KANGAROO LAKE

DOOR COUNTY, WISCONSIN

COMPREHENSIVE LAKE MANAGEMENT PLAN

Prepared for the

Kangaroo Lake Association

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NES Ecological Services

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SUMMARY

A comprehensive study of Kangaroo Lake, Door County, Wisconsin (Figure 1) was completed during 2003 and 2004. The study was completed to provide information concerning the lake and its watershed so a comprehensive lake management plan could be written for the lake. Funding for this study and the development of the plan was provided by the Wisconsin Department of Natural Resources Lake Management Grant Program and the Kangaroo Lake Association.

Data from this study were analyzed with data collected during past studies and yielded the following major results:

- Current and historic water quality analysis indicates that the water quality of Kangaroo Lake has fluctuated over the past decades, but has primarily been fair to good.
- The current trophic state of Kangaroo Lake is on the upper *mesotrophic* level.
- Kangaroo Lake was not found to stratify during the summer and winter months which does not allow the hypolimnion to become anoxic; therefore, fishkills are not a concern nor is internal phosphorus loading.
- Although Kangaroo Lake does not have a highly diverse plant community that is indicative of an undisturbed system, Floristic Quality Assessment analysis indicates that it is of higher quality than most lakes in the ecoregion and state.
- Although there are a number of desirable emergent and floating-leaf aquatic species found in and around Kangaroo Lake, their infrequency throughout the entire lake is likely the result of a combination of shoreland development and recreational boating.
- Anecdotal data from long-term lake residents and the WDNR indicates that there has been a drastic decline in bulrush populations over the past two to three decades. This decline is likely the result of shoreland development and *motorboat** traffic.
- Watershed analysis and modeling indicated that the majority of the lake's external phosphorus load originates from agricultural areas.

An action plan was developed to guide the future management efforts for Kangaroo Lake and included alternatives addressing lake water quality, aquatic plant restoration and protection, watershed issues, and the continued education of stakeholders.

*Within this document, the term "motorboat" refers to any motorized watercraft, including personal watercraft (also known as Jet Skis). Please see the glossary entry for "motorboat" for more information.

INTRODUCTION

Kangaroo Lake, Door County is a shallow, (maximum depth: 12', average depth: 6') 1,123-acre, natural, drainage lake with its water level controlled by a dam at its southeast end. The Kangaroo Lake Association (KLA), incorporated in 1969, has worked diligently to improve and protect the lake, its watershed, and its fishery. They have worked with the Wisconsin Department of Natural Resources (WDNR), and the Towns of Jacksonport and Baileys Harbor to designate portions of the lake's south end as a slow-no-wake zone to protect the few remaining bulrushes (*Schoenoplectus sp.)* that exist there from the detrimental effects of motorboats. The KLA, with support from the WDNR has also set up a voluntary slow-no-wake zone extending 500' from the lake's shore into open water. This zone is intended to slow the spread of Eurasian water-milfoil (*Myriophyllum spicatum*), to protect the lake's silty bottom from resuspension, and protect the remaining native aquatic plants within the lake. Members of the KLA also made financial contributions and applied for additional funds through a Knowles-Nelson Habitat Restoration Grant to place 31 fish cribs throughout Kangaroo Lake.

Recently, the KLA has become concerned with the loss of valuable, native aquatic plants, the spread of exotic plants, the effects of motorboats, and with non-point pollution impacts from the lake's watershed. In order to address these issues, the KLA voted to proceed with the development of a *Comprehensive Lake Management Plan* for Kangaroo Lake and its watershed. The project included studies concerning the lake's watershed, its plant communities, and its water quality. Furthermore, an educational component was incorporated within the project to raise awareness of the lake and its associated ecosystem among association members and other stakeholders. Public participation was an integral component in the development of the plan; pertaining to both the education of the stakeholders and in their input during the development of an *Action Plan*.

Notes on the Format of this Document

This document serves two purposes; 1) it fulfills the requirements for final reporting of a study that was partially funded through the Wisconsin Department of Natural Resources' (WDNR) Lake Planning Grant Program, and 2) it is the Lake Management Plan for Kangaroo Lake. Care has been taken to keep the technical aspects of the document on laymen's terms as much as possible. To facilitate the ease of reading, certain topics are expanded upon and technical terms are defined in a glossary. Furthermore, the reporting of specific data is kept to a minimum within the text but is wholly contained within the appendices. The appendices also contain the glossary mentioned above (Appendix E) (terms contained in the glossary are italicized within the text).

The study contained four major components; watershed analysis, aquatic vegetation, water quality, and education. Each section of the report and plan are generally separated into these four components.

For ease of reading and document compilation, the large format (11"x17") maps are contained near the end of this report.

RESULTS AND DISCUSSION

Lake Water Quality

Judging the quality of lake water can be difficult because lakes display problems in a multitude of ways. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region, and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water. To complete this task, three water quality parameters are focused upon:

1. **Phosphorus** is a nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the growth rates of the plants within the lake.

2. **Chlorophyll-*a*** is the pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations indicate algal abundance within a lake.

3. **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring lake health. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural, Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water.

Each of these parameters is also directly related to the *trophic state* of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: *oligotrophic*, *mesotrophic*, and finally *eutrophic*. Every lake will naturally progress through these states; however, under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not give clear indication of where a lake really exists in its trophic progression. To solve this problem, the parameters measured above can be used in an index that will indicate a lake's trophic state more clearly and provide a means for which to track it over time.

The complete results of these three parameters and the other chemical data that were collected at Kangaroo Lake can be found in Appendix A. The results and discussion of the analysis and comparisons described above can be found in the paragraphs and figures that follow.

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Door County lakes are included within the study's Southeast Region and are among 61 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide means, historical, current, and average data from Kangaroo Lake are displayed in Figures 2-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August) in the deepest location in the lake (Figure 1). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see section on internal nutrient loading).

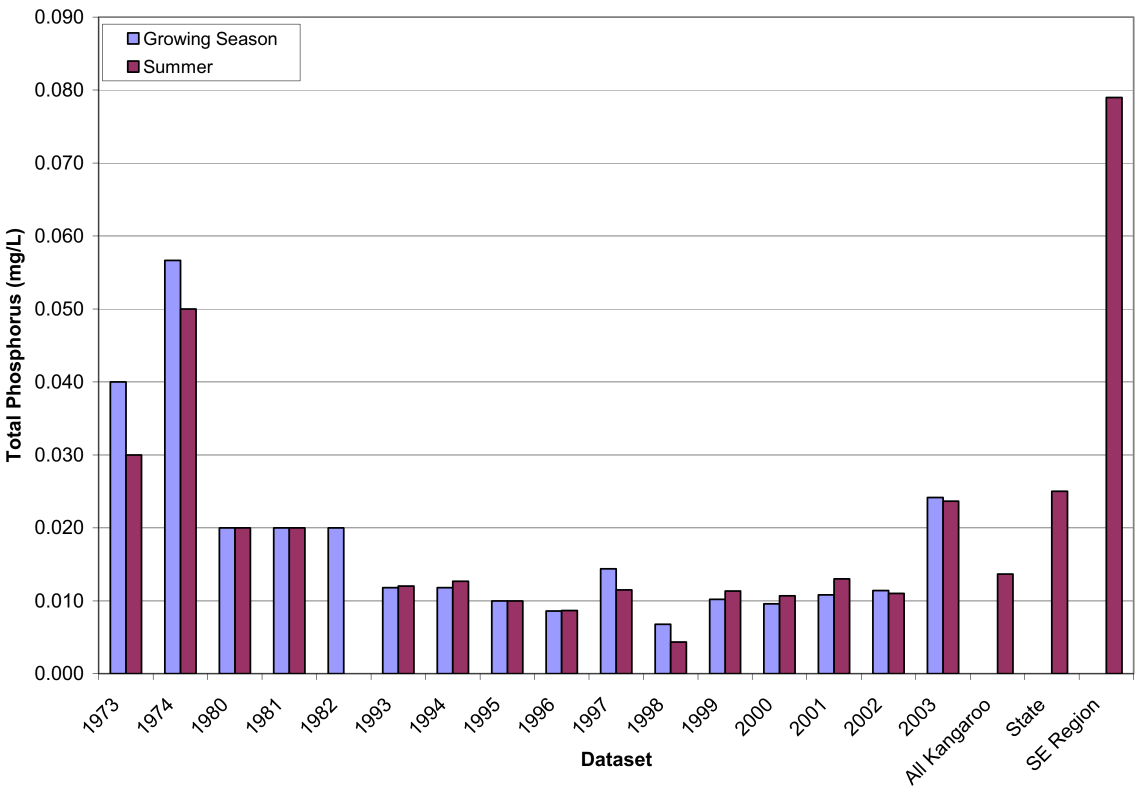

Figure 2. Mean total phosphorus concentrations from Kangaroo Lake, state and southeast region. All means were calculated from surface samples. Growing season includes April-October measurements

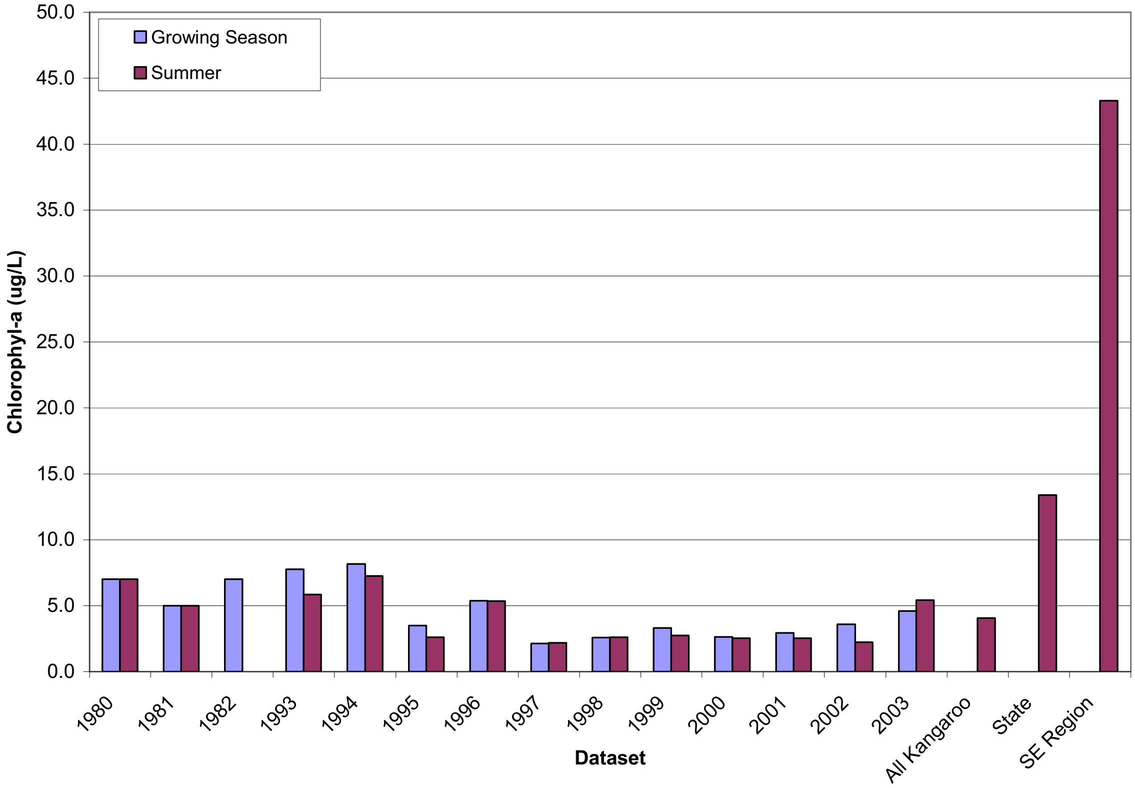

Figure 3. Mean chlorophyll-*a* concentrations from Kangaroo Lake, state and southeast region. All means were calculated from surface samples. Growing season includes April-October measurements

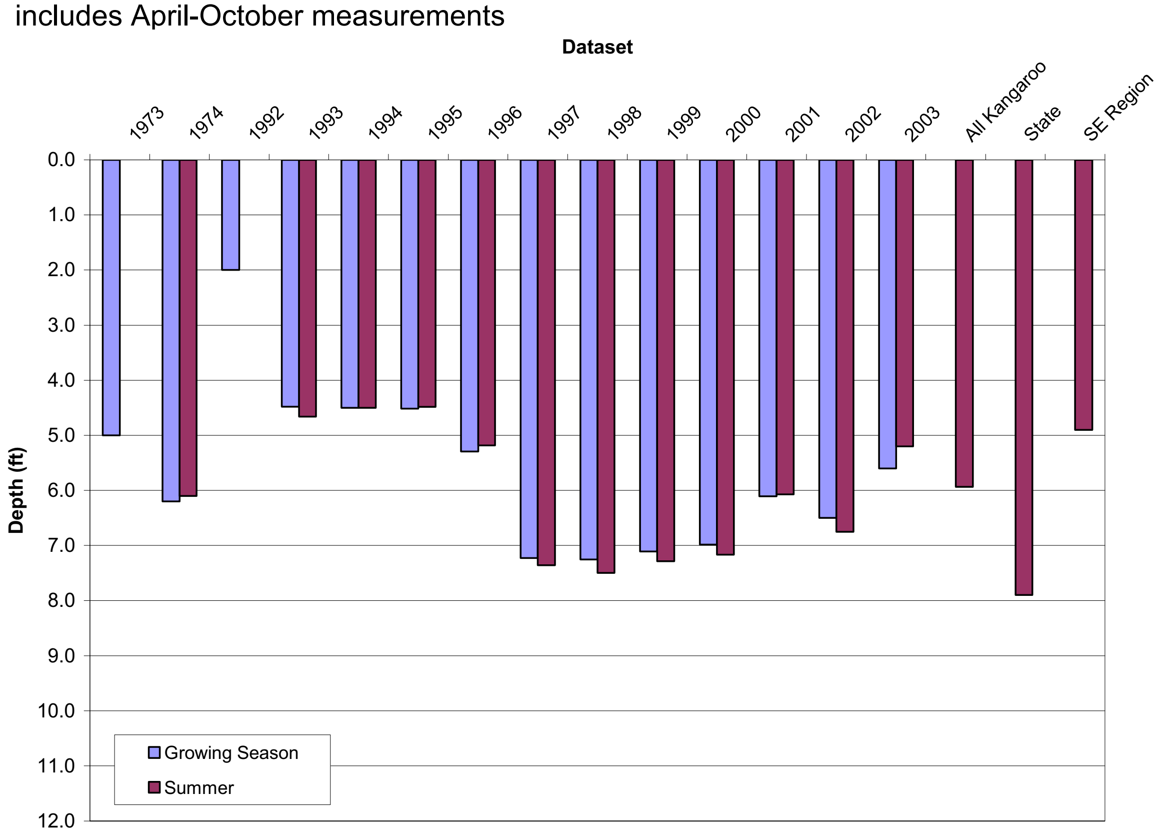

Figure 4. Mean Secchi disk transparencies from Kangaroo Lake, state and southeast region. Growing season includes April-October measurements

Examination of the graphs reveals that although all three parameters fluctuate from year to year, they mostly fall in the “Fair-Very Good” range within the Water Quality Index (WQI) developed by Lillie and Mason (1983) (Table 1). Fluctuations and even occasional spikes are normal within these parameters because so many factors affect them. Precipitation, cloud-cover, nutrient forms (particulate, dissolved), lake use, among others, all determine the concentration of chlorophyll-*a* and phosphorus and affect water clarity. Even the timing of the samples can lead to slight differences within a season. The differences are not unusual, but are an excellent example of how parameter values can fluctuate and amplify how important a long-term data set is to the management of a lake.

Table 1. Water Quality Index (WQI) developed by Lillie and Mason (1983) for Wisconsin Lakes.

	Approximate Equivalents				
WQI	**Water Clarity (m)**	**Water Clarity (ft)**	**Chlorophyll-a (µg/l)**	**Total Phosphorus (mg/l)**	**WTSI***
Excellent	>6	>19.7	<1	<0.001	>34
Very Good	3.0-6.0	9.8-19.7	1-5	0.001-0.010	34-44
Good	2.0-3.0	6.6-9.8	5-10	0.010-0.030	44-50
Fair	1.5-2.0	4.9-6.6	10-15	0.030-0.050	50-54
Poor	1.0-1.5	3.3-4.9	15-30	0.050-0.150	54-60
Very Poor	<1.0	<3.3	>30	>0.150	<60

*Calculated from water clarity values.

Overall, when compared to the WQI values in Table 1, the data found in Figures 2-4 indicate that the water quality of Kangaroo Lake is relatively good and that there is no clear evidence of major changes in water quality over the past 30 years. The higher average levels of phosphorus found during the mid 1970’s are unusual, especially when compared to Secchi disk data from the same period. Following the interrelationship discussed above, we would expect Secchi disk transparencies to decrease as phosphorus levels increase. Examination of Figures 2 and 4 indicate the contrary as the mean Secchi disk depths in 1974 were actually deeper than those from 1973 when phosphorus levels were lower. Data collected during 1973 and 1974 were limited, with only two surface samples occurring during the growing season in 1973 and three in 1974. Unfortunately, no summer Secchi disk data were collected during 1973 (the only sample is from October). The 1974 data is highly variable with the spring phosphorus sample being very low at 0.01 mg/l and the fall sample being unusually high at 0.11 mg/l. The Secchi disk transparencies for these samples were again highly variable at 9.0-feet and 3.5-feet, respectively. In the short-term, they follow the phosphorus-water clarity relationship, but tend to skew the means data as displayed in Figures 2 and 4. The outlying value for the Fall 1974 sample, if accurate, likely occurred following a heavy fall storm that temporarily raised the sediment and phosphorus levels in the lake and in the end skewed the means data to indicate a much worse water quality condition than actually occurred at the lake during the entire year.

Lake Trophic State and Limiting Nutrient

Figure 5 contains the Wisconsin Trophic State Index (WTSI) (Lillie, et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in Kangaroo Lake. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. In essence, a trophic state index is a mathematical procedure that assigns an index number that corresponds to a lake's trophic state based upon three common lake parameters; chlorophyll-*a*, Secchi disk transparency, and total phosphorus. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Self-Help Volunteers. Using an index, such as the WTSI, allows the trophic state of a lake to be more easily understood and tracked by professionals and laypersons.

Based upon total Secchi disk transparencies, the trophic state of Kangaroo Lake fluctuates within the upper mesotrophic and lower eutrophic levels; however, examination of the WTSI values calculated with chlorophyll-*a* and phosphorus concentrations indicate that the lake fluctuates more in the mesotrophic state. Carlson (1977) suggests that for TSI calculations using summer samples, as ours do, that chlorophyll-*a* produces the best indication of lake trophic status. With that in mind, we would have to conclude that Kangaroo Lake is on the upper end of mesotrophic.

In most of Wisconsin's lakes, phosphorus is considered the *limiting nutrient* and Kangaroo Lake is no exception. Data collected during the summer of 2003 indicate a nitrogen to phosphorus ratio of 41:1. Lakes with ratios exceeding 15:1 are considered to be phosphorus limited. Obviously, Kangaroo Lake is highly phosphorus limited.

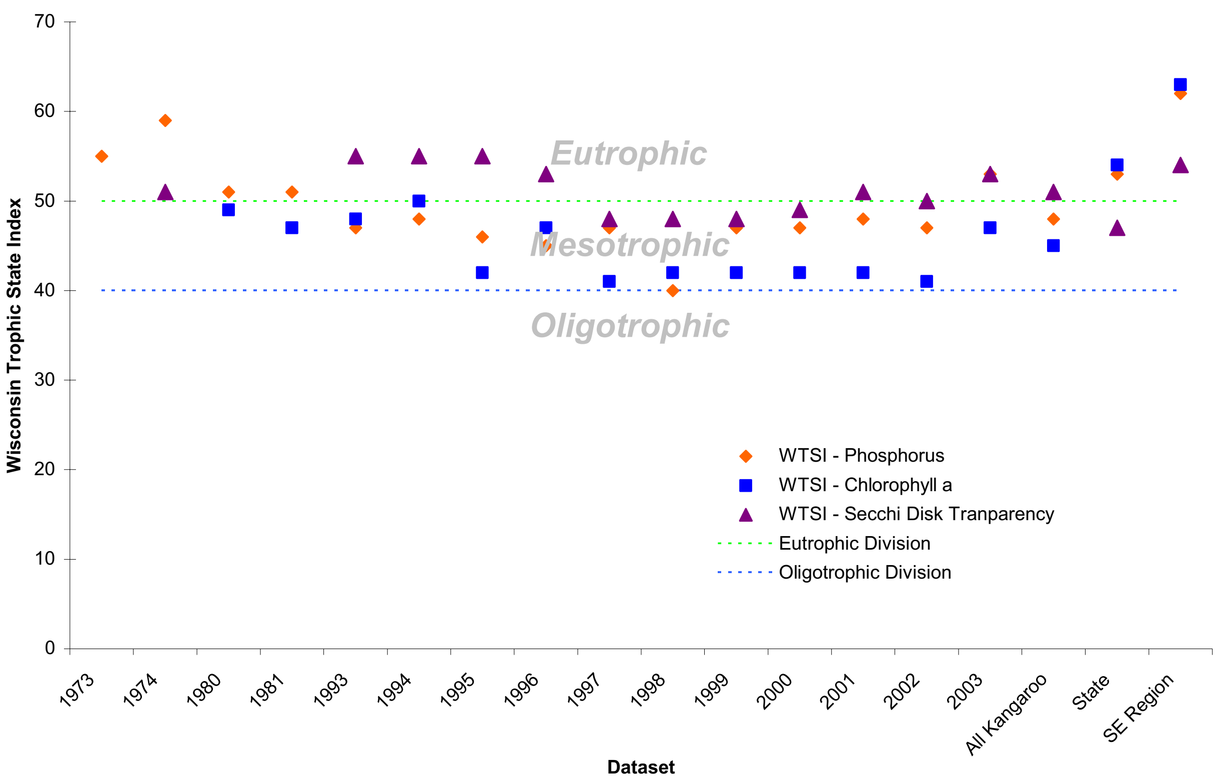

Figure 5. Wisconsin Trophic State Index results for Kangaroo Lake.

Temperature and Dissolved Oxygen

Six temperature and dissolved oxygen profiles were completed at Kangaroo Lake during 2003 (Figure 6). During each of these events, the lake was well-mixed and exhibited sufficient oxygen levels to support its fishery. This is good news considering the shallow and mesotrophic nature of Kangaroo Lake. Often, shallow lakes demonstrate *anoxic* conditions during the winter, which in turn, may lead to fishkills. At this time, there appears not to be a danger of fishkills at Kangaroo Lake.

Internal Phosphorus Loading

In lakes that have strong stratification, the *hypolimnion*, can become *anoxic* both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae. This cycle continues year after year and is termed “internal phosphorus loading;” a phenomenon that can support nuisance algae blooms decades after external sources are controlled. Internal nutrient loading is especially troubling in seepage lakes because the nutrients are not flushed out of the system, but remain to be recycled every year.

As described above, it appears that Kangaroo Lake does not stratify at any time during the year; therefore, it does not have the opportunity to become *anoxic*. In turn, this prevents the lake from experiencing large amounts of internal loadings from its sediment.

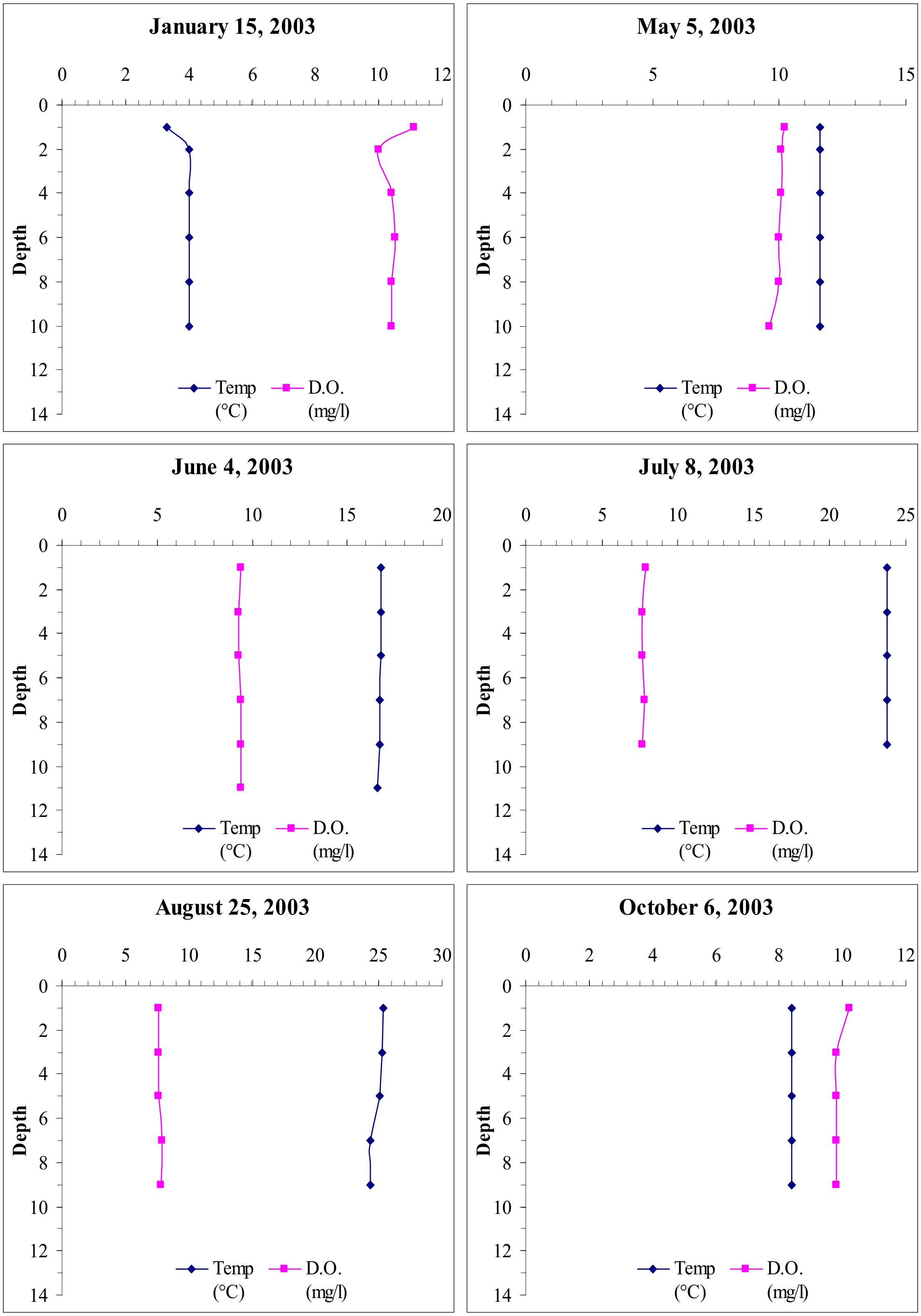

Figure 6. Results of temperature and dissolved oxygen profiles for Kangaroo Lake.

