2000 SUMMARY REPORT
of
BRESEN LAKE

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT
3010 Grand Avenue
Waukegan, Illinois 60085

Mary Colwell
Mike Adam
Mark Pfister
Joseph Marencik

July 2001

TABLE OF CONTENTS

LAKE IDENTIFICATION AND LOCATION

Bresen Lake is a 24 acre lake located in unincorporated Lake County, southwest of Gilmer Road near the Village of Hawthorn Woods (T43N, R10E, S3). Originally a slough, the lake was built in 1964 when an earthen dam was constructed at the northeast end. Two main inlets enter Bresen Lake, one draining Lake Pond-A-Rudy, and the other an adjacent pond. Water exits the lake through a spillway/dropbox near the dam and continues downstream through a small tributary to Indian Creek. Indian Creek eventually flows to the Des Plaines River. Bresen Lake has a maximum depth of 10.5 feet deep and an average depth of 5.25 feet, which is estimated at half of the maximum depth. The estimated volume of the lake is 126 acre-feet[1], or 41.1 million gallons. The shoreline length is 1.1 miles.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

The same family has owned the property since 1914 before Bresen Lake was constructed. Only two houses are along the lakefront. The owner manages the lake and treats the aquatic plants with herbicides each year to use the lake for boating. During 2000, about four gallons of the herbicide Aquathol was used to control curlyleaf pondweed. In 1989, the owner stocked the lake with 100 grass carp (white amur). The owner and guests have been using the lake for motorized and non-motorized boating, fishing, wildlife observation and aesthetics. The owner has a pier with a boatlift, a smaller fishing pier, a swim raft and a small launch consisting of wooden planks. Another small pier exists on the shoreline of the adjacent home. There is no access except through the owner's property.

LIMNOLOGICAL DATA - WATER QUALITY

Water samples were taken once a month, from May through September 2000, at the deep hole location (See Figure 1). Samples were collected at three feet and eight feet deep and analyzed for a variety of parameters. The document, "Interpreting Your Water Quality Data" explains these parameters in detail. See Appendix A for water quality sampling and laboratory methods.

The water clarity in Bresen Lake averaged 3.28 feet during the 2000 sampling season, which is below the 5.0 foot seasonal average clarity reading for Lake County lakes. Clarity was best in May at 5.12 feet, before the aquatic plants were treated with

[1] One acre-foot is one acre filled with one foot of water, or 325,900 gallons.

INSERT FIGURE 1, SAMPLE LOCATION MAP

herbicides[2]. Typically, a lake dominated by plants has better clarity than a lake dominated by algae. When aquatic plant beds die after an herbicide treatment, algae blooms can occur, resulting in a decrease in water clarity. In addition, sediment that is secured by plant roots before herbicide treatment is more easily swept up into the water column by wind, wave and carp action after plants have died. This is true in Bresen Lake. Although some scattered plants were still found after the aquatic herbicide treatment, the clarity dropped to less than three feet during the months after May. Total suspended solids (TSS), such as algae and sediment, clouded the water and decreased the clarity (See Figure 2). The concentration of TSS increased near the surface of Bresen Lake after the plants died back. The TSS concentration near the bottom in July was the highest recorded from Lake County lakes sampled from 1995 – 2000. This was probably due to sediment and the decomposing plant particles. Bresen Lake had higher seasonal results for all solid parameters than the average Lake County lake.

The trophic condition of a lake indicates the overall level of nutrient enrichment. Most lakes in Lake County are eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae and fish. Hypereutrophic lakes are those that have excessive nutrients. Nuisance plant populations and algae growth reminiscent of "pea soup" are often labeled hypereutrophic. Bresen Lake is hypereutrophic in terms of its phosphorus concentrations. The condition of the lake in terms of water clarity is eutrophic. Bresen Lake has an ample supply of nutrients (nitrogen and phosphorus) within the water column. The median total phosphorus (TP) concentration in Bresen Lake during 2000 was three times higher than the Lake County median[3]. After ranking 87 lakes in terms of their phosphorus content, Bresen Lake received a ranking of 74. The median nitrate nitrogen concentration in Bresen Lake during 2000 was nearly eight times higher than the Lake County median. Ammonia nitrogen concentrations in three of the deep water samples were high. The ratio of total nitrogen[4] (TN) to total phosphorus (TP) in the lake will signify whether the lake is in shorter supply of either nitrogen or phosphorus. Lakes with TN:TP ratios of more than 15:1 are usually limited by phosphorus. Those with ratios less than 10:1 are usually limited by nitrogen. Bresen Lake has a TN:TP ratio of 17:1, which indicates it is slightly phosphorus limited.

One reason why Bresen Lake had high nutrient concentrations is because of its internal nutrient load. Not only did decomposing plants release nutrients into the water column, but nutrients were also released from the sediment as conditions became oxygen deficient at the bottom. Because of the difference in temperature between the upper and lower water layers in Bresen Lake from May through August, the water layers had different densities, and therefore did not mix. Beneficial bacteria used oxygen to decompose the plant (and animal) materials near the bottom, and eventually caused this bottom water layer to become anoxic. Dissolved oxygen (D.O.) was measured from the surface down to the bottom at one-foot increments. The dissolved oxygen concentrations measured in

---

[2] LCHD staff visited the lake on May 4-5; the herbicide treatment was occurred on May 30, 2000.
[3] Medians and averages were calculated with LCHD water quality data collected from 72 lakes from 1995 – 2000.
[4] Total nitrogen consists of the organic forms of nitrogen plus nitrate nitrogen.

Figure 2. INSERT TSS/SECCHI GRAPH

Bresen Lake were probably sufficient for a bluegill/bass fishery (at least 3.0 mg/L in two thirds of the lake volume) for most of the season. During the July 6, 2000 sampling date, however, the concentration of D.O. was sufficient for aquatic life from the surface down to only three feet deep. No oxygen was found below three feet. Staff did notice about five dead fish in scattered locations throughout the lake on this date, which may have died from a lack of oxygen. Decomposition of the large amount of dead plants after the herbicide treatment was the reason for the D.O. loss. Without a recent, accurate bathymetric map with volume calculations, the volume of oxygenated water cannot be accurately calculated. During the other months, D.O. was sufficient down to at least six feet deep. Although no major fish kill was seen by LCHD staff or reported by the owner, the possibility of a major fish kill exists especially if a large amount of plants die and decompose rapidly. If two smaller herbicide treatments are done a few weeks apart rather than one large herbicide treatment, the impact from the dissolved oxygen loss should be less.

The Illinois Environmental Protection Agency (IEPA) has guidelines to classify Illinois lakes for their ability to support aquatic life or recreational uses. The guidelines consider several aspects, such as water clarity, phosphorus concentrations and aquatic plant coverage. Bresen Lake is slightly impaired for swimming uses because of the high phosphorus concentrations and low water clarity. This does not mean that Bresen Lake has health risks due to bacteria, but rather is impaired from a perspective of swimmer safety, due to poor visibility. The LCHD did not collect samples for bacteria, which is only one of the parameters that can be used to determine how well a lake supports swimming uses. The lake partially supports aquatic life according to the IEPA guidelines. Aquatic life is moderately impaired by turbidity in the water column. Plants cover about 70% of the lake bottom before being treated with aquatic herbicides. This, with the high nutrient content and low water clarity classifies Bresen Lake as one that does not support recreational uses. This is why the owner treats the lake with herbicides in order to use a motor boat.

The water level of Bresen Lake varied little throughout the 2000 sampling season. The difference between the minimum and maximum water level was only 2.3 inches. Rainfall from the closest rain gauge had monthly measurements that varied about one inch between most months except between July and August. The rainfall measurements between July and August differed by 5.17 inches. The lake's water level differed by only 3 inches during July and August.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

Eight species of aquatic plants and one macroalgae[5] were recorded in Bresen Lake during the 2000 sampling season (see Table 1). The three plants most commonly found were curlyleaf pondweed, an exotic (non-native) species, coontail and duckweed. Curlyleaf pondweed is commonly found in nuisance plant populations in Lake County lakes, and is

[5] This is a large alga with a plant-like appearance.

also in nuisance populations in Bresen Lake before being treated with an aquatic herbicide. This species was recorded at 50% of the Bresen Lake plant sites during the 2000 sampling season. Curlyleaf pondweed was the dominant plant species, occurring at 88% of the plant sites in May and in 68% of the plant samples in June. After the curlyleaf pondweed had died back in July, plants could still be found in 50% of the sites, but were few and scattered. Coontail was found most often after July, occurring at 50% of the plant sites in both August and September. Coontail was found in 29% of the samples throughout the 2000 season. Coontail is also a species that can reach nuisance proportions in lakes. Duckweed, a small floating aquatic plant, was noted at 22% of the sites throughout the season, and it was in small numbers at the sample locations. Cattails were present along the shore only at the end of the west bay. The variety of plant species is low, which is common for manmade lakes.

Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. In the case of Bresen Lake, light was less than 1% below 7.2 feet in early May. The plants were found in water depths up to 7.3 feet in May. However, after the herbicide treatment in late May, light was less than 1% below approximately 4.75 feet for the remainder of the season. After the herbicide treatment and subsequent algae bloom, surviving plants were most often found in depths of four feet or less. Plants were not found in large beds after the herbicide treatment except in the west bay and in the south channel. Without a bathymetric map (depth contour map), it is difficult to accurately state the amount of plant coverage across Bresen Lake. The amount of plant coverage can be loosely estimated by using the plant depth information from May, 2000. Based on the 7.3 foot maximum plant depth at that time, the aquatic plants covered approximately 17 acres, or about 70% of the lake's surface acreage. Plant coverage was difficult to estimate after the aquatic plant treatment. The west bay and the south channel, totaling approximately 2 acres, had healthy plant coverage. However, the surviving plants in the main body of the lake were found in various locations in depths less than 4 feet deep. If these plants were combined to form a more uniform and healthy plant bed, the number of acres covered by plants could be more easily estimated. From a fisheries aspect, the Illinois Department of Natural Resources recommends aquatic plant coverage to be 20% to 40% of the lake's surface area, or 4.8 to 9.6 acres in Bresen Lake. During 2000, the owner's goal was to treat approximately 8 acres of plants, which would be appropriate. The owner uses about four gallons of Aquathol using a tank sprayer to apply the herbicide. The amount of Aquathol to be applied depends on the volume of water to be treated. Although there is no bathymetric map for Bresen Lake with calculated volumes, the amount the owner used seems to be correct. However, most of the main body of the lake had very few surviving plants. Because curlyleaf pondweed naturally dies back in July, any plants that were not affected by the Aquathol probably died soon after or at the same time as the treated plants.

