Technical Report A-99-2
February 1999

US Army Corps
of Engineers
Waterways Experiment
Station

Aquatic Plant Control Research Program

Predicting the Invasion of Eurasian Watermilfoil into Northern Lakes

by John D. Madsen, WES

WES

Prepared for Headquarters, U.S. Army Corps of Engineers

PRINTED ON RECYCLED PAPER

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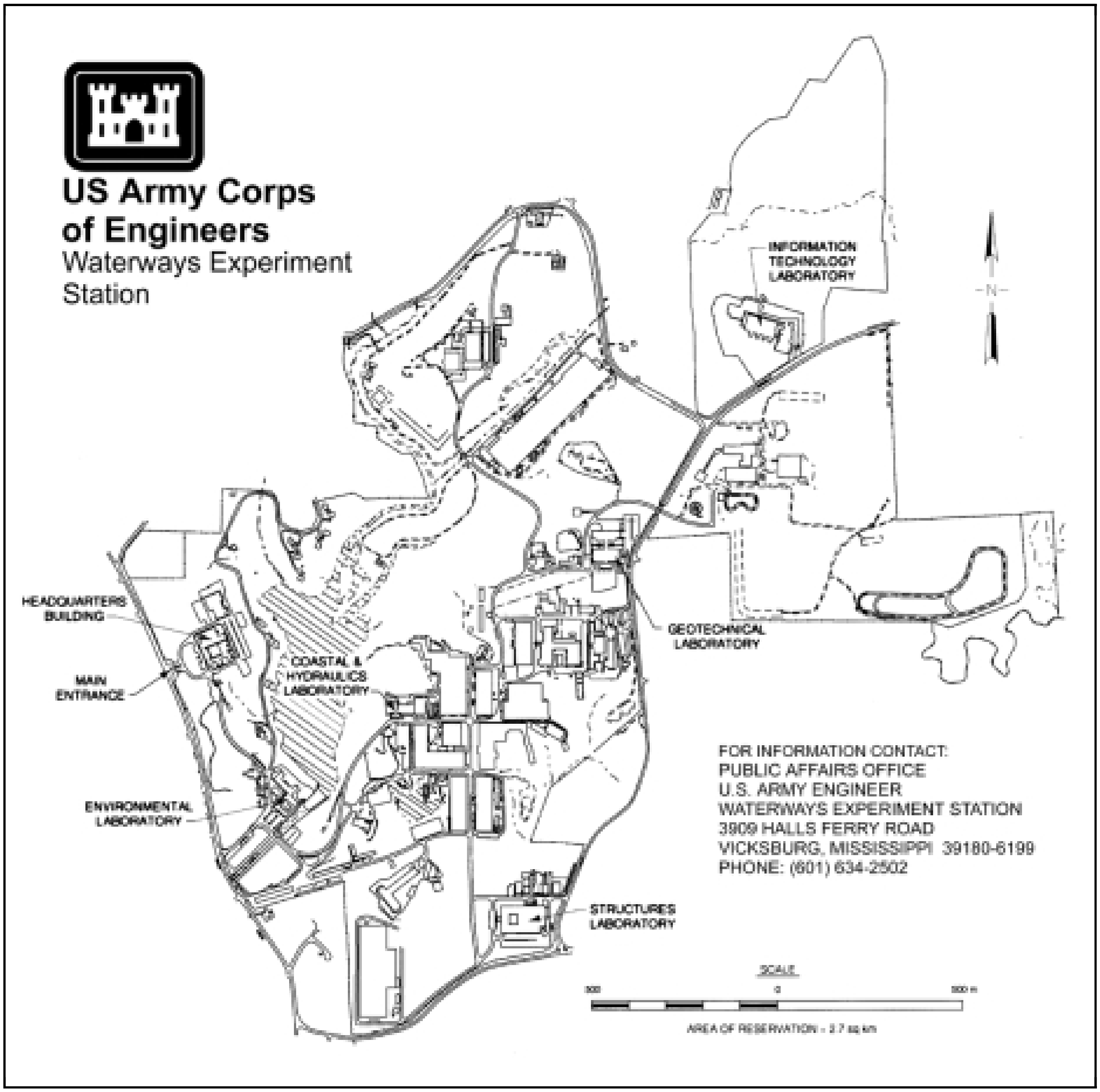
Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



Waterways Experiment Station Cataloging-in-Publication Data

Madsen, John Douglas.

Predicting the invasion of Eurasian watermilfoil into northern lakes / by John D. Madsen ; prepared for U.S. Army Corps of Engineers.

90 p. : ill. ; 28 cm. — (Technical report ; A-99-2)

Includes bibliographic references.

1. Eurasian watermilfoil. 2. Aquatic plants. 3. Plant invasions. I. United States. Army. Corps of Engineers. II. U.S. Army Engineer Waterways Experiment Station. III. Aquatic Plant Control Research Program (U.S. Army Engineer Waterways Experiment Station) IV. Title. V. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; A-99-2.

TA7 W34 no.A-99-2

Contents

Preface

The work reported herein was conducted as part of the Aquatic Plant Control Research Program (APCRP), Work Unit 32805, in cooperation with the Minnesota Department of Natural Resources. Funding was provided under Department of the Army Appropriation No. 96X3122, Construction General, and the State of Minnesota. The APCRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory (EL). The APCRP is managed under the Center for Aquatic Plant Research and Technology (CAPRT). Dr. John W. Barko, EL, was the CAPRT Director, and Mr. Robert C. Gunkel, Jr., EL was Assistant Director. Program Monitor during this study was Mr. Timothy Toplisek, HQUSACE.

This study was conducted by, and the report prepared by, Dr. John D. Madsen, Environmental Processes and Effects Division (EPED), EL, WES. Technical assistance was provided by Mr. John Skogerboe, EPED, and Ms. Chetta Owens, AScI, Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX. Unpublished data were provided by Dr. Steven Carpenter and Mr. Sarig Gafay, University of Wisconsin-Madison; Ms. Holly Crosson, Vermont Department of Environmental Conservation; Ms. Wendy Davis, COLAM; Drs. Sandy Engel and Dick Lillie and Messers. Jim Leverence, James Vennie, and Bob Wakeman, Wisconsin Department of Natural Resources; Dr. Steven Heiskary, Minnesota Pollution Control Agency; Dr. Peter Newroth, British Columbia Ministry of the Environment; Dr. Stan Nichols, Wisconsin Geological and Natural History Survey; Mr. Scott Painter, Environment Canada; Messrs. Dennis Schupp and Charles W. Welling, Minnesota Department of Natural Resources; Ms. Frances Solomon, King County, WA; Mr. Mark Swartout, Thurston County, WA; Ms. Susan Warren, Vermont Department of Natural Resources; and Mr. George Wood, Blue Spring Lake Association, WI. Mr. Skogerboe and Ms. Owens provided reviews of this report. Portions of this report have been published in modified form in the *Journal of Aquatic Plant Management* Vol. 36.

The investigation was conducted under the general supervision of Dr. John Harrison, Director, EL, and Dr. Richard E. Price, Chief, EPED, and under the direct supervision of Dr. Robert Kennedy, Acting Chief, Ecosystem Processes and Effects Branch.

At the time of publication of this report, Commander of WES was COL Robin R. Cababa, EN.

This report should be cited as follows:

> Madsen, John D. (1998). "Predicting the invasion of Eurasian watermilfoil into northern lakes," Technical Report A-99-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

1 Analysis of Limnological Data

Introduction

Littoral zone plants are an important component of the lake ecosystem (Ozimek, Gulati, and van Donk 1990), providing food and habitat for macro-invertebrates and fish (Cyr and Downing 1988, Savino and Stein 1989), stabilizing bottom sediments and binding nutrients (Maceina et al. 1992), and reducing turbidity in the water column by increasing sedimentation rates (Petticrew and Kalff 1992). Nevertheless, the introduction of nonindigenous aquatic plants into littoral zone environments may alter the complex web of biotic and abiotic interactions. Dense stands of some mat-forming plant species reduce oxygen exchange, deplete available dissolved oxygen, increase water temperatures, and increase internal loading rates of nutrients (Frodge, Thomas, and Pauley 1991; Frodge et al. 1995; Seki, Takahashi, and Ichimura 1979). Dense canopies formed by some nonindigenous species reduce native plant diversity and abundance (Madsen et al. 1991). The reduction of habitat complexity results in reduced macroinvertebrate diversity and abundance (Krull 1970, Keast 1984) and also reduces growth of fishes (Lillie and Budd 1992). The advent of non-indigenous plant species is not only deleterious to human use of aquatic systems but is also detrimental to the native ecosystem.

Eurasian watermilfoil (*Myriophyllum spicatum* L.) was first introduced to the United States in the 1940's (Couch and Nelson 1985). Presently, it is found in 44 of the lower 48 states (U.S. Geological Survey (USGS) 1997) and several Canadian provinces from Quebec to British Columbia (Aiken, Newroth, and Wile 1979; Couch and Nelson 1985). Eurasian watermilfoil is a perennial herbaceous submersed plant which forms a dense canopy of branches at the surface (Aiken, Newroth, and Wile 1979; Smith and Barko 1990). Eurasian watermilfoil spreads from one lake to another by mass flow of water and by accidental introduction by boats and boat trailers (Aiken, Newroth, and Wile 1979; Newroth 1993). Spread between lakes and within lakes is predominantly by vegetative fragments (Kimbel 1982; Madsen, Eichler, and Boylen 1988). Localized spread is by root crowns and runners (Madsen, Eichler, and Boylen 1988; Madsen and Smith 1997). Although viable seeds are formed, they are not generally significant in the perennation or spread of the plant (Madsen and Boylen 1989; Hartleb, Madsen, and Boylen 1993).

The invasion process for nonindigenous species follows a progression from introduction, establishment, and colony formation stages. Each step of this process, and subsequent growth, is moderated by environmental factors affecting the outcome. The subsequent growth of the colony is affected by a broad suite of abiotic and biotic factors. The abundance of the invading plant can be described by a Gaussian relationship (Figure 1). The curved solid line represents the upper boundary of abundance. Plant abundance also occurs below the line when limited by other environmental parameters, biotic activity, disturbance, or insufficient time elapsing to reach maximal levels. If the maximal level is of interest, then the best approach is to approximate an upper boundary to the plant abundance (Figure 1, dashed line).

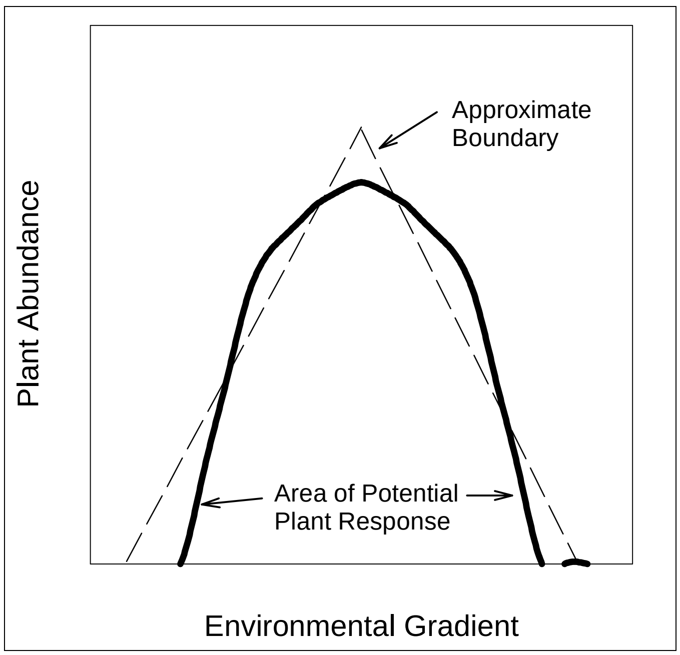


Figure 1. Diagram of a theoretical Gaussian distribution of plant abundance along an environmental gradient (solid line) and an approximated boundary (dashed line)

The goals of this study were to correlate limnological parameters to Eurasian watermilfoil dominance and, from these relationships, to develop estimates predicting invasion success. This tool would then be used to allocate resources toward monitoring and managing lakes most likely to develop problem populations of Eurasian watermilfoil.

Materials and Methods

A literature review of lakes with Eurasian watermilfoil populations resulted in data for over 300 lakes from 30 publications and 14 unpublished sources that indicated both Eurasian watermilfoil dominance and relevant limnological data. The original data compilation of all sources is presented as Appendix A. Data were obtained for lakes in Vermont, New York, Michigan, Wisconsin, Minnesota, Washington, Oregon, Alabama, Ontario, and British Columbia. Typically, only one year of data was obtained for each lake. These data were combined for lakes in order to make as complete a data matrix as possible (Appendix B). In addition, the “dominance” of Eurasian watermilfoil was calculated. This “dominance” factor was combined as percent of littoral zone in which Eurasian watermilfoil was present or as percent cover of Eurasian watermilfoil in the littoral zone. Although these parameters are not equivalent, there would have been insufficient data to evaluate any relationships without combining data at some level.

Plant abundance and distribution were measured in various ways and reported in different units. These diverse methods have been converted into a measure of Eurasian watermilfoil dominance which is computed as the proportion, or percent, of the littoral zone in which Eurasian watermilfoil was found. The necessity of restricting Eurasian watermilfoil data to this measure resulted in the discarding of some lakes and studies from consideration. A total of 103 lakes had sufficient data to calculate the estimate of Eurasian watermilfoil dominance.

Plant community data included:

a. Aquatic plant species presence and/or abundance

b. Eurasian watermilfoil biomass

c. Eurasian watermilfoil percent cover

d. Native plant percent cover

e. Eurasian watermilfoil cover area (littoral zone)

f. Native plant cover area (littoral zone)

Lake morphometry information for each lake included:

a. Maximum depth

b. Average depth

c. Area

d. Littoral zone area

e. Shoreline development

Limnological data sought included:

a. Secchi disk depth

b. Light attenuation coefficient

c. Alkalinity

d. Total phosphorus

e. Phosphorus loading rate

f. Total nitrogen

g. Nitrogen loading rate

h. Trophic state

i. Carlson’s trophic state index (Carlson 1977)

j. Dissolved inorganic carbon

k. Acid neutralizing capacity

Other information that was included:

a. State

b. County

c. Township

d. Geoposition (latitude, longitude)

e. Glaciated versus unglaciated

f. Soils

g. Soil erosion rate

h. Sedimentation rate

i. Land use

For most variables, insufficient data were found to continue analysis. Of the 31 parameter groups investigated, data will be presented for 7:

a. Cumulative native plant cover (the sum of the cover of native plant species)

b. Secchi disk depth

c. Alkalinity

d. pH

e. Sediment sand content

f. Water column total phosphorus

g. Trophic state index

Since not all lakes in the ensuing analysis had data for the above parameters available, the number of lakes per plot was not constant. No lakes were deleted as outliers.

Results and Discussion

Before discussing the relationship of Eurasian watermilfoil to the environment, one other relationship bears examination. The abundance of Eurasian watermilfoil was inversely related to cumulative native plant cover (Figure 2).

