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SUMMARY OF MAIN PROBLEMS AND THREATS

"Any people can fall into the trap of overexploiting environmental resources, because of ubiquitous problems…. That the resources seem inexhaustibly abundant; that signs of their incipient depletion become masked by normal fluctuations in resource levels between years or decades; that it's difficult to get people to agree on exercising restraint in harvesting a shared resource (the so-called tragedy of the commons); and that the complexity of ecosystems often makes the consequences of some human-caused perturbation virtually impossible to predict even for a professional ecologist."

-- Jared M. Diamond, American scientist and author

8-1 INTRODUCTION

Our activities both on and around Lake Ripley can easily impair the resource and its contribution to our local quality of life. While these impacts are mostly cumulative in nature, it takes only one careless or misguided individual or activity to negatively impact the lake forever, such as by introducing an aquatic invasive species. Consequently, many factors can negatively influence the health and condition of the lake. Irresponsible watershed development, shoreline disturbances, wetland drainage, hydrologic alterations, habitat destruction, and lake-use pressures are just some of the factors that might contribute to any number of problems and recreational impairments. Each of these activities is capable of causing instability in the ecosystem and producing a variety of unwelcome consequences.

Separating the root causes of particular problems from their more observable symptoms is the key to a successful lake management program. Listed below are some common and readily apparent *symptoms* of larger, underlying *problems*.

- Beach closings
- Murky water
- Excessive weed growth
- Blue-green algal blooms
- Stunted fish populations
- Mucky lake bottom
- Crowding and user conflicts
- Noise and safety concerns
- Fish-consumption advisories
- Loss of natural scenic beauty
- Loss of fish and wildlife diversity
- Flood damage
- Extreme water-level fluctuations
- Groundwater depletion/contamination
- Rising cost of management
- Falling real estate values

According to a recent public opinion survey, the top factors most often blamed for lake-use impairments included zebra mussels, development pressure, lake weeds, crowding and algae.[1] This marks a change from earlier surveys when boat traffic, poor water clarity and noise were given higher rankings as issues of concern.[2] Possible reasons for the change in attitude include

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[1] Lake Ripley Management District. 2007. <u>Lake Ripley Property Owner Opinion Survey</u>.
[2] University of Wisconsin-Whitewater. 1992. <u>Lake Ripley Management District: Lake Resident Study</u>.

the infestation of zebra mussels around the time of the last survey, the adoption of new lake-use policies that increased slow-no-wake zones within 200 feet of shore, and perhaps a more consistent and effective law-enforcement presence during the boating season. As far as the lake's biggest threats, 2007 survey respondents largely pointed to invasive plant and animal species, polluted runoff, overcrowding, overdevelopment, and the overuse of fertilizers and pesticides.

In dealing with these problems, we must recognize that Lake Ripley is not a static feature on the landscape. Rather, it is a dynamic and evolving product of the hydrologic cycle. Aside from hydrologic influences, the lake is defined and affected by variables such as its size, shape, depth, watershed area, geology, biota and water chemistry. Like a giant settling basin with a long-term memory, the lake both reflects and reacts to everything happening on the surrounding landscape.

We must also recognize that cause and effect are not often predictable, nor are they necessarily close in time and space. Many stressors can occur slowly and almost imperceptibly over time (i.e., the incremental loss of habitat), while others can occur in sudden but infrequent pulses (i.e., changes in pollutant loadings due to flood or drought events). Inter-annual variability often masks long-term trends, creating a tendency for people to want to overreact to short-term and often cyclical conditions. In fact, water quality trends may require at least 20-30 years of monitoring data to see beyond the background noise of natural, year-to-year variability. For these reasons, our management perspective must be broad in geography and long in chronology, with attention given to how actions and events can ripple throughout an interrelated ecosystem. Consistent monitoring and routine evaluation are also needed to measure success or failure over short and long time periods, and should be tailored to the specific management actions or questions being addressed.

8-2 HARMFUL LAND-USE PRACTICES AND HYDROLOGIC MANIPULATIONS

SHORELAND DEVELOPMENT IMPACTS

Development near water generally leads to increased stormwater runoff, which in turn results in increased sediment and phosphorus loads that impair water quality. In addition, related land-clearing activities contribute to the removal of natural habitat essential for sensitive fish and wildlife species. A number of Wisconsin studies have documented the decline of shoreline plants, songbirds, green frogs and sensitive fish species in shoreland areas due to the impacts of building and development.[3] For example, green frogs represent indicator species which largely disappear on lakes with more than 30 lakefront homes per mile.[4] Tree-falls, emergent and floating-leaved plants, shoreline bank cover, species diversity, and largemouth bass nesting

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Lake Ripley Management District. 1999, 2005. Lake Ripley Property Owner Opinion Surveys.

[3] Meyer, M., J. Woodford, S. Gillum, and T. Daulton. 1997. Shoreland zoning regulations do not adequately protect wildlife habitat in northern Wisconsin. U.S. Fish and Wildlife Service, State Partnership Grant P-1-W, Segment 17, Final Report, Madison, Wisconsin.

[4] Woodford, J. E., and M. W. Meyer. 2003. Impact of Lakeshore Development on Green Frog Abundance. Biological Conservaton 110: 277-284.

success are also shown to decline with increasing lakeshore development. [5] Lake Ripley has already surpassed this housing-density threshold, with a current lakeshore building density of about 39 lakefront homes per mile. While we may not be able to reverse today's development status, there is still ample opportunity to mitigate its impact and control its future direction.

LAND USES CONTRIBUTING TO LAKE EUTROPHICATION

Most lake impairments are the result of accelerated eutrophication, arguably one of the single largest problems still affecting Lake Ripley today. Eutrophic waters are those that are impacted by excessive nutrient enrichment and high productivity in the form of weed and algal growth. Surface waters located within larger watersheds that are urbanized, intensively farmed, or that face strong development pressures are at the highest risk of exhibiting eutrophication problems. These lakes receive a larger share of their water as surface runoff, which frequently contains pollutants such as sediment and phosphorus. Resulting symptoms may include frequent algal blooms, excessive weed growth, poor water clarity, mucky lake bottoms, and a dominance of rough-fish populations.

