2000 SUMMARY REPORT
of
TIMBER LAKE

Lake County, Illinois

Prepared by the

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LAKE IDENTIFICATION AND LOCATION

Timber Lake is located in unincorporated Cuba and Wauconda Townships near the Village of North Barrington and located southeast of Rt. 12 and Lakeshore Drive (T44N, R9E, Section 36). Timber Lake is a 32.2 acre shallow, man-made impoundment. It has an average depth of 7.6 feet and is 14.0 feet at its deepest location, which is located in the west bay by the spillway. Lake volume is estimated at 244 acre feet. Timber Lake receives most of its water from storm water runoff and creeks (when permitting). Timber Lake drains via a creek into Tower Lake and is at the headwaters of the Tower Lake Drainage, which is part of the Fox River watershed. The immediate watershed is approximately 750 acres. The depth contour of the lake is typical of many man made lakes throughout the County. Lake depth decreases in a radiating fashion from the deepest parts of the lake. The central part of the lake has steadily deepening shores with a large shelf at 9 feet and 6 feet. The far north bay is kettle shaped with a maximum depth of 6 feet. The entire lake is surrounded by low-density residential development.

BRIEF HISTORY OF TIMBER LAKE

Bottom ownership is private and divided among 26 residents of the lake and the Timber Lake Community Organization. The Timber Lake Civic Association's Lake Committee is the entity that deals with management of the lake. The lake was constructed in 1949 by damming a creek, dredging swampland, and subsequent flooding of the surrounding area by creek back up from damming. Timber Lake has had a variety of lake quality issues dating back to the late 1950s. These problems include or have included excessive aquatic plants, an unhealthy fishery, over-abundance of carp, severe algal blooms, and nutrient enrichment. Several times in the past 40 years rehabilitation of Timber Lake has been recommended by several agencies. These recommendations have not been properly implemented or have been ignored. As a consequence, Timber Lake is currently facing many major lake quality issues. In 2000, Ted Gray and Associates were hired to act as professional lake managers to help deal with these issues.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

Access to the lake is limited to due paying lake and surrounding community residents. There is one access point on the lake located on the western side of the lake, south of the spillway. This access has the only boat ramp (a low-lying grassy area) on the lake and is used by residents seasonally. In addition to the ramp, there is also storage space for rowboats and canoes of community residents. This area contains 15-20 parking spots in an adjacent gravel lot. The beach at this access point is State licensed and is monitored by the Lake County Health Department on a bimonthly basis for fecal coliform bacteria per state law. Additionally, there are barbecue grills, picnic tables, and a volleyball court. The site is open year round until 10 p.m. each day.

The lake's main use is recreational boating by sailboat, rowboat, and paddleboat. No gas motors are allowed on the lake at any time. Another use of Timber Lake is aesthetic enjoyment. Residents of the lake enjoy the year round natural views the lake can provide. Additionally, fishing is also a recreational use but due to declining fishery health, not widely practiced. Nature presents several sources of enjoyment for residents of Timber Lake. Waterfowl and other birds can be viewed at different times of the year in the few natural areas surrounding the lake. Unfortunately, many of the lake's aesthetic opportunities are being inhibited by several factors.

LIMNOLOGICAL DATA - WATER QUALITY

Water samples were collected at 3 feet and 12 feet depths from the deep hole location in the lake from May 2000 until September 2000 on a monthly basis (Figure 1). Samples from Timber Lake were analyzed for a variety of water quality parameters. The complete data set for Timber Lake is in Table 1. Due to aeration, Timber Lake is not stratified (with the exception of August), which means the lake does not strongly divide into a warm upper water (epilimnion) and cool lower water (hypolimnion) but instead the lake stays well mixed. This mixing of water is reflected in the water quality data. The concentrations of many parameters from shallow samples were very similar to the deeper sample data. Below is a discussion of the highlights of the water quality data collected over the five-month study of Timber Lake.

Secchi disk depth is a direct indicator of water clarity as well as overall water quality. In general, the greater the Secchi disk depth, the clearer the water and better the water quality. Historically, Timber Lake has had nuisance algae blooms and thus poor Secchi disk readings for decades (Figure 2). Average Secchi disk depth for Timber Lake from 1982 until 1999 was 2.5 feet, which corresponds well with 2000's average of 2.4 feet. Overall, Secchi disk readings in Timber Lake declined over the five-month study (Figure 3). In June, Secchi disk depth was 3.69 feet. The July Secchi disk depth decreased to 2.69 feet. This was followed by further decreases in August to 1.71 feet and September to 1.38 feet. The cause of decrease in Secchi disk depth was due to lake wide algal blooms in July, August, and September, which at times were extreme. Additionally, all Secchi disk readings on Timber Lake during the study were well below the Lake County average of 5.0 feet. The causes of these blooms were mainly the result of high levels of nutrients and lack of a healthy aquatic plant population.

Besides decreasing Secchi disk depth, lake wide algal blooms negatively impacted other water quality parameters such as alkalinity and total suspended solids (Figure 3). As algae blooms increased, total suspended solids (TSS) increased. Average TSS for Timber Lake was 15.0 mg/L. TSS increased from 5.7 mg/L in May to as high as 27.6 mg/L in September, which is over 3 times the County average of 8.6 mg/L (1995-2000 samples). Measurements of other types of solids, unaffected by algae growth, were high in May and June due to sediment carried in spring runoff. The fact that these other types of soil related solids decreased to near County averages after the spring rains further reinforces that the elevated TSS and decreased Secchi disk readings in July, August, and September were due to algal blooms. This is a trend that is seen in many man-made lakes throughout the County, with increase in TSS directly correlated with a decrease in Secchi Depth. This was also strikingly apparent in visual observations of massive, lake wide blue-green algal blooms during July, August, and September.