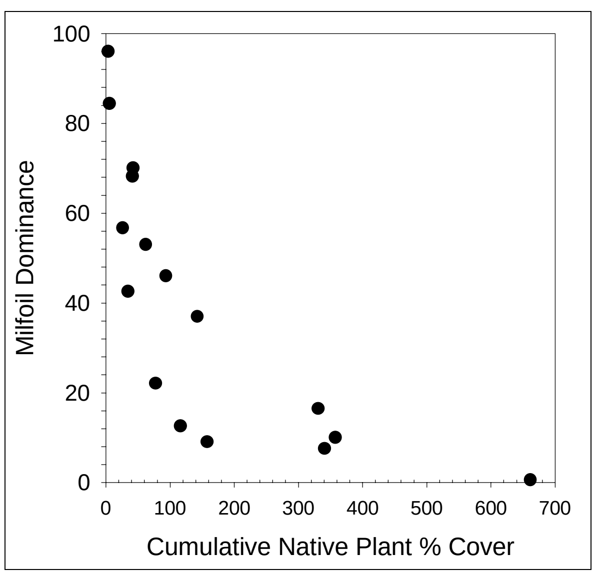


Figure 2. Relationship between Eurasian watermilfoil dominance (as percent of littoral zone with Eurasian watermilfoil) and native plant cover in 17 lakes

Lakes with more than 50 percent Eurasian watermilfoil dominance were found to have less than 60 percent cumulative native plant cover. Although this has been quantitatively documented in one instance for a given lake over time (Madsen et al. 1991) and reported as occurring in other systems (Aiken, Newroth, and Wile 1979; Grace and Wetzel 1978; Smith and Barko 1990), it documents a relationship for many lakes over a range of Eurasian watermilfoil dominance.

Dissolved organic carbon or alkalinity has often been cited as a parameter associated with the success of Eurasian watermilfoil in lakes (Grace and Wetzel 1978; Smith and Barko 1990). In fact, the photosynthetic rate in Eurasian watermilfoil has been correlated to dissolved inorganic carbon for a group of Italian lakes (Adams, Guilizzoni, and Adams 1978). Nevertheless, the present study indicated abundant Eurasian watermilfoil across a broad range of alkalinity (Figure 3). Other studies have also observed the occurrence of Eurasian watermilfoil across a broad range in alkalinity, but have not generally measured Eurasian watermilfoil abundance (Crow and Hellquist 1983). A similar plot of Eurasian watermilfoil dominance versus pH appears to give a relationship (Figure 4), but pH is a highly variable parameter. Likewise, the low number of lakes at the low end of the pH spectrum severely limits the usefulness of this relationship. Eurasian watermilfoil is not typically found in abundance in either clearwater or brownwater acid lakes (Warrington 1985).

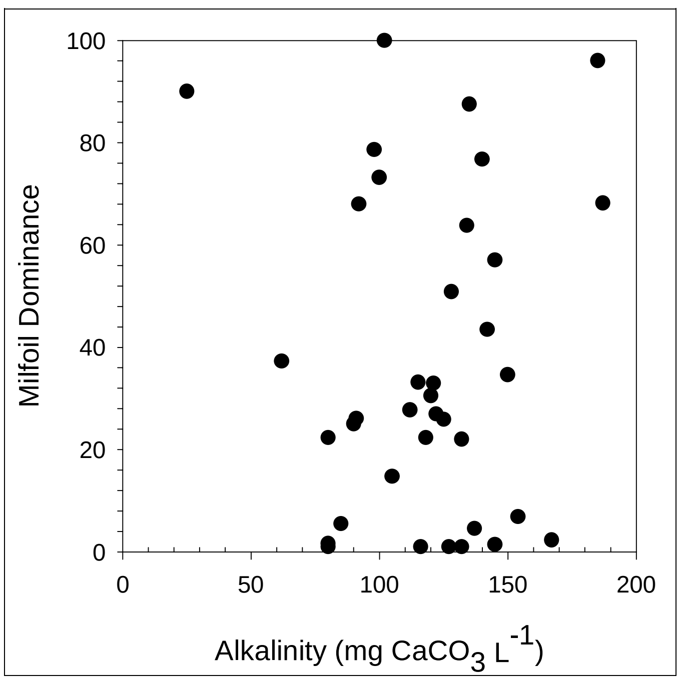


Figure 3. Relationship between Eurasian watermilfoil dominance and alkalinity (mg $CaCO_3$ L^{-1}) in 39 lakes

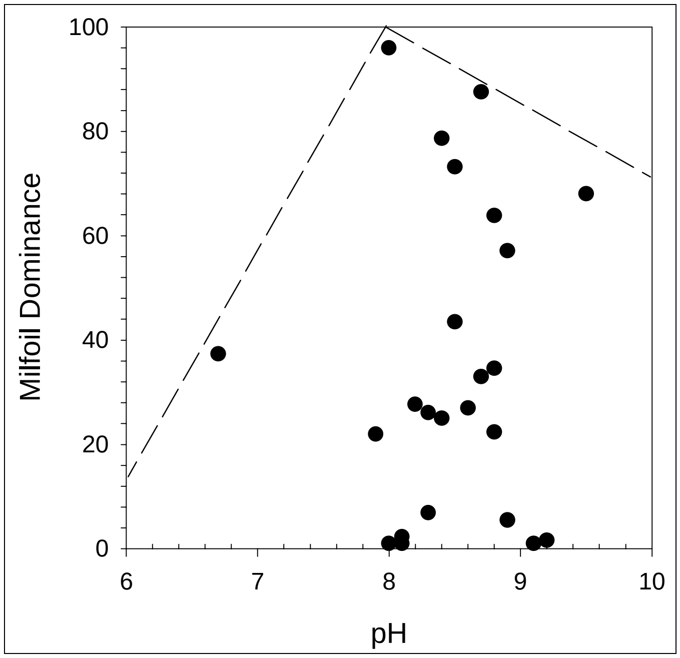


Figure 4. Relationship between Eurasian watermilfoil dominance and pH in 25 lakes, with an approximate boundary indicated with a dashed line

Light is often recognized as a parameter that controls the presence of submersed aquatic plants (Barko, Adams, and Clesceri 1986), but it is a poor predictive tool for Eurasian watermilfoil dominance relative to native plants due to its widespread effect on all plants. A plot of Eurasian watermilfoil dominance versus Secchi disk depth, as a measure of lake transparency, indicates that Eurasian watermilfoil is abundant in some very low-transparency lakes (Figure 5).

Sediment fertility has also been evaluated as related to the growth of Eurasian watermilfoil, as with other submersed macrophytes (Smith and Barko 1990). Growth limitation of Eurasian watermilfoil due to insufficient sediment nitrogen has been documented (Anderson and Kalff 1986). Unfortunately, few lakes are monitored for sediment nitrogen levels. One possible correlate is the percent composition of sand in sediment. Sandy sediments are known to be of low fertility (Barko, Adams, and Clesceri 1986). A plot of Eurasian watermilfoil dominance versus percent sand composition of sediments (Figure 6) indicates a potential maximal limit which increases from 10 percent sand to 18 percent sand, possibly indicating the low growth potential of plants rooted in highly organic sediments. Above 18 percent sand, the upper limit of Eurasian watermilfoil dominance declines, which may be indicative of reduced fertility and growth rates. The upper limit of Eurasian watermilfoil dominance is still 80 percent when the sediment composition is essentially 100 percent sand. This plot demonstrates a very low potential to discriminate between high and low dominance of Eurasian watermilfoil and relies too heavily on only four points for its shape. One confounding factor in this instance is that groundwater often

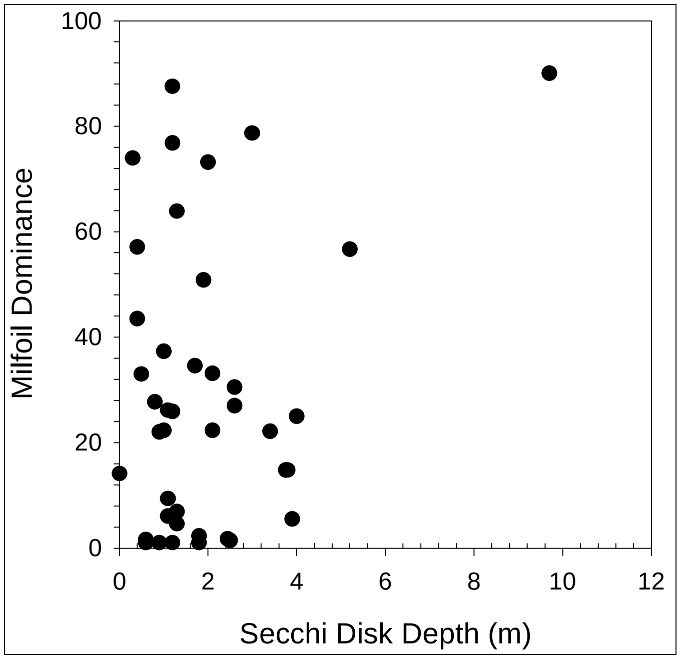


Figure 5. Relationship between Eurasian watermilfoil dominance (as percent of littoral zone with Eurasian watermilfoil) and Secchi disk depth for 42 lakes

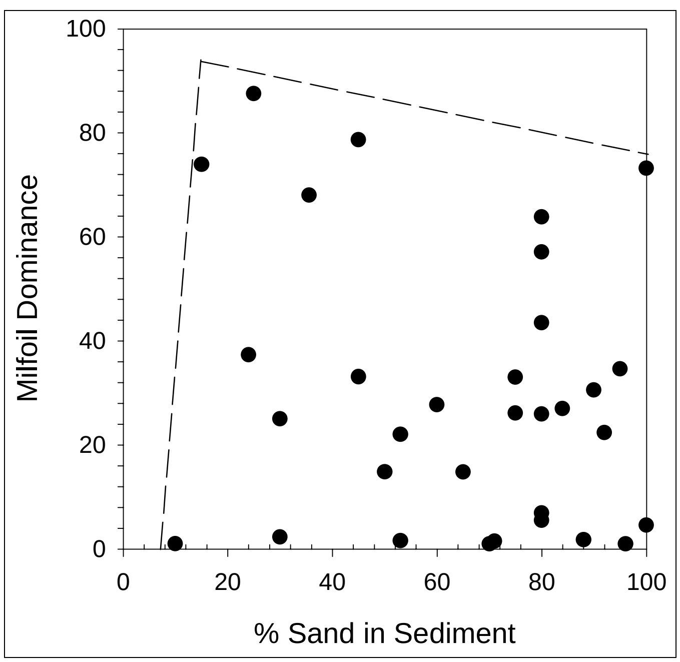


Figure 6. Relationship between Eurasian watermilfoil dominance and percent sand content of sediment for 33 lakes, with an approximate boundary indicated with a dashed line

percolates through sandy sediments, which may replenish the concentrations of nutrients in these sediments (Loeb and Hackley 1988; Lodge, Krabbenhoft, and Striegl 1989).

Eurasian watermilfoil dominance exhibits possibly the most distinct and predictive relationship with total water column phosphorus (Figure 7). The shape of this relationship most closely approximates that expected in a theoretical Gaussian relationship, being broad at the base and narrow at the top. Eurasian watermilfoil dominance increases sharply as water column phosphorus increases from oligotrophic (<10 μg L^{-1}) through mesotrophic (<30 μg L^{-1}) concentrations and decreases above 50 μg L^{-1} in what is considered moderately eutrophic lakes (Wetzel 1983; Carlson 1977). Eurasian watermilfoil, however, is probably not responding directly to water column phosphorus. Experimental studies have indicated that Eurasian watermilfoil is generally limited by nitrogen availability (Barko 1983; Anderson and Kalff 1986) and that phosphorus is taken up from the sediment rather than the water column (Carignan and Kalff 1979, 1980; Barko and Smart 1981). Total water column phosphorus may be a correlative variable for several environmental factors, including sedimentation (which initially stimulates plant growth) and phytoplankton abundance (which would shade Eurasian watermilfoil) (Jones, Walthi, and Adams 1983).

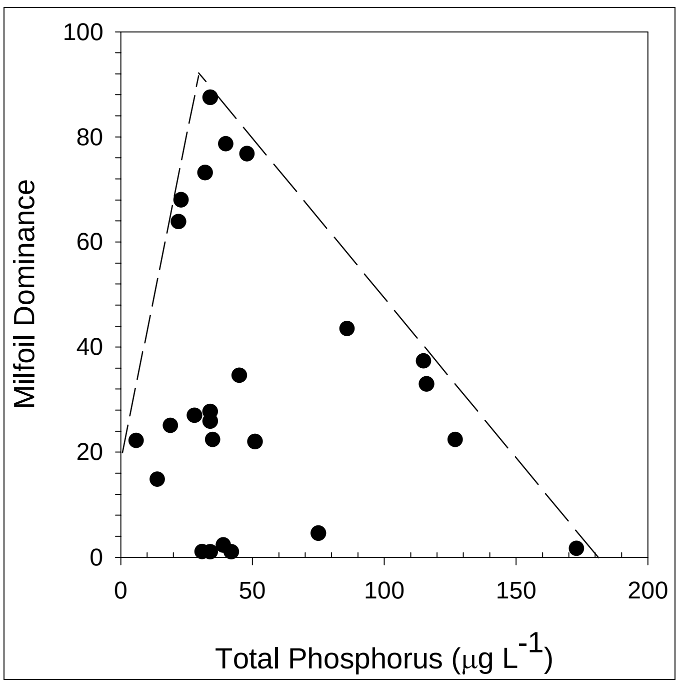


Figure 7. Relationship between Eurasian watermilfoil dominance and water column total phosphorus (μg L^{-1}) for 25 lakes, with an approximate boundary indicated with a dashed line

The plot of Eurasian watermilfoil dominance versus Carlson's trophic state index (TSI) (Carlson 1977) indicates a narrower margin of abundant Eurasian watermilfoil than might be expected (Figure 8). Eurasian watermilfoil was found in lakes ranging from 35 (transitional oligotrophic) to 70 (moderately eutrophic). Mesotrophic lakes are typically between 40 to 50 TSI (Cooke et al. 1986). This analysis corroborates observations that Eurasian watermilfoil actually appears most abundant in mesotrophic lakes and moderately eutrophic lakes (Smith and Barko 1990). If the abundant Eurasian watermilfoil lake at 35 TSI is excluded, then the remaining relationship indicates a sharp increase in abundance from 35 to 55 TSI and a decline from 55 to 75 TSI.

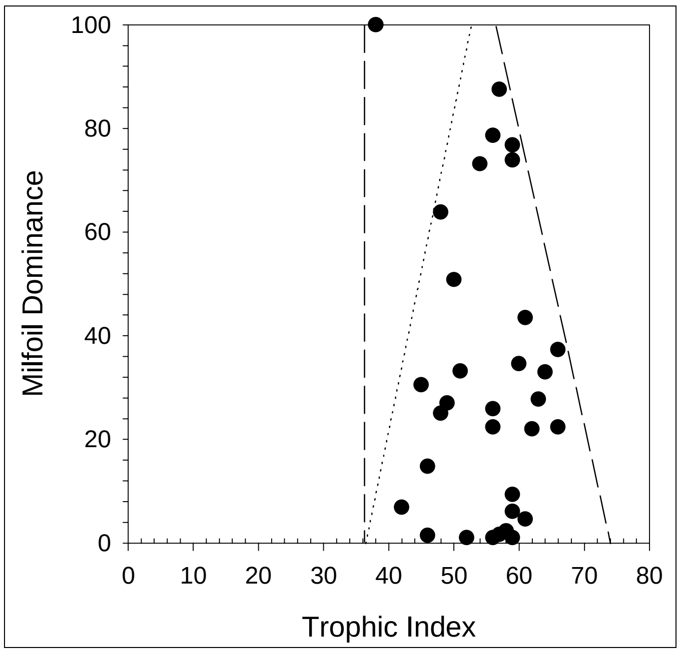


Figure 8. Relationship between Eurasian watermilfoil dominance and Carlson's trophic index for 34 lakes, with an approximate boundary indicated with a dashed line and an additional approximate boundary, disregarding one point, indicated with a dotted line

In a preliminary attempt to identify factors that might predict the eventual success of Eurasian watermilfoil in infested lakes, total water column phosphorus and Carlson's TSI were identified as potential indicators of lakes at risk. From this analysis, lakes with a total phosphorus (TP) of 20-60 $\mu g\ L^{-1}$ or a Carlson's TSI of 45-65 were most at risk of dominance by Eurasian watermilfoil. Using this type of tool, monitoring and management resources might be allocated to those lakes most likely to develop substantial nuisance growths of Eurasian watermilfoil, with the accompanying impacts to both human use and the lake ecosystem.