Eutrophication problems are caused by external phosphorus loading from the watershed, and/or internal phosphorus recycling from the lake itself. Identifying the relative nutrient contributions from each source is usually necessary before the right management strategy can be formulated. For Lake Ripley, computer modeling and other evidence suggests that the vast majority of phosphorus loading is coming from row-cropped agricultural land within the watershed. The urbanized component of the watershed is also shown to be a significant contributor of phosphorus loads. While in-lake phosphorus recycling occurs to a lesser degree, it may have the effect of delaying the lake's response to watershed-based nutrient reductions.

Although typical water quality conditions have not significantly limited recreation in most years, intense residential development near the lake and widespread agricultural land uses throughout the watershed pose real and ongoing threats to Lake Ripley. Sediment cores taken from the lake bottom as part of a paleoecological study suggest that these types of land uses have consistently degraded the lake over time, particularly in the absence of proper erosion-control measures. Results of long-term water quality monitoring support these findings. The rate and amount of runoff can increase by a factor of 10 with the onset of development that increases water-impervious surfaces, which is greatest in high-density residential areas.[6] Studies have also

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[5] Woodford, James E. and Michael W. Meyer. 2003. Impact of Lakeshore Development on Green Frog Abundance. Biological Conservation 110 (2003) 277–284.

Christensen, D.L., B.R. Herwig, D.E. Schindler, and S.R. Carpenter. 1996. Impacts of Lakeshore Residential Development on Coarse Woody Debris in North Temperate Lakes. Ecological Applications 6, 1143–1149.

Jennings, M.J., M.A. Bozek, G.R. Hatzenbeler, E.E. Emmons, and M.D. Staggs. 1999. Cumulative effects of incremental shoreline habitat modification on fish assemblages in north temperate lakes. North American Journal of Fisheries Management 19, 18–27.

Schindler, D.E., S.I. Greib, and M.R. Williams. 2000. Patterns of fish growth along a residential development gradient in north temperate lakes. Ecosystems 3, 229–237.

[6] Graczyk, D.G., R.J. Hunt, S.R. Greb, C.A. Buchwald, and J.T. Krohelski. 2003. Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999-2001: U.S. Geological Survey. Water-Resources Investigations Report 03–4144, 64 p.

consistently shown that watersheds experience damage as imperviousness increases, with some research showing a threshold of noticeable damage once 10-12% of a watershed becomes impervious.[7]

DITCHING AND STREAM CHANNELIZATION

Drainage ditching through wetlands, stream dredging and channelization, and other drainage modifications have occurred in and around Lake Ripley over the prior decades. Such hydrologic manipulations can create a number of problems, some of which are well documented from paleoecological studies that analyzed sediment cores of the lake bottom. These studies showed that widespread ditching and the channelization of the inlet around 1940 dramatically increased pollutant loads to the lake, causing significant declines in water quality.[8]

In addition, the soils associated with farm drainage ditches in the watershed are highly prone to erosion and require regular maintenance. Soil eroding from these ditch banks has reduced the functional values of adjoining and downstream wetlands, and has contributed to the bulk of sediment loading to the lake. Ditches also act as conduits of pollutants, allowing an easy path for dirty runoff to reach the lake in a rapid and unfiltered fashion. There are approximately 45,000 feet of ditched drainage channels in the Lake Ripley watershed. In the mid-1990s, eroding drainage ditches were estimated to account for 2,654 tons or 75% of the total annual sediment contribution to adjoining wetlands and Lake Ripley.[9]

WETLAND CONVERSION

The impacts of agricultural development and related wetland loss on Lake Ripley cannot be overstated. Neighboring Rock Lake offers a good basis of comparison. Rock Lake and Lake Ripley share many physical, chemical, biological and hydrologic characteristics. Each has similar watershed-to-lake ratios, soil and geologic features, and land-use representation. Each was also the subject of "Priority Watershed Project" efforts to control non-point sources of pollution. One of the major differences, however, is that Rock Lake has slightly better water quality and trophic condition. A reasonable explanation for this difference is the fact that Rock Lake's watershed is comprised of considerably more wetland acreage in relation to its agricultural component. Other factors being equal, this difference is likely to drive the lake's comparatively better water quality and trophic status.

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[7] Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales. Springer Series in Environmental Management, Vol. 28, No. 2, pp. 255-266.

[8] Wisconsin Department of Natural Resources. 1993. Lake Ripley Paleolimnological Study.
Garrison, Paul J., Pillsbury, R. 2009. Paleoecological Study of Lake Ripley, Jefferson County. Wisconsin Department of Natural Resources, Bureau of Science Services, and University of Wisconsin-Oshkosh, Department of Biology. PUB-SS-1062 2009.

[9] Wisconsin Department of Natural Resources, Wisconsin Department of Agriculture, Trade and Consumer Protection, Lake Ripley Management District, and Jefferson County Land Conservation Department. 1998. Nonpoint Source Control Plan for the Lake Ripley Priority Lake Project. Wisconsin Nonpoint Source Water Pollution Abatement Program. Publication WT-512-98.

GROUNDWATER WITHDRAWAL

Finally, the threats associated with excessive water diversions, particularly through increased groundwater pumping, should not be ignored. Groundwater is estimated to be a significant contributor to Lake Ripley's hydrologic budget. It represents a relatively clean and steady source of water that supplies baseflow to the lake's inlet and helps protect overall water quality. As development and related groundwater pumping increase around Lake Ripley, the more the lake's hydrologic budget will change as this source water is extracted and discharged as wastewater outside of the watershed. Future threats include the potential for new, high-capacity wells to be located where they could negatively impact the lake. These types of wells pump at least 100,000 gallons per day, are most often associated with municipal or industrial applications.

8-3 POLLUTED RUNOFF

According to the Wisconsin Association of Lakes, polluted runoff is Wisconsin's number one water quality problem, degrading or threatening an estimated 90% of the state's inland lakes. Phosphorus is the limiting nutrient that drives eutrophication in most lakes, including Lake Ripley. In fact, the Minnesota DNR has estimated that one pound of phosphorus delivered to a lake can produce up to 500 pounds of algae. Water bodies with large watershed-to-lake surface area ratios (>10:1) are much more likely to experience water quality problems due to nutrient loading from the adjacent landscape. Since Lake Ripley has a ratio of approximately 11:1, the watershed will always exhibit a great influence on overall lake conditions.

