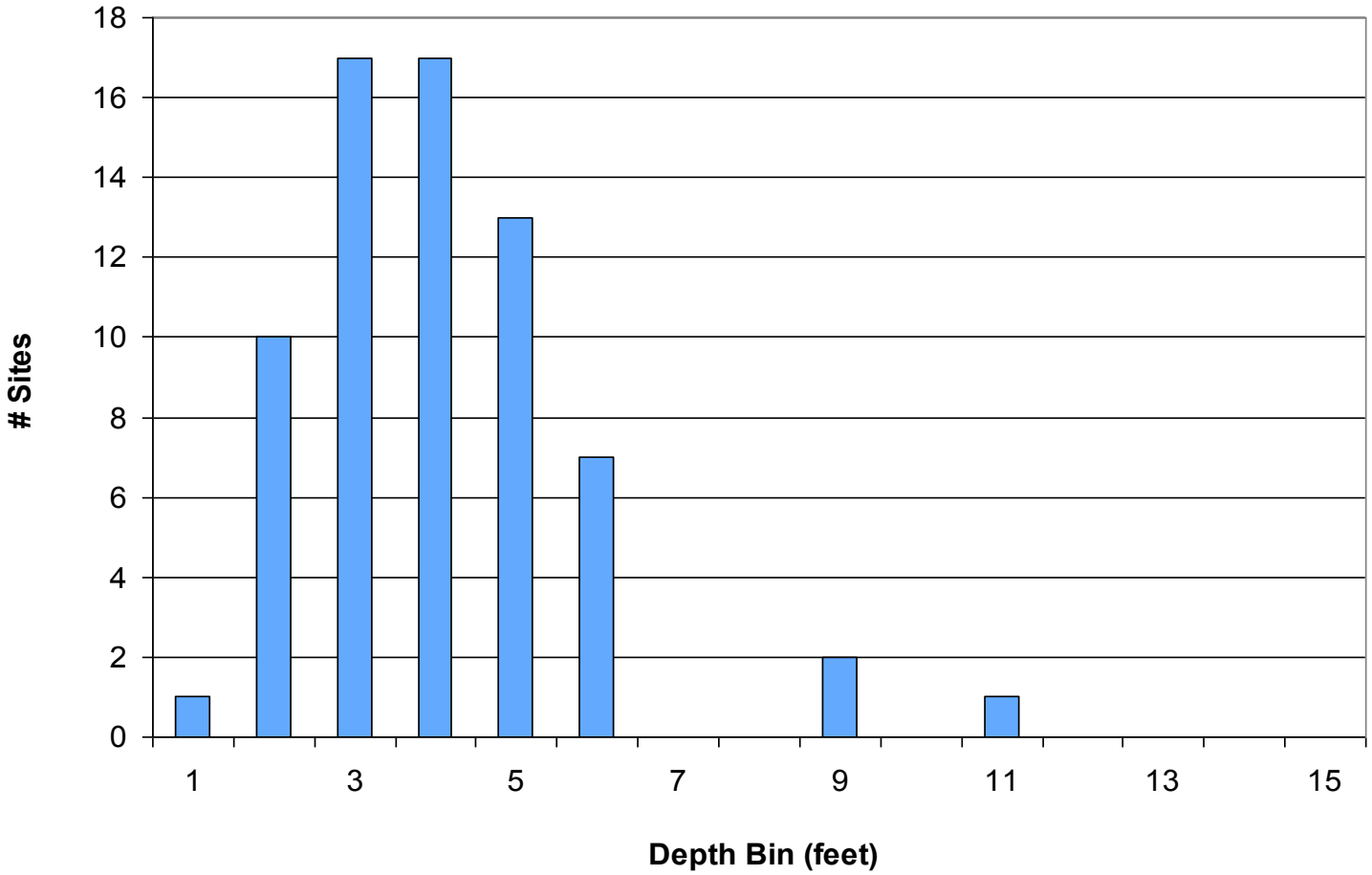


Figure 17. Lake Alice sample sites less than or equal to maximum depth of rooted vegetation (2016).

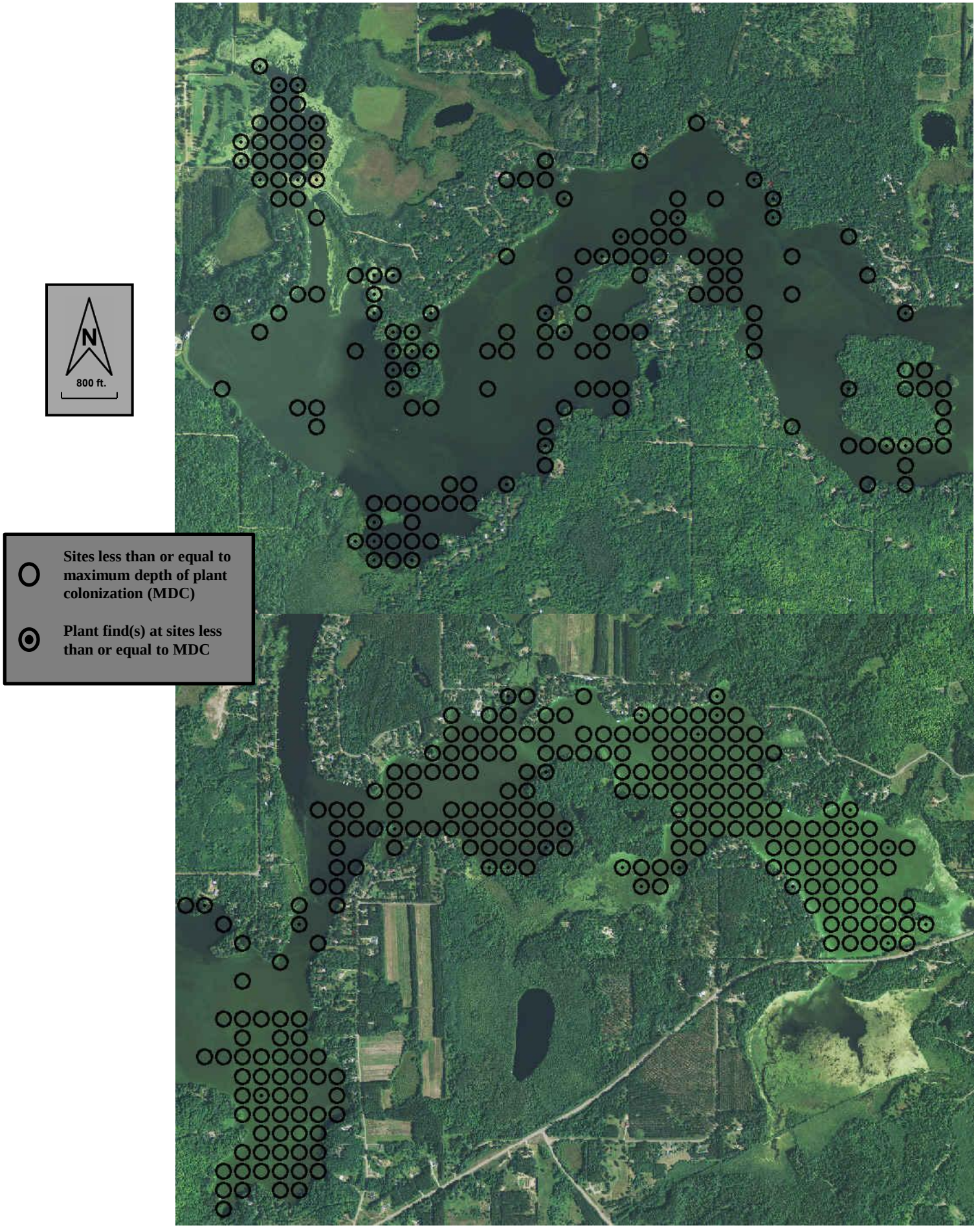


Figure 18. Lake Alice substrate encountered at sampling sites (2016).