The owner stocked the lake with 100 grass carp in 1989. Although they can be legally stocked for use as an aquatic plant control, the degree of control cannot be predicted. Grass carp have been known to virtually eliminate plant life in other lakes, leading to lake degradation. The grass carp have probably died since they were stocked as Bresen Lake still has plant growth. Other plant control options can be found in Objective II, "Formulate an Aquatic Plant Management Plan."

Table 1. Aquatic Plant and Macroalgae Species in Bresen Lake

Aquatic Plants	
Coontail	*Ceratophyllum demersum*
Curlyleaf Pondweed	*Potamogeton crispus*
Flatstem Pondweed	*Potamogeton zosteriformis*
Leafy Pondweed	*Potamogeton foliosus*
Sago Pondweed	*Stuckenia pectinatus*
Duckweed	*Lemna minor*
Watermeal	*Wolffia spp.*
Widgeon Grass	*Ruppia maritima*
Shoreline Plants	
Cattail	*Typha latifolia*
Purple Loosestrife	*Lythrum salicaria*
Macroalgae Species	
Chara/Nitella	*Chara/Nitella spp.*

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

In early May 2000, Lake County Health Department staff assessed the shoreline of Bresen Lake. See Appendix A for a discussion of the methods used. Of the 5641 feet of shoreline that rings Bresen Lake, 1069 feet, or 19% of the shoreline, is classified as being developed. This includes 363 feet of mowed turfgrass, 243 feet of seawall, 205 feet of riprap and 258 feet of unmowed buffer areas, such as the dam along the east shore. The 4572 feet of undeveloped shoreline offers good wildlife habitat such as fallen trees (deadfall) and shrubby areas. About 1700 feet of this undeveloped shoreline has continuous deadfall. Although much of the southern shoreline is undeveloped at the water's edge, an agricultural field exists about 20 feet beyond this undeveloped buffer zone. The length of eroding shoreline is 2522 feet, or 45%, of the total shoreline (See Figure 3). The shoreline along the inlet draining Pond-A-Rudy and along the northwest residential lot is moderately eroded and totals 874 feet. The severity of erosion along the 1648 feet of the southern shoreline varies from moderate to slight. Although the erosion

INSERT SHORELINE EROSION MAP

at these locations is not severe at this time, these shorelines will continue to erode as a result of speedboat wakes and wind induced wave action. This can add sediment to the water and result in a loss of shoreline property. Erosion control alternatives can be found in Objective III, “Mitigate Shoreline Erosion.”

Reed canary grass, an invasive shoreline plant, was noted along the east and southern shoreline. Another invasive shoreline plant, purple loosestrife, was growing in scattered numbers along the east shore. Although purple loosestrife is not in nuisance populations at this time, the removal of these plants is recommended before their numbers increase. Multiflora rose, which is another nuisance plant species, was spotted along the shoreline at the lot with mowed grass to the edge of the water. Removal of this plant is also recommended. Alternatives for the removal of these exotic, or non-native species, can be found in Objective IV, “Remove Invasive Shoreline Plant Species.”

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

LCHD staff observed the species of wildlife during sampling visits to Bresen Lake. Methodology is discussed in Appendix A. The deadfall found along parts of the shoreline offer good habitat for turtles and fish. The trees and shrubs in the southern inlet area, the west bay and the north inlet were good areas for songbirds and wading birds. Two birds listed as endangered in Illinois, a black-crowned night heron, and an osprey, were seen on Bresen Lake. The night heron was identified on more than one occasion, leading staff to speculate that a nest could be nearby. The osprey was noted in July, and was probably using the lake for fishing. No osprey nests were seen near Bresen Lake. Osprey sightings were noted at another nearby lake, and could have been the same individual. Other osprey habitat can also be found along the Fox River, which is about 6 miles from Bresen Lake. A listing of the wildlife can be found in Table 2. During two site visits an owl was spotted, but staff were not able to identify the species.

Table 2. Wildlife Species Observed at Bresen Lake, May – September, 2000

<u>*Birds*</u>	
Double Crested Cormorant	*Phalacrocorax auritus*
Mute Swan	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Wood Duck	*Aix sponsa*
Ruddy Duck	*Oxyura jamaicensis*
Ring-billed Gull	*Larus delawarensis*
Great Egret	*Casmerodius albus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Black-crowned Night Heron*	*Nycticorax nycticorax*
Killdeer	*Charadius vociferus*
Red-tailed Hawk	*Buteo jamaicensis*

Table 2., Wildlife Species, Con't.

Osprey*	*Pandion haliaetus*
Owl	*spp.*
Belted Kingfisher	*Megaceryle alcyon*
Common Flicker	*Colaptes auratus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Downy Woodpecker	*Picoides pubescens*
Hairy woodpecker	*Picoides villocus*
Eastern Phoebe	*Sayornis phoebe*
Purple Martin	*Progne subis*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
Yellow-rumped Warbler	*Dendroica coronata*
American Crow	*Corvus brachyrhynchos*
Blue Jay	*Cyanocitta cristata*
Black-Capped Chickadee	*Poecile atricapillus*
House Wren	*Troglodytes aedon*
Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Cedar Waxwing	*Bombycilla cedrorum*
Red-eyed Vireo	*Vireo olivaceus*
Warbling Vireo	*Vireo gilvus*
Palm Warbler	*Dendroica palmarum*
Tennessee Warbler	*Vermivora peregrina*
Red-winged Blackbird	*Agelaius phoeniceus*
Brown-headed Cowbird	*Molothrus ater*
Common Grackle	*Quiscalus quiscula*
Starling	*Sturnus vulgaris*
Northern Oriole	*Icterus galbula*
House Sparrow	*Passer domesticus*
Northern Cardinal	*Cardinalis cardinalis*
House Finch	*Carpodacus mexicanus*
American Goldfinch	*Carduelis tristis*
Indigo Bunting	*Passerina cyanea*
Chipping Sparrow	*Spizella passerina*
Song Sparrow	*Melospiza melodia*
Mammals	
Beaver	*Castor canadensis*
Cottontail rabbit	*Sylvilagus floridanus*
Amphibians	
Western Chorus Frog	*Pseudacris triseriata triseriata*
Reptiles	
Painted Turtle	*Chrysemys picta*

* Endangered in Illinois

EXISTING LAKE QUALITY PROBLEMS

- *Nutrient concentrations are elevated, resulting in excessive plant and algae growth.*

  Bresen Lake is a nutrient rich lake system in which plants dominate until they are treated with an aquatic herbicide. The lake has concentrations of both nitrogen and phosphorus that were higher than Lake County averages and medians.

- *Aquatic plants cover approximately 70% of the lake's surface before aquatic herbicide treatment as a result of shallow depths and an abundant nutrient supply.*

  Although the variety of aquatic plant species is low, before their treatment with aquatic herbicides, aquatic plants covered an estimated 70% of the lake. The nutrient rich lake system and the shallow depths allow Bresen Lake to be dominated by plants, specifically two species, curlyleaf pondweed and coontail. After the majority of the plants die back, the water column becomes turbid from disturbed sediment and some algae.

- *Slight or moderate shoreline erosion is present on 45% of the shoreline.*

  Erosion is occurring on 2522 feet, or 45% of the shoreline. Much of it occurs on the undeveloped portions such as the southern shoreline. However, 363 feet of the developed shoreline (the northwest residential lot) is moderately eroding. The turfgrass at the water's edge does not protect the shoreline from wave action.

- *Non-native invasive shoreline plant species are present.*

  Although they have not reached nuisance proportions, aggressive non-native plants were identified along the shoreline. It is recommended that these plants be removed before they populate further.

POTENTIAL OBJECTIVES FOR BRESEN LAKE MANAGEMENT PLAN

I. Create a Bathymetric Map.
II. Formulate an Aquatic Plant Management Plan.
III. Mitigate Shoreline Erosion.
IV. Remove Invasive Shoreline Plant Species.
V. Maintain or Enhance Areas for Wildlife.
VI. Reduce In-lake Phosphorus Concentrations.

ALTERNATIVES FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES FOR BRESEN LAKE

Objective I: Create a bathymetric map.

A bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features of the lake, such as depth, surface area, volume, etc. The knowledge of this morphometric information would be necessary if lake management practices such as aquatic herbicide use, fish stocking, dredging, an alum treatment or aeration were part of the overall lake management plan. Bresen Lake does not have a bathymetric map. Maps can be created by the Lake County Health Department – Lakes Management Unit or other agencies for costs that vary from $3,000-$10,000, depending on lake size.

Objective II: Formulate an aquatic Plant Management Plan.

Although there is no bathymetric map for Bresen Lake with calculated volumes, the amount of Aquathol the owner used in 2000 (approximately 4 gallons) seems to be correct. However, most of the main body of the lake had very few surviving plants, making it appear that too much of the herbicide was used. Because curlyleaf pondweed naturally dies back in July, any plants that were not affected by the Aquathol probably died soon after or at the same time as the treated plants. If the owner decides to continue using aquatic herbicides to control the nuisance plant beds in Bresen Lake, it may be beneficial to use two smaller herbicide treatments instead of one single dose. If two smaller herbicide treatments are done a few weeks apart rather than one large herbicide treatment, the impact from the dissolved oxygen loss should be less. For example, if the contact herbicide Aquathol was to be used again, half of the dosage can be applied during the second week of May, or when the curlyleaf pondweed can easily be seen. The other half of the dosage can be applied two weeks later, to the curlyleaf plant beds that were unharmed from the initial dose. This would allow control of the plants without a rapid oxygen loss from a single massive plant die-off. In any case, if aquatic herbicides will be used, they should be applied before the curlyleaf pondweed produces seeds, or the amount of curlyleaf could expand the following year. It is important that the herbicides used are those that target the dominant nuisance plant. In the case of Bresen Lake, Aquathol is suitable for the control of curlyleaf pondweed. The owner should continue to avoid treating the native plants in the northwest bay.