Extra phosphorus enters Lake Ripley predominantly as stormwater runoff from lawns, farm fields, construction sites, roads and other hard-surface or disturbed-soil areas. This nonpoint source pollution results from the influx of eroded soil, fertilizers, organic debris and other materials that wash into the lake from the surrounding watershed. Many of these pollutants are able to reach the inlet tributary and lake through a combination of farm ditch laterals and roadside swales that serve as conveyance systems for overland flow. Most of this runoff is transported rapidly with no "pretreatment" or only slight filtering before it enters the lake. Once in Lake Ripley, elevated levels of phosphorus can cause algal blooms, decreased water clarity, and impairments to recreational lake use and lakeshore property values.

Poorly managed construction sites, soil-disturbing farming practices, irresponsible fertilizer applications, vegetative clear-cutting, and unstable shorelines and drainage ditches are just a few of the mechanisms that can increase inputs of problem nutrients and contaminants to the lake. This is especially true in the absence of proper measures that control runoff and soil erosion. In particular, lawns can be large sources of fertilizers and pesticides. Rooftop areas, which may be directly or indirectly connected to the storm drainage system, are known to be sources of zinc and various atmospheric pollutants. Streets and parking lots are generally sources of heavy metals (i.e., lead and cadmium), oil, grease, sediment, salt and bacteria, depending on their condition and traffic volume.

Increased water-impervious surfaces in the watershed cause increased water volumes, pollutant loads and lake temperatures. In fact, paved surfaces and rooftops generate 16-times more stormwater runoff than the fields they replace.[10] Ironically, the same paved surfaces can also cause streams to run dry and lake levels to fall precipitously at other points of the year by preventing groundwater recharge. As a result of polluted runoff, more and more communities are finding local beaches closed, and activities like swimming and fishing restricted due to declining aquatic populations and public health advisories. They are also dealing with the increased frequency and severity of flash flooding. Adjusted for inflation, communities are now spending five times more money every year on flood damage than they did 50 years ago.[11] Increased stormwater pollution has always been a cost of development, but it is a cost that has been traditionally pushed on the public in the form of resource degradation and flood damage.

Protecting and managing the watershed is paramount to maintaining the health and quality of Lake Ripley. The sources of external nutrient loading should be addressed before any in-lake management techniques are implemented. If not, in-lake management efforts will not be as effective over the long run.

8-4 IN-LAKE RECYCLING OF PHOSPHORUS

The major source of phosphorus to the lake is runoff from the watershed. However, phosphorus is also internally recycled through plant uptake, through decomposition of plants and other lake organisms, through the breakdown of animal wastes (i.e. geese droppings), and through the re-suspension of lake-bottom sediments.[12] Phosphorus exits the lake through lake outlets, the physical removal of fish and plants, and particle settling. Overall, phosphorus inputs from external (watershed-based) sources or in-lake recycling can often greatly exceed losses.

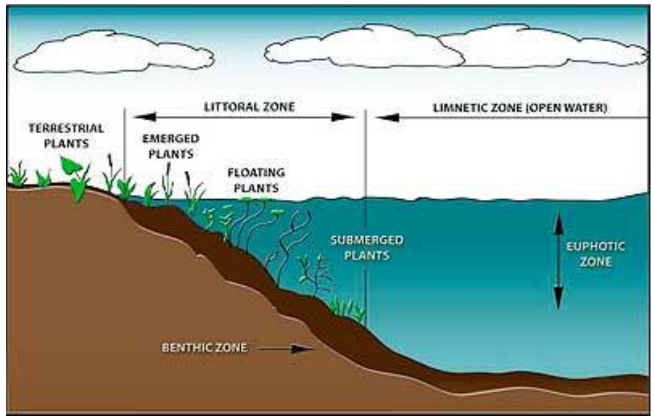
ANOXIC HYPOLIMNION

In-lake phosphorus recycling, also called internal nutrient loading, occurs when phosphorus is released from the lake bottom or by the life cycles of aquatic plants and organisms. There are multiple mechanisms that can trigger in-lake phosphorus recycling. One, well-documented mechanism is a lack of dissolved oxygen (called anoxia) at the sediment-water interface of the lake bottom. This condition frequently occurs in the hypolimnion of deep (>20 feet), eutrophic lakes where the decomposition of organic matter depletes the available supply of dissolved oxygen. In this situation, phosphorus that was previously bound to calcium, iron and aluminum as insoluble particles in the bottom sediments is chemically converted to a soluble state and released into the surrounding water. Anoxic sediment has been shown to release phosphorus as much as 1000 times faster than oxygenated sediments.[13]

[10] Wisconsin Department of Natural Resources. 2000. Creating an Effective Shoreland Zoning Ordinance: A Summary of Wisconsin Shoreland Zoning Ordinances, Section 5: Impervious Surface Area, p. 5-B-1.
[11] American Rivers, *supra* note 7 at 3
[12] Armstrong, D.E., R.F. Harris, and J.K. Seyers. 1971. Plant Available Phosphorus Status of Lakes. Technical Completion Report OWRR B-022-WIS. Madison, WI: University of Wisconsin Madison, Water Resources Center, Hydraulic and Sanitary Laboratory.
[13] Horne, A.J. and C.R. Goldman. 1994. Limnology. Second Edition. New York: McGraw-Hill. 576 pp.

Severe algal blooms can materialize if this phosphorus-rich water migrates toward the well-lit surface waters where algal populations are abundant. This migration typically occurs during spring and fall turnover when lake-wide mixing takes place in dimictic water bodies. It tends to be a bigger problem in lakes with small watersheds and long hydraulic retention times, and when mixing occurs during the summer recreational period. Fortunately, Lake Ripley is thermally stratified for much of the year, meaning little of the released phosphorus can get mixed into the water column to fuel summer algal growth.