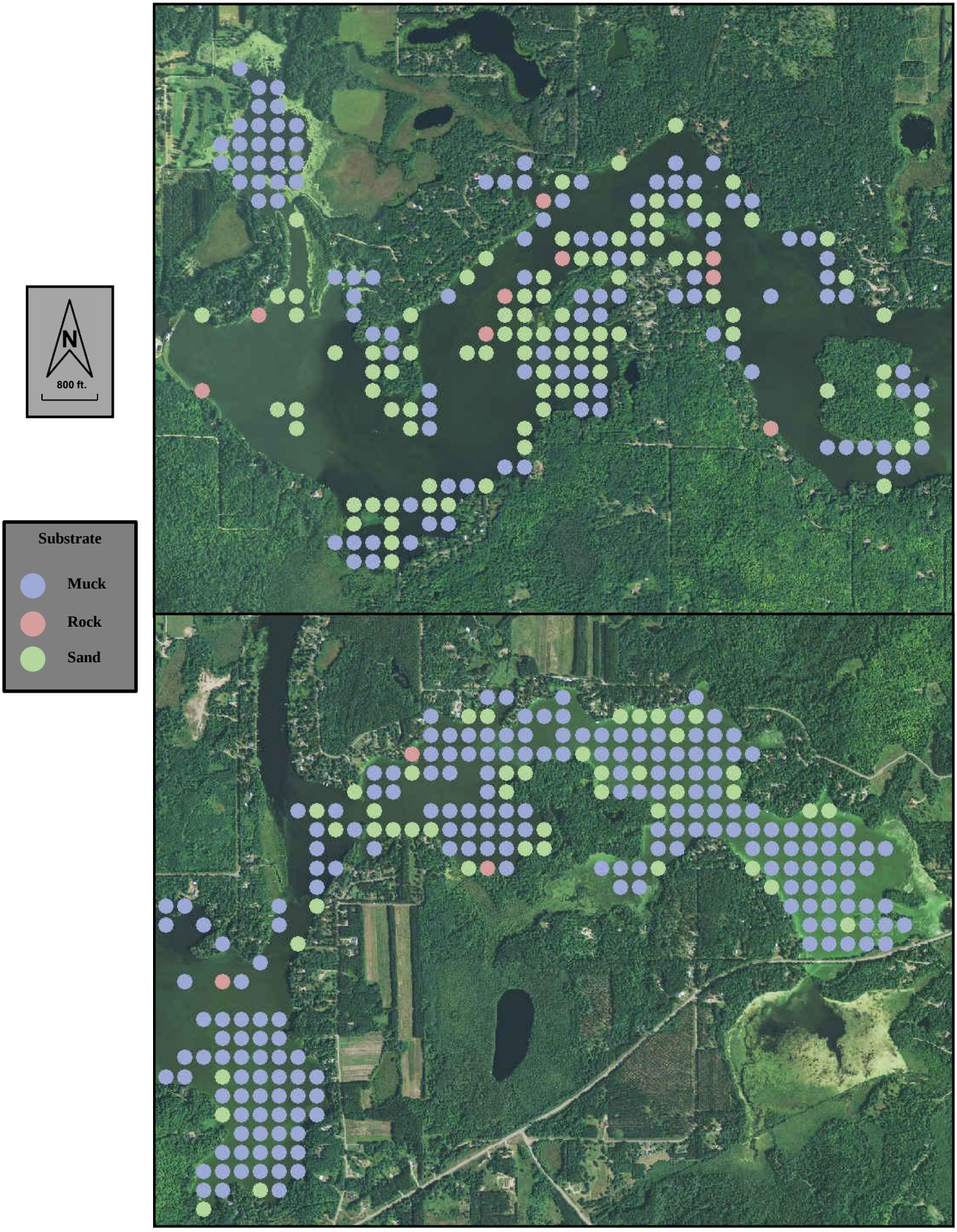
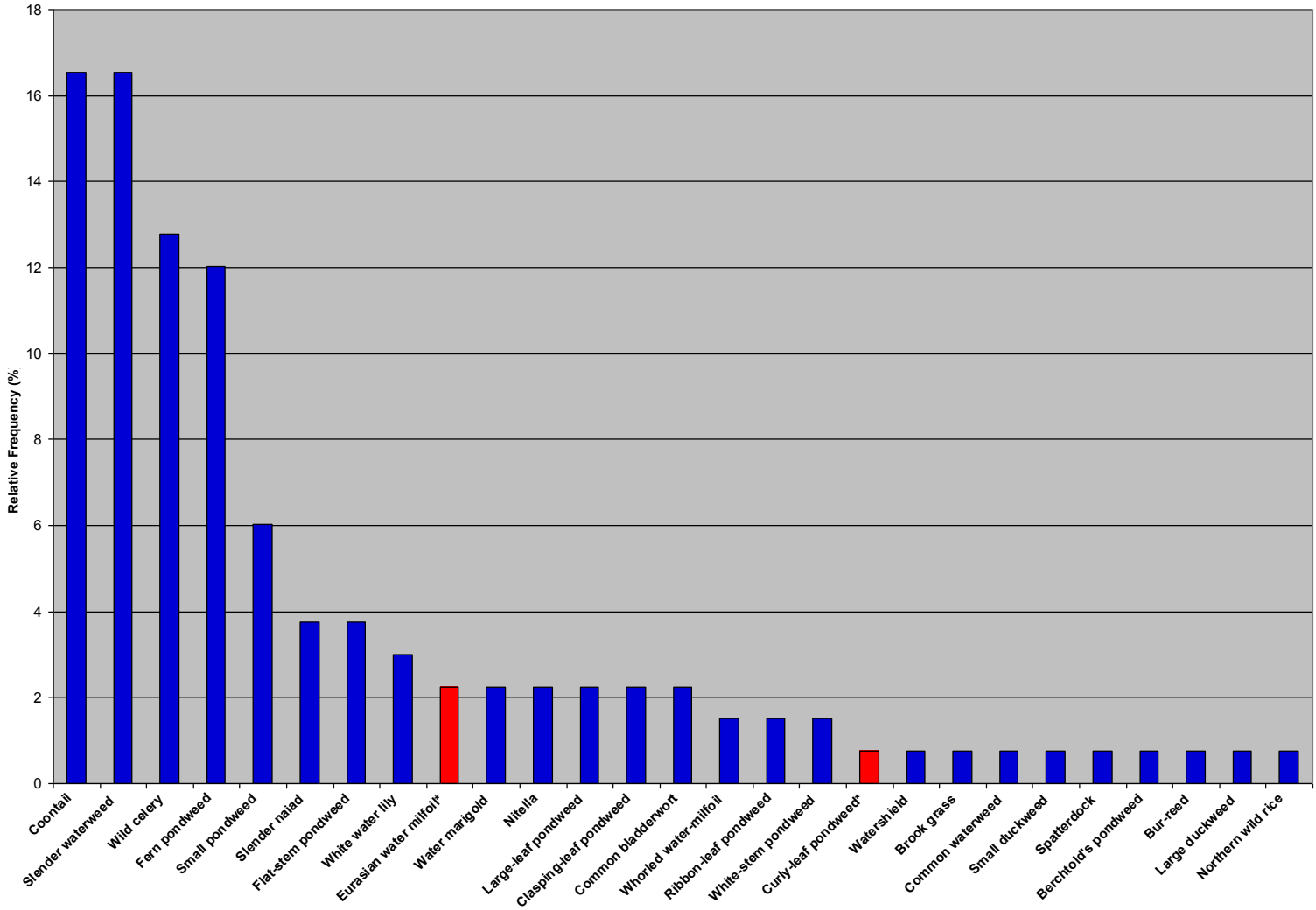


Figure 19. Lake Alice aquatic plant occurrences for 2016 point-intercept survey data.



