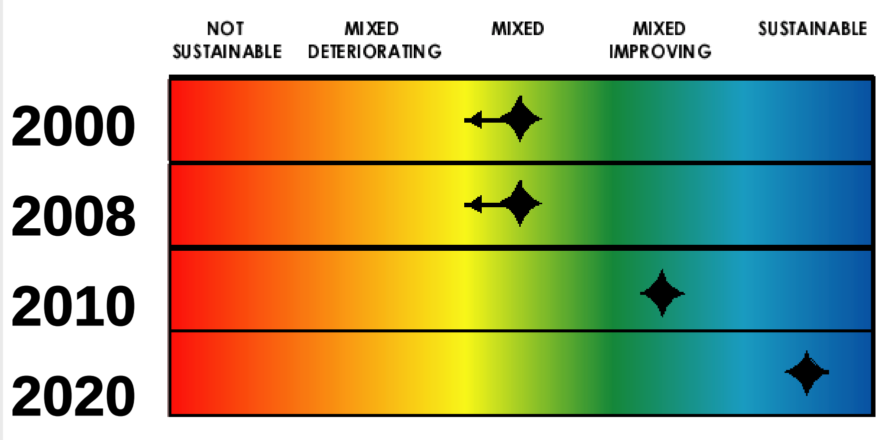
Subgoal 4
Are all habitats healthy, naturally diverse, and sufficient to sustain viable biological communities?

What is our target for sustainability?

Healthy and diverse ecosystems are intact, provide residents with wildlife watching and recreation opportunities, and meet tribal needs for cultural, spiritual, and medicinal needs.

Lake Michigan Target Dates for Sustainability



Why is this important?

The Lake Michigan ecosystem continues to experience profound changes due to pollutant loading, development, and impacts of nuisance species. Many species' habitats rank as globally rare or imperiled based on the level of threat, their restricted distribution, and ecological fragility.

What is the current status?

- The overall status is Mixed/deteriorating as habitat destruction is a permanent, irreversible loss.
- **Benthic Aquatic Habitat.** Introduction of invasive species is interrupting the aquatic food web. While aquatic invader zebra mussels are declining in numbers, they are being replaced by the invasive quagga mussel. Native diporeia continue declining significantly, leaving less native food at the base of the food chain.
- **Fish Species.** Invasive species are competing with native species for food. Lake Trout and Lake Sturgeon are making comebacks as their numbers begin to see recovery and increases. Perch year of young are seeing increases as well.
- **Terrestrial Habitat.** Development in coastal counties is taking over habitat and farmland. Some restoration of wetlands, native prairies and other habitat is taking place.
- **Terrestrial Animals.** Wolves are making a comeback in northern Wisconsin and the Upper Peninsula of Michigan. Eagles have been sighted in the Chicago Lake Calumet region. More cities are taking part in decreasing light pollution during bird migration season.

What are the major challenges?

- Climate Change: Temperature rise in tributaries and the lake will promote change to warmer water aquatic species, shrinking of wetlands, and changing of shoreline dunes and coastal ecosystems.
- Restore and protect 125,000 acres of wetlands in the basin
- Changes in climate, lake levels, and groundwater recharge of streams at lake basin and sub-watershed scale impacting native species
- Making habitat information on status and value readily available by 12-digit HUC watersheds
- Increasing stress on habitats based on predicted growth and development of coastal areas of the basin
- Promoting projects to identify, enhance, restore, or protect critical ecosystem features and habitat through purchase, voluntary protection, or improved management
- Lack of connected migration corridors for plants and animals
- Lack of precise tracking tools for reporting gains and losses
- Lack of understanding of the causes, pathways, and needed actions for addressing the deaths of shorebirds from botulism

What are the next steps?

- Collaborate with the Great Lakes Fishery Commission on protecting near and offshore spawning reefs
- Develop process to refine habitat restoration targets through public discussion and promote work toward targets
- Continue to support components of biodiversity plans through the Watershed Academy.
- Identify species sensitive to ground and surface water interaction and their current distribution
- Provide GIS tools and land use models in workshops to promote knowledge of and protection of key habitat areas
- Promote new stream buffers, wetlands, and dam removals using federal, state, local, and private resources and monitor loss and gain trends

What are some tools for addressing the challenges?

