LAKE EMILY ECOLOGICAL ASSESSMENT REPORT

Prepared for:

The Lake Emily Fishing Improvement Club

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and the

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WISCONSIN DEPT. OF NATURAL RESOURCES

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TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION

CHAPTER 2 – WATERSHED DELINEATION AND LAKE MORPHOLOGY

CHAPTER 3 – WATER QUALITY

CHAPTER 4 – AQUATIC PLANT SURVEY

CHAPTER 5 – FISH SURVEY RESULTS

CHAPTER 6 – LAKE MANAGEMENT RECOMMENDATIONS

TABLES

FIGURES

FIGURES *(continued)*

APPENDIX

CHAPTER 1 – INTRODUCTION

BACKGROUND

Lake Emily is a 286-acre shallow, natural, seepage lake located in northwest Dodge County in the Town of Lake Emily. In the past several decades, Lake Emily has experienced a gradual change in water quality as indicated by reduced water transparency, increased algae populations, increased aquatic macrophyte beds, and a declining sports fishery.

Lake Emily Fishing Improvement Club is participating in a lake planning grant project to assess the current ecological condition of the lake. There are multiple components to the project including a comprehensive fish survey, water quality monitoring, an aquatic plant survey, and watershed delineation. Lake Emily has been a participant in the WDNR Self-Help Monitoring program from 1994 through the present. While the Self-Help data provides valuable trends in water clarity, additional information on water chemistry, rooted aquatic plants, and health of the fishery are needed to act as a foundation for the development of lake management strategies. The overall goal of the project is to collect needed background information on the quality and health of Lake Emily for use in future lake management planning.

GOALS AND OBJECTIVES

The goals and objectives of the project are:

- Create a watershed delineation map
- Summarize existing Self-Help water quality data
- Complete an aquatic plant survey
- Conduct a comprehensive fish survey
- Provide planning and management recommendations.

CHAPTER 2 – WATERSHED DELINEATION AND LAKE MORPHOLOGY

INTRODUCTION

The physical characteristics of a lake and its surrounding watershed provide a context to evaluate water quality conditions, recreational activities, and lake management alternatives. These characteristics usually occur in combinations that are unique to each lake. As a result, there is no "one size fits all" lake management plan that will rehabilitate every lake. Lakes each behave and respond to their surroundings in different ways, have unique problems, and require their own set of solutions. Understanding how a lake functions internally (that includes the impacts of human use) and the relationship between lakes and their watersheds will provide an essential first step in trying to understand what drives aquatic ecosystems and how to manage their problems.

Factors such as watershed topography, soils, lake morphometry, hydrology, lake type, and watershed size all play a role in determining water quality, the aquatic plant community, and the fish community present in a lake. Since there are so many factors affecting lake ecology, the first steps in understanding a lake's ecology are to delineate its watershed and calculate basic lake morphological characteristics.

WATERSHED DELINEATION

The watershed for Lake Emily was delineated using topographic maps with 10-foot elevation contours. The boundary was determined and total area was calculated to aid in potential planning and management activities.

Lake Emily's watershed is approximately 2,950 acres. The majority of the watershed lies to the north and east of the lake with narrower bands surrounding the lake to the west and south (Figure 2-1). The watershed to surface area ratio is 10.3:1. Lakes with watershed to lake ratios greater than seven to ten are expected to be more productive than lakes with smaller watersheds. Since Lake Emily's watershed is largely agricultural, surface runoff may be the cause of declining water quality and the silty lake bottom.

Major surface water flow paths were identified as two intermittent streams. One stream drains the northern portion of the watershed while the second drains the eastern portion of the watershed. The eastern drainage area appears to empty into a small wetland before entering the lake. Water entering the lake from the west and south is primarily diffuse surface water runoff.

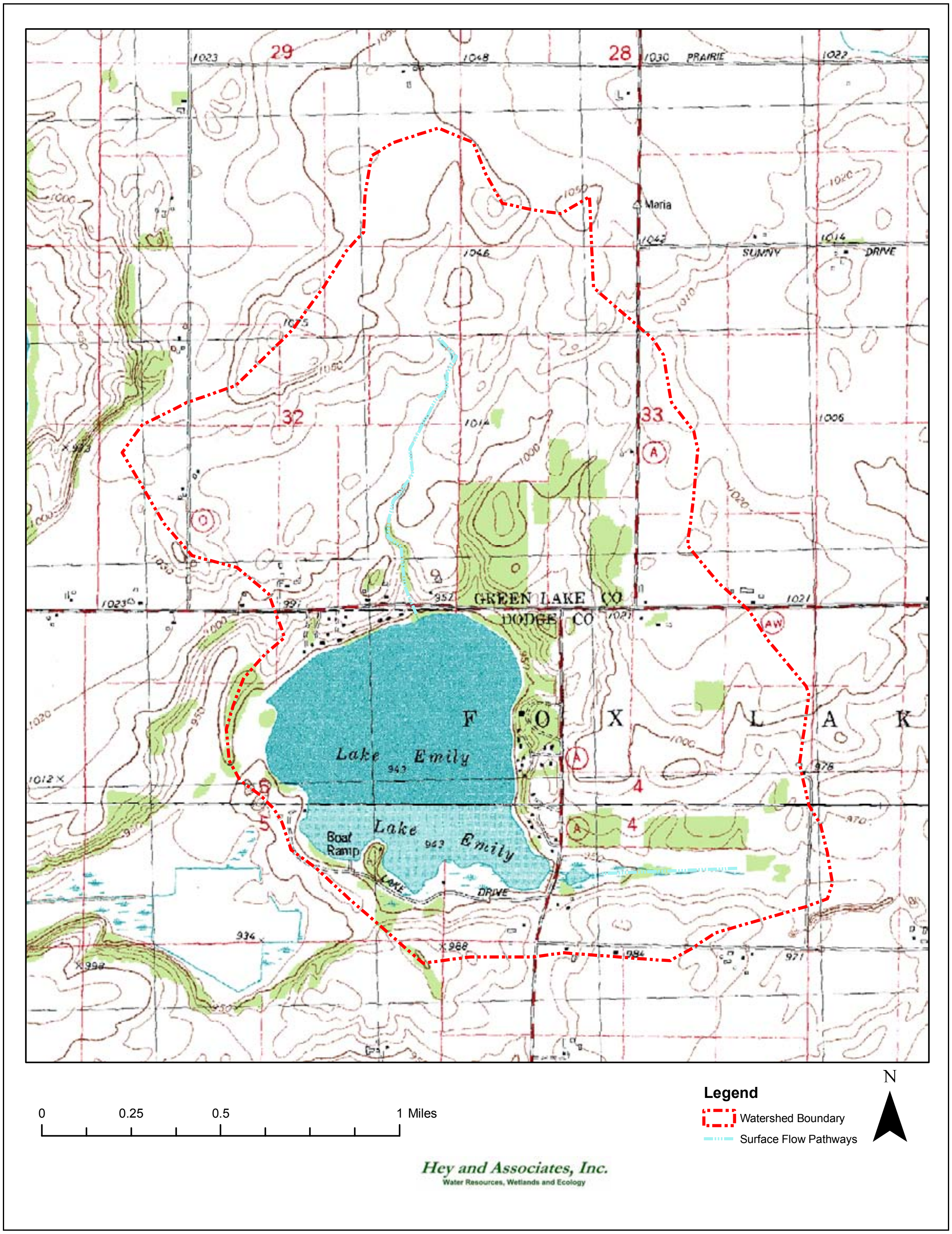

Figure 2-1

Lake Emily Watershed Boundary and Surface Flow Pathways

Source: Hey and Associates, Inc.

LAKE MORPHOLOGY

Knowledge of bathymetry and water volumes at various depths, shoreline characteristics, and other morphological features of a lake are important because the morphology affects most physical, chemical, and biological properties that we measure in lakes. Information on morphometry is needed to investigate nutrient loading rates, biological productivity, and other ecosystem structures and function in lakes. Lake morphological characteristics for Lake Emily are summarized in Table 2-1 and a bathymetric map is located in Figure 2-2.

Table 2-1
Lake Emily Basin Morphology
Source: Hey and Associates, Inc.

Parameter	Value	
Lake Surface Area	268	acres
Watershed Area	2,950	acres
Lake Volume	1,411	acre-feet
Fetch	0.9	miles
Maximum Width	0.8	miles
Shoreline Length	2.9	miles
Shoreline Development Factor	1.3	-
Littoral Zone	268	acres
Mean Depth	5.3	feet
Maximum Depth	14	feet
Relative Depth	0.4	%

SUMMARY

Since Lake Emily's watershed to lake area is greater than 10, water quality is likely sensitive to changes in land use in the watershed. The relatively shallow maximum depth and average depth indicates that Lake Emily has an extensive littoral zone and should be expected to support plants throughout the lake.

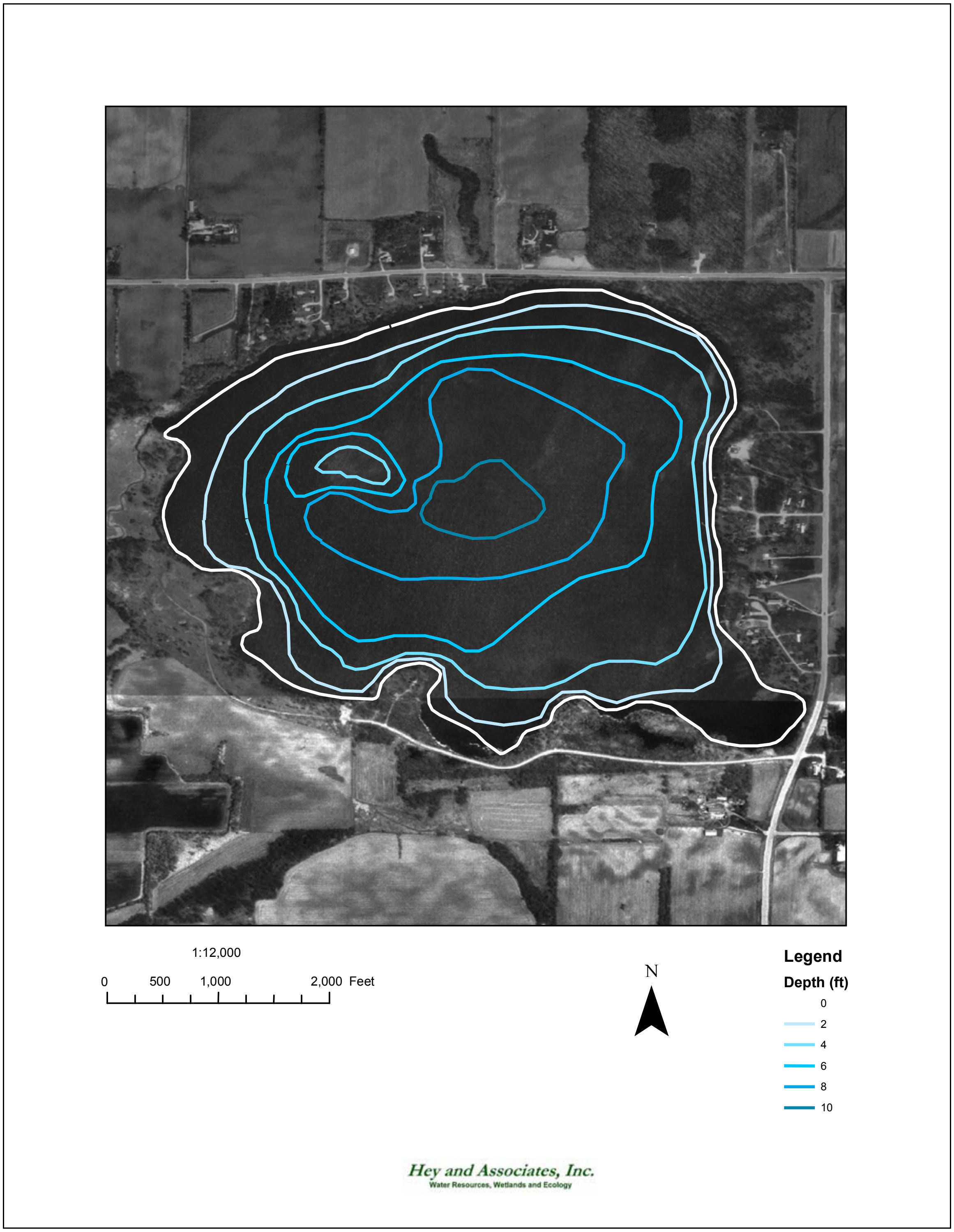

Figure 2-2
Lake Emily Bathymetric Map
Source: Hey and Associates, Inc.

CHAPTER 3 – WATER QUALITY

INTRODUCTION

Water quality is a commonly used term to describe lake condition. Water quality is a difficult term to define because there are many ways to perceive "quality". For example, swimmers might define good water quality as clear water, free of weeds. In contrast, a fisherman might not care about how clear the water is as long as there are abundant fish. To remove this type of subjective evaluation of water quality, the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension have developed index values that rank a lake's water quality from very poor to excellent based on measurements of total phosphorus, Secchi depth, and chlorophyll-a. This index is called a trophic status index. The different trophic states of lakes are oligotrophic, mesotrophic, and eutrophic – these terms will be explained in the following section.

Aging Process of Lakes

Lakes naturally progress through a series of predictable conditions as they gradually fill in with sediment from the surrounding landscape called eutrophication (Figure 3-1). The state of eutrophication is known as its trophic status. Trophic status is a lake's level of primary productivity or how many aquatic plants and algae are present. The first trophic state a lake belongs to over its aging process is oligotrophic which means the water is very clear, there is little productivity in the littoral zone (few aquatic plants), and the fishery is dominated by a few, large predatory species. As a lake ages, it becomes more productive because it grows shallower and is filled with more nutrients. The second classification for lakes is mesotrophic. Mesotrophic lakes are an intermediate stage between the oligotrophic and eutrophic states. They are characterized by moderate levels of productivity, some accumulated organic matter on the lake bed, a good fishery, and occasional algal blooms. The last phase of a lake's aging is called eutrophic. Eutrophic lakes are highly productive with frequent algal blooms, go through periods of oxygen depletion and fish-kills, and support abundant rough fish such as the Common Carp. Eventually, lakes will fill in enough where they will be too shallow and productive to be considered a lake and turn into a wetland. At its natural pace, the eutrophication process may take 1000's of years. Many activities undertaken by humans can accelerate the eutrophication process since they accelerate soil loss via erosion. This is called cultural eutrophication and it shortens the aging process down to a few hundred years.

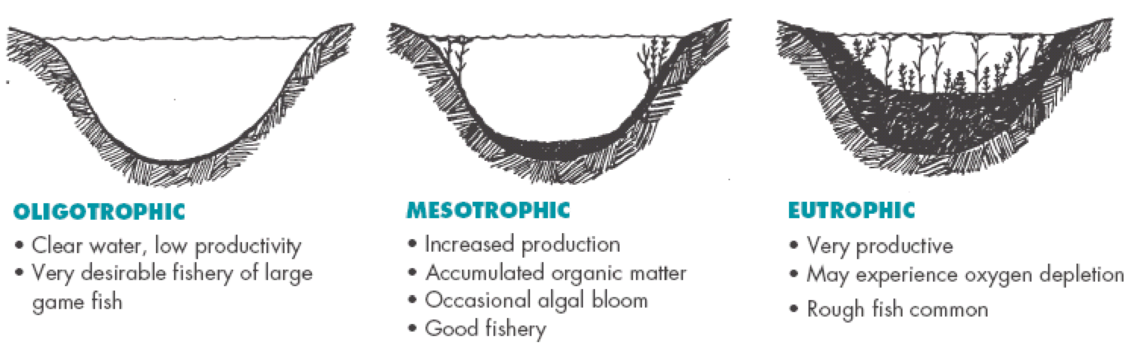

Figure 3-1
Aging Stages of Lakes and their Attributes
Source: University of WI-Extension and SEWRPC

Stratification

Thermal stratification is the result of temperature differences in the water column. Water reaches its maximum density at 4° C. It is lighter at both warmer and colder temperatures. Density variances at different temperatures within a lake can be sufficient to prevent mixing of warm and cold water. This density difference forms a barrier between the shallow and deep water of a lake that is known as thermal stratification or the thermocline (Figure 3-2).

As summer approaches, the surface waters of a lake warm, expand, and become lighter than the lower waters. A barrier begins to form between the lighter, warmer surface water and the heavier, cooler bottom water. A noticeable drop in temperature marks the barrier as depth increases to the thermocline.

The zone of transition between warm and cold water, on either side of the thermocline, is known as the metalimnion. It separates the warmer, lighter surface water known as the epilimnion from the colder, heavier bottom layer of water called the hypolimnion. During the spring and fall there is a relatively uniform temperature from the top to the bottom of the lake. However, in stratified lakes, the mid summer the temperature profile has warmer water at the surface of the lake and cooler water at the bottom. The thermocline becomes a physical barrier in the lake. The barrier is easily crossed by fish, but prohibits the exchange of water between the epilimnion and hypolimnion.

