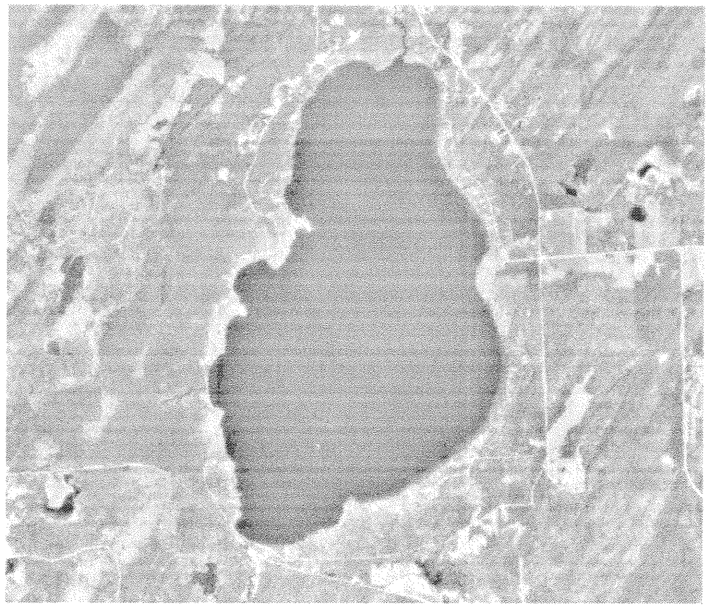
An Aquatic Plant Management Plan for Pine Lake, Forest County, Wisconsin



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Executive Summary

A thorough study of Pine Lake, Forest County, Wisconsin was conducted between May and August, 2006. The primary goal of this project has been to develop an Aquatic Plant Management Plan for the Pine Lake Protection and Rehabilitation District, as a means to 1) reduce excessive aquatic plant growth, 2) protect the native plant communities, 3) provide adequate navigation, 4) manage aquatic invasive species, and 5) develop and prioritize management recommendations based on the concerns raised by members of the District.

Project elements focused primarily on the aquatic plant community of Pine Lake, water quality parameters, and an assessment of the lake's watershed.

Results of this study include:

- The most abundant plant species encountered in Pine Lake were bushy pondweed (*Najas flexilis*), coontail (*Ceratophyllum demersum*), Robbin's (fern) pondweed (*Potamogeton robbinsii*), and common waterweed (*Elodea canadensis*).
- Hybrid watermilfoil (*Myriophyllum spicatum x sibericum*) was found in a large portion of the lake at the time of the survey. In much of it's range, it causes impairments to navigation and likely negative impacts to the native plant community.
- Curly-leaf pondweed *(Potamogeton crispus)*, although documented in 2004, was not found in Pine Lake in either the spring or summer of 2006.
- Analysis of plant data using the Floristic Quality Index (FQI) ranks Pine Lake as a higher than average quality lake.
- Pine Lake has fair water quality and exhibits characteristics of a lake near the boundary between a mesotrophic and eutrophic lake.
- Dissolved oxygen measurements indicate sufficient levels of oxygen throughout Pine Lake over the past six years. Anoxia does not appear to be a significant problem.
- Delineation found that the watershed of Pine Lake is over 10 square miles, with approximately 50% covered with forests and 40% wetlands.
- Modeling of land cover and water quality data indicated the largest contributors of phosphorus include watershed runoff, precipitation and septic systems.

Introduction

Pine Lake is a large shallow drainage lake located near the town of Hiles in Forest County (**Figure 1**). It is approximately 1670 acres with a maximum depth of 14 feet (**Figures 2 and 3**). As one of the largest lakes in Forest County with over 400 property owners in the District, Pine Lake receives heavy recreational use. Land uses in the surrounding countryside include forestry and light agriculture. Three inlet streams, Pine Creek, Wildcat Creek, and Copper Creek feed Pine Lake. The outlet for the lake is the Wolf River to the south. Directly north of Pine Lake is the Hiles Millpond. In the mid 1990's the dam on the millpond was replaced. During this process, the section of Pine Creek, between the millpond and the lake, silted in. As a result, dense vegetation has grown in the creek, bog-like conditions have been produced, and the creek has become unnavigable. Currently, every three years, the water level in the millpond is lowered for wild rice and waterfowl management. A dam located at the outlet to the Wolf River is adjusted weekly to maintain the water level in Pine Lake.

The Pine Lake Protection and Rehabilitation District represents the interests of lakeshore property owners and other lake users. District members are very concerned over the ecological health of the lake. As a result, they play an active role in lake management largely through volunteer efforts and the sponsoring of numerous studies over the years. From 1988 to 1994 and from 2001 to present, volunteers have participated in the Self-Help lake monitoring program coordinated by the Wisconsin DNR (WDNR). The earlier years focused primarily on water clarity (Secchi depths). Later, the scope of the monitoring program was expanded to include sampling for phosphorus, chlorophyll, and dissolved oxygen.

In a recent (2005) survey of property owners conducted by the District (see pages 6 and 7), a majority indicated they chose to live on Pine Lake for its recreation opportunities including swimming, fishing, relaxing and wildlife viewing. However, excessive weed growth has been a major issue for lake users for a number of years. For years, the District has operated a weed harvester to manage aquatic plants in Pine Lake. The harvesting program has encountered a number of challenges including frequent harvester breakdowns and disagreement over the use of harvesting as a management tool. Over 85% of the property owners surveyed feel aquatic plant growth continues to be excessive and the current control program is ineffective at controlling nuisance plants.

According to the Wisconsin Department of Natural Resources, Eurasian watermilfoil (*Myriophyllum spicatum*), an aggressive exotic plant species was confirmed in Pine Lake in January 2004. However, the general consensus is that Eurasian watermilfoil has been present much longer. In 1992 and 2004, Northern Lakes Service, Inc was retained by the District to conduct aquatic plant surveys. Data from these surveys were used to determine the distribution and density of aquatic plants in Pine Lake.

Figure 1. Area surrounding Pine Lake in Forest County, Wisconsin

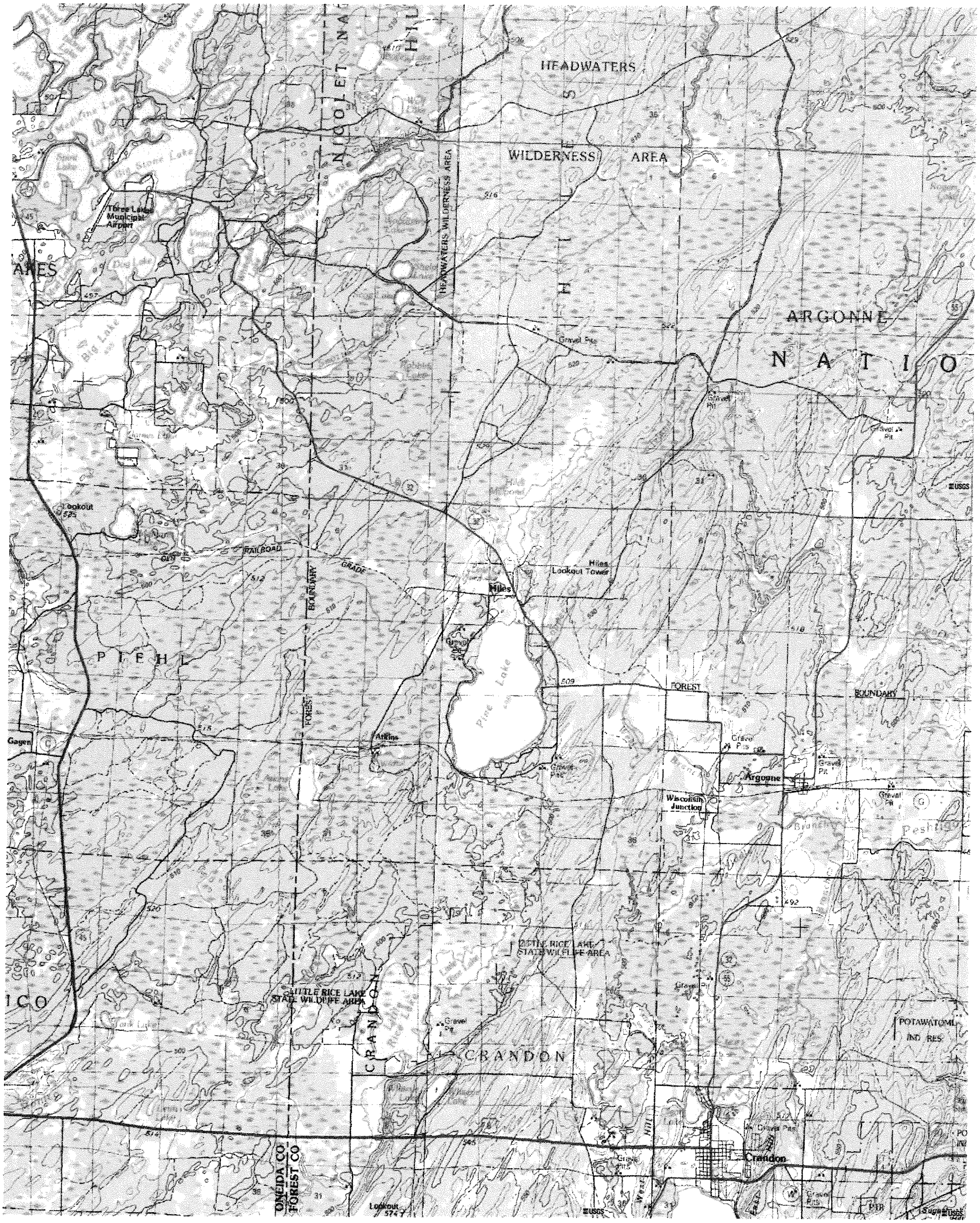


Figure 2. Pine Lake in Forest County, Wisconsin (1938).

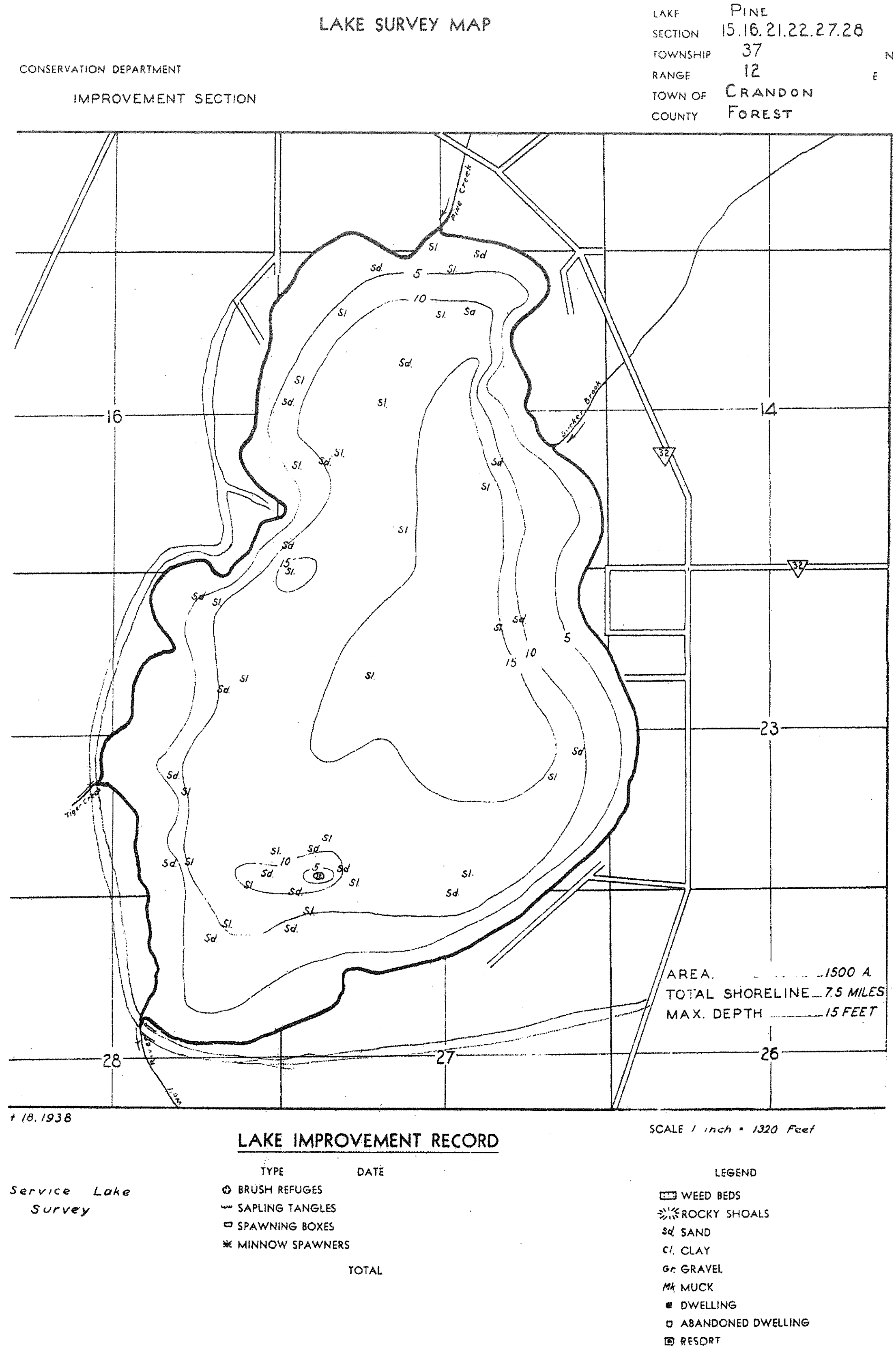
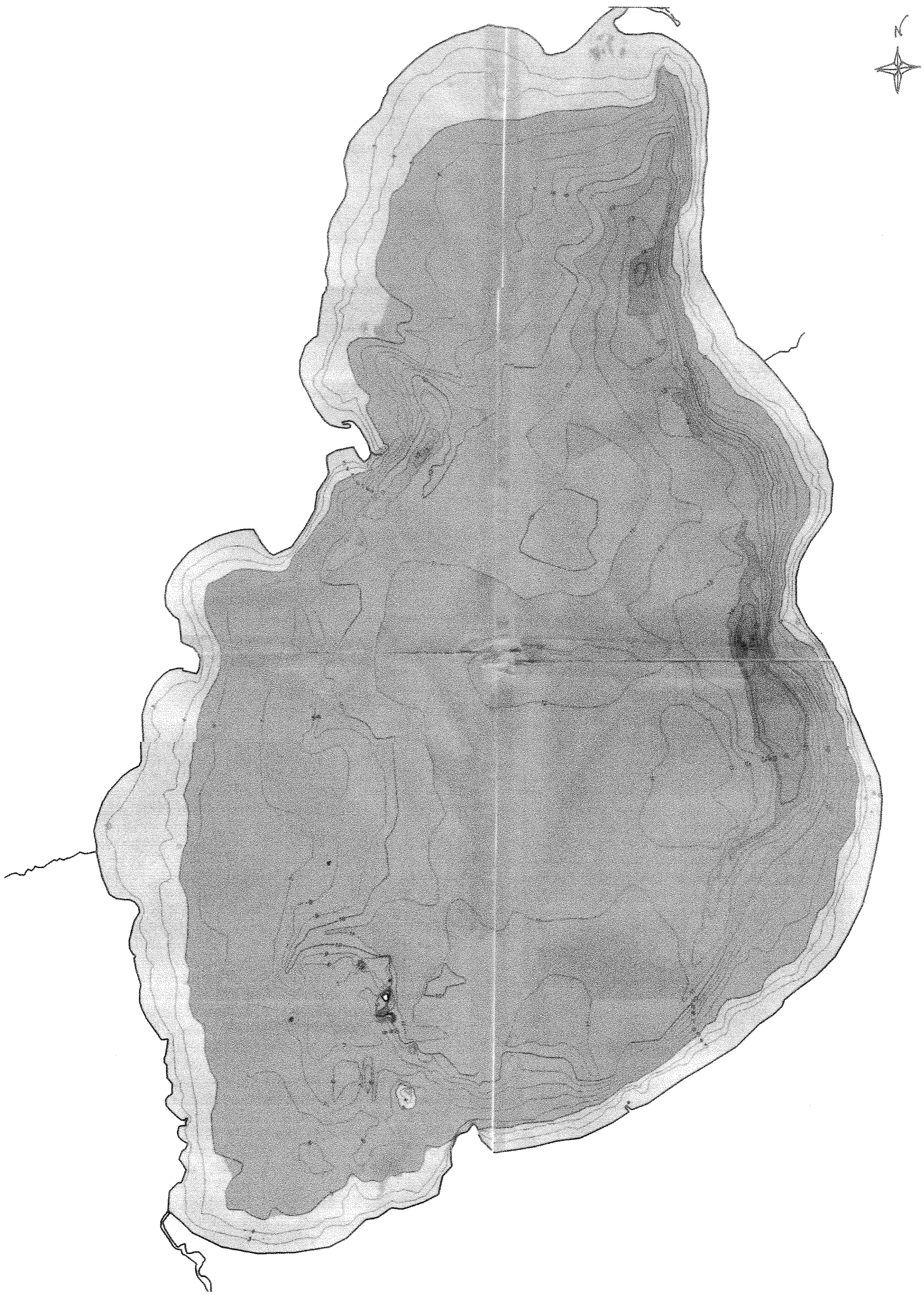


Figure 3. Pine Lake in Forest County, Wisconsin (2004).



Pine Lake Management District Survey Results
(10/19/05)

1. ***Which of the following best describes your residency status?***
   - 164 Seasonal/part-time
   - 57 Year-round/permanent

2. ***List the top three reasons why you chose to own property on Pine Lake:***
   - 42 Type & quality
   - 33 Real estate investment
   - 134 Recreational opportunities
   - 51 Cost of property
   - 8 Proximity to primary residence
   - 46 Area amenities (small town envir.)
   - 150 Peace/tranquility
   - 19 Entertaining
   - 65 Family inheritance/tradition
   - 24 Other

3. ***Which of the following describes your lake frontage within 25 feet of the water's edge?***
   - 65 Sand beach
   - 3 Retaining Wall
   - 125 Pier/dock
   - 63 Sparse vegetation
   - 75 Stabilizing Rocks
   - 56 Thick vegetation
   - 40 Boat hoist
   - 25 Unaltered/undeveloped
   - 3 Retaining Wall
   - 14 Private boat ramp

4. ***What activities do you and the members of your household most enjoy while at Pine Lake?***
   - 120 Swimming
   - 196 Fishing
   - 140 Observing wildlife
   - 155 Enjoying the view
   - 40 Water skiing
   - 61 Canoeing/Paddle boating
   - 99 Motor boating
   - 62 Entertaining
   - 14 Sailing/Wind surfing
   - 163 Relaxing
   - 26 Jet skiing
   - 20 Cross-country skiing

5. ***What types of watercraft do you use on Pine Lake?***
   - 88 Rowboat/Paddleboat
   - 79 Pontoon
   - 63 Canoe/kayak
   - 22 Runabout I/O
   - 97 Runabout O/B
   - 14 Sailboat
   - 24 Personal Watercraft

6. ***If powerboat, indicate horsepower and approximate amount of gas used annually.***
   - Highest horsepower indicated - 200
   - Highest gallons used - 360
   - Lowest horsepower indicated - 3
   - Lowest gallons used - 1

7. ***What is your opinion regarding the use of fertilizers and/or weed killer to maintain lawns around Pine Lake?***
   - 140 Not needed/not justified
   - 6 Two or more applications per year
   - 47 Needed on sporadic basis
   - 24 One application per year

8. ***Overall, how would you describe the water clarity in Pine Lake during the summer months?***
   - 121 – Clear
   - 68 - Cloudy
   - 9 - Crystal clear
   - 27 - Murky (weekends)

9. ***When is water clarity at its worst?***

__31__ Heavy boat/jet ski use
__102__ Summer
__45__ After heavy rain
__37__ During high/low lake levels
__6__ Spring
__21__ Fall
__18__ Consistently bad

10. ***Overall, how would you describe the Aquatic Plant growth in Pine Lake?***

__21__ Healthy amount of plants
__199__ Too many plants
__0__ Too few plants

11. ***Do you feel the current weed control program is effectively controlling nuisance plant growth?***

__28__ Yes
__189__ No

12. ***Do you feel that there is adequate law enforcement on Pine Lake?***

__149__ Yes
__52__ No

13. ***What is your opinion regarding lake use regulations/laws on Pine Lake in general? (Zoning & Law Enforcement)***

__116__ Sufficiently regulated
__66__ Under-regulated
__17__ Over-regulated

14. ***What do you feel are the top three factors that contribute to problems on Pine Lake?***

__34__ motor boat/jet ski traffic
__110__ Lake level fluctuation
__50__ Fertilizer
__23__ Shoreline development
__62__ Shoreline erosion
__6__ Inadequate law enforcement
__11__ Wetland destruction
__1__ Construction site
__25__ Other
__123__ Failing septic systems
__110__ Inappropriate lake mgmt.