Aquatic Vegetation

Although many lake users consider aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, they are actually an essential element in a healthy, functioning lake ecosystem. It is very important that the lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative affects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Zizania palustris*) both serve as excellent food sources for ducks and geese. In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas were plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced numbers of predator fish and a stunted pan-fish population. *Exotic* plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing *native* plants and reducing *species diversity*. These *invasive* plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant biomass negatively affects the lake ecosystem and limits the use of the resource, plant management may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods.

Aquatic Plant Management and Protection

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, grass carp (*Ctenopharyngodon idella*) are illegal in Wisconsin and rotovation is not commonly used. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below. **Although all of these techniques may not be applicable to Kangaroo Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why they are or are not applicable.**

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many new aquatic plant management regulations. The rules for the new regulations have been set forth by the WDNR as NR 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now; including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet along the shoreline and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within the 30 feet. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban

landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects. The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreline. Removal of native plants from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreline sediments vulnerable to wave action caused by boating and wind. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife.

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a *shoreland buffer zone.* The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some the shoreland's natural function.

Enhancement activities also include additions of *submergent*, *emergent*, and *floating-leaf* plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), measures used to protect the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,050.

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35’ x 100’.
  - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
  - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.

Advantages

Improves the aquatic ecosystem through species diversification and habitat enhancement.
Assists native plant populations to compete with exotic species.
Increases natural aesthetics sought by many lake users.
Decreases sediment and nutrient loads entering the lake from developed properties.
Reduces bottom sediment resuspension and shoreline erosion.
Lower cost when compared to rip-rap and seawalls.
Restoration projects can be completed in phases to spread out costs.
Many educational and volunteer opportunities are available with each project.

Disadvantages

Property owners need to be educated on the benefits of native plant restoration before they are willing to participate.
Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in.
Monitoring and maintenance are required to assure that newly planted areas will thrive.
Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The other cutting method entails a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent rerooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from \$85 to \$150. Power-cutters range in cost from \$1200 to \$11,000.

Advantages

Very cost effective for clearing areas around docks, piers, and swimming areas.
Relatively environmentally safe if treatment is conducted after June 15th.
Allows for selective removal of undesirable plant species.
Provides immediate relief in localized area.
Plant biomass is removed from waterbody.

Disadvantages

Labor intensive.
Impractical for larger areas or dense plant beds.
Subsequent treatments may be needed as plants recolonize and/or continue to grow.
Uprooting of plants stirs bottom sediments making it difficult to harvest remaining plants
May disturb *benthic* organisms and fish-spawning areas.
Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant recolonization on top of the screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation costs vary greatly depending on the size of the area to be covered and the depth of overlaying water.

Advantages

Immediate and sustainable control.
Long-term costs are low.
Excellent for small areas and around obstructions.
Materials are reusable.
Prevents fragmentation and subsequent spread of plants to other areas.

Disadvantages

Installation may be difficult over dense plant beds.
Installation in deep water may require SCUBA.
Not species specific.
Disrupts benthic fauna.
May be navigational hazard in shallow water.
Initial costs are high.
Labor intensive due to the seasonal removal and reinstallation requirements.
Does not remove plant biomass from lake.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive.

Advantages

Inexpensive if outlet structure exists.
May control populations of certain species, like Eurasian water-milfoil for up to two years.
Allows some loose sediments to consolidate.
May enhance growth of desirable emergent species.

Other work, like dock and pier repair and/or dredging may be completed more easily and at a lower cost while water levels are down.

Disadvantages

May be cost prohibitive if pumping is required to lower water levels.
Drastically upsets lake ecosystem with significant affects on fish and other aquatic wildlife.
Adjacent wetlands may be altered due to lower water levels.
Disrupts recreational, hydroelectric, irrigation and water supply uses.
May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*).
Unselective.

Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor.

Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the later route is chosen, it is very important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages

Immediate results.
Plant biomass and associated nutrients are removed from the lake.
Select areas can be treated, leaving sensitive areas intact.

Plants are not completely removed and can still provide some habitat benefits.
Opening of cruise lanes can increase predator pressure and reduce stunted fish populations.
Harvested plant materials produce excellent compost.

Disadvantages

Initial costs and maintenance are high if the lake organization intends to own and operate the equipment.
Multiple treatments may be required during the growing season because lower portions of the plant and root systems are left intact.
Many small fish, amphibians and invertebrates may be harvested along with plants.
There is little or no reduction in plant density with harvesting.
Invasive and exotic species may spread because of plant fragmentation associated with harvester operation.
Larger harvesters are not easily maneuverable in shallow water or near docks and piers.
Bottom sediments may be resuspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

1. *Contact herbicides* act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality.

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment; so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Irrigation restrictions apply.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a *surfactant* to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*).

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothal (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothal (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, Aqua-Kleen®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions apply.

Advantages

Herbicides are easily applied in restricted areas, like around docks and boatlifts.
If certain chemicals are applied at the correct dosages, they can selectively control certain invasive species, such as Eurasian water-milfoil.
Some herbicides can be used effectively in spot treatments.

Disadvantages

Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly.
Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them.
Many herbicides are nonselective.
Most herbicides have a combination of use restrictions that must be followed after their application.
Many herbicides are slow-acting and may require multiple treatments throughout the growing season.

Cost

Herbicide application charges vary greatly between $400 to $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, Wisconsin's climate is a bit harsh for these two invasive plants, so we do not use either biocontrol insect. However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water-milfoil. Wisconsin is also using two species of leaf-eating beetles

(*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These biocontrol insects are not covered here because purple loosestrife is predominantly a wetland species.

Advantages

Milfoil weevils occur naturally in Wisconsin.
This is likely an environmentally safe alternative to controlling Eurasian water-milfoil.

Disadvantages

Stocking and monitoring costs are high.
This is an unproven and experimental treatment.
There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Cost

Stocking with adult weevils costs about $1.00/weevil and they are usually stocked in lots of 1000 or more.

Nutrient Reduction

Every plant, whether it is algal or vascular, requires nutrients to grow. The three primary, macronutrients include phosphorus, nitrogen, and carbon. Under normal conditions, lakes in Wisconsin are phosphorus limited and occasionally, nitrogen limited. If more of the nutrient is added to the system, the plant population expands; if the nutrient is taken away, the plant population decreases. However, rooted, vascular plants will not respond to nutrient reductions in the open water as quickly as algal populations will because they have the ability to take up nutrients from the sediment, and unfortunately, there is not a method currently available that will reduce or deactivate phosphorus and nitrogen in lake sediments. Nevertheless, it should be the goal of every lake organization to promote the minimization of all sources of nutrients and pollution entering the lake, whether they are in the form of a *nonpoint-source pollution* like runoff from agricultural and residential lands or *point-source pollution*, like an agricultural drain tile or storm sewer outfall. The reduction of these pollutants will slow the filling of the lake and reduce plant growth in the long-term.

Analysis of Current Aquatic Plant Data

The Floristic Quality Assessment (FQA) indicates that Kangaroo Lake has a relatively high quality plant community that is made up of many species that are normally found in somewhat disturbed systems. Essentially, the FQA uses species conservatism, or a species' likelihood of occurring in an undisturbed system, along with the number of native species found in the lake to calculate the system's Floristic Quality Index (FQI) (see the Methods section for a detailed description of the FQA). The average species conservatism for the survey data from this study is slightly lower than that calculated for the state and even with that found in the Southeastern Wisconsin Till Plains Ecoregion (Figures 7 and 8). This means that the species that were located in the lake are likely to be found in more disturbed systems – systems with development and other forms of *anthropogenic* influences. However, the great variety of species found during the 2003 survey resulted in a high FQI for the lake, indicating that although the lake is moderately disturbed, it still supports an aquatic plant community of higher quality.

Unfortunately, although there is a great variety of aquatic plants associated with Kangaroo Lake (Table 2), the occurrences of most plants within the lake are quite low (Figure 9) as are their coverages (Figure 10). Considering that the substrate types and water depths of the *littoral zone* are very similar for the entire lake, it would be expected that these species would occur in greater frequencies throughout the lake instead of just a few locations and in limited numbers (Figure 11). Anecdotal information from long-term lake residents indicate that there were greater occurrences of emergent and floating-leaf species in the lake at one time. This is especially true for bulrushes, an emergent plant that was once very common within Kangaroo Lake. Examination of Figure 12 presents two important observations; 1) there has been a drastic decline in bulrush occurrence at Kangaroo Lake, and 2) those populations that do currently occur, are likely remnants of the historic stands. The decline in bulrush occurrence within the lake is likely attributable to two primary factors; 1) continued development of the lake's natural shorelands, and 2) impacts due to recreational motor boating. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. They also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines. Many studies have documented the adverse affects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic.

Figure 7. Location of Kangaroo Lake relative to the ecoregions of Wisconsin after Nichols 1999 and Omernick and Gallant 1988.

The negative affects of motorboats are amplified in shallow lakes such as Kangaroo Lake because so much of their bottom substrates are exposed to hull and propeller turbulence. Sediment disturbance has been documented at depths up to 10-feet; however, most impacts are observed in waters 6-feet deep or less (Asplund 2000, Hill and Beachler 2001 (as referenced in Dudiak and Korth 2002)). Using the 7-foot contour of Kangaroo Lake as a guide, this means that over 44% of the south basin's acreage is susceptible to the affects of motorboat disturbance. This is a significant area of exposure and has likely contributed to not only the decreased plant abundances and diversity in the southern portion of the lake, but also the perceived increases in turbidity that many lake users have reported (Szymanski 1996). The increased turbidity cannot only be attributed to the effects motorboat traffic because research has shown that those increases are relatively short-lived, lasting only a day or two and are most prevalent on weekends and holidays with higher boat traffic (Asplund 1996). Therefore, a portion the increased turbidity is likely the result of wind-resuspension. However, this scenario leads us right back to motorcboat activity because they are likely the factor that has reduced the occurrence of bulrush and other

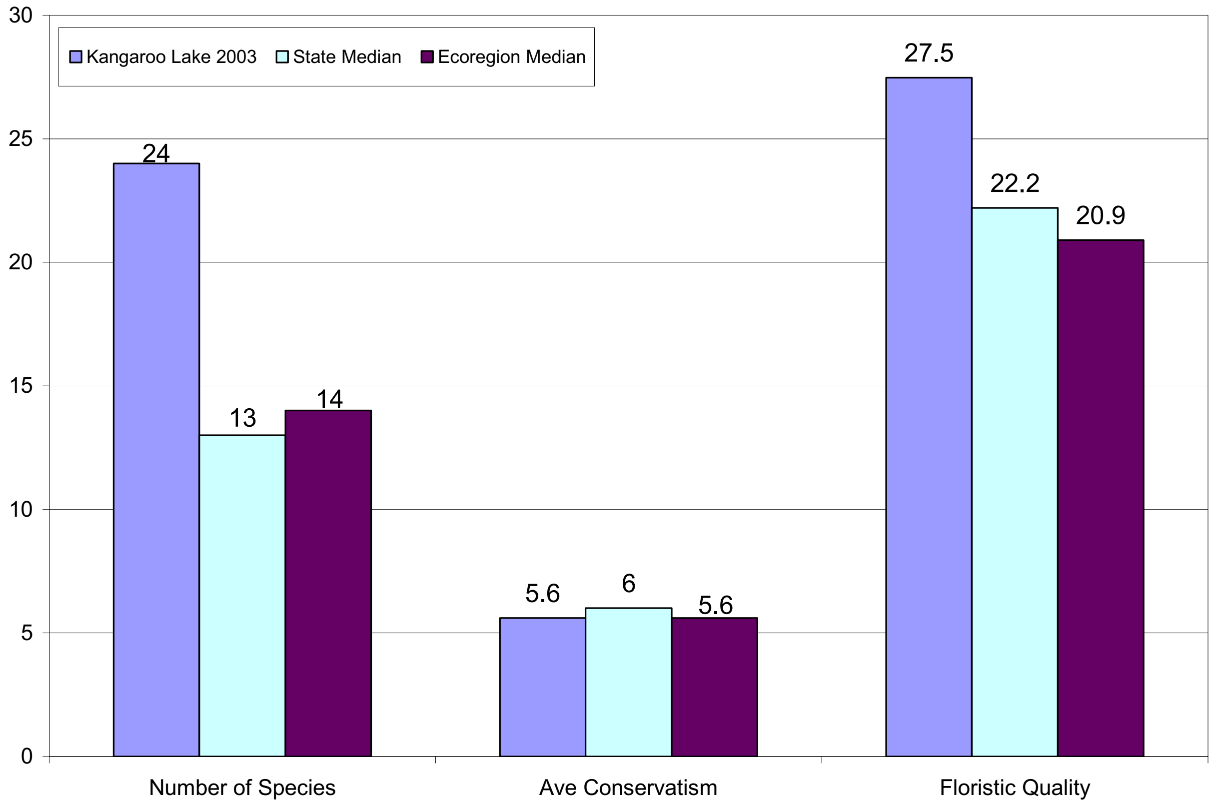

Figure 8. Floristic Quality Assessment (FQA) results for the 2003 dataset of Kangaroo Lake, the ecoregion and state. The ecoregion results shown are a combination of results from the North Central Hardwood Forest and Southeastern Wisconsin Till Plains ecoregions (Nichols 1999). Number of species only includes native species. Please see the Methods section for a detailed description of the FQA.

native aquatic plants within the lake. Aquatic plants do not only function as habitat for fish and wildlife; they also hold bottom sediments in place with their extensive root structures – a function that is incredibly important in shallow lakes. In other words, the reduced plant abundances, as brought on by motorboat traffic, have increased the occurrence of wind-induced sediment resuspension.

Boating is an economically important activity in Wisconsin and continues to grow in popularity annually. In fact, the number of registered boats increased in Wisconsin by over 300% between 1960 and 2000 (Dudiak and Korth 2002). Furthermore, according to the National Marine Manufactures Association, the horsepower of boat motors have increased nationwide from an average of 40.3 in 1975 to 82.4 in 2001. We can assume that the use and adverse affects, as outlined above, have increased on Kangaroo Lake. Few areas of high aquatic plant diversity currently exist in Kangaroo Lake with the most apparent areas being located in the basin north of causeway (see discussion below) and the bay that forms the “paw” of the lake’s namesake (or the Bayou, as it is called locally). Other areas of less diversity occur in both north corners of the south basin of the lake. Interestingly, all of these areas, especially that of the north basin and the Bayou, are protected from high-speed motorboat traffic and are likely remnants of the plant community that once existed on Kangaroo Lake. In addition, the dominance of the plant community by two, low-growing plants like muskgrass (*Chara sp.*) and slender naiad (*Najas flexilis*) (Figure 11) further indicates the negative effects of motorboat traffic on the lake’s important plant population. In the end, the apparent declines in abundance and diversity of aquatic plants within Kangaroo Lake have likely had an adverse affect on the lake’s fishery.

Table 2. Aquatic plant species occurring in Kangaroo Lake's south basin during the 2003 survey. Species are broken into community type and include coefficients of conservatism used in Floristic Quality Assessment (FQA). A detailed explanation of the FQA can be found in the Methods section. FL = Floating-leaf.

	Scientific Name	Common Name	Coefficient of Conservatism (C)	Notes
Emergent	*Eleocharis acicularis*	Needle spikerush	5	
	Eleocharis palustris	Creeping spikerush	6	
	Equisetum fluviatile	Water horsetail	7	
	Iris versicolor	Northern blue flag	5.6	
	Sagittaria latifolia	Common arrowhead	3	
	Schoenoplectus acutus[1]	Hardstem bulrush	5	
	Scirpus pungens[2]	Three-square	5	
	Schoenoplectus tabernaemontani[3]	Softstem bulrush	4	Incidental
	Sparganium fluctuans	Floating-leaf bur-reed	10	
	Typha latifolia	Broad-leaved cattail	1	
FL	*Lemna minor*	Small duckweed	5	Incidental
	Nuphar variegata	Spatterdock	6	
	Nymphaea odorata	White water lily	6	Incidental
Submergent	*Chara sp.*	Muskgrasses	7	
	Myriophyllum sibiricum	Northern water-milfoil	7	
	Myriophyllum spicatum	Eurasian water-milfoil	N/A	Exotic
	Najas flexilis	Slender naiad	6	
	Potamogeton amplifolius	Large-leaf pondweed	7	
	Potamogeton gramineus	Variable pondweed	7	
	Potamogeton illinoensis	Illinois pondweed	6	
	Potamogeton natans	Floating-leaf pondweed	5	
	Potamogeton pectinatus	Sago pondweed	3	
	Potamogeton richardsonii	Clasping-leaf pondweed	5	
	Utricularia vulgaris	Common bladderwort	7	
	Vallisneria americana	Wild celery	6	

[1]Formally know as *Scirpus acutus* [2]Formally know as *Scirpus americanus* [3]Formally know as *Scirpus validus*

Exotic Species

Eurasian water-milfoil (*Myriophyllum spicatum*), was found in several locations within Kangaroo Lake (Figure 11). The highest occurrence was located in the center of the lake south of the island; while a smaller, more concentrated colony was found near the center culverts on the south side of the causeway. Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 13). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and hampering recreational activities such as swimming, fishing, and boating.

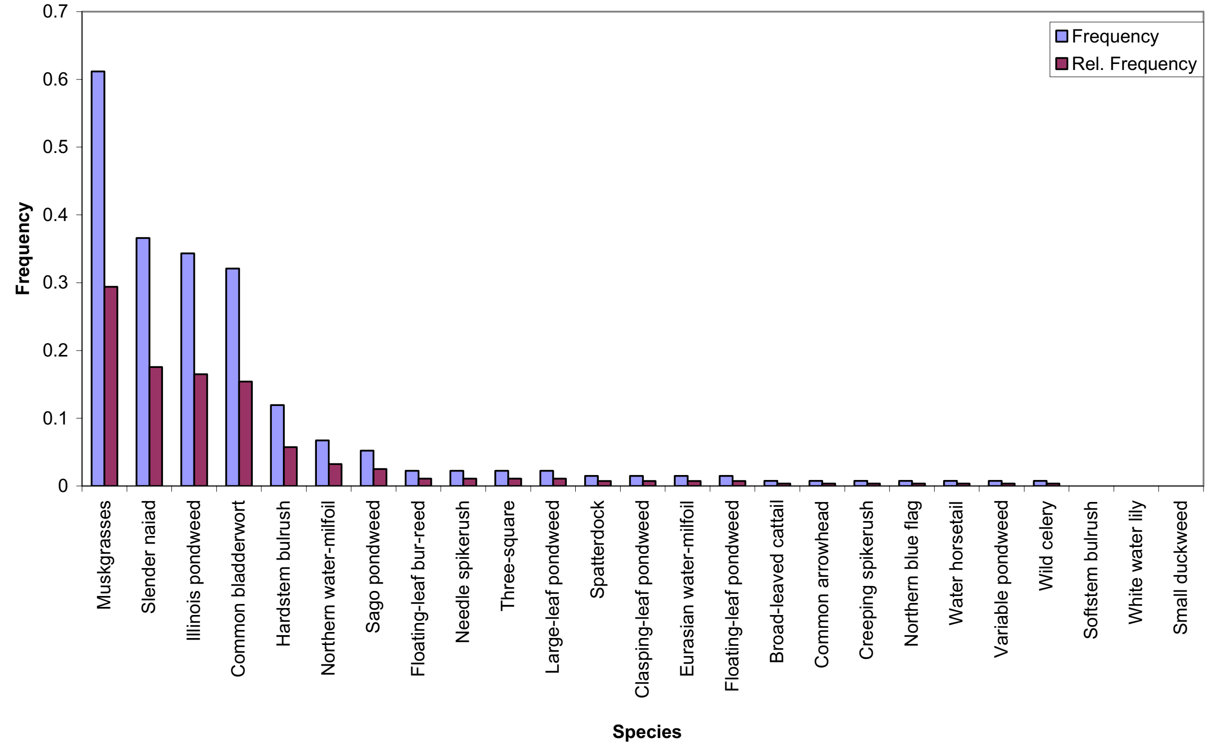

Figure 9. Frequency results for 2003 vegetation survey at Kangaroo Lake. Species with zero values were incidentals.

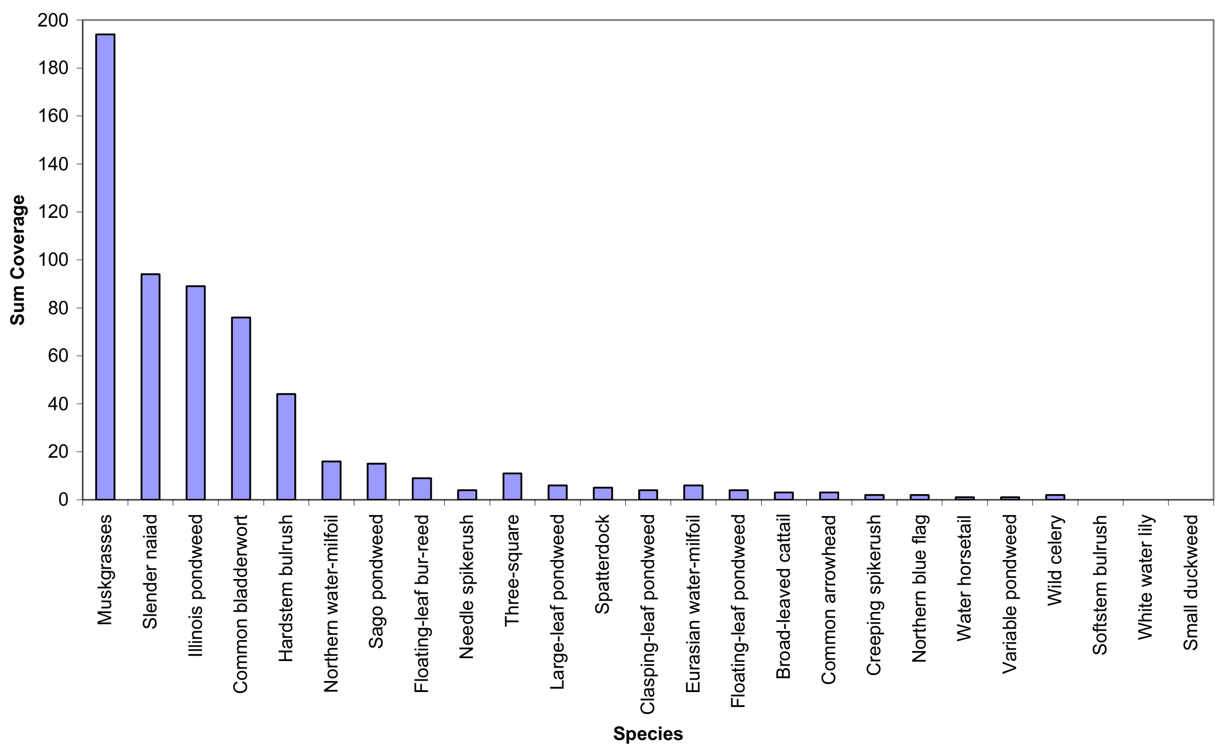

Figure 10. Total Daubenmire coverage results for 2003 survey results at Kangaroo Lake. Species with zero values were incidentals.