The thermocline becomes most noticeable in mid to late summer. This stratification period lasts until air temperatures cools the surface of the lake and wind action is able to disrupt the thermocline. As the surface water temperature cools, it becomes denser, sinking and mixing under wind action to erode the thermocline until the entire water volume of the lake is of uniform temperature. The phenomenon that follows summer stratification is known as fall turnover.

As the water temperature cools below 4° C, it becomes less dense and floats on the more dense warmer water. Eventually, the water near the surface is cooled to 0° C at which temperature ice begins to form on the surface lake, sealing it off to the atmosphere for about four months. Winter stratification occurs as the cooler, lighter water and ice remain close to the lake surface, separated from the relatively warmer, heavier water near the bottom of the lake.

The arrival of spring brings warmer weather and the reversal of the stratification process, known as spring turnover. As the surface waters warm, they become denser and begin to approach the temperature of the warmer, lower water until the entire volume of the lake reaches the same temperature. Wind action serves to mix the lake until it reaches a uniform temperature of 4° C. Beyond this point, the surface waters continue to warm, become lighter, and float on top of the cooler water. This begins the summer stratification process over again.

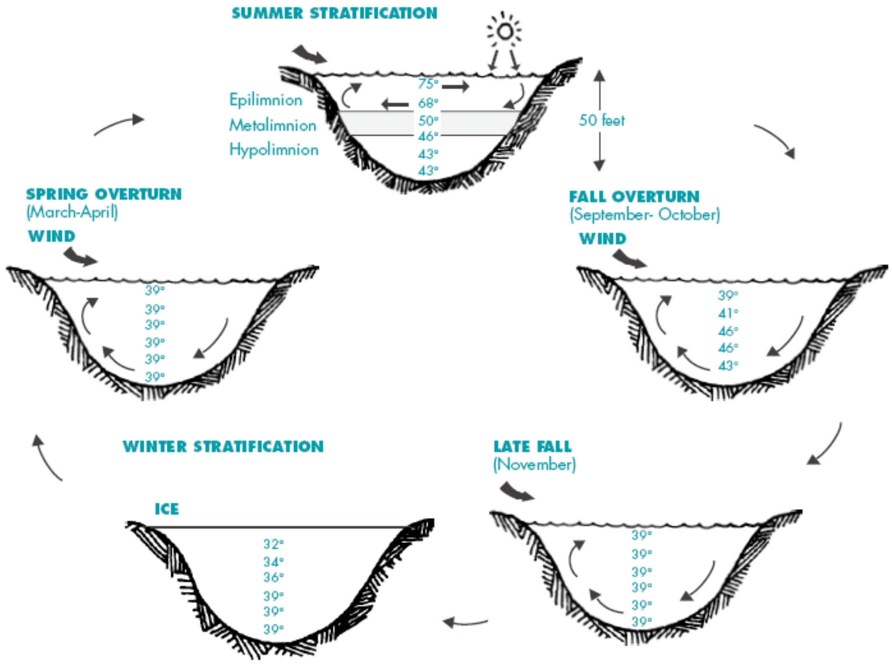

Figure 3-2
Seasonal Thermal Stratification of Lakes
Source: University of WI-Extension and SEWRPC

Stratification is also important to the dissolved oxygen levels of a lake. During stratification, the bottom waters of a lake are cut off from the atmosphere and new sources of oxygen. Oxygen levels can drop to low levels and harm aquatic life. In addition, chemical processes such as nutrient cycling in a lake are impacted by stratification.

Dissolved oxygen levels are very important to water quality. Dissolved oxygen is required by all aquatic animals and affects the chemical form of many compounds in the water column and water-sediment interface. Most warm water fish species require oxygen concentrations above 3.0 milligrams per liter (mg/l) to survive. Cold-water species require higher oxygen levels and require 5.0 mg/l of dissolved oxygen for long-term survival.

When any lake becomes stratified, decomposers and chemical processes in the hypolimnion, or deep waters, use up oxygen during the decay process. Stratification isolates the hypolimnion from the atmospheric supply of oxygen, and if stratification lasts long enough benthic dwelling organisms and organic decay may use up all of the available oxygen. This condition is called anoxia and may be harmful to aquatic life. The border between overlying oxygen rich waters and the deeper oxygen depleted waters is called the oxycline. Chemical processes are also altered in oxygen depleted waters creating a chemical gradient called a chemocline. Conceptually the oxycline and chemocline are similar to the thermocline. In anoxic waters the sediments more readily release phosphorus, manganese, and iron in the hypolimnion. Of most concern the effects of phosphorus release from the sediment. Once the lake becomes un-stratified, the phosphorus rich waters of the hypolimnion are mixed with the overlying surface waters enriching the entire water column. This process of phosphorus release from the sediments is called internal loading. The newly available nutrients may fuel algae and aquatic plant growth in following years.

METHODS

Samples were collected from the deepest point near mid-lake from June – August 2005 by John and Paul Zwick. Secchi depth, total phosphorus, chlorophyll-a, temperature, and dissolved oxygen were measured. All water quality parameters were collected, processed, and analyzed according to procedures outlined in the "Wisconsin Citizen Lake Monitoring Training Manual".

RESULTS AND DISCUSSION

Lake Emily was stratified during the months of July and August of 2005 (Figures 3-3 and 3-4). This is most evident in the declining dissolved oxygen levels from the surface to the lake bottom. Since the dissolved oxygen below the oxycline is less than 5 mg/l, that area of the lake is unsuitable for fish. Stratification is common in eutrophic lakes. While the low level of oxygen (<5 mg/l) reaches a depth of 6 feet or ~16% of the total lake volume. Low oxygen is a stress on fish populations when it isolates them from deeper, cooler water.

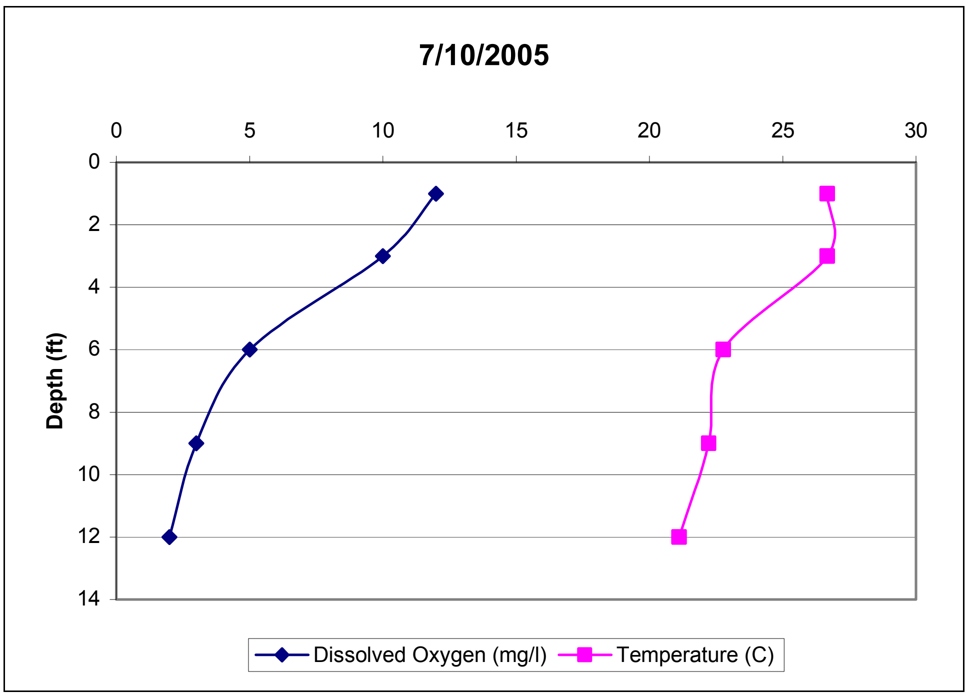

Figure 3-3
Dissolved Oxygen and Temperature Profile
Source: WDNR Self-Help

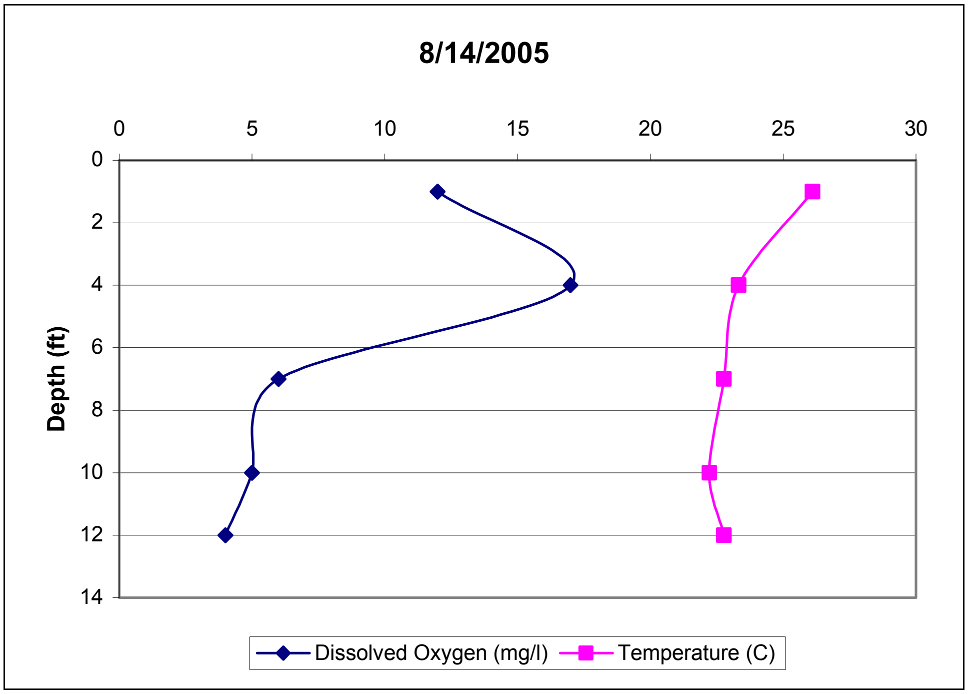

Figure 3-4
Dissolved Oxygen and Temperature Profile
Source: WDNR Self-Help

Trophic Status

Trophic status is an estimate of a lake's primary productivity and can be used to determine the nutrient enrichment of a lake. A trophic state index (TSI) assigns a trophic status (oligotrophic, mesotrophic, or eutrophic) based on growing season measurements of Secchi depths, total phosphorus, and chlorophyll-a. Carlson's trophic state index was developed to compare the three water quality values on a common scale from 0 to 100[1].

Established threshold values for TSI scores from 0 to 39 to describe lakes defined as oligotrophic – lakes that are generally clear, deep, and free of excessive rooted aquatic plants and algae blooms. Values 50 to 70 define eutrophic lakes – lakes that are high in nutrients and tend to support a large biomass of rooted aquatic plants and algae. Lakes with values above 70 may have an extreme amount of biomass are classified as hyper-eutrophic. Mesotrophic lakes have values from 40 to 49, and share characteristics of both oligotrophic and eutrophic lakes. Mesotrophic lakes may at times support dense algae growth or dense plant growth.

Water Clarity

Water clarity or transparency is an excellent indicator of overall water quality. A Secchi disk, which is a black and white eight-inch disk, is used to measure water clarity. It was created in 1865 by Pietro Angelo Secchi and is used to measure water transparency in open waters of lakes, bays, and oceans. The Secchi disk lowered slowly down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water – or the Secchi depth. Secchi depth is related to the overall turbidity of the water and is affected by water color, suspended solids, and algae density.

1 Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361-369.

The greatest advantages to using Secchi depth as an assessment tool are that it is a longstanding method to evaluate water clarity, it is inexpensive, measurements are simple, and it is easy to compare data between lakes and over time in the same lake.

As a general rule, sunlight typically penetrates to 1.7 times the Secchi depth into the water column. This region of the water column and lake bottom able to support photosynthetic organisms is called the photic zone. It is also the region of the lake where we would expect to find aquatic macrophytes and abundant aquatic life.

The average summer Secchi disk reading was 1.5 feet. The average for the Southeast Georegion was 6.2 feet. A Secchi depth of 1.5 feet corresponds to a TSI score of 71 which is just above the division between eutrophic and hyper-eutrophic categories. The current trophic state encourages nuisance macrophyte growth and algal blooms (Table 3-1).

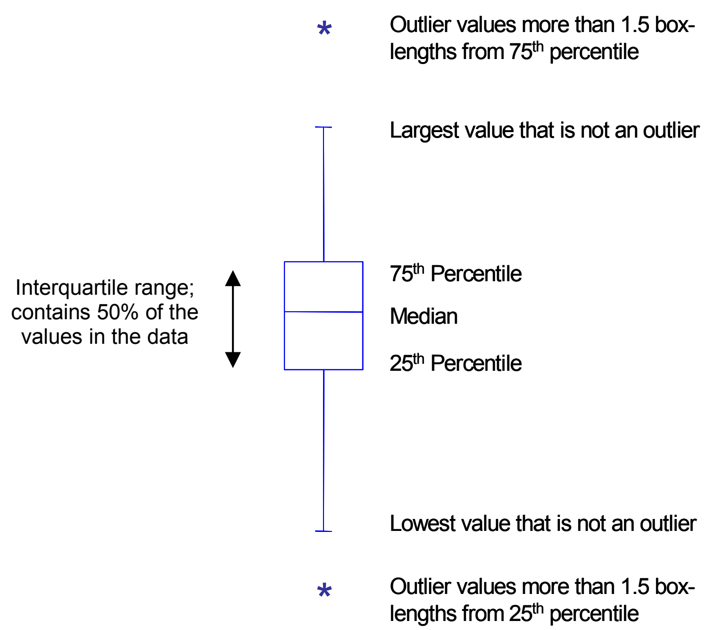

Figure 3-5
How to read a boxplot

A number of approaches are commonly used to present water quality monitoring data. While many comparisons are straightforward such as a value relative to an index, other long term or highly variable data use boxplots to visualize differences in sampling sites or sampling years. Figure 3-5 shows how to read boxplot. A boxplot is a graphing tool that displays the center, spread, and distribution of data. It provides a five-point summary of the data:

- The box represents the middle 50% of the data. This is the middle half or the typical values for the year.
- The top line of the boxed area represents the 75th percentile. Only the top 25% of value are above this point. The bottom line shows the 25th percentile.
- The dark horizontal line in the box shows the median for the group, or the point where half of the values fall above and half fall below.

- The vertical lines, or “whiskers,” extending above and below the box show the range within 1.5 box lengths from the end of the box. These represent the general range of values.
- The circles represent outliers, or rare cases, well away from the rest of the data.
- Overlap between the inter-quartile ranges usually indicates that values are the same between years.

Since all inter-quartile ranges overlap, Secchi depth indicate that the lake has had consistently low water clarity since at least 1994 (Figure 3-6)[2]. This also indicates that there is no trend indicating a decline in water clarity over this time period.

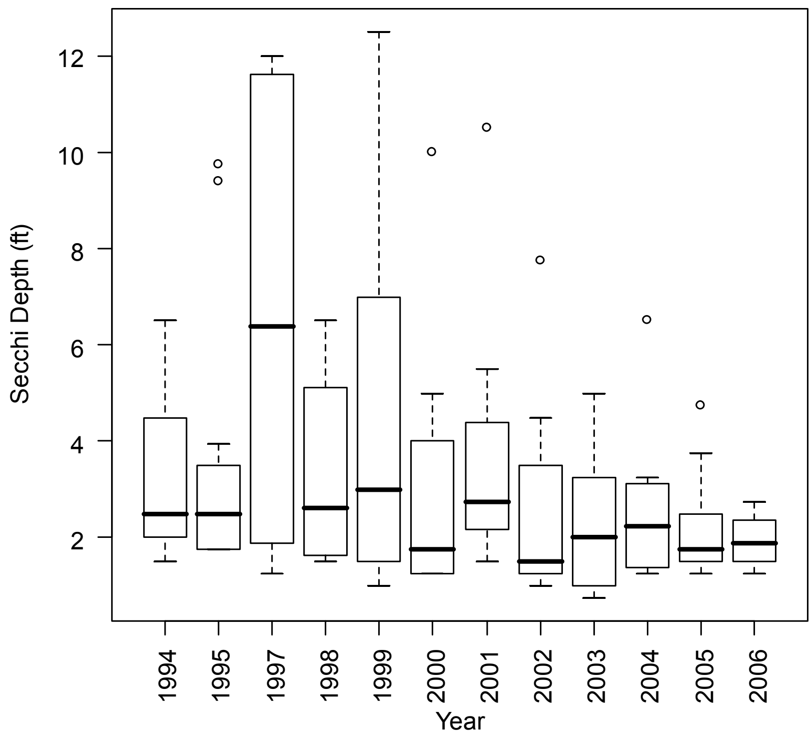

Figure 3-6
Historic Secchi Depths
Source: WDNR Self-Help Water Quality Data

[2] There was no statistically relevant pattern in water clarity using a rank-sum Kruskal-Wallace test.