*indicates invasive species

Figure 20. Lake Alice sampling sites with emergent and floating aquatic plants (2016).

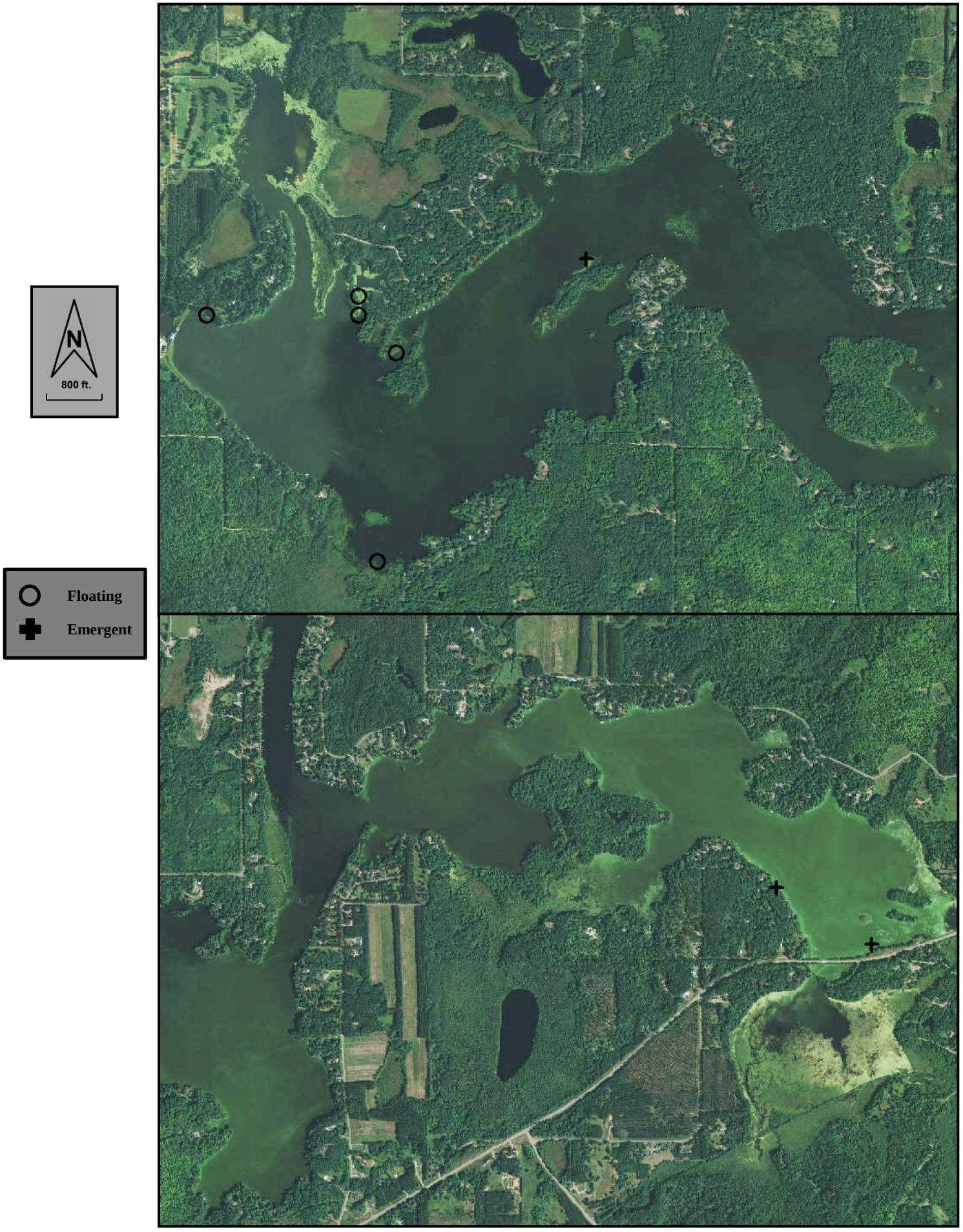


Figure 21: Distribution of Elodea nuttallii (Slender waterweed), Lake Alice, 2016