During the summer of 2003, the Eurasian water-milfoil in Kangaroo Lake did not grow to the surface and form the canopy as described above. Although this prevented the plant from becoming a navigation nuisance, it also prevented the plant colonies located south of the island from being accurately mapped from the surface using the GPS technology utilized in mapping the other plant communities within the lake. However, transect-independent plots were completed to the north and south of Eurasian water-milfoil locations provided by Dr. Paul Mahlberg and verified by NES Ecological Services. The completion of the independent plots along with those of the transect plots indicated that the colony is accurately depicted in Figure 11.

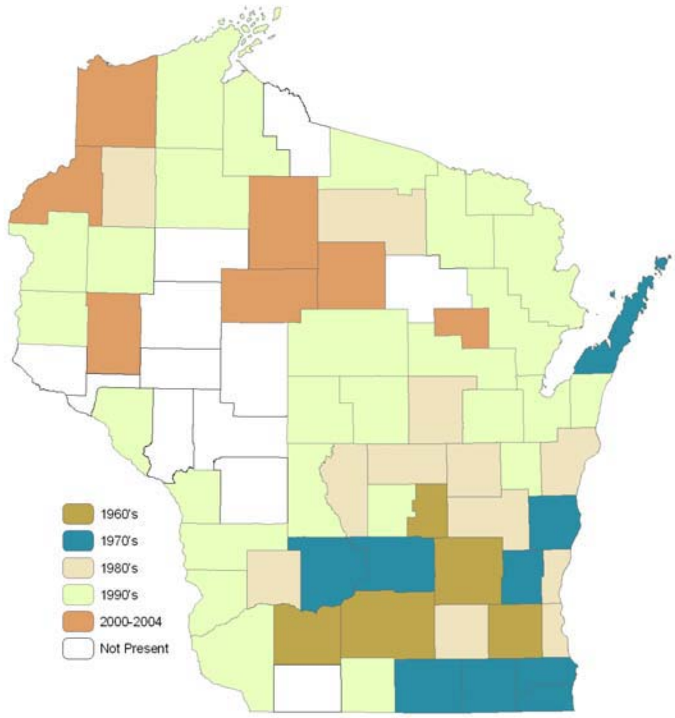

Figure 13. Eurasian water-milfoil spread in Wisconsin counties. Data from Wisconsin DNR.

A meander survey of the lake was completed over two days in early June 2003 to locate curly-leaf pondweed within Kangaroo Lake. Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle that gives it a competitive advantage over our native plants. Curly-leaf pondweed begins to *senesce* during mid-July when other plants are at the peak of their growing season. Earlier in July, it produces many turions, which lie dormant until the water temperatures reach approximately 75° F. At that time, the turions germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in May, giving the plant an early jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities with the lake. It can also cause mid-summer algal blooms spurred from the nutrients released during the plant's decomposition after it dies in July.

It is the plant's odd lifecycle that makes it necessary to complete a survey especially for the plant in late May or early June. Fortunately, no curly-leaf pondweed was found during the survey. Conversely, students from the graduate program at the University of Wisconsin-Green Bay did report curly-leaf pondweed occurrences in both the north and the south basins of Kangaroo Lake as a part of a study they conducted for the Nature Conservancy (Campion et al. 1997). However, no voucher specimens were collected and the survey was completed in October making the likelihood of actually finding curly-leaf pondweed very low.

Kangaroo Lake North Basin

Kangaroo Lake's north basin is physically separated from the south basin by the CTH E causeway which allows for only carry-in access of non-motorized boats. The entire basin was designated a sensitive area by the WDNR in 1996 and the majority of its shoreline is owned by the Nature Conservancy or The Door County Land Trust.

Specific study of the north basin was not included within the scope of this project because it is essentially a separate entity from the south basin in that they do not experience the same recreational and developmental pressures. Yet, the north basin is an integral part of the lake as a whole, so a brief description of the area, especially concerning its diverse plant community is warranted.

Casual surveys completed by the Nature Conservancy, the University of Wisconsin-Green Bay, Dr. Paul Mahlberg of the KLA, the WDNR, and NES all conclude that the plant community within the north basin is much more diverse than that of the south basin. Again, this is likely attributable to the developmental and recreational pressures that the south basin is exposed to (see discussions above). Also, the community currently existing in the north basin is probably indicative of the community that occurred in the south basin to some extent in the past. Some of the plants that have been discovered in the north basin are listed in Table 3 along with an indication if they were located during the study completed by NES during the summer of 2003.

Table 3. Aquatic plant species occurring in Kangaroo Lake north basin. .

Scientific Name	Common Name	Found in South Basin - 2003
Iris versicolor	Northern blue flag	Y
Sagittaria latifolia	Common arrowhead	Y
Schoenoplectus acutus[1]	Hardstem bulrush	Y
Schoenoplectus tabernaemontani[2]	Softstem bulrush	Y
Sparganium fluctuans	Floating-leaf bur-reed	Y
Typha latifolia	Broad-leaved cattail	Y
Lemna minor	Small duckweed	Y
Nuphar variegata	Spatterdock	Y
Nymphaea odorata	White water lily	Y
Chara sp.	Muskgrasses	Y
Myriophyllum sibiricum	Northern water-milfoil	Y
Myriophyllum spicatum	Eurasian water-milfoil	Y
Najas flexilis	Slender naiad	Y
Potamogeton amplifolius	Large-leaf pondweed	Y
Potamogeton pectinatus	Sago pondweed	Y
Utricularia vulgaris	Common bladderwort	Y
Vallisneria americana	Wild celery	Y
Menyanthes trifoliate	Buckbean	N
Sparganium americanum	Common bur-reed	N
Hippuris vulgaris	Mare's tail	N
Chelone glabra	White turtlehead	N
Typha angustifolia	Narrow-leaved cattail	N
Zizania aquatica	Wild rice	N
Carex lasiocarpa	Wire sedge	N
Potentilla fruticosa	Shrubby cinquefoil	N
Thelypteris palustris	Marsh fern	N
Sarracenia purpurea	Pitcher plant	N
Cladium mariscoides	Twig rush	N

[1]Formally know as *Scirpus acutus* [2]Formally know as *Scirpus validus*

Wisconsin Department of Natural Resources Sensitive Area Designations

On August 18, 2003, representatives of the WDNR, NES, and the KLA completed a survey to designate certain areas of Kangaroo Lake's south basin as sensitive areas. The resulting document is contained in its entirety in Appendix C.

Watershed Analysis

The Kangaroo Lake watershed is approximately 6170 acres, which yields a favorable watershed to lake area ratio of 5.5:1. In general, lakes with a ratio greater than 10:1 tend to have management problems that revolve around excessive amounts of phosphorus and/or sediments that enter the lake from its drainage basin. This is true because as the drainage area increases, so does the amount of nutrients and sediments that are delivered to the lake. This is not to say that every lake with a watershed to lake area ratio greater than 10:1 experiences problems, because the amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to infiltrate into the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas reduce infiltration and increase surface runoff. The increased surface runoff associated with these land coverage types leads to increased pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

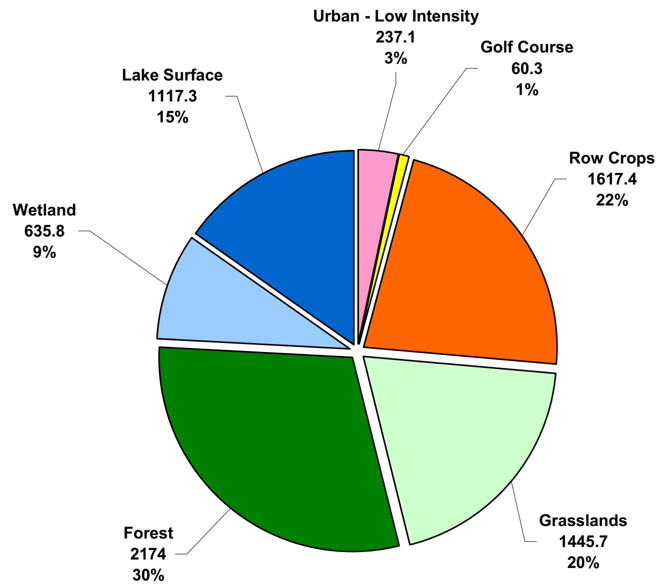

Figure 14. Land use types and associated acreages within the Kangaroo Lake watershed. Percentages indicate percent of total watershed acreage.

Land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) for the Kangaroo Lake watershed are displayed in Figures 14 and 15. Currently, the majority of land within the Kangaroo Lake watershed is forested, followed closely by row crops and grasslands. Modeling of these land uses and their associated acreages using the Wisconsin Lake Modeling Suite (WiLMS) indicated that row crops contribute the majority of phosphorus to the lake through its tributary inlets (Figure 16). However, the Phosphorus Prediction and Uncertainty Analysis Module of WiLMS further indicates that much higher levels of phosphorus would be expected in a lake with such a watershed. The differences between predicted and measured values for mean growing season phosphorus levels (44 mg/m^3 and 24 mg/m^3, respectively) are likely caused by three features of the Kangaroo Lake watershed:

1. Sandy soils – Much of Door County exhibits sandy soils and the watershed of Kangaroo Lake is no exception. These sandy soils tend to absorb precipitation; reducing surface flows that the WiLMS model assumes to occur. As a result, higher surface flows are modeled that produce exaggerated rates of phosphorus loads.
2. Wetlands – Piel Creek, Kangaroo Lake's primary inlet, is surrounded by floodplain and forested wetlands over much of its length. These wetlands act as buffers by reducing the amount of phosphorus entering the creek and making its way into the lake. The WiLMS model only accounts for a portion of this buffering capacity.

3. Kangaroo Lake's north basin – The north basin essentially acts as a large and efficient detention basin for the south basin (where the phosphorus data was collected). Again, the WiLMS model cannot account for this and provides exaggerated loading rates.

All of these factors work in favor of reducing the eutrophication rate of Kangaroo Lake. However, continued changes in the watershed, especially those involving the conversion of forested areas to agriculture or developed properties, may have a detrimental affect on the lake's water quality.

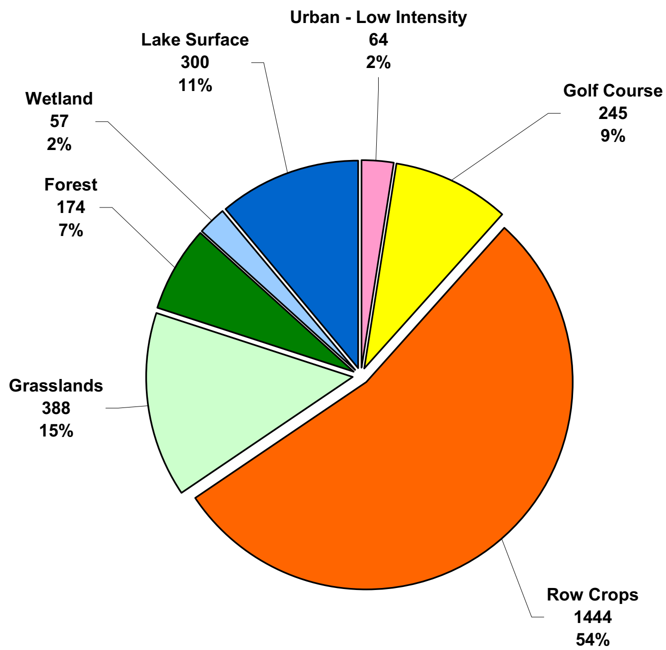

Figure 16. Estimated phosphorus loading values for the Kangaroo Lake watershed. Loads are listed in lbs/yr of phosphorus. Percentages indicate percent of total external phosphorus load.

The WiLMS model also has a difficult time assessing the impact of developed shorelands on the nutrient loads entering the lake system it is modeling. Conversion of natural shorelands to developed, urban landscapes can greatly increase the amount of nutrients entering a lake. The use of fertilizers makes this problem even worse and can lead to severe impacts on the lake. NES ecologists and representatives of the WDNR visited the lake many times during 2003 as a part of our water sampling regime, the two plant surveys that were completed, and during the sensitive area designation survey. From these visits, it is estimated that only 40% of the shorelands around the south basin of Kangaroo Lake contain sufficient buffering area to protect the lake from the ill-affects of shoreline development. In other words, 60% of the shorelands on the lake's south basin are likely contributing more phosphorus to the lake than they should be and these unneeded phosphorus loads are probably accelerating the eutrophication rate of the lake.

MANAGEMENT ALTERNATIVES

Lake management is a difficult and often controversial task to undertake because so many different types of people use our lakes for an equal variety of activities. Some people look to our lakes strictly for natural beauty, while others enjoy fishing, swimming, and recreational boating. All of these uses are important to the economic well-being of our state and local communities and can coexist if each user group takes into account the needs of the other groups and that of the lake ecosystem.

Many times lake management plans include a list of management recommendations that were created specifically for the lake in question. Although these recommendations may be appropriate for the lake, they may not be feasible for the management group to undertake. For instance, recommending that a large area of exotic plants be chemically treated may be too expensive for some lake groups to undertake even with the help of state funds, or the group may find the introduction of chemicals into their lake as unpalatable. Also, recommending that large tracts of private property be restored to the natural state may meet with great resistance because the group is not aware of the benefits of natural shorelands. Finally, many of these recommendations are not acted upon because the plan did not contain a sequence in which they should be approached nor an indication of who should implement them.

A useable lake management plan takes the needs of the stakeholders and their capacity to implement the management alternatives into account when the plan is created. In the end, these sociological factors are combined with the technical factors concerning the lake ecosystem to create a realistic action plan that will guide the group in meeting their goals. This project was designed to create such a plan.

The first step in the project was to gather information concerning Kangaroo Lake’s water quality, its watershed, and its aquatic plant community. These data were analyzed, modeled, and compared to other lakes in the region and state in order to provide insight to the lake’s condition and to create a better and more realistic understanding of the lake’s health in the minds of its stakeholders. Then, using these data and years of lake management experience, NES ecologists created a list of management recommendations and presented them, along with a detailed description of the study results, to the KLA Planning Committee during a six hour meeting held in May, 2004. After detailed discussions, the initial recommendations were modified and added to create a list of management alternatives. These alternatives were then prioritized (high, medium, or low) based upon a number of factors, including; urgency, cost, ease/difficulty of implementation, and availability of people to facilitate the tasks associated with the alternative. The prioritization is not based in anyway on the importance of the alternative or even the order the alternatives should be implemented. Rather, it is a somewhat subjective ranking that attempts to incorporate all of the factors listed above. For instance, the alternative to continue lake water quality monitoring is given a priority of “low” not because it is any less important than the others, but because it is currently in place, inexpensive, and requires no additional work to implement it.

After the prioritization step, each of the alternatives was assigned a timeframe for implementation and a facilitator (a group, committee, or individual) that would be responsible for following through with its actual implementation. Upon the completion of this step, the prioritized alternatives became an "action plan"- an action plan that truly melds the technical and sociological components into an implementable management plan.

Focus of Management Alternatives

Aquatic Plants

The fact of the matter is that Kangaroo Lake is a shallow lake and even though its water quality has only fluctuated a bit over the past decades, it is still showing signs of stress. This stress shows itself most intensely in the degradation in the lake's aquatic plant community. Obvious reductions of bulrush stands along with those communities of higher diversity all indicate degradation in the overall health of the lake. These losses affect the lake in a variety ways, including:

- Reductions in quality habitat that supports the lake's fishery and wildlife.
    - Aquatic plants provide vital nursery, rearing, and feeding habitat for game fish and waterfowl.
- Loss of plant root-structure that holds bottom sediments in place.
    - This leads to increased turbidity because waves produced by wind and motorboat traffic can resuspend bottom sediments into the water column.
- Decreased competition against the further spread of Eurasian water-milfoil and other exotics.
    - Native plants compete with exotics, slowing and at times, preventing their spread.
    - Loss of the natives opens areas for easy establishment by exotic plants, much like an exposed area of soil is first colonized by weed species.
- Decreased competition with algae.
    - Because of competition for light, nutrients, and other needs, shallow lakes are normally dominated by macrophytes (vascular plants) or algae. Lakes dominated by macrophytes are considered to be in a "clear state" (Kangaroo Lake's current state) and lakes dominated by algae are considered to be in a "turbid state" (Lake Winnebago is an excellent example).
    - Continued loss of aquatic macrophytes may cause Kangaroo Lake to shift to a "turbid state".

Recent research, as presented in the Analysis of Current Aquatic Plant Data section of this document, points to motorboat traffic as the primary factor in the reduction of these important plant communities. Yet, most lake users engage in motorboat recreation; therefore, the management alternatives presented here do not call for a complete ban on recreational watercraft use on the lake. On the contrary, they work to strike a balance between the needs of recreational boaters and the environmental needs of this delicate ecosystem. The alternatives also present methods to help restore the lake's aquatic plant community and battle the spread of Eurasian water-milfoil.

Watershed Issues

As described above, Kangaroo Lake's watershed is structured in a fashion that actually protects the lake from the undesirable affects of agriculture's high rate of phosphorus loading. Still, changes in that structure, brought on by conversion of existing natural areas by agriculture and development, may lead to increased nutrient loading to the lake and an acceleration of the eutrophication process. Furthermore, there are valid concerns regarding the amount of nutrients and sediment that are likely entering the lake from developed properties around its south basin. Therefore, alternatives are presented that will help the KLA minimize nutrient and sediment loads from both of these sources and in the end, help slow the eutrophication of Kangaroo Lake.

Lake Water Quality

Although the water quality of Kangaroo Lake has not shown significant changes in the past decades, it is still a concern of most lake users. The most realistic goal concerning water quality at Kangaroo Lake is to maintain it as it is now. The most realistic method for meeting that goal is to follow the alternatives outlined for the aquatic plant community and the watershed. Continued monitoring is also an important factor that is included.

Stakeholder Education

Education is important in any environmental management effort. If stakeholders do not understand the value of the natural ecosystem and how that ecosystem works, they will not strive to protect or enhance it. No truer statement could be made. Only a basic knowledge of lake ecology is needed for stakeholders to be able to make their own decisions concerning the well-being of their lake. As a result, continued education is stressed within the management alternatives.

Action Plan for Kangaroo Lake

Management Alternative: Experimental bulrush re-establishment project
Priority: High
Timeframe: 2005-2007
Facilitator: Board of Directors
Description: This project will help determine the practicality of enhancing the lake's plant community through the introduction of bulrushes in select areas of the lake. A Lake Protection Grant through the WDNR was applied for in May to fund 75% of the project's $11,260 cost and was awarded to the KLA in June 2004. A complete project description can be found in Appendix F.

Management Alternative: Eurasian water-milfoil monitoring with potential chemical treatment
Priority: High
Timeframe: 2004/2005
Facilitator: Paul Mahlberg
Description: NES Ecological Services will map the Eurasian water-milfoil colony south of the island at no charge if it canopies during the summer of 2004. If it does not canopy, NES will help KLA obtain a grant to pay for 50% of study to assess the size of the colony through a study utilizing the point-intercept method. Through one of these monitoring efforts, the KLA, with the help of the WDNR, will be able to determine if chemical treatments are feasible to help minimize the spread of the colony to other parts of the lake or if continued monitoring is the only requirement. If treatment is warranted, 50% matching funds may be available through the WDNR's Aquatic Invasive Species Grant Program.

Management Alternative: Expand voluntary slow-no-wake area with treatment of small Eurasian water-milfoil colony near center of causeway
Priority: High
Timeframe: 1-2 years for implementation
Facilitator: Dick Schultz
Description: This action would include the expansion of the voluntary slow-no-wake area to include all areas north of the southern tip of the island, the current area at the south end of the lake, and the current 500' from shore area (Figure 17). Guideline buoys would also be used to mark the zones along with a large sign at the main boat landing and postings at The Rushes. The remaining area open to high-speed boating would be greater than 490-acres (roughly 16.5% less than available now). It is likely that the KLA could obtain a 75% grant to help off set the costs of this portion of the management alternative through the WDNR Lake Protection Grant Program. This action would also include a treatment aimed at eradicating the small Eurasian water-milfoil colony near the center of the causeway (Figure 11) in order to prevent its competition with the possible re-establishment of desired plants to this newly created slow-no-wake area. The treatment could include manual removal of the Eurasian water-milfoil by divers and/or chemical treatment. Fifty percent matching funds may be available through the WDNR's Aquatic Invasive Species Grant Program if a chemical treatment is appropriate.

Management Alternative: Shoreland Restoration – Phase I
Priority: High
Timeframe: Starting with February 2005 Newsletter
Facilitator: Newsletter Editor and Marilyn Mahlberg
Description: This action would promote shoreland restoration through the implementation of a "No-Mow" zone around the lake. The zone would be promoted through articles in the newsletter and announcements at KLA meetings. This would be a considered the first step in a two-step project aimed at reducing nutrient and sediment loads entering the lake from developed shoreland areas.

Management Alternative: Stakeholder education
Priority: High
Timeframe: Continuous
Facilitator: Education Committee with expert assistance
Description: This action includes the education of KLA members and other lake users concerning the importance of lake and shoreland plants in a healthy lake ecosystem, aspects of shallow lake ecology, and other relevant topics. This action will also promote the attendance of KLA members to the annual Wisconsin Lakes Convention in Green Bay. Expert assistance is available through the WDNR, the UW-Extension, the Nature Conservancy, the Door County Land and Water Conservation Department, and NES Ecological Services.

Management Alternative: Committee formation to monitor and act on watershed issues
Priority: Medium
Timeframe: To start during spring 2006
Facilitator: Board of Directors to set up committee
Description: This action would begin with the Board of Directors designating a Watershed Committee. The committee would be responsible for educating themselves on county and state zoning and land use regulations and will then use that knowledge to protect and enhance Kangaroo Lake and its watershed through the enforcement of the current laws and the promotion of additional regulations. This committee would also be responsible for annual watershed surveys aimed at minimizing the effects of agricultural runoff to the lake. If areas of concern are located, the committee would be responsible for contacting the Door County Land and Water Conservation Department for help. This committee may be strengthened by teaming up with a similar group from Clark Lake.

Management Alternative: Aquatic plant survey of Kangaroo Lake
Priority: Medium
Timeframe: 2009
Facilitator: Planning Committee
Description: This would be a re-assessment of the lake's aquatic plant community as was completed for this management plan. It would be especially important to document changes in the plant community following the creation of the expanded slow-no-wake zone and for the monitoring of Eurasian water-milfoil as well as other exotic species.

Management Alternative: Shoreland restoration demo sites (Phase II)
Priority: Medium
Timeframe: 2-3 sites by 2007
Facilitator: To be determined
Description: This would expand upon Phase I by actually implementing complete restorations on 2-3 sites around the lake. The KLA would seek professional help for the design and implementation of these first sites, but would then base additional restorations on those designs and the experience gathered during creation of the first sites.

Management Alternative: Continued water quality monitoring
Priority: Low
Timeframe: Continued
Facilitator: Paul Mahlberg
Description: This alternative is currently in place and only requires annual reporting of results. However, additional personal should become involved in this task as time progresses.

METHODS

Lake Water Quality

Water Quality Monitoring

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Kangaroo Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake. Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B), and occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following normal protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included:

	Spring		June		July		August		Fall		Winter	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●						
Chlorophyll-*a*	●	●	●		●		●		●			
Total Kjeldahl Nitrogen	●	●			●	●					●	●
Nitrate-Nitrite Nitrogen	●	●			●	●					●	●
Ammonia Nitrogen	●	●			●	●					●	●
Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Total Suspended Solids	●	●			●	●	●	●	●	●	●	●
Calcium	●	●			●							

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 4.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed in the north and south basins of Kangaroo lake during June 3 and 4, 2003 field visits to in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat and wading.

Transect Surveys and Macrophyte Community Mapping

A quantitative aquatic vegetation survey was conducted July 7-9, 2003 by sampling points along 32 transects and nine independent plots located along the shoreline of the lake and in its center (Figure 11). Sampling was completed via boating, wading, and snorkeling. In order to map the macrophyte communities and to assist in determining the frequency and location of transects, visual inspections were completed throughout the lake using a combination of sketches and notes created on hardcopy maps and position data recorded with a Trimble GeoExplorer 3 GPS Data Collector. On each transect, a ten-foot diameter circle was sampled within each of five different depth ranges (Table 4). The maximum depth of sampling was determined through field observation of the approximate maximum depth of aquatic vegetation growth. At each sampling location, substrate type and species composition were recorded.

Table 4. Depth codes and ranges sampled during transect surveys.

Depth Code	Depth Range (feet)
1	0.0-1.5
2	1.5-3.0
3	3.0-5.0
4	5.0-10.0
5	10+

A visual estimate of percent foliage cover for each species was also recorded at the sampling locations. Coverage is determined as the perpendicular projection to the substrate from the outline of the aerial parts of the plant species and is typically reported as the percent of total area (e.g., substrate or water surface) covered (Brower et al. 1990). For emergent and floating-leaf vegetation, the percent of water surface covered was used in the visual estimate, and for submergent vegetation the percent of substrate covered was used. After the collection of field data, the Daubenmire Classification Scheme (Mueller-Dumbois and Ellenberg 1974) was used to rank each species observed according to estimated foliage cover (Table 5). By providing a range of percent foliage cover for each rank, the Daubenmire Classification Scheme helps to minimize errors due to observer bias, visual estimation, etc.

Table 5. Daubenmire Classification Scheme cover ranking system.