15. ***Do you feel that you have a voice in decision-making matters regarding the management of Pine Lake? If not, please explain why you think this is the case.***

__115__ Yes
__74__ No

16. ***What is your preference for the following weed control options?***

__88__ Cutting
__71__ Chemical application
__139__ Combination of cutting and chemical application

In both the 1992 and 2004 aquatic plant surveys, milfoil was found in Pine Lake. At the time of the 1992 survey, this species was identified as the native northern watermilfoil (*Myriophyllum sibericum*; formerly *Myriophyllum exalbenscens*). It was not until a few years later, however, that this species was identified as a hybrid. In 2004, DNA analysis further confirmed that the milfoil sample collected from Pine Lake was a hybrid cross between Eurasian watermilfoil and a native watermilfoil species. However, as of the 2004 survey, the hybrid milfoil had not dominated the submergent plant community. There has been and continues to be much confusion regarding not only the identification of hybrid milfoil, but also its distribution and options for management.

In addition to the hybrid milfoil, the 2004 survey identifed the presence of curly-leaf pondweed (*Potamogeton crispus*). Specimens were collected at two sample sites in the southern half of the lake.

The Wisconsin Department of Natural Resources has requested that Pine Lake develop an aquatic plant management plan in order to address current concerns over excessive aquatic plant growth within the lake. This report presents the information gathered in order to develop a long-range management plan for the District. With the knowledge gained by this project, the District hopes to take the appropriate actions needed to best manage the aquatic plants for lake users and the biotic community alike.

Management History

Information available from the WDNR regarding aquatic plant management on Pine Lake dates back to the early 1990's. This information indicates that in 1992 and 1993 small areas (<4 acres) in the northern half of the lake were treated for navigational purposes using combinations of diquat, endothall, and copper sulfate.

Some records regarding harvesting are available between 1995 and 2007.

In 1995 197 truckloads of aquatic plants were removed from the lake. It was estimated that only one-half of the areas intended to be cut were cut. Following the cutting, there was a positive response from lake users, particularly anglers. However, floating weed beds were noted as a nuisance. The map used in 1995 was also intended to be used in 1996 however; no record could be located for 1996.

No record are available from 1997-2001 either. In 2000 a map was submitted in July indicating the center of the lake was to be harvested. However, harvesting had not taken place due to a property owner dispute regarding the placement of the conveyer.

In 2002 over 205 loads of aquatic plants were removed form Pine Lake. Of these approximately 115 loads were removed from the northern half of the lake and 90 loads were removed from the southern half. It was estimated that 1-1½ hours every day were spent cleaning up floating mats of vegetation.

Data for 2003 could not be located.

In 2004, a total of 248 loads of aquatic plants were removed from Pine Lake.

In 2005, 160 cutter loads (76 truck loads) of aquatic plants were removed between July and September. Cutting took place primarily near the east and northwest shores. Some cutting took place in the center of the northern end of the lake. It was noted that the harvester operators attempted to avoid cutting in some areas due to the presence of exotics. It is most likely the presence of hybrid milfoil which was being referred to.

In 2006, 132 cutter loads (66 truck loads) were removed. The records indicate this took place within a 2.5 week time period. It was also noted that the operators believed a majority of the plant material removed to be milfoil. During the summer of 2006, the harvester tipped over and had to be repaired. After this incident, cutting did not resume on Pine Lake in 2006. The off-loading site for the cutter is located along the northeast shore near the Forest Service boat ramp.

No cutting took place in 2007.

The current equipment for weed harvesting on Pine Lake allow for a four-foot cutting depth. District representatives have pursued outside harvesting contractors which can cut to a depth of six feet. Harvesting has not typically taken place in the southern half of the lake. This is due primarily to the prevalence of large submersed rocks which are a significant hazard to the cutting equipment and crew.

Fishery of Pine Lake

In 2003, the WDNR surveyed the fishery of Pine Lake using a number of techniques including fyke netting and electroshocking in the spring and/or fall. Later that fall, the WDNR published a *Comprehensive Fisheries Survey Report* for Pine Lake. The summary of this report authored by Bob Young, Fisheries Biologist states:

"*A diverse fish community consisting of 5 gamefish, 7 panfish and 6 non-game species was sampled during the survey period. Walleye was the most commonly encountered gamefish, followed by northern pike (NP) and largemouth bass (LMB). Stocking supports the walleye population, as there is little evidence of natural reproduction. The estimated adult walleye of 0.8 per acre is well below average for even stocked lakes, but average size of walleyes is good. Walleye growth is well above average. There is fairly low density, naturally reproducing population of LMB growing at normal rates. Northern pike are numerous, naturally reproducing, and growing at average rates. Few NP seem to reach quality size and the majority captured appeared to be relatively thin.*

Among the panfish, a naturally reproducing, large population of bluegills with a fair to marginal size structure and poor growth rates is presently in Pine Lake. Pumpkinseed and black crappie are less numerous but have similar population characteristics. Rockbass and yellow perch are quite scarce. The relatively poor size structure and *growth rates of most panfish are likely related to inherent lake characteristics (dense aquatic plants), and possibly high angling pressure on larger sizes."*

This report also included the following recommendations:

"Increased plant harvesting could result in larger bass population, a reduction of bluegill numbers and corresponding improvements in bluegill sizes and growth.

Walleye stocking by WDNR should be resumed in Pine Lake, every other year.

Encouraging more panfish predators, especially largemouth bass, could eventually improve panfish size structure by reducing the number of smaller individuals, thereby increasing growth rates of remaining fish. A significant reduction of aquatic plants to decrease cover and make panfish more vulnerable to predation would also help improve panfish size structure and growth.

The lake association should refine its aquatic plant-harvesting plan to encourage both an increased harvest and cutting of well defined "lanes". Research on other similar lakes has shown that maintaining open lanes is a good method of providing predator fish better access to over-abundant panfish.

Fish surveys since 1949 have shown similar results showing: 1) a high density, average to slow growing panfish population, stable populations of LMB and NP and a low density of walleyes with normal growth rates supported almost entirely by stocking, high angling use and abundant to dense aquatic plant growth."

Methods

Aquatic Plant Assessment

On July 21-24, 2006, a submergent aquatic plant survey was conducted utilizing reproducible methods so that future surveys can accurately assess changes to the plant community. Under the guidance of Jennifer Hauxwell from the WDNR, an approved plant survey map for Pine Lake was provided (**Figure 4**). A series of grid points spaced 90 meters apart were mapped across the lake. At each point, aquatic plant samples were collected from a boat with a single rake tow. In total 828 points were sampled in the lake. Following DNR guidelines, the rake used consisted of two weighted short-toothed garden rake heads welded together and attached to a rope. At each sample point, the rake was thrown from the boat and dragged along the bottom for approximately 2.5 feet to collect plants. All plant samples collected were identified to *genus* and *species* whenever possible, and recorded. An abundance rating was given for each species collected using the criteria described in **Figure 5**. In addition to the plant data, depth and bottom substrate composition were recorded for each sampling point. Data collected were used to determine species composition, percent frequency and relative abundance.

Exotic Plant Distribution Mapping

The plant survey conducted in 2004 found a small amount of curly-leaf pondweed growing in the southern half of Pine Lake. As a result, a mapping survey was conducted in May 2006 to accurately assess the distribution of this species.

In addition, at the time of the plant survey in July, the extent and locations of exotic species, namely Eurasian watermilfoil and its hybrids were determined. While conducting the plant survey, researchers indicated on the plant survey map where milfoil was identified outside of the sampling sites. The locations of the beds were mapped using surface observations and rake tows. With the use of a Garmin V GPS unit the beds were drawn on a lake map using shoreline feature and plant survey points as references. Acreage-grid analysis was then used to determine the acres of distribution.

Figure 4. Pine Lake aquatic plant survey map.

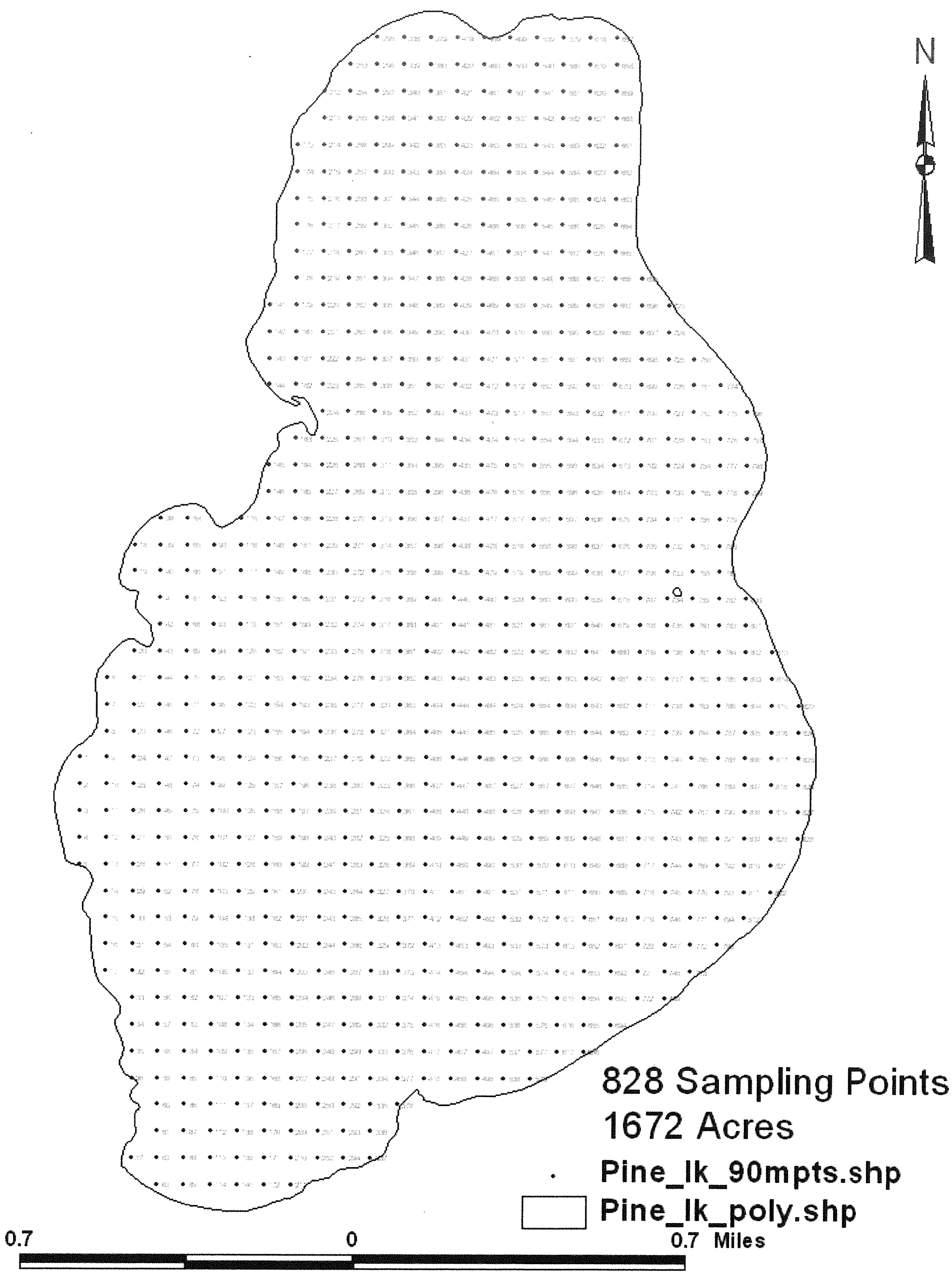
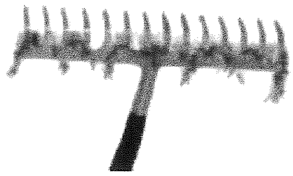
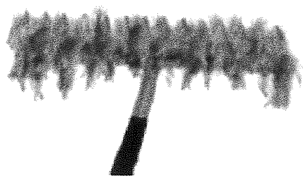
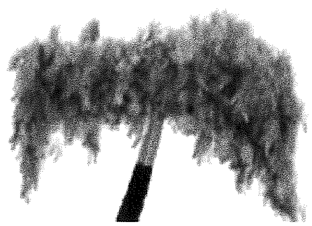


Figure 5. Plant abundance rating criteria used in submergent aquatic plant surveys.

Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Water Quality Assessment

On August 22, 2006 a one-time assessment of the water quality of Pine Lake was made. Wisconsin Lake and Pond Resource staff collected data for the following water chemistry and limnology parameters:

- pH
- Water transparency (Secchi depth)
- Dissolved oxygen
- Temperature
- Chlorophyll
- Total phosphorus
- Nitrogen (nitrate + nitrite)

Sampling took place at the deepest point on the east side of the lake. The information gathered was used to gain a better understanding of conditions in the lake at the time of sampling.

In addition, water quality data available since 1988 were compiled for analysis of previous lake conditions. These data were obtained primarily through volunteer monitoring.

Watershed Assessment

The watershed boundary of Pine Lake was delineated and its physical characteristics described by using topographic maps, county soil surveys, and land-use data available through the WDNR. Land use patterns, vegetative cover, potential nutrient loading sources, and environmentally sensitive areas were further assessed by an on-site survey conducted in July 2006. Pollutant loads for land-use types within the watershed were estimated using standard runoff coefficients.

Special attention was made to the condition of the lake's shoreline. A significant amount of nutrients and sediments can enter a lake from near-shore locations. Therefore, it was important to focus on the entire lake shore and identify potential areas of concern. These included possible areas of disturbance, high erosion, or generally poor riparian health. The potential impacts of these features on the aquatic plant community of Pine Lake are presented and discussed. Management strategies for watershed features which are potential pollution sources have been incorporated.

Results and Discussion

Aquatic Plant Communities

Coordinates for the sampling points within the lake can be found in **Appendix A**.

A total of 24 aquatic plant species were found during the 2006 survey (**Table 1**). This is well above the state-wide average of 13 species. Pine Lake lies within the Northern Lakes and Forests region of Wisconsin. The average number of species found in lakes in this region is also 13 species (Nichols, 1999). The most abundant plant species encountered in Pine Lake were coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), and Robbins (fern) pondweed (*Potamogeton robbinsii*), common waterweed (*Elodea canadensis*), and hybrid milfoil (*Myriophyllum spicatum x M. sibericum*). Each of these species was found at over 20% of the sampling points. **Figures 6-10** show the distribution and density of these species across Pine Lake at the time of the survey.

On August 7-8, 2004, and July 30, 1992 similar aquatic plant surveys were conducted. However, the point-intercept grid used for these surveys had only 62 sampling points (less than 10% of the number of sites sampled in 2006). The data for these surveys were compiled and results can also be found in **Table 1**. Percent frequency values reflect the relationship between the number of locations where a particular species was found versus the total number of locations sample. Relative frequency values reflect the abundance of a particular species in relation to all other species found.

Although the survey methods differed, some comparisons can be made with the three sets of aquatic plant survey data. Although the most abundant species differed from one survey to the next, the same small group of species appears to have dominated the plant community over the past 15 years. These include common waterweed, flat-stem pondweed (*Potamogeton zosteriformis*), white-stem pondweed (Potamogeton praelongus), milfoil (*Myriophyllum* spp.), coontail, and bushy pondweed. At the time of the 2004 survey all the milfoil present was identified as northern watermilfoil (*M. sibericum*). Again it was in 2004 that hybrid milfoil was identified in Pine Lake through DNA analysis. The differences in plant species abundance from 2004 to 2006 may be a result of the sampling methodology.

The raw data for the 2006 submergent aquatic plant survey can be found in **Appendix B**. The 2004 data can be found in the *Macrophyte Survey, Pine Lake, Forest County* (Krueger, 2004). The 1992 data can be found in the *Limnological Study of Pine Lake, Forest County; April 1992 – March 1993* (Northern Lake Service, 1993). **Figure 11** presents the relative abundance of submergent aquatic plant species found in Pine Lake at the time of the 2006 survey.

Table 1. Results of the submergent aquatic plant survey conducted on Pine Lake on July 21-24, 2006 and August 7-8, 2004.

Species		2006		2004	
common name	scientific name	Percent Frequency	Relative Frequency	Percent Frequency	Relative Frequency
Coontail	*Ceratophyllum demersum*	61.1	22.9	60.0	12.1
Bushy pondweed	*Najas flexilis*	56.1	21.0	60.0	12.1
Robbins pondweed	*Potamogeton robbinsii*	30.1	11.3	31.7	6.4
Common waterweed	*Elodea canadensis*	24.4	9.1	88.3	17.8
Hybrid watermilfoil	*Myriophyllum spicatum x M. sibericum*	21.0	7.9	--	--
Flat-stem pondweed	*Potamogeton zosteriformis*	17.6	6.6	68.3	13.8
White-stem pondweed	*Potamogeton praelongus*	16.0	6.0	28.3	5.7
Wild celery	*Vallisneria americana*	7.4	2.8	20.0	4.0
Small pondweed	*Potamogeton pusillus*	7.0	2.6	15.0	3.0
Clasping-leaf pondweed	*Potamogeton richardsonii*	5.2	2.0	--	--
Muskgrasses	*Chara* spp.	4.0	1.5	3.3	0.7
Forked duckweed	*Lemna trisulca*	2.9	1.1	8.3	1.7
Large-leaf pondweed	*Potamogeton amplifolius*	2.6	1.0	21.7	4.4
Watershield	*Brasenia schreberi*	1.8	0.7	1.7	0.3
Illinois pondweed	*Potamogeton illinoensis*	1.7	0.6	--	--
Water marigold	*Megalodonta beckii*	1.6	0.6	5.0	1.0
Spatterdock	*Nuphar variegata*	1.5	0.5	5.0	1.0
White water lily	*Nymphaea odorata*	1.2	0.5	5.0	1.0
Filamentous Algae	*Pithophora, Cladophora, etc.*	1.0	0.4	--	--
Softstem bulrush	*Schoenoplectus tabernaemontani*	1.0	0.4	1.7	0.3
Variable pondweed	*Potamogeton gramineus*	0.7	0.3	--	--
Creeping Spikerush	*Eleocharis palustris*	0.5	0.2	--	--
Common bladderwort	*Utricularia vulgaris*	0.4	0.1	--	--
Pickerelweed	*Pontederia cordata*	0.1	0.0	--	--
Northern watermilfoil	*Myriophyllum sibericum**	--	--	60.0	12.1
Curly-leaf pondweed	*Potamogeton crispus*	--	--	3.3	0.7
Needle Spikerush	*Eleocharis acicularis*	--	--	1.7	0.3
Large quillwort	*Isoetes lacustris*	--	--	3.3	0.7
Nitella	*Nitella* spp.	--	--	1.7	0.3
Water smartweed	*Polygonum amphibium*	--	--	1.7	0.3
Brown-fruited rush	*Juncus paleocarpus*	--	--	--	--
Common duckweed	*Lemna minor*	--	--	--	--
Broad-leaved cattail	*Typha latifolia*	--	--	--	--
Unknown pondweed	*Potamogeton* sp.	--	--	--	--

* Milfoil sample collected in 2004 was later determined by DNA analysis to be a hybrid milfoil.