Table 3-1
TSI Score Interpretation
Source: NALMS[3]

TSI	Attributes	Water Supply	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for an unfiltered water supply.	Salmonid fisheries dominate
30-40	Hypolimnia of shallower lakes may become anoxic		Salmonid fisheries in deep lakes only
40-50	**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible		Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scum and macrophyte problems	Episodes of severe taste and odor possible.	Nuisance macrophytes, algal scum, and low transparency may discourage swimming and boating.
70-80	**Hypereutrophy:** (light limited productivity). Dense algae and macrophytes		
>80	Algal scum, few macrophytes		Rough fish dominate; summer fish kills possible

Chlorophyll-a

Chlorophyll-a is the major photosynthetic pigment in algae that gives algae its characteristic green color. The amount of chlorophyll-a is an indicator of the amount of algal biomass in the water. Chlorophyll-a concentrations are usually lowest in the winter and reach their peak in the summer, when alga populations reach their maximum. Chlorophyll-a levels in excess of 10 ug/l typically result in water developing a green coloration that may impair some recreational activities.

Chlorophyll-a was measured on August 24th, 2005. Results showed 77.6 ug/l of chlorophyll-a. This level of chlorophyll-a usually supports a distinct green color to the water and correspond to a eutrophic TSI score of 67 (Table 3-1).

Nutrients

Nutrients are the driving force of lake ecosystems. Aquatic plants and algae require phosphorus, nitrogen, and numerous others for growth. In lakes where the supply of one or more of these nutrients is limited, plant and algae growth may also be limited. The two nutrients that most often limit growth are nitrogen and phosphorus. The limiting nutrient is determined by the ratio of total nitrogen to total phosphorus. If you add more of the limiting nutrient, you will see more algae or plant growth. Total phosphorus was measured on August 24th, 2005 at 106 ug/l. This measurement corresponds to a TSI score of 64 or the eutrophic category (Table 3-1).

[3] Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

TSI Score Interpretation

In addition to the basic information conveyed by TSI scores, the relationships between each of total phosphorus, chlorophyll-a, and Secchi depth can be a valuable tool to diagnose the sources of water quality problems (Table 3-2). Comparing the TSI scores for Lake Emily for August 2005 indicate that Lake Emily's water clarity is limited by algae dominated light attenuation (TSI(chl-a)=TSI(TP)=TSI(SD)).

Table 3-2
TSI Score Relationship Interpretation
Source: NALMS

Relationship Between TSI Variables	Conditions
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as Aphanizomenon flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation; zooplankton grazing or toxics limit algal biomass.

SUMMARY

Water quality monitoring indicates that Lake Emily is a eutrophic to hyper-eutrophic lake since at least 1994. This is supported by all three components of the TSI measured in 2005, Secchi depth, total phosphorus, and chlorophyll-a, and the historic Secchi depth Self-Help monitoring. As a result the lake is expected contain nuisance levels of aquatic plants and/or algae and support a bass-dominated fishery. The lake should exhibit periods of green coloration and odors that may discourage swimming and boating. Relationships between TSI scores indicate that the water clarity and light attenuation are primarily limited by algae in the water column.

CHAPTER 4 – AQUATIC PLANT SURVEY

INTRODUCTION

This chapter documents the results of the aquatic plant survey portion of the project. Hey and Associates, Inc. conducted the aquatic plant survey July 6th-7th, 2005. The focus of the survey was to document the abundance and distribution of rooted submergent aquatic plants, but data was also collected for floating-leaf aquatic plants, macroalgae, filamentous algae, and lake sediment characteristics. The following sections will describe the relevant ecological background, survey methods, and results.

BACKGROUND

Productivity in lakes is driven by phosphorus content. The presence of phosphorus in the water column and the lake sediments are what make many shallow lakes so biologically productive, or eutrophic. Lake Emily is at a minimum eutrophic based on water quality monitoring data and may even be shifting to an even more productive state called hyper-eutrophic.

Shallow eutrophic lakes such as Lake Emily exist in one of two conditions called "alternate stable states". They either support dense aquatic plant growth accompanied by relatively clear water, or they support dense planktonic algae growth. Characteristics of the clear water state include abundant aquatic plant growth, a diverse and productive gamefish community, and numerous zooplanktons. The turbid state is free of aquatic plants, produces dense algae populations, and supports an undesirable, bottom feeding fish population. A ball and cup model can be used to explain how the alternate stable states model functions (Figure 4-1).

The two axes of the model represent the interaction between nutrients and turbidity. Turbidity is a measure of water clarity. As turbidity increases, water becomes cloudier. The balls in the model represent potential conditions for a particular combination of nutrients and turbidity. In the two extreme examples in the alternate stable states model there is only one stable state. For the oligotrophic lake the single stable state is clear water while the alternate stable state for the ultra-eutrophic state is turbid water with dense algae. The remaining lake types may exist in either state.

For the mesotrophic, eutrophic, and hyper-eutrophic lakes the balls represent each of the alternate stable states. The left side of the model represents the clear water state while the right side represents the turbid water state. The lower the ball sits in the cup, the more likely a lake will seek out that stable state. The hump between the cups represents the amount of disturbance or management required to shift between stable states.

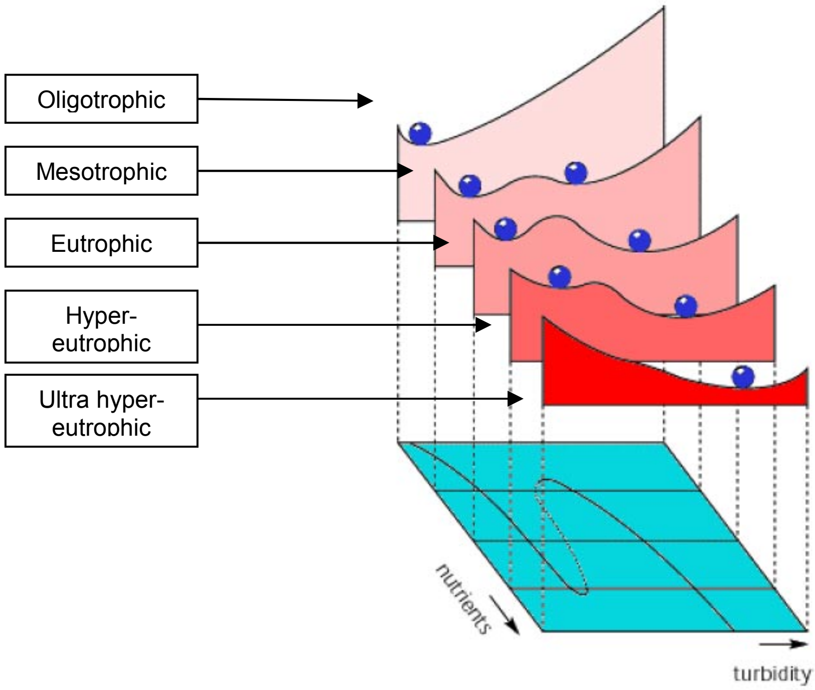

Figure 4-1
"Ball and Cup" model of alternate stable states
Modified from Sheffer 2001

Buffers are ecological factors in the lake that cause it to maintain either the clear water or turbid water states. Buffers can be viewed as the humps in the alternate stable states model.

Buffers that maintain a turbid water state include:

- Re-suspension of bottom sediment through wind action or boating activities may lead to increased turbidity that shades out aquatic plants and/or adding nutrients directly to the water column benefiting algae.

- Fish communities with a large number of Common Carp that typically uproot vegetation and re-suspend sediment and/or large numbers of zooplanktivorous fish. Common Carp can have the same effect as wind or boating on bottom sediment. Too many zooplanktivorous fish reduces the capacity for algae grazing and is usually caused by a lack of top predatory fish to regulate lower trophic levels.

- A lack of structure can reduce top predators since many fish use ambush techniques to catch their prey. A lack of structure also allows increased predation on grazing zooplankton. Both of these factors can contribute to increased algae density.

- Algae growth early in the growing season due to high nutrient availability. Since algae populations can expand rapidly under favorable conditions, aquatic plants never get established in the spring.

Buffers that tend to maintain a clear water state are:

- Plants minimize the impacts of wave energy on the lake bottom to minimize sediment re-suspension and protect existing plant beds.

- Plants compete with algae for light and nutrients.

- Plants provide refuges for zooplankton from fish predation. This facilitates grazing on algae.

- Plants provide their growing material for next year when they die back in the fall. Tightly packed or loosely packed sediment is a difficult medium for plants to grow on, but decaying plants from the previous year provide ideal growing conditions for many aquatic plants.

A “switch” is a term used for a buffer than can be manipulated in some way to cause the shift from a clear water state to a turbid state or vice versa. Research suggests that most forward switches, or a shift to a turbid state from clear water state, are largely a result of environmental degradation. Some important forward switches are the destruction of aquatic plant beds, re-suspension of sediment, and nutrient additions. Reverse switches, a shift from a turbid state to clear water state, in many cases are intentional management actions taken by lake managers. Some management activities that may promote a forward switch are called “Biomanipulation.” Biomanipulations attempt to alter the existing structure of the fish community to prevent sediment re-suspension or promote a healthy zooplankton community through a trophic cascade. Common actions include Common Carp removal or intensive stocking of top predators. In some cases installation of watershed structures designed to reduce nutrient additions to the water column can promote a forward switch.

A trophic cascade is the name for complex biological interactions occurring across a food chain (Figure 4-2). The presence/absence of aquatic plants plays an important role in trophic cascades. Trophic cascades occur in the following manner with respect to algal abundance in lakes. Top predators such as Northern pike are lost from a lake through over fishing, lack of reproduction, or reduced stocking efforts. Pike no longer feed on panfish populations so they become very large numerically yet the average panfish size decreases or becomes stunted. The overabundant small panfish feed on zooplankton and deplete the zooplankton population. Since zooplankton graze on algae suspended in the water column, reduced populations of zooplankton usually result in lower water clarity. Two of the important ecological services provided by aquatic plants are cover for predatory fish that allow them to ambush their prey and refuges for zooplankton to avoid predation by panfish.

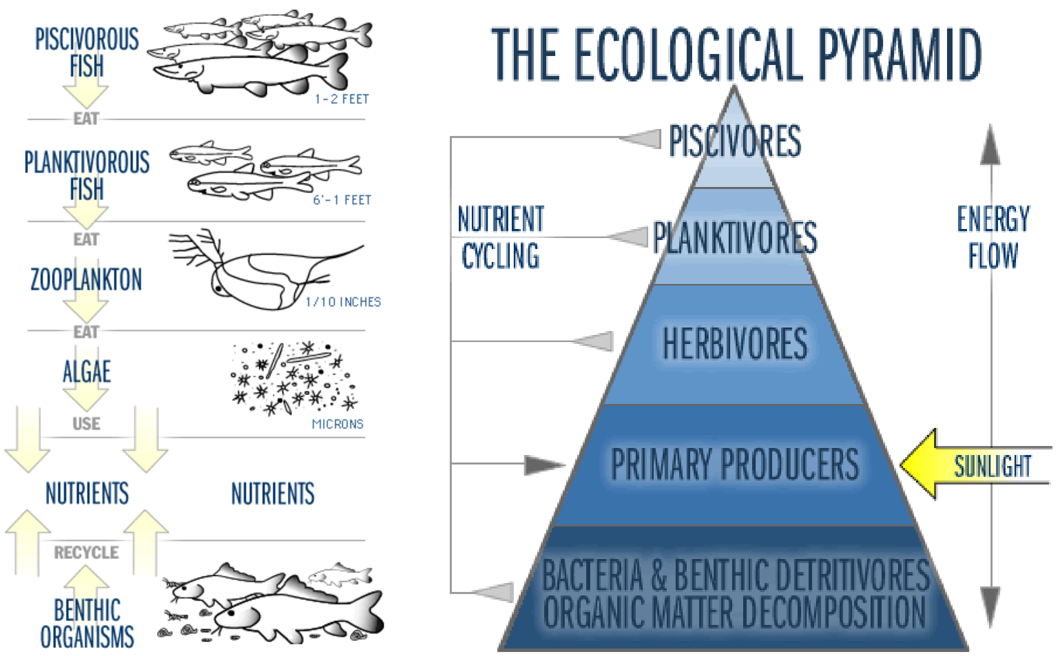

Figure 4-2
Trophic Cascade Interactions in Lakes
Source: Water on the Web

METHODS

Field Survey

A modified version of the Point Intercept Sampling survey technique was used to sample submerged aquatic plants on Lake Emily[1]. Point Intercept Sampling occurs on a regularly spaced grid throughout the littoral zone of the lake. The littoral zone is the portion of the lake extending from the shoreline lake-ward to the limit of occupancy of rooted aquatic plants.

Since there were no previous aquatic plant surveys on Lake Emily, a default depth of 20 feet was used to determine the location of the littoral zone. On Lake Emily, this includes the entire lake bottom. We overlaid a grid over a digital map using mapping software to determine sampling points. The sampling points were ~320 feet apart for a total of 115 points. Sampling points were entered into a portable global positioning system unit for easy location in the field.

Plants were sampled with a telescoping long-handled rake from a boat on July 6th and 7th, 2005. At each sampling point, four rake hauls were used to determine the abundance of aquatic plants. Abundance rankings range from zero where no plants were sampled on a rake haul to five for extremely dense plant growth. An abundance score of one means that a plant species was found on one rake haul, two means it was found on two rake hauls, and so forth. An abundance score of five means a plant was found on four rake hauls and completely covered the rake head on all four hauls.

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[1]Aquatic Plant Management in Wisconsin (draft). University of Wisconsin Extension. http://www.uwsp.edu/cnr/uwexlakes/ecology/APMguide.asp

Data Analysis

We analyzed the aquatic plant community using a statistical analysis approach recommended by the Wisconsin Department of Natural Resources[1]. Key statistics include the frequency of occurrence, relative frequency of occurrence, and the Simpson's Diversity Index.

Frequency of Occurrence

This measurement is the number of sites a plant species was collected divided by the total number of sites. The abundance of plants is not taken into account with this calculation. Only the presence/absence is noted. This value is also used to calculate the total percentage of littoral zone supporting aquatic plant growth. Estimates vary, but most healthy lakes will support aquatic plant growth in ~25 – 75% of the littoral zone.

Relative Frequency of Occurrence

The relative frequency of occurrence is the total number of occurrences of a plant species divided by the total number of sites with plant occurrences. The relative frequency tells a lake manager what type of plants to expect in areas that typically support plant growth. This is only applied to individual species and helps to identify patterns from year to year.

Density When Present

Density when present measures the sum of the individual abundance rating scores divided by the number of sample locations where the species was present. This is applied to each species and can provide information on how a species occurs. Some species occur at a low abundance lake-wide and others occur in dense, isolated patches.

Overall Density

Overall density measures the sum of the individual abundance rating scores divided by the total number of sample locations. This is applied to each species and estimates an overall lake-wide abundance. It tells us the average plant abundance per sampling site, or how many plants were found at sites with plants.

Maximum Rooting Depth (MRD)

The MRD is the deepest sampling point that contained rooted aquatic plants. This measure is an important estimate of water clarity. Aquatic plants usually grow at 2-3 times the Secchi depth.

Simpson's Diversity Index (SDI)

The SDI represents the probability that two individuals randomly selected from a sample will belong to different species. There are two components important to diversity – richness and evenness. Richness is the number of species per sample. Evenness is a measure of how species are distributed across samples. High evenness means that a most species have a moderately high relative abundance while low evenness means that one or two species dominate and the rest are rare. In a situation where a nuisance or exotic plant takes over the lake, this value will be low.

Floristic Quality Index (FQI)

The FQI is a biological index value based on the presence/absence of species and the ability of plants to tolerate disturbed conditions. FQI is calculated by multiplying the average C value for all native plant species by the square root of the number of native plant species collected. “C” is the coefficient of conservatism which is a value assigned to native aquatic plants estimating a plant’s likelihood to occur in an undisturbed lake. The values range from 0-10 with 10 representing an undisturbed condition and 0 representing severely degraded conditions.

Floating-leaf Plants

We also toured the lake and visually surveyed areas with large floating-leaf plants. Locations were noted on an aerial photograph. Since floating-leaf plants may be underrepresented in rake haul samples, this method was used to outline the location of significant plant beds.

Sediment Survey

Substrate type was determined with the telescoping rake. While sampling for aquatic plants, the rake was dragged along the lake bottom. Sediment type was determined based on the tactile qualities of the lake bottom and/or by examining material clinging to roots of aquatic plants. Categories for lake sediment are: silt, silt/sand, sand, sand/gravel, and rock boulder.

RESULTS

Aquatic Plant Survey[2]

Overall there is a moderately healthy aquatic plant community in Lake Emily, but there are also signs of stress due to the dominance of exotic and nuisance species. Submergent aquatic plants were found at 71.3% of all sampling locations at moderate densities (Figure 4-3). Both the frequency and abundance of aquatic plants are at acceptable levels to support fish, wildlife, and waterfowl. The maximum rooting depth was 11.5 feet. This means that most of the lake bottom in Lake Emily is capable of supporting aquatic plants. We calculated a Simpson’s Diversity Index value of 0.808 for Lake Emily. This score indicates a moderately diverse aquatic plant community. The Floristic Quality Index score for Lake Emily was 19.3, which is below average for Wisconsin lakes statewide (22.2). The average tolerance value, or coefficient of conservatism [3], was 5.8 and also below the statewide average (6.0). The Floristic Quality Index score and average tolerance value indicate Lake Emily has been exposed to moderate levels of disturbance in the past and its current aquatic plant community should be moderately tolerant of future disturbance.

