2004 SUMMARY REPORT (in part)
of
LAKE CHRISTA

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Lake Christa is a privately owned, 8.9-acre man-made lake in unincorporated Lake County, near the Village of Volo. The lake has a small watershed, consisting of about 65 acres. The main land uses are residential and forest/grassland. Residents use the lake primarily for swimming, fishing and aesthetics. The outflow from Lake Christa is piped underneath Christa Drive, allowing water to flow to Fischer Lake, which is part of the Fish Lake Drain. The Fish Lake Drain then flows into Squaw Creek, as it continues on its way to the Fox River Chain O'Lakes system.

The water quality of Lake Christa is typical of many shallow, man-made lakes in Lake County. Although the water clarity is better than the Lake County median, Lake Christa's seasonal average Secchi disk reading was only 4.76 feet. Factors that are causing the turbidity in the water are total suspended solids, which include suspended sediment, algae and other organic detritus. Algae, using the lake's rich supply of phosphorus for growth, dominated this lake in 2004. The average total phosphorus concentration is below the Lake County median, but an intense nuisance algae bloom occurred in late September.

The Lake Christa Homeowner's Association operates an aeration system comprised of two 2-horsepower surface aerators. This system operates continuously, 24 hours a day, year-round and may assist in mixing the water. The concentrations of dissolved oxygen in the lake appear to be adequate for aquatic life in much of the water column during 2004, and there is no consistent history of fish kills due to oxygen depletion in Lake Christa. The current use of the system does not appear to be detrimental to the lake, but perhaps the Association can tailor its use and save money in operational expenses. Options are discussed in the section titled "Options for Achieving the Lake Management Plan Objectives" in this report.

We found very few areas that supported aquatic plants during our investigation. This was primarily the result of an aquatic herbicide treatment that occurred in April 2004. We found six species, five of which are native beneficial plants, scattered in small pockets along the near shore areas in the lake. The sixth, curlyleaf pondweed, is an exotic species that was found in isolated areas, but was not causing nuisance conditions at this time. *Chara* had the highest occurrence of all plants during 2004. This species is a macroalgae, and is also beneficial since it stabilizes sediment. During the 2004 season, the amount of available sunlight reached close to the bottom during all months except September. This is enough light to have allowed aquatic plants to photosynthesize and thrive in Lake Christa.

One hundred percent of the shoreline is developed, with nearly 50% of the total shoreline having riprap. The two other most common shoreline types are seawall and beach. Very little (16%) of the shoreline is eroding. Even though these shorelines are slightly eroding, they need to be mitigated because further damage will continue if they are left alone. Because shoreline is entirely developed, very little shoreline wildlife habitat is available.

LAKE IDENTIFICATION AND LOCATION

Lake Christa is a privately owned, 8.9-acre manmade lake in west central Lake County (T45N, R9E Section 26), with a maximum depth of 11 feet. The lake has an estimated average depth of 5.5 feet, with a volume of 49 acre-feet. The length of shoreline is 0.47 miles. Lake elevation is approximately 750 feet above sea level. The Lake Christa watershed is small, with only 65.1 acres, which results in a watershed to lake ratio of 7:1. The two main land uses in the watershed are residential and forest/grassland. Roads and agricultural areas comprise less than 10% each of the total land use. Eventually, the water flowing from Lake Christa enters the Fish Lake Drain at Fischer Lake, which flows downstream through Wooster Lake and Duck Lake and eventually to the Fox River Chain O'Lakes system.

BRIEF HISTORY OF LAKE CHRISTA

Lake Christa was created in 1978 and was periodically stocked with bluegill, largemouth bass and channel catfish shortly after it was built. Unfortunately, stocking records are unavailable. Development of the surrounding residential area began in 1974, and the Lake Christa Homeowners Association (LCHA) was formed in 1988. This group installed an aeration system consisting of two Kasco surface aerators in 1999. LCHA's goal was to add more oxygen to the system and control algae and weeds. LCHA hires an aquatic pesticide applicator to treat the lake with herbicides and algicides. In April 2004, a whole-lake fluridone treatment was made to control coontail and Eurasian water milfoil. In addition, algicide treatments were also conducted during the season.

In 1996, willow branches clogged the outlet of the lake causing the water elevation to temporarily rise. This happened again before the June 2004 sampling date. Heavy rains filled the lake, and a large amount of debris was trapped inside the outflow pipe. Because water could not exit the lake, the water level increased by about 3 feet, according to high water marks and residents' reports. Unfortunately, the pier we were using to measure monthly water elevation was destroyed by the high water, so it is unknown exactly how much the water level increased. The debris was removed and the water level returned to normal by the July sampling date.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

Lake Christa is privately owned, open only to the surrounding residents and their guests. Residents use the lake for swimming, fishing and aesthetics. The lake also is a detention basin as it receives flow from the surrounding watershed.

LIMNOLOGICAL DATA – WATER QUALITY

Water samples were collected each month, from May through September 2004, at the lake's deepest location (see Figure 1). All samples were analyzed for a variety of parameters. The 2004 water quality data can be found in Table 1, Appendix A. Because both sets of water samples had similar results, the discussion of water quality will focus on samples collected from 3 feet deep. In June, heavy rains filled the lake, and a large amount of debris was trapped inside the outflow pipe. Because water could not exit the lake, the water level increased by at least 3 feet, according to high water marks and residents. The debris was removed from the outflow pipe by the June sampling date.

The rainfall pattern from May through September 2004 caused an interesting set of circumstances in Lake Christa. Stormwater runoff normally washes soil and nutrients (nitrogen and phosphorus) into lakes. The soil delivered to a lake can cause increased turbidity, and the nutrients, key ingredients for algae growth, can cause algae blooms, both of which affect the water clarity.

Water clarity, measured with a Secchi disk, is usually the first thing people notice about a lake, and typifies the overall water quality. The 2004 seasonal average Secchi disk transparency reading (4.76 feet) in Lake Christa was 55 % above the county median of 3.08 feet. The deepest Secchi reading was in May (8.73 feet), while the shallowest reading occurred in September (2.43 feet). Correlated with the Secchi disk readings were the concentrations of total suspended solids (TSS) such as sediment particles and algae. The good clarity in May correlated with a low TSS concentration of 2.2 mg/L, while the September TSS concentration of 18.0 mg/L resulted in poor clarity. TSS are composed of nonvolatile suspended solids (NVSS) such as non-organic clay or sediment materials, and volatile suspended solids (VSS) such as algae and other organic matter. The increase of TSS into the lake during the season may have been a result of sediment inputs from stormwater runoff, as a total of 8.74 inches of rain fell in the area during May and June. Using Lake Christa's estimated water volume of 48.4 acre-feet, this amount of rain is approximately 13% of the total lake volume. Because the outlet to the lake was temporarily blocked by debris during this time, this stormwater remained in the lake, and sediment and nutrients that entered with it did not immediately flush through. The drop in water clarity and the increase in TSS indicated that some sediment and nutrients remained in the lake. The negative correlation between TSS and the Secchi disk readings is illustrated in Figure 2. While the changes in water level due to the blocked outlet influenced the water sample results in June, the waters receeded by the July sample date. However, clarity continued to decrease with the subsequent increase in TSS. This is probably the result of internal resuspension of sediment from wind and wave action. We noted 15-20 mile/hour winds on the September sampling date.