Table 1 (cont.). Results of the submergent aquatic plant survey conducted on Pine Lake on July 21-24, 2006 and August 7-8, 2004.

Species common name	scientific name	1992 Percent Frequency	1992 Relative Frequency
Coontail	*Ceratophyllum demersum*	77.8	16.3
Bushy pondweed	*Najas flexilis*	35.2	7.4
Robbins pondweed	*Potamogeton robbinsii*	34.5	6.6
Common waterweed	*Elodea canadensis*	44.4	9.3
Hybrid watermilfoil	*Myriophyllum spicatum x M. sibericum*	--	--
Flat-stem pondweed	*Potamogeton zosteriformis*	42.6	8.9
White-stem pondweed	*Potamogeton praelongus*	42.6	8.9
Wild celery	*Vallisneria americana*	25.9	5.4
Small pondweed	*Potamogeton pusillus*	--	--
Clasping-leaf pondweed	*Potamogeton richardsonii*	34.5	6.6
Muskgrasses	*Chara* spp.	3.7	0.8
Forked duckweed	*Lemna trisulca*	5.6	1.2
Large-leaf pondweed	*Potamogeton amplifolius*	14.8	3.1
Watershield	*Brasenia schreberi*	5.6	1.2
Illinois pondweed	*Potamogeton illinoensis*	7.4	1.6
Water marigold	*Megalodonta beckii*	7.4	1.6
Spatterdock	*Nuphar variegata*	5.6	1.2
White water lily	*Nymphaea odorata*	5.6	1.2
Filamentous Algae	*Pithophora ,Cladophora, etc.*	--	--
Softstem bulrush	*Schoenoplectus tabernaemontani*	11.1	2.3
Variable pondweed	*Potamogeton gramineus*	13.0	2.7
Creeping Spikerush	*Eleocharis palustris*	--	--
Common bladderwort	*Utricularia vulgaris*	1.9	0.4
Pickerelweed	*Pontederia cordata*	5.6	1.2
Northern watermilfoil	*Myriophyllum sibericum*	24.1	5.0
Curly-leaf pondweed	*Potamogeton crispus*	--	--
Needle Spikerush	*Eleocharis acicularis*	1.9	0.4
Large quillwort	*Isoetes lacustris*	1.9	0.4
Nitella	*Nitella* spp.	1.9	0.4
Water smartweed	*Polygonum amphibium*	--	--
Brown-fruited rush	*Juncus paleocarpus*	1.9	0.4
Common duckweed	*Lemna minor*	1.9	0.4
Broad-leaved cattail	*Typha latifolia*	1.9	0.4
Unknown pondweed	*Potamogeton* sp.	24.1	5.0

Figure 6. 2006 Distribution coontail (*Ceratophyllum demersum*) on Pine Lake, Forest County, WI

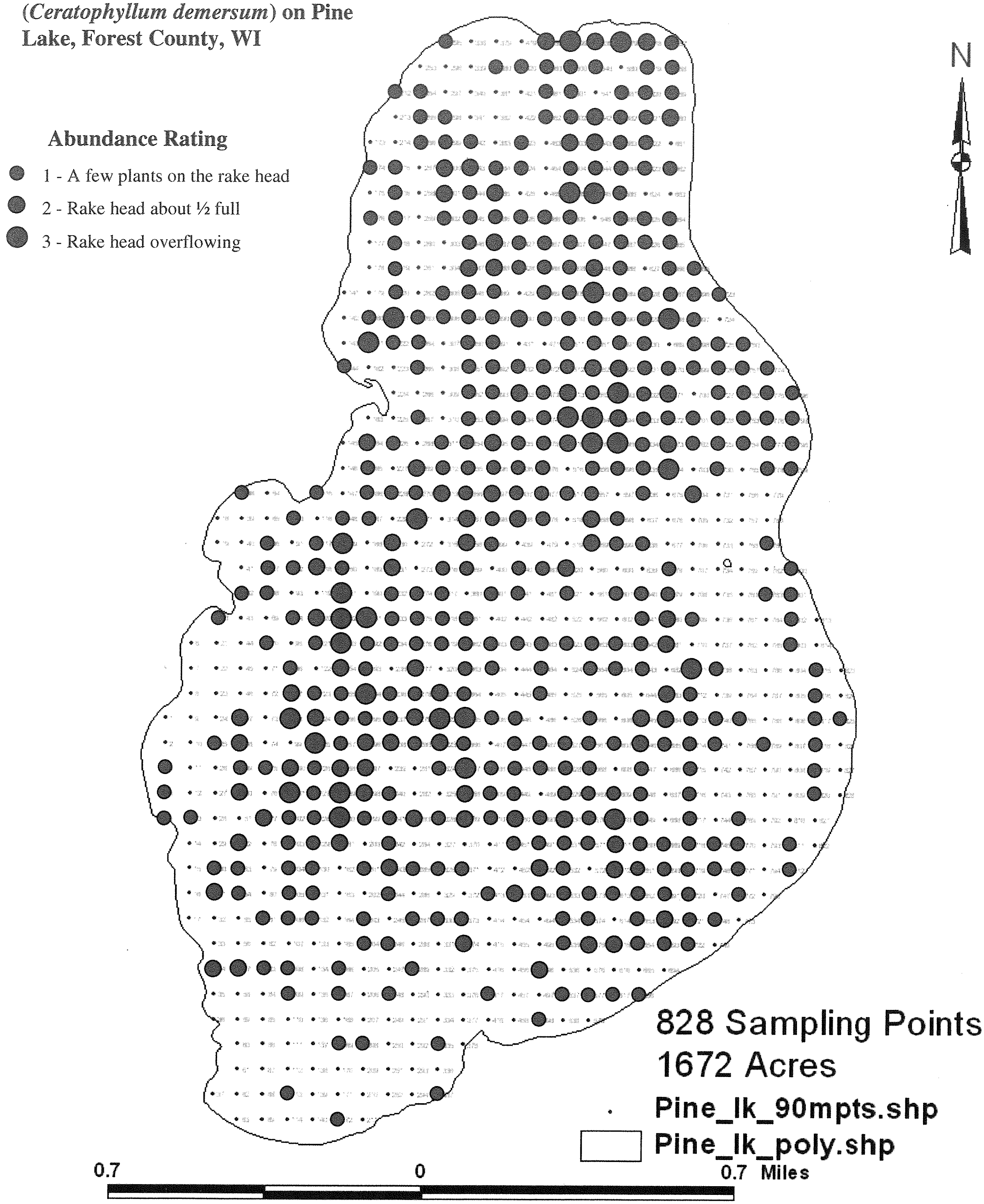


Figure 7. 2006 Distribution of bushy pondweed (slender naiad) (*Najas flexilis*) on Pine Lake, Forest County, WI

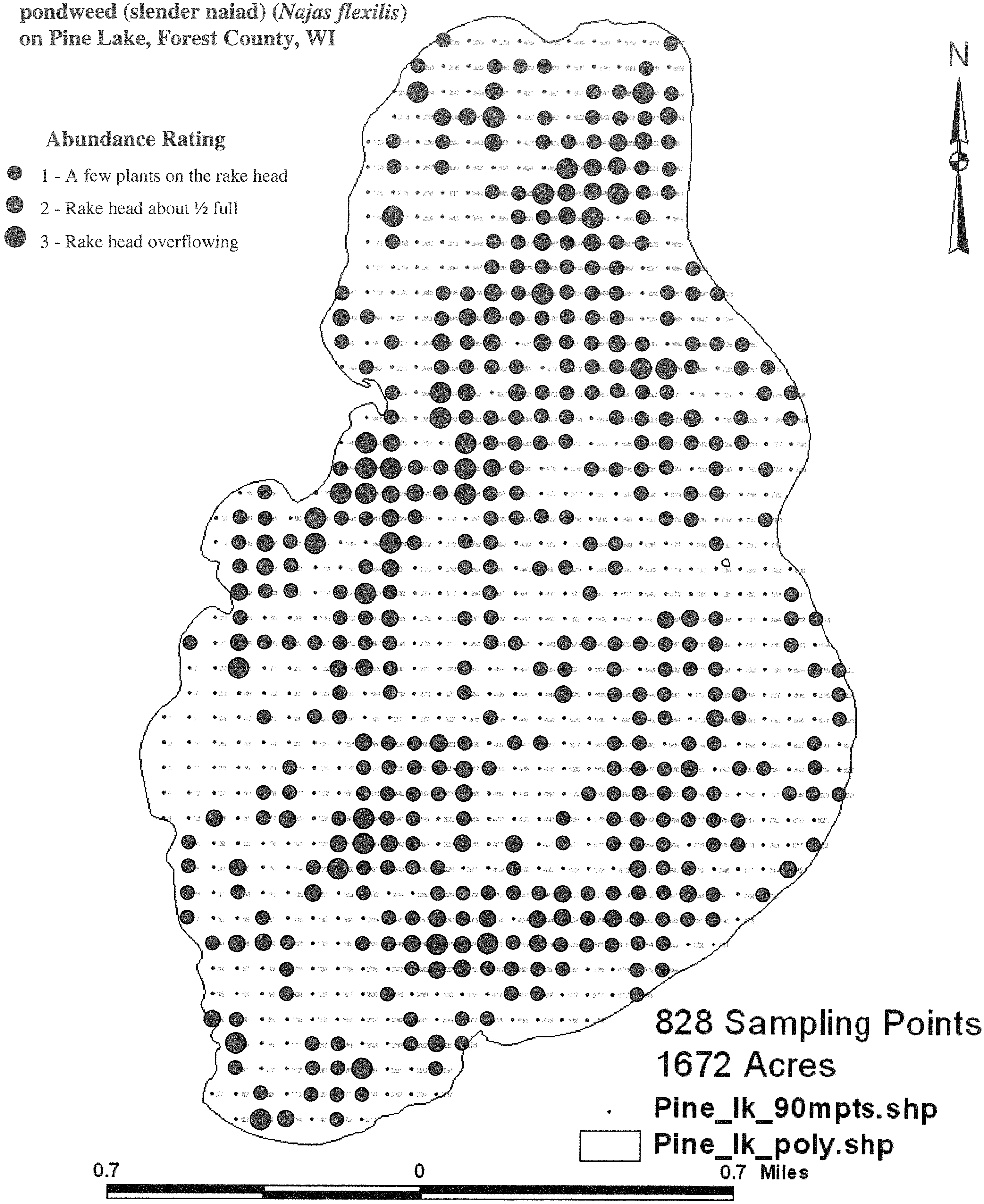


Figure 8. 2006 Distribution of Robbins (fern) pondweed (*Potamogeton robbinsii*) on Pine Lake, Forest County, WI

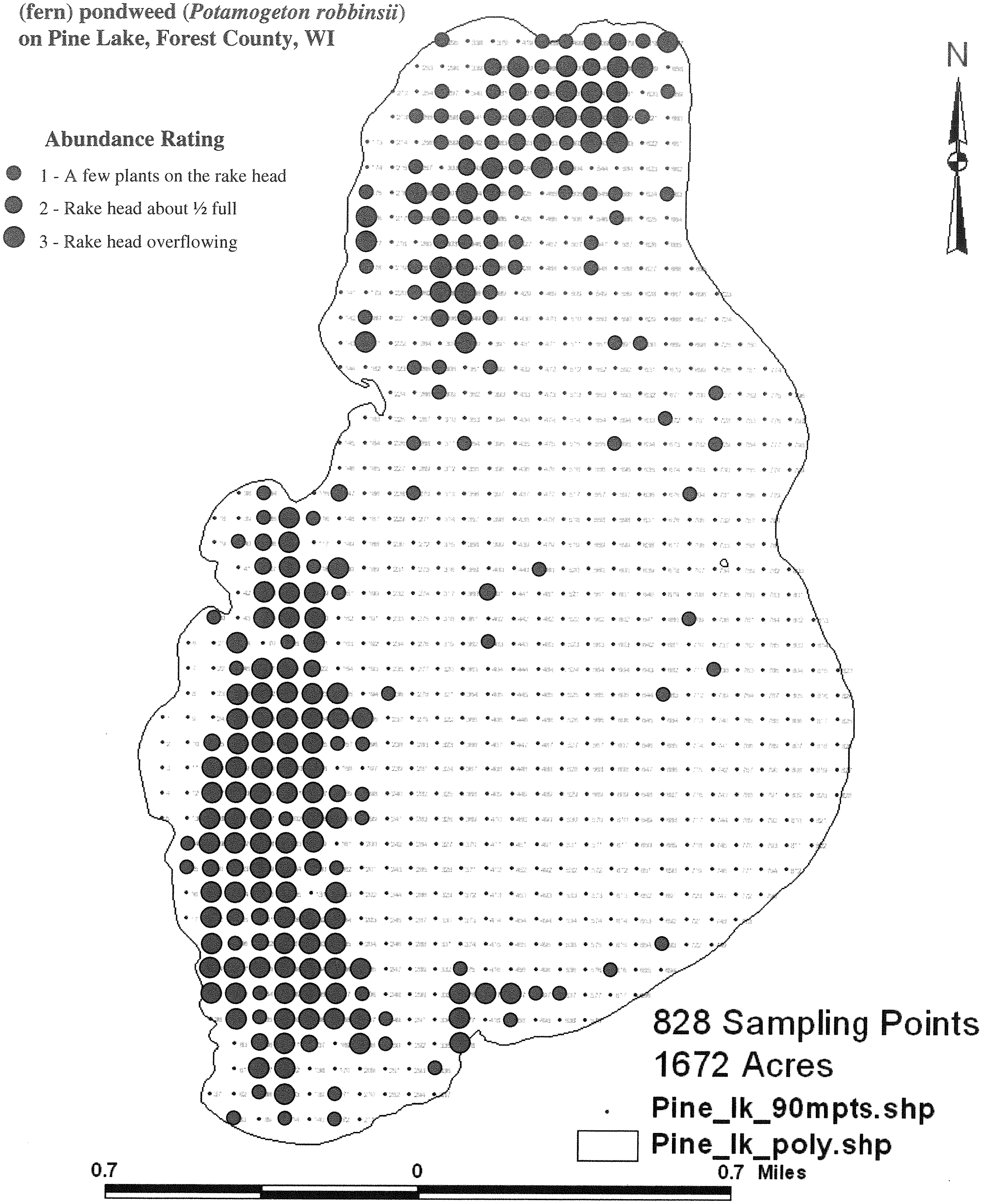


Figure 9. 2006 Distribution of common waterweed (*Elodea canadensis*) on Pine Lake, Forest County, WI

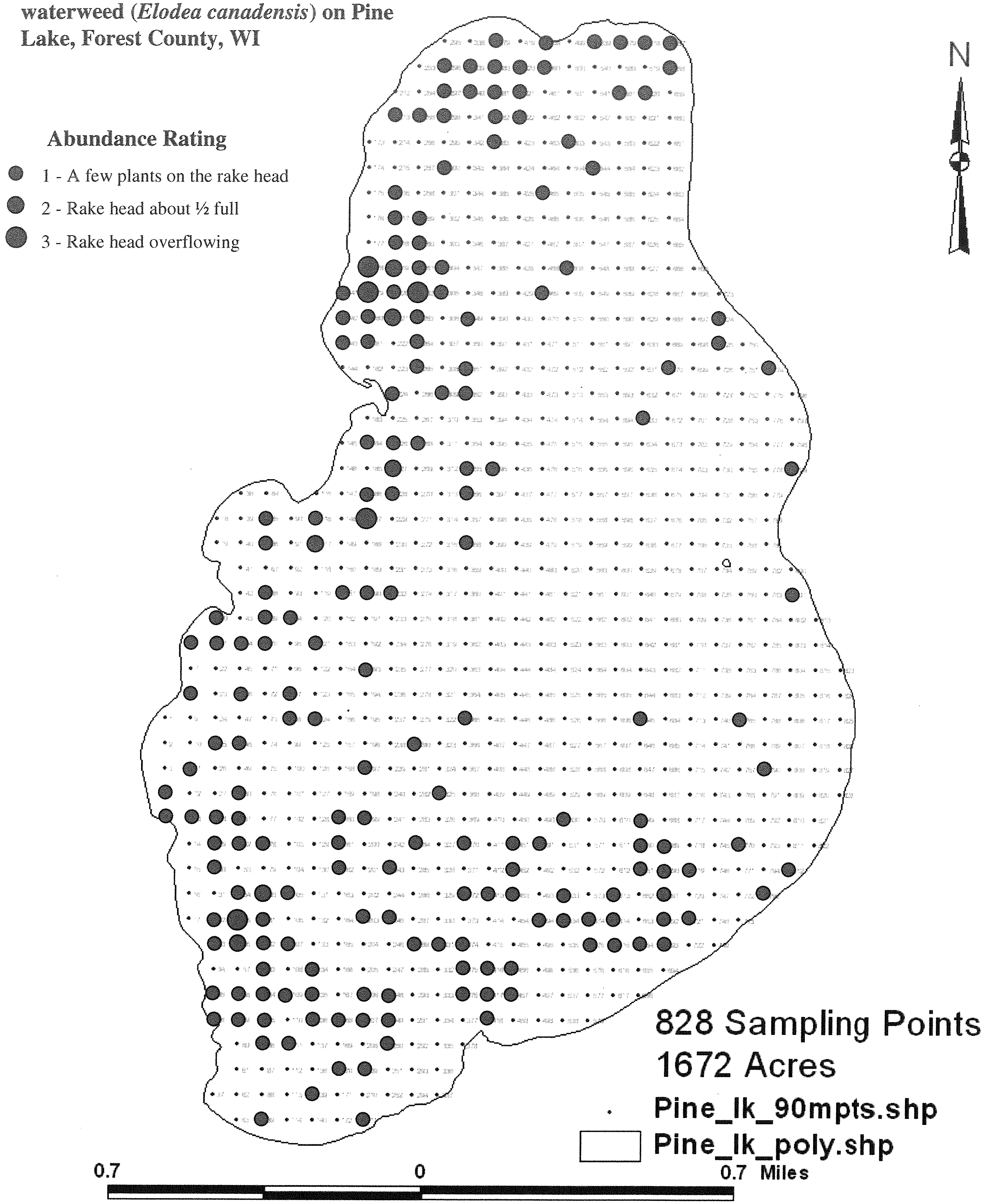


Figure 10. 2006 Distribution of hybrid milfoil (*Myriophyllum spicatum x M. sibiricum*) on Pine Lake, Forest County, WI