[2] Aquatic plant distribution maps not found in the report body are located in Appendix A.
[3] Nichols, S.A. 1999. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management 15(2):133-141.

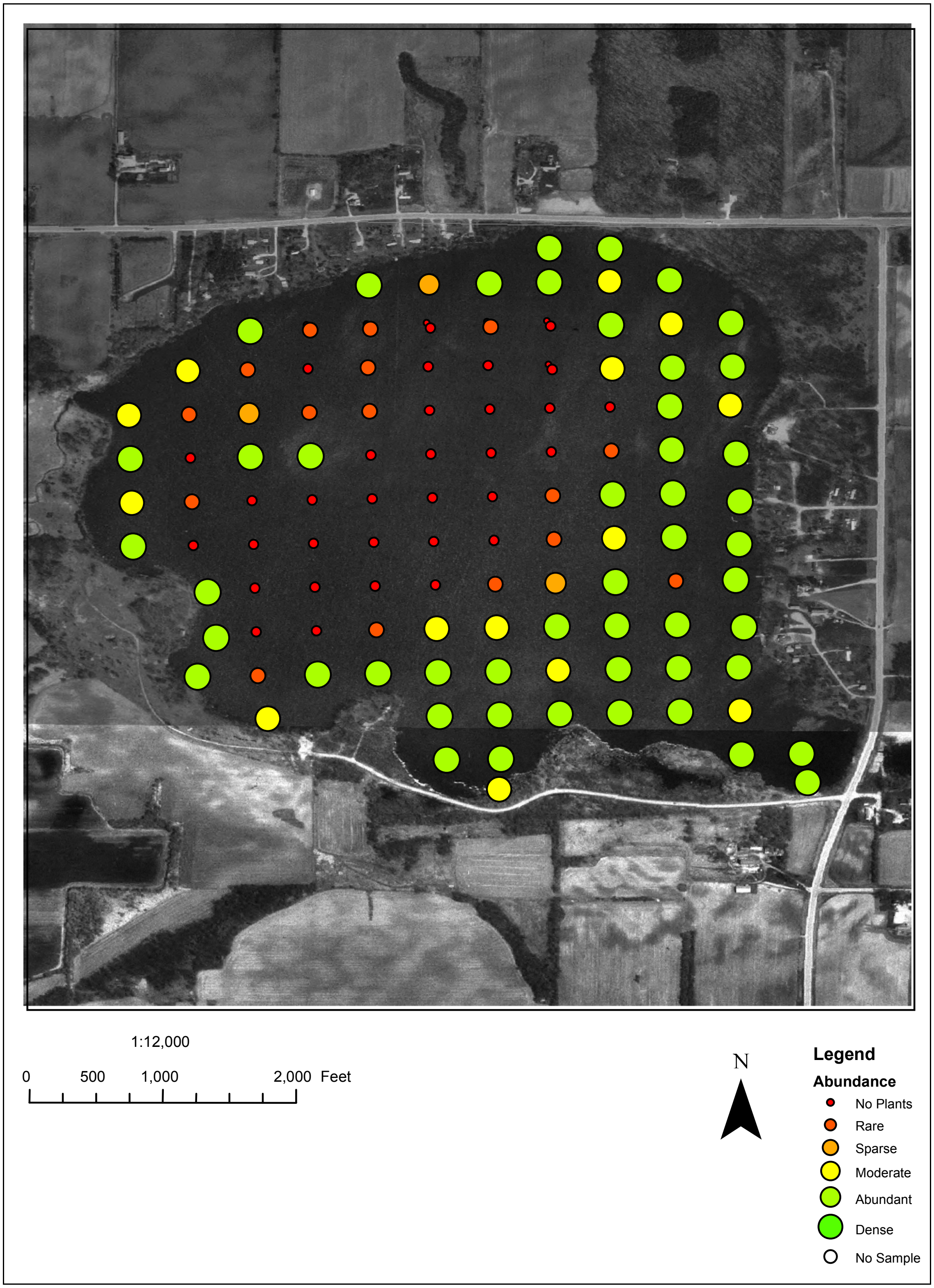

Figure 4-3
Submergent Aquatic Plant Distribution and Abundance
Source: Hey and Associates, Inc.

A total of six native and two exotic submergent aquatic plant species were collected (Table 4-1). An additional four floating-leaf aquatic plants were collected (Table 4-2). The exotic species collected were Eurasian water-milfoil (*Myriophyllum spicatum*, EWM) and Curly-leaf pondweed (*Potamogeton crispus*, CLP). Both are invasive in many lakes in Wisconsin and cause a number of ecological and recreational problems.

A stand of *Phragmites australis*, Common reed was found at the south shoreline of the lake at the edge of a cattail marsh fringe and the road side edge. Since the Common reed was growing along the road side edge and in a dense stand it should be suspect of being a non-native European strain of the plant which may require different management strategies.

In sporadic areas of the southeastern region of the lake aquatic plants were a navigational nuisance. The conditions were worst along the eastern shoreline. There plants formed dense beds at the water's surface and were composed of Eurasian water-milfoil (Figure 4-4) and Coontail (Figure 4-5). There was also a narrow band around the western shoreline of dense plant beds composed of Muskgrass *(Chara spp.)* near the water surface.

Table 4-1
Submergent Aquatic Plant Community
Source: Hey and Associates, Inc.

Name of Plant	Found at Sites	Frequency of Occurrence (%)	Density When Present	Density Overall	Relative Frequency of Occurrence (%)
All Aquatic Plants	82	71.3	2.3	1.2	100
Coontail	64	46	2.8	1.5	28.1
Eurasian water-milfoil	51	36.7	2.7	1.2	26.3
Flat-stem pondweed	24	17.3	1.5	0.3	10.5
Muskgrass	23	16.5	2.5	0.5	10.1
Curly-leaf pondweed[d]	22	15.8	2.3	0.4	9.6
Sago pondweed	12	8.6	1.8	0.2	5.3
Northern water-milfoil	10	7.2	2.8	0.2	4.7
White-stem pondweed	9	6.5	1.7	0.1	3.9

Table 4-2
Algae and Floating-leaf Aquatic Plant Community
Source: Hey and Associates, Inc.

	Found at Sites	Frequency of Occurrence (%)	Density When Present	Density Overall
Star duckweed	64	46	2.8	1.5
Filamentous algae	60	43.2	2.8	1.4
White water lily	24	17.3	1.5	0.3
Yellow water lily	23	16.5	2.5	0.5
Watermeal	22	15.8	2.3	0.4
Common duckweed	1	0.7	1	0.1

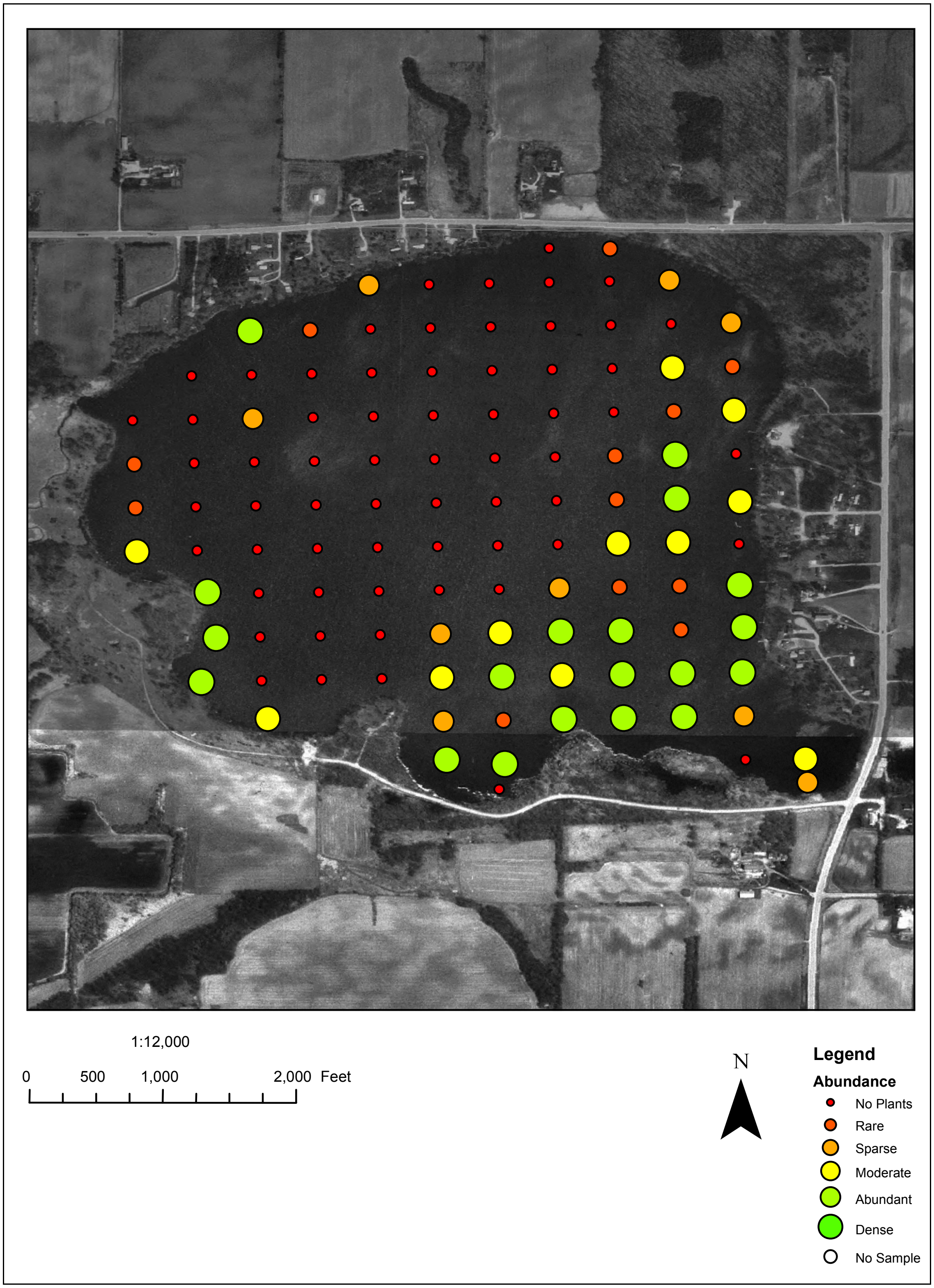

Figure 4-4
Eurasian water-milfoil Distribution and Abundance
Source: Hey and Associates, Inc.

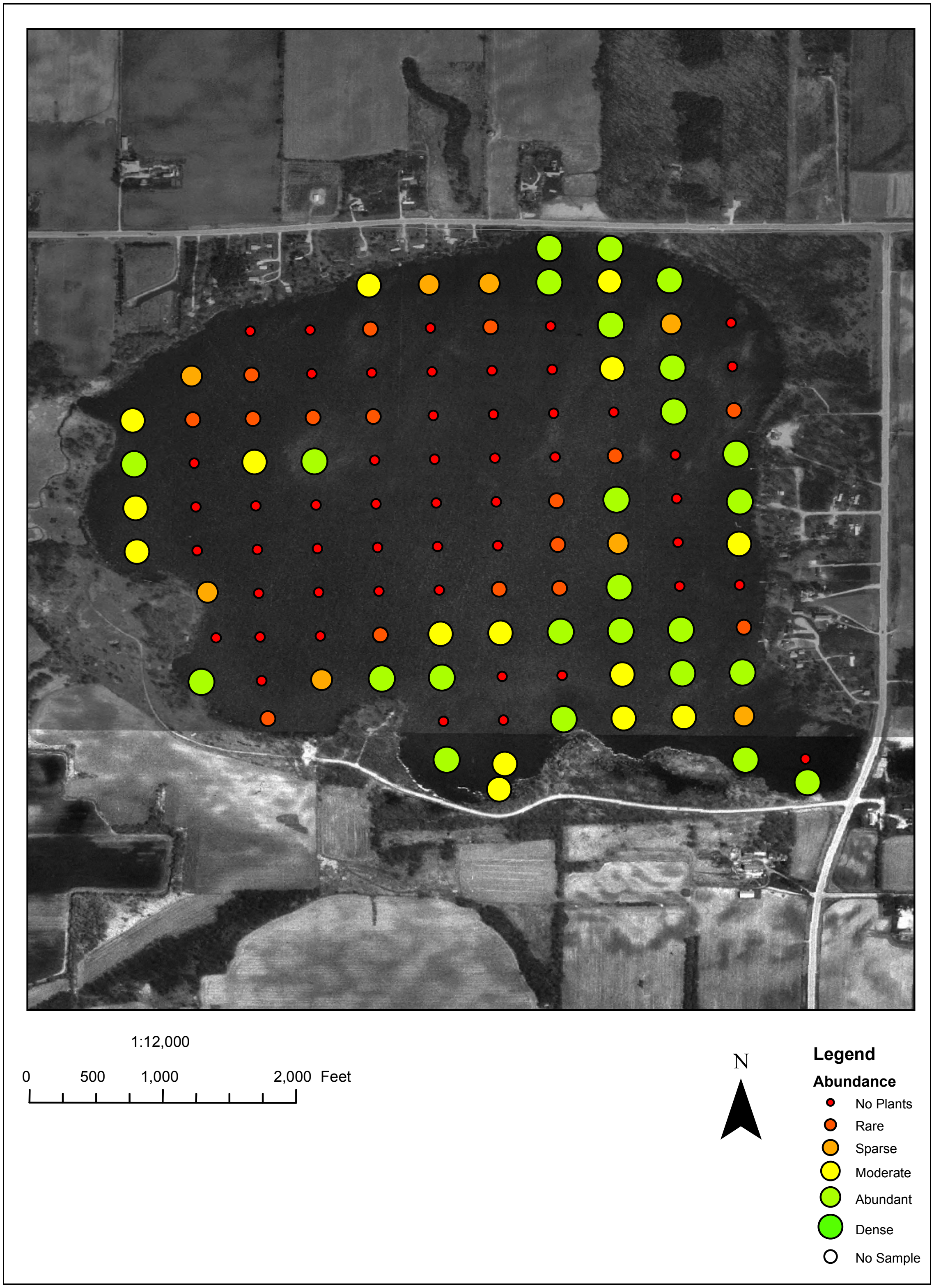

Figure 4-5
Coontail Distribution and Abundance
Source: Hey and Associates, Inc.

Non-native and Nuisance Submergent Aquatic Species

Eurasian water milfoil (*Myriophyllum spicatum*), a non-native invasive species, was found at fifty-one sampling sites on Lake Emily in 2005. It was the second most abundant plant found in the survey. EWM is highly invasive and requires management and monitoring on most lakes. In many shallow eutrophic lakes EWM takes over the entire littoral zone, pushes out native aquatic plants, and has a negative effect on fish and wildlife.

At the request of the Wisconsin Department of Natural Resources, four samples were sent to a genetic laboratory for testing to determine whether morphologically indistinct milfoil plants were of native, hybrid, or Eurasian varieties. Results confirmed our identifications of Eurasian water-milfoil and showed suspected hybrids were actually the native Northern water-milfoil. While this finding makes it easier to develop a management strategy for the lake, it may present future challenges if the native and Eurasian water-milfoil plants hybridize. Many hybrid water-milfoils that have crossed with native strains are very aggressive and well adapted to the naturally occurring conditions in Wisconsin lakes.

Curly-leaf pondweed (*Potamogeton crispus*), a non-native invasive species, was found at twenty-two sampling sites in Lake Emily. We did not actually collect the plant during the survey, but we found many turions on the lake bottom. Turions are the seeds produced by Curly-leaf pondweed that float around the lake and allow it to spread. This plant species grows from the late fall, throughout the winter, and naturally dies back during July. As a result, the density of this plant was probably higher during May and June.

Coontail (*Ceratophyllum demersum*) is a native plant that can occur at nuisance levels in some lakes. It was found at 64 sampling sites on the Lake. It was the most common plant in the lake in terms of frequency of occurrence, relative frequency of occurrence, and abundance. Since it is tolerant of cold water, Coontail provides habitat for fish and invertebrates in the winter. It is also utilized as a food source for waterfowl. Coontail may also grow in dense beds and interfere with boating. Coontail does not form true roots so it may also collect in windward areas.

Filamentous algae were found at 60 sites during the survey. Since this particular survey method is not designed to collect algae, the results were not included in some statistical calculations. The algae was usually found hanging from aquatic plants or settled on the lake bottom. An abundance of filamentous algae usually indicates that there is an excess of nutrients in the water column.

Native Aquatic Submergent Plant Species

Flat-stem pondweed (*Potamogeton zosteriformis*) was the most common non-nuisance native plant and was found at 24 sample sites. It is generally beneficial to fish, wildlife, and waterfowl. Fish use it as cover and eat invertebrates living on the plant surface. Many duck species, muskrat, and even deer will consume the plant.

Muskgrass (*Chara spp.*) is not an aquatic plant. It is actually a macroalgae that occupies an ecological niche identical to aquatic plants. It was found at 23 sampling sites. Muskgrass is valuable in terms of a source of food for ducks, cover for fish, and support invertebrate populations that feed young fish.