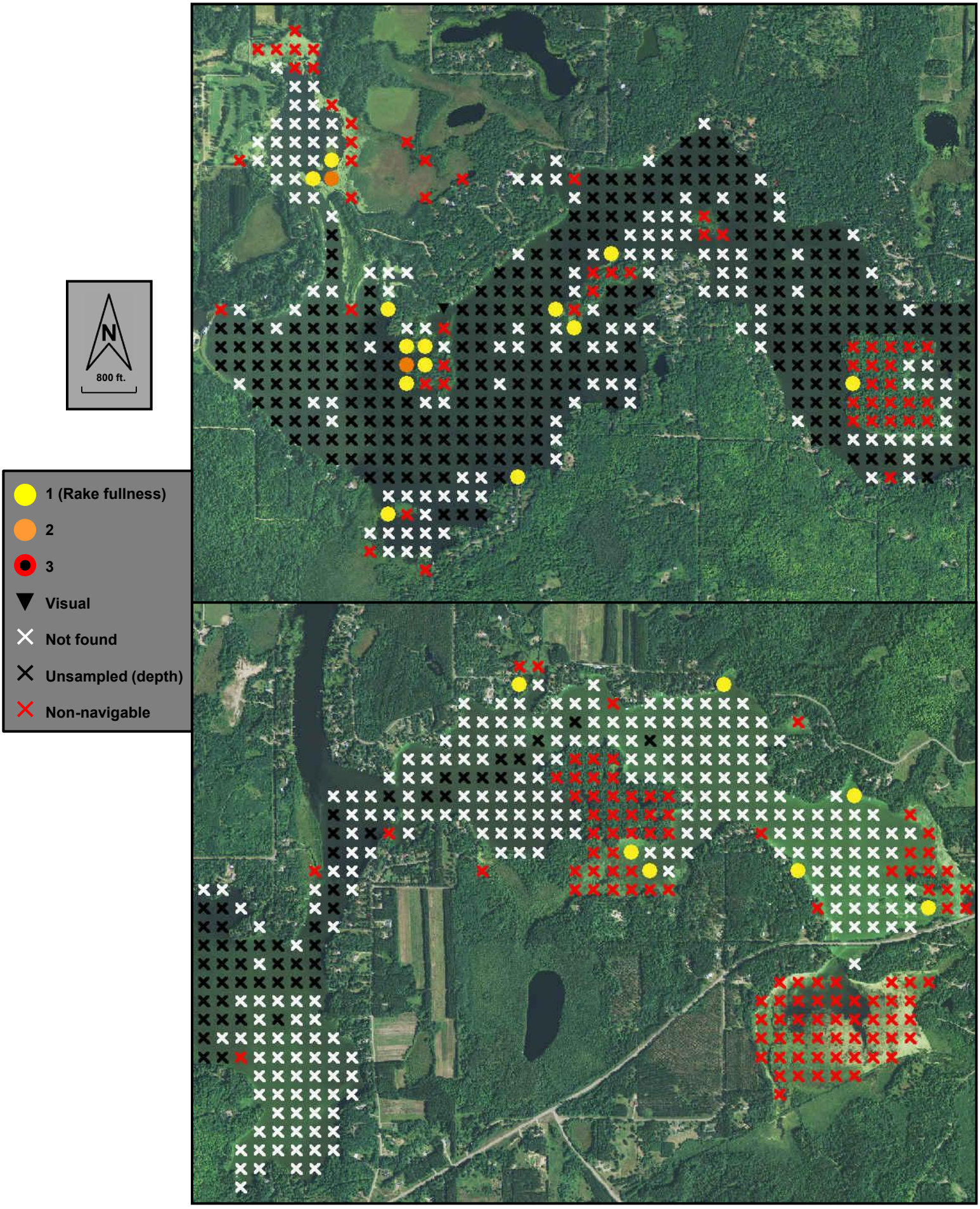


Figure 22: Distribution of Ceratophyllum demersum (Coontail), Lake Alice, 2016

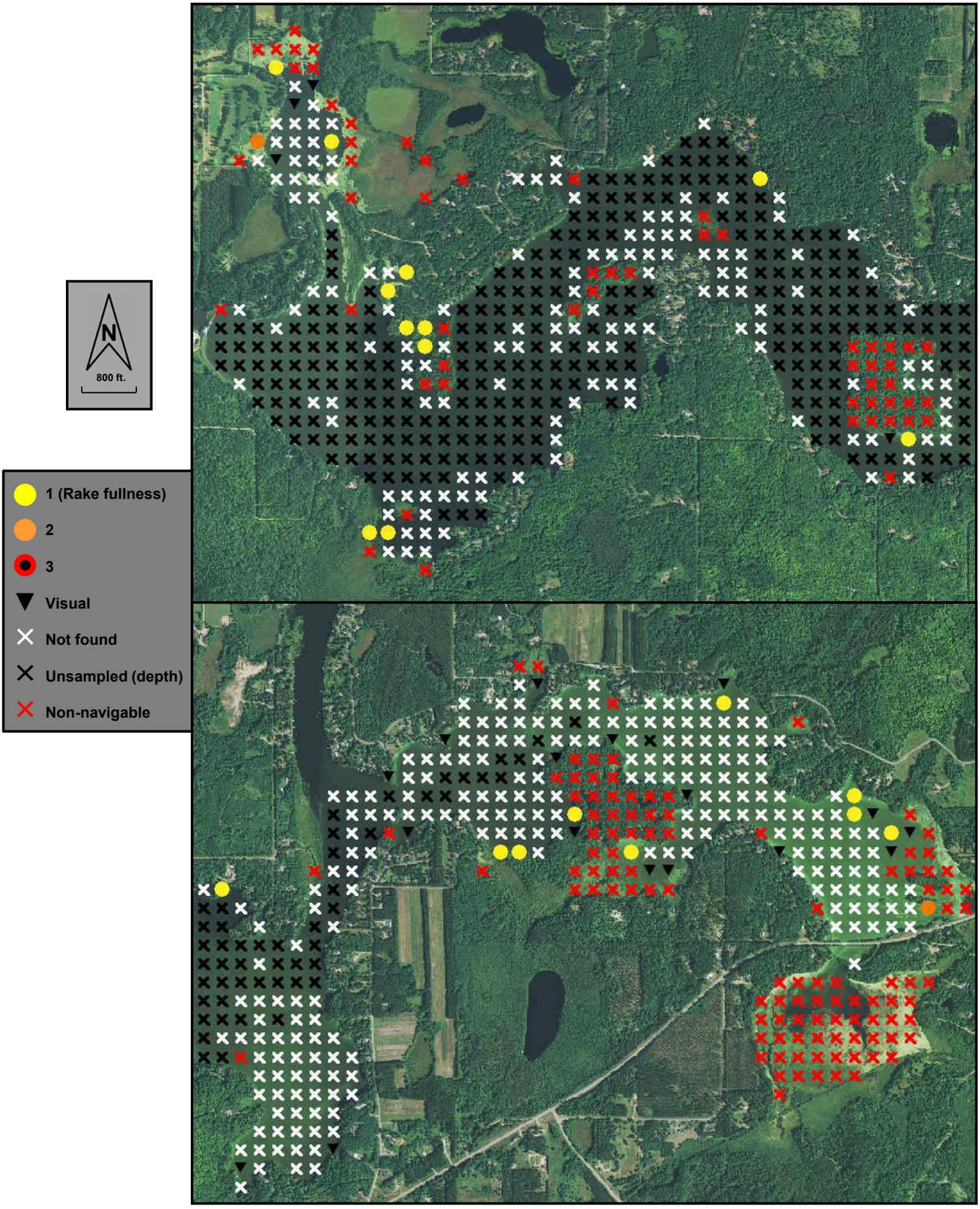


Figure 23: Distribution of Potamogeton robbinsii (Fern pondweed), Lake Alice, 2016

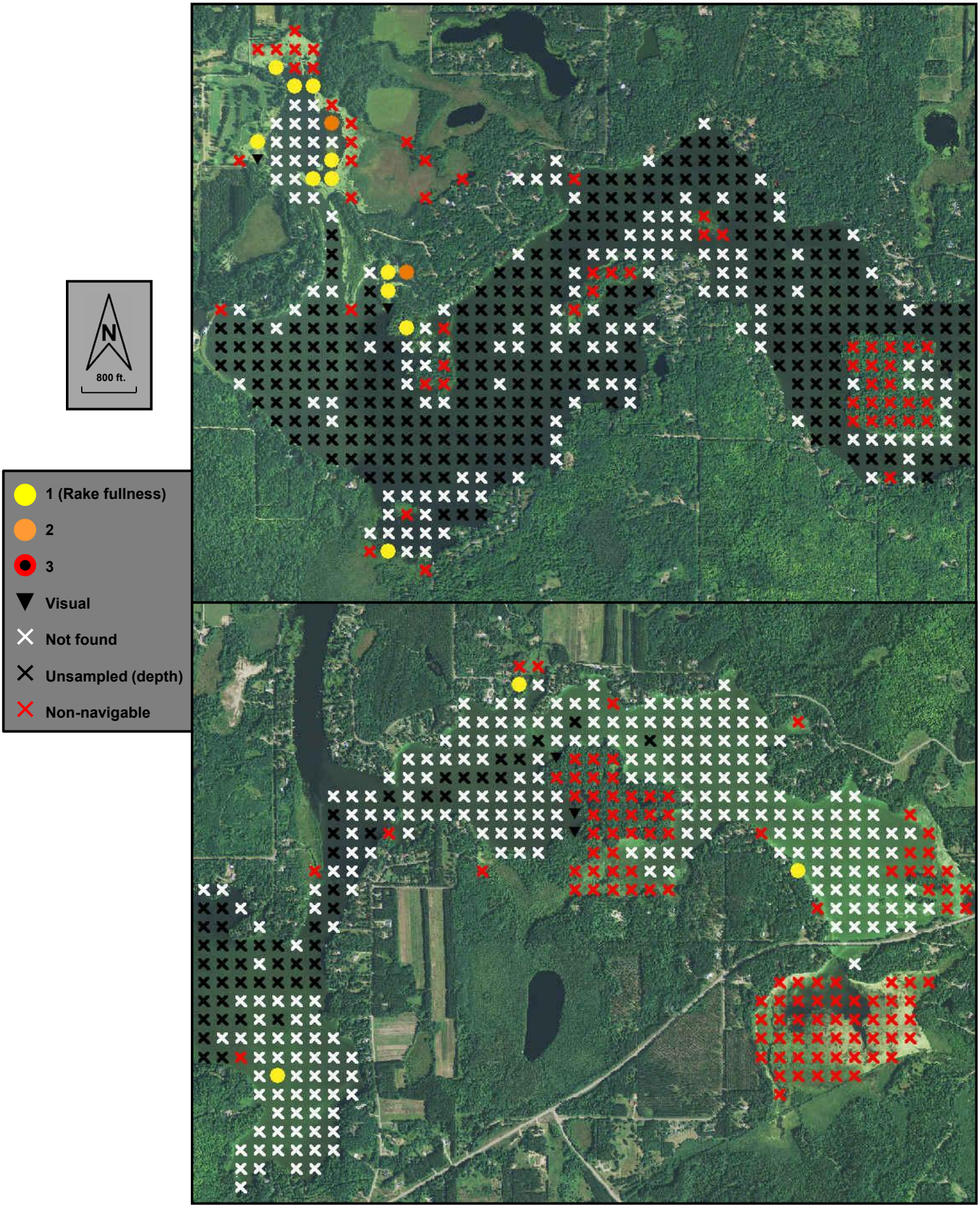


Figure 24: Distribution of Potamogeton zosteriformis (Flat-stem pondweed), Lake Alice, 2016