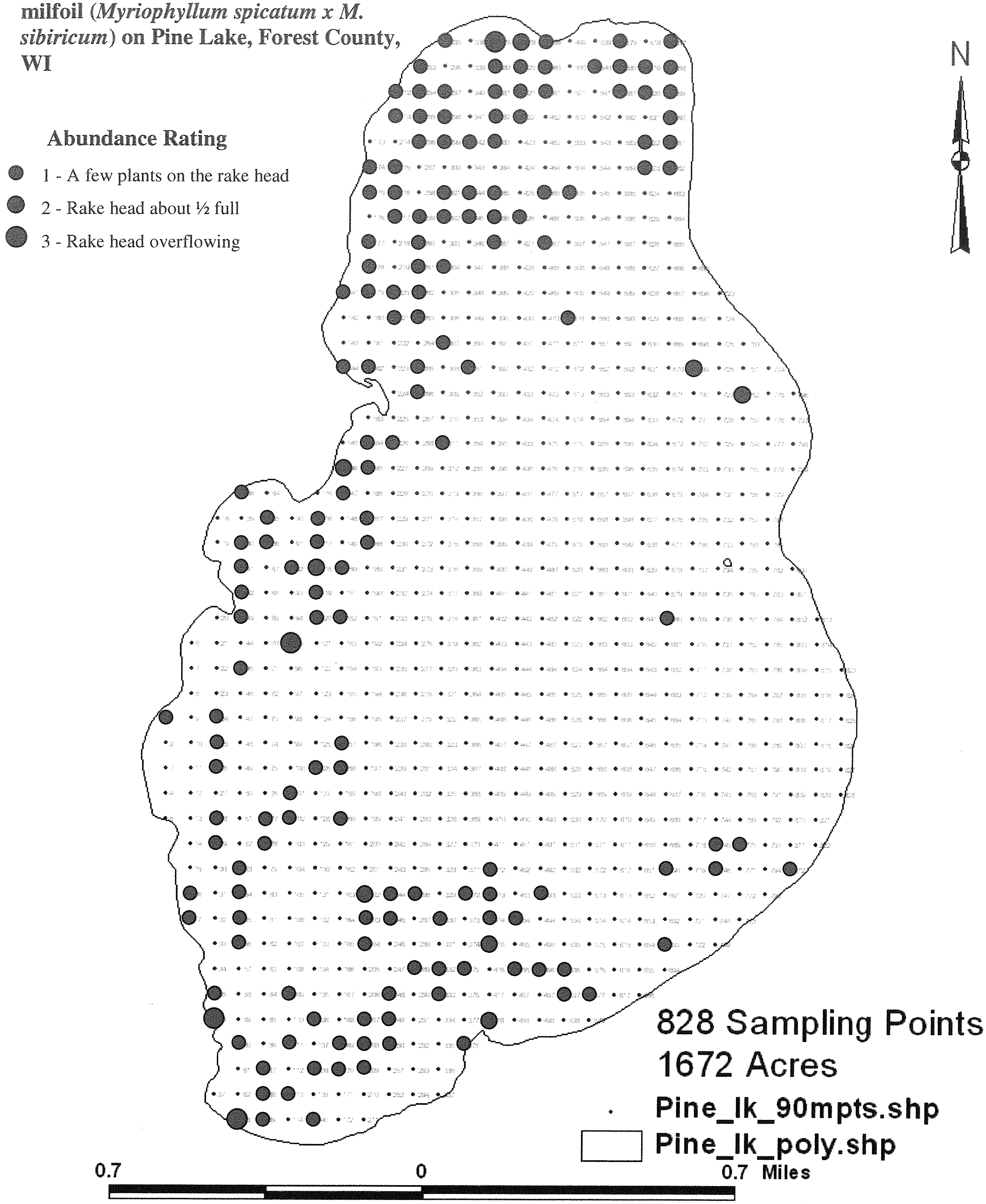
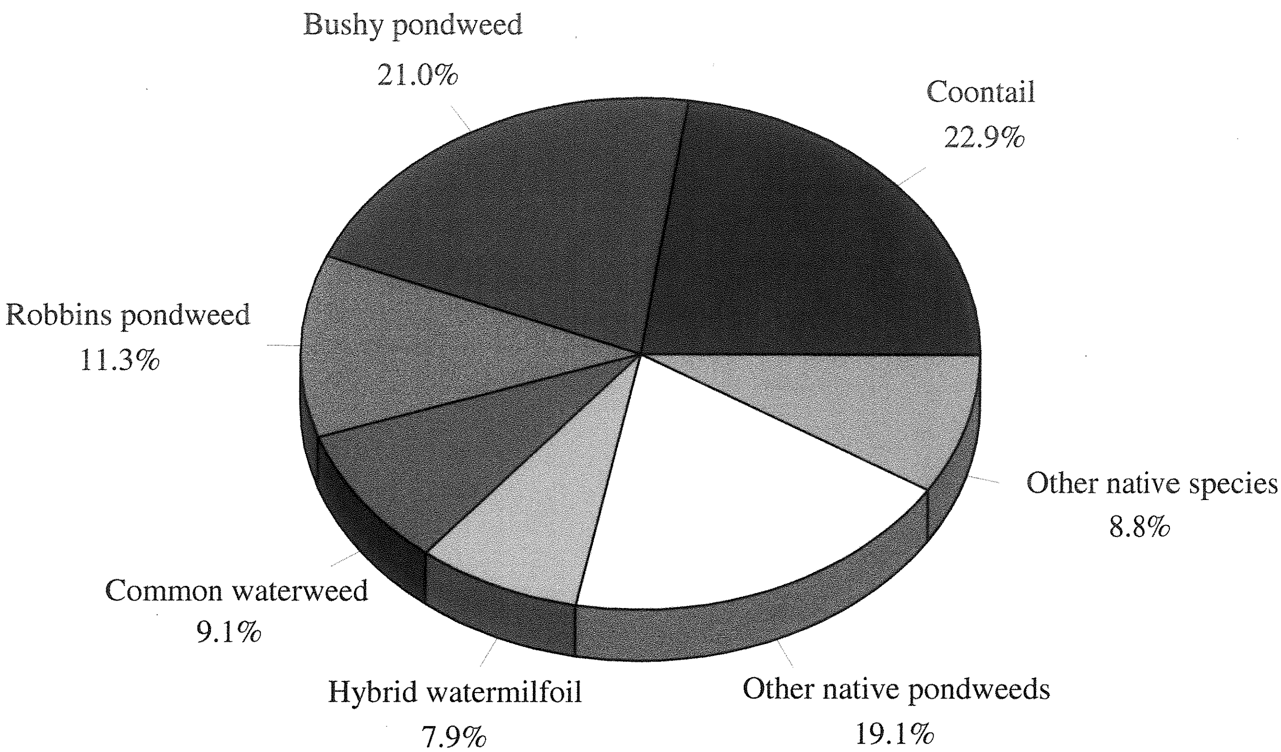


Figure 11. Submergent aquatic plant community composition for Pine Lake, Forest County, July 2006.



Simpson Diversity Index

In order to estimate the diversity of the aquatic plant community, the Simpson Diversity Index takes in account both the number of species identified (richness) and the distribution or relative abundance of each species. As these parameters increase, so does the overall diversity. With the Simpson Diversity Index (D), 1 represents infinite diversity and 0, no diversity. That is, the bigger the value of D, the higher the diversity. The value of D calculated for Pine Lake based on the 2006 data was 0.87.

Assessment of Floristic Quality

The plant data collect for Pine Lake were used to assess the "floristic quality" of the lake. The method used assigns a value to each native plant species called a Coefficient of Conservatism. Coefficient values range from 0 -10 and reflect a particular species' likelihood of occurring in a relatively undisturbed landscape. Species with low coefficient values, such as coontail, are likely to be found in a variety of habitat types and can tolerate high levels of human disturbance. On the other hand, species with higher coefficient values, such as pickerelweed, are much more likely to be restricted to high quality natural areas. By averaging the coefficient values available for the submergent and emergent species found in Pine Lake in both 2004 and 2006, a lake-wide value of 6.27 was calculated (see **Table 2**). The average value for lakes in Wisconsin is 6.0 while the average for lakes in the Northern Lakes and Forests region is 6.7 (Nichols, 1999).

Table 2. Pine Lake Floristic Quality Index (FQI) analysis table.

Species	Common Name	C
Brasenia schreberi	Watershield	7
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Eleocharis palustris	Creeping spikerush	6
Lemna trisulca	Forked Duckweed	6
Megalodonta beckii	Water marigold	8
Najas flexilis	Bushy pondweed	6
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Schoenoplectus tabernaemontani	Softstem bulrush	4
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
	N	22
	mean C	6.27
	FQI	29.4

By utilizing the Coefficients of Conservatism for the plant species of Pine Lake, further assessment of floristic quality can be made. By multiplying the average coefficient values for Pine Lake by the square root of the number of plant species found, a Floristic Quality Index (FQI) was calculated at 29.4 (see **Table 2**). In general, higher FQI values reflect higher lake quality. The average for Wisconsin lakes is 22.2. The average for lakes in the Northern Lakes and Forests region is 24.3 (Nichols, 1999). Both Coefficient of Conservatism and the Floristic Quality Index values suggest the quality of Pine Lake specifically in terms of the plant community, is above average.

Aquatic plants serve an important purpose in the aquatic environment. They play an instrumental role in maintaining ecological balance in ponds, lakes, wetlands, rivers, and streams. Native aquatic plants have many values. They serve as important buffers against nutrient loading and toxic chemicals, act as filters that capture runoff-borne sediments, stabilize lakebed sediments, protect shorelines from erosion, and provide critical fish and wildlife habitat. Therefore, it is essential that the native aquatic plant community in Pine

Lake be protected. **Appendix C** provides a list of the more abundant native aquatic plant species that were found in Pine Lake. Ecological values and a description are given for each species.

Exotic Plant Distribution Mapping

Curly-leaf pondweed was not located on Pine Lake during the May or July surveys. Assuming it was properly identified in 2004, and that it still is present in Pine Lake, the occurrence is very low and is currently not posing a threat to the plant community of Pine Lake.

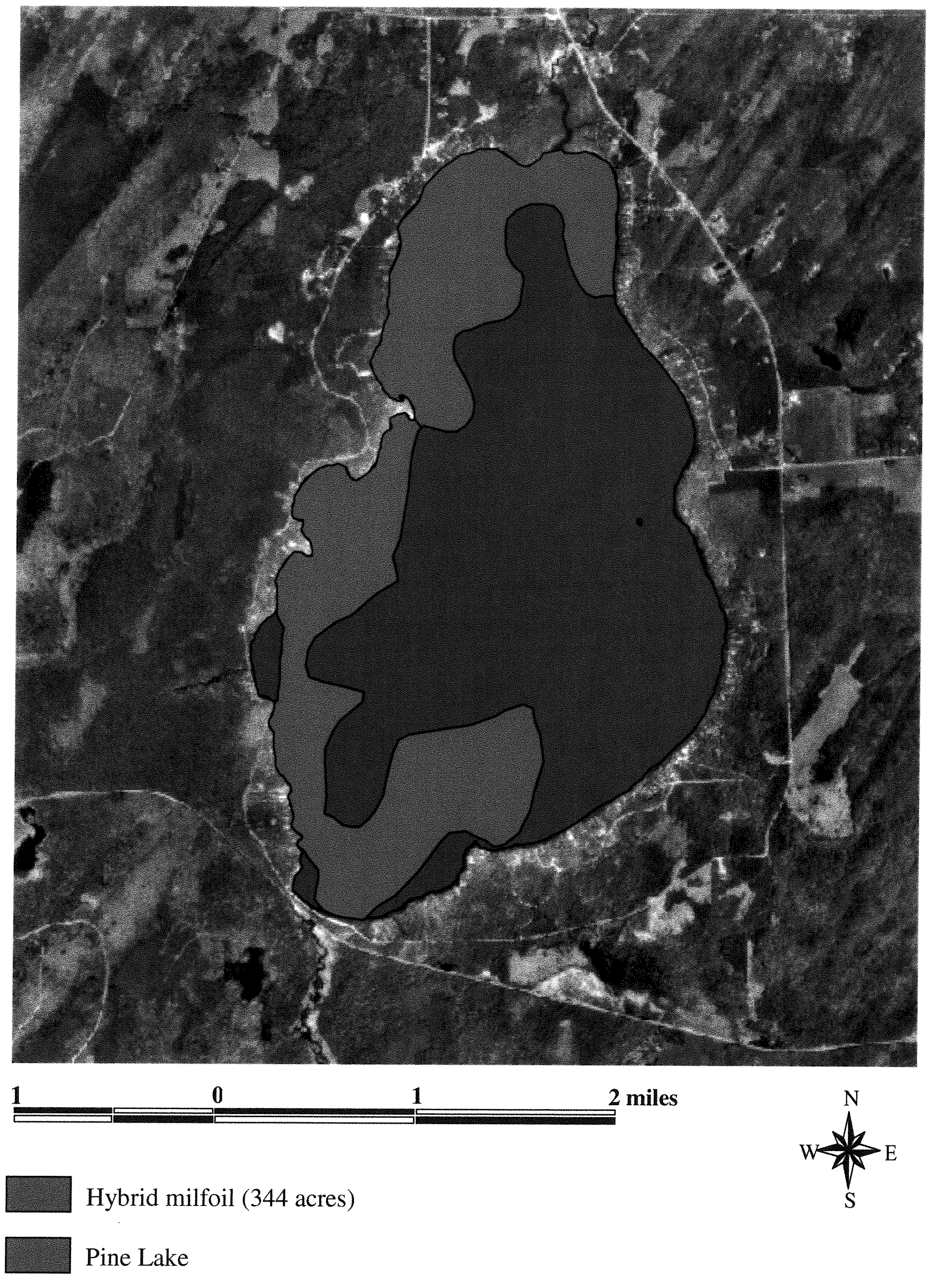
Results of the aquatic plant survey conducted in 2006 confirm that a large amount of hybrid milfoil currently infest the waters of Pine Lake. It was found at over 20% of the sampling sites. By using the information gathered during the aquatic plant survey, approximately 344 acres of milfoil were found in Pine Lake (**Figure 12**).

Wild Rice Concerns

Pine Lake lies within the 1842 ceded territories of Northern Wisconsin. The Ojibwe retain treaty rights including off-reservation hunting, fishing and gathering. The fall harvest of wild rice remains an especially important season for the Ojibwe people. By locating and reseeding current and historical wild rice beds throughout the ceded territory, biologists with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) are striving to improve wild rice abundance.

As was previously stated, every three years, the water level in the Hiles Millpond is lowered for wild rice and waterfowl management. However, wild rice is not believed to be located currently on Pine Lake. It was not identified during the 2006 plant survey. And according to Peter David of it is not listed as a lake with an existing population of wild rice. However, it is unclear if historically Pine Lake had wild rice. If it is determined that Pine Lake was once a wild rice lake, and effort are undertaken to plant or restore wild rice, it may have an impact on future aquatic plant management in Pine Lake. This impact would likely be in regards to shoreline plant management efforts near existing wild rice beds.

Figure 12. Distribution of hybrid milfoil (*Myriophyllum spicatum x M. sibericum*) in Pine Lake, Forest County, Wisconsin on July 16, 2006.



Water Quality Analysis

Data available for multiple water chemistry and water clarity parameters from the volunteer Self-Help Lake Monitoring program can be found in **Appendices D and E**, respectively.

Dissolved Oxygen and Temperature

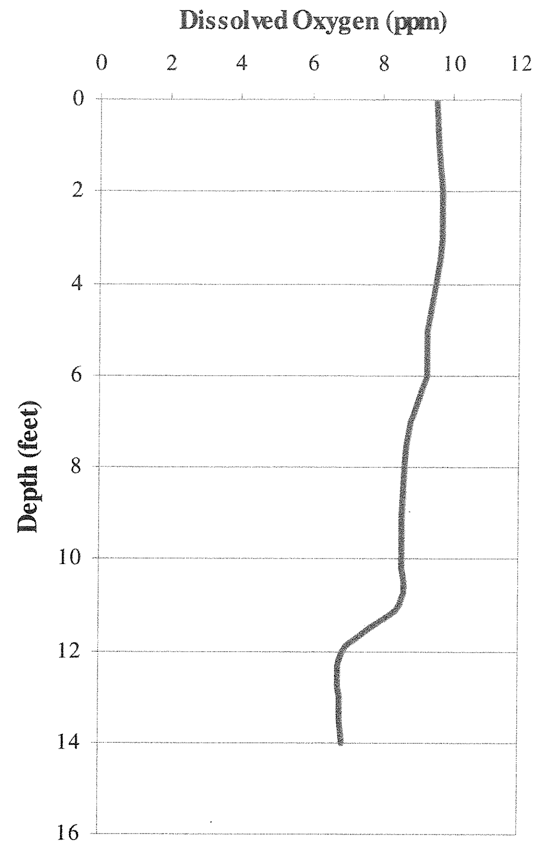
Dissolved oxygen, temperature, and percent saturation data collected for Pine Lake on August 22, 2006 are presented in **Table 3**. These data were used to develop the profile graphs shown in **Figure 13**. The profiles show that during one of the warmest parts of the year, Pine Lake had oxygen from surface to sediment. Oxygen depletion (anoxia) can occur in late summer in relatively shallow, productive lakes, with dense aquatic plant growth. The threshold level of oxygen needed for fish such as bass, perch, and sunfish to survive and grow is 5 mg/L (Shaw, et al. 2004). **Figure 8** shows that dissolved oxygen levels in Pine Lake were above this concentration as well.

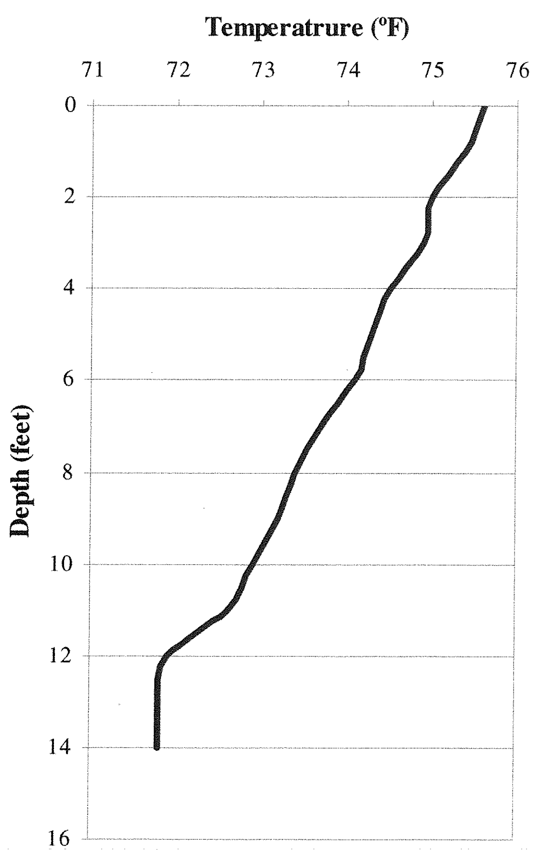
Table 3. Dissolved oxygen and temperature data collected on August 22, 2006 from Pine Lake, Forest County.

Depth (ft)	August 22, 2006 Temp (°F)	D.O. (mg/l)	% Sat.
0	75.6	9.52	120.6
1	75.4	9.60	121.1
2	75.0	9.71	122.0
3	74.9	9.69	121.3
4	74.5	9.56	119.3
5	74.3	9.31	116.1
6	74.1	9.29	115.6
7	73.7	8.83	109.4
8	73.4	8.68	107.2
9	73.2	8.60	105.9
10	72.9	8.61	105.9
11	72.6	8.55	104.3
12	71.9	6.92	84.1
13	71.8	6.86	83.3
14	71.8	6.88	83.5

In addition **Figure 14** indicates that dissolved oxygen levels taken near the surface and the bottom of Pine Lake over the past six years were very often at or above this 5 mg/l threshold. Additional dissolved oxygen data for this time period can be found in **Appendix D**. This includes winter monitoring data collected by the DNR in 1996, 1997, 2001, and 2004. These data indicate that during the coldest times of the year, Pine Lake has experienced some oxygen depletion at depths greater than 3 feet. However, at shallower depths, the oxygen levels for the data sets available remained above the 5 mg/L threshold. These data do indicate that the potential for winter fish kills exist. This is not surprising for a shallow lake with dense aquatic plant growth.