Similarly, total phosphorus (TP) showed a similar pattern in the lake. Although TP was low in May (0.018 mg/L) the TP concentration had nearly doubled by the June sample date to 0.035 mg/L, then nearly doubled again to 0.070 mg/L in July. The season TP average was 0.053 mg/L, which is 16% lower than the county median of 0.063 mg/L.

FIGURE 1

INSERT FIGURE 2 SECCHI/TSS

Values above 0.03 mg/L are considered sufficient enough to cause nuisance algae blooms. Algae, primarily planktonic, were seen throughout the sampling season. An algae bloom was occurring in July, which explains the higher TSS and TP concentrations as well as poor water clarity that month. Some of the TP probably came from the TSS concentrations found in the water, since phosphorus binds to sediment particles. The sources of the high TP could be numerous, including lake origin (i.e., underlying soils) and land uses. Once in the lake, the phosphorus is often internally recycled, making it difficult to manage. One of the largest threats to the lake is probably fertilizer (which is often high in phosphorus) applied to the lawns near the lake in the watershed. It is recommended that homeowners use a no-phosphorus fertilizer on their lawns.

To track future water quality trends, it is recommended that the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October. For more information see **Objective II: Illinois Volunteer Lake Monitoring Program.**

The relationship between the TP concentrations and the Secchi disk readings in Lake Christa can be seen in Figure 3. In August, the water clarity had improved slightly. The TSS concentrations had dropped a little because TVS had decreased, indicating that less algae may have been in the water column since July. Interestingly enough, the TP concentration increased from 0.070 mg/L in July to 0.076 mg/L in August. This slight increase could have been caused by algae senescence (either natural or from an algicide treatment), which would release TP into the water column as the algae cells decayed. Another reason that algae growth may not have increased is if some TP were adsorbed to sediment particles, it would not be available for algae growth.

In August and September, very little rain fell, causing drought-like conditions. In September, the TSS concentration increased nearly three times from the previous month causing water clarity to drop again. The NVSS concentration had increased, from 4.61 mg/L to 12.93 mg/L. Because there was very little rain to bring in sediment-laden stormwater, it’s likely that this increase occurred as sediment was resuspended from the bottom by wind, wave or carp action. Sediment played a larger role than algae in the loss of water clarity over these last two months.

A significant nuisance algae bloom was reported in the lake by residents in late September. In this case, planktonic algae were causing surface scums in the lake. A resident brought in a sample of this bloom, in which both *Anabaena* and *Microcystis* were identified. These are both nuisance blue-green algae species, and are commonly found in lakes throughout Lake County, particularly in late summer.

TP also can be used for the trophic state index (TSI), which classifies lakes according to the overall level of nutrient enrichment. Using the TP concentration in the epilimnion, the TSIp score can be calculated. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those that have excessive nutrients, with nuisance algae growth reminiscent of

INSERT FIGURE 3 SECCHI/TP

“pea soup” and have a TSIp score greater than 70. Lakes with a TSIp score of 50 or greater are classified as eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae and fish. Mesotrophic and oligotrophic lakes are those with lower nutrient levels. These are very clear lakes, with little or no plant and/or algae growth. Lakes with low TP concentrations are uncommon in Lake County. Most lakes in this area are rich in TP, resulting in a eutrophic condition. The trophic state of Lake Christa in terms of its phosphorus concentration during 2004 was eutrophic, with a TSIp of 61.4. Lake Christa ranked 62nd out of 161 Lake County lakes based on average total phosphorus concentrations of lakes studied since 2000 (See Table 2 in Appendix A). The current rank of a lake is dependent upon many factors including lake origin, water source, nutrient loads, and morphometric features (volume, depth, substrate, etc.). Thus, a small, shallow, manmade lake with high nutrient loads may not expect to achieve a high ranking even with intensive management.

Another nutrient critical for algae growth is nitrogen. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal cells. The TKN concentrations in Lake Christa increased steadily over the season. Even if nitrogen is in relatively short supply, some forms of algae, the blue-greens, are able to “fix” nitrogen from the air to use for growth. As their populations increase later in summer, so too, does the concentration of TKN. The average TKN concentration in Lake Christa is 1.57 mg/L, which was 29% higher than the Lake County TKN median of 1.22 mg/L. One note of interest is the concentrations of nitrate nitrogen in Lake Christa in May and June. Although this form of nitrogen is usually below detection limits column (< 0.05 mg/L) in the water, concentrations were 0.16 mg/L and 0.70 mg/L in May and June, respectively. For the remainder of the season, nitrate was below detection limits. The concentrations early in the season could have been inputs from fertilizers that were used in spring, brought in with the stormwater from both agricultural and residential land uses in the watershed. The watershed surrounding Lake Christa is small, about 65 acres (Figure 4)[1]. Figure 5 shows the major land uses draining to the lake, which are residential (about 43% of the watershed) and forest/grassland (28.5%). Agricultural land and impervious surfaces such as roads make up 5.2% and 10.1% of the watershed respectively (Table 3, Appendix A).

The ratio of total nitrogen (TN) to total phosphorus (TP) indicates if the lake is in shorter supply of nitrogen or phosphorus. Lakes with TN:TP ratios greater than 15:1 are limited by phosphorus. Those with ratios less than 10:1 are limited by nitrogen. In 2004, the TN:TP ratio of Lake Christa was 46:1, meaning it is limited by phosphorus. Most lakes throughout Lake County are phosphorus limited.

The aeration system installed in 1999 may assist in mixing the water column of the lake throughout the year. The system consists of two Kasco surface aerators that operate continuously, 24 hours per day, year-round. These two units can move 2,000 gallons per minute each, and together can circulate the estimated volume of the lake (15.8 million

[1] Residents are concerned about the possibility that farm tiles from nearby fields south of Lake Christa are draining to the lake. Because there are no records verifying their presence or locations, the portions of agricultural fields included in the watershed were delineated using 2-foot contours from LIDAR imagery.

INSERT FIGURE 4, WATERSHED

INSERT FIGURE 5 LAND USE MAP

gallons) in just under three days, and each unit can draw water from the surface down to 5-7 feet deep. According to the manufacturer, a recommended aeration system to fully mix the entire volume of a lake or pond would employ surface aerators of this type totaling 1 horsepower per surface acre. This assumes the units are continuously operating effectively, and can draw water from the surface down to 5-7 feet. In the case of Lake Christa, this would mean *four to five* 2-horsepower units in order to achieve this goal. However, many lakes in this area periodically have very low or no oxygen in their deepest portion. For example, in summer, thermal stratification occurs when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion in nutrient rich lakes typically becomes hypoxic (dissolved oxygen is <1.0 mg/l) by mid-summer. In the fall, when water temperatures become similar from top to bottom, the water column mixes and becomes enriched with dissolved oxygen (DO). Lake Christa stratified from May through July, but hypoxia occurred only in June and July, below 9 feet and 7 feet, respectively. The water column in some shallow lakes periodically mixes during the summer season, disrupting stratification and allowing oxygen to reach the bottom. This occurred in Lake Christa in August and September. There is no recent, accurate bathymetric map with morphometric calculations to determine the volume of water in the lake with adequate DO concentrations during the summer. It is very probable, though, that the majority of the lake has enough DO to support aquatic life because our depth soundings indicate that most of the lake is less than 7 feet deep, and hypoxic or anoxic (DO is <1.0 mg/L) conditions occurred below 9 and 7 feet during 2004. Also, since the maximum depth is 11 feet, it's estimated that the anoxic volume of the water column is small.