Algae need light and nutrients, most importantly carbon, nitrogen (N) and phosphorus (P), to grow. Light and carbon are not normally in short supply (limiting). This means that nutrients (N&P) are the limiting factors in algal growth. To compare the availability of these nutrients, a ratio of total nitrogen to total phosphorus is used (TN: TP). Ratios <10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate that there is enough of both nutrients for excessive algal growth. Most lakes in Lake County are phosphorus limited. In these phosphorus-limited lakes even a small addition of P can trigger algae blooms. Timber Lake had an average TN: TP ratio of 20:1, which means that overall, phosphorus was limiting. However, as algal blooms increased and rains subsided, the amount of nitrogen in the lake decreased. Decreased nitrogen levels along with increased phosphorus from internal release caused Timber Lake to become nitrogen limited in August and September. Additionally, since N concentrations drastically decreased in August and September, algae used less P, which further elevated P levels. As a result, due to the overall phosphorus-limited nature of Timber Lake, phosphorus is of the biggest concern. However, with a high watershed to lake size ratio of 23:1, Timber Lakes large watershed makes managing phosphorus inputs difficult.

Phosphorus levels in Timber Lake are *high*. Consequently, as phosphorus levels in Timber Lake increased so did the degree of algae growth. With the exception of May and June, which were below the Country average (0.066 mg/L), phosphorus concentrations were nearly double the County average or greater (Table 1). Phosphorus levels started to drastically increase in July reaching the peak levels in September with 0.214 mg/L (3.5 times the County average). This coincides with increasing TSS (Figure 3) and decreasing Secchi disk readings (Figure 4), which were also highest in September.

Phosphorus originates from two sources, from within the lake (internal) and from outside the lake (external). External inputs consist of a variety of sources. They can include fertilizer runoff, failing septic systems, and erosion. However, on Timber Lake these external sources are more than likely minor in comparison to internal sources. Rain data shows that during periods of elevated rainfall (May - July) phosphorus levels were actually lower than when there was little rainfall (August and September) (Figure 5). If phosphorus were coming from external sources, the opposite would occur.

Internal phosphorus sources are common in manmade lakes, which by their nature contain rich sediments. Sediment bound phosphorus is mixed into the water column by wind/wave action, carp and lack of aquatic plants (which stabilize sediments). Additionally, biological and chemical processes release phosphorus from sediments under hypoxic conditions (dissolved oxygen {D.O.} $>0\leq1.0$ mg/L). Phosphorus is then mixed into the water and is available for use by algae. Since Timber Lake is not stratified or is weakly stratified and has insufficient aeration, anoxic conditions can form near the bottom. Insufficient aeration is the result of suboptimum operation, under-sized compressors and improperly placed diffuser heads. In May and August hypoxic conditions formed near the bottom (13 feet and 11feet, respectively) and were anoxic (D.O.= 0 mg/L) at the sediment water interface. In July conditions were near anoxic at the bottom. Properly sized aerators do not allow these hypoxic conditions to form. Currently there are three ¾ hp pumps that aerate nine areas of the lake via diffusers (3 diffuser heads off each pump). These compressors in Timber Lake are only rated to supply 28.5 CFM (Cubic Feet per Minute) at peak power. Based on surface area calculations, proper aeration of Timber Lake requires 29 – 42 CFM of air. Actual output of Timber Lake's aerators is probably less than 28.5 CFM due to the suboptimum depths at which the diffusers are set. Additionally, the diffuser set at 14 feet was not properly operating in July and August, which could have contributed to the low D.O. conditions in those months. Currently, a majority of the diffusers are set in shallow waters (<8 feet contour) and are providing no benefit and may be part of Timber Lake's phosphorus problem by resuspending sediment bound P, making it available for use by algae. By adjusting the depths at which the diffusers are set they would be much more effective as well as more efficient. This would prevent low D.O. conditions from forming and may lessen the internal release of phosphorus.

Except for August and September, nitrate nitrogen (NO_3) levels in Timber Lake were well above the County average of 0.20mg/L (Table 1). The elevated levels during May (0.747 mg/L), June (0.747), and July (0.759 mg/L) could have come from a variety of sources brought in by above average rainfall during these months. Sources of nitrogen enrichment are very hard to pinpoint. However, possible sources could have included watershed inputs such as fertilizer runoff, atmospheric deposition, and failing septic systems on the lake. During August and September, nitrogen levels (NH_3 and NO_3) were very low. This was due to low amounts of rainfall and excessive algae growth, which use nitrogen as a food source (Figure 5). The algae used the nitrogen, along with phosphorus, to form lake wide blooms as a result nitrogen concentrations in Timber were reduce in later summer during the peak of the blooms. Due to high concentrations from internal release, phosphorus levels were not greatly reduced by the excessive algae growth.

Another way to look at phosphorus levels and how they affect productivity of the lake is the use of a Trophic State Index (TSI) based on phosphorus. TSI is based on phosphorus levels, chlorophyll *a* concentrations, and Secchi disk depth to classify and compare lake productivity levels (trophic state). The phosphorus TSI is setup so the higher the phosphorus concentration the greater amount of algal biomass and as a result, a higher trophic state. Based on a TSI phosphorus value of 72.3, Timber Lake is classified as hypereutropic (>70 TSI). This means that the lake is a highly productive system that has above average nutrient levels and high algal biomass (growth). Field observations reinforce that Timber Lake is hypereutrophic. Most manmade lakes in the county fall into eutrophic (TSI values >50 <70). Out of all the lakes in Lake Country studied by the LMU since 1988, Timber Lake ranks 75th out of 86 lakes based on average TSI (Table 2). Based on lakes studied in 2000, Timber Lake ranked 26th out of 32.

