ROCK LAKE:

Aquatic Plant Inventory and Management Plan

Jefferson County Land and Water Conservation Department

INTERNATIONAL
Environmental Management Services Limited

"Integrating Development and Environment through Education and Planning"

Rock Lake: Aquatic Plant Inventory and Management Plan

Prepared by:

Patricia Cicero, Resource Conservationist
Jefferson County Land and Water Conservation Department
320 S. Main Street
Jefferson, WI 53549

And inventory work and summary prepared by:

International Environmental Management Services Limited
321 Barney Street
Waukesha, Wisconsin 53186-2402

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CONTRIBUTORS

The following individuals assisted in the completion of this project:

Patricia Cicero, Resource Conservationist
Jefferson County Land and Water Conservation Department

Paul Dearlove, Project Manager
Lake Ripley Management District and Lake Ripley Priority Lake Project

Susan Graham, Lake Management Coordinator
Wisconsin Department of Natural Resources

Christine Hinz, Consulting Aquatic Ecologist
International Environmental Management Services Limited

Carl Molter, Biologist
Wisconsin Department of Natural Resources

Thomas Slawski, Director
International Environmental Management Services Limited

Rhonda Sukys, GIS and Land Use Specialist
Jefferson County Land and Water Conservation Department

Jeffrey Thornton, Managing Director
International Environmental Management Services Limited

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Chapter I
INTRODUCTION

Rock Lake, located in Jefferson County, Wisconsin, is a valuable natural resource offering a variety of recreational and related opportunities to the resident community and its visitors. The lake is located in the City and Town of Lake Mills.

Seeking to protect the biological diversity of the plant community and to plan for possible control of exotic and nuisance species of Rock Lake, the Jefferson County Land and Water Conservation Department (LWCD) decided to develop an aquatic plant management plan. As part of this process, an aquatic plant inventory was conducted in 2001 by International Environmental Management Services Ltd. (IEMS) and Christine M. Hinz, consultant aquatic ecologist, in cooperation with Jefferson County LWCD, the Lake Ripley Management District, and the Wisconsin Department of Natural Resources (DNR). The 2001 plant inventory and the development of the aquatic plant management plan were funded, in part, by a Wisconsin Department of Natural Resources Lake Management Planning Grant awarded to Jefferson County under the Chapter NR 190 Lake Management Planning Grant Program. The inventory and plan element conforms to the requirements and standards set forth in the relevant Wisconsin Administrative Codes.[1]

The DNR conducted previous aquatic plant surveys on Rock Lake in 1990, 1991, and 1996. Data from the 2001 survey and the previous surveys were used to assess and evaluate the degree and direction of change within the aquatic plant communities in the lake over the past decade. Two surveys of the bulrush beds in Korth Bay, located in the southwestern portion of Rock Lake, were performed in 1998 and 2002. The aquatic plant plan takes all of this information to the next step. The goal of the plan is to develop a road map for making future decisions on the management of the aquatic plants in Rock Lake.

PHYSICAL CHARACTERISTCS

Rock Lake is a 1,371-acre waterbody that is located within an approximately 15 square mile watershed. The lake is situated within the Lower Crawfish River watershed of the Upper Rock River basin. Rock Lake is a drainage lake – it has several inlets and one controlled outlet. There are extensive shallow areas in the lake and two distinct basins, the southernmost of which is known as Marsh Lake. Marsh Lake was basically formed when a dam was constructed in 1865 downstream from the outlet on Rock Creek. This dam is purported to have an approximate 10 or 12 foot head. Marsh Lake has not been included in any of the systematic aquatic plant surveys conducted on Rock Lake. However, a somewhat informal aquatic plant survey was performed on Marsh Lake in 1992 by a DNR employee.

Rock Lake's physical characteristics are listed in Table 1. A bathymetric map illustrating water depth contours is presented in Map 1.

[1] *This plan has been prepared pursuant to the standards and requirements set forth in three chapters of the Wisconsin Administrative Code: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" and Chapter NR 107, "Aquatic Plant Management."*

Map 1. Bathymetric Map of Rock Lake

Table 1. Physical Characteristics of Rock Lake

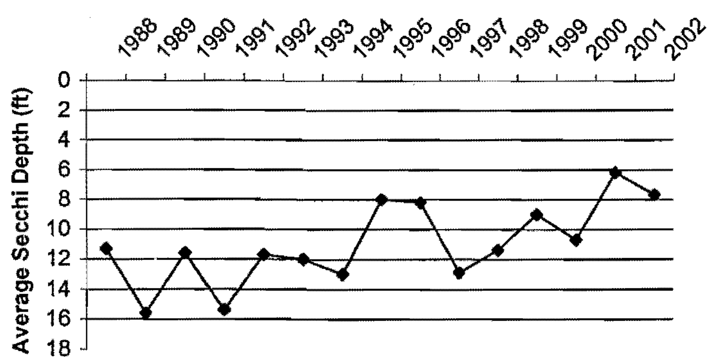
Watershed Area	15.1 square miles
Lake Surface Area	1,371 acres
Maximum Depth	56 feet
Mean Depth	16 feet
Water Volume	21,936 acre-feet
Flushing Index[1]	0.4
Shoreline Length	11.9 miles

1. Flushing index approximates the number of times per year that a lake's total water volume is replaced.

WATER QUALITY

Rock Lake is classified as a mesotrophic lake. Mesotrophic lakes, while relatively fertile and supporting abundant aquatic plant growth and productive fisheries, generally do not exhibit nuisance growths of algae and plants. The Wisconsin Trophic State Index (WTSI) was used to determine that Rock Lake is mesotrophic. It is a scale that indicates how nutrient rich a lake is and takes into account water clarity (as measured with a Secchi disk), total phosphorus, and chlorophyll-a measurements. From 1988 to 2002, Secchi depth measurements range from 2.5 feet to 27.5 feet with average depths ranging from 6.2 feet to 15.6 feet. Such transparencies are indicative of a waterbody with good water clarity.[2] This suggests that the lake had relatively low concentrations of algae and suspended sediment in the water column.[3] The water clarity measurements were obtained through the Department of Natural Resources' Self-Help Monitoring Program. The average water clarity values from 1988 through 2002 are displayed in Figure 1.

Figure 1. Average Water Clarity Measurements on Rock Lake: 1988-2002



[2] R.A. Lillie and J.W. Mason. 1983. Limnological Characteristics of Wisconsin Lake. Wisconsin Department of Natural Resources Technical Bulletin No. 138.

[3] R.A. Lillie, S. Graham, and P. Rasmussen. May 1993. "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes," Research and Management Findings. Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93.

FISHERY

Rock Lake supports a diverse fishery consisting of 32 species of fish that have been identified through years of sampling. A list of the fish present in the lake is included in Table 2.

Fishery surveys have been conducted on Rock Lake by the Department of Natural Resources during 1946, 1952, 1964, and 1974.[4] More recent surveys have been performed as part of the DNR's long-term trends monitoring program. The 1946 survey indicated that largemouth bass, bowfin, walleye, pike, bullhead, black crappie, smallmouth bass, pumpkinseed, rock bass, yellow perch, and blue gill were present in the lake. Many of these same species were recorded during the 1952 survey, which reported largemouth bass, walleye, pike, smallmouth bass, pumpkinseed, rock bass, yellow perch, and bluegill. This survey also reported northern pike as present in the lake. In the 1964 survey, largemouth bass, smallmouth bass, pumpkinseed, yellow perch, and bluegill were recorded. In addition, the 1964 survey reported brown bullhead and green sunfish. By 1974, a more extensive fish survey noted the presence not only of largemouth bass, smallmouth bass, pumpkinseed, rock bass, yellow perch, and bluegill, but also reported a variety of darters, shiners, and minnow. Bluntnose minnow; blackstripe topminnow; mimic, blacknose, emerald, and golden shiner; Iowa and least darter; brook silverside; and banded killifish were reported.

SENSITIVE AREAS

In 1995 the Department of Natural Resources, with the assistance of the Rock Lake Improvement Association and R.A. Smith and Associates, Inc. [5], designated some sensitive areas in the lake for plant protection. Sensitive areas provide unique and/or critical ecological habitat. These areas are delineated by lot lines and are displayed in Map 2.

Korth Bay: from T7N R13E Section 10 Lot 43-2 & Lot 43-12 (White Oak Drive) to T7N R13E Section 15 Lot 42-24 & Lot 42-12

Schultz Bay: from T7N R13E Section 2 Lower Rock Lake Park & Lot 33-28 to T7N R13E Section 10 Ferry Park & Lot 41-31

Marsh Lake – entire lake

Mill Pond – entire pond

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[4] *D. Fago. December 1988. Retrieval and Analysis System Used in Wisconsin's Statewide Fish Distribution Survey, Second Edition. Wisconsin Department of Natural Resources Research Report No. 148.*

[5] *R.A. Smith and Associates, Inc. May 1995. Rock Lake Planning Grant Study. Project No. 1949100-261.*

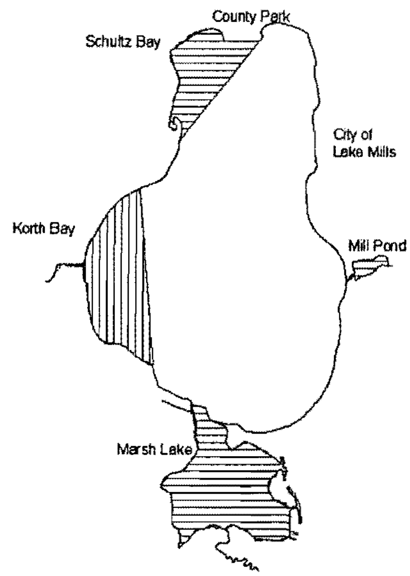
Table 2. Fish of Rock Lake[6]

Fish Species	Importance
Bowfin, *Amia clava*	"living fossil", ecological balance
Longnose Gar, *Lepisosteus osseus*	"living fossil", ecological balance
Central Mudminnow, *Umbra limi*	Game fish food
Grass Pickerel, *Esox americanus*	Biodiversity, ecological balance
Northern Pike, *Esox lucius*	Popular game fish
Common Carp*, *Cyprinus carpio*	Destroys habitat
Goldfish*, *Carassius auratus*	Escaped/released pet, destroys habitat
Golden Shiner, *Notemigonus crysoleucas*	Game fish food
Emerald Shiner, *Notropis atherinoides*	Game fish food
Blacknose Shiner, *Notropis heteroloepis*	Game fish food
Pugnose Shiner, *Notropis Anogenus*	Threatened species, biodiversity
Minic Shiner, *Notropis volucellus*	Game fish food
Bluntnose Minnow, *Pimephales notatus*	Game fish food
Fathead Minnow, *Pimephales promelas*	Game fish food, major bait species
Lake Chubsucker, *Erimyzon sucetta*	Rare species, biodiversity
White Sucker, *Catostomus commersoni*	Game fish food, major bait species
Black Bullhead, *Ictalurus melas*	Common sport fish
Yellow Bullhead, *Ictalurus natalis*	Common sport fish
Banded Killifish, *Fundulus diaphanous*	Game fish food, biodiversity
Blackstripe Topminnow, *Fundulus notatus*	Game fish food, biodiversity
Brook Silverside, *Labidesthes sicculus*	Game fish food
Smallmouth Bass, *Micropterus dolomieui*	Popular game fish
Largemouth Bass, Micropterus salmoides	Popular game fish
Rock Bass, *Ambloplites rupestris*	Incidental panfish catch
Bluegill, *Lepomis macrochirus*	Popular panfish
Pumpkinseed Sunfish, *Lepomis gibbosus*	Popular panfish
Green Sunfish, *Lepomis cyanellus*	Incidental panfish catch
Black Crappie, *Pomoxis nigromaculatus*	Popular panfish
Walleye, *Stizostedion vitreum*	Popular game fish, compete with bass
Yellow Perch, *Perca flavescens*	Popular panfish
Iowa Darter, *Etheostoma exile*	Game fish food, biodiversity
Least Darter, *Etheostoma microperca*	Rare species, biodiversity

* Nonnative (exotic) species

[6] *Wisconsin Department of Natural Resources. July 1997. Priority Lake Project Water Resources Appraisal.*

Map 2. Sensitive Areas of Rock Lake



Chapter II
Aquatic Plant Management History

PAST AND PRESENT AQUATIC PLANT MANAGEMENT PRACTICES

A variety of aquatic plant management techniques have been used in Rock Lake throughout the years. From 1950 to 1991, there are records of the application of chemicals to control "nuisance" plants. Lake residents also have hand pulled "nuisance" plants in front of their properties. A brief description of the laws regarding aquatic plant control is located in Chapter V.