For winter aeration, the goal is not to aerate the entire volume of the lake, but to create an oxygenated area for fish to use as a refuge. Research indicates that about 2.3% of the lake's surface area should be left ice-free to create this refuge[2]. For Lake Christa, that would be about 8,900 square feet. During winter 2004-05, the two aerators in Lake Christa each created a hole in the ice[3] that was about 75'- 100' in diameter, or 4,417 to 7,854 square feet, totaling 8,834 to 15,708 square feet for both units. This is appropriate for winter aeration. Further discussion on this can be found in the Potential Objectives section of this report (**Objective III: Aeration System**).

The Illinois Environmental Protection Agency (IEPA) has indices to classify Illinois lakes for their ability to support aquatic life, swimming, or recreational uses. The guidelines consider several aspects, such as phosphorus concentrations, water clarity and aquatic plant coverage. Lake Christa fully supports aquatic life and swimming uses according to these guidelines. Because the water clarity was affected by high TP and NVSS concentrations, the lake placed in the partial support category for recreational uses. The overall use support category for Lake Christa is that of full support.

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[2] Wirth, T. 1988. Lake aeration in Wisconsin lakes. Wisconsin Dept. Nat. Res. Lake Manage. Program, PUBL-WR-196, 76 p.

[3] Linda White, personal communication.

Conductivity is a measurement of water's ability to conduct electricity via total dissolved solids (TDS), which are dissolved minerals (i.e., limestone) or salts in the water column. Because of the use of road salts, lakes with residential and/or urban land uses are often noted to have higher conductivity readings and higher total dissolved solid concentrations than lakes that are not surrounded by development. Stormwater runoff from impervious surfaces such as asphalt and concrete can deliver high concentrations of these salts to nearby lakes and ponds. The Lake County median conductivity reading of lake water near the surface is 0.7652 mS/cm. During 2004, the conductivity readings in Lake Christa were close to this, averaging 0.7410 mS/cm near the surface. During 2004 the conductivity readings in the lake decreased overall from May through September. Typically, lakes that receive road salts through stormwater runoff have a steady decline in conductivity readings throughout the season as no additional road salt is applied during this time frame. Since most road salt used for de-icing is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts, the concentration of chlorides in each water sample based on conductivity readings can be calculated. The 2004 calculated seasonal average for chloride in Lake Christa is 98 mg/L in the epilimnion. The Illinois Environmental Protection Agency (IEPA) standard for chloride is 500 mg/L. Once values exceed this standard the water body is deemed to be impaired, thus impacting aquatic life. However, in a study by Environment Canada (equivalent to our USEPA), it was estimated that 5% of aquatic species such as fish, zooplankton and benthic invertebrates would be affected at chloride concentrations of about 210 mg/l. Additionally, shifts in algae populations in lakes were associated with chloride concentrations as low as 12 mg/l.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

We randomly sampled locations in Lake Christa each month for aquatic plants, and identified five species and one macroalgae (*Chara*). Table 4 lists the plants that were identified by their common and scientific names. Shoreline plants were noted, but not quantified.

Aquatic plants were scarce in Lake Christa. Table 5 in Appendix A lists the aquatic plant species and the frequency that they were found. *Chara* was found most frequently throughout the season, but only in eight samples. Sago pondweed, a beneficial plant, was found in six samples in 2004. The others, small pondweed, leafy pondweed, horned pondweed and curlyleaf pondweed were all found in only one or two samples over the season. Except for curlyleaf pondweed, the aquatic plants we found are all native, beneficial species. Curlyleaf pondweed can cause nuisance conditions, but this is not the case in Lake Christa.

Table 4. Aquatic and shoreline plant species on Lake Christa, May – September 2004.

Aquatic Plants	
Chara	*Chara* sp.
Curly leaf Pondweed	*Potamogeton crispus*
Leafy Pondweed	*Potamogeton foliosus*
Small Pondweed	*Potamoeton pusillus*
Sago Pondweed	*Stuckinia pectinatus*
Horned Pondweed	*Zannichellia palustris*
Shoreline Plants	
Canada Thistle^	*Cirsium arvense*
Hedge Bindweed	*Convolvulus sepium*
Beggar Ticks	*Bidens* sp.
Queen Anne's Lace^	*Daucus carota*
Spike Rush	*Eleocharis* sp.
Purple loosestrife^	*Lythrum salicaria*
Reed Canary Grass^	*Phalaris arundinacea*
Hardstem Bulrush	*Scirpus acutus*
Softstem Bulrush	*Scirpus validus*
Shoreline Plants	
Wild Grape	*Vitus* sp.
Bittersweet Nightshade^	*Solanum dulcamara*
Cattail	*Typha* sp.
Trees/Shrubs	
River Birch	*Betula nigra*
Red Osier Dogwood	*Cornus sericea*
Dogwood	*Cornus* sp.
Green Ash	*Fraxinus pennsylvanica*
Honeysuckle^	*Lonicera* sp.
Buckthorn^	*Rhamnus* sp.
White Pine	*Pinus strobus*
Willow	*Salix* sp.
Weeping Willow	*Salix alba tristis*
Chinese Elm^	*Ulmus parvifolia*

^Exotic species

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a lake. For example, aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. During the 2004 season, the 1% light level ranged from about 5 feet deep (September) to nearly 11 feet deep (June). Therefore, if available sunlight was the only factor in limiting aquatic plant growth in Lake Christa, plants could grow across the entire bottom over the growing season. The lack of aquatic plant growth in the lake is attributed to the whole-lake herbicide treatment that occurred in April. The plants targeted during the treatment were coontail and Eurasian milfoil (EWM). Both of these species were not detected in our plant sampling in 2004. According to the applicator, the treatment used 124 ounces of fluridone to achieve a target concentration of 20 parts per billion (ppb). However, using the estimated volume of the lake (48.4 acre-feet), the calculated applied concentration was approximately 29 ppb. The fluridone probably did not maintain this concentration for greater than 30 days since heavy rainfall was recorded in the weeks that followed, likely resulting in some dilution of the chemical. However, the exact post-treatment concentrations are unknown since no follow-up test results are known (i.e., FasTEST or AvasTEST, depending on the brand of fluridone used). While this is within the label application rates, 29 ppb is higher than is necessary, particularly since a management goal should be maintain some aquatic plants in the lake. It is recommended that another whole-lake treatment be postponed until high densities of EWM reoccur. Until then, spot treatments of nuisance aquatic plant beds can be conducted. If a whole-lake treatment is needed, the fluridone concentration should be lowered (10-12 ppb) to target EWM. At these lower concentrations milfoil can still be controlled, but native species may be less affected and may be allowed to expand. Finally, if a fluridone treatment is implemented a post treatment test (i.e., FasTEST or AvasTEST) should be conducted to determine if the target concentration is being maintained, and if needed, an additional treatment (a "bump-up") could be conducted. To maintain a healthy bluegill/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. The plant coverage in Lake Christa is estimated to be less than 5%. To increase habitat for the fishery, the Association could plant native aquatic plants or minimize herbicide treatments to allow native plant to expand. This would not only benefit the fishery but also assist in reducing sediment resuspension and subsequently improving water clarity as well as reduce the amount of algicides that are needed to control nuisance algae blooms. Approximately 50 gallons of Cutrine–Plus® was used throughout the year to control algae. With the elimination or reduction of aquatic plants, potentially more algicide treatments are necessary.