Sago pondweed (*Stuckenia pectinatus*) was found at twelve sampling sites in the lake. It is very common in lakes in southern Wisconsin. Sago pondweed is one of the most valuable food sources for waterfowl. It also provides some cover for fish. In some cases Sago pondweed will grow up to the surface, but it usually does not grow in sufficient density to become a nuisance.

White-stem pondweed (*Potamogeton praelongus*) was found at nine sampling sites in Lake Emily. It provides valuable cover for gamefish and food for waterfowl and wildlife.

Northern water-milfoil (*Myriophyllum sibiricum*) was found at ten sampling sites. It is a non-invasive native relative to EWM. While EWM thrives in disturbed lakes, Northern water-milfoil usually declines as a lake becomes more eutrophic. It does not comprise a major component of the aquatic plant community. Recent evidence suggests that Northern water-milfoil crosses with EWM to form an extremely aggressive hybrid.

Floating-leaf and Free-floating Plants

Large floating-leaf plants such as lilies (*Nymphaea spp.* and *Nuphar spp.*) were found at less than 1.0% of the sampling locations. The visual survey revealed a significant area of the lake is covered by lily pads (Figure 4-6). Lilies are a valuable component of the aquatic plant community. They provide shade and habitat for fish and invertebrates, seeds for waterfowl, and food for some wildlife.

Three types of free-floating plants were collected in the rake haul survey. They were: Star duckweed *Lemna trisulca*), Watermeal (*Wolfia columbiana*), and Common duckweed (*Lemna minor*). Star duckweed is the dominant free-floating plant in Lake Emily and found at 46% of survey sites. We typically found it on the lake bottom during the survey (not at the water's surface as expected) and believe it may have been associated with Curly-leaf pondweed beds earlier in the growing season. As Curly-leaf pondweed died off, the Star duckweed might have sunk to the lake bottom. Filamentous algae could also have attached to the duckweed and weighed it down. This appeared to be a consistent phenomenon throughout the lake where most Star duckweed we encountered was on the lake bottom. Watermeal and Common duckweed combined were only found at 17% of the survey sites.

Duckweeds spread rapidly across calm lakes that are enriched in nutrients. Under ideal conditions, duckweed populations can double in a few days. The rapid growth is caused by rapid vegetative or asexual reproduction. Studies show that duckweed can grow 30 percent faster than water hyacinth, one of the most invasive exotic aquatic plants in North America. Duckweeds are particularly successful in water with high levels of nitrogen and phosphate. As duckweeds grow they absorb these nutrients from the water column. Duckweed shades the underlying water and reduces the growth of algae. Preventing algal growth is beneficial because dead algal cells sink to the lake bottom and consume oxygen that is critical to fish and other aquatic organism health. Research has shown that duckweed spreads more quickly than other plants because they acquire nutrients directly from the water column. Under extreme conditions, submersed macrophytes may eventually decline as a result of being shaded out by algae and floating-leaf plants such as duckweed.

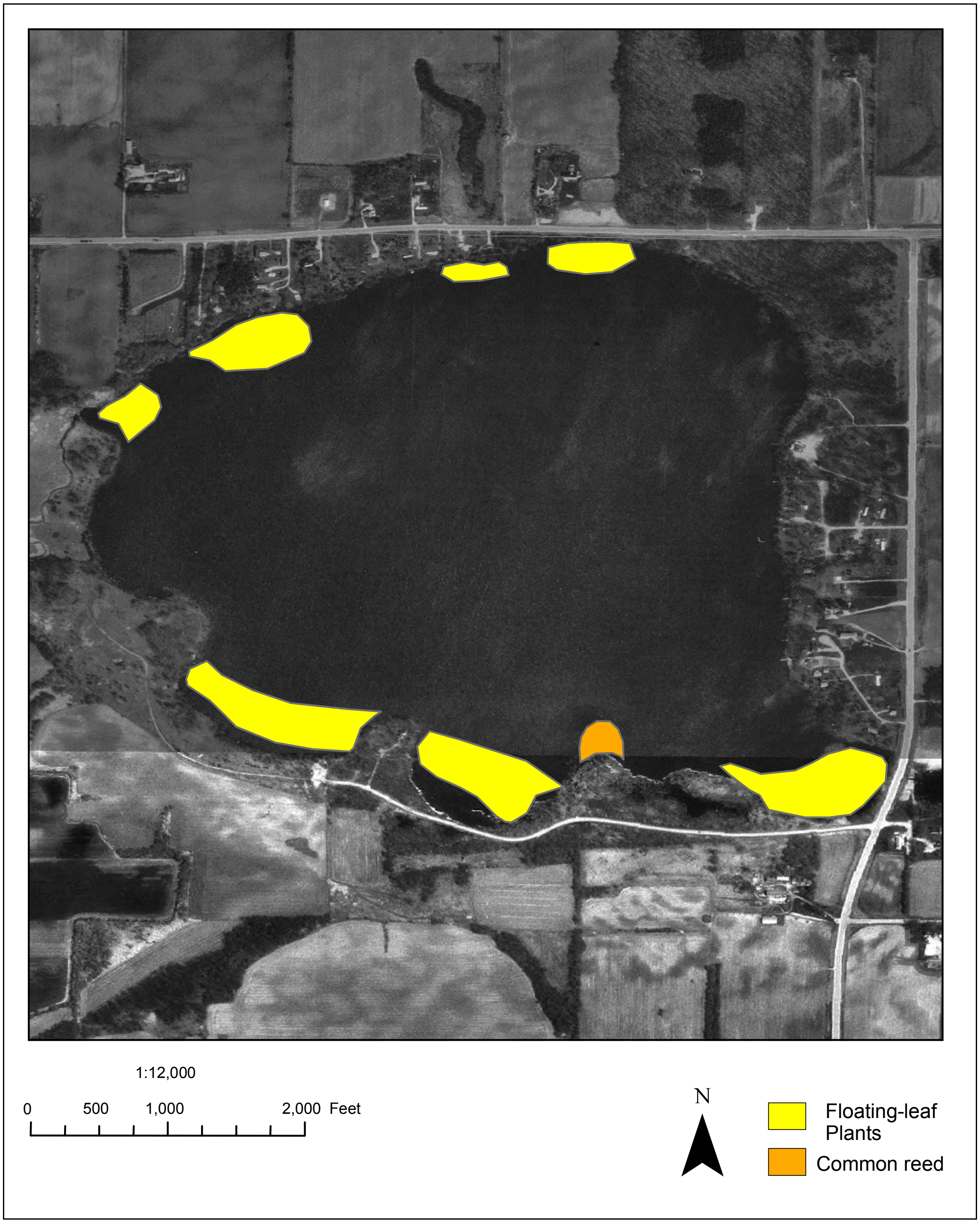

Figure 4-6
Floating-leaf Plant Distribution
Source: Hey and Associates, Inc.

Duckweeds continue to float as they initially die back using air pockets. This is an advantage in a management scenario because they can easily be skimmed off of the lake surface. Removing duckweeds in this manner also takes nutrients out of the water column and may reduce growth the following year. For this reason duckweed is used to remove nutrients in small ponds with too much nitrogen and phosphates.

Sediment Survey

We found the lake bottom composed of 92.9% silt with minimal representation of other sediment categories. It is evenly distributed throughout the lake (Figure 4-7). Silt is usually the result of land-based erosion and is very nutrient rich. As a result, silt readily supports abundant aquatic plant growth.

SUMMARY

As previously stated, there is a moderately diverse and healthy aquatic plant community in Lake Emily. There are also signs of stress due to the dominance of exotic and nuisance species. The Floristic Quality Index score for Lake Emily was below the statewide average, which indicates Lake Emily has been exposed to moderate levels of disturbance in the past. The FQI score does *not* indicate Lake Emily is among the most disturbed lakes in Wisconsin.

The exotic species present in the lake, Eurasian water-milfoil and Curly-leaf pondweed, are exotic invasive species that have negative ecological and recreational impacts. These exotic plant species are a cause for concern because of their aggressive nature. Currently they comprise about a third of the aquatic plant community. In a worst-case scenario, the entire lake bottom could be covered in dense beds of Eurasian water-milfoil.

Coontail dominates the native plant community and comprises about a third of the overall aquatic plant community. There are areas of the lake where Coontail is a nuisance to navigation. Highly beneficial native plants such as pondweeds compose the final third of the aquatic plant community.

The substrate and watershed characteristics of Lake Emily indicate that Eurasian water-milfoil may become a larger problem in the future. Turbid water conditions are known to promote topped out EWM beds and the silty soils are ideal for EWM growth.

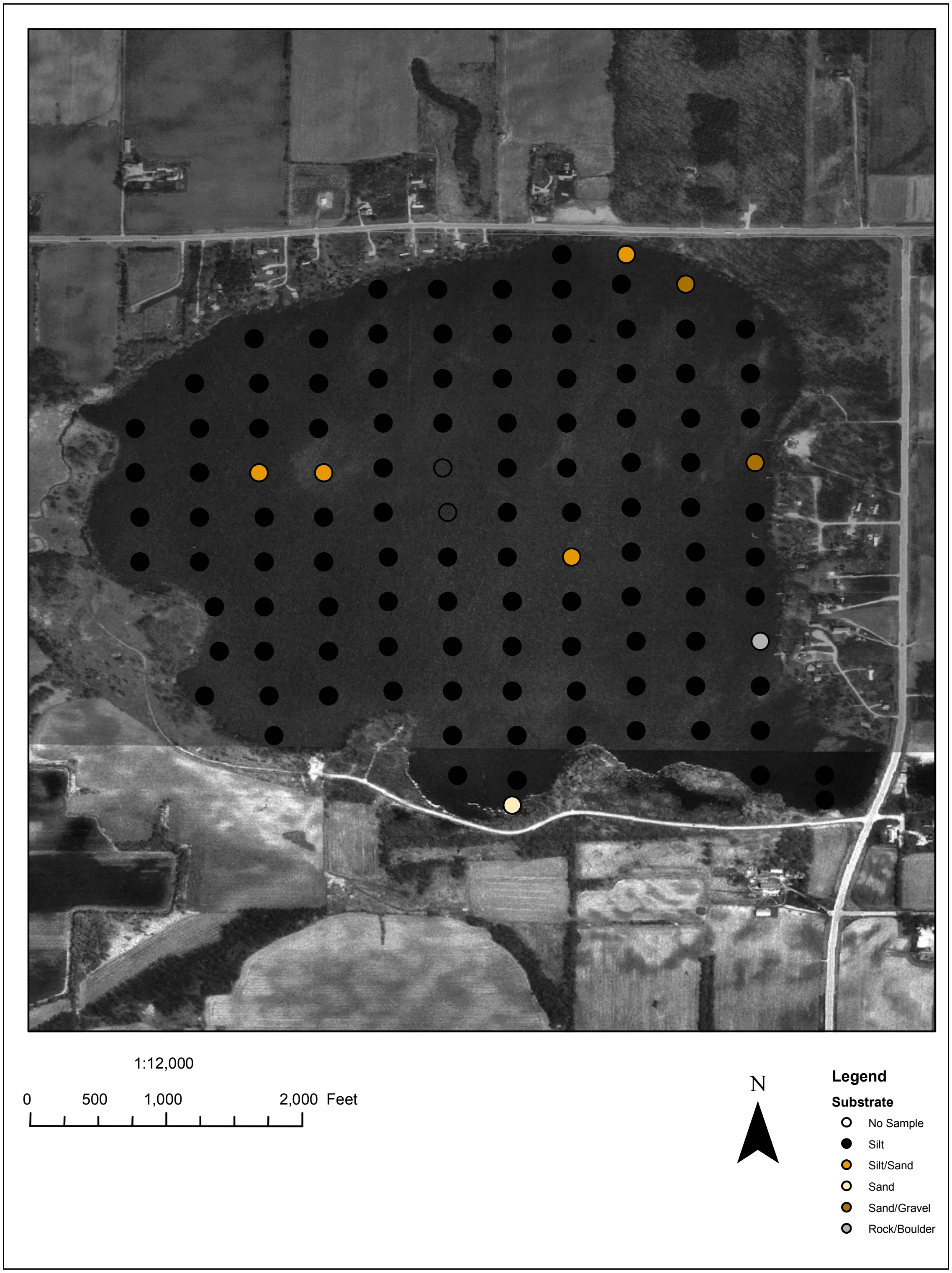

Figure 4-7
Lake Sediment Distribution
Source: Hey and Associates, Inc.

CHAPTER 5 – FISH SURVEY RESULTS

INTRODUCTION

As part of the comprehensive ecological lake assessment for Lake Emily, the Wisconsin Department of Natural Resources performed spring fyke netting and fall electrofishing surveys on Lake Emily. The following sections of this chapter contain the survey results as provided by the WDNR[1].

Spring Fyke Netting

Spring fyke netting was conducted on Lake Emily in Dodge County from March 30 through April 4, 2006. Spring fyke netting is conducted using 3-foot x 4-foot framed fyke nets set perpendicular to shore during the spring spawning season allowing for the collection of spawning northern pike. All fyke nets were set in the marshes located in the southeast corner of Lake Emily and were fished overnight, then lifted and reset each day. In order to standardize fisheries data, total effort, in the form of the number of nets fished each night is recorded and expressed as catch rates or catch-per-unit-effort (CPUE). For this survey, the total effort expended was 32 net nights. Lengths were taken from all northern pike sampled and a subset of scale samples were taken for aging analysis. Other species sampled were measured and all fish were returned to the lake. This survey and report serves as a snapshot of the fishery of Lake Emily during the spring of 2006, and is one portion of a comprehensive fishery survey being conducted on the lake throughout 2006.

Gamefish Summary

Target species for 2006 spring fyke netting was northern pike. Other gamefish species sampled during fyke netting included largemouth bass and walleye (one fish). The low number of largemouth bass sampled during this survey is typical of the fyke net gear used, and is not a reflection of low population levels. The best largemouth bass population data is obtained using electrofishing gear (to be conducted in mid-May and October 2006).

Table 5-1

Spring Fyke Netting Gamefish Summary for Lake Emily, Dodge County, WI 2006

Species	Number of Fish	Size Range (inches)	Average Length (inches)
Largemouth bass	37	5.3 – 19.0	14.8
Northern pike	766	8.3 – 32.4	21.6
Walleye	1	N/A	24.5

Northern pike

Abundance: 2006 Spring Fyke Netting Catch Rate = 766 total fish, or 33.7 fish/net night.

Size Structure: 2006 Length range = 8.3-32.4 inches.
2006 Average Length = 21.6 inches.

1 Compiled by Laura Stremick-Thompson, Department of Natural Resources (DNR) Fisheries Biologist, N7725 Hwy 28, Horicon WI 53032. Phone (920) 387-7876 or Laura.Stremick-Thompson@dnr.state.wi.us.

Northern pike catch rates for 2006 spring fyke netting were 33.7/net night. Of the 766 total northern pike measured, 114 or 15% were greater than 26 inches in length (current legal harvestable size). The average weight of the legal northern pike sampled, taking into consideration spawning condition, was 7.2 pounds. The largest northern pike sampled was a 32.4 inch female weighing 9.1 pounds. The presence of small (8-9 inch) northern pike may suggest natural reproduction as this species has not been stocked by DNR since 2002 (Figure 5-1). Scale samples will be aged at a later date to determine growth rates.

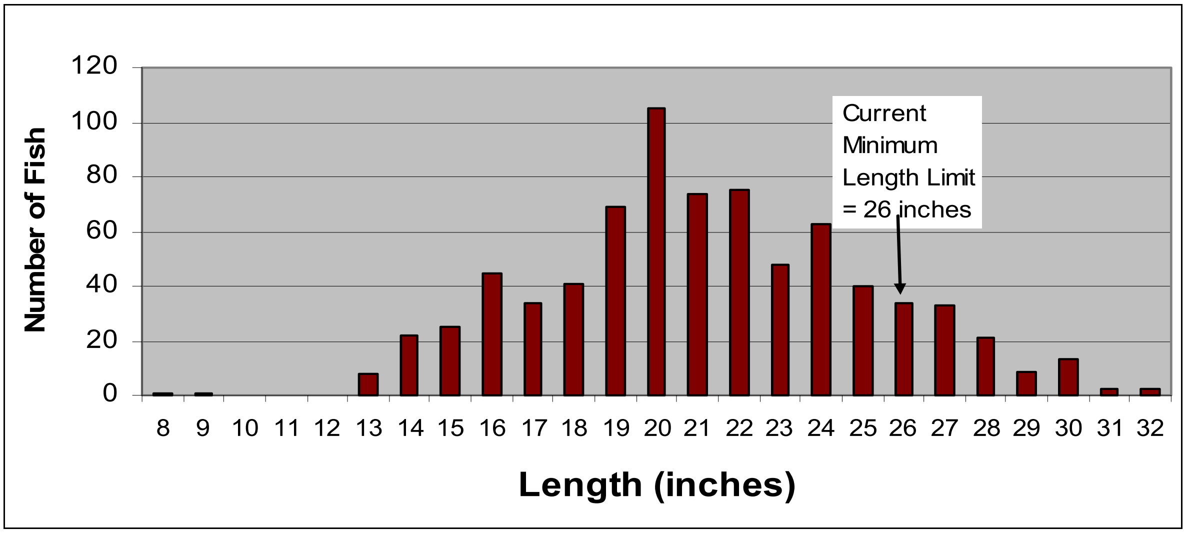

Figure 5-1
Northern Pike Size Distribution for Spring Fyke Netting 2006

Panfish Summary

The panfish species sampled during 2006 spring fyke netting included bluegill, pumpkinseed and black crappie.