Chemical controls of aquatic plants were used to a limited extent on Rock Lake since 1950, when records of aquatic plant management efforts were first maintained by the Department of Natural Resources. Prior to 1950, plant management interventions were likely, but were not recorded.

In contrast to many lakes in southern and southeastern Wisconsin, Rock Lake was not reported to have used sodium arsenite as an aquatic plant control measure.[7] Likewise, although some copper sulphate has been reported as an additive to chemical herbicide applications used on the lake, there are few records of the widespread use of this algicide in the lakes.[7] Documented chemical applications on Rock Lake are summarized in Table 3.

Table 3. Chemical Controls on Rock Lake: 1950-1991 (DNR data – permit applications and spreading reports)

Year	Acres Treated	Herbicide	Quantity	Target Species
1950-1969	?	Endothall 2, 4-D	1 gallon 50 gallons	?
1984	7	Aquathol K	35 gallons	milfoil
1985	9	Diquat Cutrine-Plus	12 gallons 12 gallons	milfoil, chara, filamentous algae, naiad
1986	9-10.9	Diquat Cutrine-Plus	9 gallons 9 gallons	milfoil, chara, coontail, sago
1987[a]	(10.4)	?	?	?
1988	6.9	Endothall Diquat Aquathol K Cutrine-Plus	0.5 gallons 11 gallons 2.5 gallons 26 gallons	milfoil, chara, niad
1989	8	Diquat Cutrine-Plus	5 gallons 19.5 gallons	milfoil, chara, filamentous algae
1990	2.8	Diquat Aquathol K Hydrothol 191 Cutrine-Plus	2 gallons 2 gallons 180 pounds 8 gallons	milfoil, chara, vallesenaria, algae, narrow-leaf pondweed
1991	2.2	2, 4-D	>2.5[b] gallons	milfoil

a Treatment of aquatic plants was permitted, but there was not a spreading report.
b Report was not complete and indicated that more chemical was used than 2.5 gallons.

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[7] *L.A. Lueschow. 1972. Biology and Control of Aquatic Nuisances in Recreational Waters. Wisconsin Department of Natural Resources Technical Bulletin No. 5.*

Chapter III
AQUATIC PLANT INVENTORY METHODOLOGY

AQUATIC PLANT SAMPLING

The Minnesota Department of Conservation developed a methodology for the conduct of a quantitative survey of aquatic plants in lakes.[8] This methodology has been widely used in the upper Midwest and has been modified for use in Wisconsin lakes by the Department of Natural Resources (DNR). The Jesson and Lound technique, as it is known, utilizes perpendicular transects extending lakeward from the shoreline, as the basis for conducting the sampling program, and a garden rake-based sampling device to harvest plant materials from the lake bed.

The Jesson and Lound technique was used during the 2001 aquatic plant survey conducted on Rock Lake. This method was selected to maintain data consistency and allow comparative analysis with the other surveys done in 1990, 1991, and 1996.

The baseline transects established for the survey were derived from a series of transects previously established and used in the prior aquatic plant surveys by the DNR. The transect locations were found during 2001 by use of pictures and descriptions from previous DNR surveys. Each transect and data point were more precisely recorded in 2001 through the use of Jefferson County's Global Positioning System (GPS). Additional transects were established during the 2001 survey to ensure uniform sampling of the plants. Transects were added to Rock Lake in those areas where the DNR designated transects were widely spaced. The transects used on Rock Lake are shown on Map 3. Appendix A also contains descriptions and new pictures taken in 2001 of each transect.

On Rock Lake, 22 transects have been used to describe the aquatic plant community, with six additional transects established during the 2001 survey. The addition of these transects did alter the analyses conducted on the aquatic plant community composition data in a significant way (please see Appendix B). The addition of these six transects in future aquatic plant studies is recommended in order to better define and understand the aquatic plant communities in Rock Lake.

Using a composite garden rake with extended handle as set forth in the Jesson and Lound methodology, samples were obtained from depth-related sampling points along each of the transects. Samples were taken at 1.5, 3, 6, 9, 12, and 15 feet of lake depth. Rake hauls were done at 18 feet of lake depth in the 1990 survey, but it is not known whether they were done for the 1991 or 1996 surveys. For the 2001 survey, a rake toss at the 18 foot depth was not performed. The likely maximum depth of colonization of aquatic plants is typically 15 feet,[9] this depth being a function, *inter alia*, of light penetration, substrate composition, and likelihood of disturbance by wind action, etc. The sampling depths corresponded, for the most part, with depths at which previous aquatic

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[8] *Robert Jesson and Richard Lound, Minnesota Department of Conservation Game Investigational Report No. 6, An Evaluation of a Survey Technique for Submerged Aquatic Plants, January 1962.*

[9] *After D.E. Canfield, K.A. Langeland, S.B. Linda , and W.T. Haller. "Relationships between Water Transparency and Maximum Depth of Macrophyte Colonization in Lake," Journal of Aquatic Plant Management, volume 23, 1985, pages 25-28: log MDC = 0.79 log (SDT) + 0.25, where MDC is the maximum depth of colonization and SDT is Secchi disc transparency, in meters.*

Map 3. Rock Lake Aquatic Plant Sampling Transects

plant samples were obtained. The locations of these sampling points were identified precisely through the use of Jefferson County's GPS during the 2001 aquatic plant survey.

At each sample point, four rake hauls were completed, one rake haul in each quadrant, approximately defined as the four "corners" of the pontoon boat from which the samples were obtained.

For each rake haul, plants were speciated on board the vessel used for sampling. Presence or absence of each species was noted on the work sheets, with additional notes regarding unusual features or abundances being made where appropriate. When plants were obtained in each of the four rake hauls, a score of "4" was noted. Similarly, where a specific plant was observed in only three of the hauls, a score of "3" was noted. A score of "0" was assigned to those hauls where no plants were obtained in any rake haul.

This scoring system differed slightly from that employed by Jesson and Lound, and in some previous DNR aquatic plant surveys conducted on Rock Lake. In these studies, a score of "5" could be assigned to those samples where a plant species was recorded in each of the four rake hauls and where the plant was exceptionally abundant. The maximum score of "5" was not consistently used in previous studies. For this reason, the maximum score used in the statistical analysis of the data from Rock Lake was set at "4", and scores of "5" were normalized to "4".

STATISTICAL METHODS

Seven indices were used to determine if the aquatic plant community species composition had changed significantly since the previous surveys. These tests, which examined a variety of factors, parallel the suite of statistical analyses identified by Nichols.[10] The examples presented below have been developed using data for muskgrass (*Chara vulgaris*) obtained during the 2001 aquatic plant survey from Rock Lake.

1. <u>The frequency of occurrence</u> (FREQ) is the number of occurrences of a species divided by the number of sampling points with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.

   Example: Based upon the data obtained during the 2001 sampling program, muskgrass was observed at 83 sites in the lake. The 83 occurrences represent the presence of muskgrass in at least one rake haul at a given sampling depth. There were a total of 132 possible occurrences, representing the total number of sampling sites visited including the 49 sites at which no muskgrass was collected. Dividing the numbers of occurrences (83) by the total possible number of occurrences of muskgrass in Rock Lake (132), results in a FREQ of 62.9 percent.

2. <u>The relative frequency of occurrence</u> (RFREQ) is the frequency of a species divided by the total frequency of all species. The sum of the relative frequencies should equal 100 percent.

[10]*Memorandum from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, and D., Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes Example," Wisconsin Geological and Natural History Survey and University of Wisconsin-Extension, February 4, 1994.*

This statistic presents an indication of how the plants occur throughout a lake in relation to each other. It is used in the calculation of the Importance Value and Simpson's Diversity Index set forth below.

Example: As previously, based upon the data obtained during the 2001 sampling program, muskgrass was observed at 83 sites in the lake. Other plants also were observed. Summing the total number of occurrences of the other aquatic plant species resulted in a total of 332 reports. Dividing the number of occurrences of muskgrass (83) by the total number of occurrences of aquatic plants at the sites sampled in Rock Lake (332), results in a RFREQ of 25.0 percent.

3. The average density (ADEN) is the sum of the density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all points sampled at a given depth—the modified Jesson and Lound protocol adopted by the DNR uses four sampling points per depth sampled. The average density presents an indication of how abundant the growth of a particular plant is throughout the lake. This measure along with the percent occurrence gives a good indication of the distribution of aquatic plant communities in a lake.

Example: Based upon the 2001 data, muskgrass was observed at 83 sites in the lake. Summing the density values for muskgrass at the 83 sites at which muskgrass occurred in Rock Lake results in a total of 271. Dividing this total by the number of sites at which the plant occurred (83) results in an ADEN of 3.27.

4. The Simpson Diversity Index (SDI) is defined as one minus the sum of each of the relative frequencies squared, and is expressed in equation form as:

$$SDI = 1 - \sum(RFREQ^2)$$

where SDI is the Simpson Diversity Index and RFREQ is the relative frequency value defined above. Based upon this index of community diversity, the closer the SDI value is to one, the greater the diversity is between the communities being compared.

Example: Using the data from the 2001 survey in Rock Lake, the sum of the squared RFREQ values is 0.125, resulting in an SDI of about 0.87.

5. The importance value (IV) is defined as the product of the relative frequency and the average density, expressed as a percentage:

$$IV = (RFREQ)\,(ADEN)\,(100)$$

where IV is the importance value, RFREQ is the relative frequency, and ADEN is the average density. This number provides an indication of the dominance of a species within a community based upon both frequency and density. It also somewhat addresses the problem of difference in stature between different plant species.

Example: The values for relative frequency (RFREQ = 0.25) and average density (ADEN = 3.27) of muskgrass in Rock Lake during 2001 are derived from the equations set forth above. Therefore, for the muskgrass community in Rock Lake during the 2001 survey, the IV can be calculated as the product: (0.25) (3.27) (100), which equals 81.75.

6. The similarity index (SI) is a means of comparing two communities by estimating the degree to which the communities share common components. The index is calculated as:

$$SI = 2W / A + B$$

where SI is the similarity index value, W is the amount two communities have in common or the lowest relative frequency of a species pair, and A plus B is the sum of the relative frequency for both communities, which should always be about 200 since the relative frequency of each community should equal 100 percent. This index could be calculated based upon average density or the importance values. However, relative frequency is a better measure since it does not change much during the growing season so the results remain comparable, even if the timing of sampling is not exactly the same, and, given that there are several methods for assigning average density, use of average density may yield a result that is not directly comparable. Use of relative frequency avoids such interpretation problems. It should be noted that, although a 100 percent similarity is theoretically possible, repeated sampling studies from the same community has shown that a similarity index of 85 percent or higher should be considered indicative of no community change.

Example: The aquatic plant communities observed in Rock Lake during 1996 and 2001 had 12 species of plants in common. Each of these species was observed during the two sampling periods. Based upon the data, W would be 80.7 percent. This value is comprised of the 2001 survey RFREQ values for muskgrass, Eurasian water milfoil, wild celery, spiny naiad, and variable pondweed, and the 1996 survey RFREQ values for Sago pondweed, bushy pondweed, coontail, Illinois pondweed, bladderwort, clasping-leaf pondweed, and stonewort. The value of A, or the cumulative value of the RFREQ values reported during 1996, was 100 percent, while the value of B, or the cumulative value of the RFREQ values reported during 2001, was 99.8. Solving for SI results in a similarity index value of 80.7 percent between these two years, or about 81 percent.

7. The p-value, or Pearson chi-squared test, is calculated using a statistical program for personal computers.[11] A p-value of less than or equal to 0.05 is the limit used to identify a significant difference between two populations. This means that, at $p = 0.05$, there is a 95 percent probability that two populations are different, or that, after comparing 100 mean values from each data set, 95 would be different and five would overlap.