Floristic quality index (FQI) is a measurement designed to evaluate the closeness of the flora (plants species) of an area to that with undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long term floristic trends, and 4) monitor habitat restoration efforts. Each floating and submersed aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). These numbers are then used to calculate the FQI. A high FQI number indicates that there are a large number of sensitive, high quality plant species present in the lake, and better plant diversity. Nonnative species are included in the FQI calculations for Lake

County lakes. The FQI scores of 150 lakes measured from 2000 through 2004 range from 0 to 37.2, with an average of 14.3. Lake Christa has a floristic quality of 11, indicating a lower than average aquatic plant diversity.

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

The shoreline was assessed at Lake Christa on July 29, 2004 for a variety of criteria (See Appendix B for methods). Based on these assessments, several important observations could be made. One hundred percent of the shoreline is developed, with nearly 50% of this consisting of riprap (Figure 6). The two other major shoreline types are seawall (21.8%) and beach (15.5%). Only 5% of the shoreline is naturalized as shrub or buffer, both of which are beneficial shoreline types. One positive aspect of this shoreline is that only 16.6% is eroding (Figure 7). These locations are considered slightly eroding, and no part of the shoreline was considered moderately or severely eroding. Even though the erosion is slight, continued neglect of these shorelines could lead to further erosion, resulting in a loss of property and soil inputs into the water that negatively affect water clarity and fill in the lake. It's much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. If these shorelines are repaired by adding deep-rooted native plants in a buffer strip, the shoreline benefits in two ways. First, the erosion is repaired and the new plants can stabilize the shoreline to prevent future erosion. Second, the addition of native plants creates habitat for a shoreline that is otherwise limited for wildlife use. Although some people become hesitant about installing buffer strips, buffer strips can be attractive and still allow lake access by adding a mowed path to the water. This is something that any portion of the shoreline can have (including those with seawalls or riprap), not just the sections that are slightly eroding. We have noted that other residents on highly developed lakes have installed attractive buffer strips with easy lake access. The majority of Lake Christa's shoreline offers very little in the way of wildlife habitat, an integral part of a lake system. A few areas around Lake Christa had some exotic shoreline plants such as reed canary grass, honeysuckle, and purple loosestrife (Figure 8.). These plants are noted to be aggressively invasive, and do not offer ideal wildlife habitat. Since these plants are not in large populations at this time, their control now would be easier than if they were allowed to spread and reach insert figure 6, shoreline type

INSERT FIGURE 7 EROSION

INSERT FIGURE 8 INVASIVES

heavy infestation. One positive aspect was the evidence of insects feeding on the purple loosestrife plants. Recently two leaf beetles (*Galerucella pusilla* and *G. calmariensis*) and two weevils, one a root-feeder (*Hylobius transversovittatus*) and one a flower-feeder (*Nanophyes marmoratus*) have offered some hopes to control purple loosestrife by natural means. These insects feed on the leaves, roots, or flowers of purple loosestrife, eventually weakening and killing the plant.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

Wildlife observations were made on a monthly basis during water quality and plant sampling activities (See Appendix B for methodology). Table 6 lists the wildlife species we noted around Lake Christa. Because the lake is in a residential setting with the majority of the shoreline as seawall, lawn or riprap, habitat for fish and wildlife is limited. In addition, the in-lake habitat is inadequate, since there are very few aquatic plants, which are used as food, shelter and nursery areas for a variety of wildlife. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones, which are recommended as one aspect of shoreline protection. Most of the birds that were seen were those tolerant of residential settings. Enhancing in-lake habitat can be done by installing fish cribs and native aquatic plants. Prior to planting aquatic species, the Association may want to find the areas with softer substrate. The locations with hard substrate should be avoided since plant roots may have a difficult time becoming established. At this time, it is unknown what the fishery is like since an assessment has not been done on this lake. According to a previous resident, Lake Christa was stocked with largemouth bass, bluegill and channel catfish shortly after it was created. The whereabouts of any stocking records are unknown.

Table 6. Wildlife species observed on Lake Christa, May – September, 2004.

<u>*Birds*</u>	
Canada Goose	*Branta canadensis*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Killdeer	*Charadrius vociferous*
Spotted Sandpiper	*Actitis macularia*
Mourning Dove	*Zenaida macroura*
Downy Woodpecker	*Picoides pubescens*
American Crow	*Corvus brachyrhynchos*
Red winged Blackbird	*Agelaius phoeniceus*
Starling	*Sturnus vulgaris*
Catbird	*Dumetella carolinensis*
Cedar Waxwing	*Bombycilla cedrorum*
Brown-headed Cowbird	*Molothrus ater*

Table 6. Wildlife Species observed on Lake Christa, May – September, 2004, con't.

Common Grackle	*Quiscalus quiscula*
Blue Jay	*Cyanocitta cristata*
House Wren	*Troglodytes aedon*
American Robin	*Turdus migratorius*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
American Goldfinch	*Carduelis tristis*
Chipping Sparrow	*Spizella passerina*
Yellow Rumped Warbler	*Dendroica coronata*
Mammals	
Eastern Chipmunk	*Tamias striatus*

EXISTING LAKE QUALITY PROBLEMS

- *Lack of a Bathymetric Map*

  A bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features of the lake, such as depth, surface area, volume, etc. The knowledge of this morphometric information would be necessary if lake management practices such as fish stocking, aquatic herbicide use, dredging, or an alum treatment were part of a future overall lake management plan. The lake does not have a recent bathymetric map. Maps can be created by the Lake County Health Department – Lakes Management Unit or other agencies for costs that vary from $2,000-$10,000, depending on lake size.

- *High Nutrient Concentrations*

  Lake Christa ranked 62nd out of 161 Lake County lakes based on average total phosphorus concentrations of Lake County lakes studied since 2000. Although the seasonal average concentration in the lake was below the Lake County median, it was plentiful enough to cause algae to bloom during the summer and create an intense nuisance bloom in late September.

- *Nuisance Algae*

  Algae is a factor in causing decreased water clarity in Lake Christa, as evidenced by the increase in total phosphorus which is present in algal bodies, and the subsequent decrease in Secchi disk readings during the 2004 season. Lake Christa also experienced a severe nuisance algae bloom of *Anabaena* and *Microcystis* in September of 2004. Both are nuisance blue-green algae species, and are commonly found in lakes throughout Lake County.

- *Lack of Aquatic Plants*

  Lake Christa has few aquatic plants, and a low diversity of plant species, due primarily to the fluridone herbicide treatment that was conducted in April 2004. This resulted in an overall lack of habitat for aquatic life. The addition of native plants would be beneficial for Lake Christa. Prior to planting aquatic species, the Association may want to find the areas with softer substrate. The locations with hard substrate should be avoided since plants may have a difficult time becoming established. Native aquatic plants should be allowed to grow and expand. Nuisance plant beds can be spot treated as needed. A whole lake treatment should be postponed until dense beds of EWM are present. Additionally, the target concentration of fluridone should be lowered to 10-12 ppb, which will control EWM, but may have minimal affects on native species.