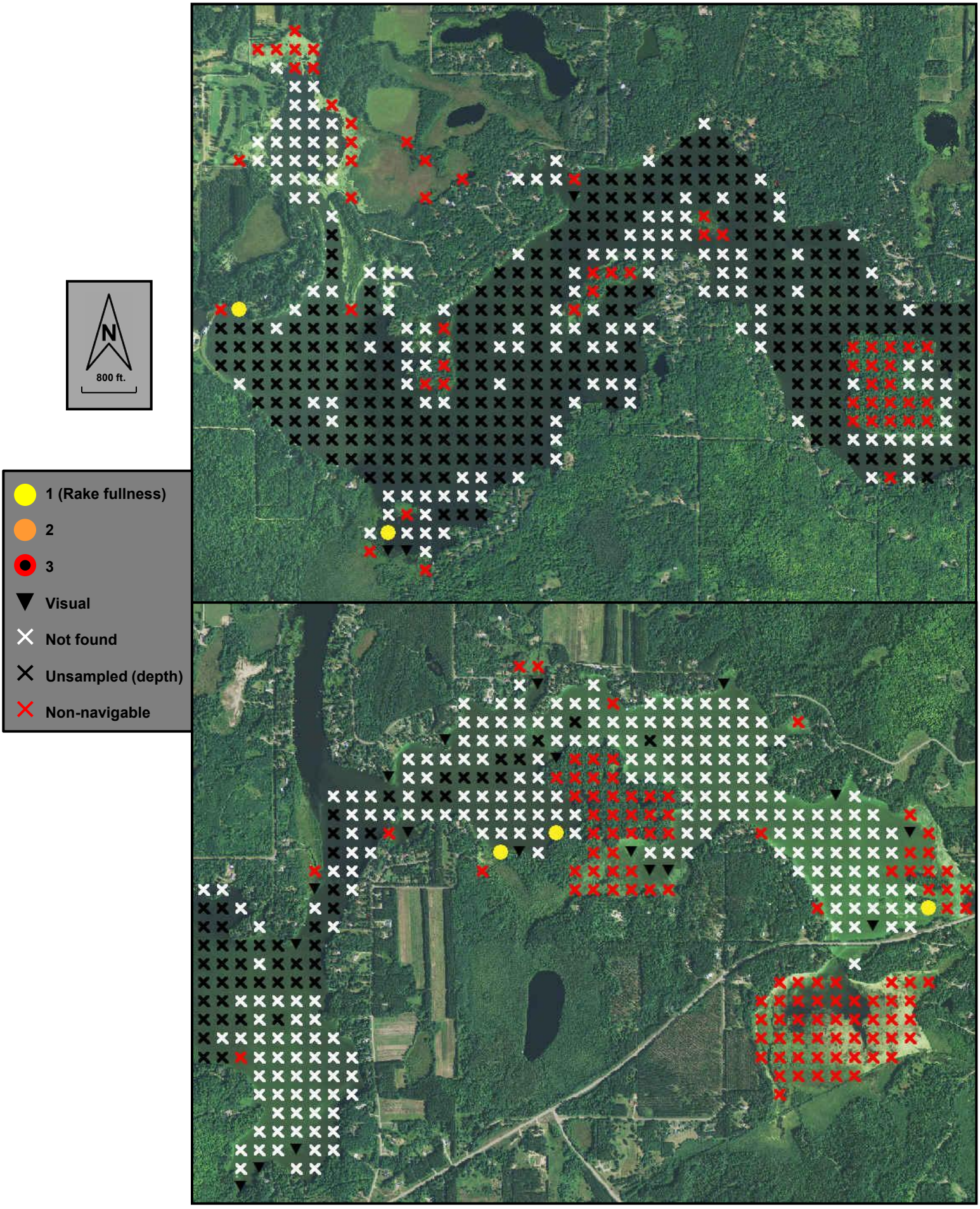


Figure 25: Distribution of Potamogeton praelongus (White-stem pondweed), Lake Alice, 2016

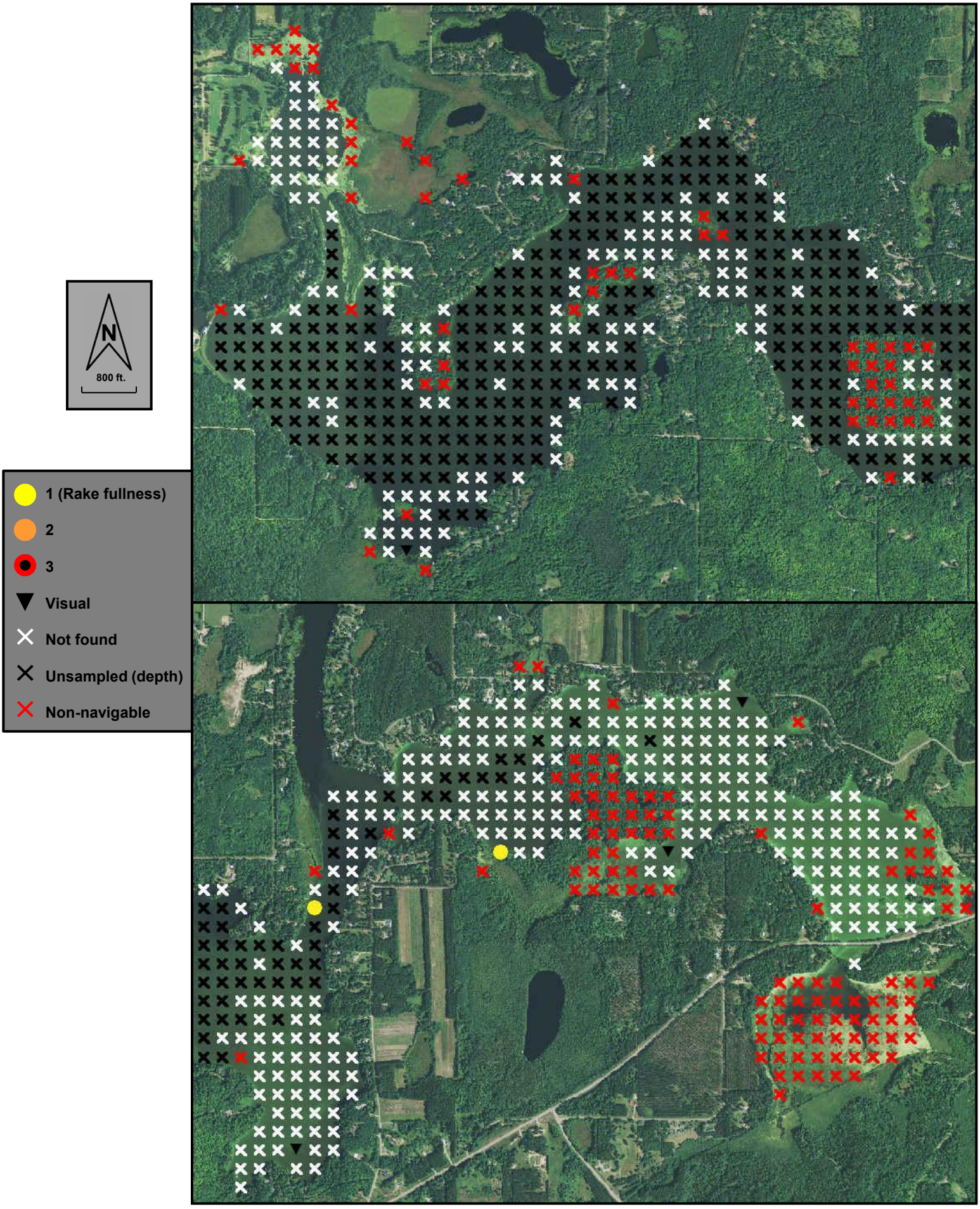


Figure 26: Distribution of Potamogeton crispus (Curly-leaf pondweed), Lake Alice, 2016