2 Application to the Distribution of Eurasian Watermilfoil in Minnesota

Introduction

One neglected aspect of aquatic plant management has been prevention, including early detection and management of new infestations. Given that many resource managers and government agencies have far more resources to manage than means to manage them, the availability of tools to focus management efforts to resources most likely to need attention would be of great benefit.

In the case of exotic plant species, several studies have already indicated ways in which resources can be focused. Research in British Columbia (Newroth 1989) and New Zealand (Johnstone, Coffey, and Howard-Williams 1985) has demonstrated the importance of boat traffic on the dispersal of exotic plant species between watersheds and lakes. Management responses to these results have included boat inspections, public education, and surveys focused on popular boating areas or near highway access. However, tools to help predict which lakes are most susceptible to the incursion of exotic plant species, such as Eurasian watermilfoil, would further refine the focus for management efforts.

Materials and Methods

The relationships defined in Chapter 1 were used to define upper maximum boundaries for relationships between Eurasian watermilfoil dominance and lake limnological parameters. The two parameters that indicated the best relationships were average lake water column total phosphorus (Figure 7) and Carlson's TSI (Figure 8). The ascending and descending boundaries for each parameter were fitted with a simple linear equation.

For water column total phosphorus (Figure 7), the equation for the ascending boundary was:

$$EWMD = 21.4 + 2.26 * (TP) \tag{1}$$

where EWMD is dominance of Eurasian watermilfoil and TP is lake water column total phosphorus. The descending boundary equation was:

$$EWMD = 111 - 0.619 * (TP) \tag{2}$$

For a given data set, both calculations are made and the lower of the two numbers is used to represent potential dominance by Eurasian watermilfoil based on TP.

For TSI, the ascending boundary equation was:

$$EWMD = -234 + 6.35 * (TSI) \tag{3}$$

The dotted line from Figure 8, which excludes one data point, was utilized for this equation. For the descending upper boundary, the equation was:

$$EWMD = 419 - 5.63 * (TSI) \tag{4}$$

As with the equations for TP, both calculations are made and the lower of the two numbers is used to represent potential dominance by Eurasian watermilfoil based on TSI.

Since the state of Minnesota has over 13,000 lakes, an existing classification set was used to compare known Eurasian watermilfoil distributions to those predicted from this data set. The Schupp lake class classifies Minnesota lakes into 44 classes based on limnological parameters and fish communities (Schupp 1992). Mean limnological parameters, such as mean TSI or TP for each lake class, were used as surrogates for actual lakes. Information on the infestation of Eurasian watermilfoil in Schupp lake classes was taken from Johnson and Newman (1994).

Results and Discussion

Predicted dominance of Eurasian watermilfoil was similar from results for TP and for TSI, so the results from TSI will be used. Predicted Eurasian watermilfoil dominance (which is an estimate of the proportion or percentage of littoral zone which will have Eurasian watermilfoil) from the TSI equations for Schupp lake classes ranged from -15 to 112 (Figure 9). While many lake classes are unlikely to have large infestations of Eurasian watermilfoil, 27 lake classes were predicted to potentially have a Eurasian watermilfoil dominance of more than

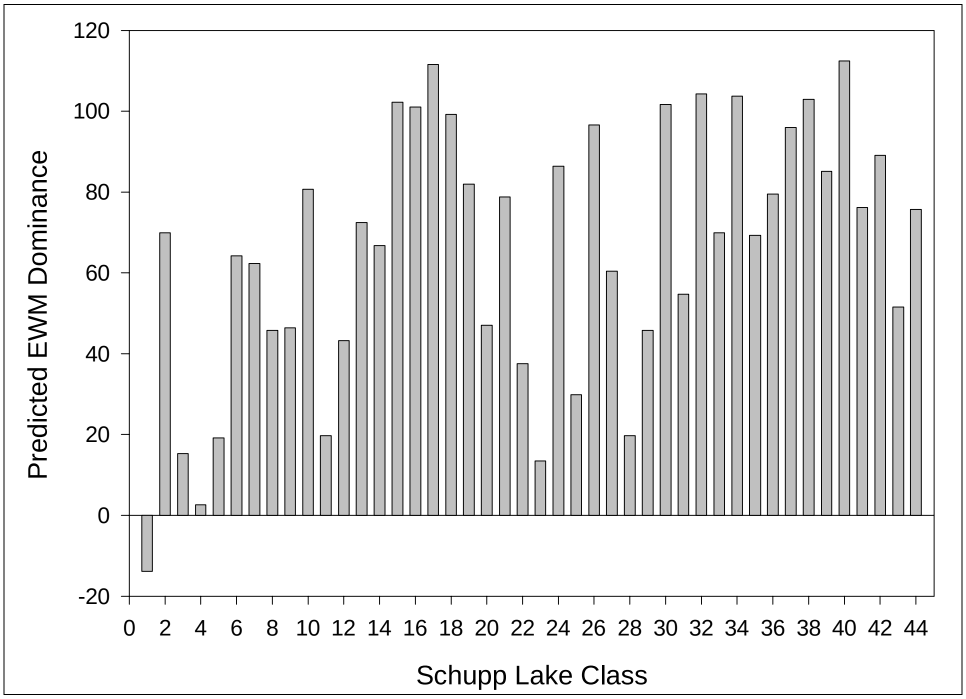


Figure 9. Predicted Eurasian watermilfoil dominance by Schupp lake class (Schupp 1992) based on prediction from Carlson's TSI

60 percent of the littoral zone. Lakes from these Schupp lake classes were found distributed throughout the state.

Johnson and Newman (1994) reported on the number of lakes in each Schupp lake class which did and did not have Eurasian watermilfoil (Figure 10). Lake class 24 had the highest number of lakes infested, with other lake classes having only a few lakes each with Eurasian watermilfoil. They attribute this to the restriction of spread from the geographic center of Eurasian watermilfoil in Minnesota, the metropolitan lakes. When the percent of lakes in the Schupp lake class are compared to the predicted potential dominance of Eurasian watermilfoil in the littoral zone of the lakes, it is clear that Eurasian watermilfoil could survive quite well in many more Minnesota lakes than are currently infested (Figure 11). Lakes with a predicted dominance of Eurasian watermilfoil above 60 percent should represent a very hospitable environment to Eurasian watermilfoil, and successful introductions should spread well within the lake. Despite this, proportionally very few lakes with high potential dominance of Eurasian watermilfoil currently have this species. Since Eurasian watermilfoil is largely found around the metropolitan area, prevention efforts of boat inspections and public education have been successful in reducing the spread of Eurasian watermilfoil. Clearly, Eurasian watermilfoil could spread well beyond the metropolitan area.

The tool presented may be utilized to suggest the potential dominance of lakes by Eurasian watermilfoil. Further refinement of this type of tool, or of other statistical models, might further assist in focusing management efforts to

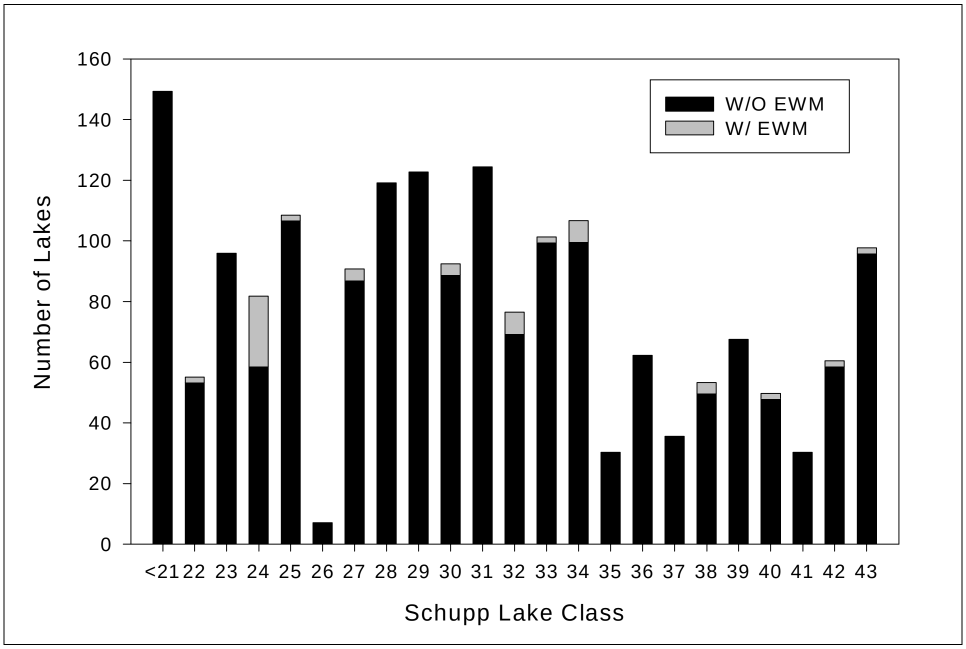


Figure 10. Lakes with and without Eurasian watermilfoil, as counted by Johnson and Newman (1994)

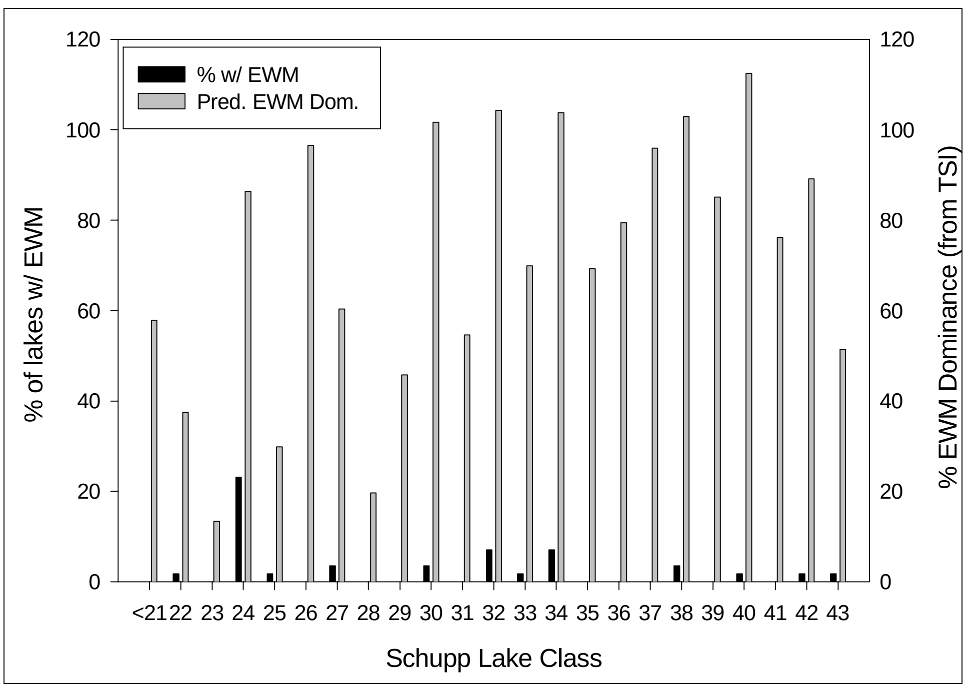


Figure 11. Percent of lakes that currently have Eurasian watermilfoil (left axis) and predicted Eurasian watermilfoil dominance of lakes (right axis) versus Schupp lake class. Current infestation data are based on Johnson and Newman (1994)

prevent the spread of Eurasian watermilfoil in Minnesota. However, this model does not predict if, or when, Eurasian watermilfoil will reach a given lake or the probability of such an event occurring. Previous assessments of the potential for Eurasian watermilfoil to spread in Minnesota have presented too narrow a range of lakes both environmentally and geographically.

3 Field Surveys of Wisconsin Lakes

Introduction

In order to supplement data available from the literature and from unpublished reports and databases (Appendix A), eight lakes in Wisconsin were surveyed for the area of littoral zone dominated by Eurasian watermilfoil.

Study Sites

Eurasian watermilfoil occurs in lakes across Wisconsin, but most of the data on its occurrence is form lakes in the southeastern portion of the state. Therefore, lakes from the northeastern (Big Sand Lake, Duck Lake, Yellow Birch Lake), northwestern (Beaver Dam Lake, Nancy Lake, Round Lake), and southwestern (Lake Delton, Mirror Lake) portions of the state were selected based on the recommendations of Wisconsin Department of Natural Resources personnel (Figure 12).

Materials and Methods

At each lake, a Trimble GeoExplorer global positioning system (GPS) unit was used to map the boundary of the lower depth limit of the littoral zone (e.g., shoreline) and the outer depth limit of the littoral zone. The outer depth of the littoral zone was defined as the 6-m (20-ft) depth contour. This value was checked for each lake against a depth of 1.5 times the Secchi disk depth, which is an approximate depth limit for many aquatic macrophytes. Secchi disk depth was measured in each lake near midday while anchored in a location at least 6 m (20 ft) deep, and generally much more, that was free of vegetation or other obstructions to visual observation of the Secchi disk. The entire perimeter of the littoral zone was examined twice, during which time a list was made of all species observed. Lastly, all dense beds of Eurasian watermilfoil were mapped using the Trimble GeoExplorer.

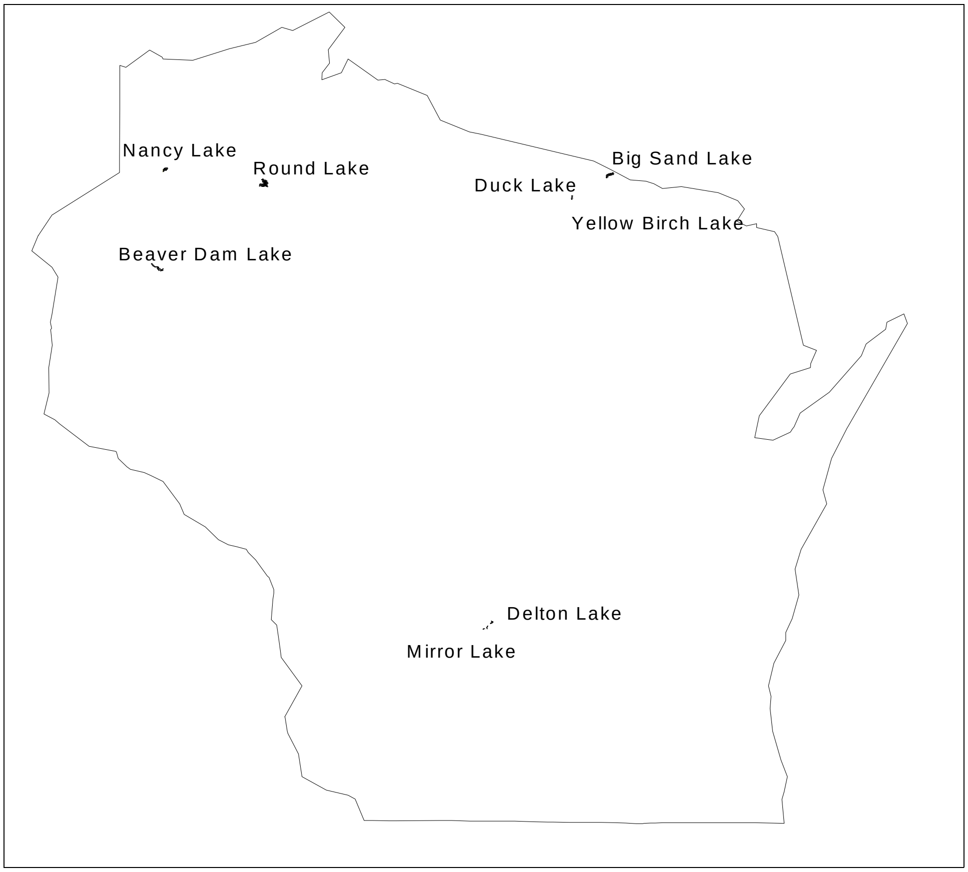


Figure 12. Locations of the eight lakes surveyed in Wisconsin

As time allowed, line intercept transects were used to evaluate vegetation composition, particularly in lakes with significant amounts of Eurasian water-milfoil. Two transects, one in unimpacted native stands of vegetation and one in areas impacted by dense Eurasian watermilfoil, were evaluated in three lakes (Beaver Dam, Big Sand, and Nancy). One transect was evaluated in Round Lake, in which no dense beds were found.