TSI values along with other water quality parameters can be used to calculate impairment indexes established by the Illinois Environmental Protection Agency (IEPA). These indexes rate a given lake based on several parameters. Using the TSI and IEPA indexes, Timber Lake was listed as having a *Slight* overall use impairment based on phosphorus and suspended solids levels. These two parameters, when elevated result in reduced visibility and overall use of the lake. Based on IEPA swimming use guidelines, Timber Lake is categorized as providing only *Partial* support. This is due to poor Secchi disk readings and high phosphorus levels, which lead to high algal biomass (increased turbidity). Additionally, Illinois Department of Public Health recommends at least 48" Secchi disk depth for safe swimming. Timber Lake's Secchi disk average was only 28.4". Based on the recreational use impairment index, Timber Lake was also categorized as providing only *Partial* support. This is due to a high TSI value and high levels of suspended sediments, both of which result in poor visibility and contribute to an overall reduction in use of the lake. Additionally, Timber Lake provided *Full* support of aquatic life use. Other individual impairment assessments (pH, low D.O., TDS, noxious plants, etc.) were categorized as none. Based on all the impairment indices, Timber Lake is listed as only providing *Partial* support for overall use.

LIMNOLOGICAL DATA - AQUATIC PLANT ASSESSMENT

Aquatic plant surveys were conducted every month for the duration of the study (*Appendix A* for methodology). Shoreline plants of interest were also observed (Table 2). However, no surveys were made of these shoreline species and all data is purely observational. The extent to which aquatic plants grow is largely dictated by light availability. Aquatic plants need at least 1% of surface light levels in order to survive. Based on the depth of the 1% light level, depth at which plant growth could occur in Timber Lake varied on a monthly basis. Based on light penetration, aquatic plant coverage of the lake could have ranged from 46 % (June) to 28 % (September). However, surveys show that plants did not grow in **any** of these areas resulting in *poor* plant diversity (Table 3).

During the course of the study Timber Lake had only eight samples out of 98 that had any vegetation (Table 4). These eight samples were the same locations just different months. Even these sites had very little vegetation consisting of only a plant or two. Timber Lake is *severely* lacking a healthy aquatic plant community. As a result, Timber Lake is experiencing a variety of problems within the lake including increased algae blooms, increased turbidity, and a poor fishery (see *Limnological Data-Water Quality*).

The 1% light level depth continually decreased from 6.3 feet in June to as little as 2.75 feet in August [1]. As a result, depth at which plant growth *could* have occurred gradually decreased over the course of the study. Loss of clarity (and light penetration) was due to the increasing dominance of blue-green algae blooms (Figure 3). The blue-green algae

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[1] September 1% light level was not measured. Based on Secchi disk readings in September light levels would have further decreased from August levels.

blooms that occur on Timber Lake are severe. These blooms, dominated by the genera *Anabanea* and *Microcystis*[2], were consistently present from June through September with varying degrees of intensity with peak blooms occurring in August. Along with foul odors, these blooms were severe enough to form surface scums and discolor shoreline plants that came into contact with the water. Furthermore, blue-green algae can release toxins that can cause skin irritations as well as fish kills.

Table 3. 2000 Aquatic and shoreline plants on Timber Lake.

<u>*Aquatic Plants*</u>	
American Elodea	*Elodea canadensis*
Small Duckweed	*Lemna minor*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Slender Naiad	*Najas flexilis*
Curlyleaf Pondweed	*Potamogeton crispus*
Leafy Pondweed	*Potamogeton foliosus*
Sago Pondweed	*Stuckenia pectinatus*
Horned Pondweed	*Zannichellia palustris*
<u>*Shoreline Plants*</u>	
Purple Loosestrife	*Lythrum salicaria*
Reed Canary Grass	*Phalaris arundinacea*
Common Reed	*Phragmites australis*
Buckthorn	*Rhamnus cathartica*
Common Arrowhead	*Sagittaria latifolia*
Common Cattail	*Typha latifolia*

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

Shoreline assessments were conducted at Timber Lake on May 31st, 2000. Shorelines were assessed for a variety of criteria (*Appendix A* for methodology). Based on these assessments several important generalizations can be made. Timber Lake's shoreline consists of a variety of different types (Figure 6). A majority of Timber Lake's shoreline

[2] Identified by the LCHD-LMU staff

is developed (97%). The majority of developed shoreline consists of buffer strips (48%). However, other major types of shoreline development were less desirable such as rip-rap (14%) and manicured lawns (22%). The high dominance of these types of undesirable shoreline is of concern. Manicured lawn is a poor shoreline water interface. This is due to the poor root structure of turf grasses, which is unable to stabilize soils, which leads to shoreline erosion. Rip-rap can be undesirable because of its tendency to reflect wave action back into the lake and lack of habitat. This can cause resuspension of near shore sediments, which can lead to a variety of water quality problems. It is the recommendation of the LMU that Timber Lake Civic Association should promote the use of naturalized shoreline and to minimize rip-rap and manicured lawns.

Another area of concern on Timber Lake was the extent of erosion (Figure 7). Overall, of developed and undeveloped shorelines, 41% was assessed to have no erosion. However, 57% had slight erosion, and 2% had moderate erosion. Interestingly, shorelines that were not eroded mainly consisted of well-maintained buffer strips and beach areas. Shoreline types that were likely to have eroded soils (slight and moderate) were poorly maintained buffer strip areas and manicured lawns to the edge. Solutions to these eroded shorelines will be discussed in detail in *Options for Achieving the Lake Management Plan Objectives* and include the use of buffer strips in most areas around the lake and rip-rap in the cases of moderate erosion on steeply sloped shores.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

Over the years several fisheries recommendations have been made by the IDNR with few being carried out properly. Most recently in 1989, IDNR made recommendations regarding stocking of several species in order to improve the fishery. Only one recommendation was carried out, stocking of grass carp. Grass carp were stocked approximately 10 years ago to help control excessive aquatic plant growth. Stocking grass carp is not advantageous and is seldom recommended anymore. However, these fish are near the end of their life span. Grass carp **SHOULD NOT** be stocked again. The grass carp, along with past excessive vegetation, and human impacts, have caused several problems on Timber Lake. Problems include an unhealthy fishery, which has been pointed out by the IDNR on several occasions, an overall decline in water quality, and over removal and eventual elimination of aquatic vegetation from Timber Lake.