- *Shoreline Erosion*

  Only 16.6% of the shoreline is eroding. However, even though the shoreline erosion is slight, continued neglect of these shorelines could lead to further erosion, resulting in a loss of property and soil inputs into the water that negatively affects water clarity and fills in the lake. It's much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion.

- *Limited Wildlife Habitat*

  Because of the residential setting, the lake has limited shoreline habitat to support wildlife. Improvements such as the addition of buffer strips of native vegetation could increase the amount of habitat. In-lake habitat is also limited, because of the general lack of aquatic vegetation.

- *Invasive Shoreline Plant Species*

  Invasive shoreline plants around Lake Christa are not in large populations at this time. However, they can cause problems if they expand. Their removal now would curtail their expansion.

- *Lack of Historical Lake Data*

  The lack of quality lake data is a common problem for many of the lakes in Lake County. Many associations do not realize that information such as dates, products, and amounts used for aquatic herbicide/algicide treatments, and fish stocking records are important for future reference. The Lake Christa Homeowner's Association has been actively managing the lake but accurate records may not have always been kept, especially in regard to aquatic herbicides or algicides. If a contractor is hired to apply these chemicals, this information should be requested from the company. Collection of this type of lake data can be very important in making decisions on the management of the lake. This data can be used to track changes (or lack of) in lake quality over many years. Additionally, this data is very important to agencies, such as our unit, when conducting studies of the lake and allows for a more complete analysis. It is our recommendation that the Lake Christa Homeowner's Association becomes involved in the IEPA's Volunteer Lake Monitoring Program (VLMP). This program uses volunteer lake residents to collect bimonthly lake data for the IEPA. This program is worth the time and effort and provides valuable information about the lake.

POTENTIAL OBJECTIVES FOR LAKE CHRISTA MANAGEMENT PLAN

I. Create a Bathymetric Map
II. Participate in the Illinois Volunteer Lake Monitoring Program
III. Aeration System Operation
IV. Nuisance Algae Management
V. Reestablish Native Aquatic Vegetation
VI. Enhance Wildlife Habitat Conditions
VII. Shoreline Erosion Control
VIII. Eliminate or Control Exotic Species

OPTIONS FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES

Objective I: Create a Bathymetric Map Including a Morphometric Table

No recent, accurate bathymetric map with volume calculations exists for Lake Christa. A bathymetric map (depth contour) map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Maps can be created by agencies like the Lake County Health Department - Lakes Management Unit or other companies. Costs vary, but can range from $2,000-10,000 depending on lake size. The Lakes Management Unit will be purchasing new bathymetry equipment, which could create a map of Lake Christa. Costs have not yet been determined.

Objective II: Participate in the Illinois Volunteer Lake Monitoring Program

In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection agency (Illinois EPA) to gather fundamental information on Illinois inland lakes, and to provide an educational program for citizens. Annually, approximately 165 lakes (out of 3,041 lakes in Illinois) are sampled by about 300 citizen volunteers. The volunteers are primarily lakeshore residents, lake owners/managers, members of environmental groups, public water supply personnel, and citizens with interest in a particular lake.

The VLMP relies on volunteers to gather a variety of information on their chosen lake. The primary measurement is Secchi disk transparency or Secchi depth. Analysis of the Secchi disk measurement provides an indication of the general water quality condition of the lake, as well as the amount of usable habitat available for fish and other aquatic life.

Microscopic plants and animals, water color, and suspended sediments are factors that interfere with light penetration through the water column and lessen the Secchi disk depth. As a rule, one to three times the Secchi depth is considered the lighted or euphotic zone of the lake. In this region of the lake there is enough light to allow plants to survive and produce oxygen. Water below the lighted zone can be expected to have little or no dissolved oxygen. Other observations such as water color, suspended algae and sediment, aquatic plants, and odor are also recorded. The sampling season is May through October with volunteer measurements taken twice a month. After volunteers have completed one year of the basic monitoring program, they are qualified to participate in the Expanded Monitoring Program. In the expanded program, selected volunteers are trained to collect water samples that are shipped to the Illinois EPA laboratory for analysis of total and volatile suspended solids, total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. Other parameters that are part of the expanded program include dissolved oxygen, temperature, and zebra mussel monitoring. Additionally, chlorophyll *a* monitoring has been added to the regiment of selected lakes. These water quality parameters are routinely measured by lake scientists to help determine the general health of the lake ecosystem.

Lake Christa is not currently participating in the VLMP at this time, and 2004 marks the only year in which any water quality information has been collected. It would be beneficial to obtain more water quality information such as the data gathered for the VLMP program. The VLMP Regional Coordinator is:

Holly Hudson
Northeast Illinois Planning Commission
222 S. Riverside Plaza, Suite 1800
Chicago, IL 60606
(312) 454-0400

Objective III: Selective Aeration System Operation

The present aeration system in Lake Christa consists of two 2-horsepower Kasco surface aerators. These two units move 2,000 gallons per minute each, and together can circulate the estimated volume of the lake (15.8 million gallons) in just under 3 days. According to the manufacturer, each unit can draw water from the surface down to 5-7 feet deep. According to the manufacturer, a recommended aeration system to fully mix the *entire* volume of a lake or pond would employ surface aerators totaling 1 horsepower per surface acre. In the case of Lake Christa with 8.9 acres, this would mean *four to five* 2 horsepower units in order to meet the manufacturer's recommendations. This is not a critical goal for every lake, though. Many stratified lakes commonly have an anoxic portion of the lake volume without adverse affects on aquatic life. Surface aeration systems like those in Lake Christa can mix the algae throughout the water column, and in some situations, this mixing action can disrupt the life cycle of some algae species and limit their growth. This does not always happen, however, as residents on Lake Christa noticed a heavy algae bloom in late September 2004, in which we identified two nuisance bluegreen algae forms, *Anabaena* and *Microcystis*. This occurred because sunlight was able to penetrate to the depth that the water column was mixing. Other types of aeration systems may limit algae in lakes under certain circumstances, but the results are widely varied and not consistent. The data we collected while *two* 2-horsepower units were running seems to indicate that the majority of the lake volume has sufficient dissolved oxygen (DO) for a bluegill-bass fishery during the summer. However, no DO data is available for Lake Christa before the installation of the aerators. It is possible that the amount of DO in this lake is sufficient to support aquatic life without the aerators. There is no documented history of fish kills due to a lack of dissolved oxygen. It's very possible that the aeration system is unnecessary in the summer. The residents could see what happens if the system was shut off for a season or two, and enlist our help in monitoring the dissolved oxygen levels.

The goal in winter is not to aerate the entire volume of the lake but to create an oxygenated area for fish to use as a refuge. Using research that indicates about 2.3% of the lake's surface area should be left ice-free to create this refuge[4], Lake Christa should have an ice-free area that would be about 8,900 square feet. During winter 2004-05, the two aerators in Lake Christa each created a hole in the ice that was about 75'- 100' in diameter, or 4,417 to 7,854 square feet, totaling 8,834 to 15,708 square feet for both units. This is appropriate for winter aeration.