- Great Lakes Basin Landscape Ecology Metric Browser
- *WildLink* Program Helps Landowners Keep Space Open for Wildlife
- Great Lakes Basin Landscape Ecology Metric Browser

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Indicator #8 - Salmon and Trout
Lake Michigan Status: Mixed; Trend: Slightly Improving

Indicator #17 - Preyfish Population
Lake Michigan Status: Mixed; Trend: Deteriorating

Indicator #18 - Sea Lamprey
Status: Good/Fair; Trend: Improving

Indicator # 68 - Native Freshwater Mussels
Status: Not Assessed; Trend: Not Assessed

Indicator # 93 - Lake Trout
Lake Michigan Status: Poor; Trend: Declining

Indicator # 104 - Benthos diversity and Abundance - Aquatic Oligochaete Communities
Lake Michigan Status: Mixed; Trend: Unchanging; Deteriorating

Indicator # 109 - Phytoplankton Populations
Status: Mixed; Trend: Undetermined*

Indicator # 111 - Phosphorus Concentrations and Loadings
Lake Michigan Status: Open Lake - Good; Nearshore – Poor; Trend: Open Lake - Improving; Nearshore - Undetermined

Indicator # 116 - Zooplantkton Populations
Lake Michigan Status: Not Assessed; Trend: Undetermined (changing)

Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Status: Mixed; Trend: Improving (for PCBs; banned organochlorine pesticides; dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)

Indicator # 122 - Hexagenia
Lake Michigan Status: Poor; Trend: Undetermined

Indicator # 123 - Abundances of the Benthic Amphipod *Diporeia* spp.
Lake Michigan Status: Poor; Trend: Deteriorating

Indicator # 124 - External Anomaly Prevalence Index for Nearshore Fish
Status: Not Assessed; Trend: Not Assessed

Indicator # 125 - Status of Lake Sturgeon in the Great Lakes
Lake Michigan Status: Mixed; Trend: Improving and Undetermined

Indicator # 4504 - Wetland-Dependent Amphibian Diversity and Abundance
Lake Michigan Status: Poor; Trend: Unchanging

Indicator # 4507 - Wetland-Dependent Bird Diversity and Abundance
Lake Michigan Status: Mixed; Trend: Deteriorating

Indicator # 4510 - Coastal Wetland Area by Type
Status: Mixed; Trend: Deteriorating

Indicator # 4858 - Ice Duration on the Great Lakes
Status: Mixed; Trend: Deteriorating

Indicator # 4861 - Effect of Water Level Fluctuations
Status: Mixed; Trend: Not Assessed

Indicator # 4862 - Coastal Wetland Plant Community Health
Status: Mixed; Trend: Undetermined

Indicator # 4863 - Land Cover Adjacent to Coastal Wetlands
Status: Not Fully Assessed; Trend: Undetermined

Indicator # 7000 - Urban Density
Status: Mixed; Trend: Undetermined

Indicator # 7002 - Land Cover/Land Conversion
Lake Michigan Status: Mixed; Trend: Undetermined

Indicator # 7006 - Brownfields Redevelopment
Status: Mixed; Trend: Improving

Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed

Indicator # 7043 - Economic Prosperity
Status: Mixed; Trend: Not Assessed

Indicator # 7054 - Ground Surface Hardening
Status: Not Assessed; Trend: Not Assessed

Indicator # 7056 - Water Withdrawals
Status: Mixed; Trend: Unchanging

Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed

Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed

Indicator # 7100 - Natural Groundwater Quality and Human-Induced Changes
Status: Not Assessed; Trend: Not Assessed

Indicator # 7101 - Groundwater and Land: Use and Intensity
Status: Not Assessed; Trend: Not Assessed

Indicator # 7102 - Base Flow Due to Groundwater Discharge
Status: Mixed; Trend: Deteriorating