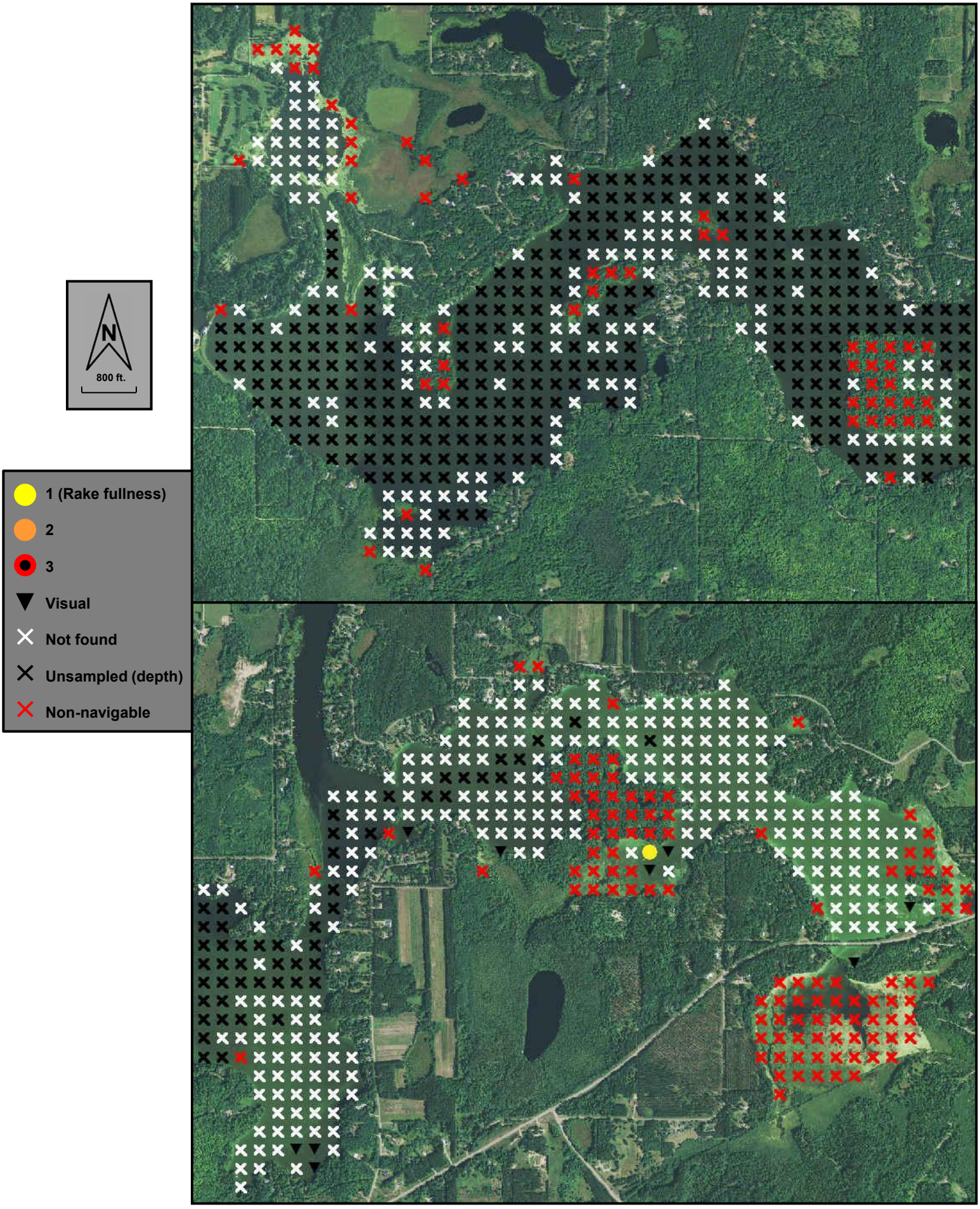
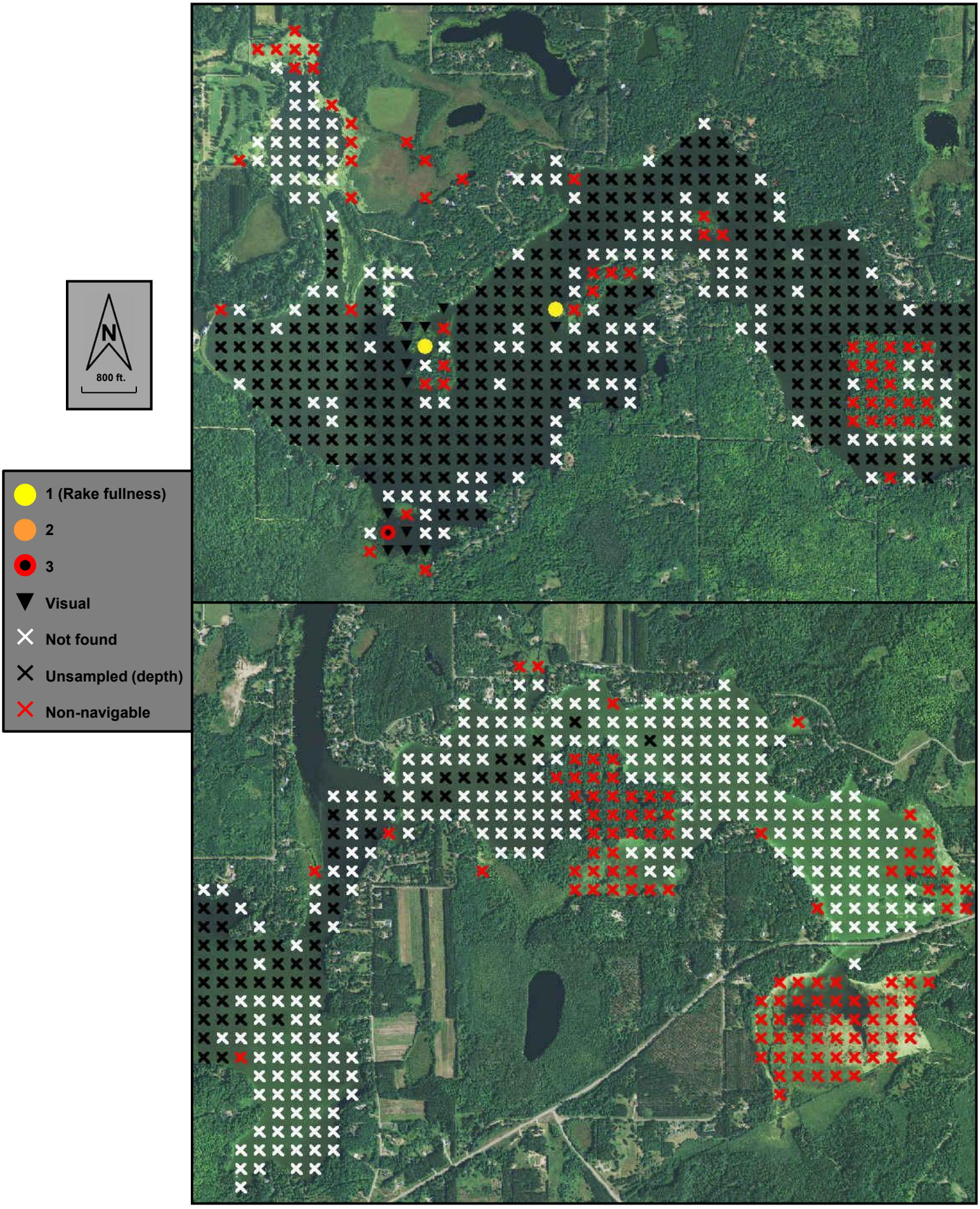