LITTORAL ZONE



Source: Wisconsin Lakes Partnership

The anoxic hypolimnion is not the only area known to experience in-lake phosphorus releases. The shallow, littoral zone may also contribute to internal phosphorus recycling. This can be caused by anoxia, sediment disturbance, the decay of plants and organic matter, carp activity,[14] increased water temperature, and elevated pH in dense plant beds or during intense algal blooms.[15]

Anoxic conditions are known to develop in shallow, weedy areas during non-daylight hours when respiration exceeds photosynthesis. This can prove problematic if the littoral sediments are high in phosphorus. Lakebed disturbances can lead to the re-suspension of nutrient-rich sediment into the water column, and is most often caused by wind and wave action, carp activity, and turbulence from motor boats. As far as pH levels, they may increase as carbon dioxide concentrations are depleted during photosynthesis. Aside from these factors, in-lake phosphorus recycling can even be driven by large congregations of geese and other waterfowl through the excretion of phosphorus-rich waste products.

Rooted aquatic plants can also be a significant contributor of dissolved inorganic phosphorus to the water. In fact, dense colonies of Eurasian watermilfoil (*Myriophyllum spicatum*) have been shown to effectively move phosphorus from the bottom sediments to the overlying water column.[16] Milfoil gets 70-100% of its phosphorus from the sediments.[17] Each square meter of milfoil can remove 3 grams of phosphorus from the sediment per year, which is stored in the plant's shoots. The nutrient does not leach from healthy milfoil shoots, but when the shoots

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[14] Chumchal, M.M. and R.W. Drenner. 2004. Interrelationships between phosphorus loading and common carp in the regulation of phytoplankton biomass. *Arch. Hydrobiol.* 161:147-158.
[15] Holdren, G.C. 1977. Factors affecting phosphorus release from lake sediments. Ph.D. thesis, Department of Water Chemistry, University of Wisconsin-Madison. 172 pp.
[16] Smith, C.S. and M.S. Adams. 1986. Phosphorus transfer from the sediments by Myriophyllum spicatum. *Limnology and Oceanography* 31(6): 1312-1321.
Carpenter, S.R., A. Gurevitch, and M.S. Adams. 1979. Factors causing elevated biological oxygen demand in the littoral zone of Lake Wingra, Wisconsin. *Hydrobiologia* 67(1): 3-10.
[17] Loucks, O.L. 1981. The littoral zone as a wetland and its contribution to water quality. In *Selected proceedings of the Midwest conference on wetland values and management*, ed. B. Richardson, pp. 125-138. St. Paul, MN: Minnesota Water Planning Board.

decay, almost the entire amount that was removed from the sediments (2.8 grams per square meter of milfoil per year) is released to the water.

Zooplankton also play a role in phosphorus cycling. Since the rate of phosphorus release is inversely related to zooplankton body size, size-selective predation by bluegills and other planktivores results in an increase in phosphorus released per unit biomass of zooplankton.[18] Therefore, changes in the lake ecosystem that affect zooplankton populations and size may, in turn, affect phosphorus cycling in the system.

EVALUATION OF LAKEBED SEDIMENTS

Knowledge of the phosphorus content of sediment in various locations along the lakebed is useful in identifying potential "hot spots." This information can be used to determine whether management techniques such as dredging and alum treatments will effectively correct a potential in-lake, nutrient-recycling problem and produce the desired results. Sediment cores are generally taken at certain locations in a lake to better characterize the depth and distribution of potentially nutrient-rich bottom sediments. In addition, total phosphorus concentrations at the top and bottom of the water column can be compared. These measurements would indicate whether phosphorus is actually collecting in the anoxic hypolimnion from sediment releases during the summer stratification period.

Sediment nutrient levels were measured in Lake Ripley's littoral zone in 1992 (Table 37).[19] These values are not considered to be unusually high relative to lakes with known in-lake phosphorus recycling problems.

Table 1: Lake Ripley littoral zone sediment nutrient levels (1992)

	NH_3 (mg/kg)	Total P (mg/kg)	% moisture
Maximum	65	580	89
Minimum	5	110	53
Mean	22.8	373.8	76.9
Standard Deviation	15.6	145.7	9.8

OVERALL PROBLEM ASSESSMENT

Although in-lake nutrient recycling does occur to some degree in Lake Ripley, its relative significance has not yet been thoroughly quantified. Over its deepest point near the lake bottom, Lake Ripley's summer mean total phosphorus concentration (based on limited data) is 70 µg/L. This compares to a summer mean total phosphorus concentration of 20 µg/L at the surface. These findings suggest sediment phosphorus release is occurring within the deep-water anoxic zone and accumulating there during summer stratification.

[18] Bartell, S.M. and J.F. Kitchell. 1978. Seasonal impact of planktivory on phosphorus release by Lake Wingra zooplankton. *Verh. Internat. Verein. Limnol*. 20:466-474.
[19] Wisconsin Department of Natural Resources, and Lake Ripley Management District. 1994. Lake Ripley Water Resources Appraisal.

However, relative to other lakes with confirmed nutrient recycling problems, the deep-water phosphorus accumulation in Lake Ripley is comparatively small. This may, in part, be the result of calcium carbonate deposits that help keep phosphorus bound to the sediments. Lake Ripley's deep-water, summer mean phosphorus concentration (70 µg/L) was found to be slightly higher than what has been recorded for neighboring Rock Lake (46 µg/L), but much lower than meso-eutrophic Fish Lake in Dane County (300 µg/L). When comparing phosphorus levels in the littoral zone sediments, Lake Ripley's 374 mg/kg mean concentration was less than both Rock Lake's (592 mg/kg) and Fish Lake's (1,142 mg/kg).[20] It is unlikely that Lake Ripley's hypolimnetic phosphorus concentrations, as measured, would be sufficient to warrant redirecting management attention away from external, watershed-based sources.

Given the various sources and mechanisms for in-lake phosphorus recycling, attempts to manage a single source may not prove effective, even if internal loading is ultimately found to be a problem worth addressing. Developing a phosphorus budget is usually recommended to more accurately identify the actual sources of internal nutrient loading, especially before an expensive management technique is considered which may not target the actual problem area. Techniques used to control internal nutrient loading include phosphorus precipitation and inactivation (via alum treatments), hypolimnetic withdrawal, artificial circulation, hypolimnetic aeration, sediment removal (via dredging), carp removal, geese control, and dilution/flushing strategies. Some of these options could be applicable to Lake Ripley, while others would not.

