Limnological Study
of Pine Lake
Forest County
April 1992 - March 1993

NORTHERN LAKE SERVICE, INC.

# Limnological Study of

# Pine Lake, Forest County

# April 1992 - March 1993

Prepared by :

Northern Lake Service, Inc.

400 North Lake Avenue

Crandon, WI 54520

July 2, 1993

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## Introduction

The following is a description of and results from the planning-grant study of Pine Lake performed by Northern Lake Service between April 1992 and March 1993. The purpose of this study was to determine current water quality for comparison to past and future data and provide a basis for recommending improvement/preservation strategies.

Pine Lake is a 1670 acre, seepage lake located in west central Forest County (Sec.22, R12E, T37N). It has a maximum depth of 14 feet, 6.42 miles of shoreline and watershed of 14.0 miles. (From Surface Water Resources of Forest County WDNR- 1977.) The shoreline is quite heavily developed, with approximately 150 dwellings.

## Study

This study consisted of five visits to the lake - 3 during open water and 2 during the winter. On the open-water trips, a water sample was collected at approximately the deepest point in the lake using a two-meter PVC sampler. The sample was dispensed into sample bottles with appropriate preservative and iced for transport to the laboratory. A portion of the sample was used for pH and conductivity determination which was done on site. Dissolved oxygen/temperature profiles were also generated and secchi disc visibility measured at the sample site. These activities were done May 5, July 30, November 11,1992. During the July 30 sampling, a general macrophyte survey was performed. For a description of this survey see appendix A.

Samples were analyzed by Northern Lake Service for alkalinity, chloride, chlorophyll $\alpha$, nitrogen (Kjeldahl, ammonia, and nitrate + nitrite) and phosphorus. These parameters are described on the following pages and all data can be found in appendix B.

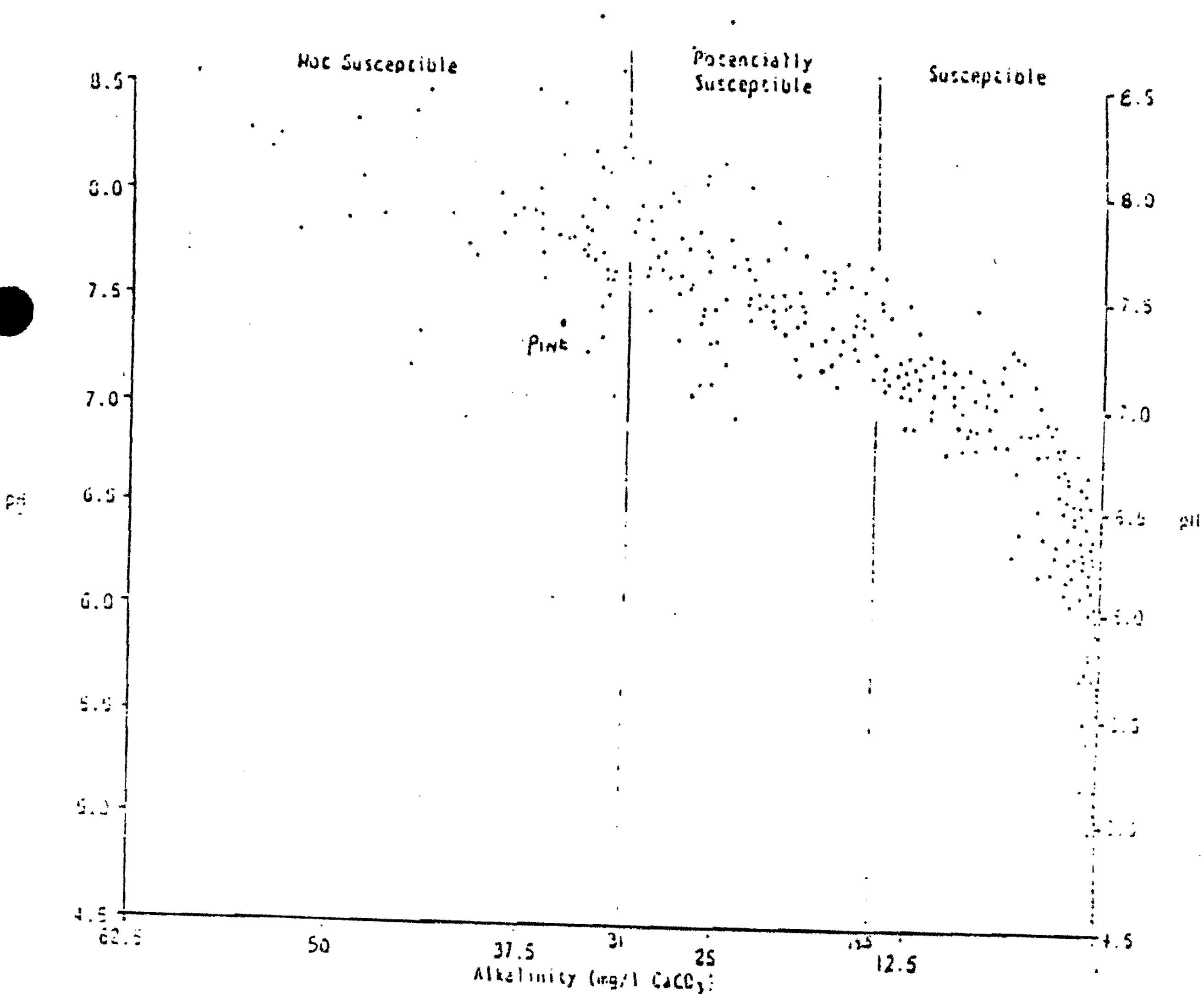
During the winter visits dissolved oxygen/temperature profiles were generated but no samples were collected.

## Survey Findings

pH and Buffering Capacity: pH and total alkalinity or acid neutralizing capacity (ANC) are indications of a lake's susceptibility to the effects of acid rain. pH is the measure of acidity on a logarithmic scale from 1 to 14. A pH factor of 1 is most acidic, 14 most basic and 7 neutral. Alkalinity measures the ability of water to neutralize substances on the upper and lower ends of the pH scale. This process, called buffering, is performed by salts, mainly calcium carbonate salts. The more of these salts present, the higher the alkalinity and the more resistant to pH changes the water is. The pH on Pine Lake ranged from 5.9 to 7.4, indicating near-neutral conditions. Alkalinity was very stable, ranging from 34 mg/l to 38 mg/l, which indicates good buffering potential. According to Surface Water Resources of Forest County (WDNR-1977), the alkalinity of Pine Lake was 37 in 1963, so there has been no depletion of buffering capacity in the last thirty years. Figure 1 shows Pine Lake's position among area lakes in acid susceptibility based on these measurements.

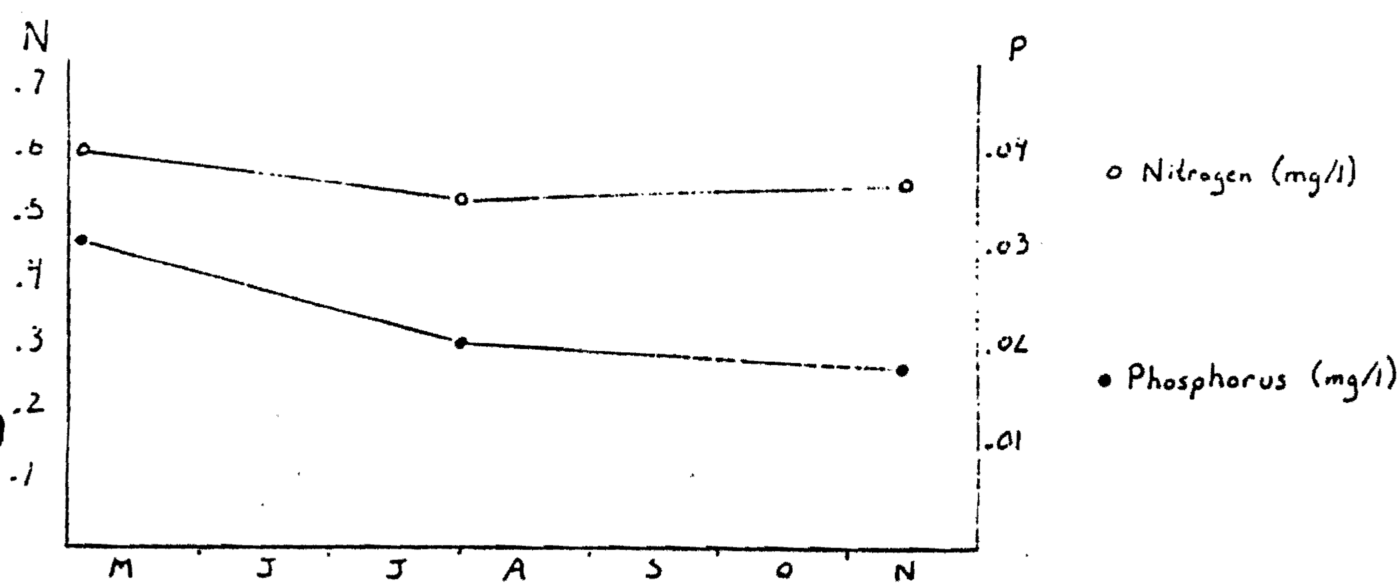
FIGURE 1

ACID RAIN EFFECT SUSCEPTIBILITY
(from Greater Bass Lake Langlade County Feasibility Results;
Management Alternatives. by WDNR Bureau of Water Resources Management - Inland Lake Renewal Section; 1983, p17.)