Results and Discussion

Table 1 presents information on the eight lakes surveyed. Of the eight, no Eurasian watermilfoil could be found in two lakes (Delton and Duck), and only a small amount of Eurasian watermilfoil was found in Round Lake and Yellow Birch Lake.

Beaver Dam Lake

The mapping for Beaver Dam Lake (Figure 13) indicated a total lake area of 1,034 acres, with 587 acres of pelagic zone and 447 acres of littoral zone. Dense Eurasian watermilfoil beds comprised 66 acres, or 15 percent of the littoral zone.

Table 1
Information on the Eight Wisconsin Lakes Surveyed

Lake	County	Lake Area Acres	Pelagic Zone Area, Acres	Littoral Area Acres	Area of Dense Eurasian watermilfoil acres (% of littoral zone)
Beaver Dam	Barron	1,034	587	447	66.2 (15)
Big Sand	Vilas	1,244	349	895	235 (26)
Delton	Sauk	228	0	228	0 (0)
Duck	Vilas	92.4	54.5	37.9	0.0 (0)
Mirror	Sauk	68.8	28.9	39.9	9.9 (25)
Nancy	Washburn	582	4.1	578	10.1 (2)
Round [1]	Sawyer				
Yellow Birch	Vilas	179	129.3	49.3	.06 (0.1)

[1] GPS mapping point files were unreadable, so calculations could not be made.

A total of 31 aquatic plant species were found in Beaver Dam Lake (Table 2), of which 5 were emergent species, 5 were floating-leaved species, and 21 were submersed species. Dominant species were *Myriophyllum spicatum*, *Potamogeton robbinsii*, and *Potamogeton zosteriformis*, as based on line intercept transect data.

Big Sand Lake

Big Sand Lake (Figure 14) totaled 1,244 acres, of which 349 acres were in the pelagic zone and 895 acres were in the littoral zone. Dense Eurasian watermilfoil beds constituted 235 acres, or 26 percent of the littoral zone.

A total of 31 species were observed in Big Sand Lake (Table 3), of which 5 were emergent species, 4 were floating-leaf species, and 22 were submersed species. Dominant species were *Myriophyllum spicatum, Potamogeton robbinsii*, and *Vallisneria americana*.

Lake Delton

Lake Delton (Figure 15) was measured as 228 acres, all of it in the littoral zone. Four aquatic plant species, all of them submersed, were observed in Lake Delton (Table 4). No transects were evaluated in this lake.

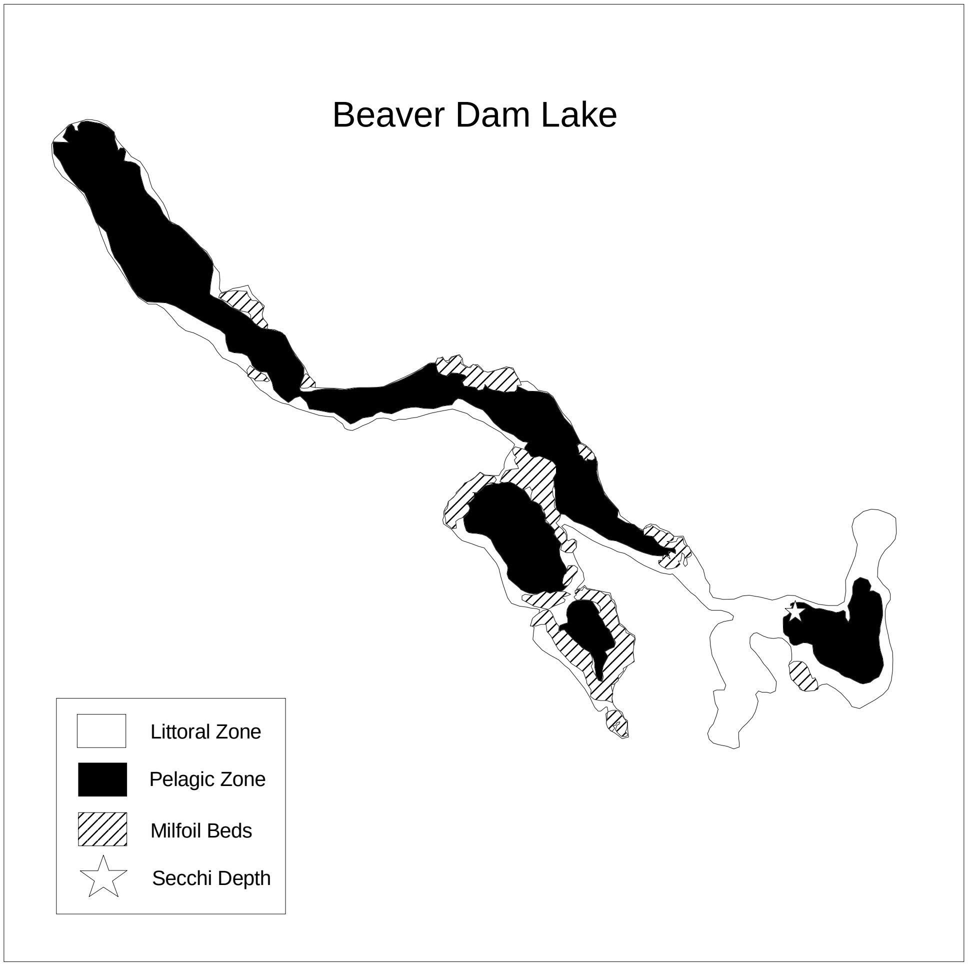


Figure 13. Map of Beaver Dam Lake indicating littoral zone, pelagic zone, Eurasian watermilfoil (milfoil) beds, and Secchi disk depth sample site

Duck Lake

Duck Lake (Figure 16) was measured to be 92.4 acres, with 54.5 acres in the pelagic zone and 37.9 acres in the littoral zone. No Eurasian watermilfoil was observed in the lake. Ten aquatic plant species were observed in the lake; one was a floating-leaf species and the others were all submersed species (Table 5).

Mirror Lake

Mirror Lake (Figure 17) was 68.8 acres, of which 28.9 were pelagic zone and 39.9 were littoral zone; 9.9 acres (or 25 percent of the littoral zone) of dense Eurasian watermilfoil was found. A total of 13 aquatic plant species were observed; one was a floating species and the rest were submersed species (Table 6).

Table 2
Species List for Beaver Dam Lake and Vegetation Composition (Percent Frequency) at Two Transects

Species	Transect 1 N = 45	Transect 2 N = 100	Sum N = 145
Brasenia schreberi J.F. Grelin			
Ceratophyllum demersum L.	7	6	6
Elodea canadensis Michx.		2	1
Heteranthera dubia (Jacq.) Small			
Juncus pelocarpus E. Meyer			
Lythrum salicaria L.			
Megalodonta beckii Torr.			
Myriophyllum alterniflorum DC		1	1
Myriophyllum sibiricum Komarov	4		1
Myriophyllum spicatum L.	80	4	28
Myriophyllum verticillatum L.			
Najas minor Allioni			
Nuphar luteum (Small) E.O. Beal			
Nymphaea odorata Aiton			
Polygonum amphibium L.			
Pontederia cordata L.			
Potamogeton amplifolius Tuckerman	29		9
Potamogeton crispus L.	4		1
Potamogeton diversifolius Raf.			
Potamogeton gramineus L.		1	1
Potamogeton natans L.			
Potamogeton obtusifolius Mert. & Koch.	4		1
Potamogeton pectinatus L.			
Potamogeton perfoliatus L.	7	1	3
Potamogeton praelongus Wulfen			
Potamogeton richardsonii (Ar. Bennett) Rydb.			
Potamogeton robbinsii Oakes	20	98	74
Potamogeton zosteriformis Fern.	36	62	54
Ranunculus longirostris Godron			
Scirpus americanus Pers.			
Typha latifolia L.			

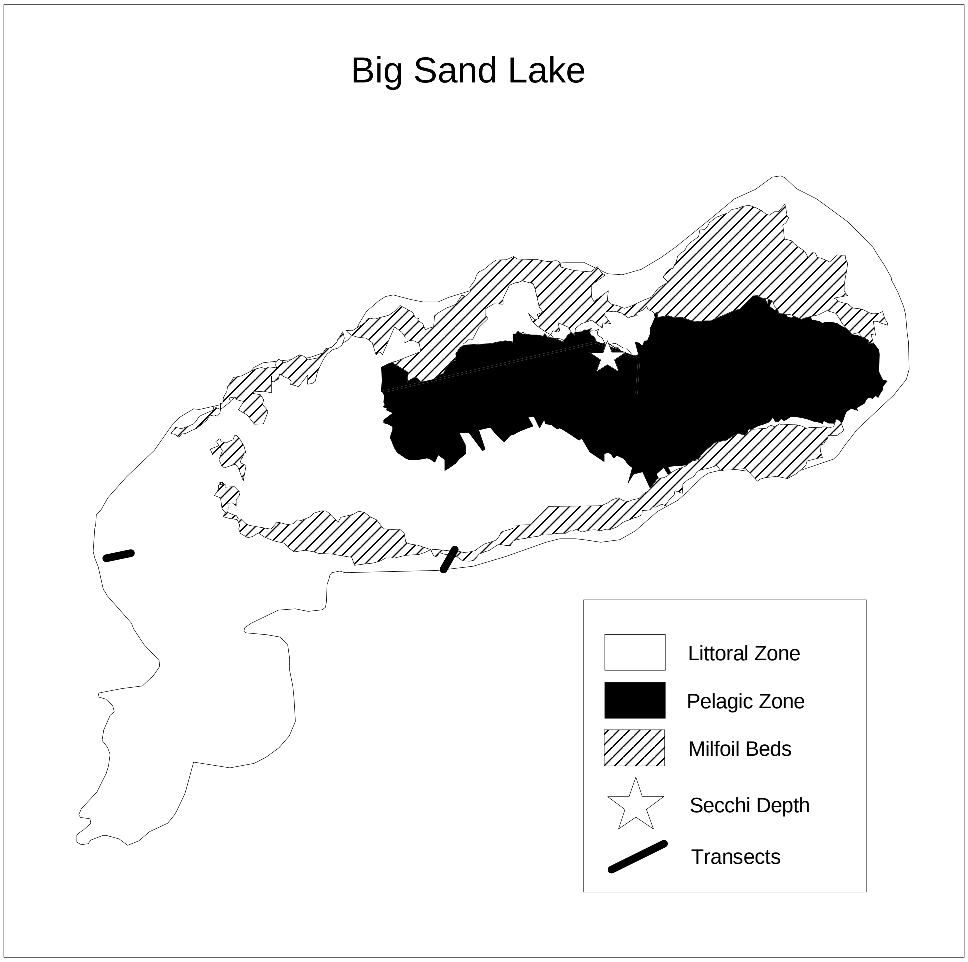


Figure 14. Map of Big Sand Lake indicating littoral zone, pelagic zone, Eurasian watermilfoil (milfoil) beds, Secchi disk depth sample site, and vegetation composition transects

Nancy Lake

Nancy Lake (Figure 18) was measured as 582 acres, with only 4 acres of pelagic zone and 578 of littoral zone. Eurasian watermilfoil beds totaled 10.1 acres, or 2 percent of the littoral zone.

Thirty-four aquatic plant species were found in Nancy Lake (Table 7). Of those, 7 were emergent, 5 were floating-leaved, and 22 were submersed species. Dominants were *Myriophyllum spicatum*, *Potamogeton amplifolius*, *Potamogeton robbinsii*, *Potamogeton zosteriformis*, and *Vallisneria americana*.

Table 3
Species List for Big Sand Lake and Vegetation Composition at Two Transects, With Sum of Transects

Species	Transect 1 N=100	Transect 2 N=100	Sum N=200
Brasenia schreberi J.F. Grelin			
Ceratophyllum demersum L.	8	1	5
Eleocharis quadrangulata (Michx.) R. & S.			
Elodea canadensis (Michx.)	15	55	35
Heteranthera dubia (Jacq.) Small			
Isoetes echinospora Durieu	7		4
Juncus pelocarpus E. Meyer	1		1
Myriophyllum sibiricum Komarov	1		1
Myriophyllum spicatum L.	70	4	37
Myriophyllum verticillatum L.			
Najas minor Allioni	21		11
Nuphar luteum (Small) E.O. Beal			
Nymphaea odorata Aiton			
Polygonum amphibium L.			
Potamogeton alpinus Balbis			
Potamogeton amplifolius Tuckerman		1	1
Potamogeton diversifolius Raf.			
Potamogeton gramineus L.	42	1	22
Potamogeton illinoensis Morong			
Potamogeton obtusifolius Mert. & Koch	3		2
Potamogeton perfoliatus L.	2		
Potamogeton praelongus Wulfen	5	19	12
Potamogeton richardsonii (Ar. Bennett) Rydb.	4	2	3
Potamogeton robbinsii Oakes	11	100	56
Potamogeton zosteriformis Fern.	5	1	3
Ranunculus longirostris Godron			
Sagittaria graminea Michx.			
Scirpus americanus Pers.			
Scirpus sp.			
Typha latifolia L.			
Vallisneria americana L.	31		16

Figure 15. Map of Lake Delton indicating littoral zone area

Table 4 **Species List for Lake Delton, Sauk County, Wisconsin**
Species
Potamogeton natans L.
Potamogeton pectinatus L.
Potamogeton pusillus L.
Vallisneria americana L.

Round Lake

The pelagic and littoral zone of Round Lake are shown in Figure 19. The GPS data file was corrupted, so calculations of acreage were not performed. Only one plant of Eurasian watermilfoil was found in the lake. Inquiries to local marina operators indicated that a herbicide treatment had recently been performed.