HARDSTEM BULRUSH SAMPLING

Inventories of the Hardstem Bulrushes (*Scirpus acutus*) in Korth Bay were performed in 1998 by the DNR and in 2002 by the DNR and the Jefferson County Land and Water Conservation

[11] *Microsoft Excel, Office 98, was used for statistical analysis of the data.*

Department. In addition, during the 2001 aquatic plant survey, a GPS unit was used to map the circumference of the bulrush beds (see Map 4).

In 1998, there were 7 transects through the bulrush beds that ran east-west. A 0.2 square meter quadrat was used in the survey. Every bulrush that fell within the quadrat was counted along the transect line. Data was documented in 5 meter increments. The total length of the line within the bulrush bed was recorded for each transect.

For each transect, a stem density per unit area is calculated. This is computed by totaling the number of stems along the transect divided by the length of the transect times 0.45 meters (the width of the quadrat). In other words, number of stems ÷ (transect length × 0.45 meters) = stem density. An average stem density is then calculated for the entire bulrush bed.

This same methodology was basically employed for the 2001 survey. However, instead of counting stems along the entire transect within the quadrat, the number of stems in the quadrat at every 5 meters was counted. This change was only done because of a misunderstanding of the methodology. Future sampling events should follow the 1998 methods.

In order to compare the 2001 data with the 1998 data, a change in the stem density calculation was made. The 2001 survey used the following stem density calculation: number of stems ÷ (number of data points × 0.45 meters × 0.45 meters). This was done because the reportable length of the transect would be the length of the quadrat times the number of data points along the entire transect.

HERBARIUM

During the 2001 aquatic plant sampling, plant specimens were collected in Rock Lake. These plants were mounted and preserved in a herbarium. The herbarium was intended to be used for educational purposes and to be used for future plant identification. The following species are in the herbarium:

Bladderwort (*Utricularia sp.*)
Bushy pondweed (*Najas flexilis*)
Clasping-leaf pondweed (*Potamogeton richardsonii*)
Common waterweed (*Elodea canadensis*)
Coontail (*Ceratophyllum demersum*)
Water celery or eel grass (*Vallisneria americana*)
Eurasian water milfoil (*Myriophyllum spicatum*)
Flat-stemmed pondweed (*Potamogeton zosteriformis*)
Floating-leaf pondweed (*Potamogeton natans*)
Illinois pondweed (*Potamogeton illinoensis*)
Muskgrass (*Chara vulgaris*)
Sago pondweed (*Potamogeton pectinatus*)
Spiny naiad (*Najas marina*)
Stonewort (*Nitella sp.*)
Variable pondweed (*Potamogeton gramineus*)

Chapter IV
FINDINGS OF AQUATIC PLANT SURVEYS

Comprehensive surveys of aquatic plant communities in Rock Lake were conducted during 1990, 1991, 1996, and 2001. Prior to 2001, the surveys were conducted by the Wisconsin Department of Natural Resources (DNR). The 1996 survey data were used in the water resources appraisal report prepared by the DNR as part of the priority lake project conducted on Rock Lake.[12] The 2001 survey was conducted by International Environmental Management Services (IEMS). An informal aquatic plant survey was performed on Marsh Lake in 1992. In addition, surveys of the bulrush beds in Korth Bay, located in the southwestern portion of Rock Lake, were conducted in 1998 and 2002.

AQUATIC PLANT COMMUNITIES IN ROCK LAKE

Twenty-seven species of aquatic plants have been reported in Rock Lake during the period between 1990 and 2001. The number of sampling sites where each species were present during the 4 surveys on Rock Lake is found in Table 4. Table 5 shows the ecological values and significance of the species present. The plants observed during the 2001 aquatic plant survey are set forth in Table 6. Tables 7 through 10 show the average density ratings, percent relative frequencies of occurrence, percent frequencies of occurrence, and importance values of each of the species found during the four surveys. Appendix B contains the sampling results from the 1990, 1991, 1996, and 2001 surveys.

The 1990 survey (conducted on July 27 and August 7) reported 15 species of aquatic plants, muskgrass and Eurasian water milfoil being the dominant species reported. Spiny naiad also was reported to be frequently observed in the aquatic plant community at this time. In August 1991, the survey of aquatic plants included 12 species of plants. Muskgrass and spiny naiad were the most frequently observed plants, with Eurasian water milfoil also being recorded. During August 1996, 14 plant species were reported, with muskgrass again being the most frequently observed plant. Spiny naiad, wild celery, and muskgrass were next most frequently reported, followed by variable pondweed and quillwort. The 2001 survey (conducted July 16, 18, 20, August 7, and September 5) recorded 15 species of aquatic plants in Rock Lake as shown in Table 6. Muskgrass was found to be much more frequent than Eurasian water milfoil in samples, with Eurasian water milfoil, wild celery, spiny naiad, and Sago pondweed being the next most frequently observed plants. The variations in numbers of species recorded during the various aquatic plant surveys most likely reflect inter-annual variability, differences in sampling technique, and the influence of seasonality in plant growth consequent to the time of year during which the surveys were conducted.

The distribution of aquatic plants within Rock Lake during the 1990, 1991, 1996, and 2001 surveys is shown on Maps 4 through 7. These data also are presented in Figure 2 which graphically summarizes the aquatic plant communities observed along each transect around the lake, and identifies the relative abundance of Eurasian water milfoil. Figure 2 indicates the relatively sparse

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[12] *Wisconsin Department of Natural Resource. July 1997. Rock Lake Priority Lake Project Water Resources Appraisal.*

nature of the aquatic flora in the lake, and suggests that growths of Eurasian water milfoil are predominantly in the deeper water areas of the lake. The figure also suggests the inter-annual variations in the abundance of the plant during the period of record, and the general trend toward increasing abundance overall.

During the 1990 survey, aquatic plant growth occurred throughout Rock Lake to depths of about 18 feet, as shown on Map 4. Muskgrass was noted to occur throughout the lake, and at all depths sampled. Six distinct communities of aquatic plants were observed: a spiny naiad community which was generally found at depth in the lake, a stonewort-quillwort community likewise generally found at depth in the lake, a muskgrass community that was widespread in the lake, a muskgrass-pondweed community, a muskgrass-naiad community was common in the mid-depth areas of the lake, and a pondweed-wild celery community that typically occurred along the western shoreline of the lake. Eurasian water milfoil, as noted, generally occurred at depth and formed a fringe around the aquatic plant communities which existed closer inshore.

During the 1991 survey, Eurasian water milfoil again was found to exist in the deeper water areas of the lake, forming a fringe around the aquatic plant communities which existed closer inshore. During this survey, six aquatic plant communities were observed, as shown on Map 5: a muskgrass community that was widespread throughout the lake, a spiny naiad community which was generally found at depth in the lake, a naiad-muskgrass community, a muskgrass-pondweed community that typically occurred along the western shoreline of the lake, and a spiny naiad-pondweed community.

During the 1996 survey, Eurasian water milfoil not only was found in the deeper water areas of the lake, forming a fringe around the aquatic plant communities which existed closer inshore, but also was found to be abundant along the northern and western shorelines. During this survey, six aquatic plant communities were observed, as shown on Map 6: a muskgrass community, a muskgrass-spiny naiad community which was generally found along the western and eastern shorelines and at depth along the western shoreline, a muskgrass-pondweed community that typically occurred along the southern shore, a muskgrass-wild celery community that typically occurred along the western shore, and a muskgrass-wild celery-spiny naiad community which was typically found along the northern and southern shorelines of the lake.

During the 2001 survey, plant growth occurred in water of at least the 15 foot depth, as shown on Map 7. Eurasian water milfoil was observed throughout the lake, most frequently in deeper water as a fringe around the aquatic plant communities which existed closer inshore, but also along the western shoreline. Diversity increased with seven aquatic plant communities being distinguished: a muskgrass community which was generally found along the eastern shore, a muskgrass-naiad community which was generally found along the northern shore, a muskgrass-naiad-pondweed community which was generally found along the eastern shore, a muskgrass-pondweed community which was generally found along the southern shore, an wild celery-naiad-pondweed community which generally formed a fringe in the deeper water portions of the lake, a muskgrass-wild celery community which was generally found along the western shoreline in the shallower water portions of the lake, and a muskgrass-wild celery-naiad community which was also generally found along the western shoreline in the shallower water portions of the lake.

Aquatic plants occurred at between 70 percent and 80 percent of sites sampled. In terms of the spatial distribution of the plants, Figure 3 suggests that the plant distribution in Rock Lake has become less evenly distributed in the lake, and patchier over the approximately 10-year period of record. It also shows that the distribution of aquatic plants in the lake during 1990 and 1991 was consistent with the forecast distribution, indicating a uniform distribution of plants in the waterbody. However, during 1996 and 2001, the distribution became multimodal, indicating a non-uniform distribution of plants in the lake. This apparent shift toward conditions of greater patchiness in the distribution of aquatic plants may reflect a real shift in plant community composition, from a more uniform plant community composition to a less uniform composition, and/or it may reflect increasingly more refined sampling methodologies employed during successive surveys. The combination of these functions best reflects the observed distribution of aquatic plants in Rock Lake during 2001, although the increase in the mean density of plant growth, from about 1.5 to 2.5 species per sample, would suggest that the shift is most likely to be the result of a more abundant flora.

Figure 4 shows the variation in frequency of occurrence of the five most common aquatic plant species over the 10-year period. Since 1990, Eurasian water milfoil has remained a relatively significant part of the aquatic plant flora of the lake (Figure 5), being present in quantities that approximate between one-fifth and two-fifths of the aquatic plant flora, as shown in Tables 7 through 10. Since 1991, Sago pondweed has become an increasingly frequent plant observed in Rock Lake, comprising over 20 percent of the aquatic plant population in the lake during 2001. Wild celery also appears to have increased in relative frequency of occurrence through 2001, when it was determined to comprise about one-third of the plant community.

Muskgrass (*Chara vulgaris*) and wild celery (*Vallisneria americana*) are low-growing plants that pose few problems for recreational lake users. Eurasian water milfoil (*Myriophyllum spicatum*), in contrast, is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its explosive growth under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations displace native plant species and interfere with the aesthetic and recreational use of the waterbodies.

Eurasian water milfoil reproduces by the rooting of plant fragments. This plant has been known to cause severe recreational use problems in lakes within southern Wisconsin. Such conflicts can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil plants. These fragments, as well as fragments that occur for other reasons such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites. The fragments also can cling to boats, trailers, motors, and bait buckets, and can stay alive for weeks contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

Based upon the data set forth in Table 4, analyses of the correlations amount data sets reported during each of the four surveys suggest few changes in the aquatic plant community within the lake. Correlations of the data ranged from 0.85, between 1991 and 1996, to 0.92, between 1996 and 2001; between 1990 and 1991, the correlation was 0.86. This is in contrast to the similarity indices (SI) calculated for Rock Lake. The SI is a means of comparing two communities by estimating the degree to which the communities share common components. Using the data obtained during the four aquatic plant surveys conducted on Rock Lake, the SI ranged from 0.66 to 0.81—a SI value of 0.85 or greater is indicative of essentially no change in the communities. Thus, the SI values for Rock Lake are suggestive of significant changes in the plant community, although the SI values alone do not provide any indication of whether the change is positive or negative from a recreational, aesthetic, or habitat value perspective.

The Simpson Diversity Indices for Rock Lake during the period between 1990 and 2001 ranged from 0.79 to 0.88. The closer the SDI value is to one, the greater the diversity is between the communities being compared. This would seem to suggest that the community has remained somewhat diverse throughout the period of record.

While there is no currently agreed definition as to what degree of difference between the values is significant, the Importance Values, shown in Table 11 and calculated for the periods between 1990 and 1991, 1991 and 1996, and 1996 and 2001, would confirm some changes in the distribution of plants within the community. IV provides an indication of the dominance of a species within a community. Muskgrass, Eurasian water milfoil, and wild celery have increased in importance in recent years, while spiny naiad has decreased in importance. The importance value incorporates both the relative frequency and average density of the plant species present in the lake.

The relative frequency, shown in Table 12, gives a good indication as to how the plants occur throughout a lake in relation to one another. These data also suggest that the plant community is changing. In 1990, for example, the relative frequencies of the three most common plants (muskgrass, milfoil, and naiad) were 35 percent, 17 percent, and 12 percent, respectively, adding up to 64 percent out of 100 percent. In contrast, the 2001 numbers are much different. These three plants had relative frequencies of 25 percent, 14 percent, and 10 percent, respectively, adding up to 49 percent out of 100 percent; wild celery and Sago pondweed contributed a further 19 percent. This means these plants are of relatively equal abundance and are fairly evenly distributed throughout the lake.