Figure 27: Distribution of Myriophyllum spicatum (Eurasian water milfoil), Lake Alice, 2016

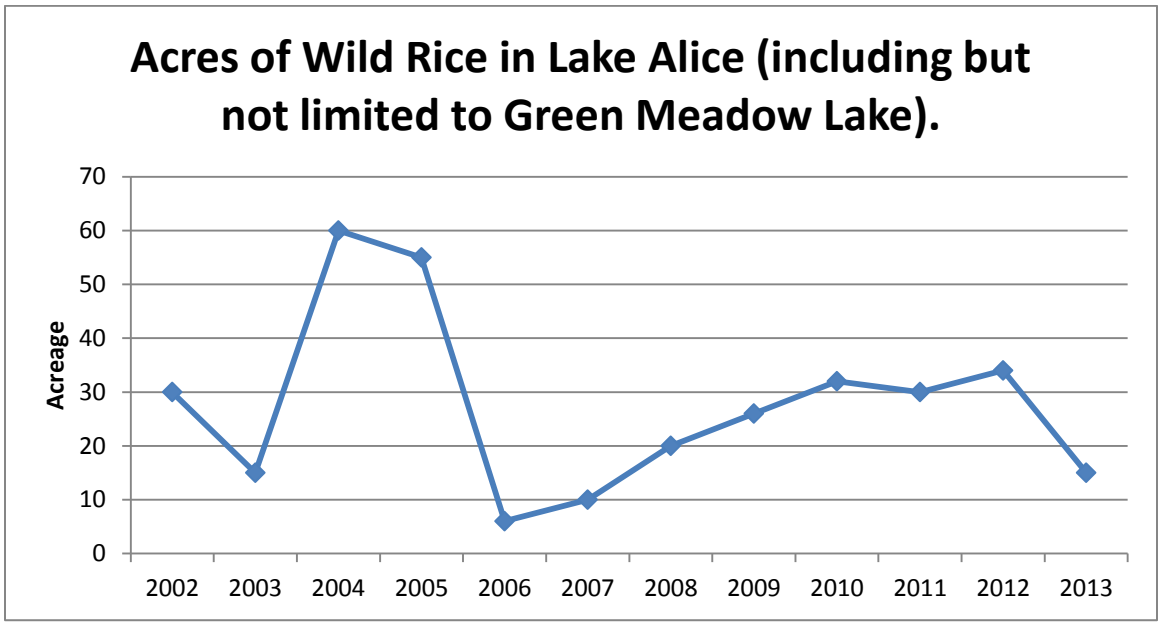


Appendix 3
Wild Rice in Lake Alice

Wild Rice in Lake Alice

Lake Alice is a 1,369 acre reservoir. Wild rice grows in the southeast end of Lake Alice where Big Pine Creek meets the reservoir. While this location produces small populations of wild rice, the majority of Lake Alice's wild rice grows in a section of the reservoir (approximately 100 acres) called Green Meadow Lake. This lake is separated from Lake Alice by a bridge, but is still considered part of the reservoir. This area is optimal for wild rice growth because it is relatively shallow and has flowing water. According to Great Lakes Indian Fish & Wildlife Commission (GLIFWIC) biologist Peter David, the acreages of rice crops found in riverine beds seem more consistent from year to year, while lake acreages tend to fluctuate (David, 2013).

Shown below is a figure displaying the total acres of wild rice within Lake Alice (including but not limited to Green Meadow Lake) from 2002 to 2013. At the end of this report are aerial images of wild rice in Green Meadow Lake from 2004-2009. The sidebar provides a personal account of picking wild rice in Lake Alice.



(David, 2008-2015)

Wild rice populations in Lake Alice have fluctuated from year to year, with small decreases, major increases, major decreases, and gradual increases. Both human and natural events are responsible for these oscillations.

Human impacts such as motorboat operation in areas with rice, dams maintaining stable water levels and shoreland development lead to decreased rice populations. Rice provides habitat for fish like walleye and northern pike, but the leaves and stems can get caught in boat propellers and can be torn off. When traveling through rice stands motor-less vessels should be used. Sometimes fishermen or landowners remove the rice because they do not like the "inconvenience."

Since wild rice prefers varying water levels and flowing water, dams that stabilize water levels, (e.g., King's Dam) may affect the rice. Stable water levels are not only unfavorable for wild rice, but allow perennial plants to take over areas with wild rice (MNDNR, 2008). On the other hand, dams can also provide some benefits to wild rice. With the rise of aquatic invasive plant species in lakes, competition for resources is become more prevalent. Dams that conduct winter drawdowns help eliminate perennial species (both native and non-native) competing with annual wild rice plants (David, 2013).

A Personal Account of Wild Rice on Lake Alice

Based on an interview of Brian Biermier on 4/27/17 by Dean Premo

Brian Biermier began collecting wild rice seed in 1970 on Lake Alice and has done so nearly continuously to the present day. He has collected wild rice on many other Wisconsin water bodies and has kept a log of his nearly 50 years of "ricing." He referred to his log during our conversation. Over the course of his experience with Lake Alice rice beds, he has seen many changes.

Not every year produces a good crop of wild rice seed. This fluctuation in yield is the result of many factors, both natural and human-caused. For example, Biermier's log reflected that 1976 produced a good crop of wild rice from Lake Alice, but not long after that Brian remembered a chemical release from the Rhinelander Paper Mill (upstream of Lake Alice) that impacted the rice beds on the Wisconsin River immediately upstream of Lake Alice. The rice produced very little seed for years afterward, despite the fact that the rice beds remained present (presumably this annual plant was sprouting each year from the "seed bank" present in the sediment). The beds slowly lost their vigor. In the 1990s the WDNR purchased wild rice seed from Brian and began to replant and restore the Wisconsin River rice beds. This restoration proved successful and by 2005, the rice was producing sufficient seed to harvest. Brian says that today the beds north of Highway A on the Wisconsin River are almost back to the size and productivity he observed in the 1970s.

Brian's ricing log reflected that good wild rice crops came about every 10 years on Lake Alice. Some years, flocks of blackbirds took their toll on the crop. The Lake Alice rice beds produced tall heavy canes that extended 6-8 feet out of the water, although the plants were never very dense. The area known as Green Meadow Pond was his favorite picking area and seemed more consistent in terms of yield. For example, his log recorded good yields of rice in 1999, 2002, and 2004. In contrast, he was able to collect very little in 2005.

One area of Lake Alice that has developed more rice since the early years of Brian's experience is the area north and west of the inlet of Big Pine Creek (on the east end of Lake Alice). In the 1970s there was no rice in this area, but in the 2000s the rice beds here established and produced good crops of seed. Canada geese have been hard on these beds over the years.

Brian Biermier generously accompanied Lake Alice Association members and Dean Premo on a "floating workshop" on Lake Alice and described his experience with Lake Alice rice. He patiently answered abundant questions about this wonderful native Wisconsin aquatic plant and its role in the Lake Alice ecosystem.

Shoreland development also has deleterious effects on wild rice stands. Development usually involves dredging, vegetation removal and runoff, which are harmful to the environment in which wild rice grows.