8-5 AQUATIC INVASIVE SPECIES

Organisms that get introduced to an ecosystem without having evolved there can dominate native species, sometimes to the point of exclusion. They do this by achieving a competitive advantage over indigenous organisms, which rarely have any natural mechanisms to combat these foreign species suddenly occupying the same niche. The end result can be a lake ecosystem completely thrown out of balance as the invading organisms multiply unchecked, displacing native flora and fauna and the important roles they once served.

GENERAL RISK ASSESSMENT

To assess risk, lakes may be viewed as islands with varying degrees of vulnerability to possible invasions and subsequent species turnover. Risk is primarily dependent on proximity and connectivity to source waters, and the degree to which recreational boat traffic moves to and from these infested waterways. The Great Lakes and Mississippi drainage systems represent large species pools that can be moved to nearby lake "islands." At last count, 185 non-native aquatic species had been documented in the Great Lakes alone. Many of these species are highly prolific, invasive and problematic, and can be easily spread to other water bodies. According to University of Notre Dame professor David Lodge, the Great Lakes are directly connected to 12%

[20] Marshall, David. 1993. Nutrient Levels in Littoral Zone Sediments from Lake Ripley and Fish Lake. Wisconsin Department of Natural Resources.

of the world's ports, and 99% of the world's ports are within just two stops from the Port of Green Bay or any other commercial dock in the Great Lakes.[21]

Once an infestation occurs, abundance of the invasive species typically peaks before eventually declining as a result of predation, disease and food-source depletion. The actual nuisance level of a particular species is determined by native extinctions and lake-function disruptions that negatively impact users. Aquatic invasive species are notoriously difficult to eradicate or even control due to their ability to reproduce, even after their populations are suppressed. Increased public awareness emphasizing self-inspection and removal, combined with the implementation of an early-detection and rapid-response program, seem to be the most promising defenses against invasive species threats.[22] These measures will become increasingly necessary as new invasive species continue to be discovered in neighboring waterways (i.e., spiny waterfleas found this summer in the Madison lakes). The following are the major aquatic invasive species currently found in Lake Ripley.

EURASIAN WATERMILFOIL AND CURLY-LEAF PONDWEED

Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) are both submersed aquatic weeds. Over the last couple decades, Eurasian watermilfoil, in particular, has been the most obvious factor affecting recreation and ecological balance in Lake Ripley. This invasive lake weed was first discovered in North America in the 1940s. It has since invaded nearly every U.S. state and at least three Canadian provinces. After finding its way into Lake Ripley, it reached its peak in 1989 when it was reported that over 40% of the lake surface was covered with milfoil canopies.

Eurasian watermilfoil (*Myriophyllum spicatum*). Source: Wisconsin DNR

Milfoil is known to form thick mats that crowd out and out-compete the lake's native flora, thereby reducing aquatic plant diversity and the quality of fishery habitat. It can also severely restrict recreational use of the lake by entangling swimmers and boat propellers, and by reducing the availability of open-water space. Large weed colonies are even shown to deplete dissolved oxygen levels and supply nutrients for algal growth during plant senescence and decay. Mechanical weed harvesting has been used to suppress the milfoil population and facilitate navigation and general lake use. Careful attention is given to collecting and removing all harvested plant material since weed fragments can re-root and grow into new plants.

Curly-leaf pondweed has the potential to create similar problems as mifoil, but has so far maintained a relatively modest presence within the overall plant community. This species has mostly been documented in portions of East Bay near the lake's inlet. It is usually more

[21] Report given at the 2009 Wisconsin Lakes Convention by Professor David Lodge of the University of Notre Dame.

[22] May 17, 2008 memorandum from Douglas Jensen, Minnesota Sea Grant 's Aquatic Invasive Species Program Coordinator, concerning assessment of public boat-washing facilities as a means of controlling aquatic invasive species,

prevalent earlier in the growing season, whereas milfoil reaches peak growth rates later in the growing season. As with mifoil, curly-leaf pondweed is also presently managed through mechanical weed harvesting. Because it is not yet widespread throughout the entire lake, the weed may be a good candidate for targeted herbicide treatments or even hand-pulling.

For controlling either of these invasive species through nutrient reduction, it is important to recognize that most of their required nitrogen and phosphorus are derived from the sediment.[23] In most cases, nitrogen in the form of ammonium is the limiting nutrient for rooted plant growth.[24] However, phosphorus can be transported from the sediment to the water column through macrophyte uptake, death and decay. Milfoil can potentially mobilize enough phosphorus from the sediments to affect the overall phosphorus budget on some lakes.[25] Repeated harvesting, therefore, may effectively remove a major source of nitrogen and phosphorus from the lake.

COMMON CARP

The common carp (*Cyprinus carpio*) is a fast-growing bottom feeder that uproots aquatic plants and churns up sediment that muddies the water. Carp spawn from late spring to early summer in warm, shallow water found along lake and stream edges. Spawning adults are easily spotted due to their energetic splashing close to shore. The common carp is native to Asia and has been introduced throughout the world for food and sport. In 1880, seventy-five carp were brought from Washington D.C. to the Nevin Hatchery in Madison for the purpose of stocking as a sport fish. Carp have since become the most widespread large fish in the state.

Lake Ripley fishery surveys performed by Wisconsin DNR suggest that the carp population has remained fairly stable in recent years and, at the present time, does not represent a major issue of concern. However, their numbers should be closely monitored since any significant increase can lead to declines in water quality and other problems. The lake's outlet, which connects to Koskkonong Creek and the Rock River, is likely to be a source of some degree of carp recruitment. A study may be warranted to determine the extent of such recruitment for purposes of controlling the resident population through carp barriers or other measures.

ZEBRA MUSSEL

The first, barnacle-like zebra mussel (*Dreissena polymorpha*) was discovered in Lake Ripley in 2005. In 2007, Lake Ripley was listed as an infested waterway after multiple adults had been found and water samples came back testing positive for the free-swimming larvae, called veligers. Native to the Baltic and Caspian Seas of Europe, the invasive mollusk was transported to the Great Lakes in

[23] Barko, John W., R. M. Smart, M. S. Mathews and D. G. Hardin. 1982. Sediment-Submersed Macrophyte Relationships in Freshwater Systems. APCRP Technical Report A-82-3.
[24] Barko, John W. and R. M. Smart. 1986. Sediment-Related Mechanisms of Growth Limitation in Submersed Macrophytes. Journal of Ecology. 67 (5) 1328-1340.
[25] Smith, Craig S. and J. W. Barko. 1990. Ecology of Eurasian Watermilfoil. Journal of Aquatic Plant Management. 28: 55-61.

the mid 1980s in the ballast water of ocean-going ships. Since then, zebra mussels have spread at an alarming rate throughout North America. The mussels can survive for days out of water, and spread primarily by attaching to boat hulls, aquatic plants and fishing equipment that then get moved from lake to lake. They can also spread as microscopic larvae in contaminated bait buckets, live wells and bilge water.