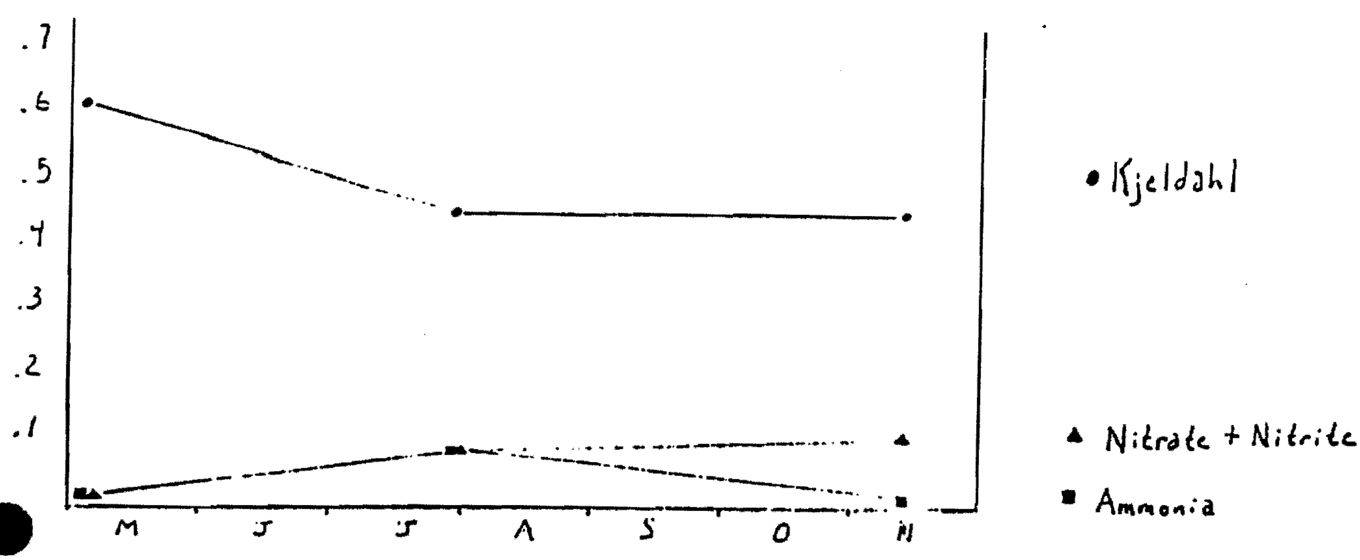
**Nutrients:** A nutrient is any element, ion or compound necessary for the growth and other life processes of an organism. Most nutrients are required in only trace amounts, but some, the macronutrients, are required in large enough amounts to dictate the productivity of a system. The macronutrients are carbon, nitrogen and phosphorus. Since carbon is so prevalent in a lake its levels do not get low enough to make it a limiting factor. (The limiting factor is the nutrient or energy source that exists in a quantity such that it dictates the extent of growth.) Therefore, nitrogen and phosphorus are considered the most important in terms of potential productivity of a lake.

The ratio of nitrogen to phosphorus remained at about 20:1 during this study. A ratio of 13:1 is generally considered the point above which phosphorus is considered the limiting factor . Graph 1 shows nitrogen and phosphorus levels on Pine Lake during the study. ( Note: On this graph nitrogen values are 10 times that of phosphorus.)



High productivity characterized by nuisance weed or algae growth can be expected when total phosphorus levels exceed 15 ug/l. Phosphorus levels in Pine Lake ranged from 18 to 32 ug/l during the study.

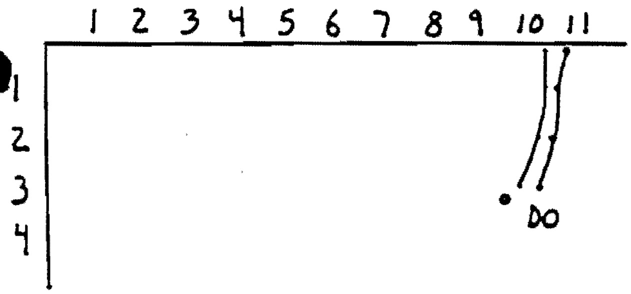
Nitrogen levels ranged from 0.54 mg/l to 0.62 mg/l. These values were consistent with many other lakes in this area. Eighty to 100% of the total nitrogen consisted of organic nitrogen. One component of organic nitrogen is ammonia which can be an indicator of septic contamination. Ammonia levels were only above detection limits on one of the three sampling dates and even then it was not significant enough to indicate a problem. The inorganic portion of total nitrogen is made up of nitrate and nitrite. High levels of these compounds can indicate nutrient contamination from fertilizer or other man-made products. Nitrate + Nitrite levels were quite low, ranging from below detection limits to .11 mg/l. Graph 2 shows the nitrogen component levels during the study.



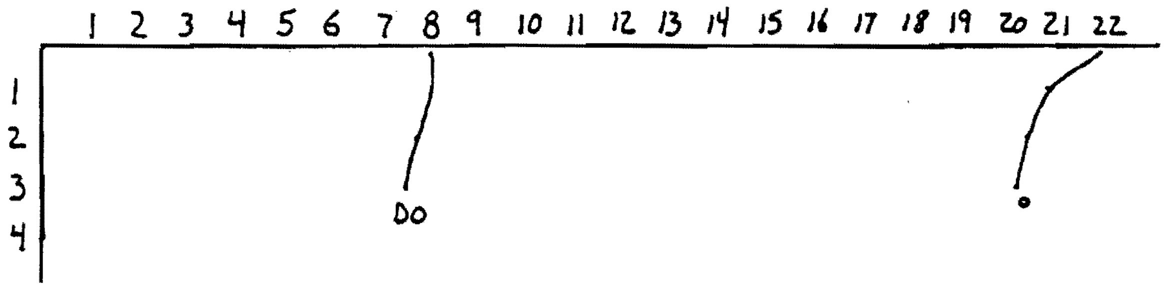
According to WDNR-1977 total nitrogen levels in 1963 were about .4 mg/l. This is not a significant difference from current levels. ( A total phosphorus value is not given for the 1963 sampling. )

<u>Dissolved Oxygen</u> - Dissolved oxygen is critical to the survival of fish. In the spring, when a lake turns over, dissolved oxygen levels will be at or near saturation throughout the water column. Over the course of the summer, levels near the surface will fluctuate slightly with variations in temperature and mixing. In shallow, productive lakes such as Pine, oxygen levels will remain fairly constant throughout the water column during open water periods, but can be depleted very rapidly during the winter when production ( by plants ) ceases but consumption ( by animals ) continues. If oxygen levels are depleted enough, fish begin to suffocate causing a phenomenon called "winter kill". Total oxygen depletion also provides a more favorable environment for nutrient recycling from the sediments, meaning more nutrients available for macrophyte or algae growth in the spring.

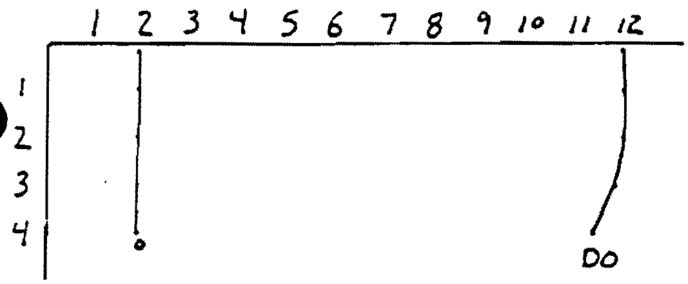
The following page includes all dissolved oxygen/temperature profiles that were generated during the study. Numbers on the vertical axis are depths in meters. Those on the horizontal axis represent both temperature in °C and dissolved oxygen in mg/l or parts per million. The last three graphs show that oxygen levels were not dramatically depleated during the winter. Dissolved oxygen and temperature data is included in appendix B.



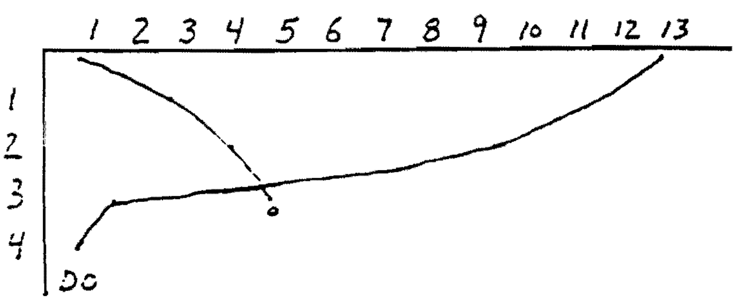

5/8/9



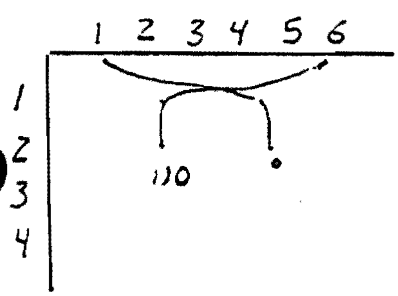

7/30/92




11/11/9

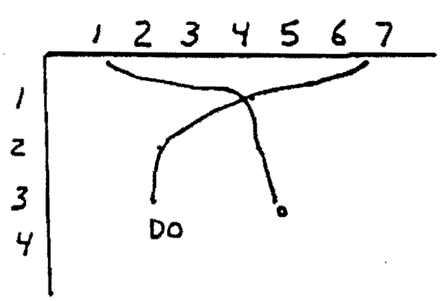



2/25/93




Site A

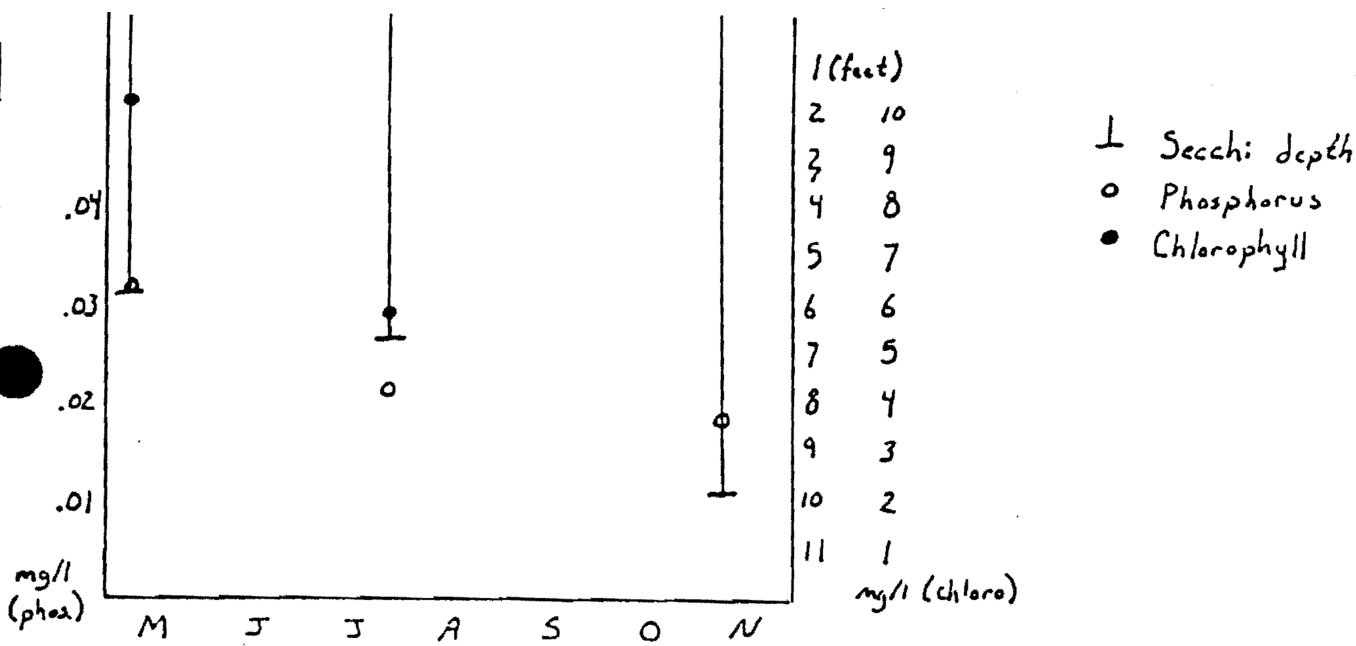
3/28/93




Site B

## Chlorophyll

Chlorophyll α, a pigment found in algae, is used as an indicator of algal growth. It is often closely associated with water clarity and phosphorus levels. Phosphorus is nesessary for algal growth and the more algae, the lower the visibility, thus the relationship. The following graph shows that relationship on Pine Lake.