Tables that show the average density and the percent frequency of occurrence for all 4 sampling years are located in Appendix B.

AQUATIC PLANT COMMUNITIES IN MARSH LAKE

On August 14, 1992, the Department of Natural Resources conducted an informal aquatic plant survey in Marsh Lake. The following species were documented:

Chara vulgaris, muskgrass
Myriophyllum sibericum, northern water milfoil
Myriophyllum spicatum, Eurasian water milfoil
Najas marina, spiny naiad
Nuphar variegata, spatterdock
Nymphaea odorata or tuberose, white water lily
Potamogeton illinoensis, Illinois pondweed
Potamogeton natans, floating-leaf pondweed
Potamogeton pectinatus, sago pondweed
Potamogeton richardsonii, clasping-leaf pondweed or Richardson's pondweed
Typha spp., cattail

Utricularia vulgaris, bladderwort
Vallisneria americana, wild celery or eel grass

Notes from the DNR monitor indicate that wild rice (*Zizania spp.*) also might be one of the aquatic plants, but this was not confirmed. Spiny naiad was the dominate plant found in Marsh Lake, with chara and the lilies as a distant second. The bladderwort was found predominantly with the lilies.

One interesting note of the survey was that on the west side of the island, there was very little northern water milfoil. However, there was a moderate growth of this native milfoil on the east side of the island. In addition, there was "very little" of the Eurasian water milfoil in Marsh Lake.

HARDSTEM BULRUSHES IN KORTH BAY

The circumference of the bulrush bed in 2001 is displayed in Map 8. The average stem density for the entire bulrush bed for both sampling years is as follows:

September 9, 1998	3.0 stems per square meter
July 23 and 24, 2002	3.4 stems per square meter

Table 4. Number of Sampling Sites where Aquatic Plant Species are Present

Species	Year			
	1990	1991	1996	2001
Chara vulgaris, muskgrass	65	51	65	83
Myriophyllum spicatum, Eurasian water milfoil	32	24	36	47
Vallisneria americana, wild celery or eel grass	13	12	30	36
Najas marina, spiny naiad	22	42	27	34
Potamogeton pectinatus, sago pondweed	2	4	7	29
Najas flexilis, bushy pondweed	5	1	10	23
Ceratophyllum demersum, coontail	1	0	9	16
Potamogeton gramineus, variable pondweed	0	2	18	15
Potamogeton zosteriformis, flat-stemmed pondweed	0	0	0	14
Potamogeton illinoensis, Illinois pondweed	2	14	3	11
Utricularia vulgaris, bladderwort	0	3	5	10
Potamogeton richardsonii, Richardson's pondweed, or clasping-leaf pondweed	15	0	1	8
Nitella sp., stonewort	6	2	2	4
Scirpus acutus, hardstem bulrush	-	6	3	2
Elodea Canadensis, waterweed	1	0	0	1
Nuphar variegata, spatterdock	3	3	1	1
Nymphaea tuberose or *odorata*, white water lily	1	2	1	1
Potamogeton crispus, curly-leaf pondweed	0	0	0	1
Isoetes sp., quillwort	4	0	18	0
Potamogeton natans, floating-leaf pondweed	1	2	1	0
Potamogeton praelongus, white-stemmed pondweed	11	0	0	0
Potamogeton pusillus, small pondweed	6	1	0	0
Myriophyllum sibericum, northern water milfoil[a]	-	-	-	-
Ranunculus aquatilis and *flabellaris*, water buttercup[a]	-	-	-	-
Sagittaria latifolia, arrowhead[a]	-	-	-	-
Typha angustifolia, narrow-leaved cattail[a]	-	-	-	-
Typha latifolia, broad-leaved cattail[a]	-	-	-	-
Total Number of Species	17	15	17	18

a. Purportedly present in the lake but not recorded in an aquatic plant survey.

Table 5. Ecological Significance of Aquatic Plant Species Present in Rock Lake

Aquatic Plant Species Present	Plant Type[a]	Native or Exotic	Ecological Significance[b]
Ceratophyllum demersum, coontail	S	N	Provides good shelter for young fish, supports insects valuable as food for fish and ducklings, and fruit are eaten by waterfowl
Chara vulgaris, muskgrass	S	N	Excellent producer of fish food, especially for young trout, bluegill, small-and largemouth bass; food for waterfowl; stabilizes bottom sediments; has softening effect on water by removing lime and carbon dioxide
Elodea canadensis, waterweed	S	N	Provides shelter and support for insects valuable as fish food, food for muskrats and waterfowl
Isoetes sp., quillwort	S	N	Provides food for wildlife
Myriophyllum sibericum, northern water milfoil[c]	S	N	Provides shelter, and is a valuable food producer for fish supporting many insects; roots provide nesting habitat for fish, leaves and fruit eaten by waterfowl
Myriophyllum spicatum, Eurasian water milfoil	S	E	Waterfowl eat fruit and leaves to a limited extent, habitat for insects but not as good as other plants
Najas flexilis, bushy pondweed	S	N	Provides food for waterfowl, some marsh birds, and muskrats; cover for young largemouth bass and northern pike and small bluegills and perch; food for fish
Najas marina, spiny naiad	S	N	Provides good food and shelter for fish and food for ducks
Nitella sp., stonewort	S	N	Provides good food and cover for fish, sometimes eaten by waterfowl
Nuphar variegata, spatterdock	FL	N	Leaves, stems, and flowers are eaten by deer; roots eaten by beaver and porcupine; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea tuberose or *odorata*, white water lily	FL	N	Provides shade and shelter for fish; seeds eaten by waterfowl; rootstocks and stalks eaten by muskrat; roots eaten by beaver, deer, moose, and porcupine
Potamogeton crispus, curly-leaf pondweed	S	E	Provides food, shelter, and shade for some fish and food for wildfowl, habitat for invertebrates
Potamogeton gramineus, variable pondweed	S	N	Provides cover for panfish, largemouth bass, and northern pike; bluegills nest near them and eat insects found on leaves; supports insects valuable as food for fish and ducklings, fruit and tubers eaten by waterfowl
Potamogeton illinoensis, Illinois pondweed	S	N	Provides cover for panfish, largemouth bass, and northern pike; nesting grounds for bluegill; supports insects valuable as food for fish and ducklings; fruit eaten by ducks and geese
Potamogeton natans, floating-leaf pondweed	S	N	Provides food for trout and wildfowl, fruit eaten by ducks and geese, shade and foraging opportunities for fish
Potamogeton pectinatus, sago pondweed	S	N	Most important pondweed for ducks, in addition to providing food and shelter for young fish, fruit and tubers are considered critical food for migrating waterfowl
Potamogeton praelongus, white-stemmed pondweed	S	N	Provides food for ducks and geese
Potamogeton pusillus, small pondweed	S	N	Provides food for ducks and geese, food and shelter for fish
Potamogeton richardsonii, Richardson's pondweed,	S	N	Provides cover for panfish, largemouth bass, and northern pike; bluegills nest near them and eat insects on leaves; supports

or clasping-leaf pondweed			insects valuable as food for fish, ducklings and geese
Potamogeton zosteriformis, flat-stemmed pondweed	S	N	Provides some cover for bluegills, perch, and northern pike; food for waterfowl; supports insects valuable as food for fish and ducklings
Ranunculus aquatilis and *flabellaris*, water buttercup[c]	S	N	Fruit and foliage eaten by waterfowl, provides habitat for invertebrates
Sagittaria latifolia, arrowhead[c]	E	N	Tubers eaten by migrating waterfowl; seed eaten by ducks, geese, marsh birds, and shorebirds; provides shade and shelter for young fish
Scirpus acutus, hardstem bulrush	E	N	Habitat for insects; shelter for young fish, especially northern pike; nutlets food for waterfowl, marsh birds, and upland birds; stems and rhizomes eaten by geese and muskrats, nesting material and cover for waterfowl, marsh birds, and muskrats
Typha angustifolia, narrow-leaved cattail[c]	E	N	Supports insects, stalks, and roots; important food for muskrat and beaver, attracts marsh birds, wildfowl and songbirds, in addition to being used as spawning grounds by sunfish and shelter for young fish, habitat for marsh birds
Typha latifolia, broad-leaved cattail[c]	E	N	Provides nesting habitat for marsh birds, spawning habitat and shelter for fish, habitat for invertebrates, shoots and rhizomes eaten by muskrats and geese
Utricularia vulgaris, bladderwort	FF	N	Provides good food and cover for fish
Vallisneria americana, wild celery or eel grass	S	N	Provides good shade, shelter, and food for fish; supports insects; food for waterfowl, especially canvasback ducks, marsh birds, and shore birds

[a] Plant type codes: S = submerged, FL = floating leaf, E = emergent, FF = free floating

[b] Information obtained from "A Manual of Aquatic Plants" by Norman C. Fassett, "A Guide to Wisconsin Aquatic Plants" by Wisconsin Department of Natural Resources, and "Through the Looking Glass: A Guide to Aquatic Plants" by Wisconsin Lake Partnership.

[c] Present in the lake but not recorded in an aquatic plant survey.

Table 6. Frequency of Occurrence and Density Ratings – 2001 Survey

Plant Species	Sites Found[a]	Frequency of Occurrence (percent)	Density in Whole Lake
Ceratophyllum demersum, coontail	16	12.1	1.4
Chara vulgaris, muskgrass	83	62.9	3.3
Elodea canadensis, waterweed	1	0.8	1.0
Myriophyllum spicatum, Eurasian water milfoil	47	35.6	2.8
Najas flexilis, bushy pondweed	23	17.4	1.8
Najas marina, spiny naiad	34	25.8	2.0
Nitella spp., stonewort	4	3.0	1.0
Potamogeton gramineus, variable pondweed	15	11.4	1.5
Potamogeton crispus, curly-leaf pondweed	1	0.8	1.0
Potamogeton illinoensis, Illinois pondweed	11	8.3	1.5
Potamogeton pectinatus, Sago pondweed	29	22.0	2.0
Potamogeton richardsonii, clasping-leaf pondweed	8	6.1	1.4
Potamogeton zosteriformis, flat-stemmed pondweed	14	10.6	1.3
Utricularia sp., bladderwort	10	7.6	1.2
Vallisneria Americana, wild celery or eel grass	36	27.3	2.6

[a]132 sampling points.

Table 7. Results of Statistical Analyses – 2001 Survey

Species	Frequency of Occurrence (percent)	Average Density	Relative Frequency	Importance Value
Ceratophyllum demersum, coontail	12.1	1.4	4.8	7
Chara vulgaris, muskgrass	62.9	3.3	25.0	82
Elodea canadensis, waterweed	0.8	1.0	0.3	0
Myriophyllum spicatum, Eurasian water milfoil	35.6	2.8	14.2	40
Najas flexilis, bushy pondweed	17.4	1.8	6.9	12
Najas marina, spiny naiad	25.8	2.0	10.2	20
Nitella spp., stonewort	3.0	1.0	1.2	1
Potamogeton gramineus, variable pondweed	11.4	1.5	4.5	7
Potamogeton crispus, curly-leaf pondweed	0.8	1.0	0.3	0
Potamogeton illinoensis, Illinois pondweed	8.3	1.5	3.3	5
Potamogeton pectinatus, Sago pondweed	22.0	2.0	8.7	17
Potamogeton richardsonii, clasping-leaf pondweed	6.1	1.4	2.4	3
Potamogeton zosteriformis, flat-stemmed pondweed	10.6	1.3	4.2	5
Utricularia sp., bladderwort	7.6	1.2	3.0	4
Vallisneria americana, wild celery or eel grass	27.3	2.6	10.8	29