Figure 13. **Profiles of dissolved oxygen, temperature, and percent saturation for Pine Lake, Forest County, on August 22, 2006.**





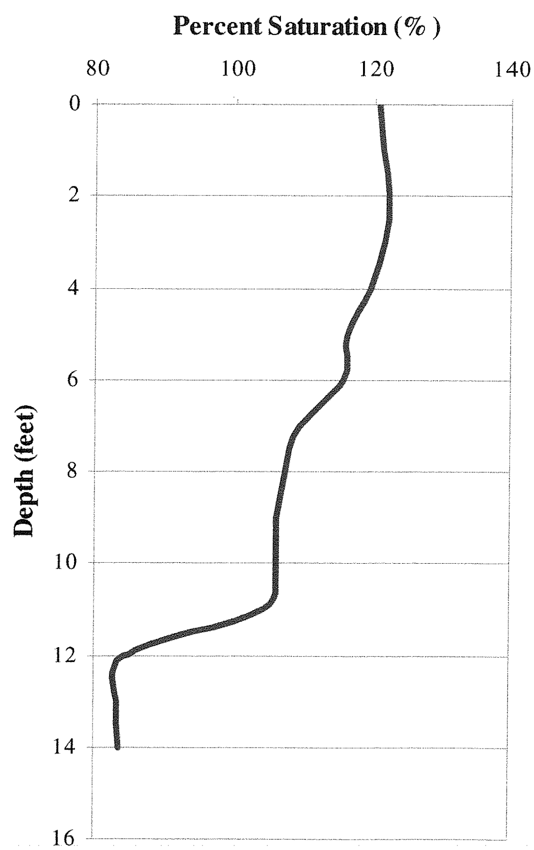
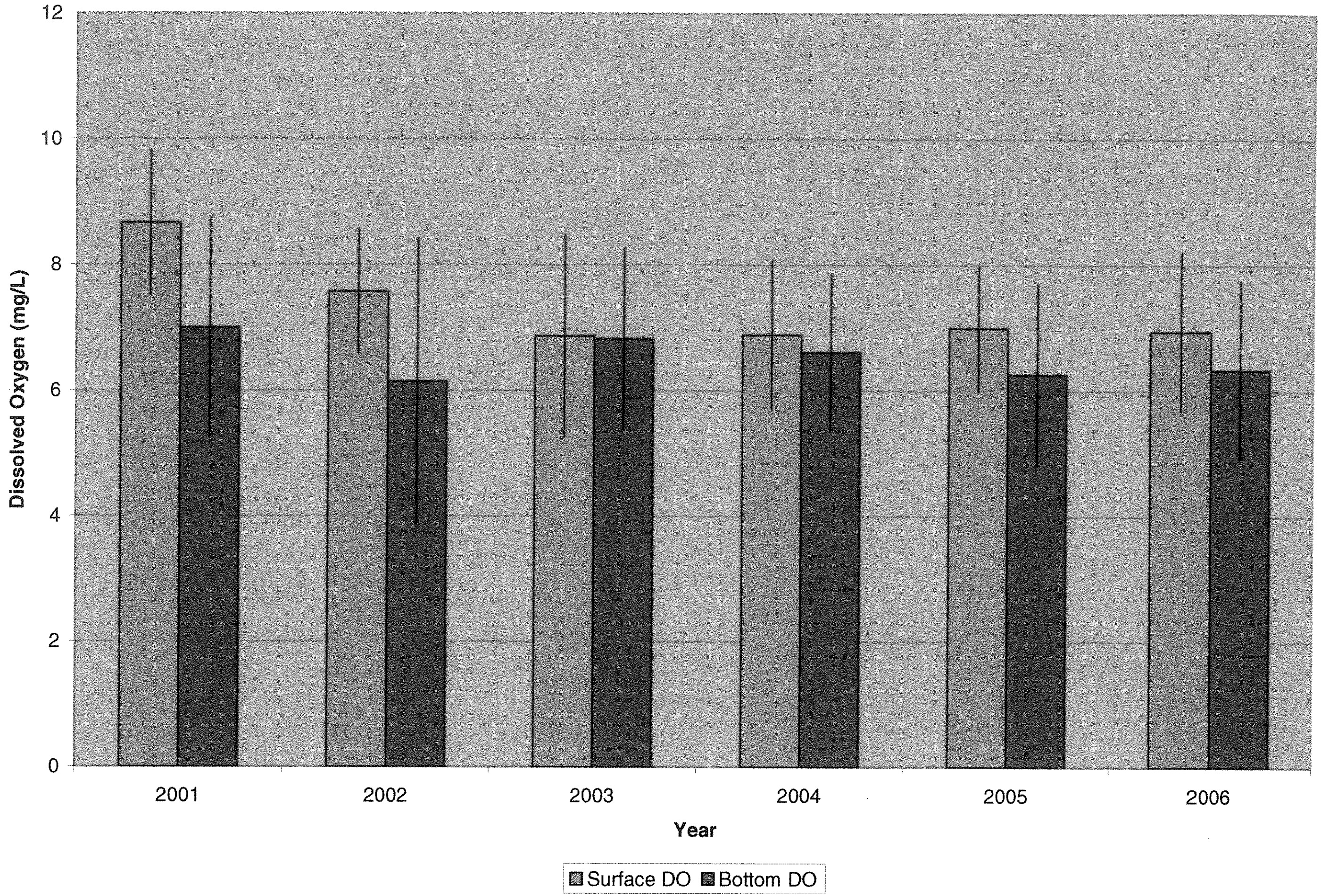


Figure 14. Average seasonal dissolved oxygen concentrations measured at 3-ft (surface) and 15-ft (bottom) in depth from 2001 through 2006 for Pine Lake, Forest County, Wisconsin.



To better understand the dissolved oxygen data, it is important to first understand the relationship between dissolved oxygen and temperature. As a rule, colder water can hold more oxygen than warmer water. **Table 4** illustrates this point. By utilizing this relationship, the level (or percent) of saturation of oxygen can be determined at a given temperature. Saturation levels from sampling at Pine Lake can be found in **Figure 13**. A number of the readings

Table 4. Oxygen solubility in water at different temperatures.

Temperature °C	°F	Oxygen solubility (mg/L)
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8

taken throughout the year appear to exceed the oxygen solubility given in **Table 4**. For these data the dissolved oxygen levels were higher than solubility levels at the corresponding temperatures. As a result, the percent saturation levels recorded in the field were quite high. Under warm sunny conditions in particular, oxygen levels in the lake can rise above 100%. This is a condition referred to as supersaturation and is due to conditions in the lakes such as wind and wave action as well as biological processes. Percent saturation values of 80-120% are considered to be excellent and values less than 60% or over 125% are considered to be poor. With a few exceptions the saturation levels in the upper portions of Pine Lake were indicative of excellent water quality.

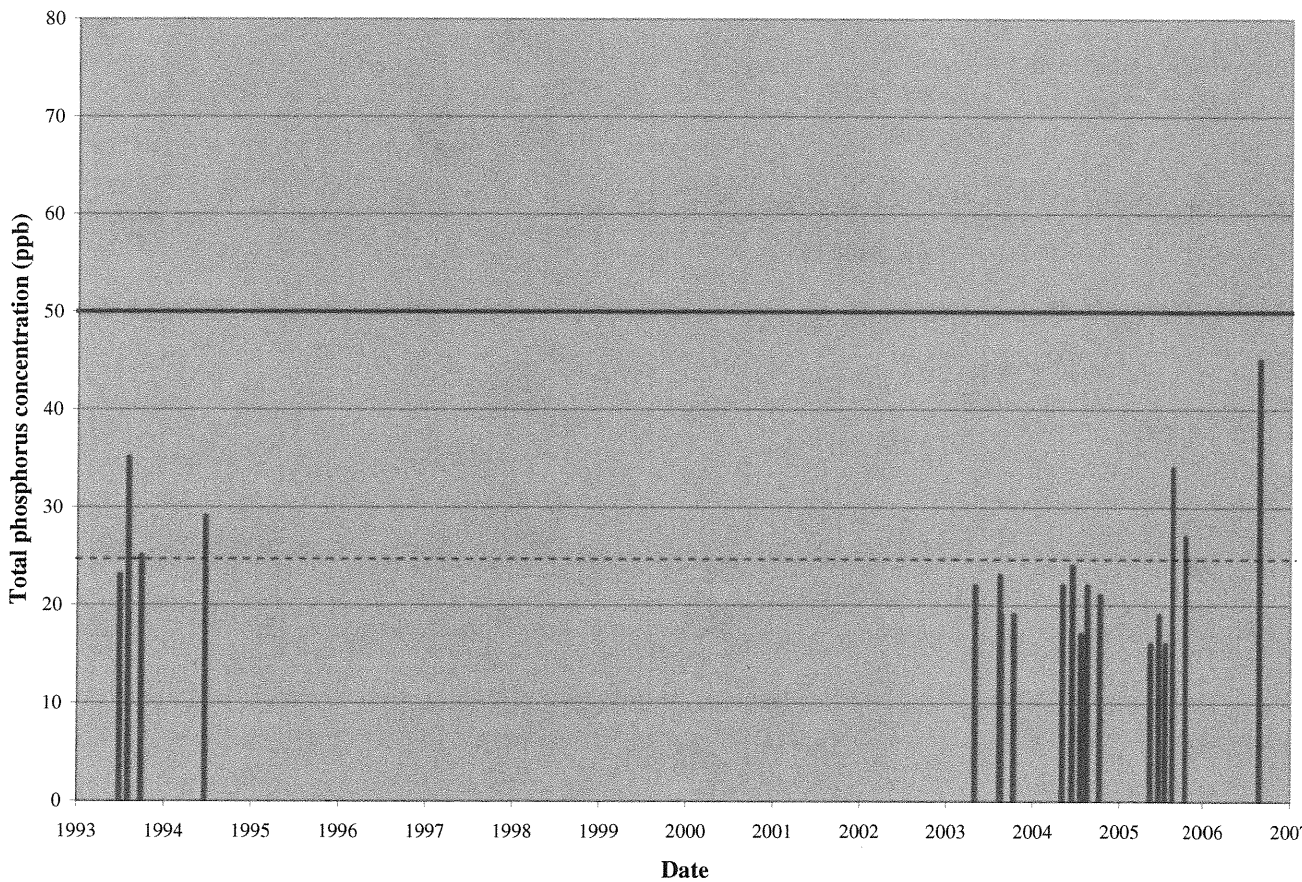
In lakes with high levels of plants and algae, large amounts of oxygen can be produced through photosynthesis. During the night when photosynthesis ceases and respiration takes over, oxygen levels can drop off significantly. Through respiration, oxygen is consumed leaving depleted levels in the lake. These wide fluctuations can be particularly stressful to many fish and invertebrate species. The dissolved oxygen data available for the past six years for Pine Lake suggest oxygen levels do not fluctuate greatly on a daily basis.

Phosphorus

Total phosphorus is one of the most important water quality indicators. Phosphorus levels determine the amount of plant and algae growth in a lake. Phosphorus can come from external sources within the watershed (fertilizers, livestock, septic systems) or to a lesser extent, from groundwater. Phosphorus can also come from within the lake. Internal loading occurs when plants and chemical reactions release phosphorus from the lake sediments into the water column.

The average phosphorus concentration for natural lakes in Wisconsin is 0.025 mg/L or 25 ppb (Shaw, et al, 2004). Values above 50 ppb are indicative of poor water quality. Phosphorus data available from 1993-1994 and 2003-2006 suggest phosphorus concentrations in Pine Lake were consistently below 50 ppb (**Figure 15**) over the past 15 years. Most of the data points were also below 25 ppb. In general, these data indicate good water quality for Pine Lake. The data used to produce **Figure 15** can be found in **Appendix D**.

Figure 15. Total phosphorus concentrations from 1993 through 2006 for Pine Lake, Forest County, Wisconsin.

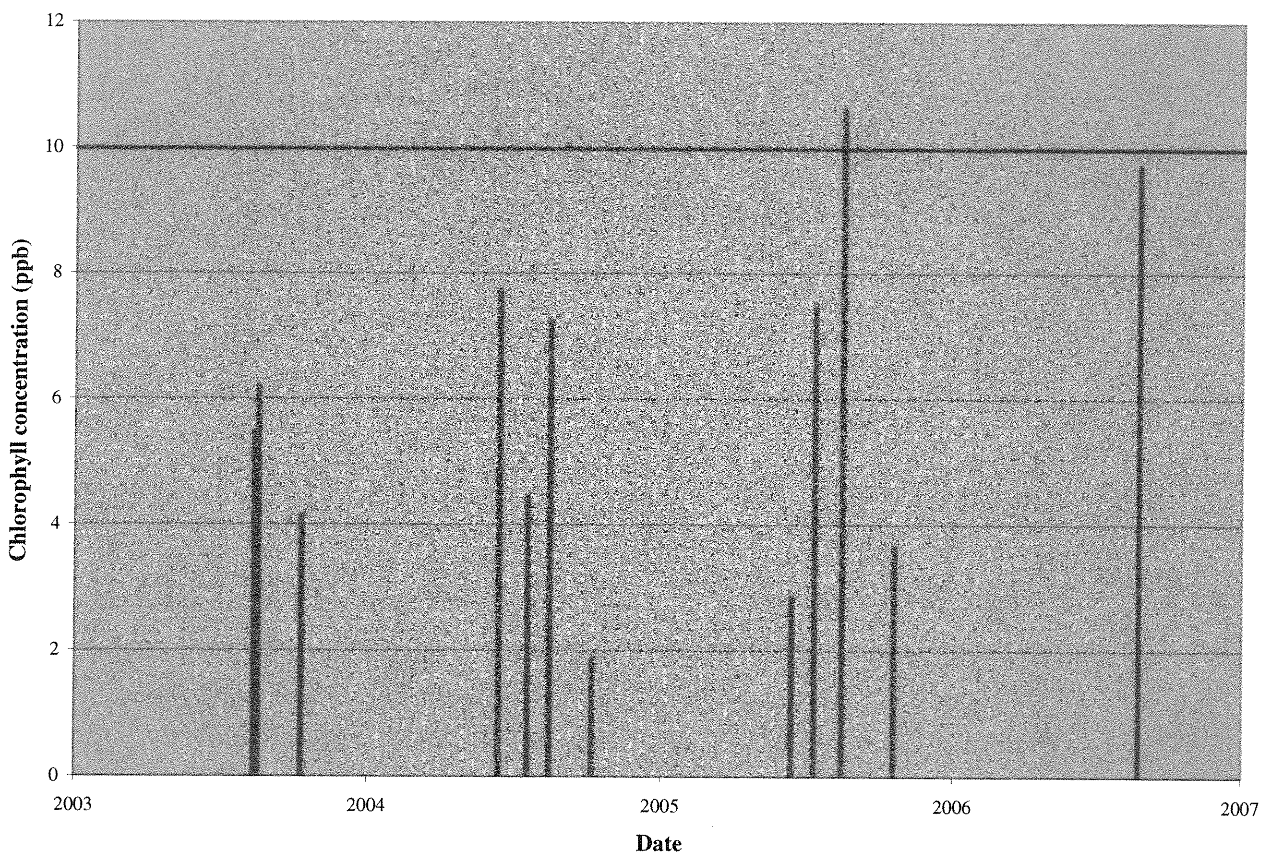


Chlorophyll

Chlorophyll is the pigment found in all green plants including algae that give them their green color. It is the site in plants where photosynthesis occurs. Chlorophyll absorbs sunlight to convert carbon dioxide and water to oxygen and sugars. Chlorophyll data is collected because this green pigment is found in algae and can be used to estimate how much phytoplankton (algae) there is in the lake. Generally speaking, the more nutrients there are in the water and the warmer the water, the higher the production of algae and consequently chlorophyll.

Chlorophyll concentrations below 10 ppb are most desirable for lakes. Data available for the past four years are shown in **Figure 16**. The highest chlorophyll concentration over this time period (10.6 ppb) was measured in August, 2005. August chlorophyll readings are often at their highest. As the season progresses, day lengths and temperatures increase which in turn encourage algal growth. Although the data in **Figure 16** show a gradual increase in chlorophyll, additional years of monitoring are needed to determine if this trend continues.

Figure 16. Chlorophyll concentrations from 2003 through 2006 for Pine Lake, Forest County, Wisconsin.



Secchi Transparency

Water clarity is often used as a quick and easy test for a lake's overall water quality, especially in relation to the amount of algae present. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible. Water clarity readings collected for Pine Lake over the past 20 years ranged between three and 17 feet in depth. All Secchi depth data are presented in **Figure 17**. **Figure 18** shows the average summer (May - September) average Secchi depth data calculated for Pine Lake since 1988. Secchi depths below six feet are generally indicative of good water quality. A majority of the readings shown in **Figure 17** were greater than six feet. However, since 2003, water clarity appears to have declined in Pine Lake. Additional years of monitoring will be needed to determine if this trend continues. All available water clarity data for Pine Lake can be found in **Appendix E**.

Figure 17. Water clarity data from 1988-1989, 1992-1994, and 2001 to present for Pine Lake, Forest County, Wisconsin.