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

This would simply mean the operation of the aeration system would remain the same, with both units running constantly throughout the year.

Pros

To create an oxygenated area for fish to use as a refuge in winter, the present use of the aeration system as it stands is appropriate. In addition, there is no history

[4] Wirth, T. 1988. Lake aeration in Wisconsin lakes. Wisconsin Dept. Nat. Res. Lake Manage. Program, PUBL-WR-196, 76 p.

of fish kills due to anoxic conditions since the system has been installed. During summer use, if constantly running, the guesswork is eliminated as to whether or not the fishery would have an adequate supply than if the aerators were turned off.

Cons

Running the system constantly is expensive, costing the Lake Christa Association approximately $2,000 per year in electricity alone. The cost could be reduced if the system was operating on even a part-time basis during the summer.

Option 2: Shut the System Off on a Trial Basis During the Summer

Lake Christa does not have a consistent history of summer fish kills due to a lack of dissolved oxygen prior to installation of the surface aeration system. However, no dissolved oxygen data is available for Lake Christa before the installation of the aerators. It is possible that the amount of DO in this lake is sufficient to support aquatic life without the aerators in the summer months. The Association could choose to shut off the system for the summer season to see what happens, and enlist our help in monitoring the dissolved oxygen. The system could be turned on if conditions warrant.

Pros

The Association could save money as they pay a smaller electric bill. Some residents complained of the noise the aerators made while operating during the summer, which would be eliminated. The money saved from operational expenses could be used toward other lake management options.

Cons

Although many shallow lake systems go through the summer without losing fish because of normal dissolved oxygen loss over the season (as opposed to herbicide or algicide induced dissolved oxygen loss), there is still an undetermined risk that this could occur. There have been cases in which treatment using aquatic herbicides or algicides caused dramatic dissolved oxygen losses due to the decomposition of large amounts of plants or algae. As a result, the lake or pond suffered a fish kill. However, aeration will not protect against this possibility, as only when herbicides/algicides are applied correctly according to the label, a situation like this is less likely to occur.

Option 3: Shut Off the System Entirely

Shutting off the system entirely would be an option after determining the outcome of Option 2 and weighing the benefits and risks of not using the system in winter. Several small lakes without aerators do not have problems with fish kills due to DO loss, and Lake Christa does not have a history that proves otherwise. The money saved in operating expenses from the yearly electric bill could be used for other lake management options. One thing the Association needs to keep in mind in the summer is that they need to work closely with their algicide applicator during algae treatments. The applicator *should* measure the DO in the water column before applying to be sure there is enough oxygen in the system to handle DO loss due to algae decomposition after the treatment.

The applicator also needs to avoid treatments on very hot, still days when DO may be low. Further discussion on this is within the Nuisance Algae Management Objective.

Pros

The money saved in operating expenses from the yearly electric bill could be used for other lake management options. Some residents also complained of the noise the aerators make, which would be silenced.

Cons

Lake Christa did stratify somewhat and low DO conditions were noted on two occasions. Without the use of the system, it could potentially have a smaller volume of DO for aquatic life.

Objective IV: Nuisance Algae Management

The growth of nuisance or excessive algae can cause a number of problems. Excessive algal growth can cause decreases in water clarity and light penetration. This can 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 nuisance algae growth. Normally, excessive/nuisance 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 nuisance algal growth involves treating the factors that cause the growth not the algae itself. Long-term solutions 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.

As with aquatic plant management techniques, 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 have been reduced/eliminated. It is critical to continually monitor problematic areas for regrowth and treat as necessary. An association or property owner 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 are not very effective, unproven, unfounded, or are too experimental to be widely used.

The phosphorus rich system in Lake Christa supported algae growth during the season, and also caused a nuisance planktonic algae bloom in late September, in which both *Anabaena* and *Microcystis* were identified. These are both nuisance blue-green algae species, and are commonly found in lakes throughout Lake County. Excessive blooms can result in lower water clarity. <u>The Association should request this information for their records from any applicator they hire for future reference.</u> It is a state law for aquatic herbicide/algicide applicators to document and file this information.

Option 1: No Action

With a no action management plan nothing would be done to control the nuisance algae regardless of type and extent. Nuisance algae, planktonic and/or filamentous, could continue to grow until epidemic proportions are reached. Growth limitations of the algae and the characteristics of the lake itself (light penetration, nutrient levels.) will dictate the extent of growth. Unlike aquatic plants, algae are not normally bound by physical factors such as substrate type. The areas in which filamentous and thick surface planktonic blooms (scum) occur can be affected by wind and wave action if strong enough. However, under normal conditions, with no action, both filamentous and planktonic algal blooms can spread to cover 100% of the surface. 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 not 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 (blue-green algae) might also increase in frequency.

Cons

Under the no action option, if nuisance algae becomes wide spread and able to reach epidemic proportions, there will be many negative impacts on the lake. The fishery of the lake may become 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 also be negatively impacted with the implementation of a 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. Boating could be nearly impossible without becoming entangled in thick mats of filamentous algae. Swimming could also 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 the thick mats and stunted fish populations. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by large green mats and/or blooms of algae and the odors that may develop, such as with large blue-green blooms. 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.

Option 2: Algicides

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. There is also a non-copper based algaecide on the market called GreenClean™ from BIOSafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, they all work the same and act as contact killers. This means that the product has to come into contact with the algae to be affective. 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 known 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 is enhanced when mixed with an algicide. When applying an algicide it is imperative that the label is completely read and followed. If too much of the lake is treated at any one time an oxygen crash may occur. This may cause fish kills due to decomposition of treated algae. 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 sections 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^{o}F) or when D.O. concentrations are low. 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 when temperature and D.O. concentrations are adequate. 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.

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 is 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. 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. These species that fill the gap can often be more difficult to control due to an inherent resistance to copper products. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

Costs

There are a few products for algae treatment, with copper sulfate products most commonly used. As an example, if Lake Christa were to be treated with a chelated copper product such as Cutrine Plus, the price range is approximately \$35 per gallon, with 0.5 – 1.5 gallons needed to treat one acre-foot of water. A bathymetric map with volume calculations would be important to obtain the most accurate amount needed for Lake Christa. As it stands, an estimate needs to be used, which is 48 acre-feet. This would result in a range of 24-72 gallons of product, with a price ranging from \$840-2520.

Option 3: Alum Treatment

A possible remedy to excessive algal growth 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. This floc layer 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 sometimes unreliable results deterred its wide spread use. Currently, alum is commonly being used in ponds and small lakes, 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 ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ratio (thermally stratified lakes) will see more longevity from an alum application 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.

In order to determine the costs and amounts for an alum treatment, more information is needed about Lake Christa, such as a bathymetric map with volume calculations, and a phosphorus budget.

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/habitat 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 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

In order to determine the costs and amounts for an alum treatment, more information is needed about Lake Christa, such as a bathymetric map with volume calculations, and a phosphorus budget.

Objective V: Reestablish Native Aquatic Vegetation

Revegetation should only be done when existing nuisance vegetation, such as Eurasian water milfoil, are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Without adequate light penetration, revegetation will have limited success. In cases such as these, emergent vegetation would be the best to start with. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis.