Percent Foliage Cover	Rank
0-5	1
5-25	2
25-50	3
50-75	4
75-95	5
95-100	6

The collected transect data were used to estimate frequency of occurrence and relative frequency of occurrence for each species observed. The frequency of occurrence is defined as the number of times a given species occurred on the total plots of all transects sampled. The relative frequency of occurrence is the frequency of that species divided by the sum of the frequencies of all species in the community (Brower et al. 1990). Sum coverage is the total Daubenmire cover found for each plant.

Floristic Quality Assessment

A Floristic Quality Assessment (FQA) was applied to the aquatic vegetation species lists generated for Kangaroo Lake using the methodology of Nichols (1999). FQA is a rapid assessment metric used to assist in evaluating the floristic and natural significance of a given area. The assessment system is not intended to be a stand-alone tool, but is valuable as a complementary and corroborative method of evaluating the natural floristic quality of a lake ecosystem.

The primary concept in FQA is species conservatism. Each native species found in the lake was assigned a coefficient of conservatism (*C*) ranging from 0 to 10. The coefficient of conservatism estimates the probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-settlement condition. A *C* of 0 indicates little fidelity to a natural community, and a *C* of 10 is indicative of restriction to high quality, natural areas. The FQA was applied by calculating a mean coefficient of conservatism for all species observed in the lake. The mean *C* was then multiplied by the square root of the total number of species to yield a Floristic Quality Index (FQI). Examination of the floristic quality index within the context of statewide and regional trends was used to provide an overall evaluation of the floristic quality of Kangaroo Lake.

Watershed Analysis

The watershed analysis began with an accurate delineation of Kangaroo Lake's drainage area using U.S.G.S. topographic survey maps. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the preliminary watershed land cover classifications. The watershed delineation and land use classifications were field verified during the spring of 2004.

The preliminary data were then corrected with the field verified data within the GIS and watershed area and acreages for each land cover were calculated. These data, along with historic and current water quality data were inputted into the Wisconsin Lake Modeling Suite (WiLMS) to determine potential phosphorus loads to the lake.

Education

Educational components were accomplished through a "Kick-off Meeting" held in July 2003, project updates created for inclusion in the Association's newsletter, a meeting held with the KLA Planning Committee in May 2004 and a "Project Completion Meeting" in July 2004 at which the final report and action plan were presented to the Association. All of these materials are included in Appendix D.

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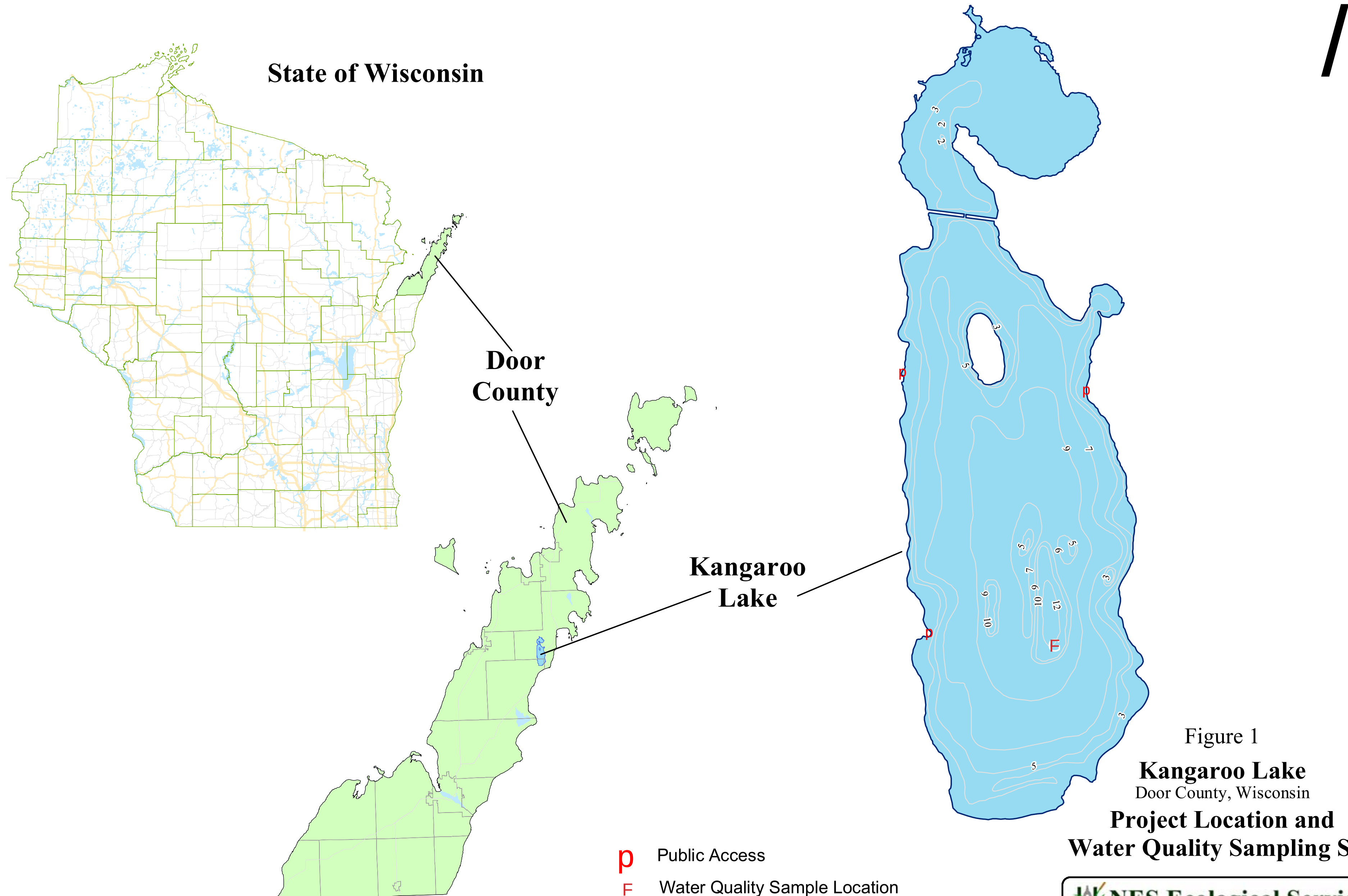

Figure 1
Kangaroo Lake
Door County, Wisconsin
Project Location and Water Quality Sampling Site

NES Ecological Services
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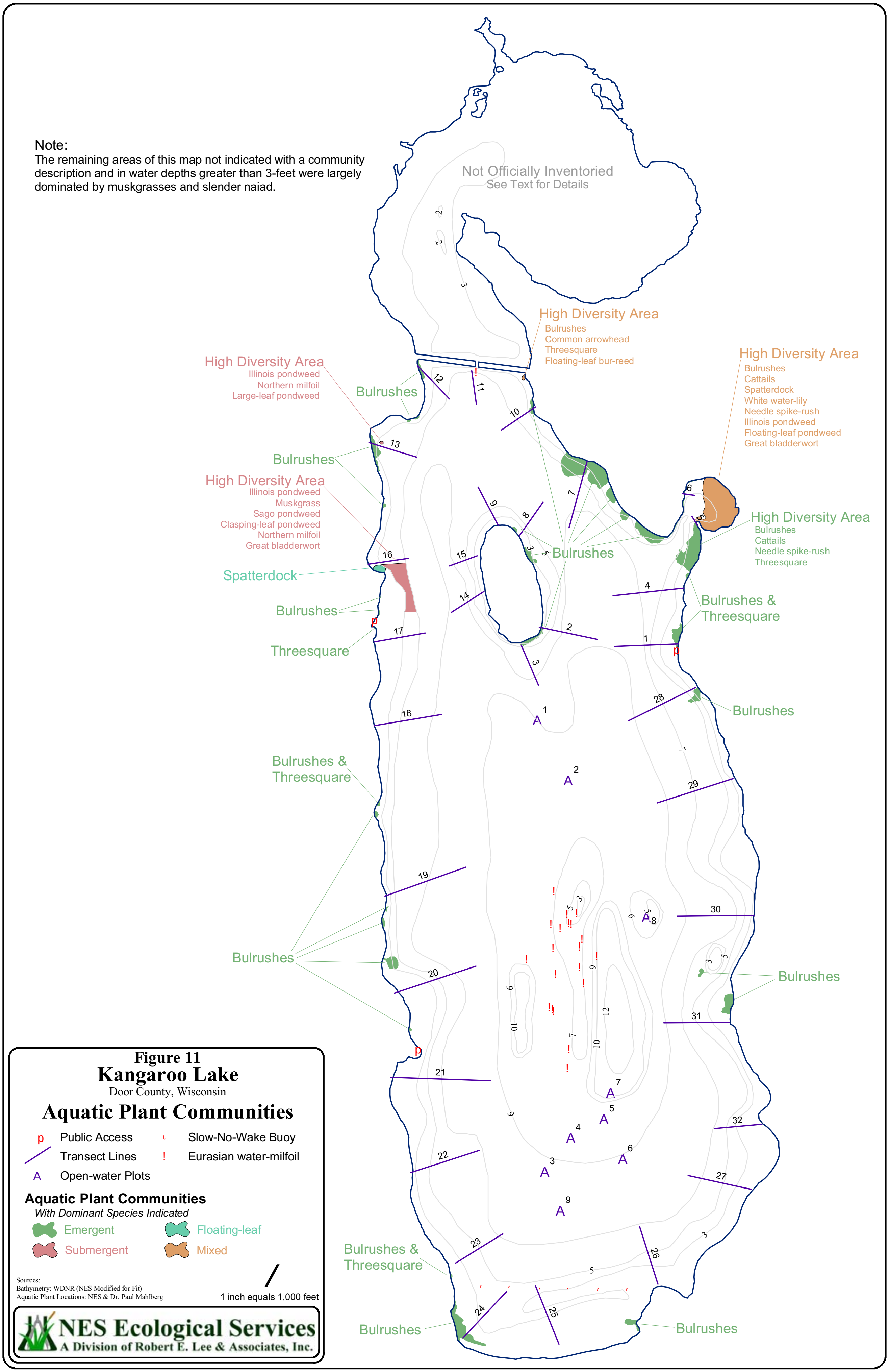
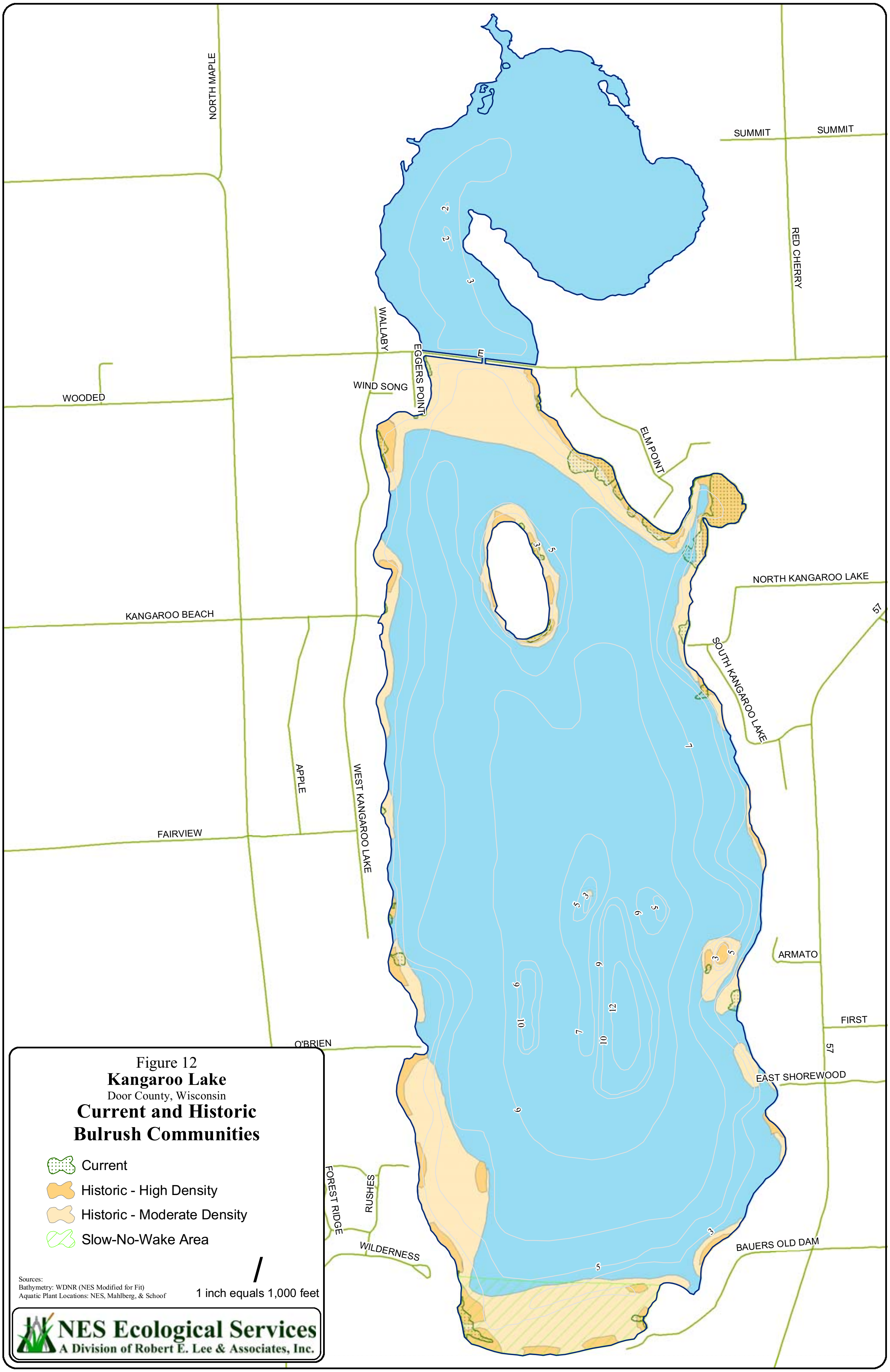


Figure 11
Kangaroo Lake
Door County, Wisconsin
Aquatic Plant Communities


NORTH MAPLE
SUMMIT
SUMMIT
RED CHERRY
WALLABY
EGGERS POINT
E
WIND SONG
WOODED
ELM POINT
NORTH KANGAROO LAKE
57
KANGAROO BEACH
SOUTH KANGAROO LAKE
APPLE
WEST KANGAROO LAKE
FAIRVIEW
ARMATO
FIRST
O'BRIEN
57
EAST SHOREWOOD
FOREST RIDGE
RUSHES
WILDERNESS
BAUERS OLD DAM
Figure 12
Kangaroo Lake
Door County, Wisconsin
Current and Historic
Bulrush Communities
Current
Historic - High Density
Historic - Moderate Density
Slow-No-Wake Area
Sources:
Bathymetry: WDNR (NES Modified for Fit)
Aquatic Plant Locations: NES, Mahlberg, & Schoof
1 inch equals 1,000 feet
NES Ecological Services
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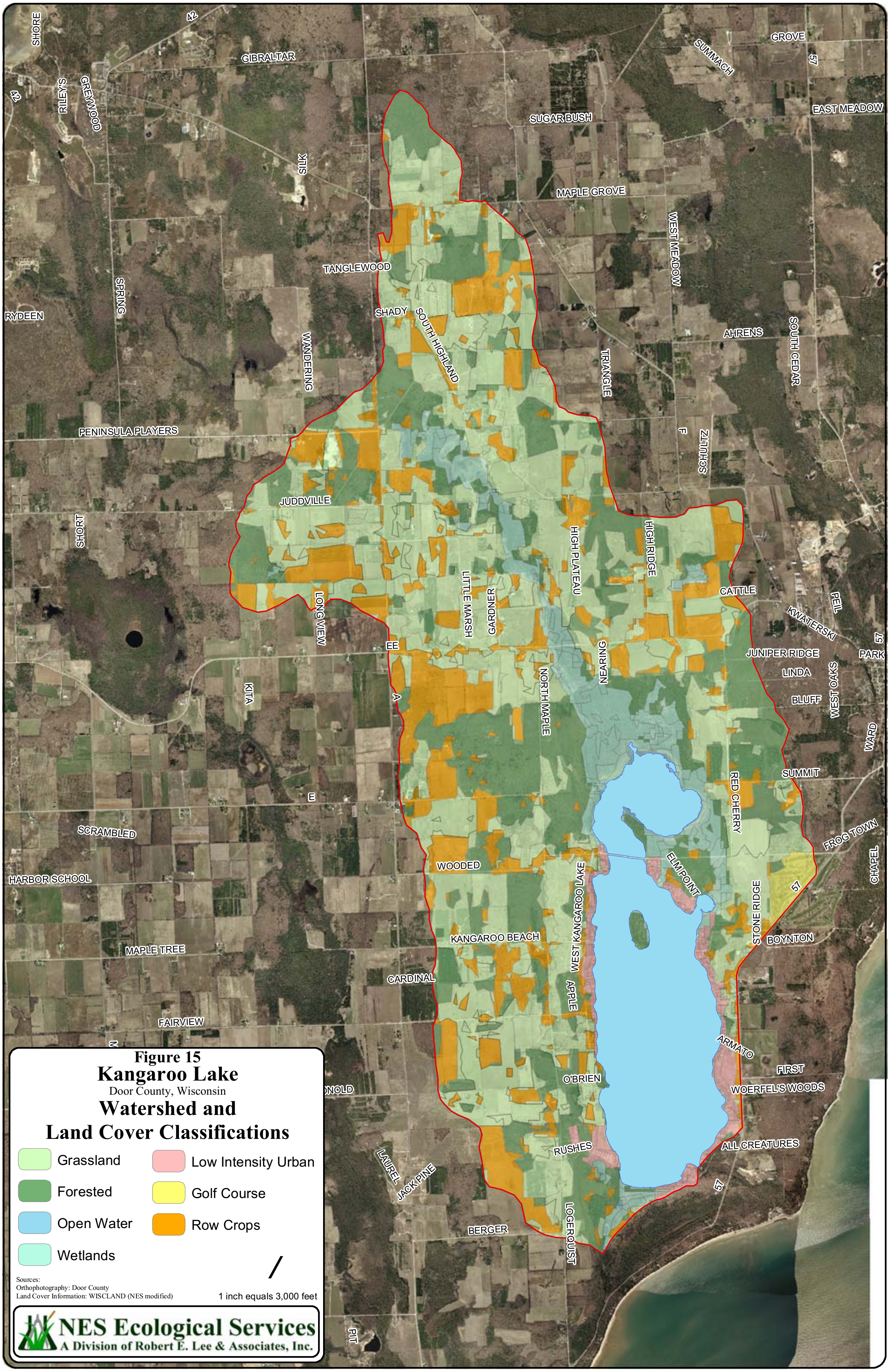

Figure 15
Kangaroo Lake
Door County, Wisconsin
Watershed and Land Cover Classifications

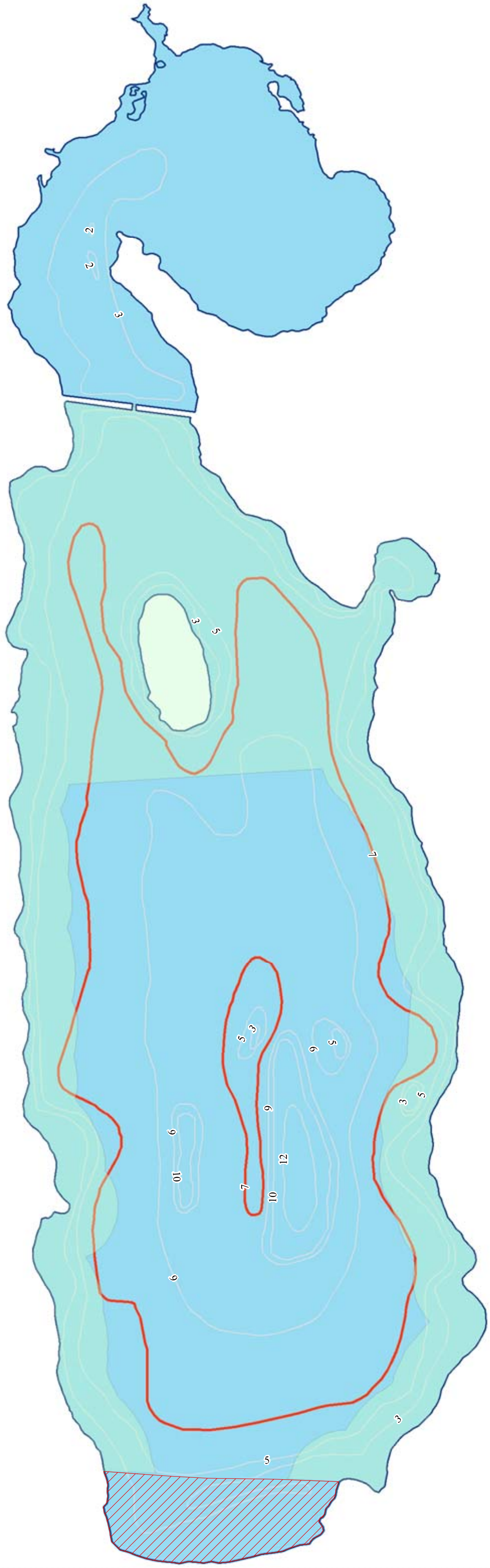

Figure 17

Kangaroo Lake

Door County, Wisconsin

Voluntary Slow-No-Wake Area

- Voluntary Slow-No-Wake Zone
- Ordinance Slow-No-Wake Zone
- 7-foot Depth Contour

Sources:
Bathymetry: WDNR (NES Modified for Fit)

1 inch equals 1,000 feet

NES Ecological Services
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A

APPENDIX A

Water Quality Dataset Collected During 2003

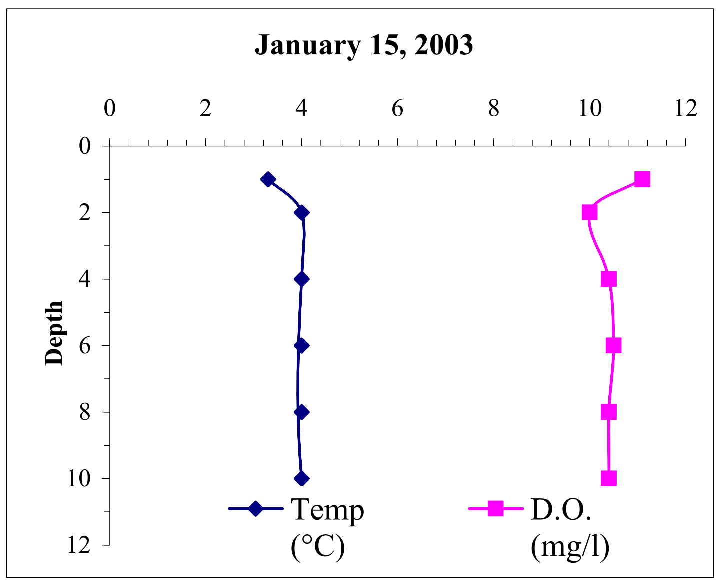
Kangaroo Lake

Date: **01-15-03**
Time: 11:30
Weather: 11F, Sunny, Breezy
Ent: tsn **Verf:** TSN/JME

Max Depth (ft): 10.6
KANS 3.0
KANB 7.0
Secchi Depth (ft): 10.0 (Bottom)

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	3.3	11.1	8.2	397
2.0	4.0	10.0	8.2	387
4.0	4.0	10.4	8.2	389
6.0	4.0	10.5	8.2	390
8.0	4.0	10.4	8.2	390
10.0	4.0	10.4	8.2	391

Parameter	KANS	KANB
Total P (mg/l)	0.027	0.013
Dissolved P (mg/l)		
Chl a (µg/l)	2.39	
TKN (mg/l)	0.87	0.70
NO_4+NO_3-N (mg/l)	0.21	0.20
NH_3-N (mg/l)	0.21	0.23
Total N (mg/l)	1.08	0.90
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		



Notes: Ice thickness = 0.6'

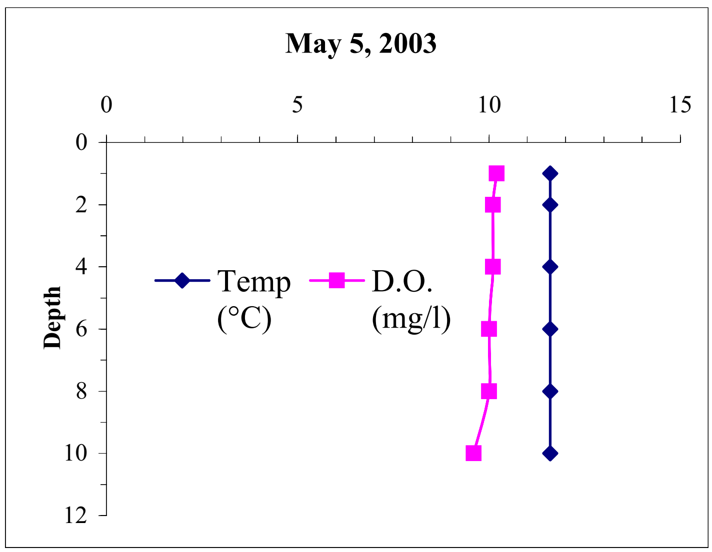
Kangaroo Lake

Date: **05-05-03**
Time: 12:30
Weather: 41F, Rainy, Windy, Choppy
Ent: TSN **Verf:** TSN/JME