Table 5-2
Spring Fyke Netting Panfish Summary for Lake Emily, Dodge County, WI 2006

Species	Number of Fish	Size Range (inches)	Average Length (inches)
Black crappie	200	5.2 – 9.2	7.7
Bluegill	1555	3.2 – 8.6	5.2
Pumpkinseed	46	3.9 – 6.6	5.7

Bluegill

Abundance: 2006 Spring Fyke Netting Catch Rate = 1555 fish total, or 48.6 fish/net night.

Size Structure: 2006 Length range = 3.2-8.6 inches
2006 Average length = 5.2 inches

Length measurements were taken on 185 of the 1555 total bluegill sampled during spring fyke netting. The majority of measured bluegill (50%) were between 5 and 6 inches in length and 30% were greater than 6 inches (Figure 5-2).

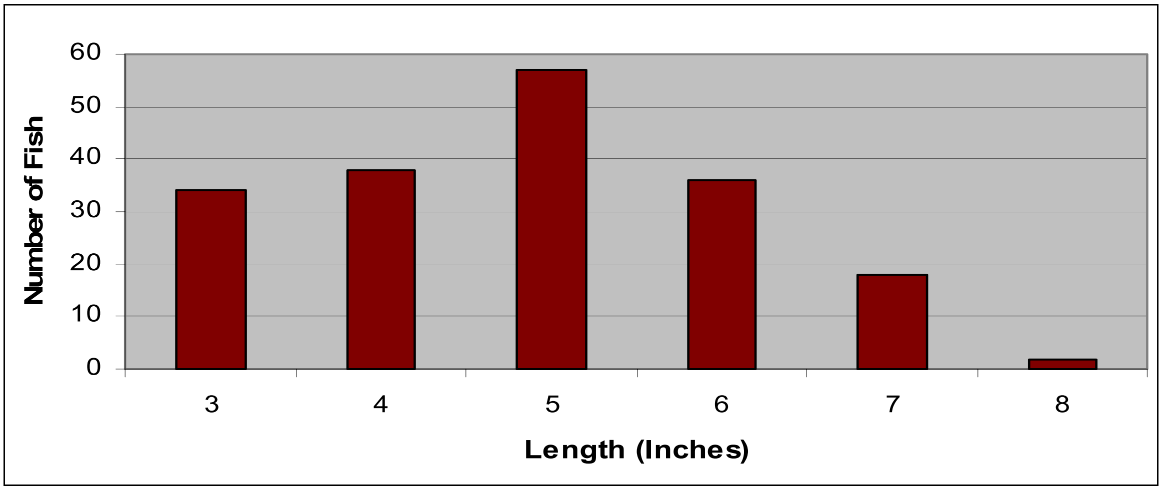

Figure 5-2
Bluegill Size Distribution for Spring Fyke Netting 2006

Other Species

Other fish species sampled during 2006 spring fyke netting included golden shiner, white sucker and brown and black bullhead. Painted turtles and snapping turtles were also sampled. The red-necked grebe, an endangered bird species in Wisconsin, was also observed on Lake Emily during this survey.

Table 5-3
Spring Fyke Netting Other Species Summary for Lake Emily, Dodge County, WI 2006

Species	Number of Fish	Size Range (inches)	Average Length (inches)
Black bullhead	1	N/A	8.2
Brown bullhead	10	8.4 – 14.1	12.8
Golden shiner	12	8.7 – 9.8	9.3
White sucker	3	17.4 – 20.4	19.3

Fall Electrofishing

Fall electrofishing was conducted on Lake Emily in Dodge County on October 12, 2006. Fall electrofishing is conducted using a large boomshocker boat allowing for the collection of young-of-the-year (YOY) and adult bass that are often undersampled by other gear types. In order to standardize fisheries data, total effort in the form of time spent shocking and/or miles of shoreline shocked is recorded. For this survey, the total effort expended was 1.47 hours (covering 2.35 miles of shoreline) and the following stations were sampled: 1.) Boat launch counter clockwise 3/4 way around the lake (60 minutes), 2.) North end of lake counter clockwise to boat launch (28 minutes). Lengths and scale samples were taken from a subset of fish collected and all fish were returned to the lake.

Our 2006 fall electrofishing survey coincided with very poor weather conditions including 30+ mph winds and temperatures below freezing. This weather pattern most likely affected the results of our survey as fish often move according to temperature changes and weather fronts and may have moved out of the shallow parts of the lake where our electrofishing gear is most effective. In addition, operation of the electrofishing boat is extremely difficult in high winds making detection of fish poor. This may explain why catch rates for all species encountered were extremely low during 2006 fall electrofishing (Figure 5-3). This summary report will present fall electrofishing data from 2006, and compare these results with similar surveys conducted in 2003.

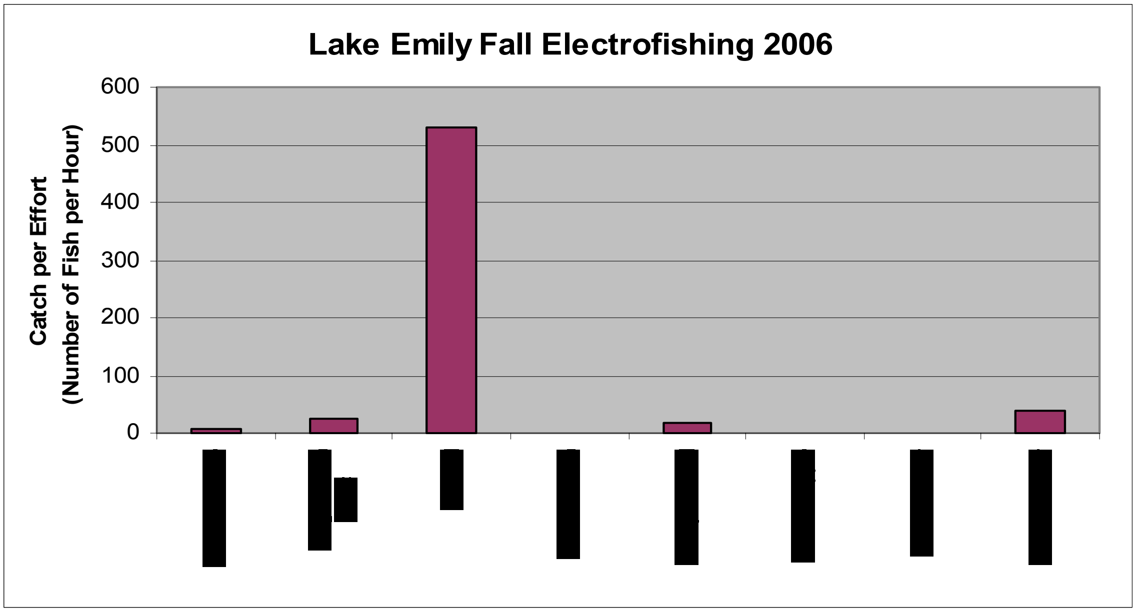

Figure 5-3
Fish Community Composition Fall Electrofishing for Lake Emily, Dodge County, WI 2006

Gamefish Summary

Largemouth Bass

Abundance:	2006 Fall Electrofishing Catch = 35 total fish or 23.8/hour 2003 Fall Electrofishing Catch = 86 total fish or 58.1/hour
Size Structure:	2006 Length Range = 3.3-15.7 inches 2003 Length Range = 2.4-16.6 inches 2006 Average Length = 11.1 inches 2003 Average Length = 10.8 inches

A total of 35 largemouth bass were sampled during 2006 fall electrofishing. The number of largemouth bass greater than 14 inches (current legal harvestable size) was 14.3% compared to 29.1% in 2003. The majority of fish sampled in 2006 (51%) were between 11.0 and 13.9 inches in length (Figure 5-4).

The largemouth bass population in Lake Emily is naturally reproducing and no stocking is currently conducted by the DNR.

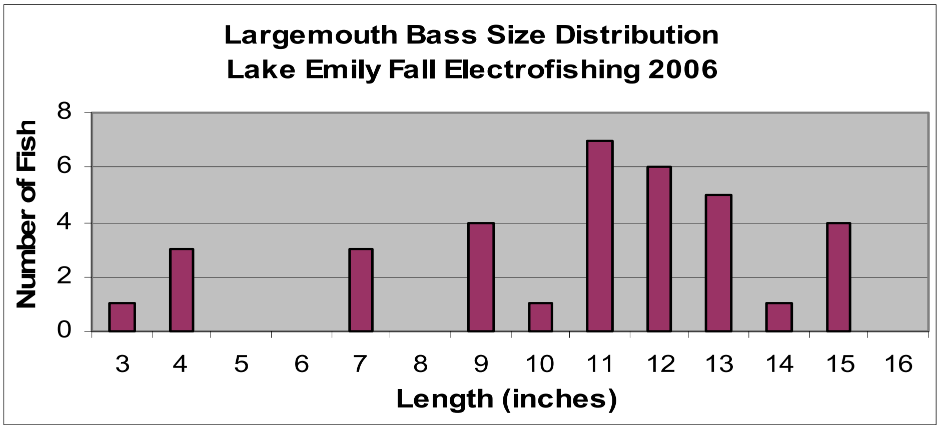

Figure 5-4
Largemouth Bass Size Distribution for Fall Electrofishing for Lake Emily, Dodge County, WI 2006

Northern Pike

Abundance: 2006 Fall Electrofishing Catch = 11 total fish or 7.5/hour
2003 Fall Electrofishing Catch = 18 total fish or 12.2/hour

Size Structure: 2006 Length Range = 12.1-23.2 inches
2003 Length Range = 17.4-34.2 inches
2006 Average Length = 18.7 inches
2003 Average Length = 21.8 inches

A total of 11 northern pike were sampled during 2006 fall electrofishing compared to 18 in 2003. The low number of northern pike sampled is typical for the electrofishing gear used, and is not a reflection of low population levels. Electrofishing is not an effective gear type to sample northern pike as their strength and swimming abilities allow them to avoid capture. The best northern pike population data is obtained using fyke nets set during the spring spawning season. The presence of northern pike under 16-inches (fish under 3-years of age) may indicate some level of natural reproduction is occurring in Lake Emily, as northern pike have not been stocked by DNR since 2002 (Figure 5-5).

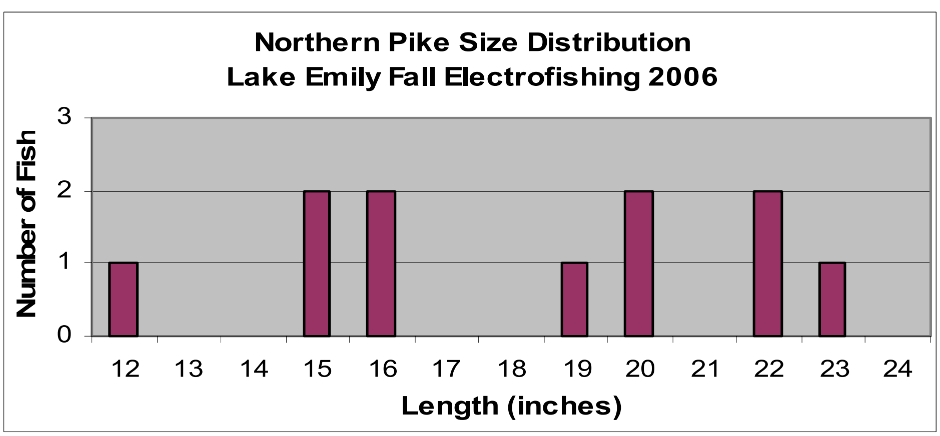

Figure 5-5
Northern Pike Size Distribution for Fall Electrofishing for Lake Emily, Dodge County, WI 2006

Panfish Summary

A large panfish community exists in Lake Emily, with bluegill being the most abundant species. Smaller populations of pumpkinseed, black crappie, and yellow perch also inhabit the lake (Figure 5-6).

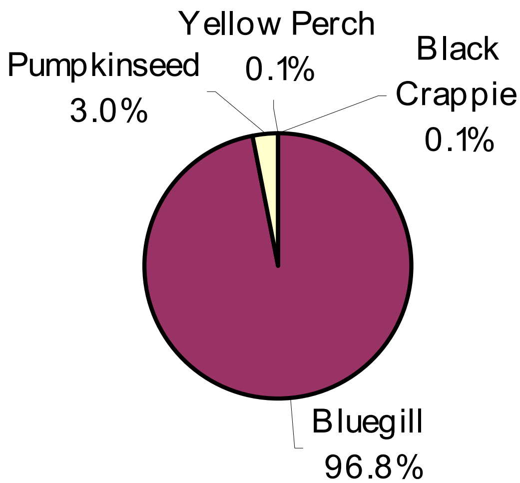

Figure 5-6
Panfish Community for Fall Electrofishing for Lake Emily, Dodge County, WI 2006 (n = 805)

Bluegill

Abundance: 2006 Fall Electrofishing Catch = 779 total fish or 529.9/hour
2003 Fall Electrofishing Catch = 8496 total fish or 5741.0/hour

Size Structure: 2006 Length Range = 2.2-7.2 inches
2003 Length Range = 1.5-8.5 inches
2006 Average Length = 5.3 inches
2003 Average Length = 4.2 inches

Length measurements were taken on 286 of the total 779 bluegill sampled, of which 30% were greater than 6 inches in length. The majority of bluegill measured (73.4%) were between 5.0 and 6.9 inches in length (Figure 5-7).

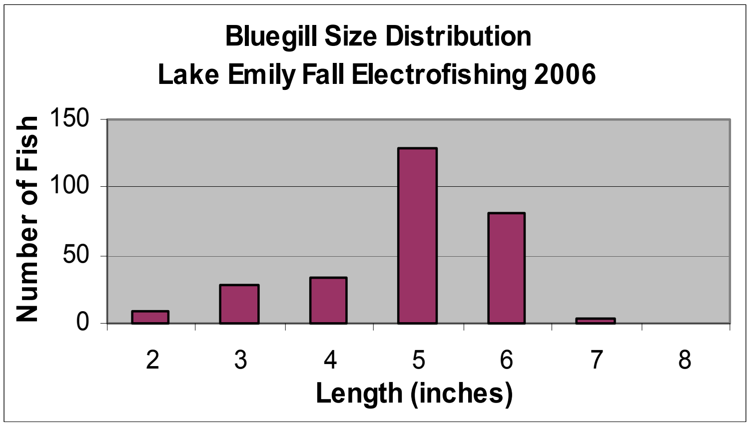

Figure 5-7
Bluegill Size Distribution for Fall Electrofishing for Lake Emily, Dodge County, WI 2006

<u>*Pumpkinseed*</u>

Abundance: 2006 Fall Electrofishing Catch = 24 total fish, 16.3/hour
2003 Fall Electrofishing Catch = 5 total fish, 3.4/hour

Size Structure: 2006 Length Range = 3.9-5.9 inches
2003 Length Range = 3.0-7.5 inches
2006 Average Length = 4.9 inches
2003 Average Length = 5.5 inches

Length measurements were taken on all 24 pumpkinseed sampled. The majority of pumpkinseed measured (95.8%) were between 4.0 and 5.9 inches in length (Figure 5-8).

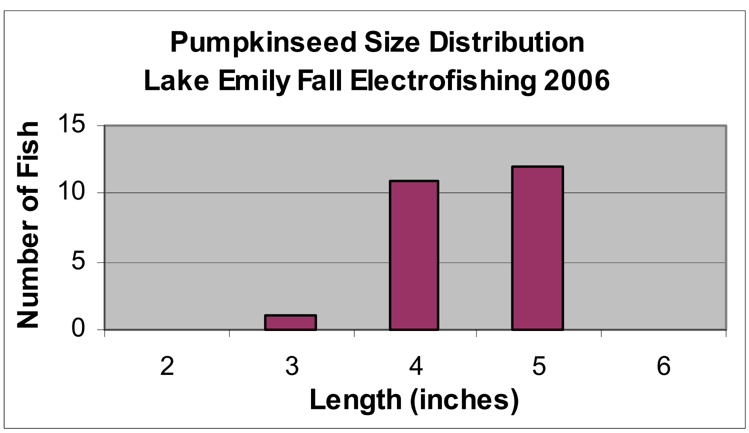

Figure 5-8
Pumpkinseed Size Distribution for Fall Electrofishing for Lake Emily, Dodge County, WI 2006

Crappie

Abundance: 2006 Fall Electrofishing Catch = 1 total fish, 0.7/hour
2003 Fall Electrofishing Catch = 6 fish total, 4.1/hour

Size Structure: 2006 Length Range = N/A
2003 Length range = 7.3-9.0 inches
2006 Average Length = 8.5 inches
2003 Average length = 8.1 inches

Yellow Perch

Abundance: 2006 Fall Electrofishing Catch = 1 total fish, 0.7/hour
2003 Fall Electrofishing Catch = 9 fish total, 6.1/hour

Size Structure: 2006 Length Range = N/A
2003 Length range = 4.4-8.4 inches
2006 Average Length = 7.3 inches
2003 Average Length = 5.5 inches

Non-game Species

Lake Emily contains a sizable population of golden shiners which serve as a primary forage species. Other species sampled during 2006 fall electrofishing included brown bullhead and white sucker.