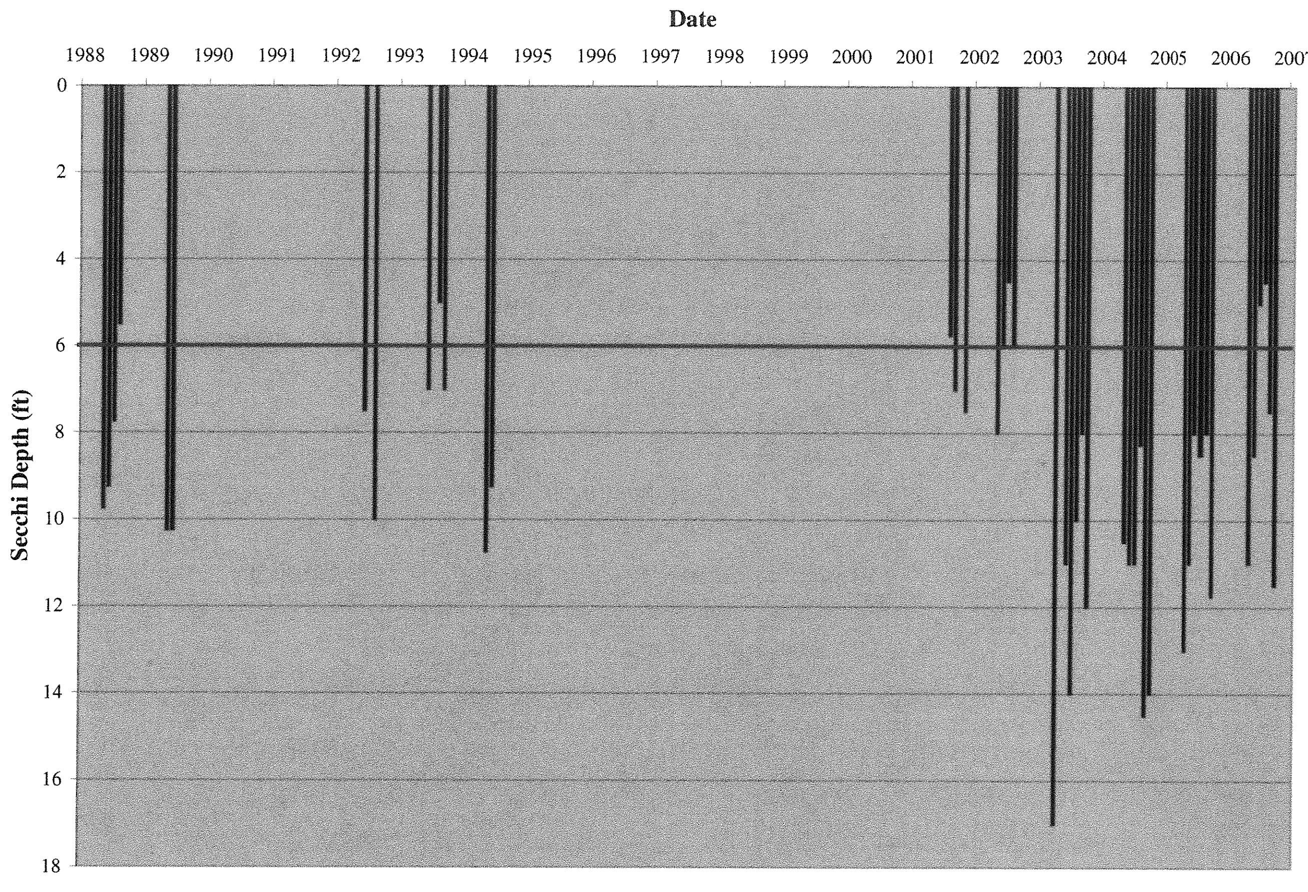
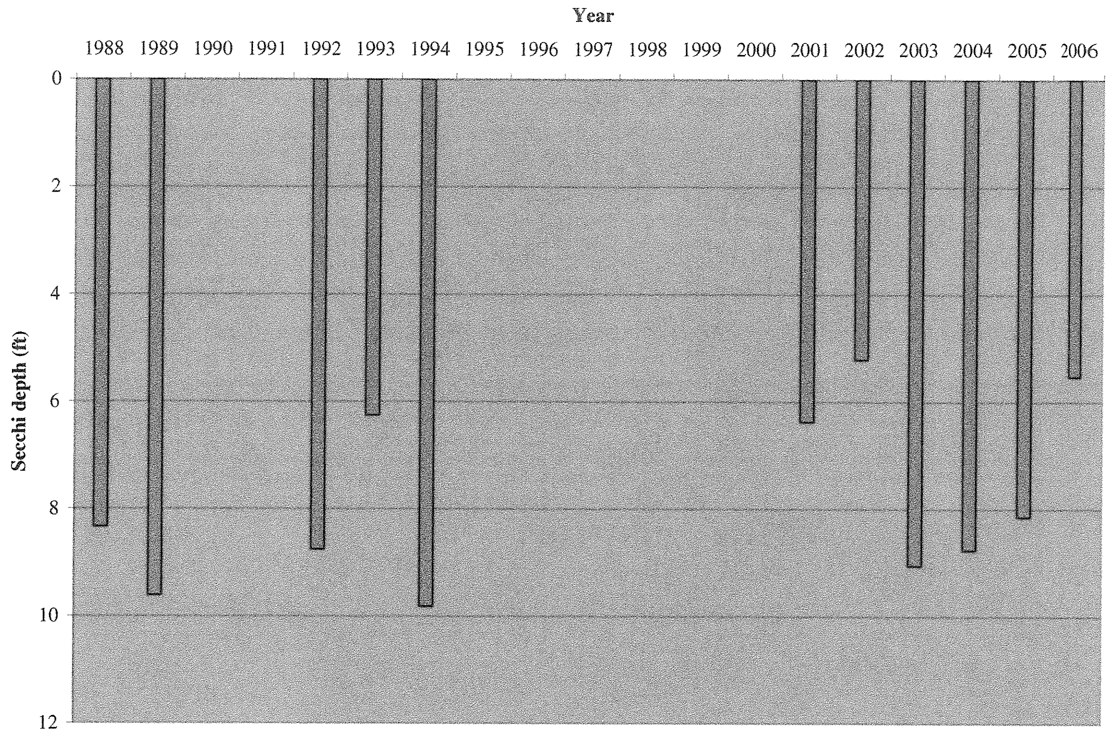


Figure 18. Average seasonal water clarity data from 1988-1989, 1992-1994, and 2001 to present for Pine Lake, Forest County, Wisconsin.



Trophic State

There is a strong relationship between levels of phosphorus and chlorophyll and water clarity in lakes. As a response to rising levels of phosphorus, chlorophyll levels increase and transparency values often decrease. The effect of this is viewed as an increase in the productivity of a lake.

Lakes can be categorized by their productivity or trophic state. When productivity is discussed, it is normally a reflection of the amount of plant and animal biomass a lake produces or has the potential to produce. The most significant and often detrimental result is elevated levels of algae and nuisance aquatic plants. Lakes can be categorized into three trophic levels:

- oligotrophic - low productivity, high water quality
- mesotrophic - medium productivity and water quality
- eutrophic - high productivity, low water quality

These trophic levels form a spectrum of water quality conditions. Oligotrophic lakes are typically deep and clear with exposed rock bottoms and limited plant growth. Eutrophic lakes are often shallow and marsh-like, typically having heavy layers of organic silt and abundant plant growth. Mesotrophic lakes are typically deeper than eutrophic lakes with significant plant growth, and areas of exposed sand, gravel or cobble bottom substrates.

Lakes can naturally become more eutrophic with time, however the trophic state of a lake is more influenced by nutrient inputs than by time. When humans negatively influence the trophic state of a lake the process is called *cultural eutrophication*. A sudden influx of available nutrients may cause a rapid change in a lake's ecology. Opportunistic plants such as algae and nuisance plant species are able to out-compete other more desirable species of macrophytes. The resultant appearance is typical of poor water quality.

Total phosphorus, chlorophyll and Secchi depth are often used as indicators of the water quality and productivity (trophic state) in lakes. Values measured for these parameters can be used to calculate Trophic State Index (TSI) values (Carlson 1977). The formulas for calculating the TSI values for Secchi disk, chlorophyll, and total phosphorus are as follows:

$$TSI = 60 - 14.41 \ln \text{Secchi disk (meters)}$$

$$TSI = 9.81 \ln \text{Chlorophyll } (\mu g/L) + 30.6$$

$$TSI = 14.42 \ln \text{Total phosphorus } (\mu g/L) + 4.15$$

The higher the TSI calculated for a lake, the more eutrophic it is (**Figure 19**). Classic eutrophic lakes have TSI values starting around 50. Secchi, chlorophyll and phosphorus data for Pine Lake were used to calculate TSI values for the past 18 years. Most of the TSI values calculated from the Pine Lake water quality data (**Appendix F**) were between 45 and 55. **Figure 20** presents the average summer (May-September) TSI values calculated for Pine Lake since 1988. These data indicate that Pine Lake exhibits characteristics of a lake near the boundary between a mesotrophic and eutrophic lake.

Figure 19. Relationship between trophic state in lakes and parameters including Secchi transparency, chlorophyll, and total phosphorus.

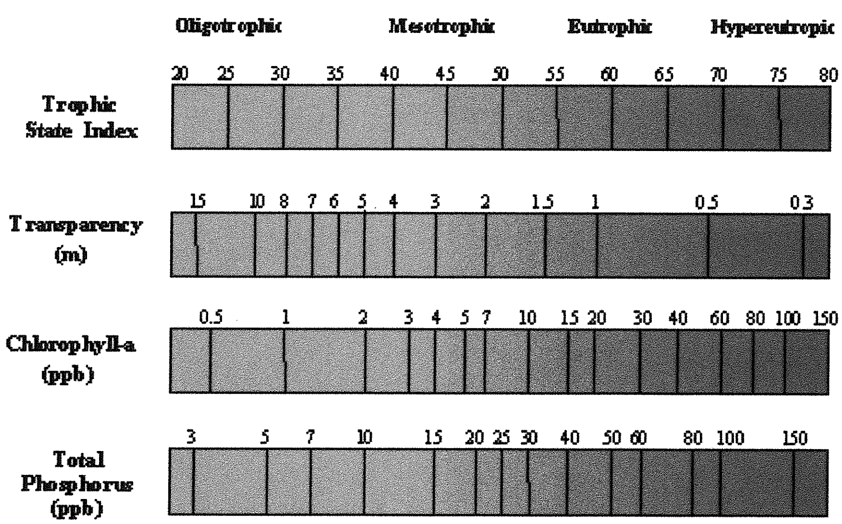
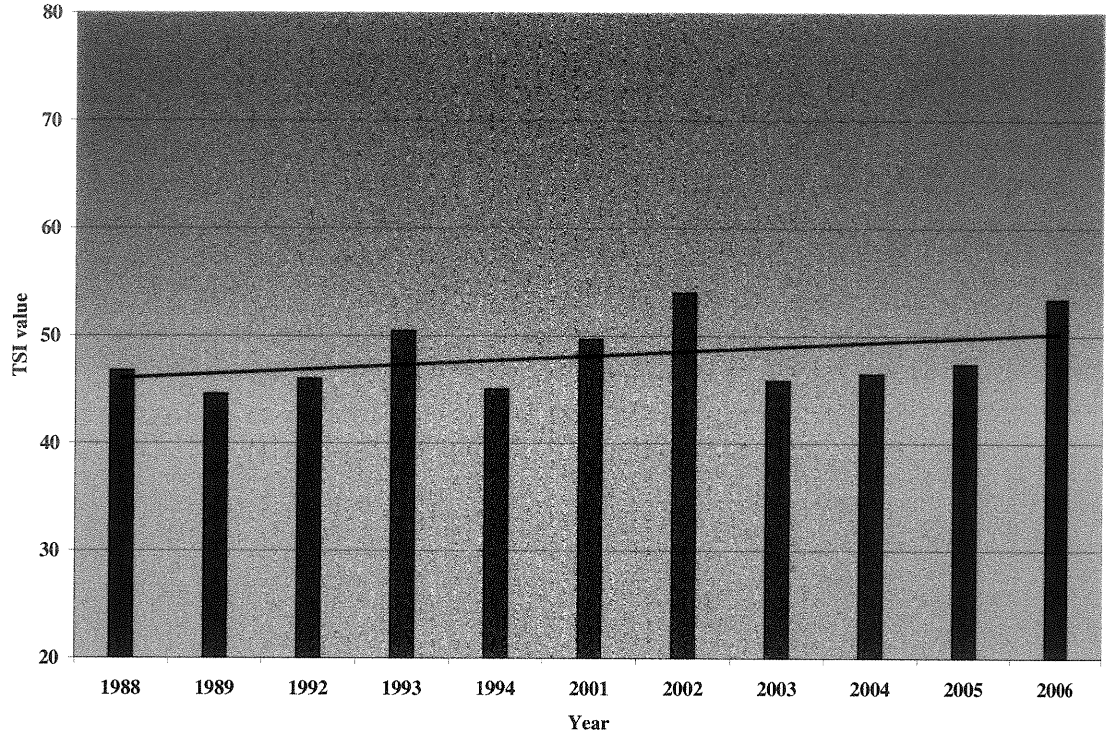


Figure 20. Average seasonal Trophic State Index values calculated for Pine Lake, Forest County, Wisconsin from 1988 through 2006.



Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) can be used to predict the trophic state of a lake given its size, watershed area, mean depth and ecoregion. Comparisons were made between the predicted TSI values and those calculated from the phosphorus, chlorophyll and Secchi data for the August sampling. The observed or measured values for these parameters were found to be slightly higher than those predicted by the WiLMS software. In other words, water quality of Pine Lake is slightly less than expected or, in other words, below the average value for the Northern Lakes and Forest Ecoregion.

Nitrogen

Nitrogen is an important nutrient for plants and algae. It can exist in a number of forms in aquatic systems. Samples collected from Pine Lake In August 2006 were tested for nitrates and nitrites which can be readily used by plants and algae. Water naturally contains less than 1 ppm of nitrogen. Results found undetectable levels of these forms of nitrogen (limit of detection = 0.025 ppm). If the concentration of nitrogen compounds exceeds 0.3 ppm, as it did in August of 2003 (0.36 ppm total nitrogen), there is sufficient nitrogen present to support algal blooms and negatively affect water quality. No other historic nitrogen data for Pine Lake could be found.

pH

pH is a measure of a lake's acid level. It is the negative log of the hydrogen ion concentration in the water. Many factors influence pH including geology, productivity, pollution, etc. pH levels between 7 and 9 are not uncommon for lakes in Wisconsin. The pH level for Pine Lake measured in August 2006 was 8.25. This does not raise concern over water quality in the lake.

Watershed Analysis

In August 2006, the watershed analysis was conducted. **Figures 21 and 22** show the delineation of the Pine Lake watershed and the land use types present. The data for the land use map (**Figure 22**) was provided by the WDNR's Bureau of Technology Services. It should be noted that the resolution of the image is not high enough to include such features as near-shore development. Impacts from shoreline properties *can* have a large impact on the water quality of a lake. This can be particularly significant for lakes with low agricultural cover in the watershed.

The survey and resulting analysis found that the watershed of Pine Lake is approximately 10.4 square miles. This area includes the waters of Pine Lake, the Town of Hiles, the Hiles Millpond and the surrounding forests and wetlands within the Nicolet National Forest.

Table 5 contains a breakdown of land use and cover types within the watershed of Pine Lake. Not surprisingly, the watershed as a whole is dominated (over half) by coniferous and deciduous forests. In addition, 40% of the watershed is wetland. The agricultural areas of the watershed (3.9%) are concentrated to the east and northwest of Pine Lake and are primarily hay, alfalfa, and fallow fields.

Table 5. Land use and cover types found within the watershed of Pine Lake, Forest County, Wisconsin.

Land Type	% cover
Forest (coniferous/deciduous)	52.1
Wetland (forested/wet meadow)	40.0
Agriculture (general/row crops)	3.9
Surface Water (not including Pine Lake)	2.3
Barren	1.3
Shrubland	0.2
Urban (Town of Hiles)	0.2
	100

Figure 21. Watershed of Pine Lake, Forest County, Wisconsin.

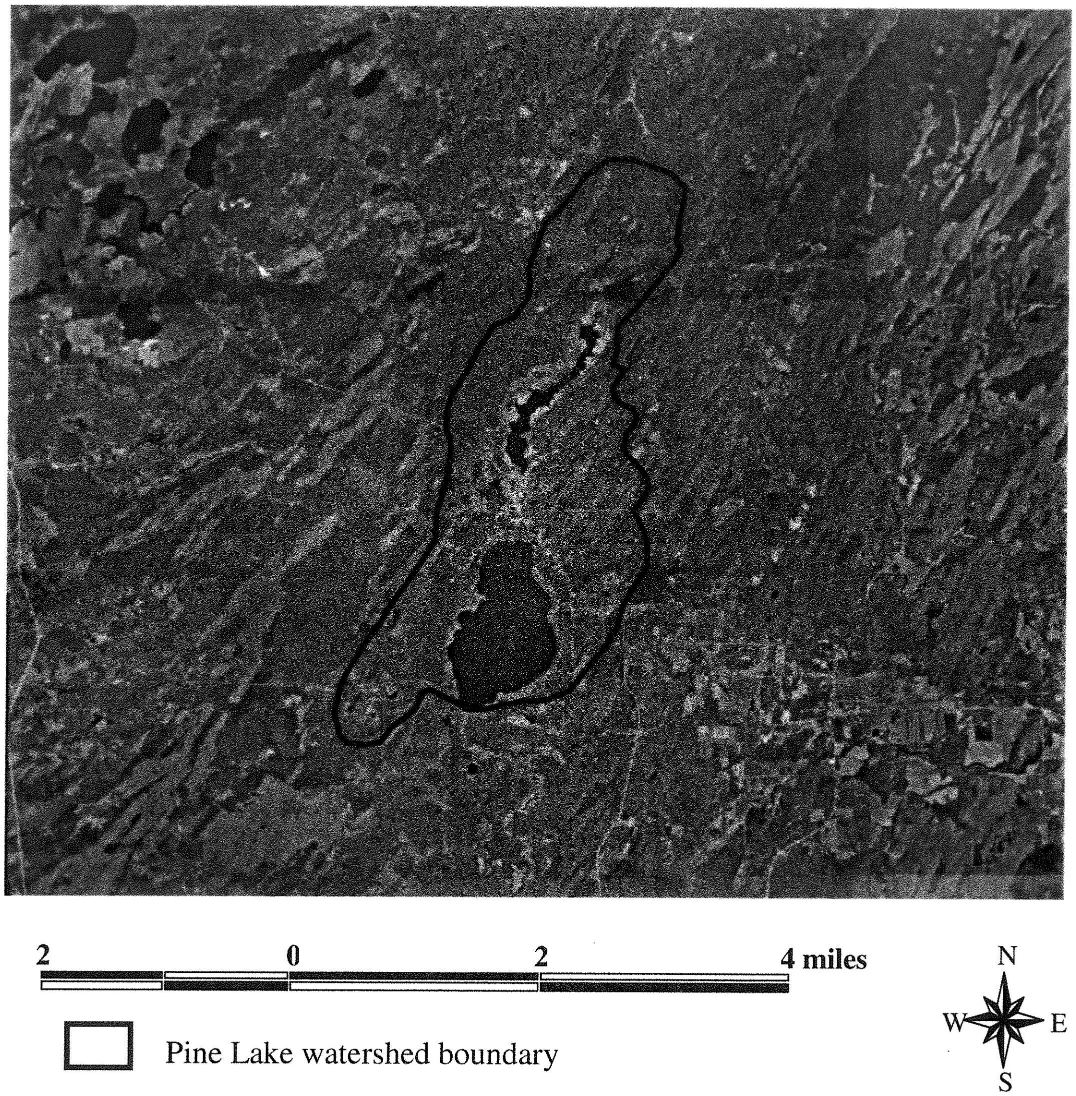
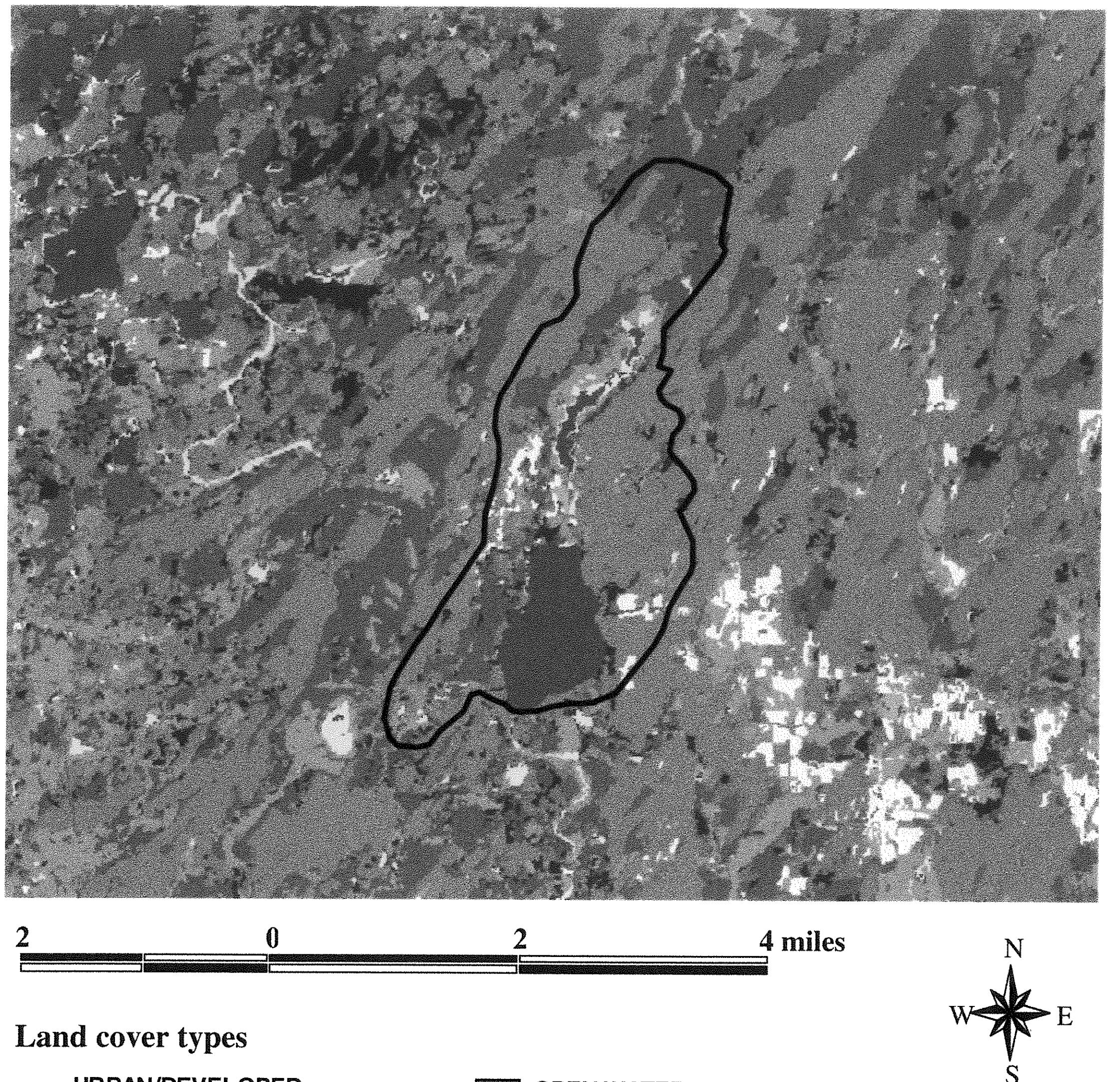


Figure 22. Land cover types and watershed delineation for Pine Lake, Forest County, Wisconsin.