Zebra mussels look like small clams with a yellowish-brown "D"-shaped shell that has alternating light and dark stripes (hence the name "zebra"), and with a flat edge on one side. They are generally less than an inch long, and typically form dense colonies. Zebra mussels are the only freshwater mollusks that firmly attach to solid objects like dock pilings, boat hulls, and submerged rocks and stumps. Juveniles are difficult to see, but will feel like grit on any solid surface they may inhabit.

Zebra mussels are prolific breeders capable of producing tens of thousands of young mussels each summer. In fact, a single female can produce 30,000 to one million eggs in one year. Because they are an introduced species with few natural predators, the mussels can multiply unchecked, disrupting food webs and throwing entire ecosystems out of balance. As filter feeders, large populations of zebra mussels can decimate plankton and zooplankton communities (tiny plants and animals) that young fish rely on for food. However, since they do not consume blue-green algal species, their feeding behavior can actually favor and thus intensify blue-green algal blooms. They also are blamed for pushing contaminants up the food chain by bio-accumulating toxins. Furthermore, the destructive mollusks have been shown to displace native mussels, and deplete oxygen levels needed for fish and other aquatic life. Finally, zebra mussels can clog boat engines and intake pipes, encrust boat hulls, piers and lifts, and cut the feet of swimmers with their sharp shells.

Unfortunately, there is no known treatment or control strategy for managing zebra mussel populations at the present time. Public-awareness campaigns, "illegal-to-transport" laws, and the careful inspection and decontamination of boating and fishing equipment are currently used as the principal strategies to prevent their continued spread to other waterways.

[CANADA GOOSE]

The Canada goose (*Branta Canadensis maxima*), while actually native and not truly "aquatic," is often considered a nuisance species that may congregate in large groups on the lake and along the immediate shoreline. The giant Canada goose is one of 11 recognized subspecies of geese in North America. It was thought to be extinct in the first half of the 20th century. While extensive management efforts resulted in a dramatic recovery, populations became increasingly adapted to urban and suburban environments. Migrating populations join these resident urban populations, which apparently serve as "decoys" that attract migrants to urban areas occupied by resident geese. Highest population densities are typically observed in the fall when migrating and resident geese comingle.

Although native to Wisconsin, Canada geese are often considered invasive because they have stopped migrating. They prefer to graze on short grasses in shoreland areas where they can keep a watchful eye out for potential predators. Geese start reproducing at two or three years of age, live over 10 years, and raise an average of four young per year. Problems include increased nutrient loading and bacterial contamination from goose droppings, overgrazing of grass and ornamental plants, attacks on humans and pets by aggressive birds, and damage to beaches, lawns and golf courses that can lead to soil erosion. Geese are also known carriers of the parasite that causes Swimmer's Itch. They have been known to number in the hundreds and thousands on lakes that are of similar size to Lake Ripley.

Geese droppings are a nuisance for park and beach users, and can contribute to bacterial and nutrient contamination of lakes. Grassy areas of Vilas Park (Madison, WI) heavily populated by geese averaged about 600 pounds per acre of feces (wet weight, as collected) in fall, with some areas receiving more than three times this amount. Surveys indicate that people do not generally consider Canada geese populations of less than 25 individuals to be a nuisance in a particular park. A population this small is also not likely to inflict serious landscape damage or contribute significantly to health or water quality problems. Geese have been successfully managed at sites throughout the country with programs approved by the Humane Society and other wildlife organizations.[26]

8-6 HABITAT LOSS

Habitat is more than the place where you might encounter a particular fish, plant, animal or insect. The ideal habitat serves multiple functions for a range of different species: a refuge from predators; a source of food; a place to nest, spawn or raise young; ample space to live and grow; suitable climate or water temperature; and adequate oxygen – just to name a few. Habitat is considered degraded, or less than optimal, when it fails to serve the needs of multiple life functions and stages.

Shoreline development is associated with many alterations to lake habitats and ecosystems, including eutrophication, loss of coarse woody structure (downed trees), removal of submersed and emergent vegetative cover, and reductions in fish growth. The removal of natural habitat features is of particular concern to the health of the lake's biota. For example, the delivery of coarse wood from shoreland forests provides critical habitat structure for fish and other aquatic life. The surfaces and detritus associated with submerged timber are also used as feeding grounds for macroinvertebrates. Furthermore, tree-falls provide vertical profiles that fish and amphibians use to attach their eggs so they remain in well-oxygenated water off the lake bottom.

Submerged timber is not the only type of habitat that is disappearing from many of our lakes. The amount and type of vegetation—both in and adjacent to the water—is also undergoing considerable change. Vegetation on shore provides habitat for terrestrial insects, which can be an important source of food for fish. However, the native trees, shrubs and groundcovers that are found along the shore are often replaced by houses, lawns, beaches and ornamental trees as a consequence of development. With the decline of terrestrial insects, fish must expend more energy seeking less energetically valuable sources of food from pelagic (open water) and benthic (lake bottom) habitats.

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[26] Friends of Lake Wingra. Spring/Summer 2005. Wingra Watershed News.

Submerged, floating-leaf and emergent aquatic vegetation is also routinely subjected to human disturbance and destruction. Aquatic vegetation is important for providing oxygen, food, cover and spawning sites for fish, absorbing the nutrients that fuel algal blooms, protecting water quality by anchoring lakebed sediments, and preventing shoreline erosion by muffling wave energy. Unfortunately, much of this vegetation becomes fragmented or eliminated entirely through a combination of activities related to pier development, beach grooming, shoreline armoring, and shallow-water motor boating.