CHAPTER 6 – LAKE MANAGEMENT RECOMMENDATIONS

INTRODUCTION

The following sections will provide a set of recommendations for lake management in 2006, implementation of key activities, and strategies for monitoring and evaluation. This section will be limited to recommendations related to water quality and aquatic plant management. The comprehensive fish survey report including recommendations for new fishing regulations on Lake Emily will be submitted by the WDNR at a later date.

Recommendations

Based on the 2005 aquatic plant surveys on Lake Emily, the following recommendations would be beneficial for future lake management and planning activities:

1. Conduct a spring aquatic plant survey to determine the abundance and distribution of Curly-leaf pondweed. Curly-leaf pondweed has a unique life cycle where it grows during the winter months. During the spring it may shade out native plants and prevent them from establishing well in the spring. When CLP dies back in late June or early July, aggressive plants such as Eurasian watermilfoil may spread into the newly unoccupied areas faster than native plants.

2. Continue to monitor the aquatic vegetation in Lake Emily to determine any trends in the native community. A robust native plant community is more resistant to exotic invaders while a declining native plant community will likely be overrun. Repeating a summer survey will allow us to begin to determine trends and anticipate management needs. At a minimum, the lake should be visually surveyed to document Eurasian watermilfoil and Coontail beds posing a recreational or navigational nuisance.

3. Develop an aquatic plant management plan. Due to the presence of exotic and nuisance aquatic plant species in Lake Emily, there may be a future need for large-scale plant harvesting or herbicide treatments. An aquatic plant management plan will facilitate the Lake Emily Fishing Improvement Club in goal setting and management strategies.

4. Prepare water, nutrient, and sediment budgets for Lake Emily and develop a comprehensive lake management plan. The purpose of the study would be to determine current nutrient and sediment inputs from the watershed and lake bottom and determine if reductions in in-lake nutrient levels are achievable. The modeling could be based on watershed characteristics and in-lake nutrient concentrations. As part of the water budget development, on inventory of potential watershed pollutant sources could be identified. The results could be used to evaluate various management scenarios. An effective nutrient management strategy could also lessen the impacts of Duckweed which is sensitive to changes in nutrient concentrations. Water and nutrient budgets are an important step in developing a comprehensive lake management plan.

APPENDIX A

AQUATIC PLANT MAPS

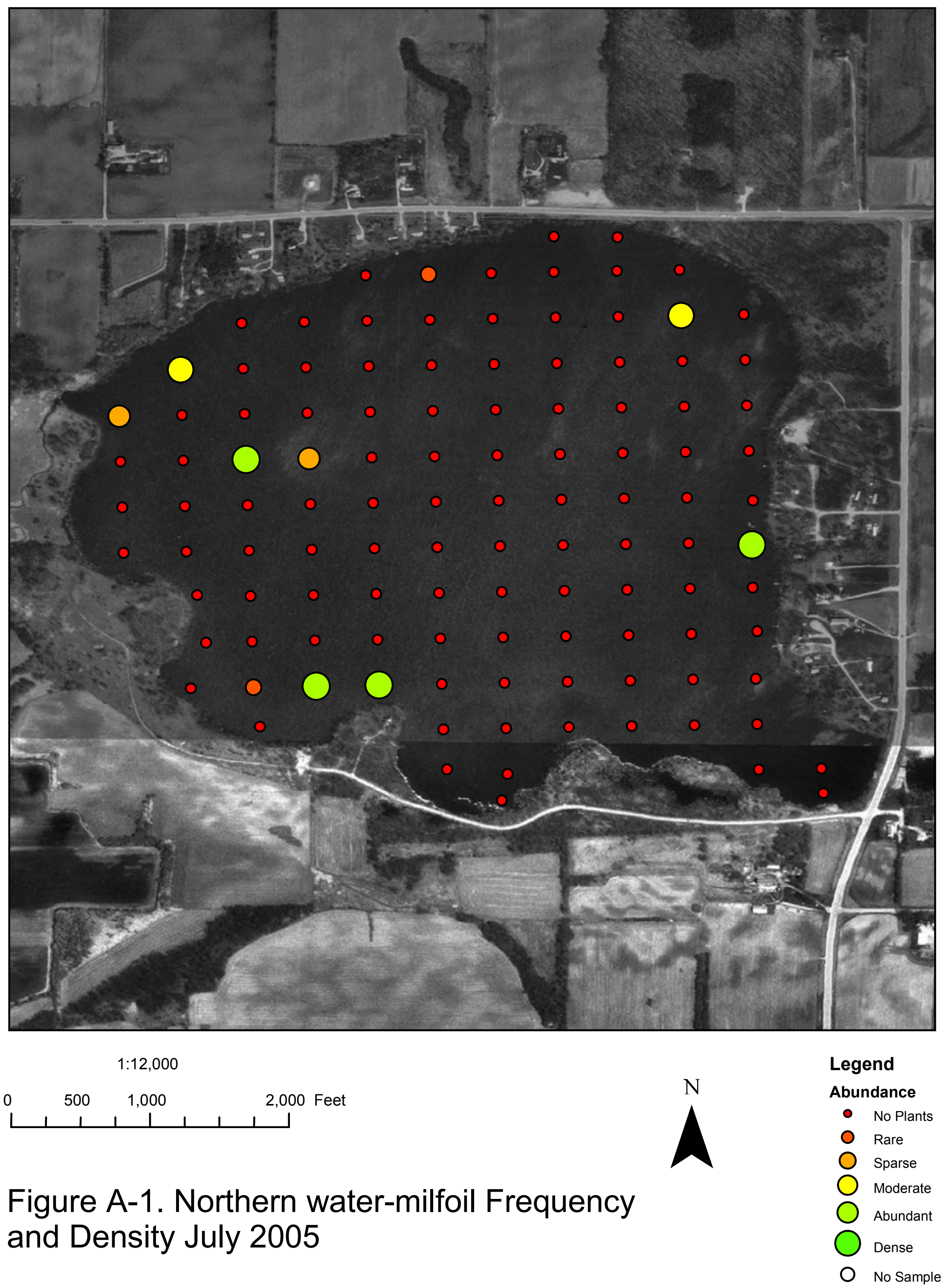

Figure A-1. Northern water-milfoil Frequency and Density July 2005

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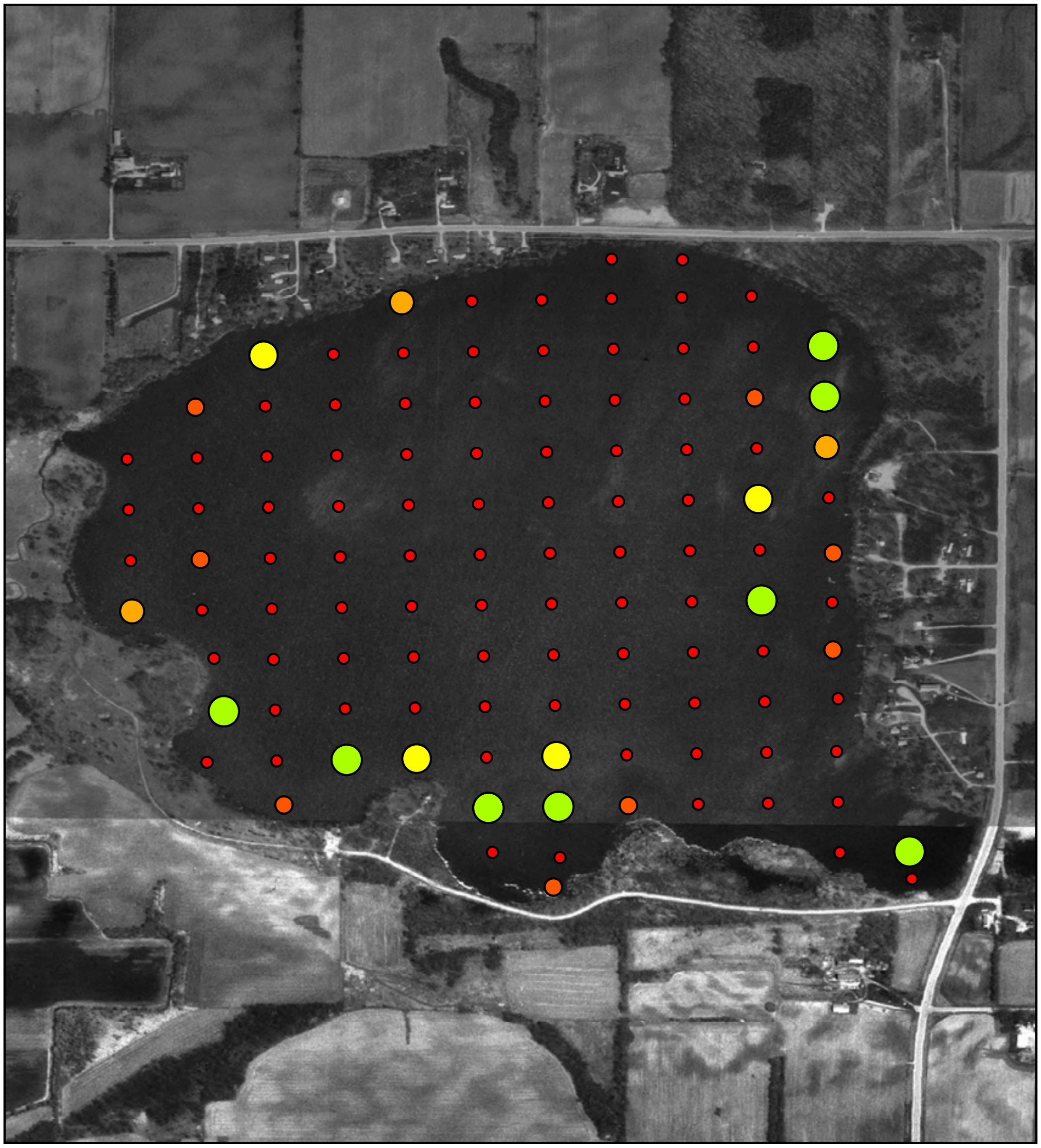
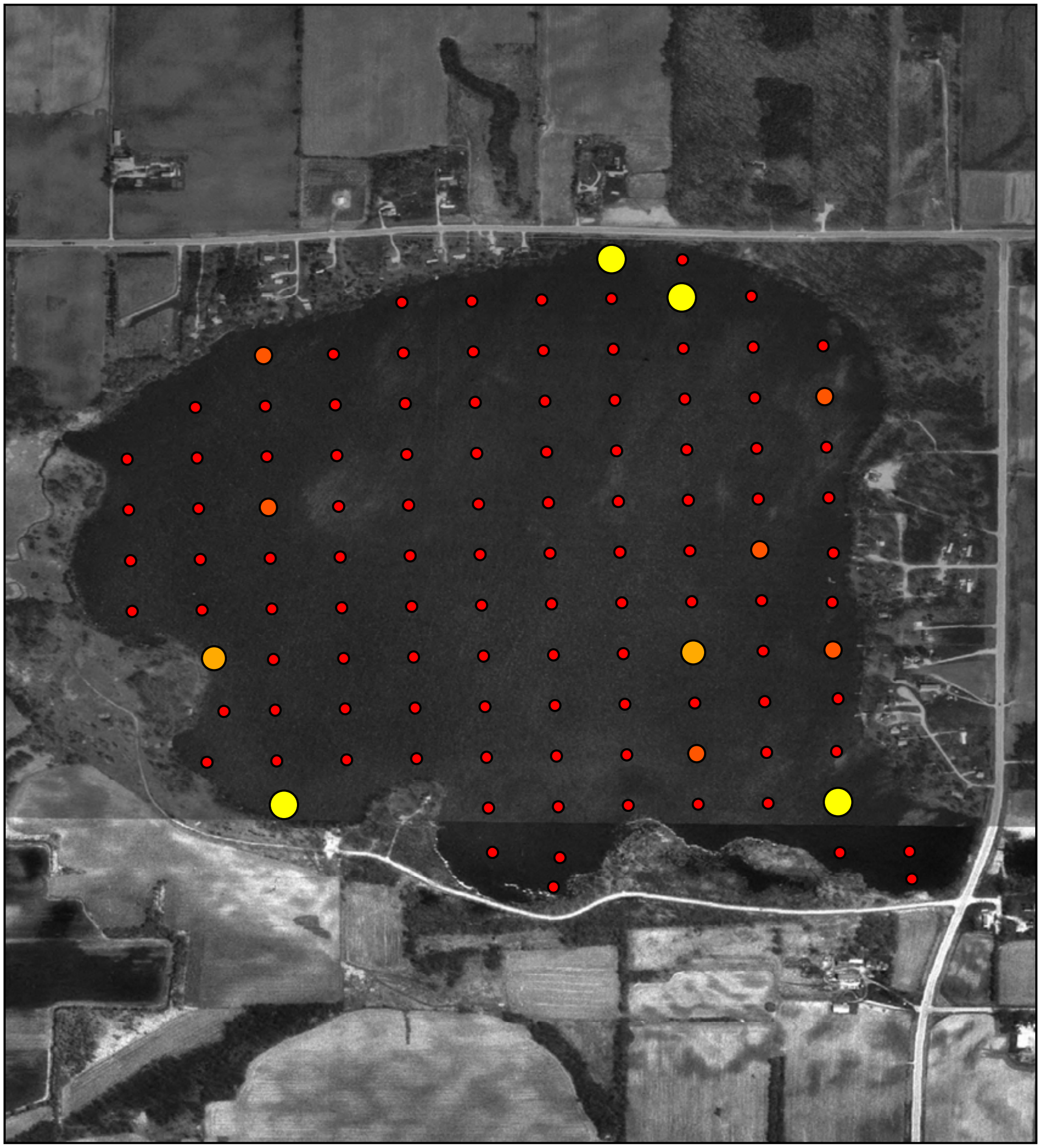


Figure A-2. Chara Frequency and Density July 2005

Hey and Associates, Inc.
Water Resources, Wetlands and Ecology



1:12,000

0 500 1,000 2,000 Feet

N

Legend

Abundance

- No Plants
- Rare
- Sparse
- Moderate
- Abundant
- Dense
- No Sample

Figure A-3. Sago pondweed Frequency and Density July 2005

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Water Resources, Wetlands and Ecology