Max Depth (ft): 10.5
KANS 3.0
KANB 7.0
Secchi Depth (ft): 6.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	11.6	10.2	8.6	370
2.0	11.6	10.1	8.6	370
4.0	11.6	10.1	8.6	370
6.0	11.6	10.0	8.6	370
8.0	11.6	10.0	8.6	370
10.0	11.6	9.6	8.6	372

Parameter	KANS	KANB
Total P (mg/l)	0.017	0.012
Dissolved P (mg/l)	ND	
Chl a (µg/l)	3.43	
TKN (mg/l)	0.53	0.64
NO_4+NO_3-N (mg/l)	0.38	0.38
NH_3-N (mg/l)	0.12	0.10
Total N (mg/l)	0.91	1.02
Lab Cond. (µS/cm)	379	380
Lab pH	8.48	8.49
Alkal (mg/l $CaCO_3$)	179	179
Total Susp Sol (mg/l)	3	3
Calcium (mg/l)	40.7	



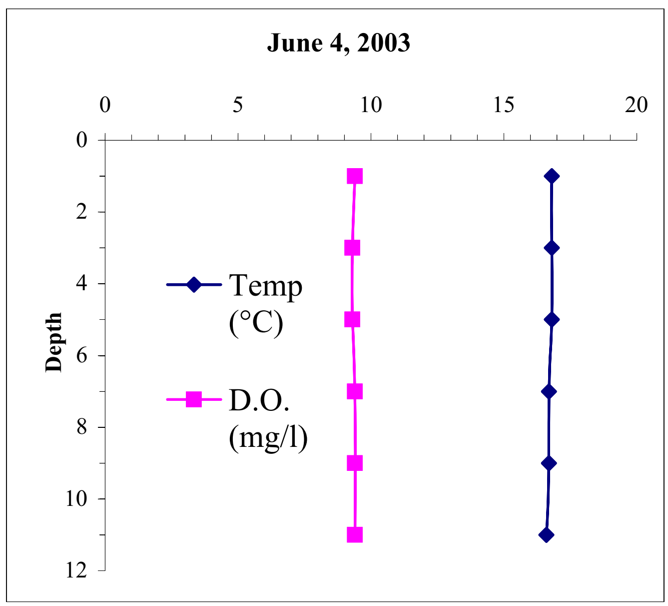
Notes: Extremely rough water. *Lab results for Dissolved P had apparent contamination. Values were 0.126, which are higher than the total P.*

Kangaroo Lake

Date:	**06-04-03**	**Max Depth (ft):**	12.0
Time:	11:45	**KANS**	3.0
Weather:	65F, Partly Cloudy, Windy	**KANB**	9.0
Ent:	TSN **Verf:** TSN/JME	**Secchi Depth (ft):**	6.5

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	16.8	9.4	8.7	380
3.0	16.8	9.3	8.7	380
5.0	16.8	9.3	8.7	380
7.0	16.7	9.4	8.8	380
9.0	16.7	9.4	8.8	380
11.0	16.6	9.4	8.8	379

Parameter	KANS	KANB
Total P (mg/l)	0.018	0.011
Dissolved P (mg/l)		
Chl a (µg/l)	4.71	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	4	4
Calcium (mg/l)		



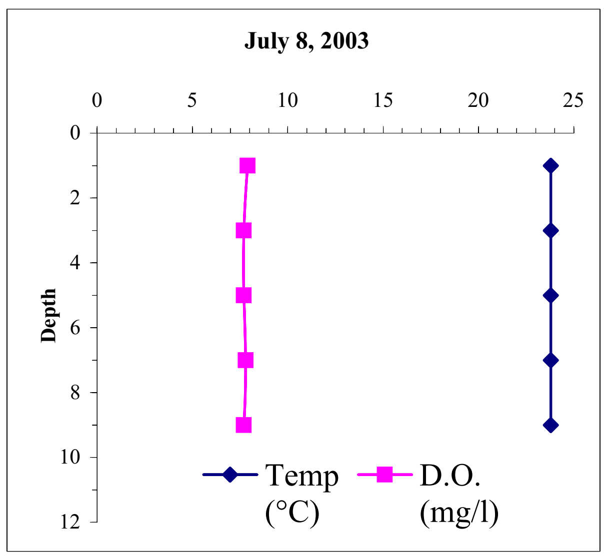
Notes: Lake was rough and a little turbid. The lake is probably benefited by marl precip.

Kangaroo Lake

Date:	**07-08-03**	**Max Depth (ft):**	10.2
Time:	16:23	**KANS**	3.0
Weather:	79F, Windy, Overcast	**KANB**	7.0
Ent:	TSN **Verf:** TSN/JME	**Secchi Depth (ft):**	5.5

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	23.8	7.9	8.4	373
3.0	23.8	7.7	8.5	374
5.0	23.8	7.7	8.5	374
7.0	23.8	7.8	8.5	373
9.0	23.8	7.7	8.5	374

Parameter	KANS	KANB
Total P (mg/l)	0.024	0.016
Dissolved P (mg/l)	0.002	0.003
Chl a (µg/l)	3.23	
TKN (mg/l)	0.91	0.85
NO_4+NO_3-N (mg/l)	0.05	0.05
NH_3-N (mg/l)	0.06	0.07
Total N (mg/l)	0.96	0.90
Lab Cond. (µS/cm)	372	369
Lab pH	8.50	8.50
Alkal (mg/l $CaCO_3$)	178	177
Total Susp Sol (mg/l)	4	3
Calcium (mg/l)		



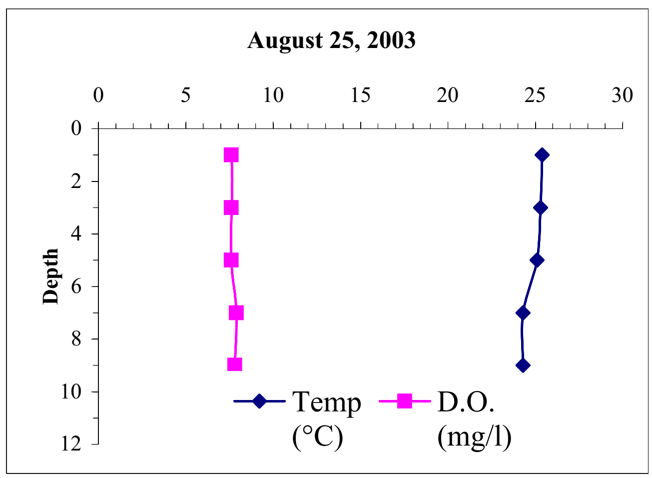
Notes: Yesterday (07-07-03) the lake was extremely rough due to strong winds, possibly accounting for the mixing affect shown by the data.

Kangaroo Lake

Date:	**08-25-03**	**Max Depth (ft):**	9.5
Time:	15:00	**KANS**	3.0
Weather:	85F, Mostly Cloudy, Breezy	**KANB**	7.0
Ent:	TSN **Verf:** TSN/JME	**Secchi Depth (ft):**	3.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	25.4	7.6	8.6	353
3.0	25.3	7.6	8.6	353
5.0	25.1	7.6	8.6	352
7.0	24.3	7.9	8.6	351
9.0	24.3	7.8	8.6	351

Parameter	KANS	KANB
Total P (mg/l)	0.029	0.012
Dissolved P (mg/l)		
Chl a (µg/l)	8.35	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	6	6
Calcium (mg/l)		



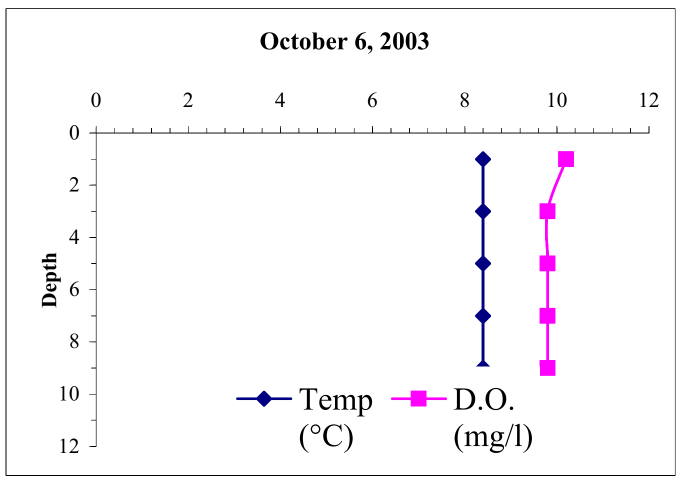
Notes:

Kangaroo Lake

Date:	**10-06-03**	**Max Depth (ft):**	9.6
Time:	10:00	**KANS**	3.0
Weather:	47F, Clear, Breezy	**KANB**	7.0
Ent:	TSN **Verf:** TSN/JME	**Secchi Depth (ft):**	4.2

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	8.4	10.2	8.5	349
3.0	8.4	9.8	8.6	348
5.0	8.4	9.8	8.6	348
7.0	8.4	9.8	8.6	349
9.0	8.4	9.8	8.6	349

Parameter	KANS	KANB
Total P (mg/l)	0.030	0.030
Dissolved P (mg/l)		
Chl a (µg/l)	5.45	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	5	4
Calcium (mg/l)		



Notes: The lake was very choppy, and appears to be mixed.

B

APPENDIX B

Comprehensive Aquatic Vegetation Survey Data (Transect Data)

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Z	Max Veg Z	Species	Common Name	Daubenmire Cover
1	1	rocky	noveg		0.5		#N/A	#N/A	0
1	2	srock	noveg		2.0		#N/A	#N/A	0
1	3	sandy	chasp	1	4.0		Chara sp.	Muskgrasses, stoneworts	1
1	4	muck	chasp	5	8.0		Chara sp.	Muskgrasses, stoneworts	2
1	4	muck	najfl	1	8.0		Najas flexilis	Slender naiad, bushy pondweed	1
1	4	muck	utrvu	1	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
2	1	rocky	sciac	80	1.0		Scirpus acutus	Hardstem bulrush	5
2	2	muck	chasp	1	4.0		Chara sp.	Muskgrasses, stoneworts	1
2	3	muck	chasp	1	5.0		Chara sp.	Muskgrasses, stoneworts	1
2	3	muck	najfl	1	5.0		Najas flexilis	Slender naiad, bushy pondweed	1
2	4	muck	chasp	10	8.0		Chara sp.	Muskgrasses, stoneworts	2
2	4	muck	najfl	1	8.0		Najas flexilis	Slender naiad, bushy pondweed	1
2	4	muck	potil	5	8.0		Potamogeton illinoensis	Illinois pondweed	2
2	4	muck	utrvu	1	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
3	1	rocky	sciac	30	0.5		Scirpus acutus	Hardstem bulrush	3
3	2	rocky	noveg		2.0		#N/A	#N/A	0
3	3	srock	noveg		4.0		#N/A	#N/A	0
3	4	muck	chasp	1	7.0		Chara sp.	Muskgrasses, stoneworts	1
3	4	muck	najfl	1	7.0		Najas flexilis	Slender naiad, bushy pondweed	1
3	4	muck	utrvu	1	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
4	1	sandy	chasp	5	1.5		Chara sp.	Muskgrasses, stoneworts	2
4	1	sandy	myrsi	1	1.5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
4	1	sandy	potil	1	1.5		Potamogeton illinoensis	Illinois pondweed	1
4	2	sandy	chasp	10	3.0		Chara sp.	Muskgrasses, stoneworts	2
4	2	sandy	eleac	1	3.0		Eleocharis acicularis	Needle spikerush, hairgrass	1
4	2	sandy	potil	1	3.0		Potamogeton illinoensis	Illinois pondweed	1
4	3	muck	chasp	40	5.0		Chara sp.	Muskgrasses, stoneworts	3
4	3	muck	najfl	5	5.0		Najas flexilis	Slender naiad, bushy pondweed	2
4	3	muck	potil	10	5.0		Potamogeton illinoensis	Illinois pondweed	2
4	3	muck	utrvu	10	5.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
4	4	muck	chasp	60	8.0		Chara sp.	Muskgrasses, stoneworts	4
4	4	muck	potil	20	8.0		Potamogeton illinoensis	Illinois pondweed	2
4	4	muck	utrvu	10	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
5	1	sandy	chasp	1	0.5		Chara sp.	Muskgrasses, stoneworts	1
5	1	sandy	eleac	5	0.5		Eleocharis acicularis	Needle spikerush, hairgrass	2
5	1	sandy	myrsi	1	0.5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
5	1	sandy	potgr	1	0.5		Potamogeton gramineus	Variable pondweed, grass-leaved pondweed	1
5	1	sandy	typla	40	0.5		Typha latifolia	Broad-leaved cattail	3
5	2	sandy w/detritus	myrsi	5	2.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
5	2	sandy w/detritus	nupva	20	2.0		Nuphar variegata	Spatterdock, bullhead pond lily	2
5	2	sandy w/detritus	potna	40	2.0		Potamogeton natans	Floating-leaf pondweed	3
5	2	sandy w/detritus	potpe	10	2.0		Potamogeton pectinatus	Sago pondweed	2
5	2	sandy w/detritus	sciac	40	2.0		Scirpus acutus	Hardstem bulrush	3
5	2	sandy w/detritus	utrvu	10	2.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
5	3	muck w/detritus	najfl	30	4.0		Najas flexilis	Slender naiad, bushy pondweed	3
5	3	muck w/detritus	potil	5	4.0		Potamogeton illinoensis	Illinois pondweed	2
6	1	rocky sand	chasp	20	1.0		Chara sp.	Muskgrasses, stoneworts	2
6	1	rocky sand	elepa	20	1.0		Eleocharis palustris	Creeping spikerush	2
6	1	rocky sand	equfl	1	1.0		Equisetum fluviatile	Water horsetail, pewterwort, joint rush	1
6	1	rocky sand	irive	5	1.0		Iris versicolor	Northern blue flag	2
6	1	rocky sand	potna	1	1.0		Potamogeton natans	Floating-leaf pondweed	1
6	1	rocky sand	utrvu	1	1.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
6	2	rocky sand	potil	1	2.0		Potamogeton illinoensis	Illinois pondweed	1
6	3	silty sand	chasp	20	3.5		Chara sp.	Muskgrasses, stoneworts	2
6	3	silty sand	najfl	20	3.5		Najas flexilis	Slender naiad, bushy pondweed	2
6	3	silty sand	potil	10	3.5		Potamogeton illinoensis	Illinois pondweed	2
6	3	silty sand	utrvu	5	3.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
7	1	rocky	eleac	1	1.0		Eleocharis acicularis	Needle spikerush, hairgrass	1
7	1	rocky	sciac	20	1.0		Scirpus acutus	Hardstem bulrush	2
7	1	rocky	sciam	80	1.0		Scirpus americanus	Three-square, chairmaker's rush	5
7	2	rocky	noveg		2.0		#N/A	#N/A	0
7	3	muck	chasp	5	4.0		Chara sp.	Muskgrasses, stoneworts	2
7	3	muck	najfl	20	4.0		Najas flexilis	Slender naiad, bushy pondweed	2
7	3	muck	potil	5	4.0		Potamogeton illinoensis	Illinois pondweed	2
7	3	muck	utrvu	1	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
7	4	muck	chasp	5	6.0		Chara sp.	Muskgrasses, stoneworts	2
7	4	muck	najfl	40	6.0		Najas flexilis	Slender naiad, bushy pondweed	3
7	4	muck	potil	5	6.0		Potamogeton illinoensis	Illinois pondweed	2
8	1	rocky	noveg		1.0		#N/A	#N/A	0
8	2	muck	najfl	1	3.0		Najas flexilis	Slender naiad, bushy pondweed	1
8	2	muck	potil	1	3.0		Potamogeton illinoensis	Illinois pondweed	1
8	3	silty	chasp	10	4.0		Chara sp.	Muskgrasses, stoneworts	2
8	3	silty	najfl	30	4.0		Najas flexilis	Slender naiad, bushy pondweed	3
8	3	silty	potil	10	4.0		Potamogeton illinoensis	Illinois pondweed	2
8	3	silty	utrvu	5	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
8	4	silty	chasp	40	5.5		Chara sp.	Muskgrasses, stoneworts	3
8	4	silty	najfl	40	5.5		Najas flexilis	Slender naiad, bushy pondweed	3
8	4	silty	potil	5	5.5		Potamogeton illinoensis	Illinois pondweed	2
8	4	silty	utrvu	5	5.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
9	1	rocky	sciac	80	0.5		Scirpus acutus	Hardstem bulrush	5

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Z	Max Veg Z	Species	Common Name	Daubenmire Cover
9	2	rocky	sciac	1	2.0		Scirpus acutus	Hardstem bulrush	1
9	3	muck	najfl	10	4.0		Najas flexilis	Slender naiad, bushy pondweed	2
9	3	muck	potil	20	4.0		Potamogeton illinoensis	Illinois pondweed	2
9	3	muck	utrvu	5	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
9	4	muck	chasp	1	5.5		Chara sp.	Muskgrasses, stoneworts	1
9	4	muck	najfl	1	5.5		Najas flexilis	Slender naiad, bushy pondweed	1
9	4	muck	potil	10	5.5		Potamogeton illinoensis	Illinois pondweed	2
9	4	muck	utrvu	1	5.5		Utricularia vulgaris	Common bladderwort, great bladderwort	1
10	1	sand	chasp	20	1.0		Chara sp.	Muskgrasses, stoneworts	2
10	1	sand	myrsi	1	1.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
10	1	sand	potpe	40	1.0		Potamogeton pectinatus	Sago pondweed	3
10	1	sand	sciac	30	1.0		Scirpus acutus	Hardstem bulrush	3
10	2	sand	chasp	70	2.0		Chara sp.	Muskgrasses, stoneworts	4
10	2	sand	najfl	5	2.0		Najas flexilis	Slender naiad, bushy pondweed	2
10	2	sand	sciac	30	2.0		Scirpus acutus	Hardstem bulrush	3
10	2	sand	utrvu	1	2.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
10	3	sand	chasp	1	3.0		Chara sp.	Muskgrasses, stoneworts	1
10	3	sand	najfl	1	3.0		Najas flexilis	Slender naiad, bushy pondweed	1
10	3	sand	potil	1	3.0		Potamogeton illinoensis	Illinois pondweed	1
10	4	muck	chasp	1	5.0		Chara sp.	Muskgrasses, stoneworts	1
10	4	muck	najfl	1	5.0		Najas flexilis	Slender naiad, bushy pondweed	1
10	4	muck	potil	10	5.0		Potamogeton illinoensis	Illinois pondweed	2
10	4	muck	utrvu	1	5.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
11	1	rocky	noveg		1.0		#N/A	#N/A	0
11	2	rocky	noveg		2.0		#N/A	#N/A	0
11	3	sand	chasp	40	4.0		Chara sp.	Muskgrasses, stoneworts	3
11	3	sand	myrsp	80	4.0		Myriophyllum spicatum	Eurasian water milfoil	5
11	3	sand	potam	10	4.0		Potamogeton amplifolius	Large-leaf pondweed, bass weed, musky weed	2
11	3	sand	potil	10	4.0		Potamogeton illinoensis	Illinois pondweed	2
11	3	sand	potpe	5	4.0		Potamogeton pectinatus	Sago pondweed	2
11	3	sand	utrvu	5	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
11	4	mucky sand	chasp	60	6.0		Chara sp.	Muskgrasses, stoneworts	4
11	4	mucky sand	myrsi	1	6.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1
11	4	mucky sand	myrsp	1	6.0		Myriophyllum spicatum	Eurasian water milfoil	1
11	4	mucky sand	potam	5	6.0		Potamogeton amplifolius	Large-leaf pondweed, bass weed, musky weed	2
11	4	mucky sand	potil	20	6.0		Potamogeton illinoensis	Illinois pondweed	2
11	4	mucky sand	utrvu	1	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
11	4	mucky sand	valam	20	6.0		Vallisneria americana	Wild celery, eel-grass, tape-grass	2
12	1	rocky	myrsi	5	1.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
12	1	rocky	sagla	30	1.0		Sagittaria latifolia	Common arrowhead, broad-leaf arrowhead, duck	3
12	1	rocky	sciac	10	1.0		Scirpus acutus	Hardstem bulrush	2
12	1	rocky	sciam	30	1.0		Scirpus americanus	Three-square, chairmaker's rush	3
12	1	rocky	spafl	40	1.0		Sparganium fluctuans	Floating-leaf bur-reed	3
12	2	rocky	myrsi	10	2.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
12	2	rocky	sciac	5	2.0		Scirpus acutus	Hardstem bulrush	2
12	2	rocky	spafl	60	2.0		Sparganium fluctuans	Floating-leaf bur-reed	4
12	3	mucky w/detritus	chasp	60	4.0		Chara sp.	Muskgrasses, stoneworts	4
12	3	mucky w/detritus	najfl	30	4.0		Najas flexilis	Slender naiad, bushy pondweed	3
12	3	mucky w/detritus	potil	20	4.0		Potamogeton illinoensis	Illinois pondweed	2
12	3	mucky w/detritus	spafl	10	4.0		Sparganium fluctuans	Floating-leaf bur-reed	2
13	1	sand	chasp	40	1.0		Chara sp.	Muskgrasses, stoneworts	3
13	1	sand	potil	5	1.0		Potamogeton illinoensis	Illinois pondweed	2
13	1	sand	sciac	15	1.0		Scirpus acutus	Hardstem bulrush	2
13	2	rocky sand	potil	20	2.0		Potamogeton illinoensis	Illinois pondweed	2
13	2	rocky sand	sciac	10	2.0		Scirpus acutus	Hardstem bulrush	2
13	3	sandy muck	myrsi	60	4.0		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	4
13	3	sandy muck	potam	10	4.0		Potamogeton amplifolius	Large-leaf pondweed, bass weed, musky weed	2
13	3	sandy muck	potil	10	4.0		Potamogeton illinoensis	Illinois pondweed	2
13	4	muck	chasp	30	5.5		Chara sp.	Muskgrasses, stoneworts	3
13	4	muck	myrsi	20	5.5		Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	2
13	4	muck	najfl	20	5.5		Najas flexilis	Slender naiad, bushy pondweed	2
13	4	muck	najfl	1	5.5		Najas flexilis	Slender naiad, bushy pondweed	1
13	4	muck	potil	10	5.5		Potamogeton illinoensis	Illinois pondweed	2
14	1	rocky	noveg		1.0		#N/A	#N/A	0
14	2	sande w/rock	chasp	30	2.0		Chara sp.	Muskgrasses, stoneworts	3
14	3	sandy muck	chasp	30	4.5		Chara sp.	Muskgrasses, stoneworts	3
14	3	sandy muck	najfl	1	4.5		Najas flexilis	Slender naiad, bushy pondweed	1
14	3	sandy muck	potil	20	4.5		Potamogeton illinoensis	Illinois pondweed	2
14	3	sandy muck	utrvu	10	4.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
14	4	muck	chasp	20	7.0		Chara sp.	Muskgrasses, stoneworts	2
14	4	muck	potil	5	7.0		Potamogeton illinoensis	Illinois pondweed	2
14	4	muck	utrvu	10	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
15	1	rocky	potpe	20	1.0		Potamogeton pectinatus	Sago pondweed	2
15	2	sandy rock	chasp	30	2.5		Chara sp.	Muskgrasses, stoneworts	3
15	2	sandy rock	utrvu	5	2.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
15	3	muck	chasp	80	4.0		Chara sp.	Muskgrasses, stoneworts	5
15	3	muck	potil	5	4.0		Potamogeton illinoensis	Illinois pondweed	2
15	3	muck	utrvu	5	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
15	4	muck	chasp	20	6.0		Chara sp.	Muskgrasses, stoneworts	2
15	4	muck	potil	5	6.0		Potamogeton illinoensis	Illinois pondweed	2