Habitat loss is also a problem throughout the larger watershed where harmful land-use and development practices have eliminated most of the wetlands, woodlands and prairies that once helped safeguard lake quality. While these landscapes may be located off the lake, they can have a tremendous influence on habitat conditions within the lake itself. Many fish and wildlife species rely on intact stream corridors and adjoining uplands for part of their life stages. These landscapes, in their natural condition, also influence the hydrologic cycle which can ultimately affect the quality and quantity of water reaching the lake.

8-7 LAKE-USE PRESSURES AND CONFLICTS

Lake Ripley is a popular and accessible water body that supports a wide array of lake uses. While many of these lake uses are somewhat compatible and complimentary, some are not. Conflict arises when mutually-exclusive activities compete for time and space on the water, or when excessive crowding limits the enjoyment of even the most compatible recreational pursuits. At some point, the degree of conflict becomes unacceptable to particular users or user groups, and the lake is said to have reached its recreational carrying capacity.

Carrying capacity thresholds can be estimated in terms of social or environmental impacts, or a combination of the two. The degree of interference experienced by two competing users or user groups illustrates conflict or pressure from a social dimension. Motor boating encroachment into shallow, sensitive areas due to crowding is an example of pressure from an environmental perspective. Regardless of how carrying capacity is defined and estimated, its value in optimizing lake-use conditions through policy enactment cannot be overstated. Multi-use management is possible as long as swimmers understand that a lake is not a swimming pool, power boaters are willing to steer clear of shallow water, and anglers recognize a desirable limit on plant density. For more information pertaining to recreational conflict and related problems, see Chapter 3.

8-8 WEATHER AND WATER QUANTITY CONCERNS

WATER LEVELS

Water pours through the Lake Ripley outlet and floods the adjoining property following a 2008 high-water event.

Lake-level changes are important because they affect how we access the lake, what we can do around the lake, and the quality of water in the lake. Water levels typically respond to natural seasonal variations in precipitation, with higher levels in the spring and fall, and lower levels in the summer and winter. Water levels are also influenced by building and development within the watershed. Conversion of the landscape to water-impervious surfaces (i.e. roofs, roads, parking lots, etc.) increases stormwater runoff volumes and discharge rates, ca rise faster and higher during larger storm events. During drought conditions, wells and related groundwater pumping can cause lake levels to fall even faster and lower.

While some variation in lake levels is both natural and ecologically valuable, extreme fluctuations caused by droughts and flood events can be a source of problems. High lake levels may cause flood damage to low-lying properties, increase the rate of shoreline erosion, degrade water quality, and limit recreational use during emergency slow-no-wake periods. Low lake levels are usually associated with less runoff and better water quality, but can increase the amount of lake bottom covered by rooted aquatic plant growth, and can restrict boat access to the water as necessary launching depths disappear around public boat landings and private piers. The degree to which lake levels fluctuate will determine the types of plants and animals that can survive in and near the lake. Depending on shoreline slope and depth of the lake, water level fluctuations may be dramatic (like on gradually-sloped shorelines), or barely noticeable (like on steeply-sloped shorelines).

Unfortunately, our ability to directly control regional and global drivers of lake change—like the weather—is often limited or entirely impractical. As a result, planning must involve the design of watershed Best Management Practices (BMPs) that account for potentially larger storm events at increased recurrence intervals, and with the goal of achieving greater watershed resiliency. The good news is that Lake Ripley is an open-basin drainage lake with both an inlet and outlet that help naturally stabilize water levels. It is also classified as a headwater lake due to its relatively high position in the landscape. The lake's high landscape position, relatively small watershed, significant groundwater component, and large storage capacity help to further moderate lake-level fluctuations.

CLIMATE CHANGE

Climate-change models predict that Wisconsin's weather is likely to get warmer and slightly dryer, but produce more intense storm events. Warming speeds up the hydrologic cycle, resulting in more severe rainfall events in terms of frequency and intensity. This situation is likely to lead to increased flooding, floodplain expansion, higher variability in stream flows and velocities, and the delivery of large pulses of nutrients, pathogens and toxins to the lake.

The prediction of warmer and dryer summers will result in higher water temperatures and more time for the lake's hypolimnion to become oxygen deficient, which adds more stress to cool water fishes such as walleye, white suckers and northern pike. Warmer water not only holds less dissolved oxygen, but can also foster harmful algal blooms and increase the toxicity of some pollutants. As waters become warmer, the aquatic life they now support will be replaced by other species better adapted to the warmer water. This process, however, will occur at an uneven pace, disrupting aquatic system health and possibly favoring non-indigenous, invasive species.

The Wisconsin Initiative on Climate Change Impacts (WICCI) was formed in response to questions raised by a bipartisan committee of state legislators who wanted to know how climate change could impact their districts and constituents. More than 40 scientists from the University of Wisconsin, Wisconsin Department of Natural Resources and other agencies and institutions met in June 2007 to explore ways to identify and measure the impacts of climate change at local and regional scales. The WICCI came up with the following conclusions:

- Except for northeastern Wisconsin, most of Wisconsin has warmed since 1950. Averaged across the state, the warming has been +1.1°F, with a peak warming of 2-2.5°F across northwest Wisconsin. Wisconsin is becoming "less cold," with the greatest warming during the winter-spring period, and nighttime temperatures increasing more than daytime temperatures. Modeling scenarios project that Wisconsin will warm by 4-9°F by the middle of this century. Northern Wisconsin is projected to warm the most, while the least warming is expected along Lake Michigan. The mean projected warming rate is about four times greater than what has been observed since 1950.

- Typically, daily high temperatures exceed 90°F roughly 12 times per year in southern Wisconsin and only 5 times per year in northern Wisconsin. By the mid-21st century, one modeling scenario predicts the frequency of such hot days may double to about 25 times per year in the south and triple to about 12 times per year in the north. This consists of 1.5 to 4 more weeks each year with daily high temperatures exceeding 90°F.

- Typically, heavy precipitation events of at least two inches occur roughly 12 times per decade (once every 10 months) in southern Wisconsin and 7 times per decade (once every 17 months) in northern Wisconsin. By the mid-21st century, one modeling scenario predicts that Wisconsin may receive 2-3 more of these extreme events per decade, or roughly a 25% increase in their frequency.