For complete chlorophyll results see appendix 2.

## Macrophytes

Aquatic plant growth occured throughout most of Pine Lake to a depth of 13 feet. Twenty-eight different species were observed during the July 30, 1992 study. Of these, four were floating-leaf plants, three were emergent, and the remaining 21 were submergent species. A separate report on this study, including field sheets, maps and species descriptions, is included as appendix A.

## Summary & Recommendations

As a lake ages and nutrients accumulate, it becomes more productive or eutrophic. The rate of this process can be dramatically effected by the activities of man. The situation on Pine Lake is one of naturally high productivity probably moderately increased by man.

Natural factors include the lake's size, shape and surounding geography. Since Pine Lake is large and relatively shallow, the action of the wind is able to keep recycling nutrients for use by plants or algae. Since the littoral zone or the area which receives enough light to support plant growth, extends over the entire bottom of the lake, the potential biomass of the system is limited only by the ammount of available nutrients. Also, the ratio of watershed to surface area is quite high (≈ 5:1 ). This means that nutrients from an area approximately five times the size of the lake are being washed into the lake. The nutrient load is also increased by the relatively heavy shoreline development.

The following two models use phosphorus, chlorophyll $\alpha$ and Secchi depth to estimate water quality and trophic state (lake age). As the models show Pine Lake is quite eutrophic (productive), but water quality is still in the "good" range.

| Trophic Level | Total Phosphorus | Secchi Disc | Chlorophyll |
|---|---|---|---|
| Eutrophic | | | |
| | 20 | 2.0 | 8.5 |
| Mesotrophic | | | |
| | 10 | 4.0 | 2.3 |
| Oligotrophic | | | |

(Carlson, R.E., 1977, A trophic state index for lakes: Limnology and Oceanography, March, v. 22(2), p. 361-369)

| Water quality index | Total Phosphorus (mg/l) | Chlorophyll $\alpha$ (ug/l) | Secchi (ft) |
|---|---|---|---|
| Excellent | <0.001 | <1 | <19.7 |
| very good | .001-.010 | 1-5 | 9.8-19.7 |
| good | .010-.030 | 5-10 | 6.6-9.8 |
| fair | .030-.050 | 10-15 | 4.9-6.6 |
| poor | .050-.150 | 15-30 | 3.3-4.9 |
| very poor | >.150 | >30 | >3.3 |

(Lillie, R.A., and J.W. Mason, 1983, Limnological characteristics of Wisconsin lakes: Wisconsin Dept. of Natural Resources Technical Bulletin No 138, 1116 p.)

A number of actual and potential problems exist due to this situation. Eutrophic conditions often mean extensive weed growth, which can limit recreational activities and adversely affect aesthetics. Macrophytes also provides cover for small fish which is necessary to an extent, but if it becomes too thick and widespread, larger predators are not able to hunt effectively, and a large population of stunted panfish may result. Shallow lakes with extensive weed growth, like Pine may also suffer winter oxygen depletion severe enough to stress or kill fish. Fortunately it seems that water coming into Pine Lake during the winter brings enough oxygen to keep this from happening.

A number of different management strategies can be considered for Pine Lake. Both chemical treatment and mechanical harvesting are classic responses to problem weed growth. Chemical treatment should be used in conjunction with a specific management plan in order to preserve areas of desirable weed growth. On Pine Lake these areas include the floating-leaf beds, especially the large one near the north shore, beds of native emergents and much of the deeper water broad-leafed pondweeds or "cabbage beds" . Table 1 shows the effectiveness of 5 currently-used herbicides on specific macrophytes. Further information on weed control chemicals can be found in DNR published information sheets--PUBL-WR-135-90 through PUBL-WR-145-90 and <u>How to Identify and Control Water Weeds and Algae</u> 1976 James C. Schmidt. Drawbacks of chemical treatment include the possibility of residual effects on non-target members of the system - especially after long-term use. Also, this method does not remove anything from the system. Nutrients are recycled and available for further weed growth.

Mechanical harvesting is very effective but also very labor and cost intensive. The size of Pine Lake and the scope of the growth would probably require full-time harvesting during the growing

Table 1. Common aquatic weed species and their responses to herbicides (modified from Pickerel/Crane Lake A Phase 1 Diagnostic & Feasibility Study 1992)

| | Diquat | Endothal | 2,4-... | Glyphosate (Rodeo) | Fluridone (Sonar) |
|---|---|---|---|---|---|
| **EMERGENT SPECIES** | | | | | |
| *Sagittaria* spp (arrowhead) | NO | NO | YES | | YES |
| *Scirpus* spp (bulrush) | NO | NO | YES | YES | YES |
| *Typha* spp (cattail) | YES | NO | YES | YES | YES |
| *Lythrum salicaria* (purple loosestrife) | | | | YES | |
| **FLOATING SPECIES** | | | | | |
| *Brasenia schreberi* (watershield) | NO | YES | YES | | NO |
| *Lemna minor* (duckweed) | YES | NO | YES | | YES |
| *Nuphar* spp (cowlily) | NO | YES | YES | YES | YES |
| *Nymphaea* spp (water lily) | NO | YES | YES | YES | YES |
| **SUBMERGED SPECIES** | | | | | |
| *Ceratophyllum demersum* (coontail) | | YES | YES | YES | YES |
| *Chara* spp (stonewort) | NO[2] | NO[2] | NO[2] | NO[2] | |
| *Elodea* canadensis (elodea) | YES | ? | NO | | YES |
| *Myriophyllum spicatum* (milfoil) | YES | YES | YES | NO | YES |
| *Najas flexilis* (najad) | YES | YES | NO | NO | YES |
| *Najas guadalupensis* (southern najad) | YES | YES | NO | | YES |
| *Potamogeton amplifolius* (large-leaf pondweed) | ? | YES | NO | | |
| *P. crispus* (curly-leaf pondweed) | YES | YES | NO | | |
| *P. natans* (floating leaf pondweed) | YES | YES | YES | | YES |
| *P. pectinatus* (sago pondweed) | YES | YES | NO | | YES |
| *P. illinoiensis* (Illinois pondweed) | | | | | YES |
| *Ranunculus spp* (buttercup) | YES | | YES | | |

YES Controlled
NO Not controlled
BLANK Information unavailable
? Questionable control
[2] controlled by copper sulfate

\macrochem.doc

season. A modified harvesting method in which large strips are harvested may be successful on Pine Lake. This is a bit less labor intensive, provides clear boating lanes, and removes some nutrients from the system. It is also beneficial to the fishery by maintaining much cover but also creating long edges where larger predator fish can hunt. Like chemical treatment, mechanical harvesting should follow a management plan to help maintain the system. Both of these methods treat only the symptoms though and last one or part of one season. (The strip harvesting has been shown in some cases to last several seasons.)

Table 2 compares harvesting, chemical treatment and a number of other management tools.

While the water quality of Pine Lake is not threatened by any serious land use problems such as industrial waste or heavy agriculture,it is effected to an extent by man's activities on the lake and in the watershed. Proper "common sense" practices can be as important as high-tech rehabilitation efforts. These are low-tech, low-cost practices by lake residents and users to avoid accelerating the lake aging process. They include the following:

* Maintain naturally vegetated "buffer zones" along the shore,
* Carefully monitor septic system performance,
* Landscape to decrease erosion,
* Divert runoff from construction sites,
* Avoid the use of chemical fertilizers,
* Operate motorized water craft slowly in shallow, heavily sedimented areas.

| | Mechanical Harvesting | Aquatic Herbicides | Dredge | Rototill | SCUBA | Bottom Screens | Drawdown | Biological |
|---|---|---|---|---|---|---|---|---|
| Effect on Ecosystem | Remove plant material, some small fish | possible residual effects | removes littoral zone, disturbs sediments | disturbs sediments | removes aquatic vegetation | creates clear-cut | downstream water quality effects, possible fishery effects | needs research |
| Effective Large-scale | yes | yes - but possible residual effects | yes | yes | no - very labor intensive | no | yes | yes |
| Effective Small-scale | no - difficult to maneuver | yes | yes | no | yes | yes | no | no |
| Species Selective | no | yes - if applied properly | yes | no | yes | no | no | yes with fungi and insects |
| Removes Nutrients | yes | no | yes | no | yes | no | no | no |
| WDNR Acceptibility | high - minimal environmental impact | low - permit required | low - many environmental impacts | medium - prefer harvesting | high - proven effective in southern WI | high - for small areas, permit required | low - physical features of dam prevents drawdown | low - many unknowns |
| Public Acceptibility | high | medium - more public info needed | medium - many environmental impacts | medium - new technology | high - has been demonstrated to maintain channels up to 2 years | medium - effective but difficult to maintain | medium - depends on many factors, may have to coordinate with utility company | medium - more research and public info needed |
| Per acre cost | $200 to $600 | $75 to $600 | $15,000 to $20,000 | $1500 | varies depending on volunteers | $10,000 to $15,000 | nominal | N/A |

format taken from "Minnesota Aquatic Plant Control Draft Reconnaissance Report," August 1989

These efforts, while they do not have exhibit the dramatic effects of high tech strategies, provide longer-lasting improvement or preservation of the system.

Finally, we recommend a long-term, self-help monitoring program. A simple program which can be an extremely effective indicator of changes in aging trends is regular Secchi disc readings. As the graph on page 6 showed, this measurement is often on indicator of nutrient levels. It should be done at regular intervals of about 2 weeks and can be used with or without annual nutrient analysis to track water quality for a minimal cost. Information on establishing a self-help monitoring program is available through the Departmant of Natural Resources.