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Z	Max Veg Z	Species	Common Name	Daubenmire Cover
15	4	muck	utrvu	10	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
16	1	sandy muck	chasp	10	1.0		Chara sp.	Muskgrasses, stoneworts	2
16	1	sandy muck	najfl	5	1.0		Najas flexilis	Slender naiad, bushy pondweed	2
16	1	sandy muck	potpe	5	1.0		Potamogeton pectinatus	Sago pondweed	2
16	1	sandy muck	potri	10	1.0		Potamogeton richardsonii	Clasping-leaf pondweed	2
16	2	muck	chasp	10	2.5		Chara sp.	Muskgrasses, stoneworts	2
16	2	muck	najfl	10	2.5		Najas flexilis	Slender naiad, bushy pondweed	2
16	2	muck	potri	10	2.5		Potamogeton richardsonii	Clasping-leaf pondweed	2
16	2	muck	utrvu	5	2.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
16	3	muck	chasp	30	4.0		Chara sp.	Muskgrasses, stoneworts	3
16	3	muck	najfl	10	4.0		Najas flexilis	Slender naiad, bushy pondweed	2
16	4	muck	najfl	10	6.5		Najas flexilis	Slender naiad, bushy pondweed	2
16	4	muck	potil	5	6.5		Potamogeton illinoensis	Illinois pondweed	2
17	1	sand	chasp	10	1.0		Chara sp.	Muskgrasses, stoneworts	2
17	1	sand	potpe	5	1.0		Potamogeton pectinatus	Sago pondweed	2
17	2	sandy	chasp	10	2.5		Chara sp.	Muskgrasses, stoneworts	2
17	3	mucky sand	chasp	10	4.0		Chara sp.	Muskgrasses, stoneworts	2
17	4	muck	chasp	10	6.5		Chara sp.	Muskgrasses, stoneworts	2
17	4	muck	najfl	20	6.5		Najas flexilis	Slender naiad, bushy pondweed	2
17	4	muck	potil	30	6.5		Potamogeton illinoensis	Illinois pondweed	3
18	1	sandy rock	chasp	5	1.0		Chara sp.	Muskgrasses, stoneworts	2
18	2	sand	chasp	10	3.0		Chara sp.	Muskgrasses, stoneworts	2
18	3	muck	chasp	20	5.0		Chara sp.	Muskgrasses, stoneworts	2
18	3	muck	najfl	10	5.0		Najas flexilis	Slender naiad, bushy pondweed	2
18	3	muck	potil	10	5.0		Potamogeton illinoensis	Illinois pondweed	2
18	4	muck	chasp	25	6.5		Chara sp.	Muskgrasses, stoneworts	3
18	4	muck	najfl	20	6.5		Najas flexilis	Slender naiad, bushy pondweed	2
18	4	muck	potil	5	6.5		Potamogeton illinoensis	Illinois pondweed	2
18	4	muck	utrvu	5	6.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
19	1	rock	noveg		1.0		#N/A	#N/A	0
19	2	sand	chasp	10	3.0		Chara sp.	Muskgrasses, stoneworts	2
19	3	sandy rock	noveg		5.0		#N/A	#N/A	0
19	4	muck	chasp	5	7.0		Chara sp.	Muskgrasses, stoneworts	2
19	4	muck	najfl	5	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
20	1	rock	noveg		1.0		#N/A	#N/A	0
20	2	sand	chasp	10	3.0		Chara sp.	Muskgrasses, stoneworts	2
20	2	sand	najfl	10	3.0		Najas flexilis	Slender naiad, bushy pondweed	2
20	3	muck	chasp	30	5.0		Chara sp.	Muskgrasses, stoneworts	3
20	3	muck	najfl	10	5.0		Najas flexilis	Slender naiad, bushy pondweed	2
20	3	muck	utrvu	10	5.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
20	4	muck	chasp	20	7.0		Chara sp.	Muskgrasses, stoneworts	2
20	4	muck	najfl	20	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
20	4	muck	potil	10	7.0		Potamogeton illinoensis	Illinois pondweed	2
20	4	muck	utrvu	10	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
21	1	rocky sand	noveg	10	1.0		#N/A	#N/A	2
21	2	sand	chasp	30	2.5		Chara sp.	Muskgrasses, stoneworts	3
21	3	sandy rock	noveg		4.5		#N/A	#N/A	0
21	4	muck	chasp	20	7.0		Chara sp.	Muskgrasses, stoneworts	2
21	4	muck	najfl	20	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
21	4	muck	potil	5	7.0		Potamogeton illinoensis	Illinois pondweed	2
21	4	muck	utrvu	5	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
22	1	rocky	noveg		1.0		#N/A	#N/A	0
22	2	sand	chasp	20	3.0		Chara sp.	Muskgrasses, stoneworts	2
22	3	rocky	noveg		4.0		#N/A	#N/A	0
22	4	muck	chasp	20	6.5		Chara sp.	Muskgrasses, stoneworts	2
22	4	muck	najfl	20	6.5		Najas flexilis	Slender naiad, bushy pondweed	2
23	1	sand	noveg		1.0		#N/A	#N/A	0
23	2	sand	chasp	40	3.0		Chara sp.	Muskgrasses, stoneworts	3
23	2	sand	potil	10	3.0		Potamogeton illinoensis	Illinois pondweed	2
23	3	muck	chasp	30	4.5		Chara sp.	Muskgrasses, stoneworts	3
23	3	muck	utrvu	5	4.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
23	4	muck	chasp	30	6.0		Chara sp.	Muskgrasses, stoneworts	3
23	4	muck	najfl	5	6.0		Najas flexilis	Slender naiad, bushy pondweed	2
23	4	muck	potil	5	6.0		Potamogeton illinoensis	Illinois pondweed	2
24	1	sand	chasp	10	1.0		Chara sp.	Muskgrasses, stoneworts	2
24	1	sand	sciac	30	1.0		Scirpus acutus	Hardstem bulrush	3
24	1	sand	sciam	30	1.0		Scirpus americanus	Three-square, chairmaker's rush	3
24	2	sand	nupva	40	3.0		Nuphar variegata	Spatterdock, bullhead pond lily	3
24	2	sand	sciac	30	3.0		Scirpus acutus	Hardstem bulrush	3
24	3	sandy muck	chasp	20	4.0		Chara sp.	Muskgrasses, stoneworts	2
24	3	sandy muck	utrvu	5	4.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
24	4	muck	chasp	30	5.5		Chara sp.	Muskgrasses, stoneworts	3
24	4	muck	najfl	10	5.5		Najas flexilis	Slender naiad, bushy pondweed	2
24	4	muck	utrvu	5	5.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
25	1	sand	noveg		1.0		#N/A	#N/A	0
25	2	rocky sand	noveg		2.5		#N/A	#N/A	0
25	3	rocky gravel	noveg		4.5		#N/A	#N/A	0
25	4	muck	chasp	20	6.0		Chara sp.	Muskgrasses, stoneworts	2
25	4	muck	potil	5	6.0		Potamogeton illinoensis	Illinois pondweed	2
26	1	rock	noveg		1.0		#N/A	#N/A	0

Transect	Depth Range	Substrate	Acronym	Aerial Cover	Z	Max Veg Z	Species	Common Name	Daubenmire Cover
26	2	sandy rock	chasp	5	2.5		Chara sp.	Muskgrasses, stoneworts	2
26	3	sandy gravel	chasp	5	4.5		Chara sp.	Muskgrasses, stoneworts	2
26	4	muck	chasp	30	7.0		Chara sp.	Muskgrasses, stoneworts	3
26	4	muck	utrvu	5	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
27	1	rock	noveg		1.0		#N/A	#N/A	0
27	2	sand	chasp	10	3.0		Chara sp.	Muskgrasses, stoneworts	2
27	3	sandy muck	chasp	30	5.0		Chara sp.	Muskgrasses, stoneworts	3
27	3	sandy muck	utrvu	10	5.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
27	4	muck	chasp	5	7.0		Chara sp.	Muskgrasses, stoneworts	2
27	4	muck	najfl	5	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
28	1	rocky	noveg		8.0		#N/A	#N/A	0
28	2	sandy rock	chasp	10	2.5		Chara sp.	Muskgrasses, stoneworts	2
28	2	sandy rock	sciac	10	1.0		Scirpus acutus	Hardstem bulrush	2
28	3	sandy gravel	chasp	10	4.5		Chara sp.	Muskgrasses, stoneworts	2
28	4	muck	chasp	20	7.5		Chara sp.	Muskgrasses, stoneworts	2
28	4	muck	najfl	10	7.5		Najas flexilis	Slender naiad, bushy pondweed	2
28	4	muck	utrvu	5	7.5		Utricularia vulgaris	Common bladderwort, great bladderwort	2
29	1	sandy rock	sciac	30	1.0		Scirpus acutus	Hardstem bulrush	3
29	2	sandy rock	noveg		2.5		#N/A	#N/A	0
29	3	sandy rock	noveg		4.0		#N/A	#N/A	0
29	4	muck	chasp	10	8.0		Chara sp.	Muskgrasses, stoneworts	2
29	4	muck	najfl	5	8.0		Najas flexilis	Slender naiad, bushy pondweed	2
29	4	muck	potil	5	8.0		Potamogeton illinoensis	Illinois pondweed	2
29	4	muck	utrvu	5	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
30	1	rocky	noveg		1.0		#N/A	#N/A	0
30	2	sandy rock	noveg		2.5		#N/A	#N/A	0
30	3	rocky sand	chasp	5	4.0		Chara sp.	Muskgrasses, stoneworts	2
30	4	muck	najfl	20	8.0		Najas flexilis	Slender naiad, bushy pondweed	2
30	4	muck	potil	20	8.0		Potamogeton illinoensis	Illinois pondweed	2
30	4	muck	utrvu	5	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
31	1	rocky	chasp	20	1.0		Chara sp.	Muskgrasses, stoneworts	2
31	2	sand	noveg		2.5		#N/A	#N/A	0
31	3	sand	noveg		4.0		#N/A	#N/A	0
31	4	muck	chasp	10	8.0		Chara sp.	Muskgrasses, stoneworts	2
31	4	muck	najfl	10	8.0		Najas flexilis	Slender naiad, bushy pondweed	2
31	4	muck	potil	20	8.0		Potamogeton illinoensis	Illinois pondweed	2
31	4	muck	utrvu	5	8.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
32	1	rock	noveg		1.0		#N/A	#N/A	0
32	2	sandy rock	chasp	10	2.0		Chara sp.	Muskgrasses, stoneworts	2
32	3	sandy rock	noveg		4.0		#N/A	#N/A	0
32	4	muck	chasp	5	7.0		Chara sp.	Muskgrasses, stoneworts	2
32	4	muck	najfl	5	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
32	4	muck	utrvu	5	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
I1	4	muck	chasp	5	6.0		Chara sp.	Muskgrasses, stoneworts	2
I1	4	muck	najfl	5	6.0		Najas flexilis	Slender naiad, bushy pondweed	2
I1	4	muck	potil	10	6.0		Potamogeton illinoensis	Illinois pondweed	2
I1	4	muck	utrvu	1	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	1
I2	4	rocky muck	chasp	1	6.0		Chara sp.	Muskgrasses, stoneworts	1
I2	4	rocky muck	najfl	1	6.0		Najas flexilis	Slender naiad, bushy pondweed	1
I2	4	rocky muck	potil	5	6.0		Potamogeton illinoensis	Illinois pondweed	2
I3	4	muck	chasp	70	6.0		Chara sp.	Muskgrasses, stoneworts	4
I3	4	muck	najfl	20	6.0		Najas flexilis	Slender naiad, bushy pondweed	2
I3	4	muck	utrvu	20	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
I4	4	muck	chasp	80	7.0		Chara sp.	Muskgrasses, stoneworts	5
I4	4	muck	potil	20	7.0		Potamogeton illinoensis	Illinois pondweed	2
I4	4	muck	utrvu	20	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
I5	4	muck	chasp	60	7.0		Chara sp.	Muskgrasses, stoneworts	4
I5	4	muck	najfl	10	7.0		Najas flexilis	Slender naiad, bushy pondweed	2
I5	4	muck	utrvu	10	7.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
I6	4	muck	chasp	40	6.0		Chara sp.	Muskgrasses, stoneworts	3
I6	4	muck	najfl	20	6.0		Najas flexilis	Slender naiad, bushy pondweed	2
I6	4	muck	potil	30	6.0		Potamogeton illinoensis	Illinois pondweed	3
I6	4	muck	utrvu	10	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2
I7	5	muck	najfl	30	10.0		Najas flexilis	Slender naiad, bushy pondweed	3
I7	5	muck	potil	5	10.0		Potamogeton illinoensis	Illinois pondweed	2
I7	5	muck	potpe	10	10.0		Potamogeton pectinatus	Sago pondweed	2
I8	4	rocky	noveg	2	5.0		#N/A	#N/A	1
I9	4	muck	chasp	60	6.0		Chara sp.	Muskgrasses, stoneworts	4
I9	4	muck	najfl	30	6.0		Najas flexilis	Slender naiad, bushy pondweed	3
I9	4	muck	potil	10	6.0		Potamogeton illinoensis	Illinois pondweed	2
I9	4	muck	utrvu	10	6.0		Utricularia vulgaris	Common bladderwort, great bladderwort	2

C

APPENDIX C

WDNR Sensitive Area Designation Report

"Guidelines for Protecting, Maintaining, and understanding Lake Sensitive Areas" is not included here as stated within the attached sensitive area report. Please contact the WDNR for a copy of the document.

Kangaroo Lake, Door County Wisconsin
(Waterbody Identification Code #98600)
Sensitive Area Designation Report

Date of survey: August 18, 2003
Number of sensitive areas: 6

Site Evaluators:	Mary Gansberg, Water Resources Biologist – Green Bay
	Jeff Pritzl, Wildlife Biologist – Mishicot
	Mike Toneys, Fishery Biologist – Sturgeon Bay
	Dr. Paul Mahlberg, Kangaroo Lake Association Member
	Tim Hoyman, Aquatic Ecologist, NES Ecological Services
Authors:	Mary Gansberg and Tim Hoyman

General Lake Information:

Kangaroo Lake is a shallow, hardwater, 1,123–acre lake located in Door County, Wisconsin. Maximum depth is 12 feet and the average depth is 6 feet. Water level is controlled on this drainage lake by a dam on the southeast end.

Kangaroo Lake is divided into two distinct basins by the CTH E causeway, which was created in the late 1800's. The smaller north basin is approximately 300 acres in size and acts as the headwaters for the lake. It is clear and quite shallow (approx. 3-4 feet) contains a variety of open water and wetland species of plants, is surrounded by undisturbed forests, and the shoreline remains undeveloped with only walk-in access available. Peil Creek drains into the north basin through an extensive maze of vegetative islands providing clean, cool water to Kangaroo Lake. Water flows from the north basin to the south basin through four culverts, which run beneath the causeway.

The larger south basin is approximately 800 acres in size and is characterized by turbid water, lack of diversified native aquatic vegetation complicated by the presence of Eurasian water-milfoil (*Myriophyllum spicatum*), significant shoreline development, and considerable recreational use.

A sensitive area designation survey was conducted on the north basin of Kangaroo Lake in 1996 and is included as Appendix A. A sensitive area designation survey on the entire larger southern end was completed in the summer of 2003. This report describes the results of that survey.

The Kangaroo Lake Association has designated portions of the lake's south end as a slow-no-wake zone to protect the few remaining bulrushes (*Schoenoplectus sp*., formerly known as *Scirpus*) that exist there from the detrimental effects of motorboats. The Kangaroo Lake

Association has also setup a voluntary slow-no-wake zone extending 500 feet from the lake's shore into open water. This zone is intended to slow the spread of Eurasian water-milfoil and to protect the lake's silty bottom from resuspension.

With cost-share assistance from the Department of Natural Resources, the Kangaroo Lake Association recently sponsored the development of a comprehensive lake management plan for Kangaroo Lake. The study assessed the lakes' watershed, water quality, aquatic plant community, and shoreline condition and then developed lake management, protection, and enhancement alternatives and recommendations.

Introduction:

A sensitive area designation survey was conducted on August 18, 2003 using the Wisconsin Department of Natural Resources guidelines for conducting and implementing sensitive areas. The purpose of the sensitive area designation survey is to identify areas within and around the shoreline of the lake that provide unique and/or critical ecological habitat or have historical, geologic, or archaeological significance. This sensitive area survey can provide lake organizations, shoreline property owners, county zoning officials, Department of Natural Resources personnel and other users with specific information that can be used for planning, decision making, and for educational efforts.

What is a Sensitive Area Designation?

Sensitive areas are defined in Wisconsin Administrative Code NR 107.05(3)(i)(1) – *Sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or life-stage requirements, or offering water quality or erosion control benefits to the body of water.* These areas may consist of valuable aquatic/wetland vegetation, terrestrial vegetation, gravel/rubble substrate, downed woody cover, and water quality buffers.

Following is a list of potential ways sensitive area designations could be used:

- To inform and educate the public of potential impacts to the aquatic ecosystem from shoreline alteration
- By managers to guide permitting processes of aquatic plant management, water regulations, fisheries management, wildlife management and local zoning activities
- By local lake organizations to help guide lake use and management activities
- As a foundation for further research or study
- As a complement to local land-use planning activities
- To provide information to potential shoreland buyers and existing shoreland owners
- As baseline data for various resource management decisions
- To provide education to the public about the benefits of protecting and restoring aquatic life habitat.

The Sensitive Area Designations:

Six sites on Kangaroo Lake were designated as sensitive areas and are delineated on the map in Figure 1. Table 1 contains the area location descriptions of each sensitive area. Table 2 lists the aquatic plant species identified at each sensitive area site.

<u>Table 1</u>. Kangaroo Lake Sensitive Area Location Descriptions

Sensitive Area 1
Area between shoreline and a line between points:

Point	Latitude	Longitude
1	45º 1’ 4.05535”N	87º 9’ 50.10772”W
	TO	
2	45º 1’ 3.06422”N	87º 9’ 16.5933”W

Sensitive Area 2
Area between shoreline and lines directly east from shoreline and between points:

Point	Latitude	Longitude
1	45º 1’ 44.47999”N	87º 9’ 57.28861”W
	TO	
2	45º 1’ 31.69795”N	87º 9’ 52.31937”W

Sensitive Area 3
Area between shoreline and lines between points:

Point	Latitude	Longitude
1	45º 2’ 34.00899”N	87º 9’ 15.63077”W
	TO	
2	45º 2’ 32.23831”N	87º 9’ 15.71862”W
	TO	
3	45º 2’ 27.1369”N	87º 9’ 6.36458”W

Sensitive Area 4
Area extending out 100-feet from island shoreline.

Sensitive Area 5
Area between 5-foot and 3-foot depths contours with north and south extents between points:

Point	Latitude	Longitude
1	45º 2’ 29.9375”N	87º 9’ 53.46926”W
	TO	
2	45º 2’ 23.73309”N	87º 9’ 53.90425”W

Sensitive Area 6
Creek along lake access road from Elm Point Road and extending between shoreline and lines between points:

Point	Latitude	Longitude
1	45º 2’ 42.02516”N	87º 9’ 26.1634”W
	TO	
2	45º 2’40.79179”N	87º 9’ 28.02987”W
	TO	
3	45º 2’ 38.15779”N	87º 9’ 24.73283”W
	TO	
4	45º 2’ 40.44231”N	87º 9’ 21.25741”W

Table 2. Kangaroo Lake Aquatic Plant Occurrences

Sensitive Area	Scientific	Common	Community
1			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Schoenoplectus sp.[1]	Bulrushes	Emergent
	Scirpus pungens [2]	Three-square	Emergent
	Nuphar variegata	Spatterdock	Floating Leaf
2			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Schoenoplectus sp.	Bulrushes	Emergent
3			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Myriophyllum sibiricum	Northern water milfoil	Submergent
	Potamogeton pectinatus	Sago pondweed	Submergent
	Potamogeton natans	Floating-leaf pondweed	Submergent
	Potamogeton gramineus	Variable pondweed	Submergent
	Eleocharis acicularis	Needle spikerush	Emergent
	Eleocharis palustris	Creeping spikerush	Emergent
	Equisetum fluviatile	Water horsetail	Emergent
	Iris versicolor	Northern blue flag	Emergent
	Schoenoplectus sp.	Bulrushes	Emergent
	Typha latifolia	Broad-leaved cattail	Emergent
	Nuphar variegata	Spatterdock	Floating Leaf
4			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Potamogeton pectinatus	Sago pondweed	Submergent
	Schoenoplectus sp.	Bulrushes	Emergent
5			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Potamogeton pectinatus	Sago pondweed	Submergent
	Potamogeton richardsonii	Clasping-leaf pondweed	Submergent
	Myriophyllum sibiricum	Northern water milfoil	Submergent
6			
	Chara sp.	Muskgrasses	Submergent
	Utricularia vulgaris	Common bladderwort	Submergent
	Najas flexilis	Slender naiad	Submergent
	Potamogeton illinoensis	Illinois pondweed	Submergent
	Schoenoplectus sp.	Bulrushes	Emergent
	Eleocharis acicularis	Needle spikerush	Emergent
	Scirpus pungens	Three-square	Emergent

[1] formerly know as *Scirpus* [2] formerly know as *Scirpus americanus*

Resource Value of Sensitive Area 1:

This site is located on the southern shore of the lake. It includes the entire area inside the buoys which is a slow-no-wake area out to approximately 5 feet deep which is about 700 feet from the shoreline out into open water.

Figure 2. Sensitive Area 1

The primary reasons for this site to be selected were the fishery values, wildlife values (and associated wetland habitat), water quality, and natural scenic beauty. This area has a diverse aquatic plant community that can provide important habitat for fish and wildlife. These plants provide important spawning, nursery, and cover area for fish and invertebrates. The aquatic vegetation provides excellent habitat for the production of macroinvertebrates (aquatic insects), which is an essential part of the food chain. The emergent bulrush stands are highly valuable in aquatic communities. The standing dead stalks are primary spawning habitat for northern pike and perch in the early spring. These species do not spawn on beds like bass and other panfish but spawn by broadcasting their eggs on standing material such as old stems, aquatic plants, or fallen timber. Without this material, spawning will not be successful. This same area could be a spawning site for smallmouth bass in late spring. Another benefit these plants have is due to the leaves having extensive spongy tissue and air space. This makes them great nesting material for ducks, shorebirds, and muskrats. Nests made of these buoyant leaves float up and down with changing water levels. The exposed woody debris provides roosting and hunting areas for birds as well as basking areas for reptiles and amphibians. The site also offers a physical buffer that protects water quality by anchoring and stabilizing sediments and protecting shorelines from wave erosion. The adjacent wetland provides excellent habitat for a variety of furbearers, birds, amphibians, and reptiles. During the blooming of the lilies this site is very colorful and adds a great deal of beauty to the lake.

Management Recommendation:

- Do not remove coarse woody cover in both the water and in the shoreland areas
- Monitor for the presence of exotic invasive species on a regular basis
- Do not remove native plants by physical, mechanical, or chemical means
- Eliminate all motorboat use inside the buoy area.
- Create an open water wildlife refuge within the buoyed area.

Resource Value of Sensitive Area 2:

This site is located on the southwest shore starting at the access site owned by the Retreat going north along the shore for approximately 1400 feet. The site averages approximately 200 feet out into the water from shore. The site follows the contiguous undisturbed shoreline and consists of a variety of near-shore terrestrial and shoreline vegetation. This site is unique in that it is an undeveloped shoreline that is not adjacent to a wetland.

Figure 3. Sensitive Area 2

This site was selected because of the wildlife values, natural shoreland, and natural scenic beauty found at this location. A diverse, minimally disturbed near-shore terrestrial plant community provides for a variety of wildlife species. Birds, reptiles, and furbearers all use this site for shelter, nesting, and feeding areas. Wildlife will concentrate in this area as well due to the emergent rushes. The bulrushes provide food and cover for wildlife such as waterfowl and furbearers. Macroinvertebrates such as dragonflies and damselflies will use the emergent vegetation to crawl out of the water during metamorphosis (as they change to adults). Natural looking shorelands like this provide aesthetic value that is otherwise very limited.

Management Recommendations:

- Protect the near-shore terrestrial vegetation for shoreland and upland wildlife and aesthetic benefits.
- Protect the emergent bulrushes
- Do not remove coarse woody cover in both the water and in the shoreland areas

Resource Value of Sensitive Area 3:

This site is on the northeast side of the lake. It consists of the entire bay area and follows the north shore approximately 250 feet. The shoreline in this area has little or no development.

Figure 4. Sensitive Area 3

The primary reasons for site selection include aquatic plant diversity, fishery values, wildlife values (and associated wetland habitat), and natural scenic beauty. The aquatic plants provide vital habitat for fish and wildlife. The vegetation provides important spawning areas for northern pike and largemouth bass. The site is used as a fish nursery and for feeding and cover for other fish and wildlife. Forage species such as minnows and suckers also utilize this area. The aquatic vegetation provides excellent habitat for the production of macroinvertebrates. Thousands of microscopic crustaceans can live on muskgrass (*Chara sp*) providing an important food source for young fish and waterfowl. The wetland complex provides excellent habitat for furbearers such as muskrat and mink. These species will take advantage of the proximity of the wetland to the lake as a place to rear young and feed. Taller trees along the fringe can be used by perching raptors such as Bald Eagle or Osprey. Both species depend on fish for food and their presence always seems to impress the people who utilize the lake. In addition to large birds, songbirds use this area for nesting and cover. Other lesser known species of salamanders depend on these types of wetlands to complete their life cycle. This minimally disturbed bay provides a peaceful oasis from the main lake. The large forested wetland adjacent to the lake provides for a natural setting on an otherwise developed lake.

Management Recommendation:
- Protect existing aquatic plant growth. Do not remove native plants by physical, mechanical, or chemical means
- Protect the adjacent wetlands
- Minimize boat traffic in bay area

<u>Resource Value of Sensitive Area 4:</u>

This site covers the entire perimeter of the 15-acre Echo Island from shore out 100 feet. The site consists of a variety of upland and near-shore plant species.

The primary reasons for the site to be selected are the natural scenic beauty and natural shoreland found at this location. The shoreline and upland areas are relatively un-impacted except for two homes on the south end of the island. Because so much of the lake is developed, the near-shore areas on this island not only provide natural scenic beauty for lake residents and lake users, but also fish and wildlife values. The shrubs/brush, fallen timber, overhanging vegetation, rubble/gravel areas, and submergent and emergent plant species present at this site are important habitat components to the lake ecosystem. Many species use these areas for one or more of their functional needs.

Management Recommendation:
- Maintain and protect entire shoreland around the island
- Minimize disturbance and structures within the littoral zone
- Protect snag trees and large trees on the island

Figure 5. Sensitive Area 4

Resource Value of Sensitive Area 5:

This site is on the west side of the lake and north of the boat landing at Kangaroo Beach Road. The site is out from shore in water three to five feet deep. The site is a sand shoal that drops off fast and has a high diversity of submerged aquatic plants.