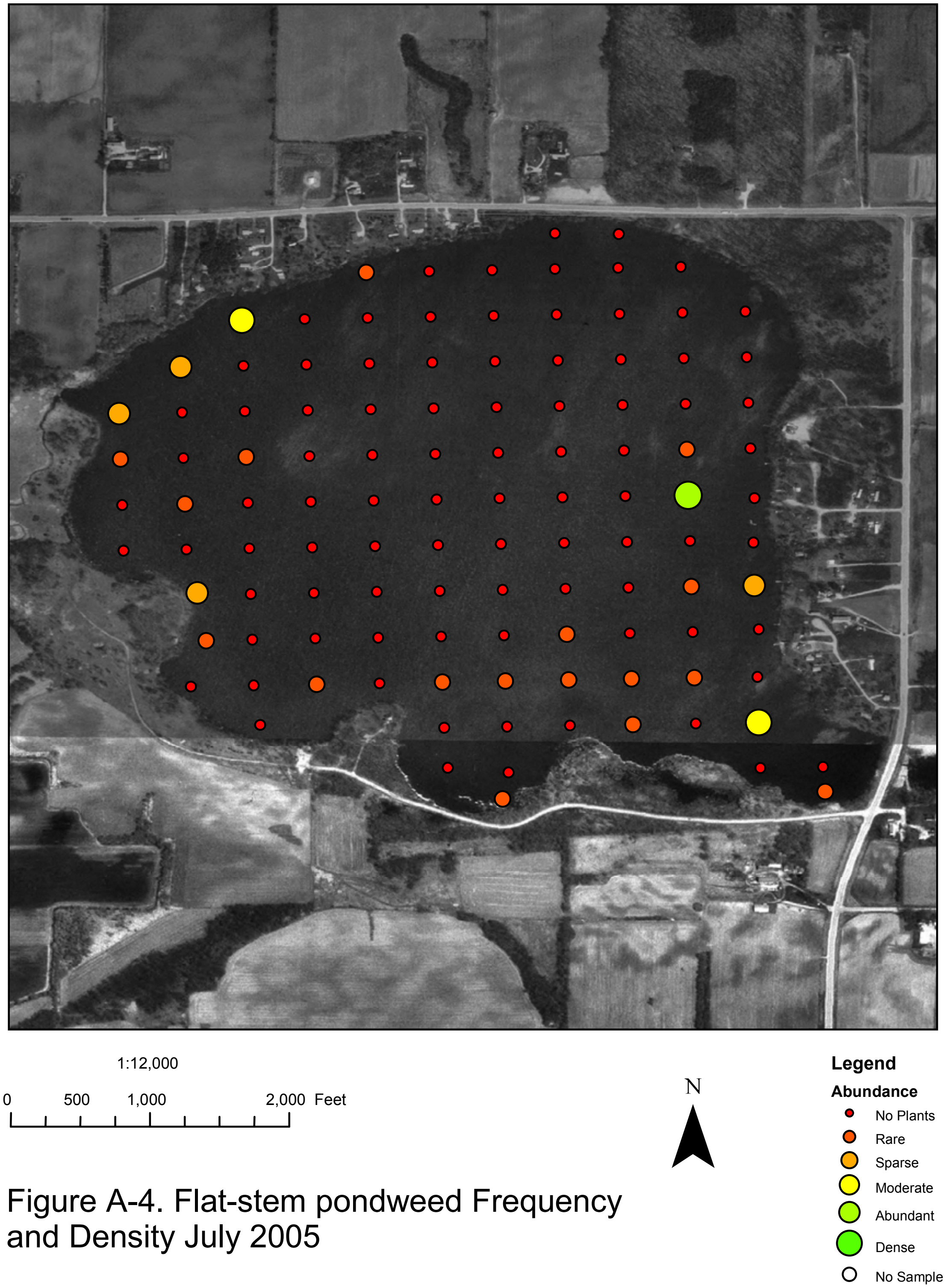

Figure A-4. Flat-stem pondweed Frequency and Density July 2005

Hey and Associates, Inc.
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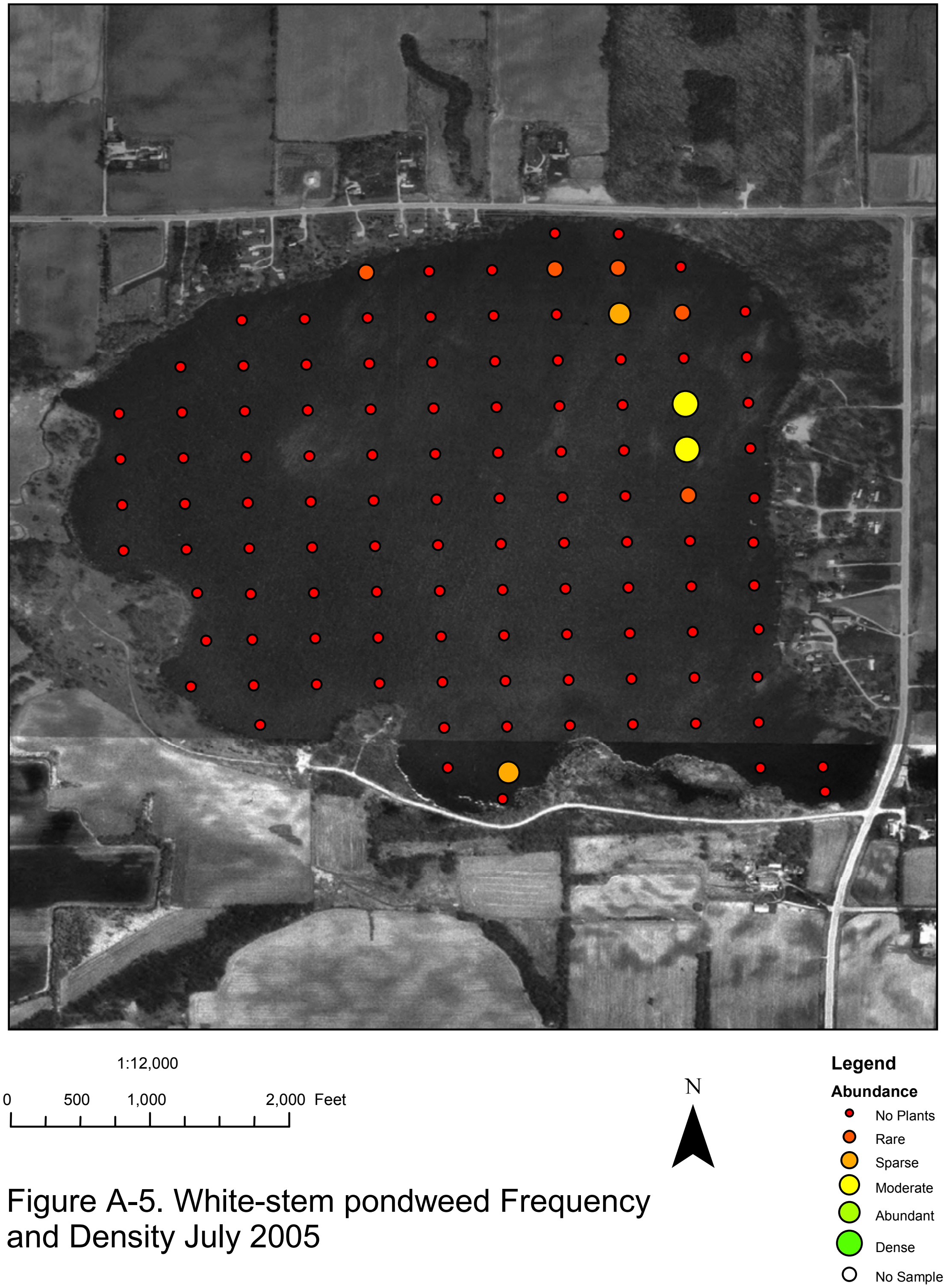

Figure A-5. White-stem pondweed Frequency and Density July 2005

Hey and Associates, Inc.
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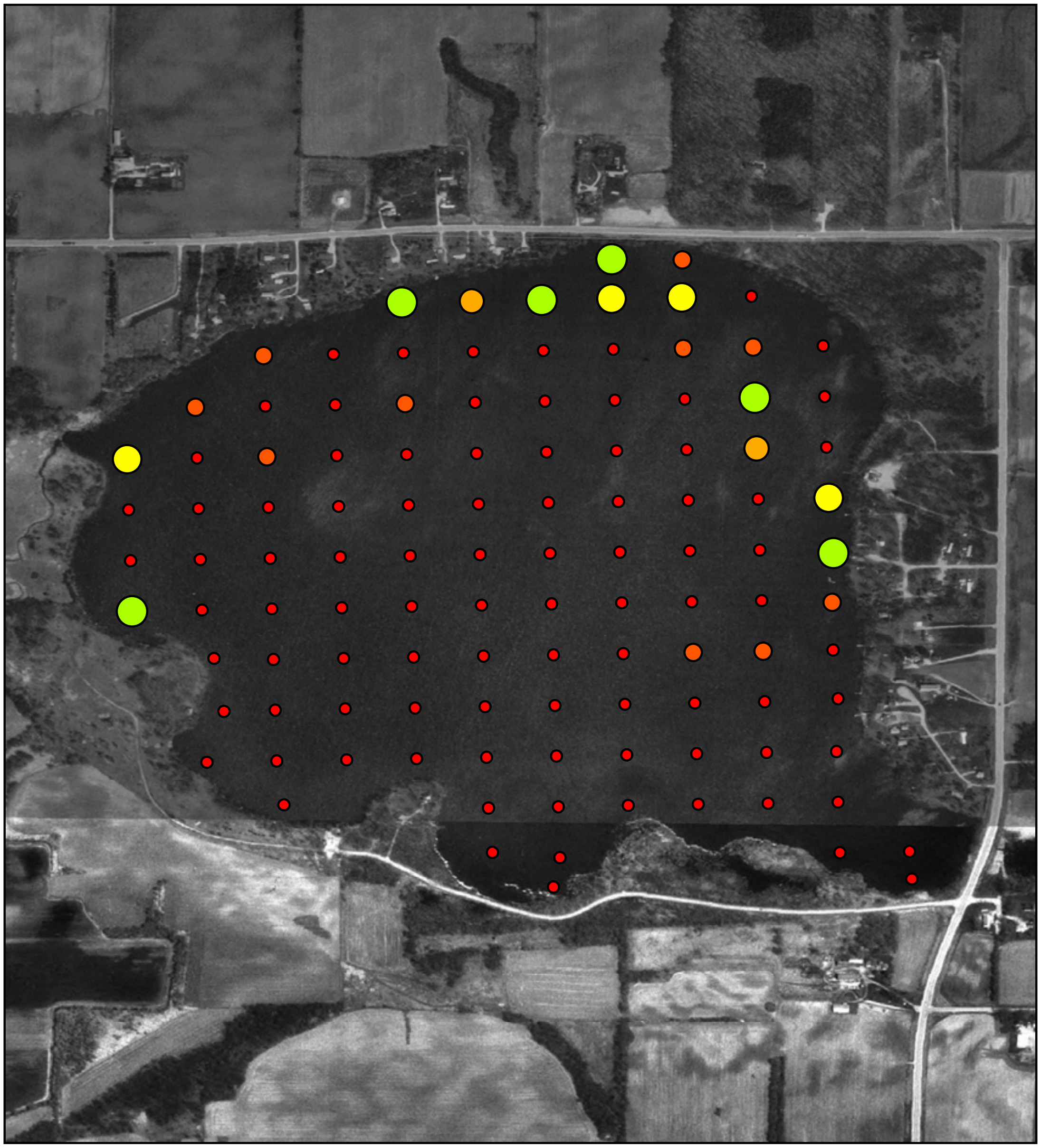

1:12,000

0 500 1,000 2,000 Feet

N

Legend

Abundance

- No Plants
- Rare
- Sparse
- Moderate
- Abundant
- Dense
- No Sample

Figure A-6. Curly-leaf pondweed Frequency and Density July 2005

Hey and Associates, Inc.
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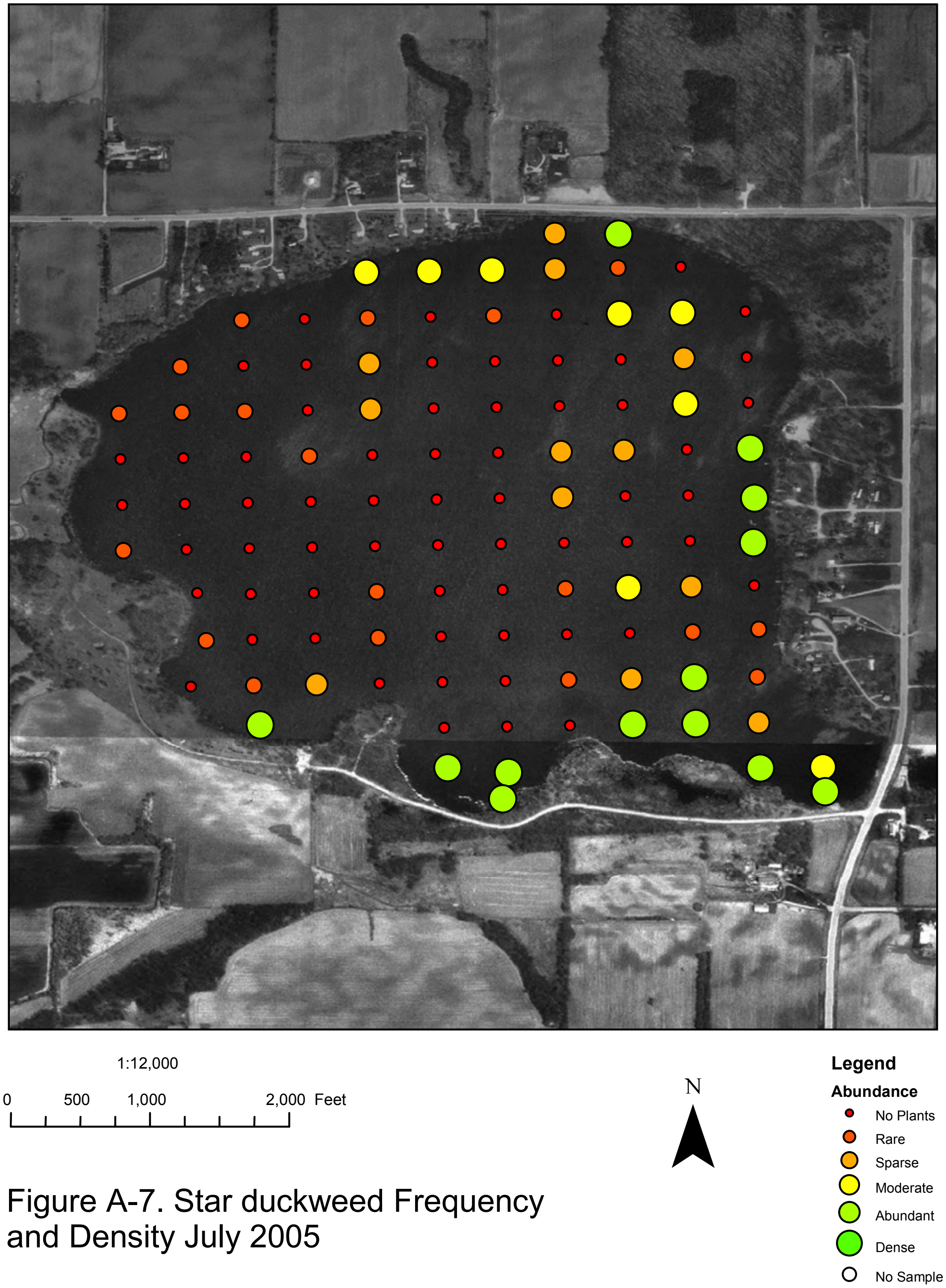

Figure A-7. Star duckweed Frequency and Density July 2005

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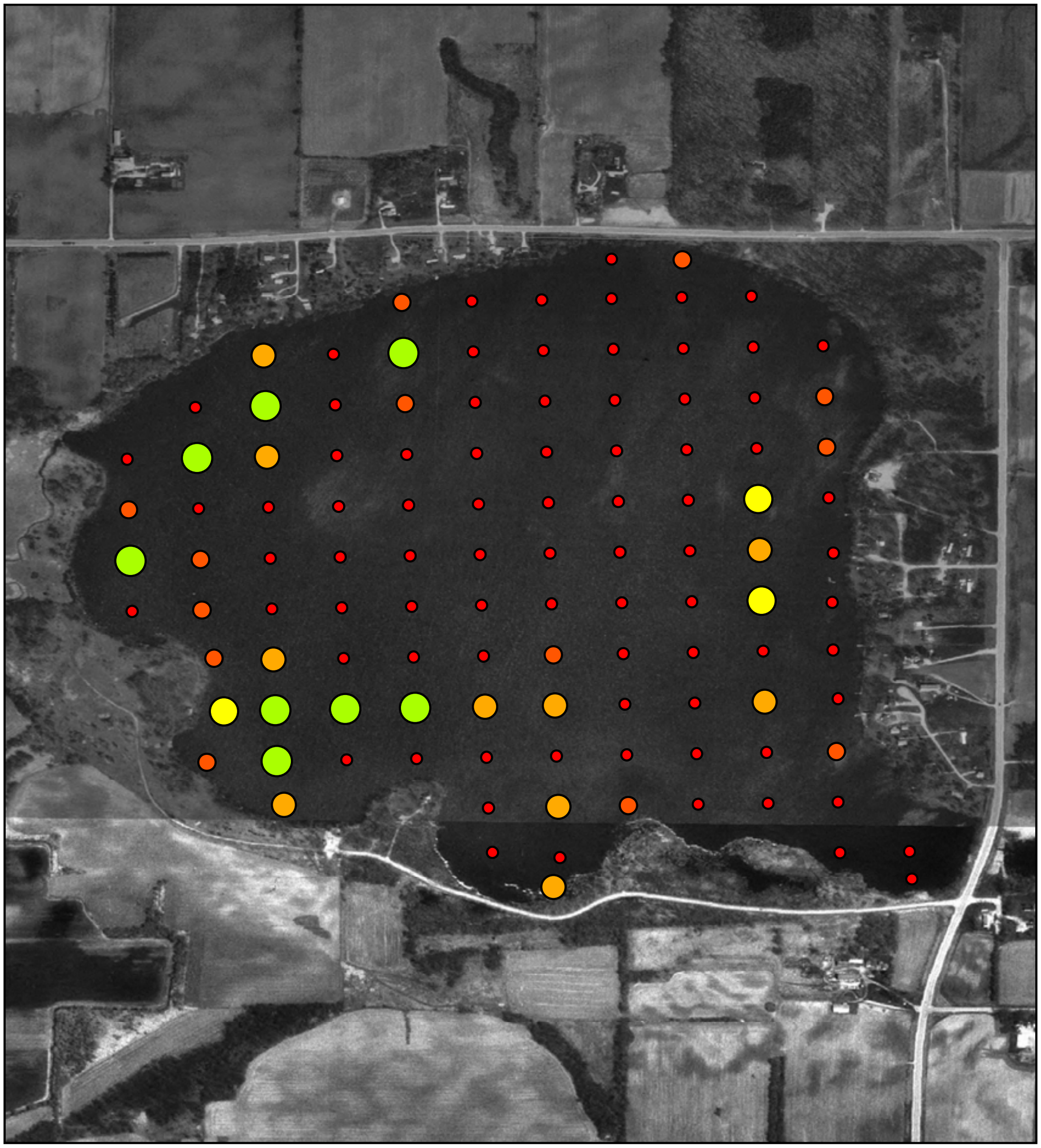

1:12,000

0 500 1,000 2,000 Feet

N

Legend

Abundance

- No Plants
- Rare
- Sparse
- Moderate
- Abundant
- Dense
- No Sample

Figure A-8. Filamentous Algae Frequency and Density July 2005