All aquatic plant management techniques have both positive and negative characteristics. If used properly, they can all be beneficial to a lake's well being. If misused or abused, they all share similar outcomes - negative impacts to the lake. Putting together a good aquatic plant management plan should not be rushed. Plans should consist of a realistic set of goals well thought out before implementation. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. For an aquatic plant management plan to achieve long term success, follow up is critical. A good aquatic plant management plan considers both the short and long-term needs of the lake.

The management of the lake's vegetation does not end once the nuisance vegetation has been reduced/eliminated. It is critical to continually monitor problematic areas for regrowth and remove as necessary. An association or property owner should not always expect immediate results. A quick fix of the vegetation problems may not always be in the best interest of the lake. Sometimes the best solutions take several seasons to properly solve the problem. The management options covered below are commonly used techniques that are coming into wider acceptance and have been used in Lake County. There are other plant management options that are not covered below as they not are very effective, or are too experimental to be widely used.

Option 1: No Action

Bresen Lake is dominated by curlyleaf pondweed, which naturally dies back in July. The plant die-off from the herbicide treatment during 2000 may have coincided with natural die-off. The owner may want to try the no-action plan for one year to see if natural die-off would be suitable. This would also allow the owner to see the extent of the plant bed across the lake. However, this may infringe upon the enjoyment of the lake, during late spring of that year. Also, the curlyleaf pondweed bed may increase the following year if a large amount of seeds, or turions, are produced.

Pros

There are positive aspects associated with the no action option for plant management. The first, and most obvious, is that there is no cost. However, if an active management plan for vegetation control were eventually needed, the cost would be substantially higher than if the no action plan had not been followed in the first place. Another benefit of this option would be the lack of environmental manipulation. Under the no action option, no chemicals, mechanical altercation, or introduction of any organisms would take place. This is important since studies have shown that nuisance plants are more likely to invade disrupted areas. Expansion of the native plant population would increase the overall biodiversity and health of the lake. Habitat, breeding areas, and food source availability would greatly improve. Use of the lake would continue as normal and in some cases might improve (fishing) if native plants kept "weedy" plants under control.

An additional benefit of the no action option is the possible improvement in water quality. Turbidity could decrease and clarity should increase due to sediment stabilization by the plant's roots. Algal blooms could be reduced due to decreased nutrient availability due to plant uptake and sediment stabilization. However, the occurrence of filamentous may increase due to their surface growth habitat.   The lake's fishery could improve due to habitat availability, which in turn would have numerous positive effects on the rest of the lake's ecosystem.

Cons

Under the no action option, if nuisance vegetation is dominant in the lake and were uninhibited and able to reach epidemic proportions, there will be many negative impacts on the lake. By their weedy nature, the nuisance plants would out-compete the more desirable native plants. This could eventually, drastically reduce or even eliminate the native plant population of the lake and reduce the lake's biodiversity. This will also impact fish populations. The fishery of the lake may become stunted due the to lack of quality forage fish habitat and reduced predation. Predation will decrease due to the difficulty of finding prey in the dense stands of vegetation. This will cause an explosion in the small fish population and with food resources not increasing, growth of fish will be reduced. Decreased dissolved oxygen levels, due to high biological oxygen demand from the excessive vegetation, will also have negative impacts on the aquatic life. Wildlife populations will also be negatively impacted by these dense stands of vegetation. Birds and waterfowl will have difficulty finding quality plants for food or in locating prey within the dense plant stands.

In addition to the ecological impacts, many physical uses of the lake will be negatively impacted. Boating could be nearly impossible without becoming entangled in thick mats of plants. Swimming could also become increasingly difficult due to thick vegetation that would develop at beaches. Fishing could become more and more exasperating due in part to the thick vegetation and also because of stunted fish population. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by tangled mats of vegetation and the odors that will develop when they decay. The combination of the above events could cause property values on the lake to suffer. Property values on lakes with weedy plant/algae problems have been shown to decrease by as much as 15-20%.

Costs

No cost will be incurred by implementing the no action management option.

Option 2: Aquatic Herbicides

Aquatic herbicides are the most common method to control nuisance vegetation/algae. When used properly, they can provide selective and reliable control. Products can not be licensed for use in aquatic situations unless there is less than a 1 in 1,000,000 chance of any negative effects on human health, wildlife, and the environment. Aquatic herbicides are not allowed to be environmentally persistent, bioaccumulate, or have any bioavailability. Prior to herbicide application, licensed applicators should evaluate the lake's vegetation and, along with the lake's management plan, choose the appropriate herbicide and treatment areas, and apply the herbicides during appropriate conditions (i.e. low wind speed).

There are two groups of herbicides: contact and systemic. Contact herbicides, like their name indicates, kill on contact. These herbicides affect only the above ground portion of the plant that they come into contact with and therefore do not kill the root system. An example of a contact herbicide is diquat. Systemic herbicides are taken up by the plant and disrupt cellular processes, which in turn cause plant death. These herbicides kill both the upper portions of the plant as well as the root system. An example of a systemic herbicide is fluridone. Both types of herbicides are available in liquid or granular forms. Liquid forms are concentrated and need to be mixed into water to obtain the desired concentration. The solution is then sprayed on the water's surface or injected into the water in the treatment areas. Granular herbicides are broadcast in a known rate over the treatment area where they sink to the bottom and slowly release the herbicide which is then taken up by the plant. These are referred to as SRP formulations (Slow Release Pellet). Other granular herbicides come in crystal form and dissolve as they come in contact with water. This is typical of herbicides such as copper sulfate. Many herbicides come in both liquid and granular forms to fit the management needs of the lake. Herbicide applications can either be done as whole lake treatments or as more selective spot treatments. Multiple herbicides are often mixed and applied together. This is called a tank mix. This is done to save time, energy, and cost.

Aquatic herbicides are best used on actively growing plants to ensure optimal herbicide uptake. For this reason, herbicides are normally applied mid to late spring when water temperatures are above 60^0F. This is the time of year when the plants are most actively growing and before seed/vegetative propagule formation. Follow up applications should be done as needed. When choosing an aquatic herbicide it is important to know what plants are present, which ones are problematic, which plants are beneficial, and how a particular herbicide will act upon these plants. The herbicide label is very important and should always be read before use. Table 1 contains information on the different aquatic herbicides and which plants they affect, application rates, cost ranges, any restrictions on use, and any additional comments. There may be more than one herbicide for a given plant. The plants best controlled by a particular herbicide are in bold. As with other management options, proper usage is the key to their effectiveness, benefits, and disadvantages.

Pros

When used properly, aquatic herbicides can be a powerful tool in management of excessive vegetation. Often, aquatic herbicide treatments can be more cost effective in the long run compared to other management techniques. A properly implemented plan can often provide season long control with minimal applications. Ecologically, herbicides can be a better management option than using mechanical harvesting or grass carp. When properly applied aquatic herbicides may be selective for nuisance plants such as Eurasian watermilfoil but allow desirable plants such as the pondweeds to remain. This removes the problematic vegetation and allows native and more desirable plants to remain and flourish with minimal manipulation.

The fisheries and waterfowl populations of the lake would greatly benefit due to an increase in quality habitat and food supply. Dense stands of plants would be thinned out and improve spawning habitat and food source availability for fish. Waterfowl population would greatly benefit from increases in quality food sources, such as large-leaf pondweed (*Potamogeton amplifolius*). Another environmental benefit of using aquatic herbicides over other management options is that they are organism specific. The metabolic pathways by which herbicides kill plants are plant specific which humans and other organisms do not carry out. Organisms such as fish, birds, mussels, and zooplankton are generally unaffected.

By implementing a good management plan with aquatic herbicides, usage opportunities of the lake would increase. Activities such as boating and swimming would improve due to the removal of dense stand of vegetation. The quality of fishing may recover because of improved habitat. In addition to increased usage opportunities, the overall aesthetics of the lake would improve, potentially increasing property values on the lake.

Cons

The most obvious drawback of using aquatic herbicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error can make them unsafe and bring about undesired outcomes. If not properly used, aquatic herbicides can remove too much vegetation from the lake. This could drastically alter the biodiversity and ecological balance of the lake. Total removal or over-removal of plants can cause a variety of problems lake-wide. The fishery of the lake may decline and/or become stunted due predation issues related to decreased water clarity. Other wildlife, such as waterfowl, which commonly forage on aquatic plants, would also be negatively impacted by the decrease in vegetation.

Another problem associated with removing too much vegetation is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. The increase in turbidity can cause a decrease in light penetration, which can further aggravate the aquatic plant community. The resuspension of nutrients will contribute to the overall nutrient load of the lake, which can lead to an increased frequency of noxious algal blooms. Furthermore, the removal of aquatic vegetation, which compete with algae for nutrients, can directly contribute to an increase in blooms.

After the initial removal, there is a possibility for regrowth of vegetation. Upon regrowth, weedy plants such as Eurasian watermilfoil and coontail quickly reestablish, form dense stands, and prevent the growth of desirable species. This causes a decrease in plant biodiveristy. Additionally, these dense stands of nuisance vegetation can lead to an overpopulation of stunted fish due to a decrease in predation of forage species by predatory fish. This disruption in the fisheries can have negative impacts throughout the ecosystem from zooplankton to higher organisms such as waterfowl and other wildlife. Additionally, some herbicides have use restrictions regarding their use in relation to fish, swimming, irrigation, etc.

Overremoval, and possible regrowth of nuisance vegetation that may follow will drastically impair recreational use of the lake. Swimming could be adversely affected due to the likelihood of increased algal blooms. Swimmers may become entangled in large mats of filamentous algae. Blooms of planktonic species, such as blue-green algae, can produce harmful toxins as well produce noxious odors. If regrowth of nuisance vegetation were to occur, motors could become entangled making boating difficult. Fishing would also be negatively impacted due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer due to an increase in unsightly algal blooms and massive stands of vegetation. This in turn could have an unwanted effect on property values. Studies have shown that problematic algal blooms can decrease property values by 15-20%.