The primary reason for site selection was aquatic plant diversity. Submerged aquatic vegetation provides important habitat for all life stages of fish and feeding areas for wildlife. Aquatic plants provide excellent habitat for the production of macroinvertebrates that are food for several fish species, amphibians, reptiles, birds, and larger insects. The root network of aquatic vegetation holds the bottom sediments in place to help prevent wave action and boat wakes from stirring up the sediment and making the water murky. This diverse aquatic plant community just off shore is unique on Kangaroo Lake and provides critical habitat for fish, macroinvertebrates, and other aquatic organisms. Because so much of the littoral zone is disturbed on Kangaroo Lake, small areas like this are important to the overall health of the lake ecosystem.

Management Recommendation:

- Monitor for the presence of exotic invasive species on a regular basis
- Do not remove native aquatic vegetation by physical, mechanical, or chemical means
- Minimize motorboat traffic in this area

<u>Resource Value of Sensitive Area 6:</u>

This site is located on the northeast side of the lake at North Cote Drive. It is comprised of the shoreline out to approximately 250 feet from shore and includes the creek mouth and wetland area just upstream from the creek mouth on the north side of North Cote Drive. Back from the shore a short distance, the unnamed creek forms a large pool filling much of the lot extending to Elm Point Road. A large population of yellow water crowfoot (*Ranunculas flabellaris*) and various orchids among other unusual plants occupy this wetland. The Hine's Emerald Dragonfly occurs in the wetland along CTH E and with the proximity of this site to CTH E, it is assumed that this pool is also probable habitat. The creek is an important component of the overall watershed. It drains the wetland area east of Elm Point Road and wetland north of CTH E. The primary reasons for site selection was wildlife habitat (and associated wetlands), and natural scenic beauty. Three-square rush (*Scirpus pungens*) is present on the gravelly shore as well as in the water surrounding the area. Bulrushes are also present in the water. Macroinvertebrates such as dragonflies and damselflies will use the emergent vegetation to crawl out of the water during metamorphosis. The wetland complex provides excellent habitat for furbearers such as muskrat and mink. These species will take advantage of the proximity of the wetland to the lake as a place to rear young and feed. The site also offers a physical buffer that protects water quality by anchoring and stabilizing sediments and protecting shorelands from wave erosion.

Management Recommendation:

- Protect the adjacent wetland
- Do not remove native aquatic vegetation by physical, mechanical, or chemical means - especially the emergent species

Figure 6. Sensitive Area 6

Whole Lake Management Recommendations:

Resource managers made several recommendations on a whole lake basis.

1. Maintain as much of naturally felled woody debris as possible.
2. Restore shoreland buffers and discourage sea walls and riprap on developed sites.
3. Remove hard shoreline structures and restore natural shorelines to enhance wildlife and fish species.
4. Protect nearshore habitats that have important fisheries values.
5. Educate landowners about the importance of a healthy lakeshore buffer.
6. Protect terrestrial vegetation within 75 feet of the shore.
7. Manage and prevent the spread of Eurasian water-milfoil and other invasive exotic species.
8. Reduce entire tree removal for viewing purposes; try to trim choice limbs.
9. Protect adjacent wetlands and spring areas from development pressures.
10. Encourage periodic water level manipulation.
11. Minimize lawn fertilization to prevent excess nutrient loading to the lake.
12. Properly maintain septic systems to protect water quality.
13. Obey all slow no-wake areas.
14. Restrict manual raking to floating mats of vegetation and leave rooted plants in place.

Conclusions:

Kangaroo Lake is a beautiful lake that deserves special attention. It is truly a unique setting in Door County due in part to the tracts of undeveloped shoreline, bulrush stands, island, and adjacent wetlands. Six sensitive areas were designated on the lake because they contribute to the uniqueness of the lake as a whole. These areas also provide essential functions that make the lake what it is. Special care should be taken to protect these areas and other areas on the lake from further disturbance. Restoring disturbed shorelines and shoreland buffers to a more natural state would be even more desirable to aquatic life and wildlife. The slow no-wake speed restriction within the buoys on the south end of the lake, combined with the voluntary slow-no-wake zone extending 500 feet from the lake's shore into open water, should help decrease shoreline erosion and protect the lake's silty bottom from resuspension. Lakes are one of the state's most valuable resources and without proper protection, the water quality will quickly deteriorate resulting in a loss of aesthetic beauty and degradation of fish and wildlife habitat. All lake ecosystems are sensitive to change and human impacts. It is critical that we protect and restore these valuable resources.

Appendix A. Kangaroo Lake Sensitive Area Designation Report, North Lobe

Appendix A is not included here. A copy of the North Lobe Sensitive Area Designation Report can be obtained from the Wisconsin Department of Natural Resources.

Figure 1
Kangaroo Lake
Door County, Wisconsin
Wisconsin Department of Natural Resources Sensitive Area Designations

D

APPENDIX D

Educational Materials

Presentation Outline

- Why is Lake Management Planning Important?
- Project Objectives
- Association Involvement

NES Ecological Services
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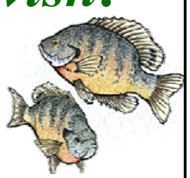
A goal without a plan is just a wish!



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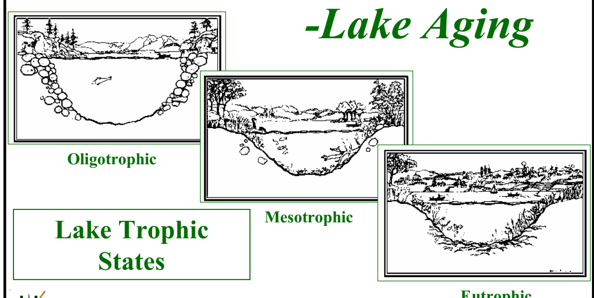
Lake Management Planning

Eutrophication

-Lake Aging



Lake Trophic States

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Lake Management Planning

Cultural Eutrophication

Accelerated eutrophication caused by human activity.

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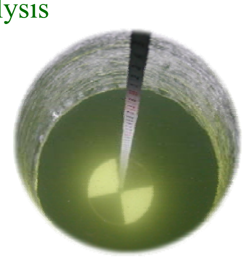
Project Objectives

- Data Collection and Analysis



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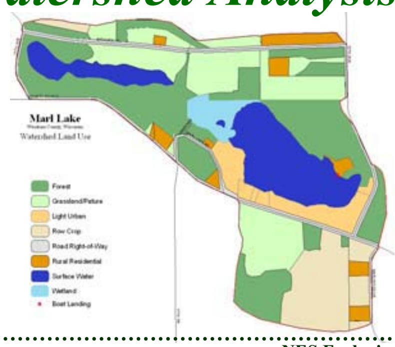
Project Objectives

Watershed Analysis



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Project Objectives

Aquatic Vegetation

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Project Objectives

Water Quality

- Current Monitoring
- Historic Data
- Region and State

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Project Objectives

- Data Collection and Analysis
- Develop A Comprehensive Management Plan for Kangaroo Lake

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Project Schedule

Task	2003											2004					
	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Kick-off Meeting																	
Water Sample																	
Plant Survey																	
Land Use Verification																	
Progress Report																	
Data Analysis																	
Report Preparation																	
Report Draft Meeting																	
Report Revisions																	
Report Delivery																	
Final Meeting																	

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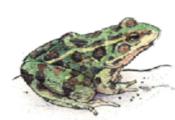
District Participation

Your Participation is Important to the Success of this Project



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District Participation

- Concerns
- Observations
- Questions

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Thank You

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UW Extension

Wisconsin Dept. of Natural Resources

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Project Update
Kangaroo Lake Management Plan Study

The study that will help us plan the management of Kangaroo Lake began this past winter with water samples collected through the ice. A special thanks to all those who kept us informed about the ice conditions on the lake.

The April samples were collected during a limnological event called “spring turnover”. This is a very important event in many Wisconsin lakes because it often replenishes oxygen to lower depths that have diminished due to decomposition of vegetation during the winter. It is also an important event for our sampling regime because it helps us determine the average concentrations for many parameters we of concern. For example, nutrients, most importantly phosphorus, tends to have higher concentrations in the deeper depths of the lake during both the summer and winter months when the lakes are stratified. Even though these concentrations can be quite high and often misleading to the actual phosphorus content in the lake, there may not be a problem because plants, both algae and vascular (rooted), never have access to it. This phenomenon occurs because many lakes loose most or all of their oxygen in the hypolimnion (deepest layer in a stratified lake), during the winter and summer months. When the hypolimnion becomes anoxic (void of oxygen), the iron that normally holds phosphorus molecules in the bottom sediments releases it to the water. As I mention above, in many lakes, this is not a big deal because there just isn’t that much phosphorus to be released, plus the stratification of the lake that keeps oxygen out of hypolimnion also keeps the phosphorus out of the water layers where algae and other plants can use it. This phenomenon does become a problem when large amounts of phosphorus have built up in the sediments over the years. In these lakes, the sediments release so much phosphorus, that much of it is recycled into the lake each turnover event (usually fall and spring in northern Wisconsin lakes). This is termed “internal nutrient cycling” or “internal phosphorus loading” and is likely not a major concern in Kangaroo Lake because of periodic mixing and its shallow depths. However, we will model the phosphorus samples that we collect over the course of the study to make sure.

The next major event for the study will be the kick-off meeting that is scheduled for 10:00 AM, July 26th at the Baileys Harbor Town Hall. This meeting is as important as any set of samples we will collect. Why? Because it is your opportunity to learn more about lake management planning, the study that is being completed, and something about what it takes to keep a lake healthy so it can support fishing, swimming, boating, and be aesthetically pleasing. It is also your opportunity to ask specific questions and to relay specific information about the lake to the ecologists that are studying the lake and helping the Kangaroo Lake Association create their plan. So, please attend the meeting and do not hesitate to participate by providing information, making comments, or asking questions.

Submitted by:
Tim Hoyman
Aquatic Ecologist
NES Ecological Services, Green Bay
(920) 499-5789
t.hoyman@releeinc.com

Project Goals & Objectives

- Data Collection and Analysis
  - Watershed
  - Aquatic Plants
  - Water Quality
- Develop Comprehensive Management Plan

Meeting Goals

Technical Alternatives

Group Alternatives

Plan Alternatives

Prioritized Action Plan

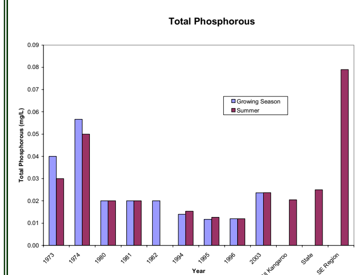
Water Quality

Phosphorus
(Limiting Plant Nutrient)

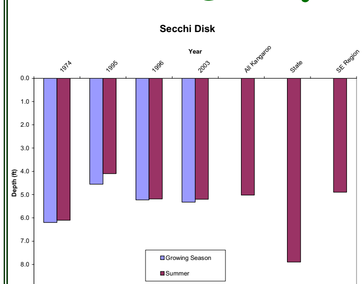
Chlorophyll-*a*
(Algal Abundance)

Water Clarity
(Secchi Disk)

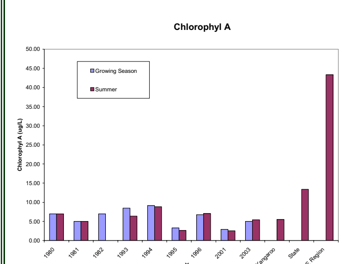
Water Quality



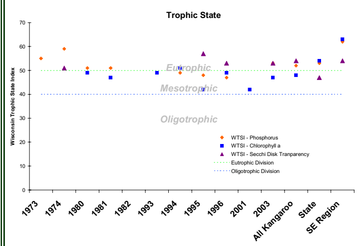
Water Quality



Water Quality



Water Quality



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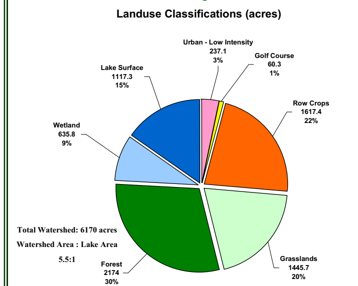
Watershed Analysis



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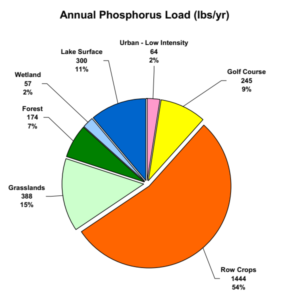
Watershed Analysis



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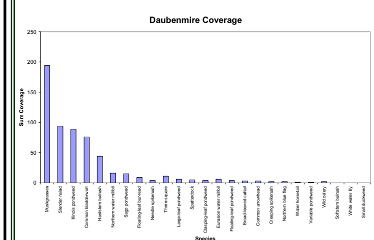
Aquatic Plants



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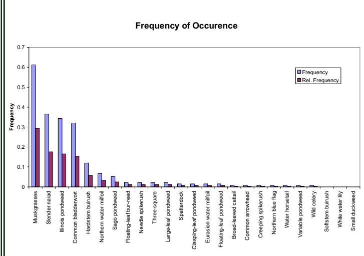
Aquatic Plants



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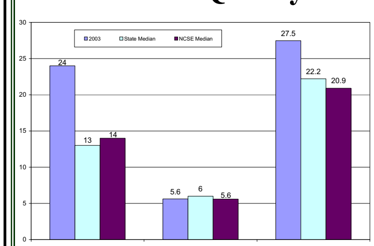
Aquatic Plants

Floristic Quality



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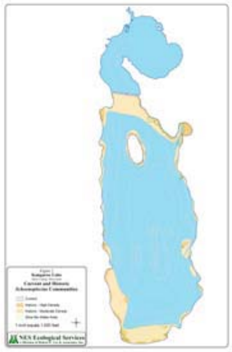
Bulrushes



Technical Alternatives

Aquatic Plants

- Eurasian water-milfoil treatment
- Periodic monitoring
- Slow-No-Wake Area
- Experimental bulrush restoration project
- Eurasian water-milfoil monitoring

Water Quality

- Continued water quality monitoring
- Slow-No-Wake Area

Watershed

- Continued monitoring of specific areas
- Septic system survey & modeling
- Update landuse modeling
- County Zoning Laws
- Septic system study (many methods)
- Shoreland restoration (buffer strip)
- Land acquisition (Land Trust)

Education

- Importance of aquatic plants
- Representatives to WI Lakes Conf.
- Shallow lake ecology

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Kangaroo Lake Association

Kangaroo Lake Comprehensive Management Plan

July 10, 2004

Timothy A. Hoyman, CLM

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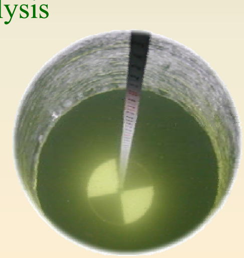
Presentation Outline

- Project Objectives
- Study Results
- Management Alternatives

Project Objectives

- Data Collection and Analysis
  - Water Quality
  - Aquatic Plants
  - Watershed
- Develop Comprehensive Management Plan



Study Results

Water Quality

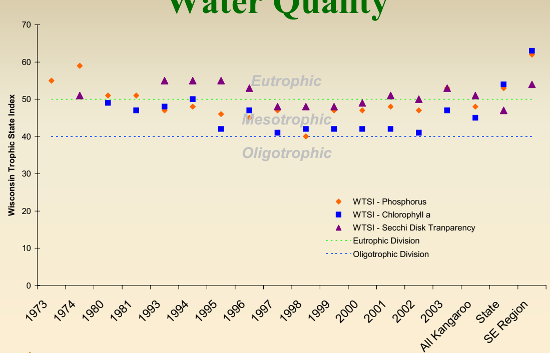
↑ Phosphorus (Limiting Plant Nutrient)

↑ Chlorophyll-*a* (Algal Abundance)

↓ Water Clarity (Secchi Disk)

Study Results

Water Quality

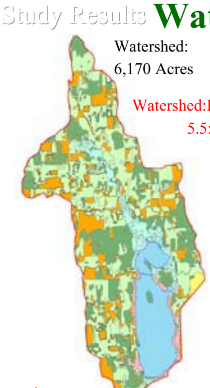


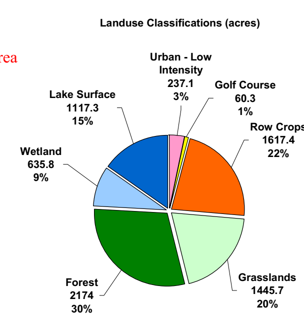
Study Results

Watershed Analysis

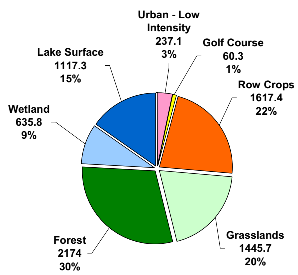
Watershed:
6,170 Acres

Watershed:Lake Area
5.5:1





Study Results Watershed Analysis



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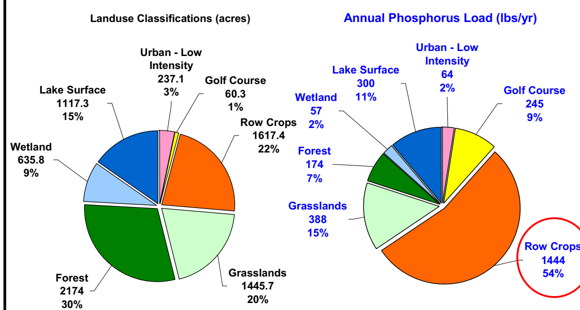
Study Results Watershed Analysis



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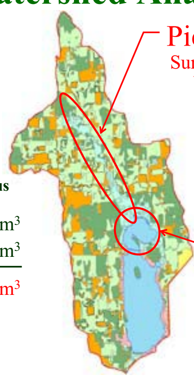
Study Results Watershed Analysis



Piel Creek
Surrounded by wetlands

Sandy Soils

Detention Basin

Model Agreement
Growing Season Phosphorus

Predicted: 44 mg/m^3
Actual: 24 mg/m^3

Difference: 20 mg/m^3

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Study Results Watershed Analysis

Shoreland Buffering

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Study Results Watershed Analysis

Shoreland Buffering

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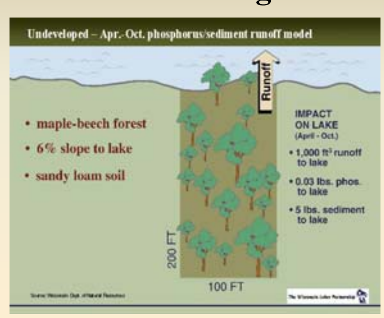
Study Results Watershed Analysis

Shoreland Buffering



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Study Results
Watershed Analysis
Shoreland Buffering

500%
666%
1800%

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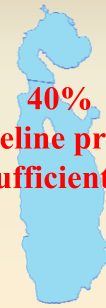
Study Results
Watershed Analysis
Shoreland Buffering



40%
of shoreline properties
contain sufficient buffering

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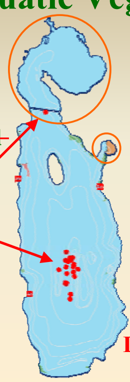
Study Results
Aquatic Vegetation

Exotic Species

~~Curly-leaf Pondweed~~

Eurasian water-milfoil



High Diversity Areas
(Healthy Areas)

Remaining Areas:
Low-Growing
Disturbance-Tolerant

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Study Results
Aquatic Vegetation

Bulrushes

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Study Results
Aquatic Vegetation

Bulrushes

Current Stands

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Study Results
Aquatic Vegetation

Bulrushes

Current Stands

Historic Stands

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Study Results

Aquatic Vegetation

WDNR
Sensitive Area
Designations

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Management Alternatives

Recommendations
(Based upon technical findings & experience)

Planning Group Input
(Based upon group's experience)

Group Alternatives

Action Plan
(Implementation Plan)

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Alternatives

Focus of Management Alternatives

Kangaroo Lake is a shallow lake

Vs.

Turbid State **Algae**

Clear State **Macrophytes**

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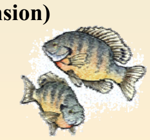
Alternatives

Focus of Management Alternatives

Loss of Aquatic Plants

- Loss of fish and wildlife habitat
- Reduced competition against Eurasian water-milfoil
- Loss of root structure (sediment resuspension)
- Reduced competition with algae



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Alternatives

Focus of Management Alternatives

Loss of Aquatic Plants

Likely Causes

Shoreland Development

66% Reduction vegetation along developed shorelands

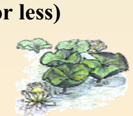
Motorboat Impacts

Bottom disturbances to 10' (most at 6' or less)

Increased turbidity & uprooting

Direct contact with plants

Wave action



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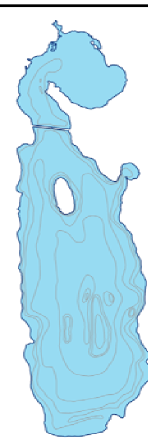
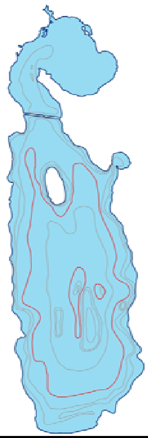


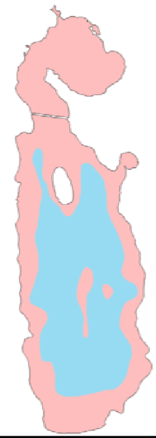


Is it all bad?

NO

Economic Importance

Most people enjoy boating



More than 45% of the south basin's bottom is susceptible to motorboat impacts

Alternatives

Focus of Management Alternatives

Watershed Issues

- **Watershed is in pretty good shape, but changes could cause problems.**
- **Developed properties are adding unneeded phosphorus to the lake.**

Lake Water Quality

- **Has been pretty good, but changes may occur (aquatic plant losses, watershed, etc.)**

Stakeholder Education

- **Always important in a management planning**

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Alternatives

Action Plan

- **Experimental bulrush re-establishment project**
- **Eurasian water-milfoil monitoring with potential chemical treatment**
- **Expand volunteer SNW area with treatment of small Eurasian water-milfoil near causeway**
- **Shoreland restoration – Phase I**
- **Stakeholder education**
- **Watershed committee formation**
- **Aquatic plant survey**
- **Shoreland restoration – Phase II**
- **Continued water quality monitoring**

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North Basin

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North Basin

South end set by ordinance

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North Basin

South end set by ordinance

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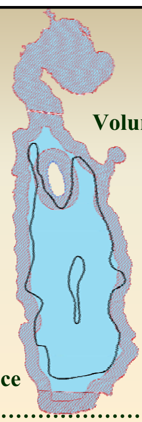
North Basin



Voluntary 500-foot

South end set by ordinance

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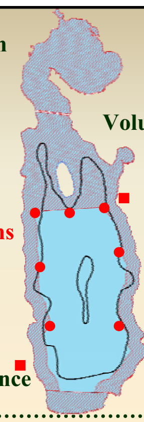
North Basin



Voluntary 500-foot

Expanded S-N-W

16.5% less than current

Marked by buoys & signs

South end set by ordinance

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Alternatives

Action Plan

- **Experimental bulrush re-establishment project**
- **Eurasian water-milfoil monitoring with potential chemical treatment**
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- **Shoreland restoration – Phase II**
- **Continued water quality monitoring**

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Extension

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Door County Advocate July 22, 2004

The quest to save Kangaroo Lake

Consultants suggest education, monitoring, restoration

By Paige Funkhouser
Advocate staff reporter

The fishing, boating and other water activities taking a toll on the ecosystem of Kangaroo Lake can be curbed, according to consultants hired by the Kangaroo Lake Association.

Studies conducted by NES Ecological Services of Green Bay over the last two years are expected to help prevent what are now small environmental problems from being aggravated into lake-threatening problems.

At its annual meeting July 10, the members of the Kangaroo Lake Association heard presentations on several studies they had instigated and helped to fund. The studies determined the effect of the surrounding watershed on the lake water, assessed water quality, and looked at aquatic plant species, populations and locations.

The studies conducted by scientists at NES were funded by grants from the Wisconsin Department of Natural Resources. NES took water samples from the lake six different times over the course of the year in order to measure phosphorus levels — which limit and control the amount of plants that can grow in a lake — and to measure the clarity of the water.

Tim Hoyman, an aquatic biologist from NES, was the project manager who devised a comprehensive plan to help the KLA restore the lake.

"The comprehensive management plan isn't just my recommendation," Hoyman said at the KLA annual meeting. "It's my findings, and your group's ideas."

The action plan Hoyman developed after completing the water quality studies included a study funded by a third Lake Protection Grant, one that plotted the locations of native lake bulrushes and will allow for the re-establishment of the species into select areas of the lake.

"The bulrushes are disappearing from the lake," Hoyman told the audience. "The DNR has sensitive area designations in the northern end of the lake, a finger in the northeast, the southern tip and around the island."

Hoyman is concerned that even though these sensitive areas are designated by slow-no-wake zones for boats, the aquatic plant populations are suffering.

"The loss of aquatic plants," Hoyman explained, "will equal the loss of fish and wildlife habitat, reduced competition against Eurasian water-milfoil ... the loss of root structure in the sediment, and reduced competition with invasive, light-blocking algae."