Land cover types

URBAN/DEVELOPED
- High Intensity
- Low Intensity
- Golf Course

AGRICULTURE
- General Agriculture
- Herbaceous/Field Crops
- Cranberry Bog

GRASSLAND

FOREST
- Coniferous
- Broad-leaved Deciduous
- Mixed Deciduous/Conferous

OPEN WATER

WETLAND
- Emergent/Wet Meadow
- Lowland Shrub
- Forested

BARREN

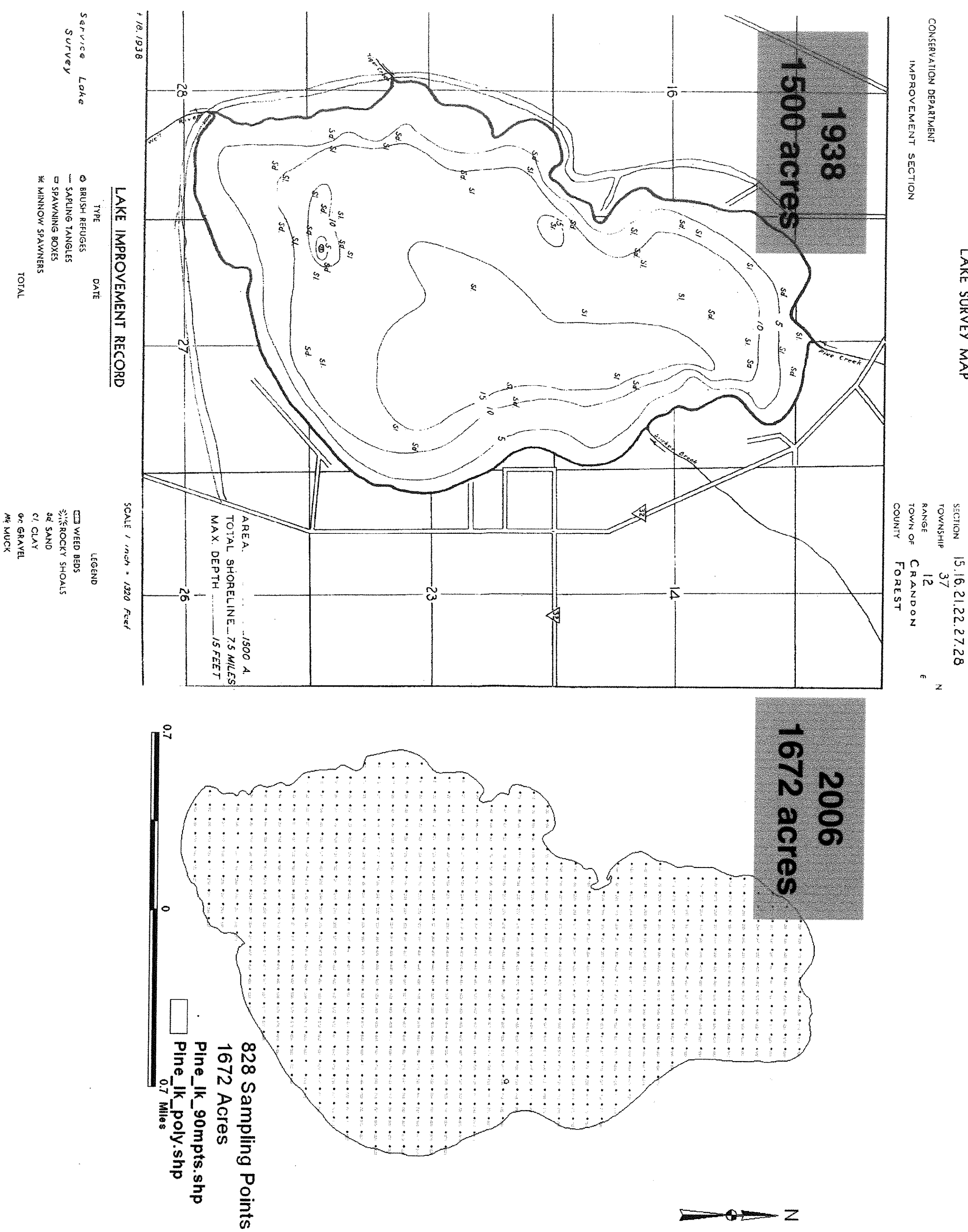
SHRUBLAND

CLOUD COVER

Pine Lake watershed boundary

During the watershed assessment, no obvious signs of runoff or erosion were found in the outlying areas. While much of the shore of Pine Lake has a high concentration of homes, areas of significant erosion were not evident near shore either. However, District members have noted that the shoreline of Pine Lake has expanded over the past 50 years or so. Individuals have noted that roads once existed very near the shore of Pine Lake. The locations are now within the lake. In addition, there are a number of areas along the shoreline of the lake which have steep slopes or exposed shorelines. A comparison of maps of Pine Lake from 1938 to present supports this observation. **Figure 23** illustrates this point. In 1938 Pine Lake was reportedly 1500 acres. However, the plant survey map provided in 2006 by the WDNR reports the lake area to be 1672 acres. Assuming the acreage estimation in 1938 was accurate the lake has since grown by approximately 172 acres. Human activity can contribute to shoreline erosion. An increase in development translates to increases in the number of lawns, driveways and other hard surfaces which are known to contribute nutrients and sediments to a lake. Often it is those areas closest to the lakes which have the greatest influence on water quality.

Figure 23. Maps of Pine Lake, Forest County, from 1938 and 2006.



The soils found in the Pine Lake watershed are dominated by loam soils (57.8 % loam, silty loam, or sandy loam) and muck soils (37.4%) (**Table 6**). The remaining soil types are sandy soils and peat. Loamy soils are comprised of relatively even amounts of the three main mineral soil components: sand, silt, and clay. Loams are gritty soils, which are pliable when wet and which retain water easily. Where slopes allow, these soils also drain well. In general these soils contain more nutrients than sandy or clay soils. Silty loam soils are less gritty than loam soils and have a higher concentration of organic matter and subsequently are higher in nutrient content. Oppositely, sandy loam soils are grittier than loam soils and have a lower concentration of organic matter and are lower in nutrient content. Muck soils are highly organic, poorly drained (wet or hydric) soils and are indicative of wetland areas. Sandy soils are well-drained soils with little water holding capacity.

Table 6. Soil types within the watershed of Pine Lake, Forest County, Wisconsin.

Map Unit Symbol	Map Unit Name	Percent of AOI
Lu	Lupton, Cathro, and Markey mucks, 0 to 1 percent slopes	32.5
MuB	Mudlake silt loam, 1 to 6 percent slopes, very stony	6.6
PaC	Padus sandy loam, 6 to 15 percent slopes	6.0
WbB	Wabeno-Goodwit silt loams, 1 to 6 percent slopes, very stony	5.4
TpA	Tipler sandy loam, 0 to 3 percent slopes	4.6
WaC	Wabeno-Goodman silt loams, 6 to 15 percent slopes, very stony	3.5
PaB	Padus sandy loam, 0 to 6 percent slopes	3.2
Ca	Capitola muck, 0 to 2 percent slopes, very stony	3.2
ArB	Argonne-Sarwet sandy loams, 1 to 6 percent slopes, very stony	3.2
LaC	Laona-Sarona sandy loams, 6 to 15 percent slopes, very stony	3.0
Lo	Loxley, Beseman, and Dawson peats, 0 to 1 percent slopes	2.9
WrA	Worcester sandy loam, 0 to 3 percent slopes	2.1
WhA	Whisklake silt loam, 0 to 3 percent slopes	1.9
Mn	Minocqua muck, 0 to 2 percent slopes	1.8
PgB	Padus-Wabeno silt loams, 1 to 6 percent slopes, very stony	1.7
PeD	Padus-Pence sandy loams, 15 to 35 percent slopes	1.7
PeC	Padus-Pence sandy loams, 6 to 15 percent slopes	1.7
WdB	Wabeno-Mudlake silt loams, 1 to 15 percent slopes, very stony	1.6
PgC	Padus-Wabeno silt loams, 6 to 15 percent slopes, very stony	1.6
PaD	Padus sandy loam, 15 to 35 percent slopes	1.1
SoD	Soperton-Goodman silt loams, 15 to 35 percent slopes, very stony	1.0
PfD	Padus-Soperton silt loams, 15 to 35 percent slopes, very stony	0.9
PsC	Pence-Vilas complex, 6 to 15 percent slopes	0.9
MaA	Manitowish sandy loam, 0 to 3 percent slopes	0.9
PkE	Pelissier gravelly sandy loam, 20 to 45 percent slopes, stony	0.9
PeB	Padus-Pence sandy loams, 0 to 6 percent slopes	0.9
StB	Stambaugh silt loam, 0 to 6 percent slopes	0.7
PhB	Padwood sandy loam, 0 to 6 percent slopes	0.5
GaA	Gastrow silt loam, 0 to 3 percent slopes	0.5
PnC	Pence sandy loam, 6 to 15 percent slopes	0.5
LaD	Laona-Sarona sandy loams, 15 to 35 percent slopes, very stony	0.4
Fm	Fordum loam, 0 to 2 percent slopes	0.4
PnB	Pence sandy loam, 0 to 6 percent slopes	0.4
StC	Stambaugh silt loam, 6 to 15 percent slopes	0.3
WtA	Wormet sandy loam, 0 to 3 percent slopes	0.3
PsB	Pence-Vilas complex, 0 to 6 percent slopes	0.3
PsD	Pence-Vilas complex, 15 to 35 percent slopes	0.3
VaB	Vanzile silt loam, 0 to 6 percent slopes	0.3
Pt	Pits, gravel	0.2
StD	Stambaugh silt loam, 15 to 25 percent slopes	0.2
FeB	Fence silt loam, 0 to 6 percent slopes	0.1
VsC	Vilas loamy sand, 6 to 15 percent slopes	0.1
VsB	Vilas loamy sand, 0 to 6 percent slopes	<0.1
Au	Au Gres loamy sand, 0 to 2 percent slopes	<0.1
CrA	Croswell loamy sand, 0 to 3 percent slopes	<0.1

External nutrient loading
The external loading of runoff pollutants, namely phosphorus, into Pine Lake can be approximated by utilizing general export coefficients and the WiLMS predictive modeling software. Export coefficients are available for a number of land use types as kilograms of pollutant per hectare per year. Coefficients for total phosphorus are given in **Table 7.**

Table 7. General Export Coefficients for total phosphorus for the Eastern U.S.

	Export Coefficients* (kg/ha/yr)
Land Use	TP
Urban	0.5
Rural/Agriculture	0.8
Forest	0.09

*From Rast and Lee (1978).

By utilizing the data available for land use types in the Pine Lake watershed and the above coefficients, it was estimated that the total input of phosphorus from direct runoff annually is approximately 448 lbs (203 kg). Other sources of phosphorus would include atmospheric contributions, namely precipitation, groundwater, and internal cycling through anoxic (anaerobic) release of nutrients from the soil (Holdren, 2001).

The WiLMS modeling software takes in account the nutrient contributions from wetlands. However, to better estimate the release of nutrients from wetland soils within the watershed, a more detailed study of groundwater including nutrient concentrations and movement would be needed. This level of detail was outside the scope of this project.

In addition, contributions of nutrients, namely phosphorus by septic tanks can be estimated with the WiLMS software. On average a septic system is expected to contribute 0.5 Kg P/capita-year. A capita year is equivalent to one person occupying a dwelling for a period of one year. This contribution assumes that 90% of this output of phosphorus within the drainage field is retained by the soil. It has been estimated that there are approximately 400 homes in the Pine Lake Management District. However, according to the survey distribute by the Lake Management District many (approximately 75%) of these are seasonal/part-time residents. The total usage of septic systems around the lake was estimated at 200-250 capita-year. As a result, the contribution of phosphorus by septic systems around Pine Lake was estimated to be 45-57 lbs (100-125 kg) of phosphorus per year.

By inputting additional data related to the oxygen stratification, measured phosphorus concentrations during turnover and the growing season, and estimated area of anoxia, the WiLMS software was able to predict the total annual phosphorus load into Pine Lake. Since anoxia does not appear to occur in Pine Lake, no internal load through nutrient release in the sediments was predicted.

Aquatic Plant Management Options

Results of the aquatic plant survey conducted in 2006 support lake users concerns that an abundant aquatic plant community exists in Pine Lake. As the data show, the most abundant species are four native aquatic plants and the hybrid milfoil. Management options for aquatic plants differ for natives and exotics. Generally, the options can be grouped into three categories: physical, biological, and chemical. The following sections present more detail into the management options for aquatic plants in Pine Lake. As a point of reference Appendix X contains the *Aquatic Plant Management Strategy* developed by the WDNR for the Northern Region of the State during the summer of 2007

Management of native aquatic plants

Options for management of native aquatic plants are generally restricted to physical and chemical means.

Mechanical harvesting

A mechanical harvesting program can provide immediate, targeted relief of nuisance aquatic plants – both exotic and native. Harvesting can be done throughout the season as well. There are many benefits of mechanical harvesting as a tool for managing native plants. In many cases it is a preferred method, particularly in the absence of exotic species. However, for a lake like Pine Lake which has both native and exotic species present, harvesting can be a complicated approach. For example, there is little evidence to suggest that harvesting will induce a shift from exotic to native aquatic plant species. It is also unlikely that mechanical harvesting would result in any long-term control of exotic plants. In addition, harvesting can encourage the spread of exotic species, especially Eurasian watermilfoil. As a result, this method is most often recommended when exotic species have been successfully managed by other means. Drawbacks of mechanical harvesting also include the inability to harvest in shallow littoral areas and high costs.

In order for the Pine Lake District to continue the aquatic plant cutting operation, it will be necessary to renew the harvesting permit. Currently, the two main areas which will likely require cutting are the northern most areas of the lake and areas near the west shoreline. In recent years, lake users and District members have expressed a desire to modify the cutting approach. As a result of conversations with the District and the harvester crew, certain modifications have been made. **Figure 18** shows the newly modified approach the District wishes to take in regards to future aquatic plant harvesting. Much of the plan has remained the same including primarily the 20 foot navigation lanes in the northern half of the lake. Again these areas would be cut as a follow-up to chemical treatment in order to maintain navigation. In addition, areas to the south have been included where uprooted floating mats of vegetation would be collected as needed. Over the past ten years it has been noted by many lake users that aquatic vegetation in these areas often becomes quite dense causing impairments to navigation. At the time of the plant survey, it was noted that a majority of the species which form these floating mats of vegetation are the finer-leaved species such ass bushy pondweed and some of the *Potamogetons.* In general, rocks in the southern half of the lake inhibit further cutting. Lake-wide a "no cut" area along the 3-5' contour will be left.

Herbicide Treatment of Navigation Lanes

As was evident from the results of the aquatic plant survey, native aquatic plants play a large part in interfering with navigation in Pine Lake. In the past, the District has relied on harvesting as a means to maintain navigation in areas of dense aquatic plant growth. However, in 2003 a petition signed by over 400 signatures requested that the Pine Lake Protection and Rehabilitation District switch from cutting navigation lanes to chemically treating these same areas. If approved, a broad spectrum herbicide or mixture of herbicides should be used to target all plant species in a treatment area. If these treatments do not provide nuisance relief throughout the entire growing season, the navigation lanes should be maintained by mechanical harvesting. **Figure 24** presents the locations where the District has decided navigation lanes would be located.

The method used for this type of chemical treatment involves spraying herbicides to the surface of the water within the treatment area. Often a mixture of three chemicals (Cutrine®, Aquathol K®, and Reward®), will be used to target all plants and algae. This approach should be used for early season applications on low-growing plants to minimize the amount of plant matter dying off at once. However, sometimes a later season follow-up treatment is needed to maintain open water. If this approach is used, it is likely that annual treatments would be needed to maintain effective control.