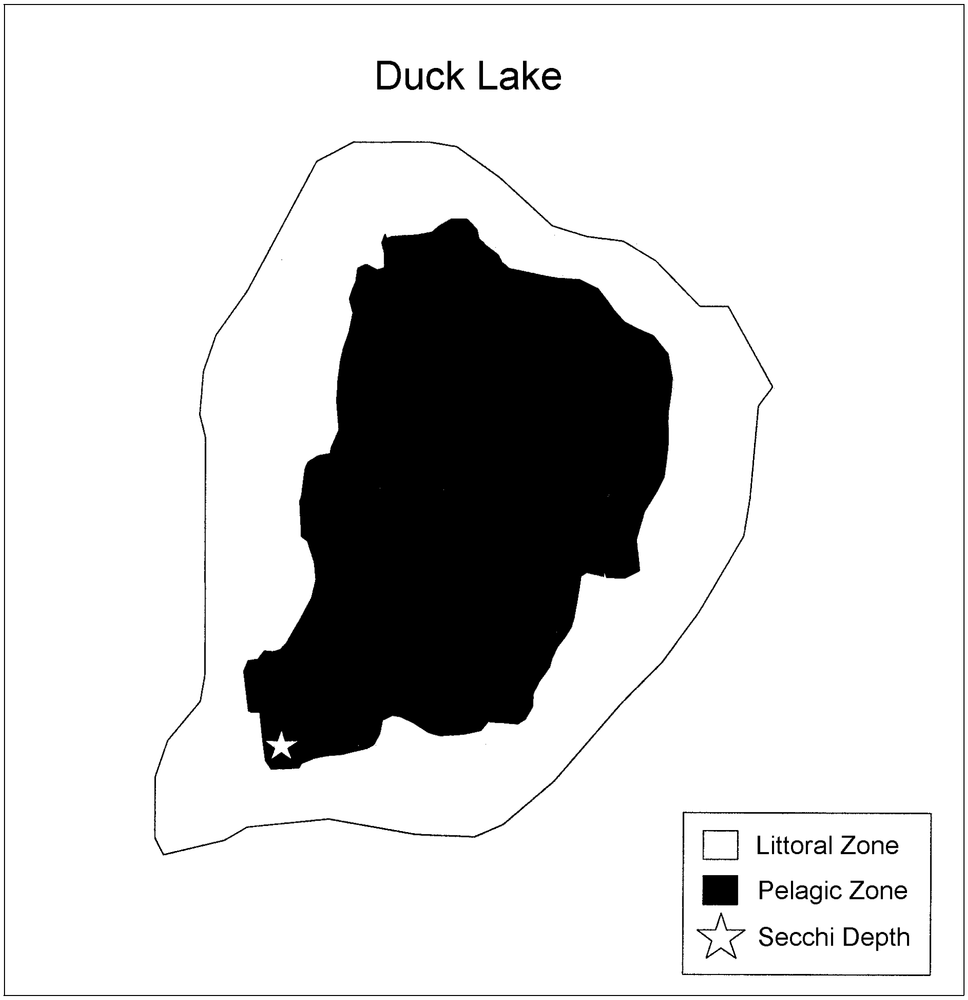


Figure 16. Map of Duck Lake indicating littoral zone, pelagic zone, and Secchi disk depth sample site

Table 5
Species List for Duck Lake, Vilas County, Wisconsin

Species
Myriophyllum sibiricum Komarov
Myriophyllum spicatum L.
Najas flexilis (Willd.) Rostk. & Schmidt
Nuphar luteum (Small) E.O. Beal
Potamogeton amplifolius Tuckerman
Potamogeton epihydrus Raf.
Potamogeton pusillus L.
Potamogeton spirillus Tuckerman
Potamogeton zosteriformis Fern.
Vallisneria americana L.

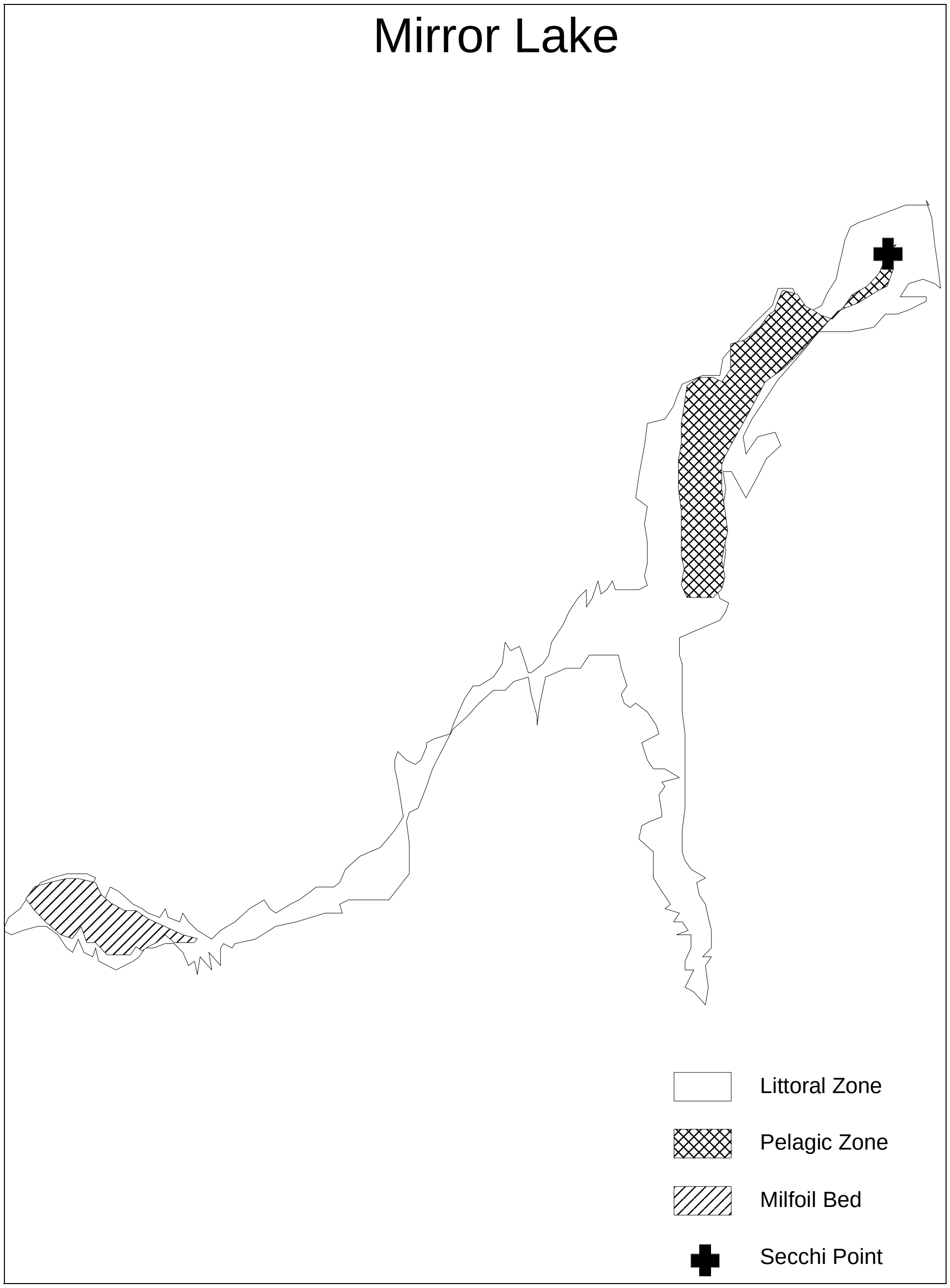


Figure 17. Map of Mirror Lake indicating littoral zone, pelagic zone, Eurasian watermilfoil (milfoil) bed, and Secchi disk depth sample site

A total of 27 aquatic plant species were observed in Round Lake (Table 8), of which 4 were emergent, 5 were floating-leaved, and 18 were submersed. Dominants were *Potamogeton gramineus* and *Potamogeton robbinsii*.

Table 6
Species List for Mirror Lake, Sauk County, Wisconsin

Species
Ceratophyllum demersum L.
Elodea canadensis Michx.
Heteranthera dubia (Jacq.) Small
Lemna minor L.
Myriophyllum sibiricum Komarov
Myriophyllum spicatum L.
Potamogeton amplifolius Tuckerman
Potamogeton crispus L.
Potamogeton nodosus Poinet
Potamogeton pectinatus L.
Potamogeton praelongus Wulfen
Potamogeton spirillus Tuckerman
Potamogeton zosteriformis Fern.

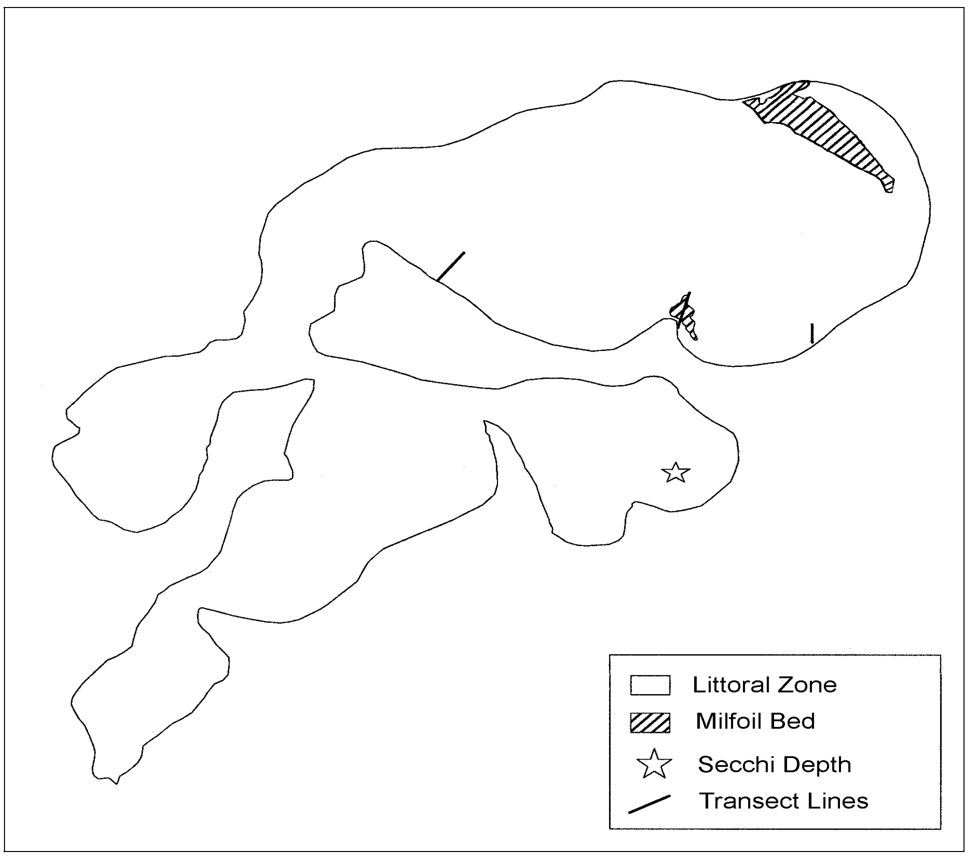


Figure 18. Map of Nancy Lake indicating littoral zone, Eurasian watermilfoil (milfoil) bed, Secchi disk depth sample site, and vegetation composition transects

Table 7
Species List for Nancy Lake and Vegetation Composition (Percent Frequency) for Two Transects and Their Summary

Species	Transect 1 N = 60	Transect 2 N = 100	Sum N = 160
Brasenia schreberi (Michx.) Roemer & Schmidt			
Ceratophyllum demersum L.			
Eleocharis acicularis (L.) Roemer & Schmidt			
Eleocharis quadrangulata (Michx.) R&S			
Elodea canadensis Michx.		23	14
Juncus pelocarpus E. Meyer	7	15	12
Megalodonta beckii Torr.	8	16	13
Myriophyllum sibiricum Komarov		3	2
Myriophyllum spicatum L.	43	3	18
Myriophyllum tenellum L.		10	6
Najas minor Allioni	8	1	4
Nuphar luteum (Small) E.O. Beal			
Nymphaea odorata Aiton			
Polygonum amphibium L.			
Pontederia cordata L.			
Potamogeton alpinus Balbis			
Potamogeton amplifolius Tuckerman	3	65	42
Potamogeton gramineus L.	23		9
Potamogeton illinoensis Morong			
Potamogeton natans L.			
Potamogeton obtusifolius Mert. & Koch	8	3	5
Potamogeton perfoliatus L.			
Potamogeton praelongus Wulfen	3		1
Potamogeton pusillus L.	10	9	9
Potamogeton robbinsii Oakes	25	84	62
Potamogeton zosteriformis Fern.	10	45	32
Ranunculus longirostris Godron	3	1	2
Ranunculus reptans L.	15		6
Sagittaria graminea Michx.		4	3
Scirpus americanus Pers.			
Scirpus subterminalis Torr.			
Sparganium eurycarpum Engelm.			
Typha latifolia L			
Vallisneria americana L.	45	31	36

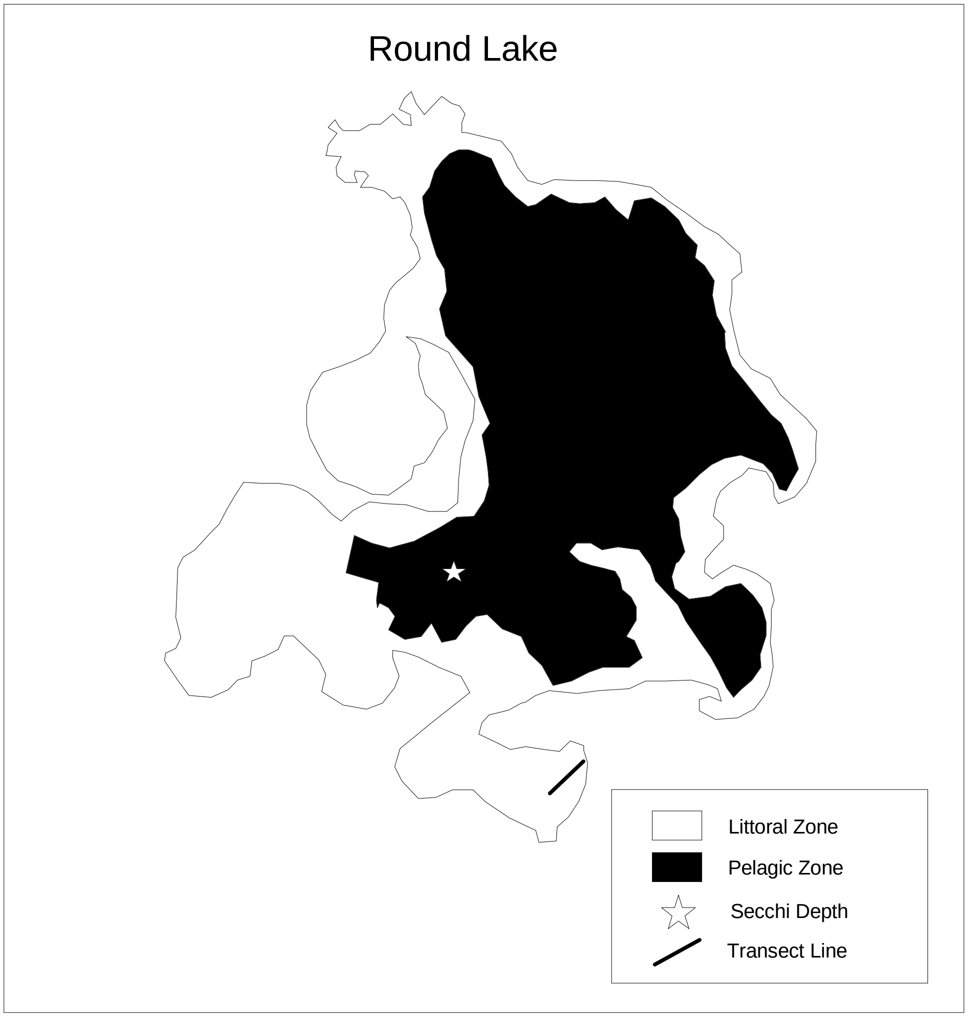


Figure 19. Map of Round Lake indicating littoral zone, pelagic zone, Secchi disk depth sample site, and vegetation composition transect

Yellow Birch Lake

Yellow Birch Lake (Figure 20) was 18.6 acres, of which 129.3 were in the pelagic zone and 49 were in the littoral zone. A small Eurasian watermilfoil bed of 0.06 acres was found, constituting 0.1 percent of the littoral zone. Twelve species of aquatic plants were found in Yellow Birch Lake (Table 9), of which one was a floating-leaved species and eleven were submersed species.