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 are allowed to naturally expand into adjacent areas thereby filling the niche left by the nuisance plants. Another technique utilizing existing plants is to transplant vegetation from one area to another. 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. Table 7 in Appendix A lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants (pondweeds, *Vallisneria*, etc). Prices, planting depths, and planting densities are included and vary depending on plant species.

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 vegetation. This provides a more natural approach as compared to other management options. In addition, using established native plants to control excessive invasive plant growth can be less expensive in the long run 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 is used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

Costs
See Table 7 for plant pricing. Costs will be higher if a consultant/nursery is contracted for design and labor. Additional costs will include herbivory protection materials such as metal posts and protective wire mesh (chicken wire).

Objective VI: Enhance Wildlife Habitat Conditions

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 mix of habitats is 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).

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

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 may be zero. However, due to continual loss of habitats many wildlife species have suffered drastic declines in recent years. The loss of habitat affects 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. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see Table 7 in Appendix A for costs and seeding rates). This will provide cover from predators and provide nesting structure for many wildlife species and their prey. It is important to control or eliminate non-native plants such as buckthorn, purple loosestrife, garlic mustard, and reed canary grass, since these species outcompete native plants and provide little value for wildlife. Although some people become hesitant about installing buffer strips along shore, buffer strips can be attractive and still allow lake access by adding a mowed path to the water. We have noted that other residents on highly developed lakes have installed attractive buffer strips with easy lake access. The majority of Lake Christa's shoreline offers very little in the way of wildlife habitat, an integral part of a lake system. The best approach would be to install buffer strips on shore behind riprap or seawall if necessary, and install aquatic plants in the shallow areas where substrate permits.

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

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

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

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

Pros

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

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

Cons

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

Costs

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

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 the Table 7 in Appendix A should be planted or allowed to grow. In addition, encourage native aquatic vegetation, such as water lily (*Nuphar* spp. and *Nymphaea tuberosa*), sago pondweed (*Stuckenia pectinatus*), largeleaf pondweed (*Potamogeton amplifolius),* and wild celery (*Vallisneria americana*) 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 exacerbate 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.

Objective VII: Shoreline Erosion Control

Erosion is a potentially serious problem to lake 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 exacerbate 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. About 16% of Lake Christa's shoreline is eroding. Although it is only slightly eroding, these shorelines should be mitigated before further damage continues.

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 a Seawall

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

Only 16% of the Lake Christa shoreline is slightly eroding. At this time, no sections are moderately or severely eroding. The installation of a seawall is overkill for the slightly eroding portions of the shoreline, and is not necessary. Other options, such as buffer strip installation, are recommended over a seawall.

Pros

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

Cons

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

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

Finally, seawalls provide no habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls.

In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e., bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e., stunted fish populations).

Costs

Depending on factors such as slope and shoreline access, cost of seawall installation ranges from $85-100 per linear foot for steel and $95-110 per linear foot for vinyl. A licensed contractor installs both types of seawall. Additional costs may occur if the shoreline needs to be graded and backfilled, has a steep slope, or poor accessibility. Price does not include the necessary permits required. Additional costs will be incurred if compensatory storage is needed. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained. For seawalls, a site development permit and a building permit are needed. Costs for permits and surveys can be $1,500-2,000 for installation of a seawall. Contact the Army Corps of Engineers, local municipality, or the Lake County Planning and Development Department.

Option 3: Install Rock Rip-Rap or Gabions

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. Gabions are wire cages or baskets filled with rock. They provide similar protection as rip-rap, but are less prone to displacement. They can be stacked, like blocks, to provide erosion control for extremely steep slopes. Both rip-rap and gabions 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 or gabions, fill will probably be needed to cover the rocks and provide an acceptable medium for plants to grow on. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below).

Only 16% of the Lake Christa shoreline is slightly eroding. At this time, no sections are moderately or severely eroding. The installation of riprap is overkill for the slightly eroding portions of the shoreline, and is not necessary. Other options, such as buffer strip installation, are recommended over riprap.

Pros

Rip-rap and gabions 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 and gabions will last for many years. Maintenance is relatively low, however, undercutting of the bank can cause sloughing of the rip-rap and subsequent shoreline. Areas with severe erosion problems may benefit from using rip-rap or gabions. 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 in the rock above water and prey upon many invertebrate species, including many harmful garden and lawn pests. Also, small fish may utilize the structure underwater 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 or gabions 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 and gabions 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 away 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.

Cost and type of rip-rap used depend on several factors, but average cost for installation (rocks and filter fabric) is approximately $35-50 per linear foot. Costs for gabions are approximately $70-100 per linear foot when filled with rocks. 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 $1,500-2,000 for installation of rip-rap or gabions, 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.

<u>Option 4: Create a Buffer Strip</u>

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

Stabilizing the shoreline with vegetation is most effective on slopes no less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems. 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, A-Jacks®, 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 7 in Appendix A 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., geese and muskrats) by placing a wire cage over the plants for at least one year.

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

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip-rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in a Table 7 in Appendix A should be considered for native plantings.

Although some people become hesitant about installing buffer strips along shore, buffer strips can be attractive and still allow lake access by adding a mowed path to the water. This is something that any portion of the shoreline can have, not just the sections that are slightly eroding. We have noted that other residents on highly developed lakes have installed attractive buffer strips with easy lake access. The majority of Lake Christa's shoreline offers very little in the way of wildlife habitat, an integral part of a lake system. The best approach would be to install buffer strips on shore, behind riprap or seawall if necessary, and install aquatic plants in the shallow areas where substrate permits.

Pros

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

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

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

Many fish and wildlife species prefer the native shoreline vegetation habitat. This habitat is an asset to the lake's fishery since the emergent vegetation cover may be used for spawning, foraging, and hiding. Various wildlife species are even dependent upon shoreline vegetation for their existence. Certain birds, such as marsh wrens (*Cistothorus palustris*) and endangered yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nest exclusively in emergent vegetation like cattails and bulrushes. Hosts of other wildlife like waterfowl, rails, herons, mink, and frogs to mention just a few, benefit from healthy stands of shoreline vegetation. Dragonflies, damselflies, and other beneficial invertebrates can be found thriving in vegetation along the shoreline as well. Two invertebrates of particular importance for lake management, the water-milfoil weevils

(*Euhrychiopsis lecontei* and *Phytobius leucogaster*), which have been shown to naturally reduce stands of exotic Eurasian water-milfoil (*Myriophyllum spicatum*). Weevils need proper over wintering habitat such as leaf litter and mud which are typically found on naturalized shorelines or shores with good buffer strips. Many species of amphibians, birds, fish, mammals, reptiles, and invertebrates have suffered precipitous declines in recent years primarily due to habitat loss. Buffer strips may help many of these species and preserve the important diversity of life in and around lakes.

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

Cons

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

Costs

If minimal amount of site preparation is needed, costs can be approximately $15 per linear foot, plus labor. Cost of installing willow posts is approximately $20-25 per linear foot. This would mean $1,500 for every 100 feet of eroding shoreline for native plants, and $2,000-2,500 for willow posts. 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 $1,500-2,000 depending on the types of permits needed.

Option 5: Install A-Jacks®

A-Jacks® are made of two pieces of pre-cast concrete when fitted together resemble a child's playing jacks. These structures are installed along the shoreline and covered with soil and/or an erosion control product. Native vegetation is then planted on the backfilled area. They can be used in areas where severe erosion does not justify a buffer strip alone.