Option 3: Hand Removal

Hand removal of excessive aquatic vegetation is a commonly used management technique. Hand removal is normally used in limited areas for selective vegetation removal. Areas surrounding piers and beaches are commonly targeted areas. Typically tools such as rakes and cutting bars are used to remove vegetation. These are easily obtainable through many outdoor supply catalogs or over the internet. Some rakes are equipped with tines as well as cutting edges. Tools can also be hand made by drilling a hole in the handle of a heavy-duty garden rake and tying it to a length of rope. Weights may be needed in order to provide forceful contact with the plants. In many instances, homeowners on lakes with near shore vegetation problems simply cut paths through the weeds to create pathways to open water.

Pros

Hand removal is a quick, inexpensive, and selective way to remove nuisance vegetation. Hand removal is an activity in which all lake residents could participate. The work involved in removing plants can provide a rewarding sense of accomplishment. By removing excess vegetation, use of beaches and piers would be improved. Wildlife habitat, such as fish spawning beds, could be greatly improved. This in turn would benefit other portions of the lake's ecosystem. Harvested plant material is often used as fertilizer and compost in gardens.

Cons

There are few negative attributes to hand removal. One negative implication is labor. Depending on the extent of infestation, removal of large amount, of vegetation can be quite tiresome. Another drawback can be disposal. Finding a site for numerous residents to dispose of large quantities of harvested vegetation can sometimes be problematic. Another drawback is possible nonselective removal by hand harvesting. By throwing a rake blindly into the depths, it is impossible to determine what plants are removed and which ones are not until the rake is pulled up. Even in shallow depths, untrained persons might mistakenly remove desirable vegetation and/or disrupt valuable habitat (fish spawning beds).

Costs

Plant removal rakes can range in price from $50-150 and cutting tools commonly range in price from $50-200. Both are available from numerous catalogs and from the internet.. A homemade rake would cost about $20-40.

<u>Objective III: Mitigate Shoreline Erosion.</u>

Erosion is a potentially serious problem to lake shorelines and occurs as a result of wind, wave, or ice action. While some erosion to shorelines is natural, human alteration of the environment can accelerate and aggravate the problem. Erosion not only results in loss of shoreline, but negatively influences the lake's overall water quality by contributing nutrients, sediment, and pollutants into the water. This effect is felt throughout the food chain since poor water quality negatively affects everything from microbial life to sight feeding fish and birds to people who want to use the lake for recreational purposes. The resulting increased amount of sediment will over time begin to fill in the lake, decreasing overall lake depth and volume and potentially impairing various recreational uses.

The length of eroding shoreline in Bresen Lake is 2522 feet, or 45%, of the total shoreline. The shoreline along the inlet draining Pond-A-Rudy and along the northwest residential lot is moderately eroded and totals 874 feet. Approximately 308 feet of shoreline is mowed turfgrass up to the water's edge. Turfgrass offers no protection against erosion. The severity of erosion along the 1648 feet of the southern shoreline varies from moderate to slight. The use of plants in a buffer strip or the use of biologs in these locations could stabilize the shoreline, and also maintain and/or enhance habitat for wildlife.

<u>Option 1: No Action</u>

Pros

There are no short-term costs to this option. However, extended periods of erosion may result in substantially higher costs to repair the shoreline in the future.

Eroding banks on steep slopes can provide habitat for wildlife, particularly bird species (e.g. kingfishers and bank swallows) that need to burrow into exposed banks to nest. In addition, certain minerals and salts in the soils are exposed during the erosion process, which are utilized by various wildlife species.

Cons

Taking no action will most likely cause erosion to continue and subsequently may cause poor water quality due to high levels of sediment or nutrients entering a lake. This in turn may retard plant growth and provide additional nutrients for algal growth. A continual loss of shoreline is both aesthetically unpleasing and may potentially reduce property values. Since a shoreline is easier to protect than it is to rehabilitate, it is in the interest of the property owner to address the erosion issue immediately.

Costs

In the short-term, cost of this option is zero. However, long-term implications can be severe since prolonged erosion problems may be more costly to repair than if the problems were addressed earlier. As mentioned previously, long-term erosion may cause serious damage to shoreline property and in some cases lower property values.

Option 2: Create a Buffer Strip

Another effective method of controlling shoreline erosion is to create a buffer strip with existing or native vegetation. Native plants have deeper root systems than turfgrass and thus hold soil more effectively. Native plants also provide positive aesthetics and good wildlife habitat. Cost of creating a buffer strip is quite variable, depending on the current state of the vegetation and shoreline and whether vegetation is allowed to become established naturally or if the area needs to be graded and replanted. Allowing vegetation to naturally propagate the shoreline would be the most cost effective, depending on the severity of erosion and the composition of the current vegetation. Non-native plants or noxious weedy species may be present and should be controlled or eliminated.

Stabilizing the shoreline with vegetation is most effective on slopes no less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems. Fortunately, none of the shoreline around Bresen Lake is severely eroding at this time.

Buffer strips can be constructed in a variety of ways with various plant species. Generally, buffer strip vegetation consists of native terrestrial (land) species and emergent (at the land and water interface) species. Terrestrial vegetation such as native grasses and wildflowers can be used to create a buffer strip along lake shorelines. Table 3 gives some examples, seeding rates and costs of grasses and seed mixes that can be used to create buffer strips. Native plants and seeds can be purchased at regional nurseries or from catalogs. When purchasing seed mixes, care should be taken that native plant seeds are used. Some commercial seed mixes contain non-native or weedy species or may contain annual wildflowers that will have to be reseeded every year. If purchasing plants from a nursery or if a licensed contractor is installing plants, inquire about any guarantees they may have on plant survival. Finally, new plants should be protected from herbivory (e.g., muskrats) by placing a wire cage over the plants for at least one year.

A technique that is sometimes implemented along shorelines is the use of willow posts, or live stakes, which are harvested cuttings from live willows (*Salix* spp.). They can be planted along the shoreline along with a cover crop or native seed mix. The willows will resprout and begin establishing a deep root structure that secures the soil. If the shoreline is highly erodible, willow posts may have to be used in conjunction with another erosion control technique such as biologs, or rip-rap.

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip-rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in Table 3 should be considered for native plantings.

Pros

Buffer strips can be one of the least expensive means to stabilize shorelines. If no permits or heavy equipment are needed (i.e. no significant earthmoving or filling is planned), the property owner can complete the work without the need of professional contractors. Once established (typically within 3 years), a buffer strip of native vegetation will require little maintenance and may actually reduce the overall maintenance of the property, since the buffer strip will not have to be continuously mowed, watered, or fertilized. Occasional high mowing (1-2 times per year) for specific plants or physically removing other weedy species may be needed.

The buffer strip will stabilize the soil with its deep root structure and help filter run-off from lawns and agricultural fields by trapping nutrients, pollutants, and sediment that would otherwise drain into the lake. This may have a positive impact on the lake's water quality since there will be less "food" for nuisance algae. Buffer strips can filter as much as 70-95% of sediment and 25-60% of nutrients and other pollutants from runoff.

Another benefit of a buffer strip is potential flood control protection. Buffer strips may slow the velocity of flood waters, thus preventing shoreline erosion. Native plants also can withstand fluctuating water levels more effectively than commercial turfgrass. Many plants can survive after being under water for several days, even weeks, while turfgrass is intolerant of wet conditions and usually dies after several days under water. This contributes to increased maintenance costs, since the turfgrass has to be either replanted or replaced with sod. Emergent vegetation can provide additional help in preserving shorelines and improving water quality by absorbing wave energy that might otherwise batter the shoreline.

Calmer wave action will result in less shoreline erosion and resuspension of bottom sediment, which may result in potential improvements in water quality.

Many fish and wildlife species prefer the native shoreline vegetation habitat. This habitat is an asset to the lake's fishery since the emergent vegetation cover may be used for spawning, foraging, and hiding. Various wildlife species are even dependent upon shoreline vegetation for their existence. Certain birds, such as marsh wrens (*Cistothorus palustris*) and endangered yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nest exclusively in emergent vegetation like cattails and bulrushes. Hosts of other wildlife like waterfowl, rails, herons, mink, and frogs to mention just a few, benefit from healthy stands of shoreline vegetation. Dragonflies, damselflies, and other beneficial invertebrates can be found thriving in vegetation along the shoreline as well. Two invertebrates of particular importance for lake management, the water-milfoil weevils (*Euhrychiopsis lecontei* and *Phytobius leucogaster*), which have been shown to naturally reduce stands of exotic Eurasian water-milfoil (*Myriophyllum spicatum*). Weevils need proper over wintering habitat such as leaf litter and mud which are typically found on naturalized shorelines or shores with good buffer strips. Many species of amphibians, birds, fish, mammals, reptiles, and invertebrates have suffered precipitous declines in recent years primarily due to habitat loss. Buffer strips may help many of these species and preserve the important diversity of life in and around lakes.

In addition to the benefits of increased fish and wildlife use, a buffer strip planted with a variety of native plants may provide a season long show of various colors from flowers, leaves, seeds, and stems. This is not only aesthetically pleasing to people, but also benefits wildlife and the overall health of the lake's ecosystem.

Cons

There are few disadvantages to native shoreline vegetation. Certain species (i.e. cattails) can be aggressive and may need to be controlled occasionally. If stands of shoreline vegetation become dense enough, access and visibility to the lake may be compromised to some degree. However, small paths could be cleared to provide lake access or smaller plants could be planted in these areas.

Costs:

If minimal amount of site preparation is needed, costs can be approximately $10 per linear foot, plus labor. Cost of installing willow posts is approximately $15-20 per linear foot. The labor that is needed can be completed by the property owner in most cases, although consultants can be used to provide technical advice where needed. This cost will be higher if the area needs to be graded. If grading is necessary, appropriate permits and surveys are needed. If filling is required, additional costs will be incurred if compensatory storage is needed. The permitting process is costly, running as high as $1,000-2,000 depending on the types of permits needed. Plants and prices are listed below in Table 3.