Table 8. Results of Statistical Analyses – 1996 Survey

Species	Frequency of Occurrence (percent)	Average Density	Relative Frequency	Importance Value
Ceratophyllum demersum, coontail	6.8	1.3	3.9	5
Chara vulgaris, muskgrass	49.2	3.3	28.0	94
Elodea canadensis, waterweed	0.0	- -	0.0	- -
Myriophyllum spicatum, Eurasian water milfoil	27.3	2.2	15.5	35
Najas flexilis, bushy pondweed	7.6	1.4	4.3	6
Najas marina, spiny naiad	20.5	2.3	11.6	27
Nitella spp., stonewort	1.5	1.0	0.9	1
Potamogeton gramineus, variable pondweed	13.6	1.8	7.8	14
Potamogeton crispus, curly-leaf pondweed	0.0	- -	0.0	- -
Potamogeton illinoensis, Illinois pondweed	2.3	2.0	1.3	3
Potamogeton pectinatus, Sago pondweed	5.3	1.0	3.0	3
Potamogeton richardsonii, clasping-leaf pondweed	0.8	1.0	0.4	0
Potamogeton zosteriformis, flat-stemmed pondweed	0.0	- -	0.0	- -
Utricularia sp., bladderwort	3.8	1.6	2.2	3
Vallisneria americana, wild celery or eel grass	22.7	2.3	12.9	30

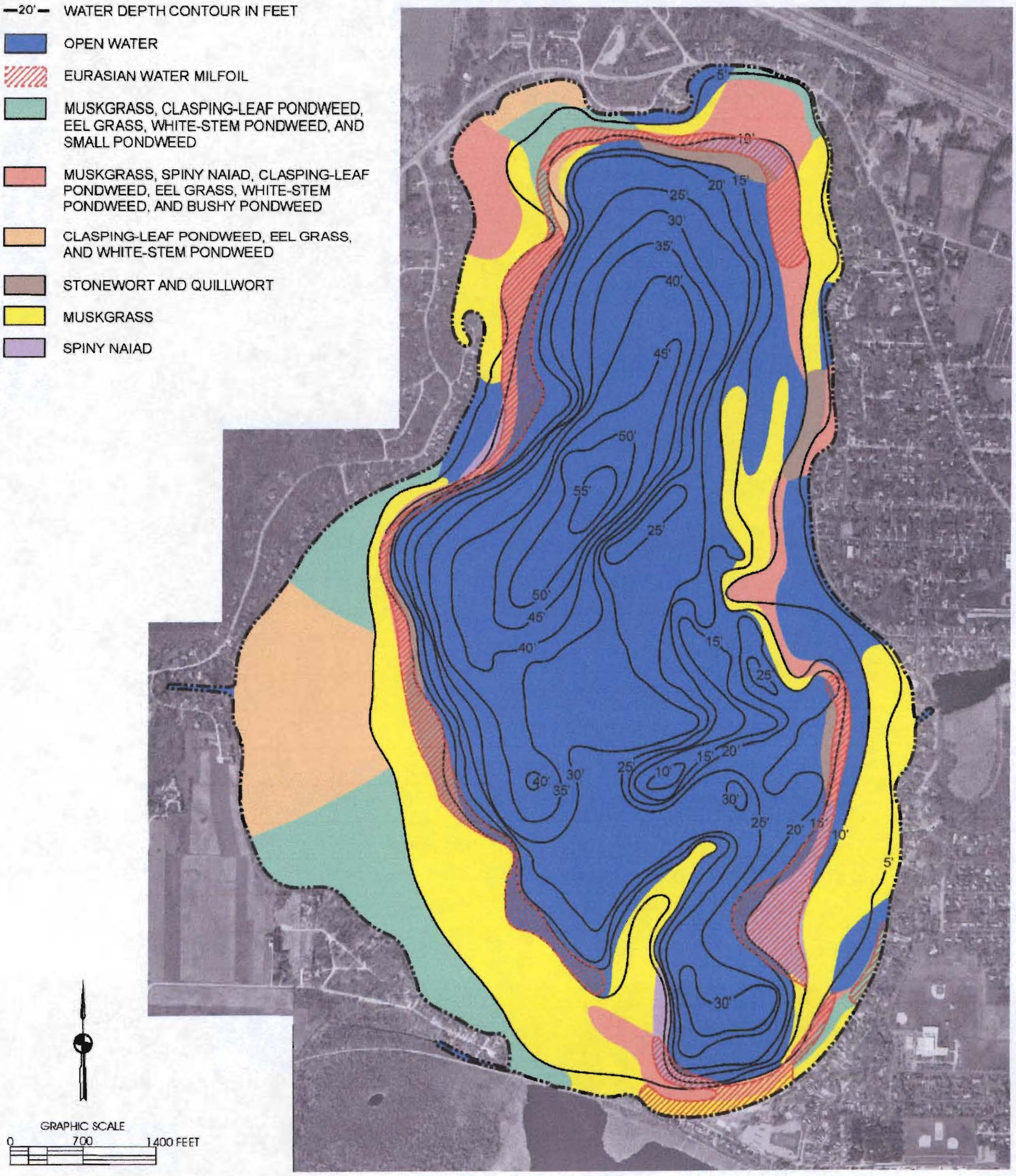
Table 9. Results of Statistical Analyses – 1991 Survey

Species	Frequency of Occurrence (percent)	Average Density	Relative Frequency	Importance Value
Ceratophyllum demersum, coontail	0.0	- -	0.0	- -
Chara vulgaris, muskgrass	38.6	2.0	32.3	66
Elodea canadensis, waterweed	0.0	- -	0.0	- -
Myriophyllum spicatum, Eurasian water milfoil	18.2	1.5	15.2	23
Najas flexilis, bushy pondweed	0.8	3.0	0.6	2
Najas marina, spiny naiad	31.8	2.7	26.6	71
Nitella spp., stonewort	1.5	1.0	1.3	1
Potamogeton gramineus, variable pondweed	1.5	1.5	1.3	2
Potamogeton crispus, curly-leaf pondweed	0.0	- -	0.0	- -
Potamogeton illinoensis, Illinois pondweed	10.6	1.8	8.9	16
Potamogeton pectinatus, Sago pondweed	3.0	1.2	2.5	3
Potamogeton richardsonii, clasping-leaf pondweed	0.0	- -	0.0	- -
Potamogeton zosteriformis, flat-stemmed pondweed	0.0	- -	0.0	- -
Utricularia sp., bladderwort	2.3	1.7	1.9	3
Vallisneria americana, wild celery or eel grass	9.1	1.6	7.6	12

Table 10. Results of Statistical Analyses – 1990 Survey

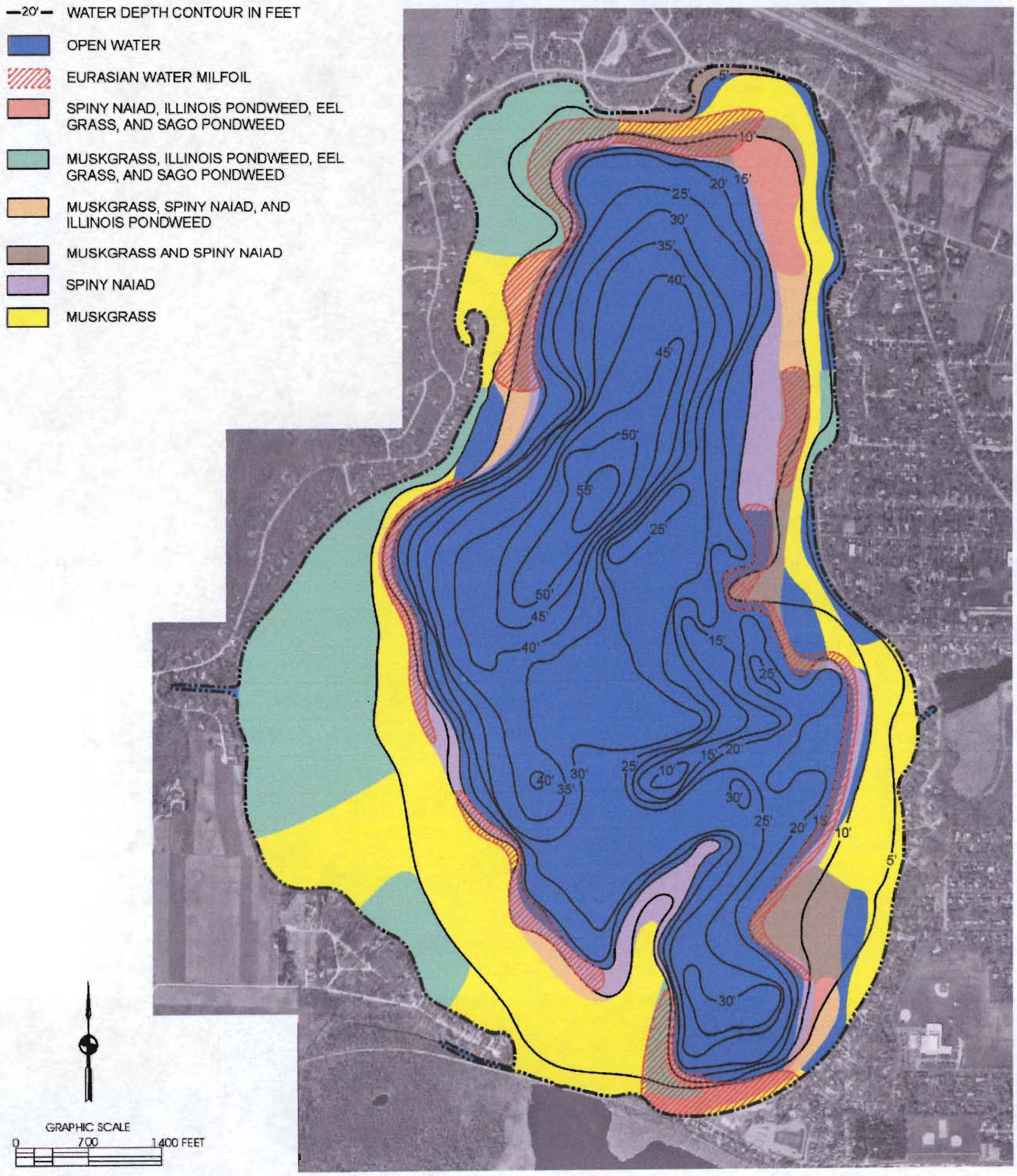
Species	Frequency of Occurrence (percent)	Average Density	Relative Frequency	Importance Value
Ceratophyllum demersum, coontail	0.8	1.0	0.5	1
Chara vulgaris, muskgrass	49.2	2.1	34.9	74
Elodea canadensis, waterweed	0.8	3.0	0.5	2
Myriophyllum spicatum, Eurasian water milfoil	24.2	2.2	17.2	38
Najas flexilis, bushy pondweed	3.8	1.0	2.7	3
Najas marina, spin y naiad	16.7	1.2	11.8	15
Nitella spp., Stonewort	4.5	1.5	3.2	5
Potamogeton gramineus, variable pondweed	0.0	- -	0.0	- -
Potamogeton crispus, curly-leaf pondweed	0.0	- -	0.0	- -
Potamogeton illinoensis, Illinois pondweed	1.5	1.5	1.1	2
Potamogeton pectinatus, Sago pondweed	1.5	1.0	1.1	1
Potamogeton richardsonii, clasping-leaf pondweed	11.4	1.1	8.1	9
Potamogeton zosteriformis, flat-stemmed pondweed	0.0	- -	0.0	- -
Utricularia sp., bladderwort	0.0	- -	0.0	- -
Vallisneria americana, wild celery or eel grass	9.8	1.6	7.0	11