If climate-change modeling scenarios prove correct, answers to a number of questions will be needed. Will pollutant loading from the watershed increase due to increased storm runoff volumes, or will there be a dilution effect? Is total pollutant load more important than concentration, or vice versa? How will the timing of these loading events affect the lake's biotic response in terms of algal growth? How will climate change impact species turnover and the trophic cascade of life within Lake Ripley? At a minimum, management decisions such as the design of BMPs should be made in the context of possible climate-change scenarios.

8-9 MERCURY CONTAMINATION

A new U.S. Environmental Protection Agency (EPA) study shows concentrations of toxic chemicals in fish tissue from lakes and reservoirs in nearly all 50 U.S. states. For the first time, EPA is able to estimate the percentage of lakes and reservoirs nationwide that have fish containing potentially harmful levels of chemicals such as mercury. The data show mercury concentrations in game fish exceeding EPA's recommended levels at 49 percent of lakes and reservoirs nationwide. Burning fossil fuels, primarily coal, accounts for nearly half of mercury air emissions caused by human activity in the U.S., and those emissions are a significant contributor to mercury in water bodies. Emissions of mercury into the air decreased by 58 percent from1990 through 2005, but it still represents the largest source of mercury contamination for the nation's lakes.

Results from the four-year *National Study of Chemical Residues in Lake Fish Tissue* show that mercury is widely distributed in U.S. lakes and reservoirs. Mercury was detected in all of the fish samples collected from the nationally representative sample of 500 lakes and reservoirs in the study. Because these findings apply to fish caught in lakes and reservoirs, it is particularly important for recreational and subsistence fishers to follow their state and local fish-consumption advisories.

8-10 CHLORIDE CONTAMINATION

Based on available monitoring data, chloride concentrations are not currently a problem in Lake Ripley. However, the use of rock salt (NaCl) on U.S. roads has skyrocked in the last 70 years. While road salting is widely viewed as necessary for maintaining public safety, excessive amounts of salt contribute to greater corrosion of automobiles and the premature degradation of roads and bridges. More importantly from a lake-management perspective, this extra salt can leach into groundwater aquifers or easily wash into area streams and lakes during spring snowmelt. Toxic chloride concentrations are commonly found near storm water outfalls in urban lake settings. Chloride concentrations often do not return to normal levels after the road-salting season since salt concentrations can build up over many years and remain perpetually high in the soil and groundwater.[27]

At sufficient concentrations, chloride-related problems can include toxicity to plants and fish, groundwater contamination, and human health interactions related to salt intake and hypertension. Long-term studies have found a logarithmic relationship between the proportion of pavement in a watershed and the mean annual chloride concentration in streams. Above 15% impervious cover, chloride concentrations were shown to be strong enough to damage some plants, and, above 40%, the study streams crossed the 250 mg/L U.S. EPA contaminant level for freshwater aquatic life.[28]

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[27] Kaushal, S.S., P.M. Groffman, G.E. Likens, K.T. Belt, W.P. Stack, V.R. Kelly, L.E. Band and G.T. Fisher. (2005) Proc. Natl. Acad. Sci. USA. 102, 13517-13520.

[28] Ibid

Every effort should be made to keep chloride concentrations in Lake Ripley well below the 395 mg/L chronic toxicity and 757 mg/L acute toxicity levels established by the Wisconsin DNR (Administrative Code NR 105). For potable water, NR 140 establishes a groundwater preventative action limit of only 125 mg/L for chloride, and an enforcement standard of 250 mg/L. As far as sodium (Na), the U.S. Environmental Protection Agency recommends that drinking water levels not exceed 20 mg/L.

8-11 POTENTIAL FOR PUBLIC APATHY AND COMPLACENCY

One of the biggest threats to the future of Lake Ripley may be a failure of the general public to act with urgency on its behalf. It is vitally important that area property owners and lake users fully understand and appreciate what it will take to bring about real, positive change at a watershed scale. There needs to be a collective recognition that the solutions to our challenges cannot wait until we find ourselves faced with the next crisis. Government programs alone will not be enough, regardless of budget. Rather, every individual must be called upon to make the sustained investments and adopt the specific behavior changes that will be required. Only then can we expect to witness the significant, cumulative transformations that are well within our reach. In the end, successfully protecting and rehabilitating the resource will require the participation and shared sacrifice of the larger community. It will require nothing short of an informed and actively engaged public to focus political will and leverage available resources. Anything less will be remembered as a missed opportunity to preserve the very things that contribute to our local quality of life here on Lake Ripley.

Human behaviors and activities are at the root of almost every challenge facing Lake Ripley. Additionally, most resource managers agree that without incentives, and unless required by regulation, landowners adopt new BMPs or behaviors they perceive as being in their best interest. If we do not account for this social dimension, our efforts to protect and enhance the lake will fall short. Consequently, there is a need to develop new and more effective ways to motivate meaningful behavior changes, especially among targeted watershed residents and property owners. This becomes especially critical when the success of many management efforts relies on the voluntary action of area property owners. Disseminating information and simply asking people to do the right thing is not enough. Even the offering of cost-share incentives can fail to generate the level of participation that is needed to achieve the desired change.

2007 photo showing U.W.-Madison and Lake District representatives who contributed to the development of CBSM programs for Lake Ripley.

To overcome these challenges, community-based social marketing (CBSM) programs were developed in partnership with the U.W.-Madison's Department of

Urban and Regional Planning.[29] These programs set forth a procedure for selecting behaviors that are environmentally meaningful, and that are amenable to CBSM tools of change that go beyond educational or standard "marketing" approaches. Social indicators are then used to evaluate program effectiveness. The CBSM programs follows protocols established by Doug McKenzie-Mohr in his seminal 1999 publication: *Fostering Sustainable Behavior – An Introduction to Community-Based Social Marketing*.

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[29] Cipiti, M., P. Heiberger, N. Hunt, J. Keeley, B. Panke and E. Sievers. 2007. Rain Gardens for Lake Ripley Watershed: How a Community-based Social Marketing Program Can Promote Rain Gardens. Human Behavior and Environmental Problems course report, University of Wisconsin-Madison.

Fogarty, E., J. Huston, R. Maskin, B. Van Belleghem and S. Vang. 2007. Phosphorus Free for Lake Ripley: A Community-based Social Marketing Program to Use Phosphorus-free Lawn Fertilizer. Human Behavior and Environmental Problems course report, University of Wisconsin-Madison.