Wildlife observations were made on a monthly basis during water quality and plant sampling actives. All observations were visual. Several types of waterfowl were observed during the course of the study (Table 5). There are a few healthy areas of mature trees that provide good habitat for a variety of bird species. There are also a few large dead trees that provide excellent habitat. Additionally, there are a few shrub areas that provide habitat for smaller bird and mammal species. However, there are several areas for habitat improvement on Timber Lake. There are two invasive species that should be controlled/eliminated, purple loosestrife and buckthorn. These species have been noted 35 % of shoreline sites around the lake (Figure 1). These plants are seldom used by wildlife for food or shelter. They should be eliminated before they spread and displace other native and more desirable plant species. Additionally, shoreline habitat should be improved and should include buffer strips and more naturalized shoreline areas (*see Objective VI: Wildlife Habitat Improvement*).

Table 5. Observed Wildlife Species on Timber Lake, May-September 2000

<u>*Birds*</u>	
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Great Blue Heron	*Ardea herodias*
Unknown Sandpiper	*Calidris* sp.
Common Flicker	*Colaptes auratus*
Willow Flycatcher	*Empidonax traillii*
<u>*Reptiles*</u>	
Snapping Turtle	*Chelydra serpentina*

EXISTING WATER QUALITY PROBLEMS

- *Algae Blooms*

  Algal blooms are wide spread in Timber Lake starting in mid-June. Blooms largely consist of planktonic blue-green algae. These blooms are caused by the lack of aquatic vegetation and high phosphorus levels. The increase in algal blooms over the course of the summer leads to the drastic decreases in water clarity and light penetration, increases in TSS and pH, and an overall decrease in water quality. With decreasing light levels, aquatic vegetation is no longer able to inhabit the lake. Thus the benefits they can provide, such as sediment stabilization, competition with algae for resources, and wildlife habitat, are lost. There are several ways to decrease the algae blooms and thus lessen their negative effects. Two realistic techniques would be copper sulfate to kill the algae and proper operation of the aerators. The way in which these aerators are set up now are more than likely contributing to the severity of the algae blooms by resuspending nutrients from the sediment and allowing anoxic conditions to form during part of the summer.

- *Poor Plant Diversity/Densities*

  One key to a healthy lake is a healthy aquatic plant population. Timber Lake has poor plant densities as well as continued poor clarity. The lack of quality aquatic plants, and subsequent loss of water quality, is mainly the result of grass carp and low light penetration caused by lake wide algae blooms (which itself is due the lack of aquatic plants). The negative impacts associated with a deficiency of quality aquatic plant community are wide spread including those on water quality and fishery health. Establishment of a healthy aquatic plant community is essential in improving the quality of Timber Lake. This is a long-term process and involves other management practices as well. The first step is the elimination of carp and the control of nuisance algae blooms, both of which reduce light penetration and thus deter plant growth. After improved water clarity is achieved, revegetation can be undertaken in order to improve the overall health of Timber Lake.

- *Carp*

  One of the main sources of Timber Lake's water quality problem is carp (both common and grass). The carp population of Timber Lake has been negatively impacting Timber Lake since the 1960's. Carp can cause a variety of water quality problems including resuspension of sediments and nutrients, disruption of aquatic plants, and low D.O. conditions. Additionally, this disruptive nature slowly deteriorates the quality of the lake's fishery until conditions are only suitable for their own survival. Therefore, the carp in Timber Lake should be eliminated. This has been the recommendation of the IDNR on several occasions. However, these recommendations have been not been carried out and growth of the carp population has gone uninhibited. The process of carp elimination is one of sacrifice. The levels of rotenone (the product used to remove fish) that are needed to kill carp are high enough to kill all of the other fish in Timber Lake. Therefore, fishing opportunities on Timber Lake would temporarily be lost. As a result, Timber Lake would have to be restocked with fish after the rotenone treatment.

- *Shoreline Erosion*

  As stated previously, Timber Lake has some form of erosion on 59% of its shoreline. This erosion is occurring for several reasons. These include lack of suitable shoreline vegetation, failing existing erosion control structures, ice damage, and water fluctuations. Erosion is contributing to other water quality problems such as sedimentation, nutrient enrichment and resulting nuisance algae blooms. If left unattended the problem will continue to worsen, further aggravating related issues. Shoreline erosion on Timber Lake should be addressed immediately. Depending on the severity of erosion these techniques on Timber Lake include the use of rip-rap, biologs, and buffer strips. On Timber Lake, buffer strips are the single most important control technique. These buffer strips can also improve the quality of wildlife habitat on Timber Lake (discussed below).

- *Wildlife Habitat Improvement*

  Overall, wildlife habitat on Timber Lake is *fair*. The main problem is the lack of quality shoreline habitat. A large part of Timber Lake's shoreline is developed and offers no/little habitat. This is a common problem on residential lakes with highly developed shorelines (rip-rap, beaches, lawns, etc.). Often, the only shoreline habitat consisted of invasive species, which offer little/poor quality habitat. Habitat can be greatly improved by the use of other management techniques, such as the use of buffer strips for erosion control, and removal of invasive species such as purple loosestrife and buckthorn. Additionally, it would be beneficial to establish wildlife sanctuary areas around the lake. Areas such as the park, which contains areas of unused land and shoreline, would be ideal locations.