Table 3. Prices for Buffer Strip Plants

Terrestrial-Dry soil	**Seeding Rate**	**Seed Price**	**Planting Rate**	**Price/Plant**
Big Bluestem Grass (*Andropogon gerardii*)	10-25b lbs/acre	$20/lb	NA	$4-5
Bluejoint Grass (*Calamagrostis canadensis*)	2 lbs/acre	$2-4/oz	NA	$4-5
Little Bluestem Grass (*Andropogon scoparius*)	10-25 lbs/acre	$20/lb	NA	$4-5
Prairie Cord Grass (*Spartina pectinata*)	0.25-1.0 lbs/acre	$2-3/oz	250-500/acre	$2-4
Switch Grass (*Panicum virgatum*	0.5-2.0 lbs./acre	$6-7/oz	NA	$1-5
Terrestrial-Wet Soil	**Seeding Rate**	**Seed Price**	**Planting Rate**	**Price/Plant**
Blue Flag (*Iris versicolor*)	NA	$10/oz	1000/acre	$0.60-1.50
Blue Vervain (*Verbena hastata*)	NA	$6/oz	500-1000/acre	$0.80-1.00
Blunt Spike Rush (*Eleocharis obtusa*)	NA	$30/oz	500-1000/acre	$0.50-1.00
Boneset (*Eupatorium perfoliatum*)	0.006-0.25 lbs./acre	$6-7/oz	500-700/acre	$1.00
Water Horsetail (*Equisetum fluviatile*)	NA	NA	1000/acre	$0.50
Joe-Pye-Weed (*Eupatorium maculatum*)	NA	$8/oz	500-700/acre	$0.50-1.00
Sweet Flag (*Acorus calamus*)	NA	$10/oz	250/acre	$0.50-1.00
Wild Rice (*Zizania aquatica*)	NA	$5.00/lb	1000/acre	$0.50-0.20
Trees and Shrubs	**Seeding Rate**	**Seed Price**	**Planting Rate**	**Price/Plant**
Bur Oak (*Quercus macrocarpa*)	NA	NA	NA	$5-6
Buttonbush (*Cephalanthus occidentalis*)	NA	NA	NA	$6-7
Red Osier Dogwood (*Cornus stolonifera*)	NA	$9/oz	NA	$2-5
White Oak (*Quercus alba*)	NA	$5-8/oz	NA	$6-7
Seed Mixes	**Seeding Rate**	**Seed Price**	**Planting Rate**	**Price/Plant**
Forb and Grass Seed Mix	500 square ft	$20-60	NA	NA
Forb and Grass Seed Mix	1000 square ft	$66-108	NA	NA

<u>Option 3: Install Biolog, Fiber Roll, or Straw Blanket with Plantings</u>

These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Once established, a buffer strip of native plants can be planted along side or on top of the roll (depending if rolls are made of synthetic or natural fibers). They are most effective in areas where plantings alone are not effective due to already severe erosion. In areas of severe erosion, other techniques may need to be employed or incorporated with these products.

Pros

Biologs, fiber rolls, and straw blankets provide erosion control that secure the shoreline in the short-term and allow native plants to establish which will eventually provide long-term shoreline stabilization. They are most often made of bio-degradable materials, which break down by the time the natural vegetation becomes established (generally within 3 years). They provide additional strength to the shoreline, absorb wave energy, and effectively filter run-off from terrestrial sources. These factors help improve water quality in the lake by reducing the amount of nutrients available for algae growth and by reducing the sediment that flows into a lake.

Cons

These products may not be as effective on highly erodible shorelines or in areas with steep slopes, as wave action may be severe enough to displace or undercut these products. On steep shorelines grading may be necessary to obtain a 2:1 or 3:1 slope or additional erosion control products may be needed. If grading or filling is needed, the appropriate permits and surveys will have to be obtained.

Costs

Costs range from $25 to $35 per linear foot of shoreline, including plantings. This does not include the necessary permits and surveys, which may cost $1,000 – 2,000 depending on the type of earthmoving that is being done. Additional costs may be incurred if compensatory storage is needed.

<u>Option 4: Install Rock Rip-Rap</u>

Rip-rap is the term for using rocks to stabilize shorelines. Size of the rock depends on the severity of the erosion, distance to rock source, and aesthetic preferences. Generally, four to eight inch diameter rocks are used. Rip-rap can be incorporated with other erosion control techniques such as plant buffer strips. If any plants will be growing on top of the rip-rap, fill will probably be needed to cover the rocks and provide an acceptable medium for plants to grow on. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below).

Pros

Rip-rap can provide good shoreline erosion control. Rocks can absorb some of the wave energy while providing a more aesthetically pleasing appearance than seawalls. If installed properly, rip-rap will last for many years. Maintenance is relatively low, however, undercutting of the bank can cause sloughing of the rip-rap and subsequent shoreline. Areas with severe erosion problems may benefit from using rip-rap. In all cases, a filter fabric should be installed under the rocks to maximize its effectiveness.

Fish and wildlife habitat can be provided if large boulders are used. Crevices and spaces between the rocks can be used by a variety of animals and their prey. Small mammals, like shrews can inhabit these spaces and prey upon many invertebrate species, including many harmful garden and lawn pests. Also, small fish may utilize the structure created by large boulders for foraging and hiding from predators.

Cons

A major disadvantage of rip-rap is the initial expense of installation and associated permits. Installation is expensive since a licensed contractor and heavy equipment are generally needed to conduct the work. Permits are required if replacing existing or installing new rip-rap and must be acquired prior to work beginning. If any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain.

While rip-rap absorbs wave energy more effectively than seawalls, there is still some wave deflection that may cause resuspension of sediment and nutrients into the water column.

Small rock rip-rap is poor habitat for many fish and wildlife species, since it provides limited structure for fish and cover for wildlife. As noted earlier, some small fish and other animals will inhabit the rocks if boulders are used. Smaller rip-rap is more likely to wash way due to rising water levels or wave action. On the other hand, larger boulders are more expensive to haul in and install.

Rip-rap may be a concern in areas of high public usage since it is difficult and possibly dangerous to walk on due to the jagged and uneven rock edges. This may be a liability concern to property owners.

Costs:

Cost and type of rip-rap used depend on several factors, but average cost for installation (rocks and filter fabric) is approximately $30-45 per linear foot. Costs for a 150 foot length of shoreline would range $4,500-$6,750. The steeper the slope and severity of erosion, the larger the boulders that will need to be used and thus, higher installation costs. In addition, costs will increase with poor shoreline accessibility and increased distance to rock source. Costs for permits and surveys can be $1,000-2,000 for installation of rip-rap, depending on the circumstances. Contact the Army Corps of Engineers, local municipalities, and the Lake County Planning and Development Department.

<u>Option 5: Install a Steel or Vinyl Seawall</u>

Seawalls are designed to prevent shoreline erosion on lakes in a similar manner they are used along coastlines to prevent beach erosion or harbor siltation. Today, seawalls are generally constructed of steel, although in the past seawalls were made of concrete or wood (frequently old railroad ties). Concrete seawalls cracked or were undercut by wave action requiring routine maintenance. Wooden seawalls made of old railroad ties are not used anymore since the chemicals that made the ties rot-resistant could be harmful to aquatic organisms. A new type of construction material being used is vinyl or PVC. Vinyl seawalls are constructed of a lighter, more flexible material as compared to steel. Also, vinyl seawalls will not rust over time as steel will.

Pros

If installed properly and in the appropriate areas (i.e. shorelines with severe erosion) seawalls provide effective erosion control. Seawalls are made to last numerous years and have relatively low maintenance.

Cons

Seawalls are disadvantageous for several reasons. One of the main disadvantages is that they are expensive, since a professional contractor and heavy equipment are needed for installation. Any repair costs tend to be expensive as well. If any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain. Permits and surveys are needed whether replacing and old seawall or installing a new one (see costs below).

Wave deflection is another disadvantage to seawalls. Wave energy not absorbed by the shoreline is deflected back into the lake, potentially causing sediment disturbance and resuspension, which in turn may cause poor water clarity and problems with nuisance algae, which use the resuspended nutrients for growth. If seawalls are installed in areas near channels, velocity of run-off water or channel flow may be accelerated. This may lead to flooding during times of high rainfall and run-off, shoreline erosion in other areas of the lake, or a resuspension of sediment due to the agitation of the increased wave action or channel flow, all of which may contribute to poor water quality conditions throughout the lake. Plant growth may be limited due to poor water clarity, since the photosynthetic zone where light can penetrate, and thus used by plants, is reduced. Healthy plants are important to the lake's overall water clarity since they can help filter some of the incoming sediment, prevent resuspension of bottom sediment, and compete with algae for nutrients. However, excessive sediment in the water and high turbidity may overwhelm these benefits.

Finally, seawalls provide no habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls. In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e. bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e. stunted fish populations).

Costs

Depending on factors such as slope and shoreline access, cost of seawall installation ranges from $65-80 per linear foot for steel and $70-100 per linear foot for vinyl. A licensed contractor installs both types of seawall. Additional costs may occur if the shoreline needs to be graded and backfilled, has a steep slope, or poor accessibility. Price does not include the necessary permits required. Additional costs will be incurred if compensatory storage is needed. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained. For seawalls, a site development permit and a building permit are needed. Costs for permits and surveys can be $1,000-2,000 for installation of a seawall. Contact the Army Corps of Engineers, local municipality, or the Lake County Planning and Development Department.

<u>Option 7: Limit Boating Speed</u>

Waves caused by motor boating aggravate shoreline erosion conditions. However, this option may be unsuitable for the owners of Bresen Lake since they use the lake for motor boating. Because of Bresen Lake's size, boating further from shore is not an option. Low speeds may help reduce the size of the waves, but the speed at which the boat begins to plane also creates large waves.