Indicator # 7103 - Groundwater Dependent Plant and Animal Communities
Status: Not Assessed; Trend: Not Assessed

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Alvers
Status: Mixed; Trend: Not Assessed

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Cobble Beaches
Status: Mixed; Trend: Deteriorating

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Islands
Status: Mixed; Trend: Undetermined

Indicator # 8129 - Area; Quality and Protection of Special Lakeshore Communities - Sand Dunes
Status: Not Assessed; Trend: Not Assessed

Indicator # 8131 - Extent of Hardened Shoreline
Status: Mixed; Trend: Deteriorating

Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving

Indicator # 8147 - Population Monitoring and Contamination Affecting the American Otter
Status: Mixed; Trend: Not Assessed

Indicator # 8164 - Biodiversity Conservation Sites
Status: Not Assessed; Trend: Undetermined

Indicator # 8500 - Forest Lands - Conservation of Biological Diversity
Status: Mixed; Trend: Undetermined

Indicator # 8501 - Forest Lands - Maintenance of Productive Capacity of Forest Ecosystems
Status: Not Assessed; Trend: Undetermined

Indicator # 8503 - Forest Lands - Conservation and Maintenance of Soil and Water Resources
Lake Michigan
Status: Mixed; Trend: Undetermined

Indicator # 9002 - Non-Native Species - Aquatic
Lake Michigan
Status: Poor; Trend: Deteriorating

Indicator # 9002 - Non-Native Species - Terrestrial
Status: **Not Assessed;** Trend: **Undetermined**

Background

Habitats in the Great Lakes basin are many and varied. This chapter discusses the status and challenges of aquatic, terrestrial, and animal habitats. Each faced challenges based on significant changes in land use, invasive species, pollution, and climate change.

Past LaMP Updates have detailed the elements that make up the Lake Michigan basin's many diverse ecosystems- from southern dune and swale to northern forest and the open lake's very significant aquatic food web. For LaMP 2008 we are presenting the lake by its 33 drainage basin watersheds. These watershed fact sheets contain information that resulted from a unique partnership with the Nature Conservancy's Great Lakes Program. They have provided us with the "headlines" of their very detailed work on Great Lakes biodiversity and the Natural Heritage Programs' data and for the first time broken down to the watershed level. Their complete work can be found at www.nature.org/greatlakes or contact them at greatlakes@tnc.org (see Chapter 12).

We are presenting details from the Great Lakes Fishery Commission's 2007 Lake Michigan Report on the aquatic food web and its stressors. We are also presenting an update on the efforts to protect and restore wetlands as called for by the Great Lakes Regional Collaboration. An estimated 65,000 acres of wetlands have been protected, improved and restored across the Great Lakes basin since December 2005 by federal agencies and their partners. This estimate was obtained from a data call to the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Natural Resources Conservation Service, U.S. Forest Service, National Oceanic and Atmospheric Administration and U.S. EPA that adopted reporting conventions of the Council of Environmental Quality's annual, national wetlands report. Agencies were asked to report 2006 and 2007 accomplishments for completed wetlands restoration projects only. The information is intended to provide an estimate of where Federal agencies and their partners are in contributing to the Great Lakes Regional Collaboration's goal of protecting and restoring 200,000 acres of wetlands across the basin.

The LaMP Habitat Committee responded to the GLRC target goals for the Great lakes basin by reviewing habitat losses and proposing to increase net wetlands by 125,000 acres for the Lake Michigan basin. Eighty-nine thousand of these acres would be in Michigan and 30,000 in Wisconsin. Illinois and Indiana have also committed to 1,000 acres each . Additional details are provided in LaMP 2006.

Threats to the Food Web Foundation

The plankton communities (microscopic plant and animals) of Lake Michigan are the foundation of the aquatic food web and therefore are one of the most critical components of the lake's ecosystem.