MACROPHYTE SURVEY

# PINE LAKE
# FOREST COUNTY, WISCONSIN

PERFORMED BY: R.T. KRUEGER & G.A. KRUEGER

NORTHERN LAKE SERVICE, INC.
400 NORTH LAKE AVENUE
CRANDON, WISCONSIN 54520
JULY 30, 1992

PREPARED:
AUGUST 14, 1992

## Introduction

On July 30, 1992, a general macrophyte survey was conducted on Pine Lake, Forest County. This was done to determine density, diversity, and distribution of aquatic plants. General observations were made throughout the lake with depth and density measurements made at specific numbered stations. The 55 stations on Pine Lake represent intersection points on a grid approximately 400 yds on the side. While this grid is larger than that used in 1977, I feel, due to the structure of the lake and nature of the plant communities, this study is as representative as the earlier work. This study also included sampling points in deeper areas of the lake which were not taken into consideration in 1977.

## Methodology

At each numbered station a 10 foot circle is visualized and divided into 4 quadrants. Macrophytes are then collected, identified, and ranked as follows: 1 if present in 1 quadrant, 2 if present in 2 quadrants, etc... A ranking of 5 signifies complete or near complete dominance by one species, occupying a significant portion of the water column. If a species is observed growing outside the circle it is given a "p" for present. Species receiving only this designation are not considered when relative frequency, average density, and depth to growth are calculated, but are included on the species list. If a specimen cannot be identified to species it is referred to by the generic name followed by "sp". ("spp" indicates the presence of more than one unidentified species of the given genus). Water depth, depth to vegetation, percent open water, and bottom type (if depth permits) are also recorded at each station.

Bottom type descriptions are as follows: D=detritus, G=gravel, H=hard, clay like, M=muck, r=rocks, S=sands.

Survey Finding

Pine Lake continues to support abundant and diverse plant growth. Vegetation was collected at all but 6 stations, and even these areas probably support some macrophyte growth albeit extremely sparse.

The most diversity was exhibited at station 2 with 15 species present. Three stations along the west shore share (9, 19, & 32), and three on the south end (53, 54, & 55) support at least 10 species. Most other stations with depths of under 10 ft supported 3 to 7 species.

The most abundant species were *Ceratophyllum demersum* or coontail which was present in about 75% of the lakes and *Elodea canadensis* which was present at about 45% of the stations. In combination these plants were present at all but one vegetated station, from depths of 2.5 ft. to 13 ft. *Ceratophyllum* and *Elodea* generally produce low but dense growth - sometimes to nuisance proportions.

At the time of this study they were not surfacing and therefore not hampering recreation. (It has been pointed out that weed growth is down significantly from previous years.) In Pine Lake these two species account for approximately 45% of the plant biomass.

The genus *Potamogeten* contributes another 45%. This is an extremely diverse taxa. *Potamogeten praelongus*, white-stem pond weed and *P. zosterformes*, flat-stem pondweed were the most prevailant, both present at 22 of the 55 stations. *P. robbinsii* and *P. richardsoni* were both present at over 25% of the stations with *P. robbinsii* receiving the highest average density of any species present at more than 3 stations, at 3.2. Five other *Potamogetens* were present. Most of the *Potamogetens* in Pine Lake have long erect stems (to 11 ft.) and are not as dense as *Ceratophyllum* and *Elodea*.

The remaining submergent species account for little biomass. *Myriophyllum exalbescens* (milfoil) was present in most of the beds of broadleaf pond weeds. *Vallisneria americana* and *Chara* (a large rigid algae) were the most prevailant on the sandy, wind-swept east shore.

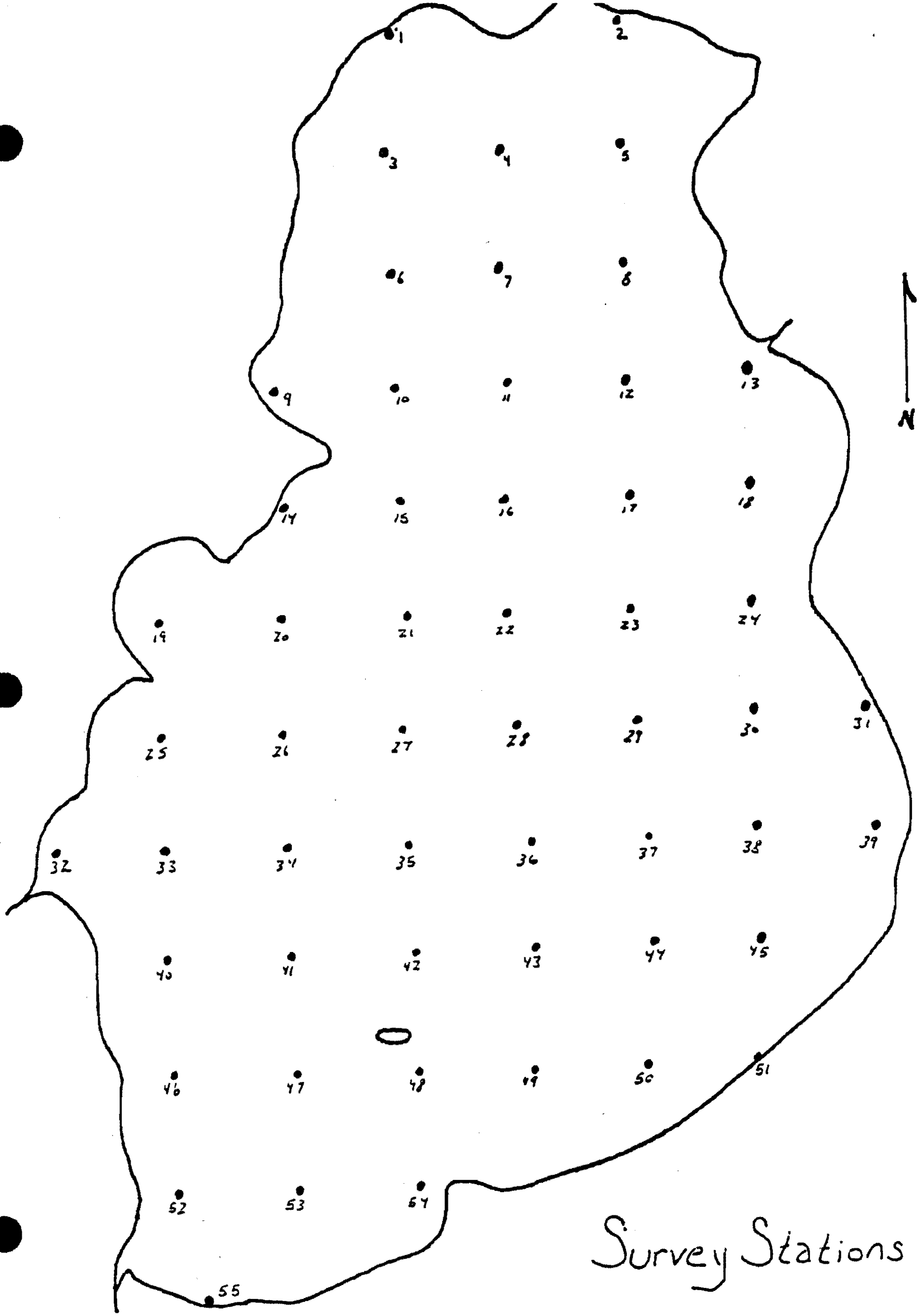
Beds of emergent vegetation were present on approximately 5% of the surface area of the lake. These beds consisted mostly of the bulrush *scirpus heterochaetus* and were located near the south shore and at the mouth of Wildcat Creek. These areas generally had a sandy bottom without much muck accumulation. Other emergents included *Typha latifolia* or cattail near the north and south shores and *Pontederia cordata* found at the mouth of Wildcat Creek. Emergents grew at depths of 3 to 5 ft.

Floating leaf vegetation was also present over about 5% of Pine Lake. The largest beds were near stations 2 and 32. The bed at station 2 consist of *Nuphar variegatum* and *Nymphaea odorata* while the one at 32 consisted of these two species along with *Brasenia shreberi*.

Summary

At the time of this survey, Pine Lake supported macrophyte growth nearly throughout. Plant growth extended to 13 ft deep and grew to an average of approximately 5.9 ft below the water's surface. (The average at the 13 stations 7 ft deep or less was 2.1 ft, while the remaining vegetated stations averaged 8 ft to growth.) Twenty-eight species were noted: 4 floating leaf, 3 emergents, and 21 submergents, two of which are actually large colonial algae. The vast majority of the plant biomass was accounted for by the submergent species, especially *Ceratophyllum demersum*, *Elodea canadensis*, and the *Potamogetens*.

As the macrophyte community maps indicate, distribution of community types and extent of growth have changed very little over the last 15 years. The species list and corresponding numbers are also quite similar. Also like the original, this study found plant growth extended to depths beyond the predicted maximum. This is probably due clearer water conditions earlier in the year when growth began.




Survey Stations

NORTHERN LAKE SERVICE, INC.