Table 8
Species List for Round Lake and Vegetation Composition (Percent Frequency) for One Transect

Species	Transect 1 N=100
Brasenia schreberi J. F. Grelin	
Ceratophyllum demersum L.	
Elodea canadensis Michx.	1
Isoetes echinospora Durieu	3
Juncus pelocarpus E. Meyer	5
Megalodonta beckii Torr.	12
Myriophyllum sibiricum Komarov	2
Myriophyllum spicatum L.	
Najas minor Allioni	24
Nuphar luteum (Small) E. O. Beal	
Nymphaea odorata Aiton	
Polygonum amphibium L.	
Potamogeton amplifolius Tuckerman	5
Potamogeton gramineus L.	55
Potamogeton illinoensis Morong	4
Potamogeton natans L.	
Potamogeton perfoliatus L.	3
Potamogeton praelongus Wulfen	12
Potamogeton pusillus L.	4
Potamogeton robbinsii Oakes	50
Potamogeton zosteriformis Fern.	12
Sagittaria graminea Michx.	10
Scirpus americanus Pers.	
Sparganium eurycarpum Engelm.	
Typha latifolia L.	
Utricularia vulgaris L.	
Vallisneria americana L.	66

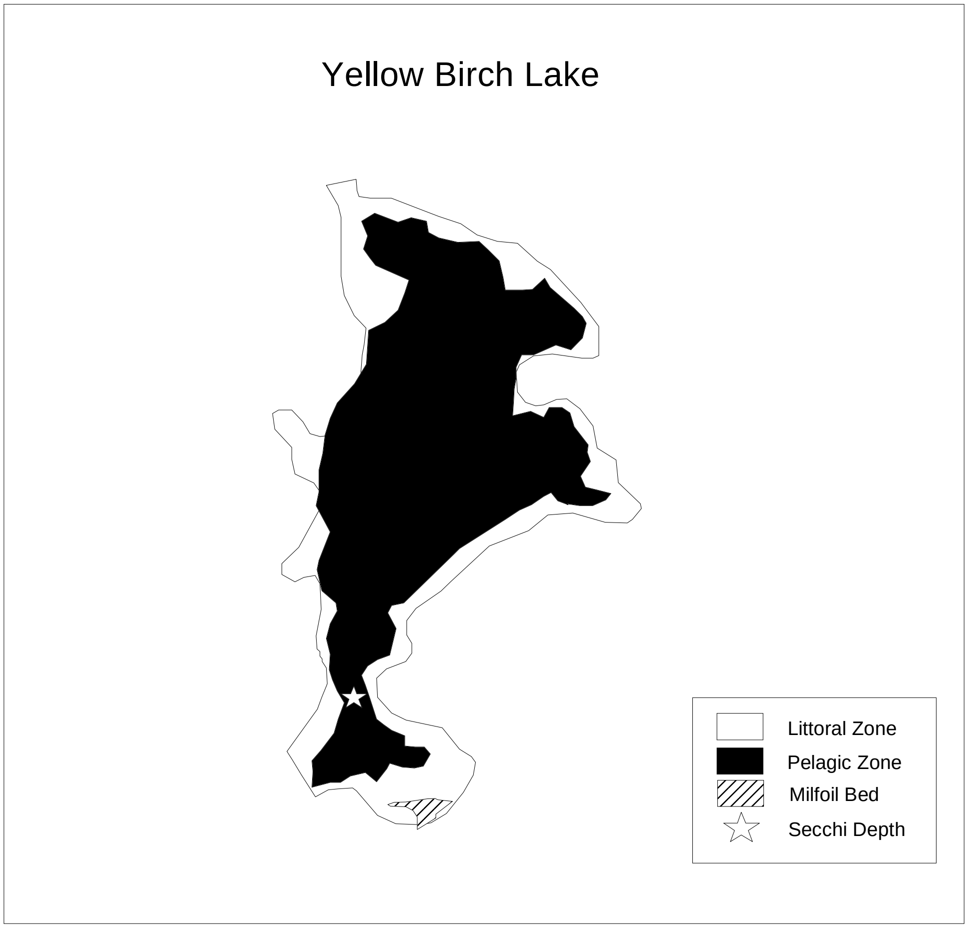


Figure 20. Map of Yellow Birch Lake indicating littoral zone, pelagic zone, Eurasian watermilfoil (milfoil) bed, and Secchi disk depth sample site

Table 9
Species List for Yellow Birch Lake, Vilas County, Wisconsin

Species
Elodea canadensis Michx.
Myriophyllum sibiricum Komarov
Myriophyllum spicatum L.
Najas flexilis (Willd.) R & S
Nuphar luteum (Small) E. O. Beal
Potamogeton amplifolius Tuckerman
Potamogeton epihydrus Raf.
Potamogeton pusillus L.
Potamogeton robbinsii Oakes
Potamogeton spirillus Tuckerman
Potamogeton zosteriformis Fern.
Vallisneria americana L.

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Appendix A
Data From Literature Sources

Table A1 presents data from the literature and unpublished reports for lakes with Eurasian watermilfoil in North America.

The variables used in Table A1 are as follows:

CASE = case number
LAKE = lake name
STATE = abbreviation of state or province
COUNTY = county name
TWNSHP = township designation
LAT = latitude
LONG = longitude
YR = last two digits of year of study
CIT# = citation number (see reference list that follows)
%SAND = percent sand in lake sediment
RELMS = relative abundance of Eurasian watermilfoil
MSCOV = percent cover of Eurasian watermilfoil
MSAREA = area of Eurasian watermilfoil in lake
SUBM = number of submersed species in lake
FLOAT = number of floating-leaved species in lake
EMERG = number of emergent species in lake
AREA= area of lake, in acres
LAREA = area of lake littoral zone, in acres
SECCHI = Secchi disk depth, in meters
ALKAL = alkalinity of lake water, in mg $CaCO^3$ L^{-1}
TP = total phosphorus of lake water, in µg L^{-1}
TSI = Carlson’s trophic state index

The following is a list of references cited in Table A1:

Published citations (P):

1,P = Thurston County 1994
2,P = Warren 1995
3,P = Madsen 1994
4,P = Kimbel and Carpenter 1981
5,P = British Columbia 1981
6,P = Nichols 1994
7,P = Bates, Burns, and Webb 1985
8,P = Gibbons and Gibbons 1985
9,P = Miller and Trout 1985
10,P = Truelson 1985
11,P = Newroth 1993
12,P = Madsen et al. 1994
13,P = Madsen and Getsinger 1995
14,P = Rogers, James, and Barko 1995
15,P = Rybicki and Carter 1995
16,P = Doyle and Smart 1995
17,P = Hough et al. 1989
18,P = Hough, Allenson, and Dion 1991
19,P = Soltero et al. 1991
20,P = Lillie and Barko 1990
21,P = WATER Environmental Services 1995
22,P = Newman and Maher 1995
23,P = Crosson 1987

Unpublished citations (U):

1,U = Lillie, R. A. "A quantitative survey of the floating-leaved and submersed macrophytes of Fish Lake, Dane County, Wisconsin," unpublished report, Wisconsin Department of Natural Resources.

2,U = Welling, C. 1995. Selected comments from a meeting on current research on Eurasian watermilfoil held on 14-15 March 1995 in Hudson, Wisconsin, 25 April 1995.

3,U = Memorandum for record, John D. Madsen, for site visit to Blue Springs Lake, WI, 28 August 1993

4,U = Leverance, J. 1993. "Blue Spring Lake herbicide treatment, summer 1993," unpublished report, Wisconsin Department of Natural Resources, Southern District.

5,U = Wood, G. 1993. "History of nuisance weeds at Blue Spring Lake 1950-1993," unpublished report.

6,U = Welling, C. H. 1993. List of lakes in Minnesota with Eurasian watermilfoil, 14 June 1993.

7,U = Wisconsin Department of Natural Resources, Fact Sheet, Beaver Dam Lake, Barron Co., WI

8,U = Wisconsin Department of Natural Resources, Fact Sheet, Nancy Lake, Washburn Co., WI.

9,U = Helsel, D. R., Gerber, D. T., and Engel, S. 1995. “Comparing 2,4-D and bottom fabrics to control Eurasian watermilfoil. Beulah Lakes, 3 May 1995,” unpublished report, Wisconsin Department of Natural Resources

10,U = Chapter 3 of this report.

11,U = Database of macrophyte survey of 31 southcentral Wisconsin lakes, 1993. Professor Steve Carpenter and Sarig Gafny, University of Wisconsin-Madison, Center for Limnology.

12,U = Personal communication, Scott Painter, Ontario Ministry of Environment.

13,U = “Minnesota lake water quality assessment data: 1994,” provided by Steven Heiskary, Minnesota Pollution Control Agency.

14,U = “Wisconsin ambient lakes,” provided by James Vennie, Wisconsin Department of Natural Resources.

Table A1
Data From Literature Sources for Lakes with Eurasian Watermilfoil in North America

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
1	CHICKAMAUGA	AL					84	7,P				593.04									
2	FT. LOUDOUN	AL					84	7,P				111.19									
3	GUNTERSVILLE	AL					94	16,P													
4	GUNTERSVILLE	AL					84	7,P				7462.4									
5	MELTON HILL	AL					84	7,P				210.1									
6	NICKAJACK	AL					84	7,P				259.45									
7	WATTS BAR	AL					84	7,P				271.81									
8	BRANNEN	BC					89	11,P				5.69	3			269.34	64.26				
9	CHAMPION	BC	KOOTENAY				79	11,P				0	3			29.65	9.39				
10	CHRISTINA	BC	KOOTENAY				79	11,P				0	3			6444.6	126.02				
11	CULTUS	BC	LOW MNLD				79	11,P				51.89	3			1549	91.42				
12	CULTUS	BC					84	10,P				46.21					15				
13	DIVER	BC	VANCOUVER				89	11,P				2.47	3			39.56	14.82				
14	ELLISON	BC	OKANAGAN				79	11,P				0	3			489.26	148.26				
15	HATZIC	BC					78	5,P				590.56									
16	HATZIC	BC	LOW MNLD				79	11,P				590.59	3			741.3	642.46				
17	KALAMALKA	BC	OKANAGAN				79	11,P				9.884	3			6399.89	375.59				
18	LONG	BC	VANCOUVER				89	11,P				39.54	3			106.43	32.12				
19	MARA	BC	SHUSWAP				79	11,P				0	3			4801.15	333.58				
20	OKANAGAN	BC	OKANAGAN				79	11,P				995.82	3			85990.8	4771.5				
21	OSOYOOS	BC	OKANAGAN				79	11,P				192.74	3			3718.75	859.91				
22	SHUSWAP	BC	SHUSWAP				79	11,P				0	3			76601	3459.4				
23	SKAHA	BC	OKANAGAN				79	11,P				175.44	3			4966.71	783.31				
24	SWALWELL	BC	OKANAGAN				79	11,P				0	3			751.18	239.69				
25	VASEUX	BC	OKANAGAN				79	11,P				149.75	3			679	392.88				
26	VASEUX	BC					77	5,P				185.32									
27	WOOD	BC	OKANAGAN				79	11,P				42.01	3			2298.03	140.85				

(Sheet 1 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
28	EAST GRAHAM	MI	OAKLAND				89	17,P			18		6			11.12		5.2			
29	EAST GRAHAM	MI	OAKLAND				89	17,P			34		6			11.12		5.2			
30	SHOE LAKE	MI	OAKLAND				91	18,P					6			4.69		2.7	2.99	20	
31	SHOE LAKE	MI	OAKLAND				89	17,P			0	0	5			4.69		3.8			
32	AUBURN	MN	CARVER	T116N; R24W;S10			95	22,P													
33	AUBURN	MN	CARVER				92	6,U				50					151				
34	AUBURN (EAST)	MN	CARVER				94	13,U								120		0.4	130	92	71
35	AUBURN (WEST)	MN	CARVER				94	13,U								140		1.9	118	38	57
36	BALD EAGLE	MN	RAMSEY				93	6,U				28					615				
37	BAVARIA	MN	CARVER				94	13,U								164		2		34	56
38	BAVARIA	MN	CARVER				93	6,U				65					65				
39	BEEBE	MN	WRIGHT				94	13,U								315		1.1			59
40	BEEBE	MN	WRIGHT				93	6,U				17					182				
41	BRYANT	MN	HENNEPIN				94	13,U								174		1.6	145	34	57
42	BRYANT	MN	HENNEPIN				92	6,U				56					64				
43	BUSH	MN	HENNEPIN				92	6,U				40					160				
44	BUSH	MN	HENNEPIN				94	13,U								207		2.9	145	19	48
45	CALHOUN	MN	HENNEPIN				90	6,U				90					123				
46	CALHOUN	MN	HENNEPIN				94	13,U								421		2	99	32	54
47	CALHOUN	MN	HENNEPIN	T28N; R24W;S5			95	22,P													
48	CEDAR	MN	HENNEPIN				90	6,U				14					62.7				
49	CEDAR	MN	HENNEPIN	T29N; R24W;S29			95	22,P													
50	CEDAR	MN	HENNEPIN				94	13,U								170		1.8	97	35	56
51	CENAIKO	MN	ANOKA				93	6,U				12					12				
52	CHRISTMAS	MN	HENNEPIN	T117N; R23W;S35			95	22,P													
53	CLEARWATER	MN	WRIGHT				92	6,U				100					1455				

(Sheet 2 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
54	CLEARWATER	MN	WRIGHT				94	13,U								3182		2.1	166	69	59
55	CLEARWATER	MN	WRIGHT	T121N;R27W; S13			95	22,P													
56	GREEN	MN					92	6,U				320					1227				
57	GREEN	MN	CHISAGO	T33N;R21W; S13			95	22,P													
58	GULL	MN	CASS	T134N;R30W; S24			95	22,P													
59	INDEPENDENCE	MN	HENNEPIN	T118N;R23W; S7			95	22,P													
60	INDEPENDENCE	MN	HENNEPIN				94	13,U								851		1.5		34	54
61	INDEPENDENCE	MN	HENNEPIN				93	6,U				110					425				
62	ISLAND	MN	RAMSEY				93	6,U				21					56.3				
63	ISLAND (N)	MN	RAMSEY				94	13,U								20		1.4	63	139	63
64	ISLAND (S)	MN	RAMSEY				94	13,U								36		1	62	115	66
65	KNIFE	MN	KANABEC				94	13,U								1039		0.7	101	173	72
66	KNIFE	MN	KANABEC				93	6,U				20					1256				
67	LAKE OF ISLES	MN	HENNEPIN				90	6,U				98					89.4				
68	LAKE OF ISLES	MN	HENNEPIN	T29N;R24W; S32			95	22,P				M									
69	LIBBS	MN	HENNEPIN				94	13,U								17		1.1			59
70	LIBBS	MN	HENNEPIN				90	6,U				17					23				
71	LITTLE WAVERLY	MN	WRIGHT				93	6,U				20					330				
72	LITTLE WAVERLY	MN	WRIGHT				94	13,U								278		1.1			59
73	LAKE OF ISLES	MN	HENNEPIN				94	13,U								103		0.9	76	52	63
74	LONG	MN	HENNEPIN				93	6,U				29					130				
75	LONG	MN	HENNEPIN				94	13,U								272		1	118	127	66
76	LONG	MN	HENNEPIN	T118N;R23W; S34			95	22,P													
77	LOTUS	MN	CARVER				93	6,U				40					182				
78	LOTUS	MN	CARVER				94	13,U								252		1.2	133	51	63
79	LOWER PRIOR	MN					93	6,U				210					368				