Management of Shoreline Vegetation

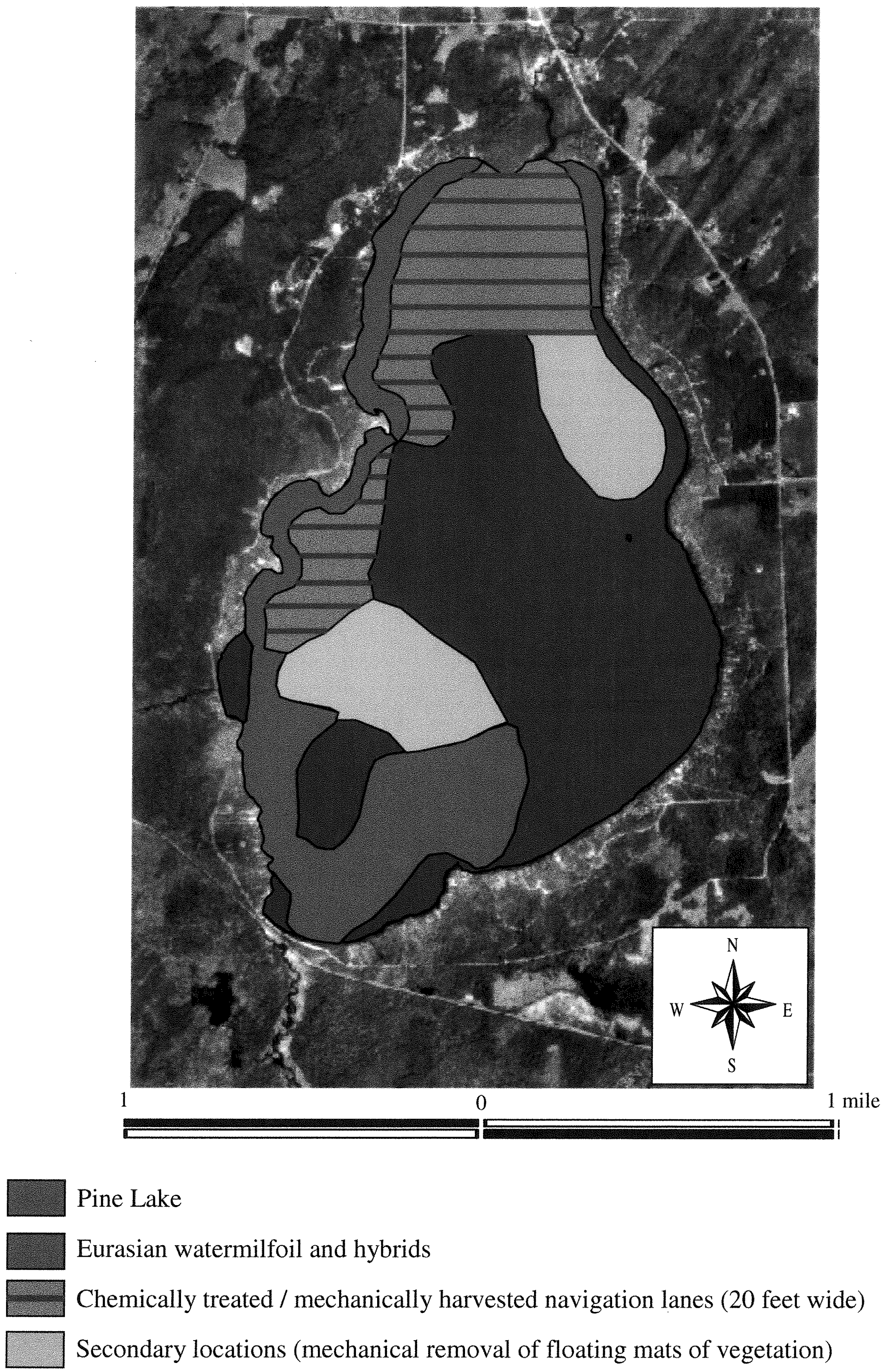
Aquatic vegetation can grow to nuisance levels in the near-shore areas of a lake. Since conventional weed harvesting equipment is unable to operate in the shallow waters along shore, other management options are available to riparian property owners. Typically, there are four management options for control of aquatic vegetation. They are biological, physical, manual/mechanical or chemical. Biological and physical options are limited and are typically used in very specific circumstances. For the homeowners living on Pine Lake, manual removal and chemical control are the best options for successful control. It is important to note that the removal of native vegetation from a lake regardless of the method being employed can create conditions favorable for colonization by opportunistic plants. This is particularly the case for more aggressive exotics species such a Eurasian watermilfoil.

Manual removal of shoreline vegetation

Individuals can remove aquatic vegetation in front of their homes, however, there are limitations as to where it can occur and how much can be removed. In most instances, control of native aquatic plants is discouraged or should be limited to areas next to piers and docks.

While larger-scale mechanical removal of vegetation requires a permit from the WDNR, manually removing plants along shore (i.e. hand-pulling or using rakes) does not. However, when aquatic vegetation is manually removed it is restricted to an area that is 30 feet or less in width along the shore. The non-native invasive plants (Eurasian watermilfoil, curly-leaf pondweed, and purple loosestrife) may be manually removed beyond 30 feet without a permit, as long as native plants are not harmed.

Figure 24 Aquatic plant harvesting approaches proposed by the Pine Lake District.



Herbicide treatment of shorelines

Members of the Pine Lake District must contend with the problems associated with excessive growth of both native and exotic aquatic plants. One option commonly utilized by individual property owners involves near shore chemical treatment of aquatic plants. Individuals can obtain a permit from the WDNR to chemically treat aquatic plants in a 30-foot strip along their property extending out 150 feet if necessary. The same three chemicals used in treating navigation lanes would be use in this approach as well.

Before any treatment plan is adopted for a lake, a number of concerns should be addressed.

Are these herbicides safe for humans? Navigate® (chemical name: 2,4-D), Aquathol K® (chemical name: endothall) and Reward® (chemical name: diquat) are all organic herbicides, while Cutrine® is a copper-based herbicide. The Environmental Protection Agency (EPA) lists 2,4-D and endothall as Class D herbicides. This classification means that there are insufficient data to suggest that this compound causes cancer or is harmful to humans. The University of Michigan School of Public Health in 2002 concluded a review of more than 160 toxicological and epidemiological studies on 2,4-D and concluded that there was not adequate evidence to link 2,4-D exposure to any forms of cancer (Garabrant and Philbert, 2002). Nor does 2,4-D from treated lakes appear to be able to contaminate well water. The Michigan Department of Environmental Quality recently released results of a 4-year study of drinking water wells surrounding twelve lakes heavily treated with 2,4-D (Bondra, 2002). To date, no traces of 2,4-D have been found in any of the test wells.

Diquat is classified as a Class E herbicide. This means diquat is a chemical for which there is no evidence of carcinogenicity for humans based on studies with two species, rat and mouse. At the rates applied with this approach the concentration of copper in the water column is at such a low concentration that there are no health risks to humans.

The EPA product label lists no water use restrictions for swimming or fish consumption following treatment with 2,4-D or endothall, while the diquat label lists a three-day waiting period for drinking and a five-day waiting period for irrigation of food crops. Copper-containing herbicides do not have such use restrictions. At the rates applied with this approach the concentration of copper in the water column is at such a low concentration that there are no health risks to humans.

While it is not possible to guarantee that any herbicide is 100% safe, the overwhelming body of evidence suggests that these herbicides when properly used pose minimal risks to humans.

Are these herbicides safe for the environment? All three of the organic herbicides biodegrade quickly in aquatic environments and do not bioaccumulate. For example, even if fish consume 2,4-D pellets, the chemical is quickly excreted without entering muscle tissues. The Navigate® label does state that 2,4-D is toxic to fish. The butoxy ethyl ester (BEE) formulation of 2,4-D in Navigate® has higher toxicity to fish when compared to other formulations (USDA, 2006). However, when applied at specified labeled rates between 100-200 lbs/acre, the risk to the environment is minimized. For these reasons, there are no label restrictions on fish consumption. Generally, fish species are tolerant of the Aquathol® formulation of endothall at concentrations of approximately 100 ppm or greater. Meanwhile, concentrations of only 0.5 to 5.0 ppm are generally required for aquatic plant control. Endothall also has a low toxicity to crustaceans and a medium toxicity to aquatic insects. Diquat is a broad-spectrum contact herbicide. It is used to control a wide variety of submersed, floating and marginal aquatic weeds as well as algae. For this reason, it is important to minimize the use of such chemicals. Impacts to desirable native plants can be minimized by treating early in the season only in areas of highest priority. Diquat dissipates so quickly it is often undetectable 1-3 days following treatment. Although copper is considered to be toxic to mollusk and fish, it is applied at a low enough rate to target only aquatic plants, algae in particular.

Are they effective? These herbicides have been used on thousands of lakes throughout North America. To date 2,4-D treatments have been one of the most, if not *the* most, effective Eurasian watermilfoil control method. In fact, the number of lakes in Michigan having Eurasian watermilfoil problems has actually declined as a result of 2,4-D use (Pullman, 1993). The success of endothall in the control of curly-leaf pondweed depends heavily on timing as well as application rates. As previously stated, early season, low-dose applications have been the most successful control measure for curly-leaf pondweed. The three-way mix of herbicides has shown itself to be effective against a wide range of aquatic weeds. When applied at the labeled rates, this combination will eliminate all plant species in the treatment area.

Will these herbicides affect desirable plants? Applied correctly at prescribed rates (100-150 lbs/acre), 2,4-D is highly selective to Eurasian watermilfoil. According to the product label, coontail, spatterdock, and bladderwort, which were found in Pine Lake, are slightly to moderately resistant to 2,4-D at higher rates (150-200 lbs/acre). At lower rates these and other native plants respond positively to treatments and the resulting decreases in milfoil distribution.

When applied at low rates (0.5-1.5 ppm), endothall can be used as an effective control option for curly-leaf pondweed. At rates above 1.0 ppm, other native pondweeds, coontail, and milfoils can be affected. As a result, endothall treatments are timed early in the season and at low rates to target curly-leaf pondweed while native plant species have not begun to actively grow.

Diquat is a broad-spectrum contact herbicide. It is used to control a wide variety of submersed, floating and marginal aquatic weeds as well as algae. For this reason, it is important to minimize the use of such chemicals. Impacts to desirable native plants can be minimized by treating early in the season only in areas of highest priority.

Are they economical? While no control method could be considered cheap, herbicide treatments are among the least costly of methods. This is in part due to the relatively low labor costs in comparison to measures such as hand-pulling, mechanical harvesting, etc. Perhaps the greatest consideration is that these herbicides typically produce long-term control of exotics. If treatments are successful, lake management units will not need to spend as much in the long-term as they do for the initial treatments. Once the target species are brought under control, the costs of annual maintenance treatments are often minimal.

What are the disadvantages? The greatest disadvantage of herbicide treatments is that they rarely produce 100% control. In most cases, herbicides tend to work only where applied. This is more so the case with granular formulations. Unnoticed and untreated plants may eventually grow to dense beds if left unchecked. Factors such as pH and plant maturity may also reduce treatment efficacy. Several follow-up treatments, whether in-season or in subsequent years, may be needed to reduce exotic species to target levels.

Impacts to water quality can also result from herbicide treatments. When aquatic plant biomass decays following a treatment, it can reduce dissolved oxygen and/or feed planktonic and filamentous algae blooms. This fact can be a major determining factor in any herbicide permit and application.

Although the plant survey data is unable to accurately determine the spread of milfoil in the lake, members of the District are certain that milfoil has e waters of Pine Lake and has become a significant nuisance to navigation and recreation. It was found at 21% of the sampling sites and totaled approximately 344 acres. Although documented in 2004, the presence of curly-leaf pondweed could not be confirmed. The hybrid watermilfoil, in particular, poses a threat to the biotic community in Pine Lake. As a result, the management of aquatic plants in Pine Lake needs to address both native and non-native species. Because of the risks posed by exotic species to the health of a lake, it is important that management efforts begin.

The primary objectives for aquatic plant management in Pine Lake are to 1) reduce hybrid watermilfoil to less than 10% frequency, 2) continue monitoring for curly-leaf pondweed and other exotic species, 3) manage native plants, for recreation/navigation purposes, 4) monitor the effects of exotic species control on the native aquatic plant community, and 5) continue to encourage the involvement of property owners and the Pine Lake District in preventing the spread of exotic species and improving the quality of Pine Lake. This plan has been written as a five-year approach. However, this approach should be reevaluated annually to determine if conditions on the lake warrant any modifications of changes.

Eurasian watermilfoil and curly-leaf pondweed have interfered with recreational activities including swimming, pleasure boating, hunting, and fishing in numerous lakes throughout Wisconsin. Communities of native aquatic plants as well as fish and wildlife have also suffered as a result of these aquatic invaders. In terms of exotic species, it is safe to say that Eurasian watermilfoil and its hybrids currently pose the greatest threat to Pine Lake. In order to maintain the beneficial uses of Pine Lake it is recommended that milfoil be managed throughout the lake.

While control efforts will play a large part in this plan, it will also rely heavily on continued volunteer-based education and prevention efforts. Through this plan, the Pine Lake District can hope to effectively manage exotic species and set an example of lake management to other lake organizations.

It is recommended that treatments for Eurasian watermilfoil and its hybrids begin on Pine Lake. It is expected that annual treatments will be necessary for the foreseeable future to reduce the extent of exotic species to below nuisance levels. Each treatment should be able to reduce the extent *and* density of exotic species in the treated areas. Until large-scale control is achieved, herbicide treatments will be the most practical management option for the Pine Lake District.

Eurasian watermilfoil and its hybrids should be treated with Navigate® (granular 2,4-D) at rates of 100-150 lbs/acre. The rate of application would depend upon the size and density of the individual bed being treated. Smaller bed of milfoil may require higher per acre rates of herbicide application. Higher rates offset the effects of dilution and maintain the concentration of herbicides at the treatment location.

Because such a large percentage of the lake has milfoil, it may not be financially or logistically feasible to treat the entire distribution of milfoil at one time. It is recommended that a series of annual treatments be scheduled to systematically target milfoil growing in Pine Lake. The first treatment should begin in the southern portion of the lake where submersed rocks prohibit such plant management practices as harvesting. Each subsequent treatment should then focus on targeting areas farther north as well as regrowth in previous treatment areas.

Education and Prevention

To this end, Pine Lake should be monitored annually for exotic species. Lake residents should undertake an active monitoring program for the purpose of identifying and documenting exotic species. Education should play a big part in this program. All individuals willing to participate should be taught to identify exotic species. The District should make it a priority to include such measures during all normally scheduled meetings whenever possible. In addition, special meetings should be considered to focus primarily on the identification of these species for riparian property owners and frequent lake users. Native plants grow in abundance in Pine Lake. Because many superficially look much like Eurasian watermilfoil and/or curly-leaf pondweed, care should be taken to specifically learn to differentiate between the native and exotic species.

Appendix G gives information regarding the identification and life history of four species which have been introduced to lakes throughout Wisconsin. These include Eurasian watermilfoil, curly-leaf pondweed, purple loosestrife (*Lythrum salicaria*), and zebra mussels (*Dreissena polymorpha*). Although purple loosestrife and zebra mussels have not been found in Pine Lake, it would be wise to educate as many District members as possible to identify these species and to the threats these species pose to lakes in

Wisconsin. Further information and education materials are available through the WDNR and the local UW-Extension office.

Curly-leaf Pondweed Contingency Plan

Because curly-leaf pondweed has been previously documented in the southern portion of Pine Lake, it will be important to pay particular attention to the possible, if not likely, reemergence of this species. Because of the added risks posed by curly-leaf pondweed to Pine Lake, it is important that a contingency plan be put in place to respond to the reemergence of this species as quickly as possible. Curly-leaf pondweed is a cold-water species that begins growing early in the spring before most other plant species. By mid to late summer, warmer waters cause this species to die back for the remainder of the year. As a result, monitoring efforts for Pine Lake need to begin soon after ice-out and continue until mid-summer. The District should organize lake volunteers to regularly monitor the lake for curly-leaf pondweed and other exotic species. If a volunteer locates what he or she believes to be an exotic species, its location should be documented by recording GPS coordinates. In addition, a sample should be collected and taken to a member of the District's Board or a coordinator of the monitoring program if one is appointed. Any suspicious material should be sent to the nearest WDNR office for verification.

Aquatic Plant Monitoring

In addition to volunteer monitoring, it would be wise to call upon the assistance of lake management consultants to annually survey the lake for exotic species. Pine Lake should be surveyed annually to determine the presence, distribution and area of exotic aquatic plants, particularly Eurasian watermilfoil and curly-leaf pondweed. This information will be essential to the District's efforts to manage and restore the lake. If the identification is confirmed it will be important to initiate management measures as quickly as possible. The extent of an exotic species infestation often dictates which management option is most likely to result in successful control. As a result, **Appendix G** also contains information regarding management options for the four exotic species previously mentioned. As always, education should be a key component of any exotic species management effort.

In addition, the aquatic plant survey conducted in 2006 should be duplicated every three years. Such thorough aquatic plant surveys not only allow for added monitoring of exotics, but also allow the District to assess changes to the native plant community.

Water Quality Management

Water quality does not appear to be a serious problem for Pine Lake. However there is some concern with the overall trend in water quality over recent years. Dissolved oxygen, water clarity, phosphorus and chlorophyll data suggest a slight decline in water quality, particularly over the past five years. These conditions indicate that management of Pine Lake's water quality must also continue to be a priority. To best ensure this trend does not continue, it is recommended that the District encourage riparian landowners to focus on improvements to individual lakeshore properties. Improved land use practices within watershed will help maintain water quality in Pine Lake. A number of water quality and shoreline improvement options are described in **Appendix H**.

Conclusions and Recommendations

Additional District Involvement

Improved public awareness is one of the most important aspects of any lake management effort. By becoming knowledgeable about the condition of Pine Lake, the District can learn what practices are necessary to reduce nutrient inputs and keep the lake healthy. There are a number of activities that District members can carry out to improve lake users' awareness of the problems facing Pine Lake.

It is important that the boat landings on Pine Lake be posted with exotic species prevention signs. There are signs available through the WDNR (see **Figure 19**). These signs should be posted and maintained at all access points to Pine Lake including boat launches and walk-ins. Many lake organizations choose to design and erect larger signs designed to call attention to specific concerns related to their lake. Since exotic species have been documented in Pine Lake, the focus of these signs should be education and prevention.

It is recommended that all signs posted around the lake encourage boaters entering or leaving the lake to remove any plant or animal material from their watercrafts.

Figure 19. Exotic species prevention signs available through the Wisconsin DNR.

Several other prevention and educational awareness activities should be planned. This can include public notices regarding exotic species, distribution of WDNR educational literature to public lake users, and conducting watercraft inspections. These volunteer efforts should focus on preventing the spread of Eurasian watermilfoil and other exotic species. Watercraft inspections can also be used as a tool to document potential watercraft infestations that can be communicated to the WDNR.

Wisconsin Citizen Lake Monitoring Network

The Wisconsin DNR's Self-Help Lake Volunteer Monitoring Network provides an opportunity for volunteers from lake organizations to assist in state-wide water quality monitoring. Through this program volunteers collect a variety of water quality data in order to gain a better understanding of lake conditions. Through a database managed by the DNR, information gathered can be shared and archived. The types of data collected depend on what concerns and interests are for a particular lake as well as the amount of time available for monitoring. Monitoring of this type has occurred sporadically on Pine Lake over the past 20 years.

The most common type of monitoring is for water transparency with the use of a Secchi disc. Volunteers collect water clarity data during spring and fall turnovers as well as throughout the summer. After collecting Secchi data for one or more years, some organizations begin collecting additional water quality data. Volunteers can collect phosphorus and chlorophyll samples in addition to collecting Secchi data. The data collected allows lake managers and the WDNR to assess the nutrients present in a lake. In addition, temperature and dissolved oxygen data are also commonly collected on lakes. Other volunteer activities include monitoring for zebra mussels, Eurasian watermilfoil, Purple loosestrife, and curly-leaf pondweed. The Pine Lake District is encouraged to again participate in this program.

For more information contact Laura Herman, Citizen Lake Monitoring Network Educator, at (715) 346-3989 (Stevens Point) or (715) 365-8984 (Rhinelander), or by email at Laura.Herman@uwsp.edu.

For more information visit: http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/

To download a printable manual for the Self-Help Lake Volunteer Monitoring program go to: http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/manual/lakesmanual_2006rev.pdf

Clean Boats, Clean Waters

The WDNR in cooperation with the UW-Extension Lakes Program have developed a volunteer watercraft inspection program designed to educate motivated lake organizations in preventing the spread of exotic plant and animal species in Wisconsin lakes. This program would be particularly useful to Pine Lake since Eurasian watermilfoil has been found in nearby lakes. Through the Clean Boats, Clean Waters program, volunteers are trained to organize and conduct boater education programs.

For more information contact:
Erin Henegar
Clean Boats, Clean Waters Program Coordinator
Wisconsin Invasive Species Program
Ph: 715-346-4978
ehenegar@uwsp.edu

To download a printable brochure regarding the Clean Boats, Clean Waters program go to http://www.uwsp.edu/cnr/uwexlakes/CBCW/Pubs/CBCW_brochure.pdf.

State and Federal Grants

A number of grants are available to lake organizations wishing to implement effective lake management efforts or conduct lake related research. It is recommended that the Pine Lake District pursue these and other grant options in an attempt to offset the cost of aquatic plant management. **Appendix I** describes a number of the most applicable grants, who qualifies and what type of projects can be funded.

Plan Development and Approval Process

Will insert review and District approval process here. Will also emphasize the District's long-term commitment to this plan.

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