POTENTIAL OBJECTIVES FOR TIMBER LAKE MANAGEMENT PLAN

I. Algae management plan
II. Carp removal
III. Erosion control
IV. Elimination/Control of invasive species
V. Habitat improvement

OPTIONS FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES

Objective I: Algae Management Plan

The growth of nuisance or excessive algae can cause a number of problems. On Timber Lake excessive algal growth has lead to decreases in water clarity and light penetration. This has lead to several major problems such as loss of aquatic plants, decline in fishery health, and interference with recreational activities. Health hazards, such as swimmer's itch and other skin irritations have been linked to excessive algal growth. Normally, excessive algae growth is a sign of larger problems such excessive nutrients and/or lack of aquatic plants. Some treatment methods, such as copper sulfate, are only quick remedies to the problem. Solving the problem of excessive algal growth involves treating the factors that cause the excessive growth not the algae it self. Long term solutions to excessive algae typically include an integrated approach such as alum treatments, revegetation with aquatic plants, and limiting external sources of nutrients. Interestingly enough, these long-term management strategies are seldom used, typically because of their high initial costs. Instead, the cheap, quick fix of using copper sulfate, though temporary, is much more widely used. However, the costs of continually applying copper sulfate over years, even decades, can eventually far exceed the costs of a slower acting, eventually more effective, integrated approach.

Algae management practices have both positive and negative characteristics. If used properly, they can 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 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 (beaches, boat ramps, etc.), habitat maintenance/restoration issues, and nutrient levels. For an algal management plan to achieve long term success, follow up is critical. The management of the lake's algae problem does not end once the blooms and/or mats has been reduced/eliminated. It is critical to continually monitor problematic areas for regrowth and treat as necessary. An association should not always expect immediate results. A quick fix of the algal problem may not always be in the best interest of the lake. Sometimes the best solutions take several seasons to properly address the problem. The management options covered below are commonly used techniques and those that are coming into wider acceptance, and have been used in Lake County. There are other algae management options that are not covered below as they not are very effective, or are too experimental to be widely used.

<u>Option 1: No Action</u>
With a no action management plan nothing would be done to control the nuisance algae on Timber Lake, regardless of type and extent. Blue-green algae blooms will continue to be problematic. Growth limitations of the algae and the characteristics of the lake itself

(light penetration, nutrient levels.) will dictate the extent of infestation. On Timber Lake, algal blooms will continue to be widespread due to large concentrations of nutrients such as N and P. Unlike aquatic plants, algae are not bound by physical factors such as substrate type. The areas in which filamentous and thick surface planktonic blooms (scum) occur can be affected by strong wind and wave action. However, under normal conditions, with no action, both planktonic and filamentous algal blooms can spread to cover 100% of the surface of Timber Lake. This could cause major inhibition of the lakes recreational uses and impact fish and other aquatic organisms adversely.

Pros

There are positive aspects associated with the no action option for nuisance algae management. The first, and most obvious, is that there is no cost. However, if an active management plan for algae control were eventually needed, the cost would be substantially higher than if the no action plan had been followed in the first place. Another benefit of this option would be the lack of environmental manipulation. Under the no action option, chemicals or introduction of any organisms would take place. Use of the lake would continue as normal unless blooms worsened. In this case, activities such as swimming might have to be suspended due to an increase in health risks. Other problems such as strong odors produced by the blue-green alga might also increase in frequency.

Cons

Under the no action option, if nuisance algae become wide spread and able to reach epidemic proportions, there will be many negative impacts on Timber Lake. The fishery of the lake may become more stunted due the to lack of quality forage fish habitat and reduced predation. This will cause an explosion in the small fish population and with food resources not increasing, growth of fish will be reduced. Fish kills can result from toxins released by some species such as some blue-green algae. Blue-green algae can also produced toxins that are harmful to other algae. This allows blue-green algae to quickly dominate a body of water. Decreased dissolved oxygen levels, due to high biological oxygen demand from the excessive algae growth, will also have negative impacts on the aquatic life. Wildlife populations will also be negatively impacted by dense growths of algae. Birds and waterfowl will have difficulty finding quality plants for food or in locating prey within the turbid green waters. Additionally, some species, such as blue-green algae, are poor sources of food for zooplankton and fish.

Water quality could be negatively impacted with the no action option. Decomposition of organic matter and release of nutrients upon algal death is a probable outcome. Large nutrient release with algae die back could lead to lake-wide increases of internal nutrient load. This could in turn, could increase the frequency or severity of other blooms. In addition, decomposition of massive amounts of algae, filamentous and planktonic, will lead to a depletion of dissolved oxygen in the lake. This can cause fish stress, and eventually, if stress is frequent or severe enough, fish kills. All of the impacts above could in turn have negative impacts on numerous aspects of the lake's ecosystem.

In addition to ecological impacts, many physical lake uses will be negatively impacted. Swimming could become increasingly difficult and unsafe due to thick mats and reduction in visibility by planktonic blooms. Fishing could become more and more exasperating due in part to low visibility and stunted fish populations. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by blooms of algae and the odors that may develop; such as with large blue-green blooms seen on Timber Lake. The combination of above events could cause property values on the lake to suffer. Property values on lakes with 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.