MACROPHYTE SURVEY OF: Pine BY: RTK & GAK ON: 7-30-92

| TAXA STATION | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Brasenia Shreberi* | | | | | | | | | 2 | | | | | | |
| *Ceratophyllum demersum* | 2 | 4 | 1 | 1 | 3 | 2 | 4 | 3 | 2 | | 1 | | 3 | 3 | |
| *Chara* | | | | | | | | | | | | | | | |
| *Eleocharis acicularis* | | | | | | | | | | | | | | | |
| *Elodea canadensis* | 1 | 2 | | | 1 | 2 | 1 | | 2 | 2 | | | | 2 | |
| *Heteranthera dubia* | | | | | | | | | | | | | | | |
| *Juncus pelocarpus* | | | | | | | | | | | | | | | |
| *Lemna minor* | | | | | | | | | P | | | | | | |
| *Lemna trisulca* | 3 | 1 | | | | | | | 3 | | | | | | |
| *Megalodonta Beckii* | | 1 | | | | | | | | | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | | | | |
| *M.* | | 2 | | | | | | | 1 | 3 | | | 1 | 1 | |
| *M.* | | | | | | | | | | | | | | | |
| *Musci* | | | | | | | | | | 2 | | | | | |
| *Najas flexilis* | | | | | | | 1 | | P | 1 | | | 2 | 1 | |
| *N.* | | | | | | | | | | | | | | | |
| *Nitella* | | | | | | | | | | 4 | | | | | |
| *Nuphar variegatum* | | 4 | | | | | | | 2 | | | | | | |
| *Nymphaea* | | 2 | | | | | | | | | | | | | |
| *Pontederia cordata* | | P | | | | | | | | | | | | | |
| *Polygonum natans* | | | | | | | | | | | | | | | |
| *Potamogeton amplifolius* | | P | | | | 2 | | | | | | | | 1 | |
| *P. gramineus* | | | | | | | | | | | | | 2 | | |
| *P. praelongus* | | 1 | | | 2 | 2 | 2 | | | | | | | | |
| *P. zosteriformes* | | 2 | | 1 | 3 | 1 | | | P | 2 | | | | | |
| *P.* robbinsii | 2 | 3 | 4 | 4 | 4 | 4 | | | 3 | | | | | | |
| *P.* richardsoni | 1 | 1 | 2 | | 1 | 2 | | | P | 2 | | | 1 | | |
| *P.* illinoensis | | P | | | | 2 | | | | 1 | | | | | |
| *P.* Sp. III | | | | | | | 1 | 1 | | | | | | | |
| *Scirpus* | | | | | | | | | P | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | | | | |
| *Spirodella polycarpum* | | | | | | | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | |
| *Utricularia* | | 1 | | | | | | | | | | | | | |
| *Vallisneria americana* | 4 | | | | | | | | 3 | 4 | | | 2 | 3 | |
| *Wolffia columbiana* | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Depth to vegetation | 2½ | — | 3.5 | 3.5 | 2 | 1.5 | 6.5 | 12 | | 6 | 10.5 | | 3 | 5.5 | |
| % Open water @ 0.5' depth | | 40 | | | | | | | 90 | | | | | | |
| Water depth (ft) | 4 | 3 | 5 | 4 | 9 | 7.5 | 9 | 12.5 | 3.5 | 7 | 11 | 14 | 4.5 | 6 | 12 |
| Bottom type | M | M | M | M | M | M | M | M | M | S | M | M | S | S | S |

**MACROPHYTE SURVEY OF:** Pine **BY:** RJK & GAK **ON:** 7-30-92

| TAXA / STATION | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Brasenia Shreberi* | | | | | | | | | | | | | | | | |
| *utophyllum demersum* | 2 | 2 | 1 | | 3 | 2 | 2 | | | 2 | 4 | 3 | 1 | 2 | 1 | |
| *Chara* | | | | | | | | | | | | | | | | |
| *Eleocharis acicularis* | | | | | | | | | | | | | | | | |
| *Elodea canadensis* | 1 | | | | | | 1 | | | 2 | | | | | | |
| *Heteranthera dubia* | | | | | | | | | | | | | | | | |
| *Juncus pelocarpus* | | | | | | | | | | | | | | | | |
| *Lemna minor* | | | | | | | | | | | | | | | | |
| *Lemna trisulca* | | | | | | | | | | | | | | | | |
| *Megalodonta Beckii* | | | | | | | | | | 3 | | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | | | | | |
| *M.* | | | | | | | | | | | | | | | | |
| *M.* | | | | | | | | | | | | | | | | |
| *Musci* | | | | | | | | | | | | | | | | |
| *Najas flexilis* | | 1 | | | | | | | | | | 2 | | | | |
| *N.* | | | | | | | | | | | | | | | | |
| *Nitella* | | | | | | | | | | | | | | | | |
| *Nuphar variegatum* | | | | | | | | | | | | | | | | |
| *Nymphaea* | | | | | | | | | | | | | | | | |
| *Pontederia cordata* | | | | | | | | | | | | | | | | |
| *ygonum natans* | | | | | | | | | | | | | | | | |
| *Potamogeten amplifolius* | | | | 2 | | | | | | 2 | | | | | | |
| *P. gramineus* | | | | | | | | | | | | | | | | |
| *P. praelongus* | 2 | 1 | | 3 | ~~2~~1 | 3 | | | | | P | | | | | |
| *P. zosteriformes* | | | | 3 | | | | | | 1 | | | | | | |
| *P. robbinsii* | | | | 4 | 2 | | | | | | 3 | | | | | |
| *P. richardsonii* | | | 1 | 1 | | | | | | | | | | | | |
| *P. illinoensis* | | | | | | | | | | | | | | | | |
| *P. Sp.* [illegible] | | | | | 2 | | | | | | 1 | 4 | | | | |
| *Scirpus* validus | | | | | | | | | | P | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | | | | | |
| *Spirodella polycarpum* | | | | | | | | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | | |
| *Utricularia* | | | | | | | | | | | | | | | | |
| *Vallisneria americana* | | | | | | | | | | 3 | | | | | | |
| *Wolffia columbiana* | | | | | | | | | | | | | | | | |
| I. Sp. III | | | 1 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| th to vegetation | 10.5 | 11 | 11.5 | 6in. | 2 | 2 | 10.5 | | | 1.5 | 7½ | 11 | 11.5 | 11.5 | 12.5 | |
| % Open water @ 0.5' depth | | | | | | | | | | | | | | | | |
| Water depth (ft) | 11 | 11.5 | 12 | 6 | 10 | 12 | 11 | 11.5 | 12 | 5 | 9 | 12 | 12 | 12 | 13 | |
| Bottom type | m | m | | [illegible] | M | m | m | M | | H | M | m | m | m | M | |

NORTHERN LAKE SERVICE, INC.

MACROPHYTE SURVEY OF: Pike BY: RTK & GAK ON: 7-30-92

| TAXA STATION | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Brasenia Shreberi* | | P | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | 1 | 1 | | 3 | 4 | 3 | 3 | 3 | 3 | | 4 | | 2 | 1 | |
| *Chara* | | | | | | | | | | | | | | | |
| *Eleocharis acicularis* | | | | | | 2 | | | | | | | | | |
| *Elodea canadensis* | 2 | | 2 | 2 | | | | | | 3 | | | | | |
| *Heteranthera dubia* | | | | | | | | | | | | | | | |
| *Juncus pelocarpus* | | | | | | | | | | | | | | | |
| *Lemna minor* | | | | | | | | | | | | | | | |
| *Lemna trisulca* | | | | | | | | | | | | | | | |
| *Megalodonta Beckii* | | | | | | | | | 1 | 2 | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | | | | |
| *M.* | | | 1 | | | | | | | 3 | | | | | |
| *M.* | | | | | | | | | | | | | | | |
| *Musci* | | | | | | | | | | | | | | | |
| *Najas flexilis* | 2 | | | | | | 1 | 2 | 1 | | | | 1 | 3 | |
| *N.* | | | | | | | | | | | | | | | |
| *Nitella* | | | | | | | | | | | | | | | |
| *Nuphar variegatum* | | 2 | | | | | | | | | | | | | |
| *Nymphaea* | | 2 | | | | | | | | | | | | | |
| *Pontederia cordata* | | P | | | | | | | | | | | | | |
| *Polygonum natans* | | | | | | | | | | | | | | | |
| *Potamogeten amplifolius* | | | | | | | | | | 2 | | | | | |
| *P. gramineus* | | 2 | P | | | | | | | | | | | | |
| *P. praelongus* | | | | 2 | 3 | 1 | 3 | 1 | 1 | 1 | 2 | | | 1 | |
| *P. zosteriformes* | | 1 | 2 | 1 | 1 | | | ~~1~~ | 1 | 3 | ~~2~~ 2 | | | | |
| P. robbinsii | | P | 4 | 4 | | | | 1 | | | | | | | |
| P. richardsoni | | | 2 | | | | | | | 3 | | | | | |
| P. illinoensis | | | 4 | | | | | | | | | | | | |
| P. Sp. | | | | | 3 | | | | | | | | | 1 | |
| *Scirpus* validus | | 3 | P | | | | | | | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | | | | |
| *Spirodella polycarpum* | | | | | | | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | |
| *Utricularia* | | | | | | | | | | | | | | | |
| *Vallisneria americana* | 4 | 1 | | | | | | | | 1 | | | | | |
| *Wolffia columbiana* | | | | | | | | | | | | | | | |
| P. Sp. III | | | | | | 1 | 1 | 3 | 1 | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Depth to vegetation | | | 6in. | 4 | 6 | 11 | 6 | 4* | 3* | 1 | 5 | | 11 | | |
| % Open water @ 0.5' depth | 4.5 | 50 | | | | | | | | | | | | | |
| Water depth (ft) | 5 | 3 | 7 | 9 | 9.5 | 11.5 | 11 | 12 | 10.5 | 5 | 9.5 | 11 | 11.5 | [illegible] | 15 |
| Bottom type | GrS | S | m | m | m | M | M | M | M | S | M | M | M | m | [illegible] |

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(10.5')

NORTHERN LAKE SERVICE, INC.

MACROPHYTE SURVEY OF: Pine BY: RK & GAK ON: 7-30-92

| TAXA STATION | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brasenia Shreberi | | | | | | | | | | | | 1 | | | | |
| Ceratophyllum demersum | | 1 | 3 | 2 | 2 | 1 | | | 4 | 1 | | | | | | |
| Chara | | | | | | | 2 | | | 2 | | | | | | |
| Eleocharis acicularis | | | | | | | | | | | | | | | | |
| Elodea canadensis | 3 | 1 | 3 | 2 | | 3 | 2 | 3 | 3 | 2 | | | | | | |
| Heteranthera dubia | | | | | | | | | | | | | | | | |
| Juncus pelocarpus | | | | | | | | | 1 | | | | | | | |
| Lemna minor | | | | | | | | | | | | | | | | |
| Lemna trisulca | | | | | | | | | | | | | | | | |
| Megalodonta Beckii | | | | | | | | | | | | | | | | |
| Myriophyllum exalbescens | | | | | | | | | | | | | | | | |
| M. | P | 2 | | | | 1 | P | 4 | 1 | | | | | | | |
| M. | | | | | | | | | | | | | | | | |
| Musci | | | | | | | | | | | | | | | | |
| Najas flexilis | | | 3 | 2 | 1 | | 2 | | 3 | 3 | | | | | | |
| N. | | | | | | | | | | | | | | | | |
| Nitella | | | | | | | | | | | | | | | | |
| Nuphar variegatum | | | | | | | | | | | | | | | | |
| Nymphaea | | | | | | | | | | P | | | | | | |
| Pontederia cordata | | | | | | | | | | P | | | | | | |
| Polygonum natans | | | | | | | | | | | | | | | | |
| Potamogeten amplifolius | | | | | | | | 2 | 1 | | | | | | | |
| P. gramineus | | | | | | 2 | 1 | 2 | 3 | | | | | | | |
| P. praelongus | 2 | 3 | 1 | | | | | 1 | | | | | | | | |
| P. zosteriformes | 2 | 3 | 2 | | | 1 | 1 | 2 | 1 | 1 | | | | | | |
| P. robbinsii | 4 | 4 | 1 | | | | | | | | | | | | | |
| P. richardsoni | P | P | | | | 2 | | 2 | | 1 | | | | | | |
| P. illinoensis | | | | | | | | | | | | | | | | |
| P. sp. 2 w/u | | | | | | | | 1 | | | | | | | | |
| Scirpus Validus | | | | | | | | P | P | 1 | | | | | | |
| Sparganium eurycarpum | | | | | | | | | | | | | | | | |
| Spirodella polycarpum | | | | | | | | | | | | | | | | |
| Typha latifolia | | | | | | | P | | | | | | | | | |
| Utricularia | | | | | | | | | | | | | | | | |
| Vallisneria americana | | | | | | 2 | 2 | 2 | 4 | 2 | | | | | | |
| Wolffia columbiana | | | | | | | | | | | | | | | | |
| Isoetes | | | | | | | 3 | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Depth to vegetation | 2 | 1 | 6 | 10 | 11 | 1.5 | 3 | 1 | 3 | ~~95~~ | | | | | | |
| % Open water @ 0.5' depth | | | | | | | | | | 95 | | | | | | |
| Water depth (ft) | 4.5 | 9 | 9 | 10.5 | 11.5 | 4 | 5 | 6.5 | 6 | 2.5 | NM | | | | | |
| Bottom type | M | M | M | M | M | S | S | S | SR | S | [illegible] | | | | | |