Map 4. Aquatic Plant Community Distribution in Rock Lake - 1990



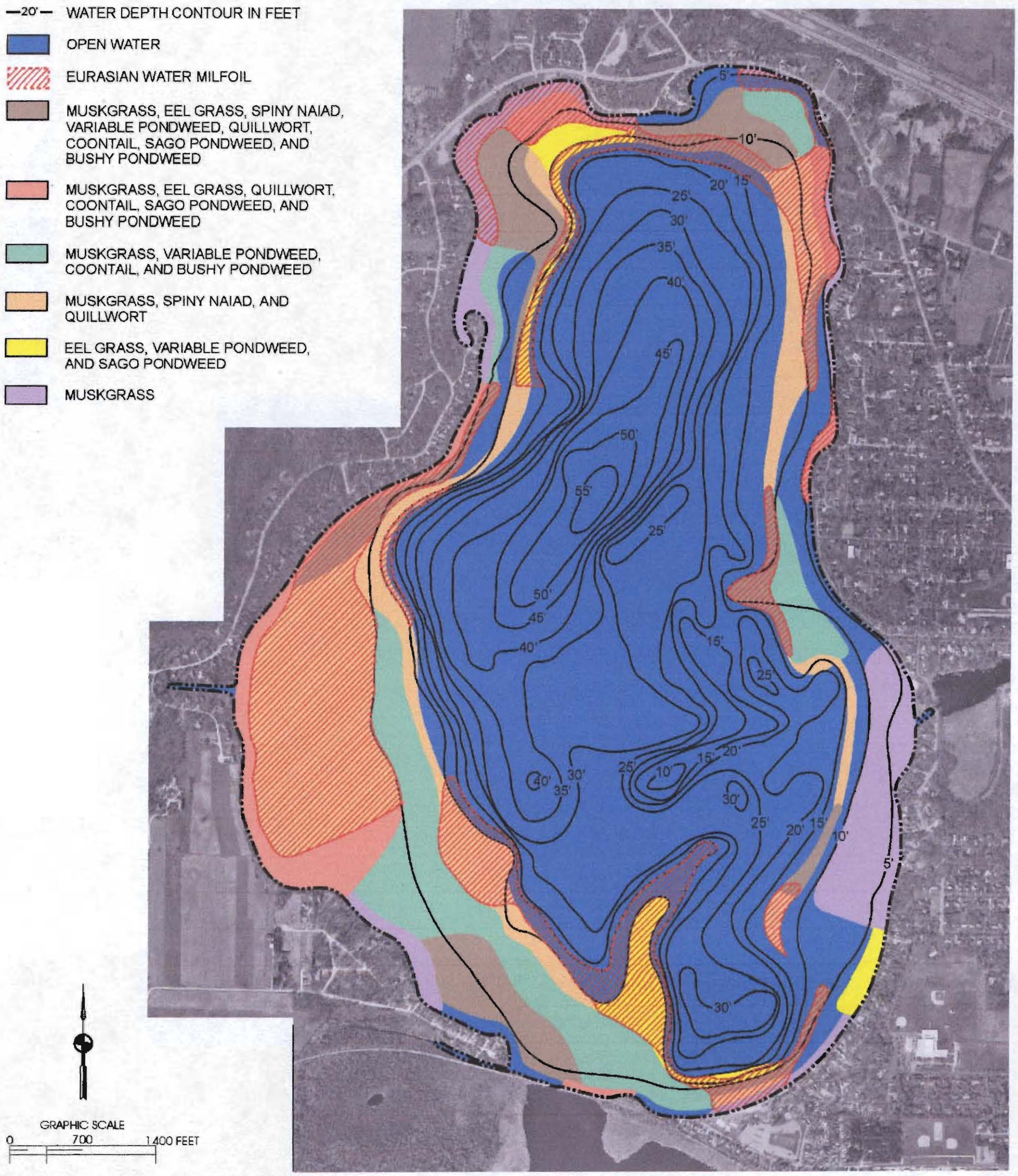
Source: Wisconsin Department of Natural Resources

Map 5. Aquatic Plant Community Distribution in Rock Lake - 1991



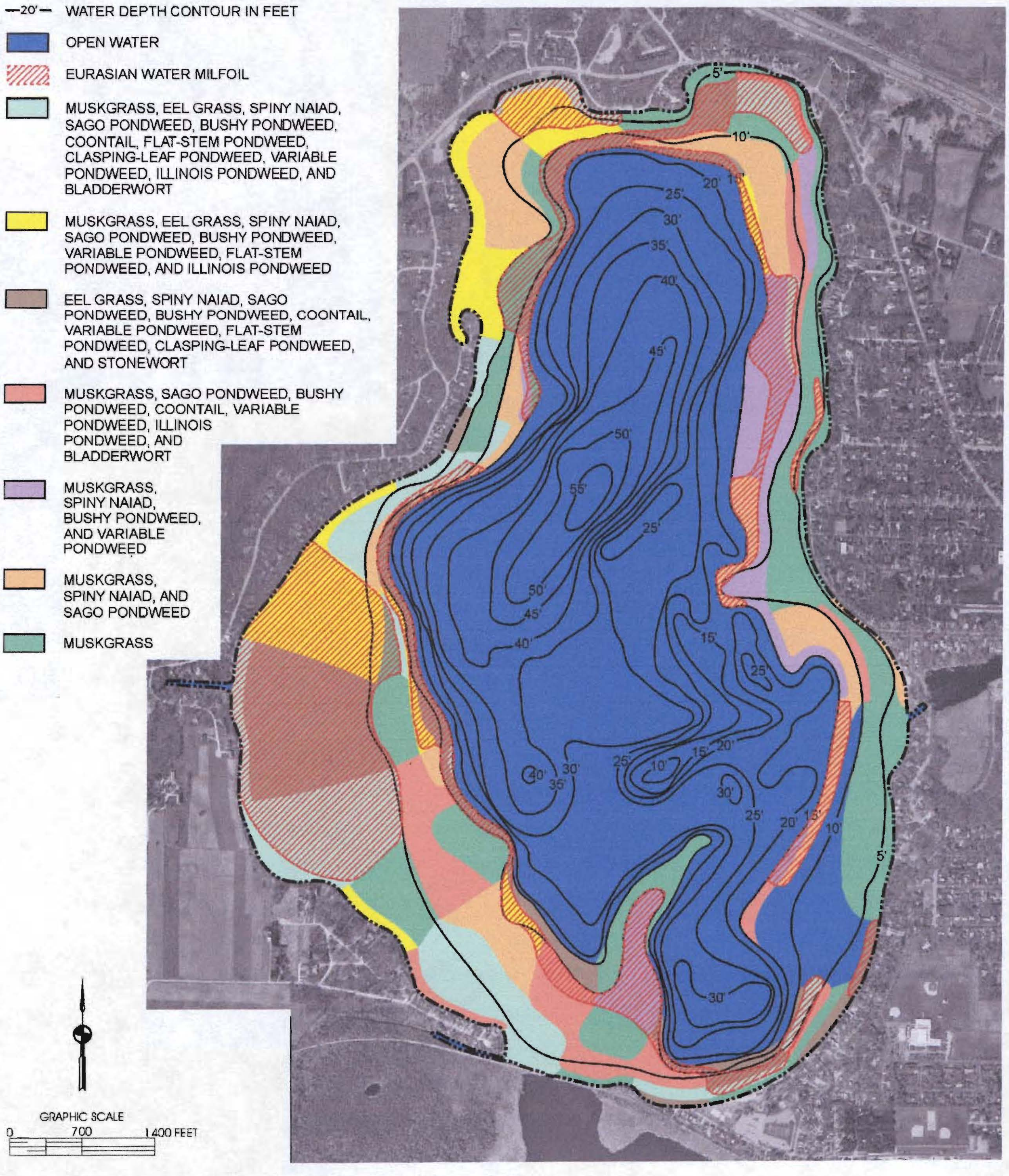
Source: Wisconsin Department of Natural Resources

Map 6. Aquatic Plant Community Distribution in Rock Lake – 1996



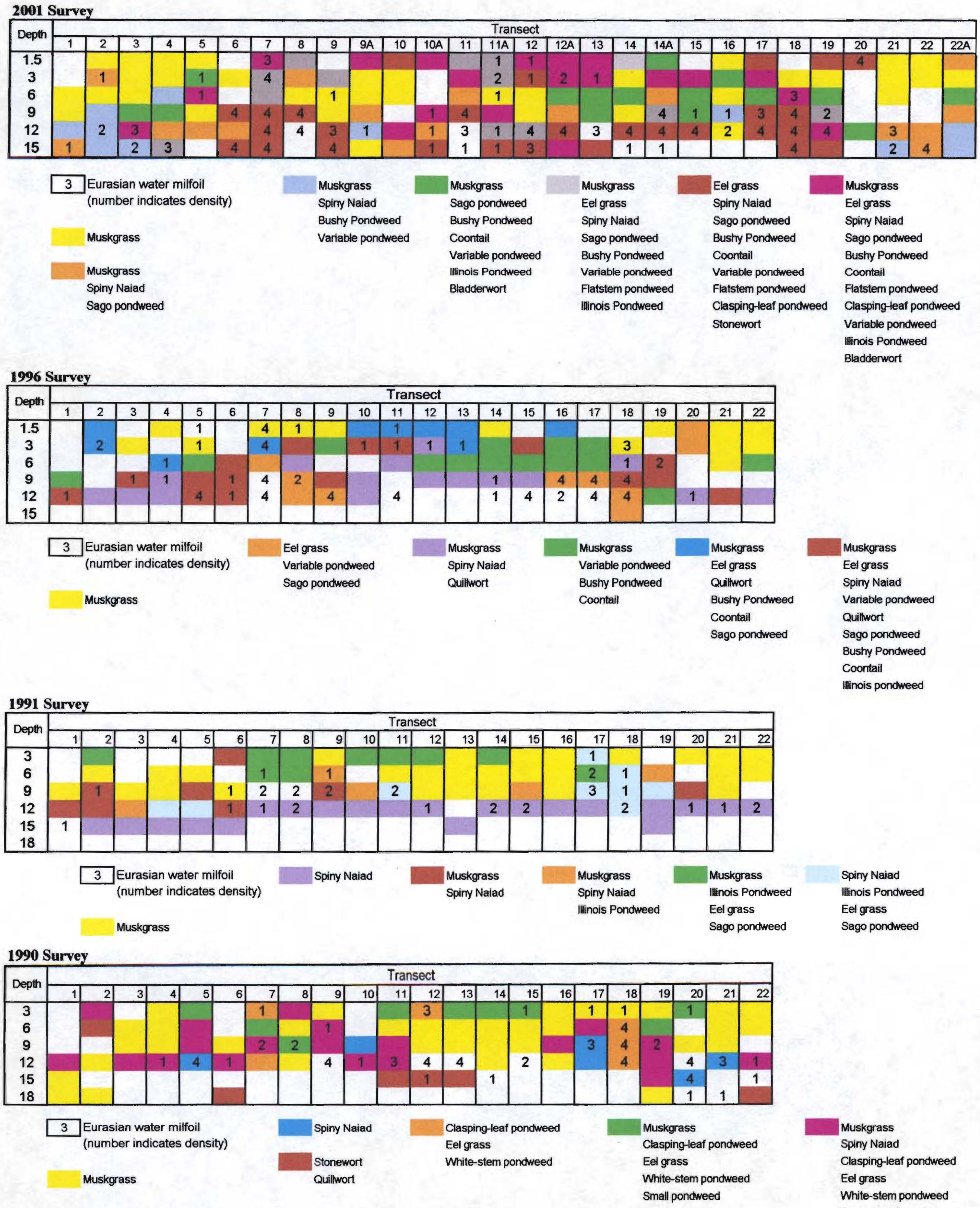
Source: Wisconsin Department of Natural Resources