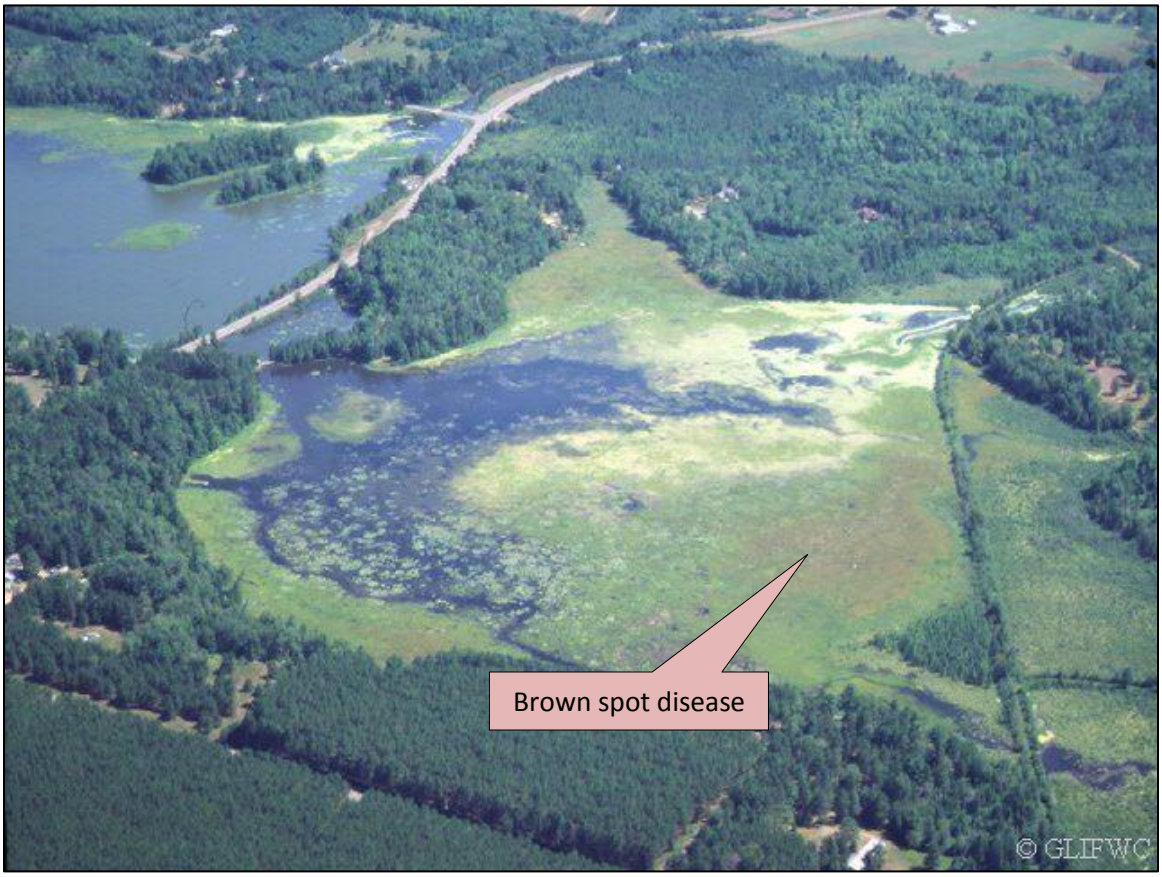
Although human impacts could pose considerable threats to the wild rice population in Lake Alice, natural events can also have negative effects. Natural threats to wild rice range from temperature changes, changing nutrient levels in lakes, naturally varying water levels, animal foraging, invasive species, disease, rice worms, and perhaps most importantly, climate change.

As mentioned above, varying water levels can be both a hindrance and a benefit to wild rice. Lower levels can help reduce the number of plants competing for resources, but if levels drop too low, wild rice cannot survive. On the other hand, wild rice cannot grow if water levels are too high. Moreover, if levels increase too rapidly, plants can be ripped from the substrate and be washed away.

Many animals eat wild rice plants. Beavers and muskrat feed on rice plants, along with many types of waterfowl. If these animals feed in large numbers, they can impair the outcome of rice crops. Beavers can also affect wild rice by drowning plants when they build their dams. In Lake Alice, and specifically Green Meadow Lake, goose browsing has been a considerable hindrance in the success of wild rice (David, 2013).

A number of invasive species are found in areas with wild rice, but in Lake Alice curly-leaf pondweed (*Potamogeton crispus*) and rusty crayfish (*Orconectes rusticus*) are sources of concern. Curly leaf pondweed is an aggressive invasive plant that can choke out nearby plants, including wild rice. In 2010, curly-leaf pondweed was found on the southeast end of Lake Alice, north of Green Meadow Lake. In addition to curly-leaf pondweed out-competing wild rice, the treatment of invasive species by chemical and manual control can also harm rice stands (David, 2013). Rusty crayfish are a concern because they feed on aquatic vegetation. Although rusty crayfish have the potential to hamper the wild rice stands, they usually prefer harder substrates, whereas wild rice prefers softer, mucky substrate (David, 2013).

Another problem that has become fairly common and more prevalent is brown spot disease. The disease occurs when temperatures are warm and humidity is high, leaving the plant continuously wet. Diseased plants can result in reduced or negligible seed production. According to Peter David, brown spot disease can be the "canary in the coal mine" when it comes to climate impacts on rice (2013). In Lake Alice, brown spot disease's first major impact on wild rice was in 2005. Aerial photos from 2005 show where the disease had infected a large portion of the crop in Green Meadow Lake. In the 2006 season, there was a significant decrease in wild rice acreage, which may have been the result of diseased plants not producing many seeds from the 2005 season.



Wild rice in Green Meadow Lake. Brown spot disease is observed in the right corner of the picture (GLIFWC, 2005).

2010 was another marked year for brown spot disease. No aerial photos were collected that year, but coverage in Green Meadow Lake was similar to that in 2005.

Noctuid moths (*Apamea apamiformis*) lay their eggs on wild rice flowers, and the "rice worms" (larval stage) feed on the plant as they grow. At the end of the season, they burrow inside the stem and over-winter in the plant. Research in Minnesota found that one larva per plant reduces yield by 10% (Oelke et al., 1997). No information about rice worms in Lake Alice is available.

Climate change is playing a major role in many aspects of lake ecology, and this does not exclude wild rice. Since the 1970s, average surface temperatures have risen at an average rate of 0.26 to 0.43 degrees per decade (USEPA, 2015). Because wild rice has specific requirements for optimal growth, climate change, including increasing surface temperatures, may put a hamper on future wild rice crops. Additionally, when the average annual temperature increases every year, disease becomes more prevalent and invasive species move in where sensitive plants, like wild

rice, cannot handle the stressors. Because climate change is the root of many problems, it is likely the underlying source for the decrease in wild rice across the northern Mid-west states.

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Wild Rice, Lake Alice-Green Meadow Lake, 2004.

Wild Rice, Lake Alice-Green Meadow Lake, 2005.

Wild Rice, Lake Alice-Green Meadow Lake, 2006.

Wild Rice, Lake Alice-Green Meadow Lake, 2007.

Wild Rice, Lake Alice-Green Meadow Lake, 2008.

Wild Rice, Lake Alice-Green Meadow Lake, 2009.

Wild Rice, Lake Alice-Green Meadow Lake, 2011.

Wild Rice, Lake Alice-Green Meadow Lake, 2012.

Wild Rice, Lake Alice-Green Meadow Lake, 2013.

Wild Rice, Lake Alice-Green Meadow Lake, 2014.

Wild Rice, Lake Alice-Green Meadow Lake, 2015.

Wild Rice, Lake Alice-Green Meadow Lake, 2016.

Appendix 4
Curly-leaf Pondweed in Lake Alice