<u>Option 2: Algicides</u>

Algicides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ($CuSO_4$) and chelated copper products are the two main algicides in use. These two compounds are sold by a variety of brand names by a number of different companies. They all work the same and are contact killers. This means that the product has to come into direct contact with the algae to be effective. Algicides come in two forms, granular and liquid. Granular herbicides are spread by hand or machine over an effected area. They can also be placed in a porous bag (such as a burlap sack) and dragged though the water in order to dissolve and disperse the product. Granular algicides are mainly used on filamentous algae where they are spread over the mats. As the granules dissolve, they kill the algae. Liquid algicides, which are much more widely used, are mixed with a known amount of water to achieve a given concentration. The mixture is then sprayed onto/into the water. Liquid algicides are used on both filamentous and planktonic algae. Liquid algaecides are often mixed with herbicides and applied together to save on time and money. The effectiveness of some herbicides are enhanced when mixed with an algicide. When applying an algicide it is imperative that the label is completely read and followed. The label is the law. If too much of the lake is treated at any one time an oxygen crash may occur due to the decomposition of massive amounts of dead algae (a process that uses oxygen). This D.O. crash may cause fish kills. Additionally, treatments should never be made when blooms/mats are at their fullest extent. It is best to divide the lake into at least two treatment areas depending on the size of the lake. Larger lakes will need to be divided into more sections. Then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algicides should never be done in extremely hot weather (>90^oF). This will help lessen the likelihood of an oxygen crash and resulting fish kills. When possible, treatments should be made as early in the season as possible. It is best to treat in spring or when the blooms/mats starts to appear there by killing the algae before they become a problem. Use of algicides will not completely eliminate algal blooms. Typically, continuous treatments are needed over a season to control algal blooms.

Pros
When used properly, algicides can be a powerful tool in management of nuisance algae growth. A properly implemented plan can often provide season long control with minimal applications. Another benefit of using algicides are their low costs. The fisheries and waterfowl populations of the lake would greatly benefit due to a decrease in nuisance algal blooms. By reducing the algae, clarity would increase. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would 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*) and sago pondweed (*Potamogeton pectinatus*). Additionally, copper products, at proper dosages, are selective in the sense that they do not affect aquatic vascular plants and wildlife.

By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae. Health risks associated with excessive algae growth (toxins, reduced visibility, etc.) The quality of fishing may recover due to improved habitat and feeding opportunities. In addition to increased usage opportunities, overall aesthetics of the lake would improve, potentially increasing property values.

Cons
The most obvious drawback of using algicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. By continually killing particular algal species, lake managers may unknowingly be creating a larger problem. In many instances, over use of copper is leading to selection of species tolerant to copper. As the algae are continuously exposed to copper, some species are becoming more and more tolerant.   This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are filling the empty gap. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for actives such as dredging. Due to large amount of copper in the sediments, special permits and disposal methods would have to be utilized.

Costs
A whole lake treatment of copper sulfate for Timber Lake would be approximately $4,700. If the algae were hard to control the use of a chelated copper (such as Cutrine-Plus® or Cleargate®) would be advisable. The

approximate lowest cost to treat all of Timber Lake with Cutrine-Plus® would be $8,200. These prices are for one application. Repeat application will be needed during a season to curb regrowth. The whole lake should not be treated all at once no matter what product is used. These prices are approximate and include product and labor.

Option 3: Alum Treatment

A possible remedy to excessive algal growth on Timber Lake is to eliminate or greatly reduce the amount of 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-borne 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 deterred its wide spread use. Currently, alum is commonly being used in ponds, and its 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 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.

Pros

Phosphorus inactivation is a possible long-term solution 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. The 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 provide improved food sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations. Typically, there is a slight invertebrate decline immediately following treatment but populations recover fully by the following year.

Cons

There are several drawbacks to alum. External nutrient 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 alum is not properly applied toxicity problems may occur. Typically aluminum toxicity occurs if pH is below 6 or above 9. Most of Lake County's lakes are in this safe range. However, at these pHs, special precautions must be taken when applying alum. By adding the incorrect amounts of alum, pH of the lake could drastically change. Due to these dangers, it is highly recommended that a lake management professional plans and administers the alum treatment.

Costs

Cost for an alum treatment based on volume and phosphorus concentrations in Timber Lake would be approximately $30,000. This is based on full lake volume. A water draw down would decrease the costs proportionally. Draw down could be easily carried out on Timber via the spillway. Additionally, rotenone treatment (see *Objective II: Carp Eradication*) of the lake for carp could also be carried out during draw down to save money. These costs are approximate and include labor. When doing an alum treatment it is best to hire an *experienced* applicator. If alum treatments are not properly done, the alum may be ineffective and/or bring about several unwanted effects.

Option 4: Revegetation With Native Aquatic Plants

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a very sparse plant population or none at all. This is due to reduction in light penetration brought about by years of excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, such as on Timber Lake, these problems must be addressed before a revegetation plan is undertaken. Without adequate light penetration, revegetation will not work. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis. If aquatic herbicides are being used to control what vegetation does exist there use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake would be allowed to naturally expand into adjacent areas thereby filling the niche left by the nuisance algae. This is not an option on Timber Lake, as it does not have any aquatic plants.

The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with one another in order to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from herbivory by waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire are erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration as several factors would have to be taken into consideration. Table 3 lists common, native plants that should be considered when developing a revegetation plan. Included in this list are aquatic shoreline vegetation (rushes, cattails, etc) and deeper water plants (pondweeds, *Vallisneria*, etc). Prices, planting depths, and planting densities are included and vary depending on plant species. When revegetating, the goal is to revegetate 20-40% total surface acreage. The amount of revegetation is dependent on lake use. For a healthy fishery 25-30% surface acreage coverage is recommended. Revegetaion could be selectively done. This would allow for high usage areas the lake to be sparsely vegetated while other areas of the lake, that see little or no usage, could be heavily vegetated. Recommended plants would be largeleaf pondweed (*Potamogeton amplifolius*), Illinois pondweed (*Potamogeton illinoensis*), sago pondweed (*Stuckenia pectinatus*), Vallisneria (*Vallisneria americana*), and water stargrass (*Heteranthera dubia*). These plants are readily available though aquatic nurseries.