Map 7. Aquatic Plant Community Distribution in Rock Lake – 2001



Source: Wisconsin Department of Natural Resources

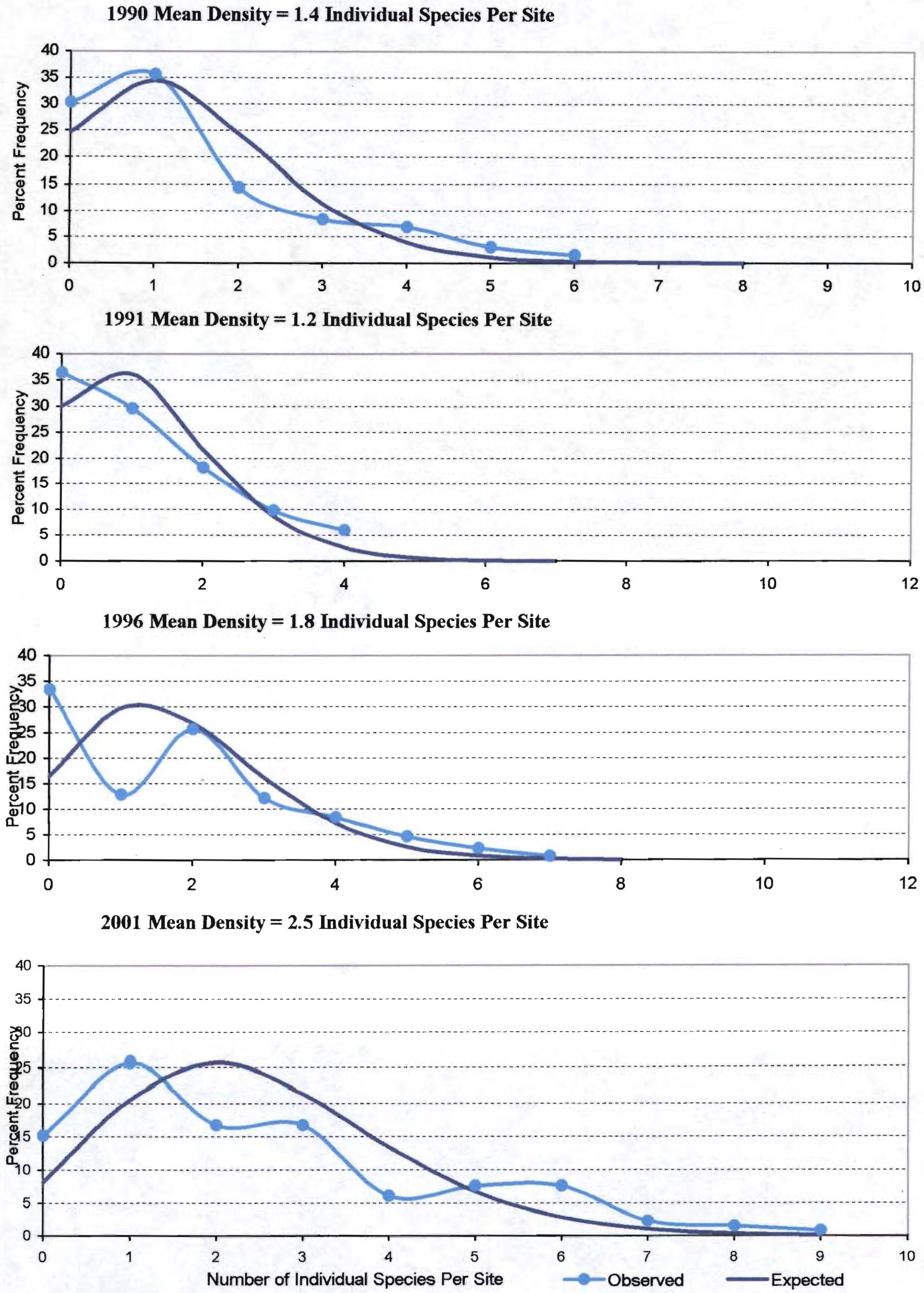
Figure 2. Aquatic Plant Community Distribution among Transect and Depth: 1990-2001



[a]Individual plant species with less than three percent frequency occurrence were not included.

Source: Wisconsin Department of Natural Resources

Figure 3. Observed Spatial Distribution of Aquatic Plant Populations and Random Probabilities of Occurrence Predicted from the Poisson Distribution within Rock Lake – 1990-2001



Source: Wisconsin Department of Natural Resources

Figure 4. Total Number and Composition of Dominant Aquatic Plant Species found among Sample Sites within Rock Lake: 1990-2001

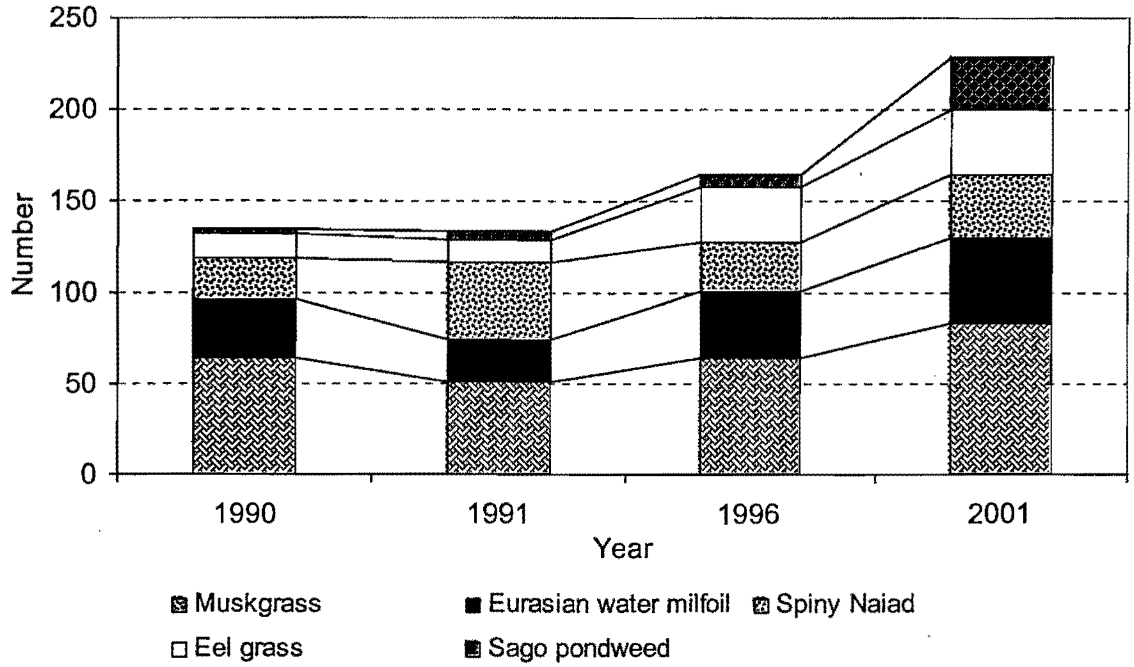


Figure 5. Total Number and Composition of Eurasian Water Milfoil found among Density Categories 1-4 within Rock Lake: 1990-2001

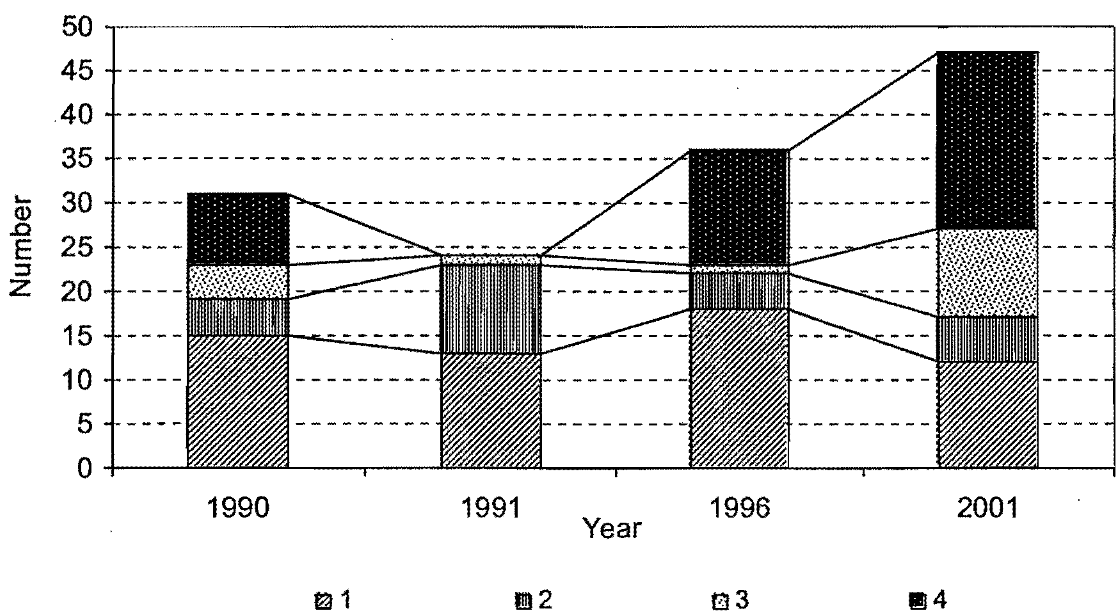


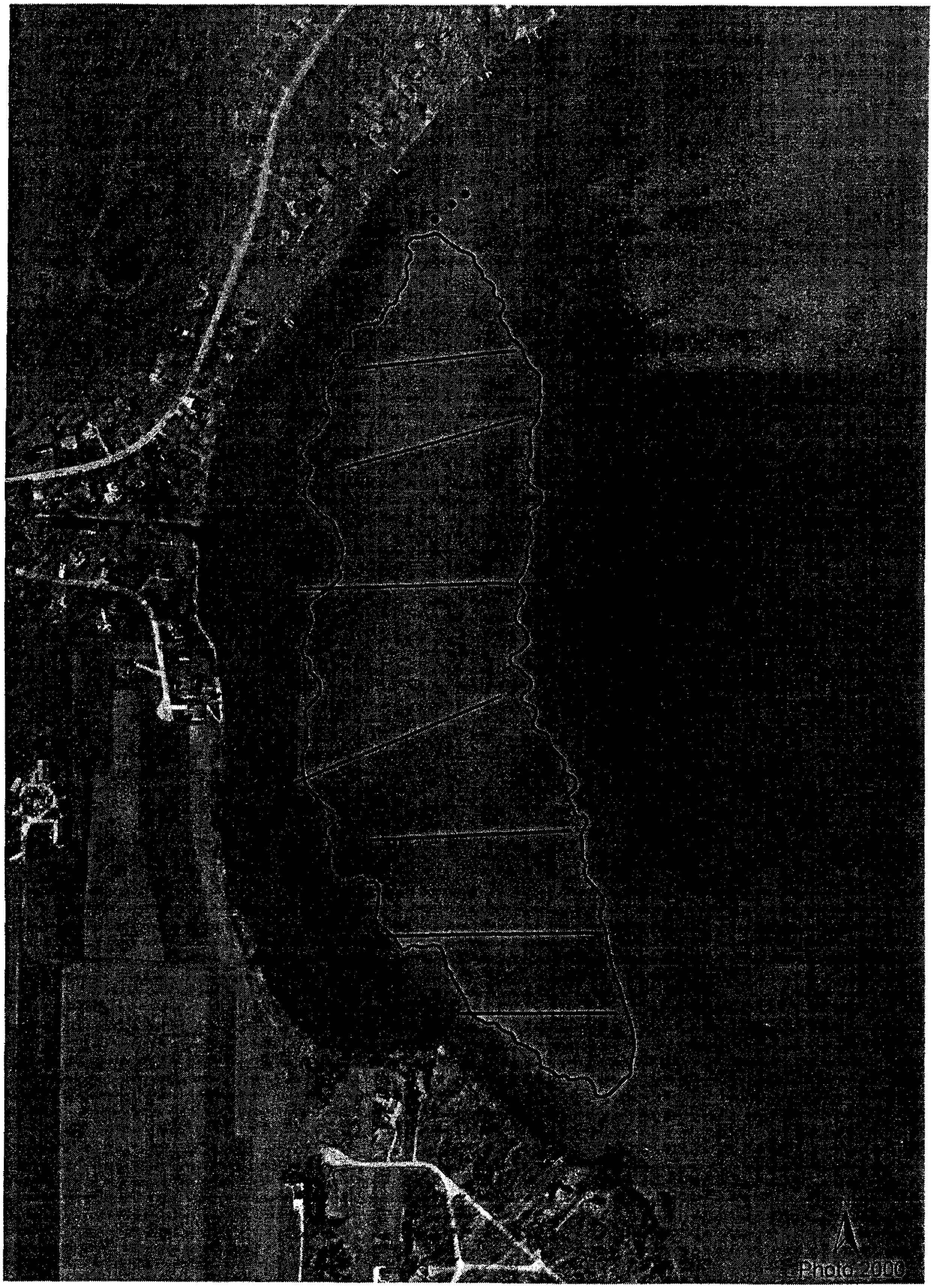
Table 11. Importance Value of Aquatic Plant Species within Rock Lake

Species	Year			
	1990	1991	1996	2001
Muskgrass	74	66	94	82
Eurasian water milfoil	38	23	35	40
Water celery	11	12	30	29
Spiny naiad	15	71	27	20
Sago pondweed	1	3	3	17
Bushy pondweed	3	2	6	12
Coontail	1	--	5	7
Variable pondweed	--	2	14	7
Flatstem pondweed	--	--	--	5
Bladderwort	--	3	3	4
Illinois pondweed	2	16	3	5
Clasping-leaf pondweed	9	--	0	3
Stonewort	5	1	1	1
Elodea	2	--	--	0
Curly-leaf pondweed	--	--	--	0
Small pondweed	5	2	--	--
Floating-leaf pondweed	1	2	0	--
White-stem pondweed	6	--	--	--
Quillwort	2	--	13	--

Table 12. Percent Relative Frequency of Occurrence of Aquatic Plant Species within Rock Lake

Species	Year			
	1990	1991	1996	2001
Muskgrass	34.9	32.3	28.0	25.0
Eurasian water milfoil	17.2	15.2	15.5	14.2
Water celery	7.0	7.6	12.9	10.8
Spiny naiad	11.8	26.6	11.6	10.2
Sago pondweed	1.1	2.5	3.0	8.7
Bushy pondweed	2.7	0.6	4.3	6.9
Coontail	0.5	0.0	3.9	4.8
Variable pondweed	0.0	1.3	7.8	4.5
Flatstem pondweed	0.0	0.0	0.0	4.2
Bladderwort	0.0	1.9	2.2	3.0
Illinois pondweed	1.1	8.9	1.3	3.3
Clasping-leaf pondweed	8.1	0.0	0.4	2.4
Stonewort	3.2	1.3	0.9	1.2
Elodea	0.5	0.0	0.0	0.3
Curly-leaf pondweed	0.0	0.0	0.0	0.3
Small pondweed	3.2	0.6	0.0	0.0
Floating-leaf pondweed	0.5	1.3	0.4	0.0
White-stem pondweed	5.9	0.0	0.0	0.0
Quillwort	2.2	0.0	7.8	0.0

Map 8. Circumference of 2001 Bulrush Bed, including Transect Locations



Chapter V
AQUATIC PLANT MANAGEMENT

The purpose of this report is to summarize the various aquatic plant surveys done on Rock Lake and to plan for future management decisions that will protect and enhance the aquatic plant communities.