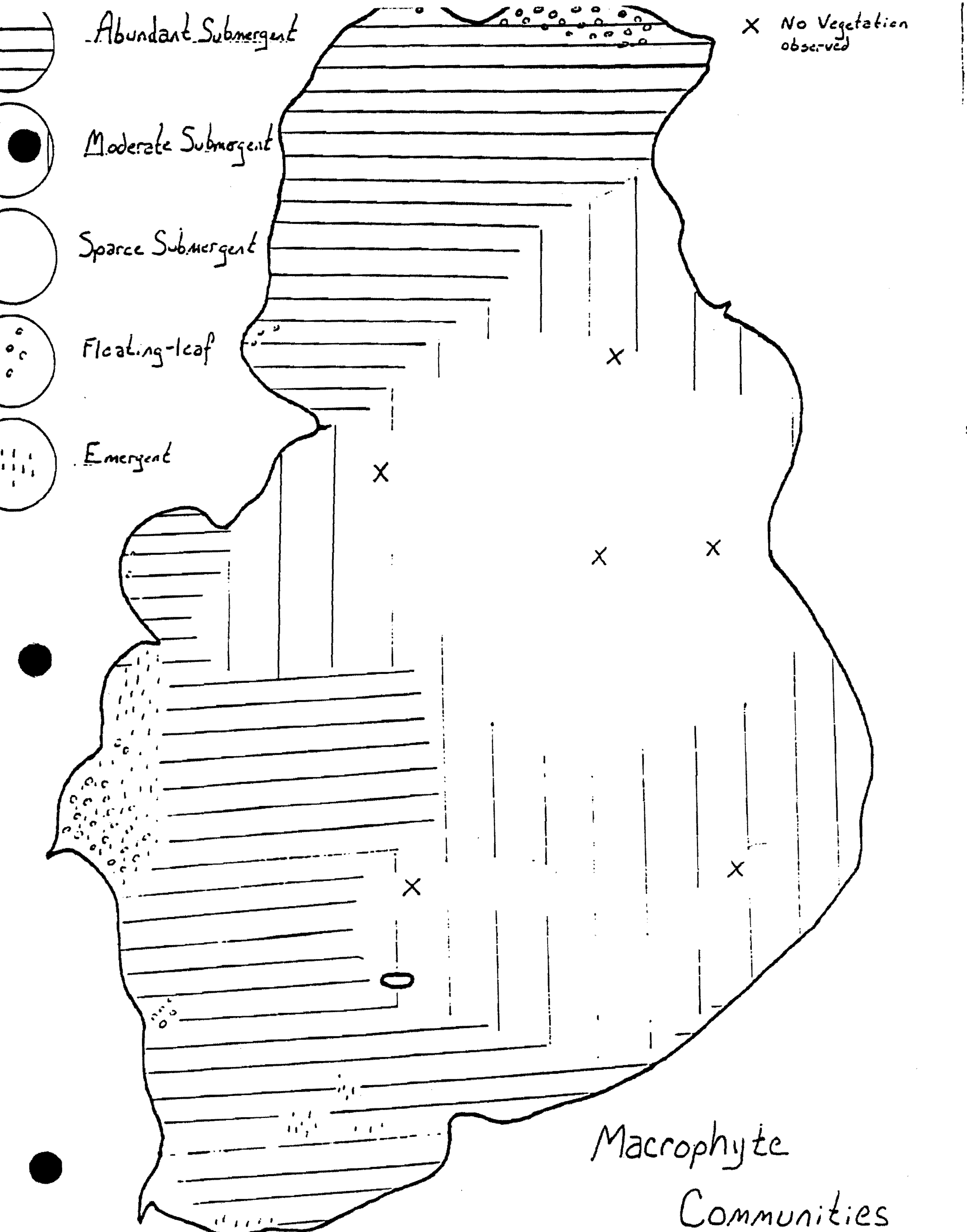
## PINE LAKE MACROPHYTE SPECIES LIST

| Species (common name) | Relative Frequency(%) | Average Density | Depth of Growth(ft.) |
|---|---|---|---|
| Brasenia shreberi (water shield) | 1.8 | 2 | 3.5 |
| Ceratophyllum demersum (coontail) | 76.4 | 2.2 | 3 - 13 |
| Chara (muskwort) | 3.6 | 2 | 2.5 - 5 |
| Eleocharis acicularis (spike rush) | 1.8 | 1 | 11.5 |
| Elodea canadensis (American elodea) | 44.0 | 2 | 2.5 - 11 |
| Isoetes (quillwort) | 1.8 | 3 | 5 |
| Lemna minor (lesser duckweed) | p | p | --- |
| Lemna trisulca (star duckweed) | 5.5 | 2.3 | 3 - 4 |
| Megalodonta beckii (water marigold) | 1.8 | 3 | 3 |
| Myriophyllum exalbescens (milfoil) | 20.0 | 1.8 | 3 - 8 |
| Najas flexilis (slender naiad) | 32.7 | 1.8 | 2.5 - 12 |
| Nitella (nitella) | 1.8 | 4 | 7 |
| Nuphar variegatum (yellow pond lily, spatterdock) | 5.5 | 2.7 | 3 - 3.5 |
| Nymphaea sp. (white water lily) | 3.6 | 3 | 3 |
| Pontedaria cordata (pickerel weed) | p | p | --- |
| Potamogeten amplifolius (large leaf pondweed) | 12.7 | 1.7 | 5 - 8.5 |
| P. berchtoldi (Berchtold's pondweed) | 9.1 | 2.2 | 8.5 - 12 |
| P. gramineus (variable pondweed) | 10.9 | 2 | 3 - 6.5 |
| P. foliosus (leafy pondweed) | 14.5 | 1.3 | 6.5 - 12.5 |

PINE LAKE MACROPHYTE SPECIES LIST

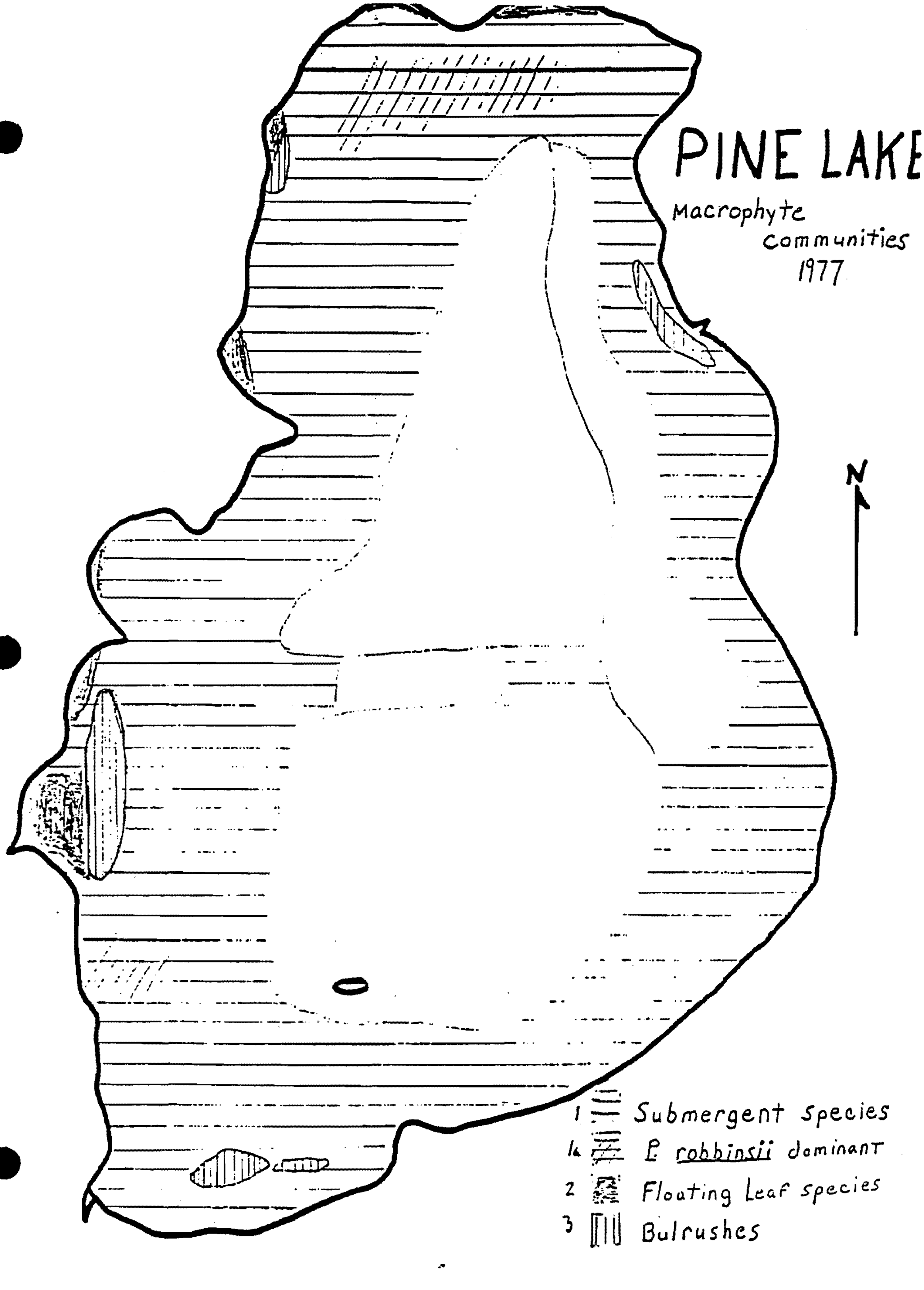
| Species (common name) | Relative Frequency(%) | Average Density | Depth of Growth(ft.) |
|---|---|---|---|
| P. illinoensis (Illinois pondweed) | 5.5 | 2.3 | 7 - 8.5 |
| P. praelongus (white stem pondweed) | 40.0 | 1.8 | 3 - 12 |
| P. richardsoni (Richardson's pondweed) | 25.5 | 1.6 | 2.5 - 12 |
| P. robbinsii (Robbin's pondweed) | 29.1 | 3.2 | 3 - 12 |
| P. zosteriformes (flat-stem pondweed) | 40.0 | 1.7 | 2.5 - 10.5 |
| Scirpus heterochaetus (slender bulrush) | 3.6 | 2 | 2.5 - 3 |
| Typha latifolia | p | p | --- |
| Utricularia vulgaris (bladderwort) | 1.8 | 1 | 3 |
| Vallisneria americana (eelgrass, wild celery) | p | p | --- |

Note: p=present, but not found at any numbered station.