<u>Objective IV: Remove Invasive Shoreline Plant Species.</u>

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. Plants such as purple loosestrife (*Lythrum salicaria*), buckthorn (*Rhamnus spp.*), and reed canary grass (*Phalaris arundinacea*) are three examples. The outcome is a loss of plant and animal diversity. This section will address terrestrial shoreline exotic species.

Bresen Lake's shoreline does not have an abundance of exotic species, but purple loosestrife and reed canary grass are present in small numbers by the shoreline. It would be beneficial for these plants to be removed now, before their populations increase.

Purple loosestrife is responsible for the "sea of purple" seen along roadsides and in wetlands during summer. It can quickly dominate a wetland or shoreline. Due in part to an extensive root system, large seed production (estimates range from 100,000 to 2.7 million per plant), and high seed germination rate, purple loosestrife spreads quickly. Buckthorn is an aggressive shrub species that grows along lake shorelines as well as most upland habitats. It shades out other plants and is quick to become established on disturbed soils. Reed canary grass is an aggressive plant that if left unchecked will dominate an area, particularly a wetland or shoreline, in a short period of time. Since it begins growing early in the spring, it quickly out-competes native vegetation that begins growth later in the year. Control of purple loosestrife, buckthorn, and reed canary grass are discussed below. However, these control measures can be similarly applied to other exotic species such as garlic mustard (*Allilaria officianalis*) or honeysuckle (*Lonicera* spp.) as well as some aggressive native species, such as box elder (*Acer negundo*).

Presence of exotic species along a lakeshore is by no means a death sentence for the lake or other plant and animal life. If controlled, many exotic species can perform many of the original functions that they were brought here for. For example, reed canary grass was imported for its erosion control properties. It still contributes to this objective (offering better erosion control than commercial turfgrass), but needs to be isolated and kept in control. Many exotics are the result of garden or ornamental plants escaping into the wild. One isolated plant along a shoreline will probably not create a problem by itself. However, problems arise when plants are left to spread, many times to the point where treatment is difficult or cost prohibitive. A monitoring program should be established, problem areas identified, and control measures taken when appropriate. This is particularly important in remote areas of lake shorelines where the spread of exotic species may go unnoticed for some time.

Option 1: No Action

No control will likely result in the expansion of the exotic species and the decline of native species. This option is not recommended if possible.

Pros

There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics when possible. Appendix B lists several native plants that can be planted along shorelines.

Cons

Native plant and wildlife diversity will be lost as stands of exotic species expand. Exotic species are not under the same stresses (particularly diseases and predators) as native plants and thus can out-compete the natives for nutrients, space, and light. Few wildlife species use areas where exotic plants dominate. This happens because many wildlife species either have not adapted with the plants and do not view them as a food resource, the plants are not digestible to the animal, or their primary food supply (i.e., insects) are not attracted to the plants. The result is a monoculture of exotic plants with limited biodiversity.

Recreational activities, especially wildlife viewing, may be hampered by such monocultures. Access to lake shorelines may be impaired due to dense stands of non-native plants. Other recreational activities, such as swimming and boating, may not be effected.

Costs

Costs with this option are zero initially, however, when control is eventually needed, costs will be substantially more than if action was taken immediately. Additionally, the eventual loss of ecological diversity is difficult to calculate financially.

Option 2: Control by Hand

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation, such as the case with Bresen Lake. Some exotics, such as purple loosestrife and reed canary grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is excavated. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites.

Pros

Removal of exotics by hand eliminates the need for chemical treatments. Costs are low if stands of plants are not too large already. Once removed, control is simple with yearly maintenance. Control or elimination of exotics preserves the ecosystem's biodiversity. This will have positive impacts on plant and wildlife presence as well as some recreational activities.

Cons

This option may be labor intensive or prohibitive if the exotic plant is already well established. Costs may be high if large numbers of people are needed to remove plants. Soil disturbance may introduce additional problems such as providing a seedbed for other non-native plants that quickly establish disturbed sites, or cause soil-laden run-off to flow into nearby lakes or streams. In addition, a well-established stand of an exotic like purple loosestrife or reed canary grass may require several years of intense removal to control or eliminate.

Costs

Cost for this option is primarily in tools, labor, and proper plant disposal.

Option 3: Herbicide Treatment

Chemical treatments can be effective at controlling exotic plant species. However, chemical treatment works best on individual plants or small areas already infested with the plant. In some areas where individual spot treatments are prohibitive or unpractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option due to the fact that in order to chemically treat the area a broadcast application would be needed. Since many of the herbicides that are used are not selective, meaning they kill all plants they contact; this may be unacceptable if native plants are found in the proposed treatment area.

Herbicides are commonly used to control nuisance shoreline vegetation such as buckthorn and purple loosestrife. Herbicides are applied to green foliage or cut stems. Products are applied by either spraying or wicking (wiping) solution on plant surfaces. Spraying is used when large patches of undesirable vegetation are targeted. Herbicides are sprayed on growing foliage using a hand-held or backpack sprayer. Wicking is used when selected plants are to be removed from a group of plants. The herbicide solution is wiped on foliage, bark, or cut stems using a herbicide soaked device. Trees are normally treated by cutting a ring in the bark (called girdling). Herbicides are applied onto the ring at high concentrations. Other devices inject the herbicide through the bark. It is best to apply herbicides when plants are actively growing, such as in the late spring/early summer, but before formation of seed heads. Herbicides are often used in conjunction with other methods, such as cutting or mowing, to achieve the best results. Proper use of these products is critical to their success. Always read and follow label directions.

Pros

Herbicides provide a fast and effective way to control or eliminate nuisance vegetation. Unlike other control methods, herbicides kill the root of the plant, which prevents regrowth. If applied properly, herbicides can be selective. This allows for removal of selected plants within a mix of desirable and undesirable plants.

Cons

Since most herbicides are non-selective, they are not suitable for broadcast application. Thus, chemical treatment of large stands of exotic species may not be practical. Native species are likely to be killed inadvertently and replaced by other non-native species. Off target injury/death may result from the improper use of herbicides. If herbicides are applied in windy conditions, chemicals may drift onto desirable vegetation. Care must also be taken when wicking herbicides as not to drip on to non-targeted vegetation such as native grasses and wildflowers. Another drawback to herbicide use relates to their ecological soundness and the public perception of them. Costs may also be prohibitive if plant stands are large. Depending on the device, cost of the application equipment can be high.

Costs

Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40.

Objective V: Maintain or Enhance Areas for Wildlife.

Much of the area surrounding Bresen Lake offers good habitat for wildlife. This should be preserved. The key to increasing wildlife species in and around a lake can be summed up in one word: habitat. Wildlife need the same four things all living creatures need: food, water, shelter, and a place to raise their young. Since each wildlife species has specific habitat requirements, which fulfill these four basic needs, providing a variety of habitats will increase the chance that wildlife species may use an area. Groups of wildlife are often associated with the types of habitats they use. For example, grassland habitats may attract wildlife such as northern harriers, bobolinks, meadowlarks, meadow voles, and leopard frogs. Marsh habitats may attract yellow-headed blackbirds and sora rails, while manicured residential lawns attract house sparrows and gray squirrels. Thus, in order to attract a variety of wildlife, a variety of habitats are needed. In most cases quality is more important than quantity (i.e., five 0.1-acre plots of different habitats may not attract as many wildlife species than one 0.5 acre of one habitat type).

It is important to understand that the natural world is constantly changing. Habitats change or naturally succeed to other types of habitats. For example, grasses may be succeeded by shrub or shade intolerant tree species (e.g., willows, locust, and cottonwood). The point at which one habitat changes to another is rarely clear, since these changes usually occur over long periods of time, except in the case of dramatic events such as fire or flood.

In all cases, the best wildlife habitats are ones consisting of native plants. Unfortunately, non-native plants dominate many of our lake shorelines. Many of them escaped from gardens and landscaped yards (i.e., purple loosestrife) while others were introduced at some point to solve a problem (i.e., reed canary grass for erosion control). Wildlife species prefer native plants for food, shelter, and raising their young. In fact, one study showed that plant and animal diversity was 500% higher along naturalized shorelines compared to shorelines with conventional lawns (University of Wisconsin – Extension, 1999). More information about non-native (exotic) plants can be found in the section Objective IV: "Remove Invasive Shoreline Plant Species."

Option 1: No Action

This option means that the current land use activities will continue. No additional techniques will be implemented. Allowing a field to go fallow or not mowing a manicured lawn would be considered an action.

Pros

Taking no action may maintain the current habitat conditions and wildlife species present, depending on environmental conditions and pending land use actions. If all things remain constant there will be little to no effect on lake water quality and other lake uses.

Cons

If environmental conditions change or substantial land use actions occur (i.e., development) wildlife use of the area may change. For example, if a new housing development with manicured lawns and roads is built next to an undeveloped property, there will probably be a change in wildlife present.

Conditions in the lake (i.e., siltation or nutrient loading) may also change the composition of aquatic plant and invertebrate communities and thus influence biodiversity. Siltation and nutrient loading will likely decrease water clarity, increase turbidity, increase algal growth (due to nutrient availability), and decrease habitat for fish and wildlife.

Costs

The financial cost of this option is zero. However, due to continual loss of habitats many wildlife species have suffered drastic declines in recent years. The loss of habitat effects the overall health and biodiversity of the lake's ecosystems.

<u>Option 2: Increase Habitat Cover</u>

This option can be incorporated with Option 3 (see below). One of the best ways to increase habitat cover is to leave a minimum 25 foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see Appendix A for costs and seeding rates). This will provide cover from predators and provide nesting structure for many wildlife species and their prey. It is important to control or eliminate non-native plants such as buckthorn, purple loosestrife, garlic mustard, and reed canary grass, since these species outcompete native plants and provide little value for wildlife.

Occasionally high mowing (with the mower set at its highest setting) may have to be done for specific plants, particularly if the area is newly established, since competition from weedy and exotic species is highest in the first couple years. If mowing, do not mow the buffer strip until after July 15 of each year. This will allow nesting birds to complete their breeding cycle.

Brush piles make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They should be place at least 10 feet away from the shoreline to prevent any debris from washing into the lake.

Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets.

Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife.

Pros

Increased cover will lead to increased use by wildlife. Since cover is one of the most important elements required by most species, providing cover will increase the chances of wildlife using the shoreline. Once cover is established, wildlife usually have little problem finding food, since many of the same plants that provide cover also supply the food the wildlife eat, either directly (seeds, fruit, roots, or leaves) or indirectly (prey attracted to the plants).

Additional benefits of leaving a buffer include: stabilizing shorelines, reducing runoff which may lead to better water quality, and deterring nuisance Canada geese. Shorelines with erosion problems can benefit from a buffer zone because native plants have deeper root structures and hold the soil more effectively than conventional turfgrass. Buffers also absorb much of the wave energy that batters the shoreline. Water quality may be improved by the filtering of nutrients, sediment, and pollutants in run-off. This has a "domino effect" since less run-off flowing into a lake means less nutrient availability for nuisance algae, and less sediment means less turbidity, which leads to better water quality. All this is beneficial for fish and wildlife, such as sight-feeders like bass and herons, as well as people who use the lake for recreation. Finally, a buffer strip along the shoreline can serve as a deterrent to Canada geese from using a shoreline. Canada geese like flat, open areas with a wide field of vision. Ideal habitat for them are areas that have short grass up to the edge of the lake. If a buffer is allowed to grow tall, geese may choose to move elsewhere.

Cons

There are few disadvantages to this option. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline. Composition and density of aquatic and shoreline vegetation are important. If vegetation consists of non-native species such as or Eurasian water milfoil or purple loosestrife, or in excess amounts, undesirable conditions may result. A shoreline with excess exotic plant growth may result in a poor fishery (exhibited by stunted fish) and poor recreation opportunities (i.e. boating, swimming, or wildlife viewing).

Costs

The cost of this option would be minimal. The purchase of native plants can vary depending upon species and quantity. Based upon 100 feet of shoreline, a 25-foot buffer planted with a native forb and grass seed mix would cost between $165-270 (2500 sq. ft. would require 2.5, 1000 sq. ft. seed mix packages at $66-108 per package). This does not include labor that would be needed to prepare the site for planting and follow-up maintenance. This cost can be reduced or minimized if native plants are allowed to grow. However, additional time and labor may be needed to insure other exotic species, such as buckthorn, reed canary grass, and purple loosestrife, do not become established.

<u>Option 3: Increase Natural Food Supply</u>

This can be accomplished in conjunction with Option 2. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Plants found in Table 3 within Objective III, "Mitigate Shoreline Erosion." should be planted or allowed to grow. In addition, encourage native aquatic vegetation, such as water lily, sago pondweed, largeleaf pondweed, and wild celery to grow. Aquatic plants such as these are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration.

Providing a natural food source in and around a lake starts with good water quality. Water quality is important to all life forms in a lake. If there is good water quality, the fishery benefits and subsequently so does the wildlife (and people) who prey on the fish. Insect populations in the area, including beneficial predatory insects, such as dragonflies, thrive in lakes with good water quality.

Dead or dying plant material can be a source of food for wildlife. A dead standing or fallen tree will harbor good populations of insects for woodpeckers, while a pile of brush may provide insects for several species of songbirds such as warblers and flycatchers.

Supplying natural foods artificially (i.e., birdfeeders, nectar feeders, corn cobs, etc.) will attract wildlife and in most cases does not harm the animals. However, "people food" such as bread should be avoided. Care should be given to maintain clean feeders and birdbaths to minimize disease outbreaks.

Pros

Providing food for wildlife will increase the likelihood they will use the area. Providing wildlife with natural food sources has many benefits. Wildlife attracted to a lake can serve the lake and its residents well, since many wildlife species (i.e., many birds, bats, and other insects) are predators of nuisance insects such as mosquitoes, biting flies, and garden and yard pests (such as certain moths and beetles). Effective natural insect control eliminates the need for chemical treatments or use of electrical "bug zappers" that have limited effect on nuisance insects.

Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish. In fact, most migrating birds are dependent on food sources along their migration routes to replenish lost energy reserves. This may present an opportunity to view various species that would otherwise not be seen during the summer or winter.

Cons

Feeding wildlife can have adverse consequences if populations become dependent on hand-outs or populations of wildlife exceed healthy numbers. This frequently happens when people feed waterfowl like Canada geese or mallard ducks. Feeding these waterfowl can lead to a domestication of these animals. As a result, these birds do not migrate and can contribute to numerous problems, such as excess feces, which is both a nuisance to property owners and a significant contribution to the lake's nutrient load. Waterfowl feces are particularly high in phosphorus. Since phosphorus is generally the limiting factor for nuisance algae growth in many lakes in the Midwest, the addition of large amounts of this nutrient from waterfowl may aggravate a lake's excessive algae problem. In addition, high populations of birds in an area can increase the risk of disease for not only the resident birds, but also wild bird populations that visit the area.

Finally, tall plants along the shoreline may limit lake access or visibility for property owners. If this occurs, a path leading to the lake could be created or shorter plants may be used in the viewing area.

Costs

The costs of this option are minimal. The purchase of native plants and food and the time and labor required to plant and maintain would be the limit of the expense.

Option 4: Increase Nest Availability

Wildlife are attracted by habitats that serve as a place to raise their young. Habitats can vary from open grasslands to closed woodlands (similar to Options 2 and 3).

Bat houses such as the one on the north shore of Bresen Lake are also recommended for any area close to water. Bats are voracious predators of insects and are naturally attracted to bodies of water. They can be enticed into roosting in the area by the placement of bat boxes. Boxes should be constructed of rough non-treated lumber and placed >10 feet high in a sunny location.

Standing dead or dying trees provide excellent habitat for a variety of wildlife species. Birds such as swallows, woodpeckers, and some waterfowl need dead trees to nest in. Generally, a cavity created and used by a woodpecker (e.g., red-headed or downy woodpecker, or common flicker) in one year, will in subsequent years be used by species like tree swallows or chickadees. Over time, older cavities may be large enough for waterfowl, like wood ducks, or mammals (e.g., flying squirrels) to use. Standing dead trees are also favored habitat for nesting wading birds, such as great blue herons, night herons, and double-crested cormorants, which build stick nests on limbs. For these birds, dead trees in groups or clumps are preferred as most herons and cormorants are colonial nesters.

In addition to allowing dead and dying trees to remain, erecting bird boxes will increase nesting sites for many bird species. Box sizes should vary to accommodate various species. Swallows, bluebirds, and other cavity nesting birds can be attracted to the area using small artificial nest boxes. Larger boxes will attract species such as wood ducks, flickers, and owls. A colony of purple martins can be attracted with a purple martin house, which has multiple cavity holes, placed in an open area near water.

Pros

Providing places were wildlife can rear their young has many benefits. Watching wildlife raise their young can be an excellent educational tool for both young and old.

The presence of certain wildlife species can help in controlling nuisance insects like mosquitoes, biting flies, and garden and yard pests. This eliminates the need for chemical treatments or electric “bug zappers” for pest control.

Various wildlife species populations have dramatically declined in recent years. Since, the overall health of ecosystems depend, in part, on the role of many of these species, providing sites for wildlife to raise their young will benefit not only the animals themselves, but the entire lake ecosystem.

Cons

Providing sites for wildlife to raise their young have few disadvantages. Safety precautions should be taken with leaving dead and dying trees due to the potential of falling limbs. Safety is also important when around wildlife with young, since many animals are protective of their young. Most actions by adult animals are simply threats and are rarely carried out as attacks.

Parental wildlife may chase off other animals of its own species or even other species. This may limit the number of animals in the area for the duration of the breeding season.

Costs

The costs of leaving dead and dying trees are minimal. The costs of installing the bird and bat boxes vary. Bird boxes can range in price from $10-100.00. Purple martin houses can cost $50-150. Bat boxes range in price from $15-50.00. These prices do not include mounting poles or installation.

Option 5: Limit Disturbance

Since most species of wildlife are susceptible to human disturbance, any action to curtail disturbances will be beneficial. In Bresen Lake, limit the disturbance in the shallow west bay and south inlet.

Pros

Limiting disturbance will increase the chance that wildlife will use the lake, particularly for raising their young. Many wildlife species have suffered population declines due to loss of habitat and poor breeding success. This is due in part to their sensitivity to disturbance.

This option also can benefit the lake in other ways. Limited boat traffic may lead to less wave action to batter shorelines and cause erosion, which results in suspension of nutrients and sediment in the water column. Less nutrients and sediment in the water column may improve water quality by increasing water clarity and limiting nutrient availability for excessive plant or algae growth.

Cons

Because Bresen Lake is used for motor boating, limiting this use would interfere with the owner's enjoyment of the lake.

Objective VI: Reduce In-lake Nutrient Concentrations.

Typically, Midwestern manmade lakes are nutrient-rich systems, usually limited by phosphorus. Sources for these nutrients are internal, such as the lake sediment, and from external sources such as the watershed. These lakes are often surrounded by land with nutrient rich soils. In the case of Bresen Lake, nutrients are being released from the sediment, and may also be flowing in from the north inlet that drains Pond-A-Rudy. Some nutrients may be entering the lake (or may have entered the lake in the past) from the adjacent agricultural field.

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of available phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum does not directly kill algae as copper sulfate does. Instead, alum binds phosphorus making it unavailable thus reducing algal growth. Alum binds water born phosphorus and forms a flocculent layer that settles on the bottom, which can then prevent sediment bound phosphorus from entering the water column. Phosphorus inactivation using alum has been in use for 25 years. However, cost and unreliable results have deterred its wide spread use. Due to better understanding, alum is commonly being used in ponds and use in larger lakes is increasing. Alum treatment typically lasts 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratios are good candidates. This encompasses many lakes within Lake County. Lakes that are thermally stratified experience longer inactivation than non-stratified lakes due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited. Alum treatments must be carefully planned and carried out by an experienced professional. If not properly done, there may be many detrimental side effects. A bathymetric map of Bresen Lake is needed to correctly calculate the areas of treatment and the amount of alum needed. In addition, phosphorus inputs from the two inlets would need to be calculated.