Looking at the data trends, the plant communities in the lake have been somewhat diverse throughout the years. In 2001 the diversity increased slightly to seven aquatic plant communities – one more community compared with previous years. Over the 10-year period of record, the distribution of the plants has become less uniform. This shift is likely due to changes occurring within the aquatic plant community, as the mean density of aquatic plants has increased over this period. Comparing the data from the 2001 survey to those data acquired during the previous surveys conducted indicates that aquatic plants in Rock Lake have become more abundant.

Eurasian water milfoil, sago pondweed, and wild celery all appear to have increased in relative frequency of occurrence. The increase in Eurasian water milfoil is a concern because this exotic species can threaten the diversity of the aquatic plant community in the lake. In addition, milfoil can adversely effect recreational uses and impair the aesthetic quality of the lake.

AQUATIC PLANT LAWS

State laws always should be checked prior to initiating any management actions to control nuisance aquatic plants. (At this time there are no local or county laws regulating aquatic plant control.) In some cases, state permits might be required. This section briefly explains some of the laws regarding aquatic plant control. The Department of Natural Resources (DNR) should be consulted before taking any action.

The Department of Natural Resources regulates the removal of aquatic plants through chemical, mechanical, biological, and some manual means. Approved chemicals can be applied to control nuisance aquatic plants but only after obtaining a permit. Plants to be controlled must be correctly identified so that the appropriate chemical is chosen. In addition, the chemical treatment must occur at the proper timing and dosage. In order to apply chemicals in liquid form, the applicator must be licensed with the State.

Mechanical harvesting of nuisance plants requires a permit from the DNR. This activity includes the use of a harvesting machine designed specifically to cut plants or use of mechanical means (including use of a boat motor) to cut or remove plants from the water. An aquatic plant management plan that sets out a plan for mechanical harvesting is more than likely required before such a permit will be considered.

A DNR permit is not required for manual cutting and raking (no external or auxiliary power can be used) if the area of plant removal is a single area with a maximum width of no more than 30 feet along the shoreline. Any piers, boatlifts, swim rafts, and other recreational and water use devices must be located within that 30 feet. All cut plants must be removed from the water. A permit is required if the plant removal area is more than 30 feet wide along the shoreline. Exotic invasive plants (Eurasian water milfoil, curly-leaf pondweed, and purple loosestrife) can be manually removed without a permit as long as native plants are not harmed.

In some cases, there are biological controls for the control of exotic invasive species. A DNR permit is necessary for this means of control.

In 2001, a law was passed in Wisconsin that makes it illegal to transport boats or boating equipment that has aquatic plants or zebra mussels attached. Boaters must remove all aquatic plants and zebra mussels from their boat, trailer, and boating equipment. This includes draining water from live wells, bilges, and bait wells, as well as disposing of leftover bait in the trash.

The DNR should be consulted about permit requirements if aquatic plants are planted in Rock Lake.

RECOMMENDATIONS

Monitoring

Aquatic plant surveys should be performed every 3-5 years on Rock Lake to keep track of community changes and the appearance or spread of invasive species.

The survey on the bulrush beds should be performed at the same time as the survey done in the main basin of the lake.

An aquatic plant study should be performed on Marsh Lake (following the methodology employed on the main basin). An informal aquatic plant survey was done in 1992. However, this survey only documented the different species present. Little information on density and location was recorded.

All future aquatic plant surveys should employ the 6 extra transects established in 2001 for a total of 28 transects. The addition of these extra transects was shown to better document the aquatic plant communities in the lake.

Future aquatic plant studies should check to see if aquatic plants are growing at the 18 foot depth. In 1990, rake hauls were performed at the 18 foot depth and plants were present. A rake haul at this depth was not performed during the other survey years.

Management of Exotic Species

The abundance and location of Eurasian water milfoil should be carefully watched. At this point, it is not taking over habitat of native species and is not a serious problem for recreation on the lake. The results of future surveys should be shared with the Department of Natural Resources so that management options can be considered if warranted.

In terms of the various Eurasian water milfoil control options, the advantages and disadvantages of each are located in the Table 13.

Table 13. **Advantages and Disadvantages of Eurasian Water Milfoil Control Options**

Manual Control	
Advantages	**Disadvantages**
- usually very simple and inexpensive - immediate removal of plants and associated nutrients - improves recreational access	- labor and time intensive - disposal of plants is required - only suitable for small areas - multiple treatments throughout the growing season are required - desired species may be removed - potentially can remove beneficial animals - can disturb bottom sediments - treated areas are prone to the establishment of invasive species
Mechanical Harvesting	
Advantages	**Disadvantages**
- immediate removal of plants and associated nutrients - cuts plants within 5 feet of surface, thus improving recreational access - some species selectivity if timing and location of cutting is done correctly - reduces the potential for floating plant debris caused by motors	- short-term control because plants continue to grow (not as effective on fast-growing plants) - multiple treatments throughout the growing season are required - disposal of plants is required - uncollected plants will re-root in other areas - desired species may be removed also - may benefit disturbance-tolerant species - potentially can remove beneficial animals - can disturb shallow sediments – and should only be performed in depths greater than 3-5 feet - high initial cost for acquiring the equipment - yearly costs for equipment maintenance, storage, insurance, labor, etc.
Chemical Control	
Advantages	**Disadvantages**
- some herbicides can be species specific to some extent - proper timing can result in good effectiveness and reduced side effects - proper doses will generally not result in fish toxicity - treatment of large areas in small amount of time	- plants differ in their susceptibility to chemicals - generally, application must be repeated either seasonally or annually - chemical drift can cause damage to desired species - plants are not removed, and their decomposition may result in depleted dissolved oxygen, nutrient release, and silt accumulation - long-term risks of some chemicals are not well understood - same water activities may be restricted following a chemical application - treated areas are prone to the establishment of invasive species

At this time, the opinion of the Department of Natural Resources and the Jefferson County Land and Water Conservation Department is that the Eurasian water milfoil population is not at a point where mechanical and chemical control techniques are warranted. Diversity and abundance of aquatic plants have increased – so the milfoil doesn't seem to be "crowding out" other species.

In terms of biological control, there is a native milfoil weevil (*Euhrychiopsis lecontei*) that might adversely influence the growth of Eurasian water milfoil. This insect has been shown to actually prefer Eurasian water milfoil over native milfoil plants. It burrows inside the milfoil stem and damages the plant causing it to collapse and die. Research has shown that the milfoil weevil is effective at some sites, but ineffective at other sites. Unfortunately, the research is not refined enough to predict when, where, and how weevils will be effective at controlling Eurasian water milfoil.

Rock Lake is known to have a native population of milfoil weevils. A few of the important factors to a healthy population of weevils are over-wintering habitat, predation pressure, and food abundance. Weevils need natural shoreline vegetation for over-wintering. Lawns maintained to the edge of the water will not support weevils in the winter. Sunfish have been shown to include milfoil weevils as a part of their diet. Rock Lake has a population of pumpkinseed which is a sunfish. If weevil densities in the lake are low, then predation would probably be a significant limiting factor to the insect's population. Alternatively, if milfoil densities are moderate or high, then sunfish would have little effect on the populations. Finally, milfoil populations and distribution throughout the lake may impact the number of weevils present in the lake.

Some biological control of the Eurasian water milfoil by the native milfoil weevil might already be happening in Rock Lake. However, it might be beneficial to release more native weevils. The Land and Water Conservation Department, in conjunction with the Rock Lake Improvement Association, should consult with the DNR on this possible control technique. As a starting point, perhaps a study should be done to determine the density and distribution of the milfoil weevil in Rock Lake.

In the future, mechanical harvesting could be an option to clear navigational channels. As long as the diversity of the aquatic plants in Rock Lake remains high, mechanical harvesting of Eurasian water milfoil should not be considered. There is too much risk of making the problem worse with this technique since cut plants that are not collected can spread to new locations.

In the future, chemical treatment should not be undertaken unless the following circumstances are met:

- there is no other management alternative
- treatment will not result in the loss of native species
- it can be shown that chemical treatment will result in an improvement to the aquatic ecosystem
- recreational uses are significantly hampered by the nuisance species

Furthermore, chemical treatments should not be undertaken in designated sensitive areas.

Curly-leaf pondweed is another exotic that was found in the 2001 survey. This species can interfere with recreational activities in the spring, and creates a sudden loss of habitat and nutrient release in mid-summer when it dies off. The number and distribution of this species should be tracked with future aquatic plant studies.

Management of Aquatic Plant Diversity

The sensitive areas in Rock Lake were designated in 1995. Because the aquatic plant communities have changed since then, the Land and Water Conservation Department should consult with the DNR to see if a new sensitive area survey should be performed on Rock Lake. This would involve a team approach with the fishery biologist, water resource specialist, water regulation personnel, aquatic plant specialist, and the wildlife biologist.

There are plans underway to do some aquatic plant plantings in Korth Bay along the shoreline of Jefferson County's Korth Park. The success of this project should be monitored so that plantings could be potentially employed in other locations around the lake. Locations that are possibilities include other park areas or areas where development will not occur such as Tyranena Park, parts of Schultz Bay, and along the Glacial Drumlin Trail.

Education

Prevention of the introduction of exotic species to Rock Lake is essential. Unfortunately, zebra mussels are found in waters of at least 3 of the 5 surrounding counties of Jefferson County. Therefore, activities should be initiated to educate the public about the threat and the various prevention practices that they should adopt. The following is a list of potential activities that should be developed:

- Write and submit articles to the local and county newspapers on exotic species
- Work with various groups (DNR wardens, schools, community groups, etc.) on educational activities
- Volunteers should be recruited to educate others about exotic species. The state's Adopt-A-Lake Program offers a workshop to train volunteers and provide "Milfoil Masters" toolkits on how to talk with boaters about Eurasian water milfoil and other invasive species.
- A tour or presentation could be organized to highlight a few invasive species issues. Participants could be shown how to inspect and clean boats and trailers for hitch-hiking exotics. Control methods for established nuisance species could be covered at the educational event.

To augment the native milfoil weevil population, and to reduce the amount of nutrients feeding the invasive plant species, landowners should be encouraged to install native plantings along their shoreline.

To reduce the amount of nutrients entering the water, landowners should be educated about the use of no-phosphorus fertilizers. Phosphorus should only be used when soil tests indicate a depletion of the nutrient. The Land and Water Conservation Department should work with the Rock Lake Improvement Association on developing a list of no-phosphorus fertilizers and encouraging local stores to sell this fertilizer option.

Landowners should be educated about the aquatic plant removal laws. In particular, the degree of manual cutting that is allowed should be communicated. The landowners also should be told the difference between exotic species and beneficial native species. When possible, the Land and Water Conservation Department should offer assistance of identifying plants so that only exotic species are manually removed.