(Sheet 3 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
80	MEDICINE	MN	HENNEPIN				94	13,U								936		1.6	145	34	57
81	MEDICINE	MN	HENNEPIN				92	6,U				110					397				
82	MINNETONKA	MN	HENNEPIN	T117N; R23W;S27			95	22,P													
83	MINNETONKA	MN	HENNEPIN				94	13,P					19	1							
84	MINNETONKA	MN	HENNEPIN				92	6,U				3000					5900				
85	MINNETONKA (BL)	MN	HENNEPIN				94	13,U								74		1.8			
86	MINNEWASHTA	MN	CARVER				94	13,U								747		2.6	136	28	49
87	MINNEWASHTA	MN	CARVER	T116N; R23W;S5			95	22,P													
88	MINNEWASHTA	MN	CARVER				92	6,U				100					371				
89	MINNETONKA (ST. ALBANS)	MN	HENNEPIN				94	13,U								168		3.1			44
90	MINNETONKA (CARSON)	MN	HENNEPIN				94	13,U								116		2.7			46
91	MINNETONKA (CRYSTAL)	MN	HENNEPIN				94	13,U								830		1.3	138	49	60
92	MINNETONKA (GRAYS)	MN	HENNEPIN				94	13,U								188		2			50
93	MINNETONKA (HALSTED)	MN	HENNEPIN				94	13,U								544		0.9			62
94	MINNETONKA (JENNINGS)	MN	HENNEPIN				94	13,U								297		0.8	127	177	72
95	MINNETONKA (LOWER LAKE)	MN	HENNEPIN				94	13,U								6128		3	133	42	51
96	MINNETONKA (MAXWELL)	MN	HENNEPIN				94	13,U								297		1.1	110	42	60
97	MINNETONKA (NORTH ARM)	MN	HENNEPIN				94	13,U								326		1.3	130	47	60
98	MINNETONKA (STUBBS)	MN	HENNEPIN				94	13,U								198		1		44	62
99	MINNETONKA (UPPER LAKE)	MN	HENNEPIN				94	13,U								4280		2	127	55	55
100	MINNETONKA (WEST ARM)	MN	HENNEPIN				94	13,U								825		0.8			63

(Sheet 4 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
101	OTTER	MN	ANOKA				94	13,U								338		1.3	83	62	59
102	OTTER	MN	ANOKA				92	6,U				100					328				
103	OTTER	MN	ANOKA	T30N; R22W;S3			95	22,P													
104	PARKERS	MN	HENNEPIN	T118N; R22W;S28			95	22,P													
105	PARKERS	MN	HENNEPIN				94	13,U								92		1.6			67
106	PARKERS	MN	HENNEPIN				92	6,U				68					67.7				
107	PIERSONS	MN	CARVER				93	6,U				60					119				
108	PIERSONS	MN	CARVER				94	13,U								340		1.8	124	112	58
109	PULASKI	MN	WRIGHT				93	6,U				18					122				
110	PULASKI	MN	WRIGHT				94	13,U								770		3.8	114	14	46
111	REBECCA	MN	HENNEPIN				94	13,U								261		1.5	142	86	61
112	REBECCA	MN	HENNEPIN				92	6,U				60					138				
113	RILEY	MN	CARVER				93	6,U				38					110				
114	RILEY	MN	CARVER				94	13,U								301		1.7	59	13	60
115	ROCK	MN	WRIGHT				93	6,U				76					99				
116	ROCK	MN	WRIGHT				94	13,U								175		1.2	140	48	59
117	SARAH	MN	HENNEPIN				94	13,U								586		1.1	129	116	64
118	SARAH	MN	HENNEPIN				92	6,U				87					264				
119	SARAH	MN	HENNEPIN	T118N; R24W;S2			95	22,P													
120	SCHMIDT	MN	HENNEPIN				93	6,U				34					34				
121	SCHULTZ	MN	CARVER				94	13,U								105		1.5	128	42	59
122	SCHULTZ	MN	CARVER				92	6,U				40					40				
123	ST.CROIX R.	MN					92	6,U				18					0				
124	STONE	MN	CARVER				92	6,U				10					71				
125	VADNAIS	MN	RAMSEY	T30N; R22W;S30			95	22,P													

(Sheet 5 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
126	VADNAIS	MN	RAMSEY				93	6,U				216					216				
127	VADNAIS	MN	RAMSEY				94	13,U								369		2.9	138	31	52
128	VIRGINIA	MN	CARVER	T116N; R23W;S6			95	22,P													
129	WACONIA	MN	CARVER				94	13,U								2607		1.3	160	39	58
130	WACONIA	MN	CARVER				93	6,U				38					1660				
131	WAVERLY	MN	WRIGHT				94	13,U								179		3.6	153	22	48
132	WAVERLY	MN	WRIGHT	T119N; R26W;S32			95	22,P													
133	WAVERLY	MN	WRIGHT				93	6,U				90					141				
134	WHITE BEAR	MN	WASHINGTON				93	6,U				72					1314				
135	ZUMBRA	MN	CARVER	T116N; R24W;S2			95	22,P													
136	ZUMBRA-SUNNY	MN	CARVER				89	6,U				70					89				
137	ZUMBRA-SUNNY	MN	CARVER				94	13,U								162		2	100	40	56
138	CAYUGA	NY					77	9,P				648	4								
139	GEORGE	NY					89	3,P			90		3			28158					
140	KAWARTHA	ON	PETER-BOROUGH	44.5N 78.5W			94	12,U			85							1		0.02	
141	SUDBURY LKS	ON	SUDBURY	46.5N 81.0 W			94	12,U			75										
142	KIRK	OR					94	12,P	42		68.9		3	3	6	59.31			58	40	
143	TIDAL POTOMAC	VA					94	15,P			45		7					0.61			
144	ARROWHEAD MTN	VT					88	2,P								732					
145	AUSTIN	VT					92	2,P								28					
146	BEEBE	VT					91	2,P								100					
147	BERLIN POND	VT					86	2,P								256					
148	BLACK	VT					87	2,P								20					
149	BOMOSEEN	VT					82	2,P								2360					
150	BROWNINGTON	VT					86	2,P								136					

(Sheet 6 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
151	BURR POND	VT					91	2,P								74					
152	CARMI	VT					79	2,P								1375					
153	CEDAR	VT					90	2,P								114					
154	CHAMPLAIN	VT					62	2,P								1728					
155	DUNMORE	VT					89	2,P								985					
156	ECHO	VT					89	2,P								53					
157	FAIRFIELD	VT					93	2,P								464					
158	GLEN	VT					83	2,P								191					
159	HALLS	VT					91	2,P								84					
160	HORTONIA	VT					87	23,P					13	0		450					
161	HORTONIA	VT					84	2,P								449					
162	HORTONIA	VT					87	23,P					9	0		450					
163	IROQUOIS	VT					90	2,P								229					
164	LILY POND	VT					83	2,P								21					
165	LOVESMARSH	VT					88	2,P								62					
166	LOWER POND	VT					87	2,P								61					
167	MEMPHREMAGOG	VT					89	2,P								6317					
168	METCALF	VT					84	2,P								71					
169	MILL POND	VT					87	2,P								70					
170	MOREY	VT					91	2,P								538					
171	N.MONTPELIER	VT					82	2,P								72					
172	NORTON BROOK	VT					85	2,P								20					
173	PARAN	VT					79	2,P								40					
174	PARSON MILL	VT					89	2,P								39					
175	RICHVILLE	VT					88	2,P								124					
176	ROUND	VT					90	2,P								30					
177	SHELBURNE	VT					92	2,P								450					

(Sheet 7 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
178	ST. CATHERINE	VT					83	2,P								852					
179	SUNRISE	VT					87	2,P								52					
180	SUNSET	VT					90	2,P								195					
181	WINONA	VT					86	2,P								234					
182	LONG	WA	THURSTON				91	1,P					11	2	1	330					
183	PEND OREILLE	WA					82	8,P				208	7								
184	SACHEEN	WA	PEND OREILLE	T31N,R43E	48 8' 47"	117 20'5"	91	19,P			22.1		5			320		3.4		6	
185	TWELVE	WA	KING				94	21,P			0.57	24	6	4	5	42					
186	AMNICON LAKE	WI	DOUGLAS	T46N R14 W 12			86	14,U								426					
187	BASS LAKE	WI	ST.CROIX	T30N R19W 26			86	14,U								33					
188	BEAR PAW LAKE	WI	OCONTO	T31N R17E 8			86	14,U								49					
189	BEAVER DAM	WI					95	10,U			14.95	66.19				1034.32	447.33				
190	BEAVER DAM	WI	BARRON				95	7,U	50							1112		3.75			
191	BECKER	WI	CALUMET				92	11,U		0			4	1							
192	BEULAH	WI	WALWORTH				93	9, U			90		13			832.72			187		
193	BIERBRAUER	WI	ST. CROIX	T31N; R17W;S4			95	22,P													
194	BIG CEDAR	WI	WASHINGTON	T10N R19E 5			86	14,U								932					
195	BIG GREEN	WI	GREEN LAKE	T15N R12E 6			86	14,U								7346					
196	BIG LONG	WI	MANITOWOC	T19N R21E 6			86	14,U								120					
197	BIG MCKENZIE	WI	BURNETT	T40N R14W 25			86	14,U								1185					
198	BIG SAND	WI					95	10,U			26.28	235				1244.1	349.14				
199	BIG TWIN	WI	WAUSHARA				92	11,U		20			11	1							
200	BLUE SPRING	WI	JEFFERSON				93	5,U					3								
201	BLUE SPRING	WI	JEFFERSON				93	4,U					2			137			185		
202	BLUE SPRING	WI	JEFFERSON				93	3,U			96	130	8			137					
203	BROWNS	WI	RACINE	T03N R19E 27			86	14,U								396					

(Sheet 8 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
204	BUTTERNUKE	WI	PRICE	T40N R01W 4			86	14,U								1006					
205	CARSTENS	WI	MANITOWOC				92	11,U		89			2	1							
206	CEDAR	WI	MANITOWOC				92	11,U		20			15	1							
207	CEDAR LAKE	WI	POLK	T32N R18W 34			86	14,U								1107					
208	CLARK LAKE	WI	DOOR	T28N R27E 3			86	14,U								868					
209	COMSTOCK	WI	MARQUETTE				92	11,U		5			10	1							
210	CRYSTAL	WI	SHEBOYGAN	T16N R21E 31			86	14,U								152					
211	DEVIL'S	WI	SAUK				90	20,P	70				2			373		19.7	0.4		
212	DEVIL'S	WI	SAUK	T11N;R6E; S13			95	22,P													
213	DUCK	WI					95	10,U			0	0				95.37	37.89				
214	DUTCH HOLLOW	WI	SAUK	T13N R03E 18			86	14,U								210					
215	E. ALASKA	WI	KEWAUNEE				92	11,U		82.5			6	1							
216	EAST	WI	KENOSHA				92	11,U		0			10	0							
217	EAU CLAIRE, LOW	WI	DOUGLAS	T44N R10W 25			86	14,U								802					
218	EAU CLAIRE, UPP	WI	BAYFIELD	T44N R09W 10			86	14,U								1030					
219	ENNIS	WI	MARQUETTE				92	11,U		2.5			5	1							
220	ESCANABA	WI	VILAS	T41N R07E 2			86	14,U								293					
221	FISH	WI	DANE		43 17' 14"	89 39' 08"	95	2,U			93					251	123.55				
222	FISH	WI	DANE	T9N;R7E; S3			95	22,P													
223	FISH	WI	DANE				92	11,U		129			4	1							
224	FISH	WI	DANE		43 17' 14"	89 39' 08"	92	1,U			92	100	14	4	3	251					
225	FISH	WI	DANE		43 17' 14"	89 39' 08"	91	1,U			91	100	14	4	3	251					

(Sheet 9 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
226	FISH	WI	DANE		43 17' 14"	89 39' 08"	94	1,U			86	100	14	4	3	251					
227	FISH	WI	DANE		43 17' 14"	89 39' 08"	93	1,U			95	100	14	4	3	251					
228	FISH	WI	DANE	T09N R07E 3			86	14,U								252					
229	FOX LAKE	WI	DODGE	T13N R13E 22			86	14,U								2625					
230	FRANKLIN LAKE	WI	ONEIDA	T39N R05E 16			86	14,U								161					
231	FRIESS LAKE	WI	WASHINGTON	T09N R19E 17			86	14,U								118					
232	GEORGE	WI	KENOSHA				92	11,U		1.6			5	1							
233	HARPT	WI	MANITOWOC				92	11,U		0			6	1							
234	HEIDMANNS	WI	KEWAUNEE				92	11,U		84			10	1							
235	HOOKER	WI	KENOSHA				92	11,U		10			9	1							
236	HORSESHOE	WI	MANITOWOC				92	11,U		68			12	1							
237	KENTUCKY	WI	VILAS	T41N R1E 27			86	14,U								957					
238	KEYES	WI	FLORENCE	T40N R17E 36			86	14,U								202					
239	KROHNS	WI					92	11,U		0											
240	KUSEL	WI	WAUSHARA				92	11,U		128			8	1							
241	LAC COURTE ORE	WI	SAWYER	T39N R09W 2			86	14,U								5039					
242	LAC LABELLE	WI	WAUKESHA	T08N R17E 19			86	14,U								1164					
243	LAKE DELTON	WI					95	10,U			0	0				227.54	227.54				
244	LILLY	WI	BROWN				92	11,U		0			11	1							
245	LONG, CHIPPEWA	WI	CHIPPEWA	T32N R08W 8			86	14,U								1060					
246	LONG,FOND DU LAC	WI	FOND DU LAC	T14N R19E 13			86	14,U								427					
247	LOST	WI	FLORENCE	T39N R15E 12			86	14,U								89					
248	MALLALIEU	WI	ST. CROIX	T29N;R19 W;S18			95	22,P													

(Sheet 10 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
249	MASON	WI	ADAMS	T14N R07E 25			86	14,U								857					
250	MAUTHE	WI	FOND DU LAC				92	11,U		117			10	1							
251	MAYFLOWER	WI	MARATHON				92	11,U		3			11	1							
252	MINOCQUA	WI	ONEIDA	T39N R06E 13			86	14,U								1360					
253	MIRROR	WI					95	10,U			24.75	9.87				68.79	39.87				
254	MONTELLO	WI	MARQUETTE				92	11,U		58			6	0							
255	NAGAWICKA	WI	WAUKESHA	T07N R18E 8			86	14,U								917					
256	NANCY	WI	WASHBURN	T42N; R13W			95	8,U	88							772		2.44			
257	NANCY	WI					95	10,U			1.75	10.14				581.7	577.62				
258	NAPOWAN	WI	WAUSHARA				92	11,U		122			11	1							
259	ONALASKA	WI	LA CROSSE	T17N; R7W;S31			95	22,P													
260	ONALASKA	WI					94	14,P													
261	PATTEN LAKE	WI	FLORENCE	T39N R17E 18			86	14,U								255					
262	PELICAN LAKE	WI	ONEIDA	T35N R10E 23			86	14,U								3585					
263	PEWAUKEE LAKE	WI	WAUKESHA	T07N R18E 13			86	14,U								2493					
264	PIKE	WI	MARATHAN	T27N R09E 13			86	14,U								205					
265	PIKE	WI	WASHINGTON	T10N R18E 23			86	14,U								522					
266	POTTERS	WI					92	11,U		0											
267	RANDOM	WI	SHEBOYGAN				92	11,U		26			9	1							
268	REDSTONE	WI	SAUK	T13N R03E 1			86	14,U								612					
269	RICE	WI	WALWORTH				92	11,U		90			4	0							
270	RIPLEY	WI	JEFFERSON	T06N R13E 7			86	14,U								418					