Only 16% of the Lake Christa shoreline is slightly eroding. At this time, no sections are moderately or severely eroding. The installation of A-Jacks® is overkill for the slightly eroding portions of the shoreline, and is not necessary. Other options, such as buffer strip installation, are recommended over A-Jacks®.

Pros

The advantage to A-Jacks® is that they are quite strong and require low maintenance once installed. In addition, once native vegetation becomes established the A-Jacks® cannot be seen. They provide many of the advantages that both rip-rap and buffer strips have. Specifically, they absorb some of the wave energy and protect the existing shoreline from additional erosion. The added benefit of a buffer strip gives the A-Jacks® a more natural appearance, which may provide wildlife habitat and help filter run-off nutrients, sediment, and pollutants. Less run-off entering a lake may have a positive effect on water quality.

Cons

The disadvantage is that installation cost can be high since labor is intensive and requires some heavy equipment. A-Jacks® need to be pre-made and hauled in from the manufacturing site. These assemblies are not as common as rip-rap, thus only a limited number of contractors may be willing to do the installation.

Costs

The cost of installation is approximately $50-75 per linear foot, but does not include permits and surveys, which can cost $1,500-2,000 and must be obtained prior to any work implementation. Additional costs will be incurred if compensatory storage is needed.

Option 6: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

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

Pros

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

Cons

These products may not be as effective on highly erodible shorelines or in areas with steep slopes, as wave action may be severe enough to displace or undercut these products. On steep shorelines grading may be necessary to obtain a 2:1 or

3:1 slope or additional erosion control products may be needed. If grading or filling is needed, the appropriate permits and surveys will have to be obtained.

Costs

Costs range from $40 to $45 per linear foot of shoreline, including plantings. This would cost about $4,000-4,500 per 100 feet of eroding shoreline. This does not include the necessary permits and surveys, which may cost $1,500 – 2,000 depending on the type of earthmoving that is being done. Additional costs may be incurred if compensatory storage is needed.

Objective VIII: Eliminate or Control Exotic 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 cathartica*), and reed canary grass (*Phalaris arundinacea*) are three examples. The outcome is a loss of plant and animal diversity. This section will address terrestrial shoreline exotic species.

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 seeds 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, its roots exude a chemical that discourages other plant growth, and it is quick to become established on disturbed soils. Reed canary grass is an aggressive plant species that was introduced as a shoreline stabilizer. It is found on lakeshores, stream banks, marshes and exposed moist ground. Although it does serve to stabilize shorelines to some extent, it has low food value and does not provide winter habitat for wildlife. It is very successful in taking over disturbed areas and, 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*).

The 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, but its removal early on is best. 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.

Since these invasive plants are not in large populations around Lake Christa, their control now would be easier than if they were allowed to spread and reach heavy infestation. One positive thing we recorded was the evidence of insects feeding on the purple loosestrife plants. Recently two leaf beetles (*Galerucella pusilla* and *G. calmariensis*) and two weevils, one a root-feeder (*Hylobius transversovittatus*) and one a flower-feeder

(*Nanophyes marmoratus*) have offered some hopes to control purple loosestrife by natural means. These insects feed on the leaves, roots, or flowers of purple loosestrife, eventually weakening and killing the plant.

Option 1: No Action

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

Pros

There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics whenever possible. A Table 7 in Appendix A 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 affected.

Costs

Costs with this option are zeroing 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: Biological Control

Biological control (bio-control) is a means of using natural relationships already in place to limit, stop, or reverse an exotic species' expansion. In most cases, insects that prey upon the exotic plants in its native ecosystem are imported. Since there is a danger of bringing another exotic species into the ecosystem, state and federal agencies require testing before any bio-control species are released or made available for purchase.

Recently two leaf beetles (*Galerucella pusilla* and *G. calmariensis*) and two weevils, one a root-feeder (*Hylobius transversovittatus*) and one a flower-feeder (*Nanophyes marmoratus*) have offered some hope to control purple loosestrife by natural means. These insects feed on the leaves, roots, or flowers of purple loosestrife, eventually weakening and killing the plant or, in the case of the flower-feeder, prevent seeding. In large stands of loosestrife, the beetles and weevils naturally reproduce and in many locations, significantly reduce plant densities. The insects are host specific, meaning that they will attack no other plant but purple loosestrife. Currently, the beetles have proven to be most effective and are available for purchase. There are no designated stocking rate recommendations, since using bio-control insects are seen as an inoculation and it may take 3-5 years for beetle populations to increase to levels that will cause significant damage. Depending on the size of the infested area, it may take 1,000 or more adult beetles per acre to cause significant damage.

Because purple loosestrife is not in a large population around Lake Christa and because we did note evidence of the presence of the leaf beetles, this would not be a recommended option at this time.

Pros

Control of exotics by a natural mechanism is preferable to chemical treatments. Insects, being part of the same ecological system as the exotic plant (i.e., the beetles and weevils and the purple loosestrife) are more likely to provide long-term control. Chemical treatments are usually non-selective while bio-control measures target specific plant species. This technique is beneficial to the ecosystem since it preserves, even promotes, biodiversity. As the exotic plant dies back, native vegetation can reestablish the area.

Cons

Few exotics can be controlled using biological means. Currently, there are no bio-control techniques for plants such as buckthorn, reed canary grass, or a host of other exotics. One of the major disadvantages of using bio-control is the costs and labor associated with it.

Use of biological mechanisms to control plants such as purple loosestrife is still under debate. Similar to purple loosestrife, the beetles and weevils that control it are not native to North America. Due to the poor historical record of introducing non-native species, even to control other non-native species, this technique has its critics.

Costs

The New York Department of Natural Resources at Cornell University (email: bb22@cornell.edu, 607-255-5314, or visit the website: www.invasiveplants.net) sells overwintering adult leaf beetles (which will lay eggs the year of release) for $1 per beetle and new generation leaf beetles (which will lay eggs beginning the following year) at $0.25 per beetle. The root beetles are sold for $5 per beetle.

Some beetles may be available for free by contacting the Illinois Natural History Survey (INHS; 217-333-6846). The INHS also conducts a workshop each spring at Volo Bog for individuals and groups interested in learning how to rear their own beetles.

Option 3: Control by Hand

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 removed. 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 since regrowth is common. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites.

This may be a viable option for exotic plant removal around Lake Christa because the exotic plants are in small populations at this time. If the populations increase, however, more aggressive control may be warranted, such as the use of herbicides.

Pros

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

Cons

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

Costs

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

Option 4: 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 impractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option because in order to chemically treat the area, a broadcast application would be needed.

Because many of the herbicides 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 an herbicide-soaked device. Trees are normally treated by cutting off a ring of bark around the trunk (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.

Because the exotic plant species are not in large populations around Lake Christa, this would not be a recommended option.

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

Two common herbicides, triclopyr (sold as Garlon ™) and glyphosate (sold as Rodeo®, Round-up™, Eagre™, or AquaPro™), are sold in 2.5 gallon jugs, and cost approximately $200 and $350, respectively. Only Rodeo® is approved for water use. A Hydrohatchet®, a hatchet that injects herbicide through the bark, is about $300.00. Another injecting device, E-Z Ject® is $450.00. Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40. A girdling tool costs about $150.