Pros

By revegetating newly opened areas that were once infested with nuisance species, the lake will benefit in several ways. Once established, expanded native plant populations will help to control growth of nuisance algae by shading and competition for nutrients. This provides a more natural approach as compared to other management options. In addition, using established native plants to control excessive invasive plant growth is less expensive than other options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also increase due to the improvement in water quality and the suppression of weedy species.

Cons

There are few negative impacts to revegetating a lake. One possible drawback is the possibility of new vegetation expanding to nuisance levels and needing control. However, this is an unlikely outcome. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

Costs
Prices for Timber Lake would vary on the extent of revegetation. An experienced aquatic nursery or consultant should design and preferably plant to ensure good results. See Table 6 for pricing on different species of aquatic plants suitable for revegetation.

Objective II: Carp Removal

A frequent problem that plagues many of the lakes in the County is the presence of common carp (*Cyprinus carpio*). Common carp were first introduced into the United States from Europe in the early 1870's, and were first introduced into Illinois river systems in 1885 to improve commercial fishing. The carp eventually made their way into many inland lakes and are now so wide spread that many people do not realize that they are not native to the U.S.

Carp prefer warm waters in lakes, streams, ponds, and sloughs that contain high levels of organic matter. This is indicative of many lakes in Lake County. Carp feed on insect larvae, crustaceans, mollusks, and even small fish by rooting through the sediments. Immature carp feed mainly on small crustaceans. Because their feeding habits cause a variety of water quality problems. Carp are very undesirable in lakes. Rooting around for food causes resuspension of sediments and nutrients, which can both lead to increased turbidity. Additionally, spawning, which occurs near shore in shallow water, can occur from late April until June. The spawning activities of carp can be violent further contributing to turbidity problems. Adult carp can lay between 100,000 –500,000 eggs, and hatch in 5-8 days. Initial growth is rapid with young growing 4 ¾" to 5" in the first year. Adults normally range in size from 1-10 lbs., with some as large as 60 lbs. Average carp lifespan is 7-10 years, but they may live up to 15 years.

There are several techniques to remove carp. However, rarely does any technique eradicate carp from a lake. Commonly, once a lake has carp, it has carp forever. However, it is up to the management entity to dictate how big the problem is allowed to become. Rotenone is the only reliable piscacide (fish poison) on the market at this time, but it kills all fish that is comes into contact with. Currently, there is a rotenone laced baiting system that can selectively remove carp. While the process is a step in the right direction, several factors still need to be worked out in order for it to be a viable alternative to the whole lake treatment. Until this baiting technique is further developed and produces consistent results, it is not recommended.

Option 1: No Action

By following a no action management approach, nothing would be done to control the carp population of the lake. Populations will continue to expand and reach epidemic proportions if they do not already exist.

Pros

There are very few positive aspects to following a no action management plan for excessive carp populations. The only real advantage would be the money saved by taking no action.

Cons

There are many negative aspects to a no action management plan for carp management. The feeding habits of carp cause most of the associated problems. As carp feed they root around in the lake sediment. This causes resuspension of sediment and nutrients. Increased nutrient levels can lead to increased algal blooms, which, combined with resuspended sediments, lead to increased turbidity. As a result there is a decrease in light penetration, negatively impacting aquatic plants. Additionally, the rooting action of the carp causes the direct disruption of aquatic plants. Loss of aquatic plants can further aggravate sediment and nutrient loads in the water column due to loss of sediment stabilization provided by the plants. Additionally, the fishery of the lake may decline and/or become stunted due to predation issues related to decreased water clarity and loss of habitat. Other wildlife, such as waterfowl, which commonly forage on aquatic plants and fish, would also be negatively impacted by the decrease in vegetation.

The loss of aquatic plants and an increase in algae will drastically impair recreational use of the lake. Swimming could be adversely affected due to the increased likelihood of algal blooms. Swimmers may become entangled in large mats of filamentous algae, and blooms of planktonic species, such as blue-green algae, can produce harmful toxins and noxious odors. Fishing would also be negatively affected due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer from an increase in unsightly algal blooms, having an unwanted effect on property values.

Costs

There is no cost associated with the no action option.

Option 2: Rotenone

Rotenone is a piscacide that is naturally derived from the stems and roots of several tropical plants. Rotenone is approved for use as a piscacide by the USEPA and has been used in the U.S. since the 1930's. It is biodegradable (breaks down into CO_2 and H_20) and there is no bioaccumulation. Because rotenone kills fish by chemically inhibiting the use of oxygen in biochemical pathways, adult fish are much more susceptible than fish eggs (carp eggs are 50 times more resistant). Other aquatic organisms are less sensitive to rotenone. However, some organisms are effected enough to reduce populations for several months. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal. More sensitive nonfish species include frogs and mollusks but these organisms typically recover to pretreatment levels within a few months. Rotenone has low mammalian and avian toxicity. For example, if a human consumed fish treated with normal concentrations of rotenone, approximately 8,816 lbs. of fish would need to be eaten at one sitting in order to produce toxic effects in humans. Furthermore, due to its unstable nature, it is unlikely that the rotenone would still be active at the time of consumption, and warm-blooded mammals have natural enzymes that would break down the toxin before it had any effects.

Rotenone is available in 5% and 2.5% concentrations. Both concentrations are available as synergized formulations. The synergist (piperonal butoxide) is an additive that inhibits fish detoxification of rotenone, making the rotenone more effective. Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and green sunfish, are high enough to kill more desirable species such as bass, bluegill, crappie, walleye, and northern pike. Therefore, it is difficult to selectively remove undesirable fish while leaving desirable ones. Typically, rotenone is used at concentrations from 2 ppm (parts per million) – 12 ppm. For removal of undesirable fish (carp, bullhead and green sunfish) in lakes with alkalinities in the range found in Lake County, the target concentration should be 6 ppm. Sometimes concentration will need to be increased based on high alkalinity and/or high turbidity. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are $<50^{o}$F. Under these conditions, rotenone is not as toxic as in warmer waters but it breaks down slower and provides a longer exposure time. If treatments are done in warmer weather they should be done before spawn or after hatch as fish eggs are highly tolerant to rotenone.