(Sheet 11 of 13)

Table A1 (Continued)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
271	ROCK	WI	JEFFERSON	T07N R13E 14			86	14,U								1371					
272	ROLLINGSTONE	WI	LANGLADE	T34N R12E 13			86	14,U								640					
273	ROUND	WI	CHIPPEWA	T32N R09W 14			86	14,U								216					
274	SAND	WI	RUSK	T31N R08 W 15			86	14,U								262					
275	SCHOOL SECTION	WI	MARQUETTE				92	11,U		8			3	1							
276	SCHOOL SECTION	WI	WAUPACA	T24N R13E 16			86	14,U								39					
277	SHARON	WI	MARQUETTE				92	11,U		1.3			13	0							
278	SHEA	WI	KEWAUNEE				92	11,U		32			3	1							
279	SHELL LAKE	WI	WASHBURN	T37N R12W 29			86	14,U								2580					
280	SILVER	WI	WAUPACA				92	11,U		108			12	0							
281	SILVER,BARRON	WI	BARRON	T36N R13W 24			86	14,U								337					
282	SILVER,WAUPACA	WI	WAUPACA	T23N R11E 14			86	14,U								68					
283	SPRING	WI	BUFFALO	T20N; R12W;S17			95	22,P													
284	SQUAW	WI	ST. CROIX	T31N R18W 8			86	14,U								129					
285	THUNDER	WI	ONEIDA	T38N R10E 11			86	14,U								1768					
286	TUMA	WI	MANITOWOC				92	11,U		83			11	1							
287	W.ALASKA	WI	KEWAUNEE				92	11,U		501			6	1							
288	WALLACE	WI					92	11,U		117			4	1							
289	WHITE CLAY	WI	SHAWANO	T27N R17E 23			86	14,U								234					
290	WHITE MOUND	WI	SAUK				92	11,U		45			5	0							
291	WHITEWATER	WI	WALWORTH	T04N R15E 35			86	14,U								640					

(Sheet 12 of 13)

Table A1 (Concluded)

CASE	LAKE	STATE	COUNTY	TWNSHP	LAT	LONG	YR	CIT #	%SAND	RELMS	MSCOV	MSARE	SUBM	FLOAT	EMERG	AREA	L AREA	SECCHI	ALKAL	TP	TSI
292	WILKE	WI	MANITOWOC				92	11,U		85			6	1							
293	WILSON	WI	IRON	T42N R03E 16			86	14,U								162					
294	WINGRA	WI	DANE				70	6,P			65		1	1		345.94	126.46				
295	WINGRA	WI	DANE				75	4,P													
296	WINGRA	WI	DANE				92	11,U		0			6	1							
297	WOOD	WI	VILAS				92	11,U		0			6	0							
298	YELLOW BIRCH	WI	VILAS				95	10,U			0.125	0.06				178.59	49.31				

(Sheet 13 of 13)

Appendix B Data for Lakes Used in Limnological Comparisons

Table B1 presents data obtained from lakes for limnological comparisons.

The variables used in Table B1 are as follows:

CASE = case number
LAKE = lake name
STATE = abbreviation of state or province
COUNTY = county name
YR = last two digits of year the data were collected
SUBM = number of submersed species in lake
FLOAT = number of floating-leaved species in lake
EMERG = number of emergent species in lake
AREA = area of lake, in acres
LAREA = area of lake littoral zone, in acres
SECCHI = Secchi disk depth, in meters
ALKAL = alkalinity of lake water, in mg $CaCO_3$ L^{-1}
TP = total phosphorus of lake water, in µg L^{-1}
TSI = Carlson's trophic state index
RELMS = relative abundance of Eurasian watermilfoil, or "dominance" as used in this report
MSLTCV = littoral area coverage of Eurasian watermilfoil, in acres
MSRLCV = relative coverage of Eurasian watermilfoil in lake, in percent
pH = pH of lake water, in units
%SAND = percent sand in lake sediment

Table B1
Summarized Data for Each Lake Used in Limnological Comparisons

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
1	CHICKAMAUGA	AL		84														
2	FT. LOUDOUN	AL		84														
3	GUNTERSVILLE	AL		84														
4	MELTON HILL	AL		84														
5	NICKAJACK	AL		84														
6	WATTS BAR	AL		84														
7	BRANNEN	BC	VANCOUVER	89				109	26									
8	CULTUS	BC	LOW MNLD	79				627	37									
9	DIVER	BC	VANCOUVER	89				16	6									
10	HATZIC	BC	LOW MNLD	78				300	260						88			
11	KALAMALKA	BC	OKANAGAN	79				2590	152									
12	LONG	BC	VANCOUVER	89				43	18									
13	OKANAGAN	BC	OKANAGAN	79				34800	1931									
14	OSOYOOS	BC	OKANAGAN	79				1505	348									
15	SKAHA	BC	OKANAGAN	79				2010	317									
16	VASEUX	BC	OKANAGAN	77				275	159						52			
17	WOOD	BC	OKANAGAN	79				930	57									
18	EAST GRAHAM	MICH	OAKLAND	89	6			4.5		5.2						56.6667		
19	AUBURN	MN	CARVER	92				106	61	2.1	115		51					45
20	AUBURN (EAST)	MN	CARVER	93				120		0.4	130	92	71					
21	AUBURN (WEST)	MN	CARVER	94				140		1.9	118	38	57					
22	BALD EAGLE	MN	RAMSEY	93				409	248	1.3	137	75	61					100
23	BAVARIA	MN	CARVER	93				80.9	6526	1.8	127	34	56					96
24	BEEBE	MN	WRIGHT	93				120	74	1.1			59					
25	BRYANT	MN	HENNEPIN	93				65	25	1.2	135	34	57				8.7	25

(Sheet 1 of 6)

Table B1 (Continued)

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
26	BUSH	MN	HENNEPIN	92				77	65	4	90	19	48				8.4	30
27	CALHOUN	MN	HENNEPIN	90				162	49.7	2	100	32	54				8.5	100
28	CEDAR	MN	HENNEPIN	90				68.7	25	2.1	80	35	56				8.8	92
29	CANAIKO	MN	ANOKA	93				12	4.8		102		38					
30	CLEARWATER	MN	WRIGHT	92				1287	588	1.3	154		42				8.3	80
31	GREEN	MN	CHISAGO	92				693	496	1.1	91						8.3	75
32	INDEPENDENCE	MN	HENNEPIN	93				341	172	1.2	125	34	56					80
33	ISLAND (NORTH)	MN	RAMSEY	93				8.1		1.4	63	139	63				6.7	24
34	ISLAND (SOUTH)	MN	RAMSEY	93				14		1	62	115	66				6.7	24
35	KNIFE	MN	KANABEC	93				509	508	0.6	80	173	57				9.2	53
36	LAKE OF ISLES	MN	HENNEPIN	90				44	36	0.9	100	52	63				8.8	70
37	LIBBS	MN	HENNEPIN	90				9	9	0.3			59					15
38	LITTLE WAVERLY	MN	WRIGHT	93				133	133	1.1			59					
39	LONG	MN	HENNEPIN	93				105	52	1	118	127	66					
40	LOTUS	MN	CARVER	93				99	73	0.9	132	51	62				7.9	53
41	LOWER PRIOR	MN	RAMSEY	93				331	148	0.4	145						8.9	80
42	MEDICINE	MN	HENNEPIN	92				358	160	0.8	112	34	63				8.2	60
43	MINNETONKA	MN	HENNEPIN	94	19	1		5787	2387	1.9	128		50					
44	MINNEWASHTA	MN	CARVER	92				300	150	2.6	122	28	49				8.6	84
45	OTTER	MN	ANOKA	92				134	132	2.6	120		45					90
46	PARKERS	MN	HENNEPIN	92				39	27	2.5	145		46					71
47	PELICAN	MN						3986		2.5	184		46					
48	PIERSON	MN	CARVER	93				95	48	2.4	130	112	58				8.7	75
49	PULASKI	MN	WRIGHT	93				284	49	3.8	105	14	46					65
50	REBECCA	MN	HENNEPIN	92				102	55.8	0.4	142	86	61				8.5	80

(Sheet 2 of 6)

Table B1 (Continued)

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
51	REITZ	MN	CARVER	93				28		0.9	171	114	70					
52	RILEY	MN	CARVER	93				121	44.5	1.7	150	45	60				8.8	95
53	ROCK	MN	WRIGHT	93				73	40	1.2	140	48	59					
54	SARAH	MN	HENNEPIN	92				212	106	0.5	121	116	64				8.7	75
55	SCHANDELL	MN						41		1.6	96		53					
56	SCHMIDT	MN	HENNEPIN	93				15	13.7	0.6	80						9.1	70
57	SCHUTZ	MN	CARVER	92				42	16	0.9	116	42	59				8.1	
58	STONE	MN	CARVER	92				40	28	0								
59	ST. CROIX R	MN		92														
60	VADNAIS	MN	RAMSEY	93				87	87	1.2	132	31	52				8	10
61	VIRGINIA	MN	CARVER	95				44.5	12	0.6	122						8.6	60
62	WACONIA	MN	CARVER	93				1212	671	1.8	167	39	58				8.1	30
63	WAVERLY	MN	WRIGHT	93				196	57	1.3	134	22	48				8.8	80
64	WAVERLY LIT	MN	WRIGHT	93				133	133	1.1	165		59					
65	WHITE BEAR	MN	WASHINGTON	93				977	531	3.9	85						8.9	80
66	ZUMBRA SUNNY	MN	CARVER	89				65	36	3	98	40	56				8.4	45
67	CAYUGA	NY	M	77	4			1600							90			
68	BRANT	NY		94						5.3	18							
69	EAGLE	NY		94						9.3	30							
70	GALWAY	NY		94						2.7	64							
71	LAKE LUZERNE	NY		94						4.7	18							
72	GEORGE	NY	M	89						9.7	25							
73	KAWARTHA	ON	PETERBOROUGH	94						1		0.02						
74	SUDBURY LKS	ON	SUDBURY	94														
75	KIRK (WEST)	OR		94	3	3	6	24			26.3	55					7.4	35.6

(Sheet 3 of 6)

Table B1 (Continued)

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
76	KIRK (EAST)	OR	M	94	3	3	6	24			92	23			68		9.5	35.6
77	PEND OREILLE	WA	PEND ORIELLE	82	7													
78	SACHEEN	WA	PEND ORIELLE	91	5			320		3.4		6				22.122122		
79	TWELVE	WA	KING	94	6	4	5	16.9		3.7								
80	BEAVER DAM (EAST)	WI	BARRON	95				2747		0.5								50
81	BEAVER DAM (WEST)	WI	BARRON	95				2747		3.75								50
82	BEULAH	WI	WALWORTH	93	13			832.7			187					68.181818		
83	BIG HILLS	WI		79												12.55		
84	BIG SAND	WI		95				503	141									
85	BIG TWIN	WI	WAUSHARA	92	11	1								20	19.6			
86	BLUE SPRING	WI	JEFFERSON	93	8			55			185					96	8	
87	CARSTENS	WI	MANITOWOC	92	2	1								89	43.8			
88	CEDAR	WI	MANITOWOC	92	15	1								20	20.2			
89	CEDAR	WI	POLK	86				448										
90	COMSTOCK	WI	MARQUETTE	92	10	1								5				
91	DELTON	WI		95				227.5	227.5									
92	DEVILS	WI	SAUK	90	2			151		9	0.4	9						70
93	EAST	WI	KENOSHA	92	10	0								0	7.1			
94	ENNIS	WI	MARQUETTE	92	5	1								2.5	2.1			
95	E. ALASKA	WI	KEWAUNEE	92	6	1								82.5	75			
96	FISH	WI	DANE	92	14	4	3	101	49					129	84.4	93		
97	GEORGE	WI	KENOSHA	92	5	1								1.6	1.2			
98	GEORGE	WI		79												70		
99	HEIDMANNS	WI	KEWAUNEE	92	10	1								84	79.7			
100	HOOKER	WI	KENOSHA	92	9	1								10	35			

(Sheet 4 of 6)

Table B1 (Continued)

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
101	HORSESHOE	WI	MANITOWOC	92	12	1								68	68.2			
102	KROHNS	WI	M	92										0	29.2			
103	KUSEL	WI	WAUSHARA	92	8	1								128	56.7			
104	LILLY	WI	BROWN	92	11	1												
105	LILLY	WI		79												10		
106	LITTLE ELKHART	WI		79												16.5		
107	MAUTHE	WI	FOND DU LAC	92	10	1								117	76.9			
108	MAYFLOWER	WI	MARATHON	92	11	1								3	2.6			
109	MIRROR	WI		95				27.8	16									
110	MONTELLO	WI	MARQUETTE	92	6	0								58	50			
111	NANCY	WI	WASHBURN	95				312	233	2.44								88
112	NAPOWAN	WI	WAUSHARA	92	11	1								122	85.9			
113	OKAUCHEE LAKE	WI		79												7.6		
114	ONALASKA	WI	LA CROSSE	94														
115	PIGEON	WI		79												0.6		
116	PINE	WI		79												53		
117	POTTERS	WI		92										0	36.7			
118	PRETTY	WI		79												9.1		
119	RANDOM	WI	SHEBOYGAN	92	9	1								26	26.6			
120	RICE	WI	WALWORTH	92	4	0								90	66.7			
121	SCHOOL SECTION	WI	MARQUETTE	92	3	1								8	8.3			
122	SCHOOL SECTION	WI	WAUPACA	86				15.7										
123	SHARON	WI	MARQUETTE	92	13	0								1.3				
124	SHEA	WI	KEWAUNEE	92	3	1								32	20			
125	SILVER	WI	WAUPACA	92	12	0		27.5						108	87.5			

(Sheet 5 of 6)

Table B1 (Concluded)

CASE	LAKE	STATE	COUNTY	YR	SUBM	FLOAT	EMERG	AREA	LAREA	SECCHI	ALKAL	TP	TSI	RELMS	MSLTCV	MSRLCV	pH	% SAND
126	TICHIGAN	WI		79												46		
127	TUMA	WI	MANITOWOC	92	11	1								83	79.7			
128	TWIN VALLEY	WI		79												37		
129	WALLACE	WI		92	4	1								117	81.3			
130	WHITE MOUND	WI	SAUK	92	5	0								45	28			
131	WILKE	WI	MANITOWOC	92	6	1								85	78.9			
132	WINGRA	WI	DANE	92	6	1		140	46					0	42.5	65		
133	W. ALASKA	WI	KEWAUNEE	92	6	1								501	64.6			
134	YELLOW BIRCH	WI		95				72	19.8									

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Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 1999	Final report

4. TITLE AND SUBTITLE
Predicting the Invasiion of Eurasian Watermilfoil into Northern Lakes

5. FUNDING NUMBERS
98X3122

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report A-99-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A better understanding of factors related to invasion and colonization success of exotic species might improve both planning and implementation of management for invasions in new areas. Data from lakes containing Eurasian watermilfoil were evaluated to compare the extent of Eurasian watermilfoil dominance to common limnological parameters. The best predictors of Eurasian watermilfoil dominance were water column total phosphorus and Carlson's Trophic State Index. This analysis corroborates observations that Eurasian watermilfoil appears most abundant in mesotrophic lakes and moderately eutrophic lakes. An application of this model to an ecological classification of Minnesota lakes suggests that a large proportion of lakes in Minnesota across a broad geographical area could support significant infestations of Eurasian watermilfoil.

14. SUBJECT TERMS
Colonization
Exotic aquatic macrophyte
Myriophyllum spicatum
Nonindigenous aquatic plant

15. NUMBER OF PAGES
90

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102