Macrophyte Communities
1992

RTK/NLS 30


PINE LAKE
Macrophyte communities 1977
N
1 Submergent species
1a P. robbinsii dominant
2 Floating Leaf species
3 Bulrushes

## SPECIES GLOSSARY

Brasenia shreberi - Water shield; football-shaped floating leaves approximately 12 cm x 7 cm; thin, red stem attached to center of leaf; red waxy flower held about 1 cm above water surface; stem and underside of leaf extremely slimy.

Ceratophyllum demersum - Coontail; leaves 1 - 3.5 cm long, whorled on stems, palmately divided and serrated on one side; leaves crowded at tips of stems giving "coontail" effect.

Chara sp. - Muskwort; rigid, often brittle algae growing to 1 ft.; "leaves" simple, whorled around stems; plants reddish brown, yellow or green; strong musty smell when crushed.

Eleocharis acicularis - Needle rush; usually inconspicuous small grass-like plant; leaves linear ≈ 1 mm diameter to 10 cm long.

Elodea canadensis - American elodea; leaves 1-2 cm long by 1.5-3 mm whorled on stems in groups of 3's or 4's; whorls about 0.5-1 cm apart; stemn this, light colored and brittle; flowers, with extremely thin white petiole, float on surface.

Isoetes sp. - Quillwort; leaves 10-30 cm, grass-like, hollow, recurved pointed; leaf bases swollen clasping.

Lemna minor - Lesser Duckweed; consists of only small floating leaf with tiny white root. Leaf ≈ 3 mm diameter.

Lemna trisulca - Star Duckweed; small (≈ 7 mm) spatula-shaped segment connected to one another by "stalk" portion; each segment with one tiny root; plants often form large, tangled, sinking mats.

Megalodonta beckii - Water marigold; submerged leaves somewhat stiff finely dissected and crowded at the nodes; nodes 2-4 cm apart; stems ≈ 4 mm diameter; flower daisy-like, held above the water and very rare.

Myriophyllum exalbescens - Northern water milfoil; submerged leaves to 3 cm long, in whorls of 3,4, or 5, dissected into 6-10 pairs of thin segments form a central axis; flower small on a spike held above the water; floral bracts very small.

Naja flexilis - Slender naiad; leaves 1-3.5 cm long, opposite on stems, tapering to a slender pointed tip; leaf bases clasping; stems slender, flexible; plant ext. limp out of water.

Nitella sp. - large limp algae; dark green, almost transparent; "leaves" whorled on stems, with forked tips.

Nuphar variegatum - Yellow pond lily, spatterdock; leaves large (to 50 cm) oval, basal lobes rounded; stem stout, attached to leaf between basal lobes; flowers large (to 10 cm), yellow spherical.

Nymphaea odarata - white water lily; leaves large (to 40 cm) nearly circular; basal lobes pointed; stem stout attached to leaf between basal lobes; flower large (to 20 cm) with 25-50 waxy white petals surrounding yellow center.

Pontedaria cordata - Pickeral weed; leaves large (to 30 cm) heart-shaped, held upright above water; flowers numerous ≈ 2 cm, usually purple, held above water in a spike-like arrangement (to 10 cm).

Potamogeten amplifoliuos - Large-leaf pondweed; leaves to 20 cm, folded along midrib and recurved (banana-shaped); plants often turning brown; flowers on dense spike (to 8 cm) held above the water; stipules rigid, persistant (to 4 cm); often with elliptical floating leaves.

P. berchtoldi - Berchtolk's pondweed; inconspicuous small-leafed pondweed; leaves 1-5 cm x 1 mm, linear with 3 veins, paired glans at leaf bases; stems very slender with little or no branching.

P. gramineus - Variable pondweed; leaves variable usually to 7 cm x 8 mm somewhat bluntly tapered; veins 3-7, often several erect branching stems on runner-like horizontal stem; stipules persistant ≈ 2 cm long; fruits dense on 1-3 cm spike.

P. foliosus - Leafy pondweed; leaves usually 2-5 cm x 2.mm, linear 3-5 veins; stem slender with much branching; fruit spike spherical.

P. illinoensis - Illinois pondweed; leaves lanceolate to 20 cm veins 9-19; stipules persistant, rigid to 8 cm; stem stout, branching; fruits dense on 6 cm spike.

P. praelongus - White-stem pondweed; stems stout often whitish and zig-zag; leaves to 20 cm often with conspicuous white midvein, clasping; leaf tips rounded into boat shape which splits when pressed; stipules paper-like persistant ≈ 5 cm long; spike dense to 6 cm long.

P. richardsoni - Richardson pondweed; superficially very similar to p. praelongus; leaves to 10 cm, often with conspicuous white midvein, wavy leaf margins, clasping stems tapering to slender tip; stipules blunt, <u>not</u> persistant; stem usually white; floral spike to 3 cm.

P. robbinsii - Robbin's pondweed; leaves strongly two ranked (plant resembles a fern under water), stiff, ≈ 10 cm x 5 mm; stipules not persistant; stem slightly flattened usually unbranched.

P. zosterformes - Flat-stem pondweed; leaves linear to 20 cm x 5 mm; stem to 5 mm wide, strongly flattened slightly winged, limp; stipules to 3 cm; peduncle to 5 cm often curved.

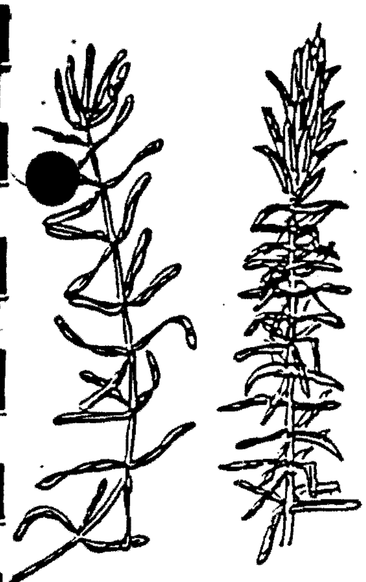
Scirpus sp. - Bulrush; stems simple, rigid, linear, erect to 2 m, round, mostly hollow; flowers spraying out from side of stem near tin (actually end of stem with bract).

Typha latifolia - Cattail; leaves sword-like to 2 m, stiff; slow to 3 m stiff, erect; flowers tiny crowed into large (to 20 x 5 cm) cigar-like spike.

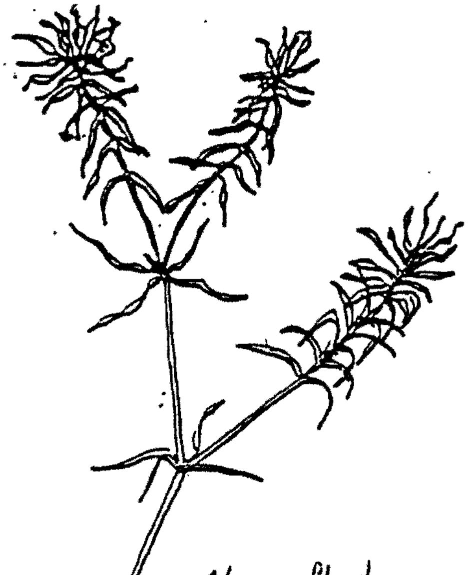
Utricularia vulgaris - Common bladderwort; leaves numerous, 1-3.5 cm, forked dissected into narrow segments- "net-like"; stems with many small egg-shaped bladders (≈ 2 mm) flowers conspicuous yellow, lipped, held above water; plant often not rooted but suspended in large masses.

Vallisneria americana - Eel grass, wild celery; leaves ribbon-like to 1 m x ≈ 1.5 cm wide; flowers, white ≈ 1 cm, floating on long, slender, spirally stem.

(These definitions have been written with regard to the species and variations of species found in Pine Lake, Forest County. It should not be relied upon as a key, especially on other lakes.)