Rotenone rarely kills every fish (normally 99-100% effective). Some fish can escape removal and rotenone retreatment needs to occur about every 10 years. At this point in time, carp populations will have become reestablished due to reintroduction and reproduction by fish that were not removed during previous treatment. To ensure the best results, precautions can be taken to assure a higher longevity. These precautions include banning live bait fishing (minnows bought from bait stores can contain carp minnows) and making sure every part of the lake is treated (i.e., cattails, inlets, and harbored shallow areas). Restocking of desirable fish species may occur about 30-50 days after treatment when the rotenone concentrations have dropped to sub-lethal levels. Since it is best to treat in the fall, restocking may not be possible until the following spring. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois as it is a restricted use pesticide.

Pros
Rotenone is one of the only ways to effectively remove undesirable fish species. This allows for rehabilitation of the lake's fishery, which will allow for improvement of the aquatic plant community, and overall water quality. By removing carp, sediment will be left largely undisturbed. This will allow aquatic plants to grow and help further stabilize the sediment. As a result of decreased carp activity and increased aquatic plant coverage, fewer nutrients will be resuspended, greatly reducing the likelihood of nuisance algae blooms. Additionally, reestablishment of aquatic plants will have other positive effects on lake health and water quality, increases in fish habitat and food source availability for wildlife such as waterfowl.

Cons
There are no negative impacts associated with removing excessive numbers of carp from a lake. However, in the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. Other aquatic organisms, such as mollusks, frogs, and invertebrates (insects, zooplankton, etc.), are also negatively impacted. However, this disruption is temporary and studies show that recovery occurs within a few months. Furthermore, the IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species. Another drawback to rotenone is the cost. Since the whole lake is treated and costs per gallon range from $50.00 - $75.00, total costs can quickly add up. This can be off-set with lake draw down to reduce treatment volume. Unfortunately, draw down is not an option on all lakes.

Costs
As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and green sunfish), approximately 470 gallons of rotenone would be needed. This would come to a total cost of between $23,600 – 35,400. In waters with high turbidity and/or planktonic algae blooms, the ppm may have to be higher which will further increase costs.

Objective III: Erosion Control

Erosion on Timber Lake is a potentially serious problem to shorelines and occurs as a result of wind, wave, or ice action or from overland rainwater runoff. While some erosion to shorelines is natural, human alteration of the environment can accelerate and exasperate 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.

Option 1: No Action

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: Install Rock Rip-Rap
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. It is imperative that filter fabric be used under the rip-rap to provide quality, long lasting results. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below). Rip-rap is best used for areas of **moderate erosion** and gentle to moderately sloped

shores (<2:1). If rip-rap is to be used on shorelines steeper than 2:1, then grading must be done in order to reduce grade to ≤ 2:1, preferably 3:1.

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 slight to moderate 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 absorb 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. Based on assessed *moderately* eroded shoreline, Timber Lake would need approximately 162 linear feet of rip-rap. This would come to a cost of approximately $4,860 –

$7,290. 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. Additional costs will be incurred if compensatory storage is needed. Contact the Army Corps of Engineers, local municipalities, and the Lake County Planning and Development Department.

Option 3: Buffer Strips

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 shorelines with **slight erosion** and 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 more severe erosion problems. Areas where erosion is severe or where slopes are greater than 3:1, additional erosion control techniques may have to be incorporated such as Biologs or rip-rap.

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 6 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 more highly eroded, willow posts may have to be used in conjunction with another erosion control technique such as biologs or rip-rap. The use of buffer strips in conjunction with other methods such as rip-rap and seawalls is highly recommended.

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 6 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 and "weedy" aquatic plants. 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. 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. Based on assessment *slightly* eroded shoreline, Timber Lake would need approximately 4,406 linear feet buffer strip. This would come to a cost of $44,060. It is advisable that buffer strips be planted on all appropriate shoreline areas on Timber Lake (approximately 6000 linear feet). However, some of this shoreline would be better suited for use of biologs (see *Option 4* below), which includes the use of buffer strips. 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.

<u>Option 4: 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. These products are best used in areas on more **moderately** eroded shorelines or areas with highly erodable soil types.

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. Based on moderately eroded shorelines, Timber Lake would need 162 linear feet of one of the above products on the moderate eroded areas of shoreline. This would cost approximately $4,050 - $5,670. 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.

Objective IV: Elimination/Control Invasive Species

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 athartica*), and reed canary grass (*Phalaris arundinacea*) are three examples of invasive species observed on Timber Lake. The eventual outcome is a loss of plant and animal diversity.

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.

<u>Option 1: No Action</u>
No action will likely result in the expansion of the exotic species on Timber Lake 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. Table 6 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: Hand Removal

Hand removal is the most viable option for removal of invasive species on Timber Lake. Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. 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. This option could easily be carried out by lake residents on their own accord.

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. Table 7 contains herbicides that are approved for use near water for control of nuisance vegetation. Included in this table are rates, costs, and restrictions on use.

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
See Table 7 for herbicide rates and prices. A Hydrohatchet®, a hatchet that injects herbicide through the bark, is about $300.00. Another injecting devise, E-Z Ject® is $450.00. Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40.

Objective V: Wildlife Habitat Improvement

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: Eliminate/Control Exotic Spec*ies**.**

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.

Option 2: Increase Habitat Cover

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 (see *Objective IV: Erosion Control – Option 3: Buffer Strips*). Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see Table X 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 out-compete 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. feet would require 2.5, 1000 sq. feet 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.

Option 3: Increase Natural Food Supply
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 6 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 exasperate 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).

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.

Bat houses 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.

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.