Pros

Phosphorus inactivation is a possible long-term control option for controlling nuisance algae and increasing water clarity. Alum treatments can last as long as 20 years. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Studies have shown reductions in phosphorus concentrations by 66% in spring and 68% in summer. Chlorophyll *a*, a measure of algal biomass, was reduced by 61%. Reduction in algal biomass caused an increase in dissolved oxygen and a 79% increase in secchi disk readings. Effects of alum treatments can be seen in as little as a few days. This increase in clarity can have many positive effects on the lake's ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provided improved food sources for other organisms. Recreational actives such as swimming and fishing would be improved due to increased water clarity and plant populations. There is slight invertebrate decline immediately following treatment but populations recover fully by the following year.

Cons

There are several drawbacks to alum. External inputs must also be reduced or eliminated for alum to provide long-term effectiveness. With larger watersheds this could prove to be physically and financially impossible. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If the lake is relatively shallow like Bresen Lake, increased plant growth could result from the increase in clarity. If alum is not properly applied toxicity problems may occur. Typically aluminum toxicity occurs if pH is below 6 or above 9. At these pHs, special precautions must be taken when applying alum. By adding the incorrect amounts of alum, pH of the lake could be drastically change. Due to these dangers, it is highly recommended that a lake management professional plans and administers the alum treatment.

Costs

Costs and corresponding rates for aluminum sulfate use are 40-80 pounds per acre-foot at 35-60 cents per pound. For a reasonable cost estimate, a recent accurate bathymetric map would be necessary.

Table 4. WATER QUALITY DATA

Epilimnion

DATE	DEPTH	ALK	TKN	NH3	NO3	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	D.O.
5/4/00	3	142	1.36	<0.1	1.34	0.04	<0.005	558	4.9	596	211	5.12	0.7997	9.04	12.96
6/8/00	3	164	1.6	<0.1	0.261	0.1	0.013	498	9.6	521	187	2.90	0.7512	8.89	12.93
7/6/00	3	166	1.3	<0.1	0.544	0.12	0.007	458	16	477	148	2.59	0.7117	8.09	7.55
8/10/00	3	167	1.3	<0.1	<0.05	0.12	<0.005	396	13	430	148	2.99	0.6117	8.90	7.97
9/7/00	3	186	2.02	<0.1	<0.05	0.19	0.056	401	12.4	440	153	2.79	0.6564	8.38	7.47
Median		166	1.36	<0.1	0.544	0.12	0.013	458	12.4	477	153	2.90	0.7117	8.89	
Average		165	1.52	<0.1	0.715[k]	0.113	0.025[k]	462	11.2	493	169	3.28	0.7061	8.66	9.78

Hypolimnion

DATE	DEPTH	ALK	TKN	NH3	NO3	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	D.O.
5/4/00	8.5	168	1.83	<0.1	0.773	0.12	0.006	596	36	674	234	NA	0.8753	7.39	0.63
6/8/00	8	173	1.62	0.238	0.166	0.08	<0.005	490	9.2	534	183	NA	0.7605	7.33	0.20
7/6/00	8	195	2.13	1.2	0.678	0.34	0.042	463	89	578	187	NA	0.7473	7.42	0.06
8/10/00	8	184	2.3	0.832	<0.05	0.35	0.123	406	42	460	156	NA	0.6608	7.80	0.25
9/7/00	8	186	1.92	<0.1	<0.05	0.17	0.067	398	11.8	427	133	NA	0.6574	8.38	7.54
Average		181	1.96	0.757[k]	0.539[k]	0.21	0.060[k]	471	37.6	535	179	NA	0.7403	7.66	1.74

Glossary

ALK = Alkalinity, mg/L CaCO3
TKN = Total Kjeldahl nitrogen, milligrams per liter (mg/L)
NH3-N = Ammonia nitrogen, mg/L
NO3-N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L
pH units are equal o the -Log of (H) ion activity.

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable

Appendix C. Plant Species and Occurrences in Bresen Lake

5/5/00-9/7/00	Coontail	Curly leaf Pondweed	Duckweed	Flatstem Pondweed	Leafy Pondweed	Nitella	Sago Pondweed	Widgeon Grass	Watermeal
Num. of Sites	24	41	18	2	4	1	3	1	11
% Occurence	29%	50%	22%	2%	5%	1%	4%	1%	13%

5/5/00	Coontail	Curly leaf Pondweed	Duckweed	Flatstem Pondweed	Leafy Pondweed	Nitella	Sago Pondweed	Widgeon Grass	Watermeal
Num. of Sites	3	7	1	0	0	0	0	1	0
% Occurence	38%	88%	13%	0%	0%	0%	0%	13%	0%

6/6/00	Coontail	Curly leaf Pondweed	Duckweed	Flatstem Pondweed	Leafy Pondweed	Nitella	Sago Pondweed	Widgeon Grass	Watermeal
Num. of Sites	2	17	6	0	1	0	1	0	2
% Occurence	8%	68%	24%	0%	4%	0%	4%	0%	8%

6/29/00	Coontail	Curly leaf Pondweed	Duckweed	Flatstem Pondweed	Leafy Pondweed	Nitella	Sago Pondweed	Widgeon Grass	Watermeal
Num. of Sites	7	9	7	0	3	1	2	0	5
% Occurence	27%	35%	27%	0%	12%	4%	8%	0%	19%

8/8/00	Coontail	Curly leaf Pondweed	Duckweed	Flatstem Pondweed	Leafy Pondweed	Nitella	Sago Pondweed	Widgeon Grass	Watermeal
Num. of Sites	6	4	2	1	0	0	0	0	1
% Occurence	50%	33%	17%	8%	0%	0%	0%	0%	8%

9/7/00	Coontail	Curly leaf	Duckweed	Flatstem	Leafy	Nitella	Sago	Widgeon	Watermeal

		Pondweed		Pondweed	Pondweed		Pondweed	Grass	
Num. of Sites	6	4	2	1	0	0	0	0	3
% Occurence	50%	33%	17%	8%	0%	0%	0%	0%	25%

Appendix A. Methods for Field Data Collection and Laboratory Analyses

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were generally at the deepest point in the lake (see sample site map), three feet below the surface, and approximately two feet off the bottom. Samples were collected with a horizontal or vertical Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. TestAmerica Incorporated, an environmental services lab, analyzed samples collected for total Kjeldahl nitrogen (TKN). The Health Department lab analyzed all other samples. Analytical methods for the parameters are listed in Table 1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Total Kjeldahl nitrogen was analyzed by method 351.2 from the Methods for Chemical Analyses of Water and Wastes (EPA 600 Series). Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every foot until reaching the bottom in lakes ≤ 15 feet deep, and every two feet in lakes >15 feet.

Plant Sampling

Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At random locations in the littoral zone, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, any plants on the rake were identified and recorded. Plants that were not found on the rake but were occularly seen in the immediate vicinity of the boat at the time of sampling, were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation. Approximate locations of each point were drawn on an aerial photo of the lake. Locations of the plant edge were also identified and marked on the aerial photo. The plant edge was defined as the area where aquatic plants presence dissipated, typically toward the deeper portions of the lake. The number of sample locations was contingent upon lake surface area, area of littoral zone, and presence and distribution of plants.

Shoreline Assessment

To assess the current condition of each lake's shoreline, a shoreline assessment was completed in 2000. This survey was conducted with the use of a boat, aerial photos, and county parcel maps. The shoreline along the land/water interface on each parcel was observed from a boat and various parameters were assessed (Table 2). Shorelines were first identified as developed or undeveloped. The type of shoreline was then determined and length of each type was recorded based on the parcel map or was occularly estimated. In addition, several other parameters were measured including: the extent of shoreline vegetation, the degree of slope and erosion, and the presence of inlets, recreational structures (including boats, canoes, jetskis, boat ramps, piers, boat lifts, swimming platforms, etc.), aerators, irrigation pumps, water control structures, invasive vegetation, beaver activity, and deadfall (trees or shrubs lying in the water).

Frequently a parcel consisted of several shoreline types. For example, a parcel may have a beach, a steel seawall, and rip-rap along the its shore. In this case, the parcel was subdivided into three separate sections.

Data was entered and analyzed in ArcView 3.2 © Geographic Information System (GIS) software. Total shoreline lengths and percentages for each category were determined using Excel software.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal. Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical Methods Used for Water Quality Parameters.

Parameter	*Method*
Temperature	Hydrolab DataSonde® 4a
Dissolved oxygen	Hydrolab DataSonde ®4a
Nitrate nitrogen	Brucine method
Ammonia nitrogen	Electrode method, #4500F
Total Kjeldahl nitrogen	EPA 600 Series, Method 351.2
pH	Hydrolab DataSonde® 4a, Electrometric method
Total solids	Method #2540B
Total suspended solids	Method #2540D
Total dissolved solids	Method #2540C
Total volatile solids	Method #2540E, from total solids
Alkalinity	Method #2320B, titration method
Conductivity	Hydrolab DataSonde® 4a
Total phosphorus	Methods #4500-P B 5 and #4500-P E
Soluble reactive phosphorus	Methods #4500- P E and #4500-P B1
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a, LI-COR® 192 Spherical Sensor

Table A2. Shoreline Type Categories and Assessment.

Category	*Assessment*
Developed	Yes, No
Inlets	None, Culvert, Creek, Farm Tiles, Storm Water Outlet, Swale, Sump
Shoreline Vegetation	None, Light, Moderate, Heavy
Type	Prairie, Shrub, Wetland, Woodland, Beach, Buffer, Canopy, Lawn, Rip-rap, Seawall, Vacant
Slope	Flat, Gentle, Steep
Erosion	None, Slight, Moderate, Severe
Water Control Structures	None, Culvert, Dam, Spillway
Recreational Structures	Yes, No
Irrigation Present	Yes, No
Aerator Present	Yes, No
Invasive Vegetation	Yes, No
Beaver Activity	Yes, No
Deadfall	Yes, No

APPENDIX B. multiparameter data

APPENDIX C. PLANT SPECIES AND OCCURRENCES