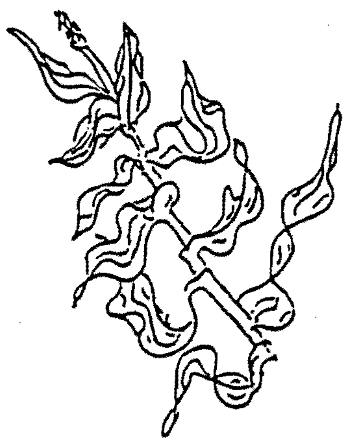
Elodea canadensis



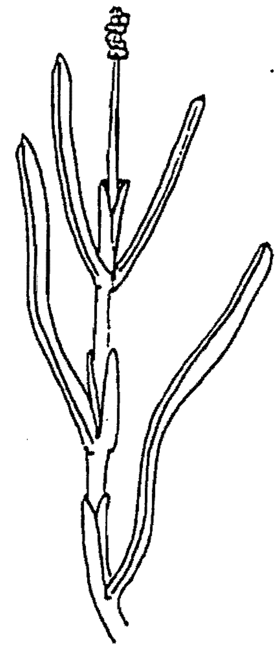
Najas flexilis

Potamogeton praelongus

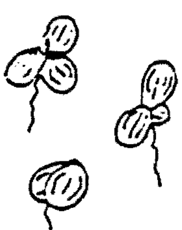
Potamogeton amplifolius



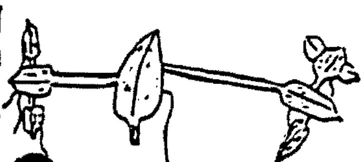
Potamogeton richardsonii



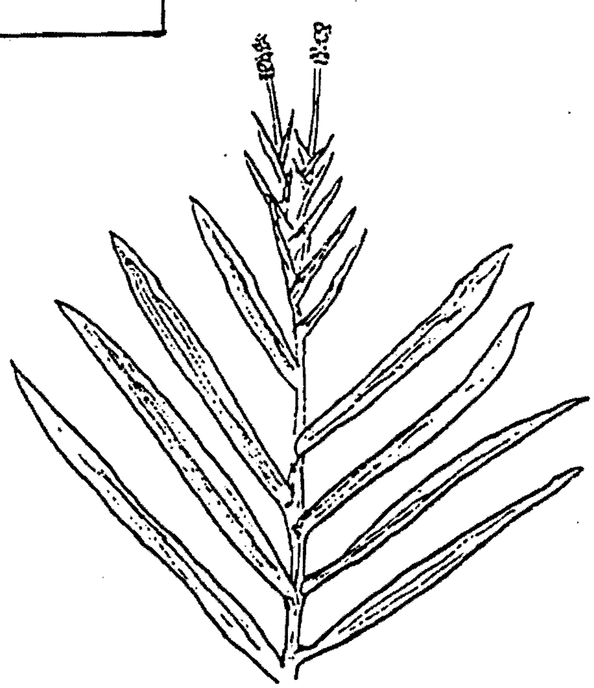
Potamogeton zosterformes



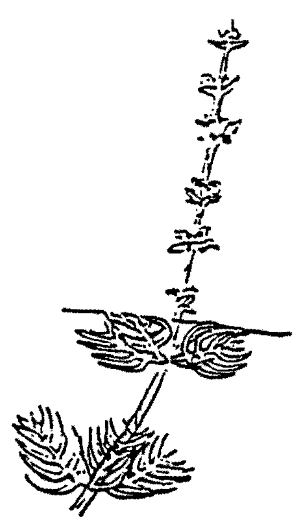
Lemna minor



Lemna trisulca

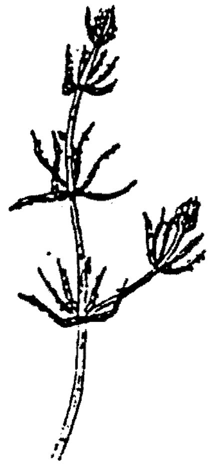


Potamogeton robbinsii

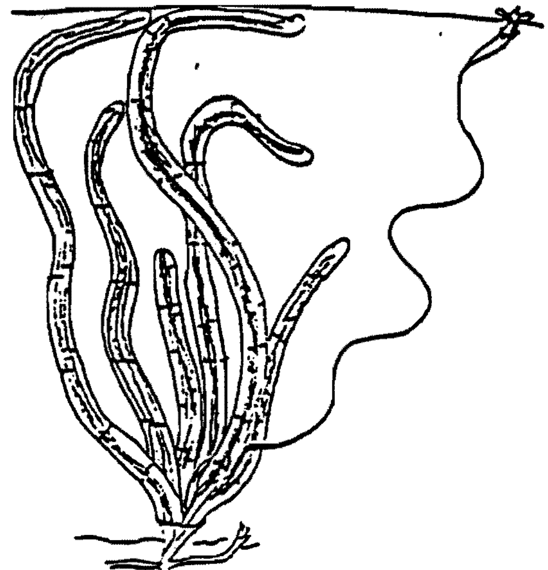


Myriophyllum exalbescens

Potamogeton gramineus

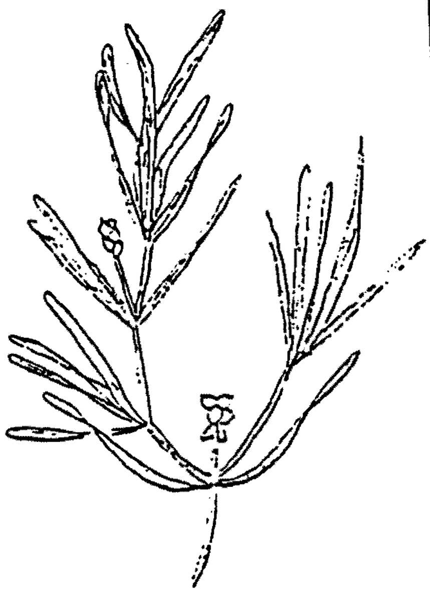


Chara sp

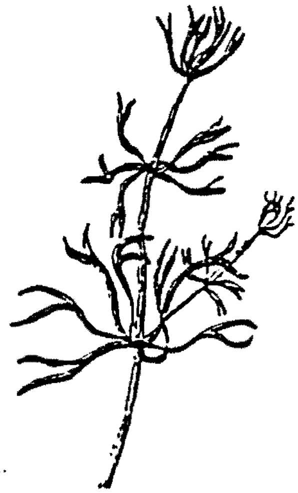


Vallisneria americana

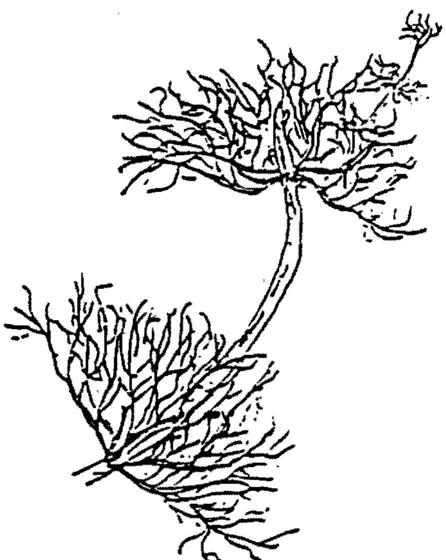

Ceratophyllum demersum



Potamogeton foliosus

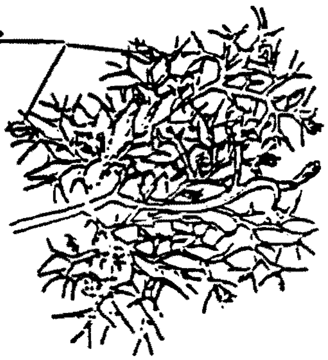


Nitella sp

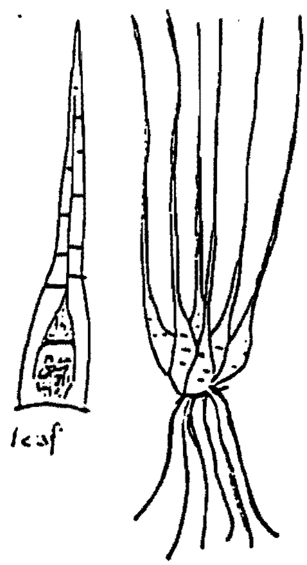


Megalodonta beckii

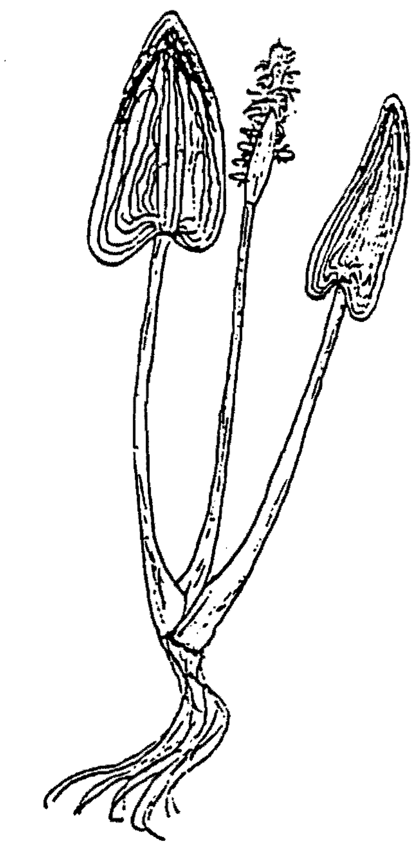
bladders



Utricularia vulgaris




Isoetes sp



Pontederia cordata

# Analytical Results

Appendix B

| | 5/8 | 7/30 | 11/11 |
|---|---|---|---|
| Conductivity umbo (@25c) | 85 | 90 | 87 |
| pH (s.u.) | 7.4 | 7.4 | 5.9 |
| Alkalinity (mg/l) | 34 | 38 | 36 |
| Chloride (mg/l) | < 1 | < 1 | 3 |
| Nitrogen, ammonia (mg/l) | < 0.05 | 0.08 | < 0.05 |
| Nitrogen, $NO_2$ & $NO_3$ (mg/l) | (0.05 | 0.08 | 0.11 |
| Nitrogen, Kjeldahl (mg/l) | 0.62 | 0.46 | 0.45 |
| Phosphorus, total (mg/l) | 0.032 | 0.022 | 0.018 |
| Secchi disc (ft.) | 5.7 | 7.7 | 9.9 |

| Chlorophyll | CCa α | Pheo α | TC α | TCb | TCc |
|---|---|---|---|---|---|
| 05/08/92 | 10.12 | 3.82 | 12.76 | 0.666 | 1.72 |
| 07/30/92 | 5.70 | 0.73 | 6.34 | 0.15 | 0.72 |

CC α = Corrected Chlorophyll

Pheo α = Pheophytin α

TC α = Trichromatic Chlorophyll α

TCb = Trichromatic Chlorophyll b

TCc = Trichromatic Chlorophyll c

unit = ug/l

## Dissolved Oxygen/Temperature

| | 5/8/92 | 7/30/92 | 11/11/92 |
|---|---|---|---|
| 0.1 m | 10.7/10.4° | 8.0/21.8° | 11.8/1.9 |
| 1 | 10.6/10.4° | 8.0/20.8° | 11.9/1.9 |
| 2 | 10.5/10.1° | 7.7/20.4° | 11.9/1.9 |
| 3 | 10.1/9.8° | 7.5/20.1° | 11.7/1.9 |
| 4 | 3.5 bottom | 3.5 bottom | 11.2/1.9 |
| | | | 4.5 bottom |

## Winter DO/Temp.

| | 02/25/93 | 03/28/93 site A | 03/28/93 site B |
|---|---|---|---|
| 0.1m | 12.7/0.7 | 5.7/1.1 | 6.6/1.3 |
| 1 | 9.3/2.6 | 2.3/4.4 | 4.0/4.1 |
| 2 | 1.5/3.9 | 2.2/4.7 | 2.3/4.4 |
| 3 | 0.7/4.6 | | 2.3/4.8 |
| | 3.5 bottom | | 3.5 bottom |