> **"The comprehensive management plan isn't just my recommendation. It's my findings, and your group's ideas."**
>
> — Tim Hoyman
> *aquatic biologist*

When he explained his action plan, Hoyman said that the primary cause of aquatic plant loss is motorboat disturbance.

"A motorboat can cause disturbances on the lake-bottom up to 10 feet deep," he said. "Even if boats are going moderately slow, most disturbance occurs in 6 feet of water."

Boat motors, which Hoyman and members of the audience agreed have increased in power over the last 20 years, have a direct effect on plants. Wave action from boats, ski and propellers are partly responsible for uprooting and endangering aquatic plants.

To help save the struggling ecosystem of the lake, Hoyman recommended the KLA implement the following:

➤ Monitoring Eurasian milfoil with potential chemical treatment;

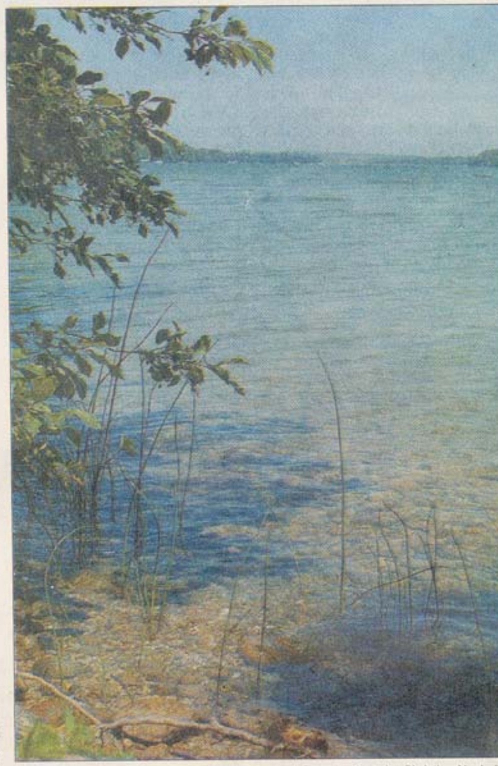
➤ Expansion of the voluntary slow-no-wake area by 16.5 percent from the current restricted zone;

➤ Implement shoreland restoration — by encouraging lakefront property owners not to "mow" lake plants. The limitation would help reduce nutrient and sediment loads from entering the lake from developed shoreland areas;

➤ Educate lake-area stakeholders on the importance of native lake and shoreland plants.

The proposals upset some people in the audience who questioned the reduction of

See LAKE, Page 3



Advocate photo by Christine Nesheim

THE KANGAROO LAKE ASSOCIATION hopes to restore the bulrushes along the shore and educate lake-area stakeholders about the necessity of native lake and shoreland plants.

LAKE:
Boat motors bigger

FROM PAGE 1

already limited space available for recreation.

Former KLA board vice president Jim Musiel said he supported the plan to educate people about environmental hazards such as zebra mussels and Eurasian milfoil.

"There's milfoil straight off (my property)," Musiel said, "and they found some new growths by the causeway. Cormorants are a big problem, too."

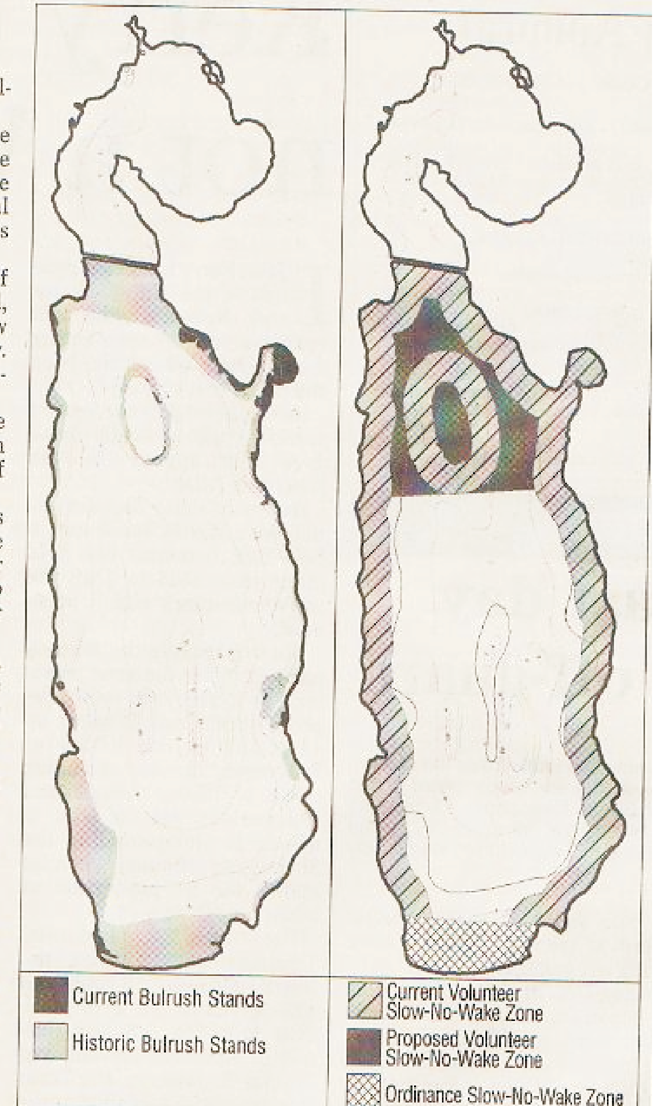
Increasing the slow-no-wake zone might not make much difference in the ecology of the lake, Musiel continued.

"I've got mixed emotions with the no-wake zone," he said. "The motors that can stir up the bottom in 8-foot-deep water are few and far between on this lake.

"I had a conversation with Paul Mahlberg (one of the people who helped with the lake studies) last night," Musiel continued. "He said that if we don't do something to save this lake, our property values are going to go down. I said, 'If we don't allow boats on the lake our property values are going to go down.'"

Several people, including Musiel, said they've seen the bulrushes come and go in cycles, a pattern that made them less concerned with reintroducing the species to the lake.

The KLA board decided to table some of the bigger recommendations Hoyman made, such as chemical treatments to kill milfoil, until they could further discuss their options.



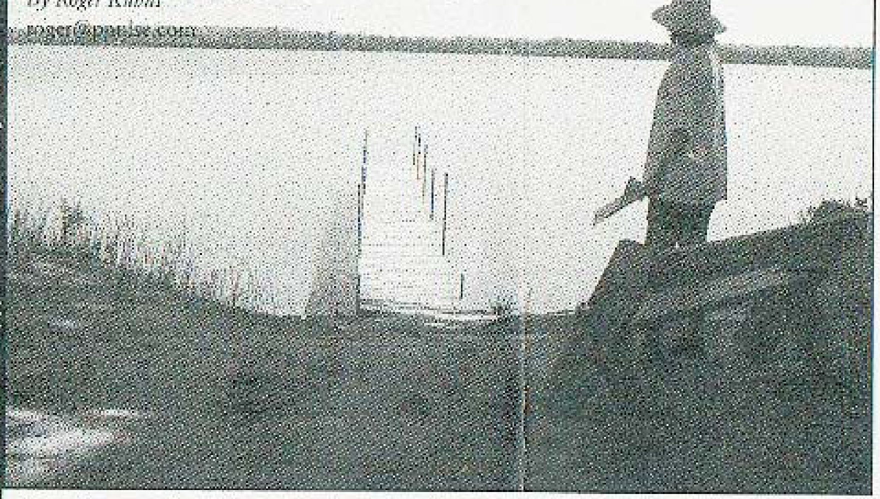
Advocate graphic by Mike Jarman

MAPS PROVIDED BY THE KANGAROO LAKE ASSOCIATION show how bulrushes have nearly disappeared from the inland lake's shoreline, and a proposed expanded slow/no-wake zone.

Peninsula Pulse August 2004

Kangaroo Lake Gets A Fairly Good Bill Of Health

By Roger Kuhns
roger@ppulse.com



The people with properties around Kangaroo Lake turned out in force on July 10th to elect new Kangaroo Lake Association members and to get an update on the state of their lake. Timothy Hoyman, an aquatic ecologist with NES Ecological Services out of Oneida, Wisconsin, spearheaded the development of a lake management plan that included program design, research, data-gathering phases, and planning. Hoyman was quick to note that "This takes commitment and involvement. I can lay the foundations, but the Kangaroo lake Association's involvement will make it a useable management plan."

The project started two years ago, being initially funded by DNR grants in August 2002 ... winter of 2003. The study's objective was to collect and analyze data to better understand the lake's eco-system. This involved collecting water quality samples six times annually, two aquatic plant survey studies, and a watershed study. Once the results were collected Hoyman could develop a Comprehensive Lake Management Plan (CLMP).

The field and laboratory studies measured three important aspects of the lake, all of which indicate the healthiness of the eco-system: phosphorus, chlorophyll-a, and water clarity. Phosphorus levels control the amount of what grows in the lake; it is food for the plants. A measure of algal growth is recorded through the chlorophyll-a abundance. Water clarity is affected ... suspended sediment. "This is usually what most people first look at when making a judgment about the health of the lake," Hoyman said. "These three components are very related, when phosphorus goes up, algae growth goes up, and water clarity goes down." By assessing these factors Hoyman can judge the lake's eutrophication. "This is an assessment of the natural or accelerated aging of the lake."

A lake naturally ages over tens of thousands of years. Lakes become more productive as they age because slowly over time natural phosphorus accumulates in the eco-system. This increases plant and zooplankton growth, which in turn increases the fish population. In time the lake shallows, as it fills with sediment and organic matter. Kangaroo Lake is naturally shallow, with a maximum depth of 12 feet, and an average depth of 6 feet.

But this normally slow aging process can be greatly accelerated when human activities impact a lake. Hoyman explained that there is a spectrum of levels regarding a lake's productivity. They are divided into three major where there is low productivity and few fish. Signifying increasing productivity is mesotrophic, eutrophic and hyper-eutrophic states. "When we talk about these trophic states it is hard to say what is happening," Hoyman said. "The trophic state index is a way to understand lakes like Kangaroo Lake. Our field measurements of chlorophyll-a suggest Kangaroo Lake is in a eutrophic state, but phosphorus and water clarity data suggest it is in a mesotrophic state. It has fluctuated over the years, since data collection in 1973 from mostly eutrophic, down to lower mesotrophic in the mid-late 1980s, then up to eutrophic now." A mesotrophic state is about normal for a Door County lake. "That's pretty good news," Hoyman said. "If we looked at phosphorus, chlorophyll-a and water clarity data separately, Kangaroo Lake fluctuates between fair to good water quality."

Kangaroo Lake Watershed Components

LAND USE	PERCENT	PHOSPHORUS Contribution to lake
Wooded	30%	7%
Grasslands	20%	15%
Row crops	22%	54%
Golf courses	1%	?
Urban - low intensity	3%	2%
Lake surface	15%	
Wetlands	9%	2%

Kangaroo Lake

Continued from Page 6

Hoyman rhetorically asked the crowd, "Is the lake getting worse? I don't know, I don't think so. It may just be natural fluctuations."

Kangaroo Lake's watershed includes 6,170 acres, and development around the lake is characterized as light urban. Hoyman uses a watershed-to-lake-area ration to determine the impact of watershed contamination to the lake. Kangaroo's ratio is 5.5:1. "This is manageable," Hoyman said, "I was working on lakes in Iowa that had ratios of 110:1, and these had real problems." He presented a breakdown of the watershed land use components.

Actual phosphorus input into Kangaroo Lake during growing season is about 24 milligrams per cubic meter (mg/m3). "Our models have a hard time predicting this," Hoyman said, "because Piel Creek is surrounded by wetlands, and water is filtered through them, which keeps the phosphorus down. Phosphorus tends to bind to sediment, so if you see sediment plumes in a lake, then you know that phosphorus is entering the lake in a big way. The north detention basin captures phosphorus and sediments, and buffers and protects the main part of the lake."

One of Hoyman's greatest concerns is shoreline development. "A study ten years ago indicated that people came to Wisconsin to enjoy the scenic natural beauty of the lakes," he said. "But the first thing people want to do is modify their lake side property so it is an urban dwelling." Therein lies a serious problem. Hoyman gave an example that showed a five-times increase of sediment input into the lake where the shoreline had been developed. This equated into a ten-times increase in the phosphorus loading into the lake. "A big responsibility of the KLA is to ensure responsible shoreline development, and that shoreline buffers are used so the run-off can be filtered," Hoyman said. "Right now only about 40 percent of Kangaroo Lake's shoreline has sufficient buffering. That means 60 percent of the lake has more phosphorus going into it that should not be there. This is a big concern; this accelerates the eutrophication of the lake and impacts wildlife habitats.

Hoyman reviewed the status of aquatic vegetation, noting that natural high diversity areas in the lake survived in the north basin, and to a lesser degree in select inlets. "These are remnants of the healthy lake plant community. The lack of more of this is a concern. The Bulrushes are disappearing from the lake. At Kangaroo Lake the most important thing is the loss of aquatic plants. The loss of plants is a big sign that there is something wrong." Hoyman suggested this is due to shoreline development, motorboat and wave impacts that increase the turbidity of the lake.

Management Alternatives were discussed and will be reviewed by the KLA. "These must be what the association wants to do, and what they can afford to do," Hoyman said. He recommended continued monitoring, and identification of who is to be responsible for various aspects of data gathering, budgeting, education, and other tasks.

E

APPENDIX E

Lake Term Glossary

Algae	Microscopic plants that use sunlight as an energy source. Algae can be unicellular (Diatoms), filamentous (many green or blue-green species), colonies in a gelatinous mass (many blue-greens) or more complicated colonies like *Chara sp.*
Alum Treatment	An in-lake treatment used in reducing internal nutrient loading. The treatment includes the application of aluminum sulfate or other aluminum salt (alum) directly to the lake. Once added to the lake, the alum changes form and begins to form a floc. As the floc settles to the bottom, it pulls phosphorus and particulate matter down with it. Finally, the floc settles to the bottom creating a "blanket" or barrier that prevents phosphorus from entering the water column from the bottom sediments and as a result, reduces internal phosphorus loading significantly.
Anthropogenic	An occurrence caused or produced by the action of humans.
Anoxic	Devoid of dissolved oxygen.
Benthic	Pertaining to a river bed or lake floor
Contact Herbicide	A plant specific pesticide which causes extensive cellular damage exclusively to the areas of the target which come in contact with the herbicide (Affects contacted area only)
Ecosystem	The interaction of a community of organisms with each other and with the characteristics that make up their environment (Aquatic ecosystem, Northern Boreal Forest)
Emergent	An aquatic plant having most of its vegetative parts above the water surface (Cattail, Common Arrowhead)
Epilimnion	The upper most layer of water within a stratified lake. During the summer, this layer holds the warmest water and during the winter it holds the coldest water. This layer continuously circulates.
Eutrophic	A trophic classification of a lake that is highly productive.
Exotic	A non-native organism that has been introduced into an area (Purple Loosestrife, Eurasian Water Milfoil)
Floating-leaf	Plants rooted in the sediment or free-floating with leaves lying flat on the water surface (Duckweed, White Water Lilly)
Hypolimnion	The deepest layer of water within a stratified lake. In the winter it holds the warmest water and in the summer it holds the coldest water.
Interspecific	Between two or more distinct species.
Invasive	An organism which readily colonizes a disturbed area and tends to take it over by out-competing other plants. These can be native (Cattail) or exotic species (Purple Loosestrife).
Limiting Nutrient	The nutrient, usually phosphorus, which is in shortest supply and controls the growth rate of algae and macrophytes. As an analogy: if we wanted to bake four cakes and each cake required two eggs and two cups of sugar, flour, and water, but we only had six eggs, the eggs would be the limiting ingredient in the scenario. With only six eggs, we could bake three cakes even though we have plenty of the other ingredients. Once we obtained two more eggs, we could bake the fourth cake.
Littoral Zone	Pertaining to the shallow water zone of a lake that has sufficient light penetration to support macrophytes.
Macrophyte	A multicelled plant, usually with roots, stems, and leaves. A vascular plant (Cattail, Eurasian water-milfoil, pondweeds)

Median Value	A value in a set which has an equal number of observations above it and below it.
Mesotrophic	A trophic classification of a lake that is moderately productive, between *oligotrophic* and *eutrophic*.
Metalimnion	This is the layer between the epilimnion and the hypolimnion that has the greatest range of temperature change with depth. The metalimnion contains the thermocline, but is not the same thing.
Motorboat	Wisconsin Statutes 30.50(2) states: "Boat" or "vessel" means every description of watercraft used or capable of being used as a means of transportation on water, except a seaplane on the water and fishing raft. Wisconsin Statute 30.50(6) further states: "Motorboat" means any boat equipped with propulsion machinery, whether or not the machinery is the principal source of propulsion. Therefore, motorboat includes all powered watercraft, including personal watercraft or jet skis.
Native	An organism that is naturally occurring to an area (White Water Lilly, Northern Water-milfoil)
Nitrogen to Phosphorus Ratio	Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 16:1, the lake is considered phosphorus limited; if it is less than 16:1, it is considered nitrogen limited. The key ratio of 16:1 is related to the normal nitrogen to phosphorus ration found in most algae.
Non-Point Source Pollution	A source of pollution that comes from an indirect point of discharge (Overland flow)
Oligotrophic	A trophic classification of a lake that is very low in productivity.
Periphyton	A community of algae, and fragments of algae, which are attached to submerged objects such as plants and stones
Photosynthesis	The process in which chlorophyll producing organisms convert CO2 and water into sugar and oxygen, using sunlight as an energy source
Phytoplankton	Free-floating (not attached) algae.
Point Source Pollution	A source of pollution that comes from a direct point of discharge (Drain Tile Outfall)
Senesce	To complete a life cycle; to die off
Shoreland Buffer Zone	A buffer of native plants and habitat that occurs between the lake and developed property. The buffer zone serves to filter sediment and nutrients that wash off of a developed area before they reach the lake.
Species Diversity	An index that relates the number of species to their relative abundances. A community with many species with similar numbers (abundances) is more diverse than a community with the same number of species, but only a few of the species dominate the area with their abundances.
Species Richness	The total number of species occurring in a community
Submergent	An aquatic plant growing entirely under the water surface (Coontail, Large-leaf pondweed, Eurasian water-milfoil)
Systematic Herbicide	A plant specific pesticide which causes systematic cellular damage after coming in contact with the target. These herbicides spread through the entire plant.
Trophic State	Productivity or nutrient enrichment status of the lake. Lakes generally classified into one of three trophic states or classifications depending upon the level of their nutrient enrichment and primary productivity rate; *oligotrophic*, *mesotrophic*, or *eutrophic*.

Trophic State Index (TSI)	A tool used by lake scientists to assign a numerical value to the trophic state of a given lake. The index can be calculated using Secchi disk transparency, chlorophyll-*a*, or total phosphorus. Use of an index allows trends in a lake's trophic status to be more easily understood by laypersons and more easily tracked through long-term trend analysis.
Water Residence Time	The average amount of time water resides in a lake. Usually measured in years or days. A lake with a long residence time would have a slow flushing rate.
Zooplankton	Microscopic animals that are free-floating with in a water body. Many prey on algae and are an important food source for young fish.

F

APPENDIX F

Experimental Bulrush Re-establishment Grant Application (Project Scope)

PROBLEM IDENTIFICATION & PROJECT GOALS

Kangaroo Lake, Door County (Figure 1) is a shallow, (maximum depth: 12', average depth: 6') 1,123-acre, natural, drainage lake with its water level controlled by a dam at its southeast end. Over the past decades, the lake's bulrush population has slowly diminished. Although stands of bulrush still exist, they do not compare with the stands that once occurred within the lake (Figure 2). The loss of these valuable emergents is likely the result of increased and more powerful motor boat traffic and lakeshore development. Recently, the Kangaroo Lake Association (KLA) worked to have a slow-no-wake zone set that extends 750-feet north from the lake's most southern shore (Figure 2) with the intention of protecting some the remaining bulrush.

Attempts to re-establish emergent vegetation within lakes often fail because the inhibiting factors, such as shoreland development, carp activity, competitiveness of invasive species, or high speed boating continue to impact the area and prevent establishment of the newly installed emergents. This is much like treating a symptom of an illness without first treating the disease.

The goal of this project is to experiment with the re-establishment of native bulrushes within a small portion of Kangaroo Lake – a portion that has recently been set aside as a protected, slow-no-wake zone. Essentially, plots of hard-stem bulrush (*Schoenoplectus acutus*) and soft-stem bulrush (*Schoenoplectus tabernaemontani*) would be planted in plots at different lengths from the shoreline within the southern slow-no-wake area and monitored to verify if they establish and expand. Both species and possibly a hybrid are believed to occur within the lake. The results of this experiment would then guide the KLA and Wisconsin Department of Natural Resources (WDNR) in future decision making concerning additional bulrush enhancements to the lake.

PROJECT SCOPE

Task 1 – Experimental Plot Installations

A mixture of hard-stem and soft-stem bulrushes would be planted within eight 4m x 4m plots. One-half of the plots (4) would be protected with temporary wavebreaks, while the other half would not. Paired plots of contradicting treatments would be planted near the shoreline (0-feet) and at 100-foot increments extending to 300-feet from shore. Plot positioning would be staggered to minimize the ability of the more distant plots from protecting the plots behind them. Plot corners would be permanently marked with pipes driven into the bottom substrate and temporarily marked for the open water season with painted t-posts. The t-posts would be removed prior to ice cover, as would the temporary wavebreaks. Both would be reinstalled following ice-out. The center of each plot location would be GPS located to facilitate their relocation the following season.

Bare-root stock would be installed by hand at 0.5m increments throughout each plot, yielding 64 plants per plot. Hard-stem and soft-stem species would be mixed randomly throughout the plots. During planting, diagrams of species location of each plot would be created. If, by chance, a plot was initially located in an area with unsuitable substrate for bulrush installation (e.g. rocky or gravel substrate), the entire plot would be relocated to more suitable planting substrate at the same distance to the shore.

Temporary wave breaks would be created by attaching a double layer of orange snow-fence to t-posts. The wavebreaks would be approximately 20-feet long and be placed directly in front of the plot they were to protect. Wavebreaks would be used only during the first two growing seasons; meaning that all plots would be unprotected during the third growing season.

Task 2 – Control Plot Selection and Marking

A healthy, but small stand of bulrushes exists in the southern slow-no-wake zone (Figure 2). This stand would have four control plots of identical size to those of the experimental plots and would be marked in the same manner. The plots would be located on the lakeward edge of the existing colony to minimize the possible affects of wave protection caused by having the plots located near the back of the colony. If applicable, efforts would be made to have the control plots located at different distances from the shore similar to the experimental plots.

The control plots would be used to monitor the existing colony's expansion or decline and would also serve as a comparison for the experimental plots.

Task 3 – Monitoring

Plots would be monitored three times per year for three growing seasons (June/August/September). During the first growing season, professional ecologists from NES Ecological Services would attend all three monitoring events. During these events, NES staff would train volunteers from the KLA to complete the monitoring tasks. During the second and third growing seasons, NES staff would only participate in the July monitoring event.

Monitoring activities would include two primary measurements:

1. **Stem counts** One-meter square subplots for stem counts would be generated randomly and would include a single subplot within each of the four, 2m quadrates of each plot. The stem counts would be used to indicate changes in bulrush density within the control and experimental plots.
2. **Bulrush location relative to plot boundary** During each visit, the two closest bulrush plants to each side of each experimental plot and the lakeward edge of each control plot would be measured to the closest 1/100th-foot. Each measurement would also indicate whether the plant was inside or outside of the plot boundary. This parameter would be used to monitor geographic expansion or decline of the plot's colony.

PUBLIC EDUCATION

The first-hand involvement of the volunteers within the project would be an excellent in which to educate the lake stakeholders about the project, its goals, and its importance. However, a broader audience would be educated through project updates included within the KLA newsletter, a association-wide mailing, and via signage posted at the boat landings and experimental plantings location.

PROJECT DELIVERABLES

The final product for this project would be a report detailing the findings of the study. The report would also contain recommendations based on those findings for the next step in the KLA's quest to restore the bulrush community of Kangaroo Lake. Copies of the report would be supplied to the WDNR in hardcopy and PDF format.

PROJECT TIMELINE

Plant Installation	May 2005
Monitoring	June, July, August 2005
Project Update	October 2005
Monitoring	June, July, August 2006
Project Update	October 2005
Monitoring	June, July, August 2007
Data Analysis	October 2007
Report Completed	December 2007

ITEMIZED COST BREAKDOWN

	Cash Costs	*Donated Value*
Labor		
Installation and Monitoring	$ 4,254.00	$ 896.00
Mapping / GIS / Permits	$ 868.00	
Public Education	$ 576.00	
Data Analysis and Report Development	$ 2,140.00	
Travel (Time at ½ normal rate, mileage)	$ 1,220.00	
Materials		
Plants	$ 832.00	
Wavebreak and Plot Marking		$ 250.00
Signs	$ 250.00	
Column Subtotals	*$ 10,140.00*	*$ 1,146.00*
TOTAL PROJECT	**$ 11,286.00**	
STATE SHARE REQUESTED	**$ 8,464.50**	