Monitoring the Benthic Community

The U.S. Environmental Protection Agency's Great Lakes National Program Office (GLNPO) is responsible for monitoring the benthic community health over time to identify any emerging water quality or food chain problems. Benthic organisms inhabit the bottom sediments of the Great Lakes and form an essential part of the food chain. The Research Vessel Peter L. Wise Lake Guardian is used to conduct the surveys. Diporeia, the formerly dominant benthic macroinvertebrate in offshore waters of the Great Lakes, decreased in abundance in southern Lake Michigan by 89%, 91% and 45% at sites at depths of < 30 m, 31-50 m, and 51-90 m between 1993 and 2002.

More information is available at: http://www.epa.gov/glnpo/monitor.html

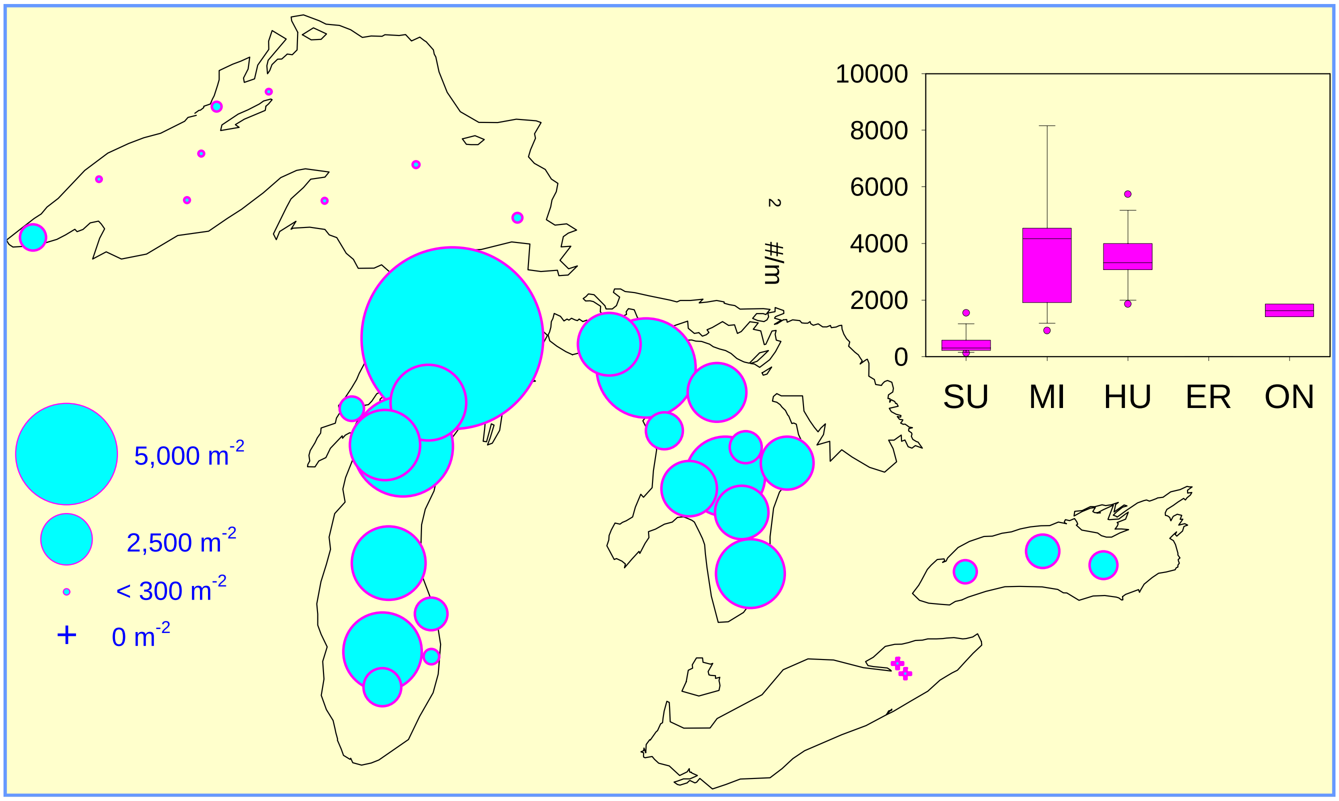


Figure 4-1. Diporeia density in the Great Lakes 1997

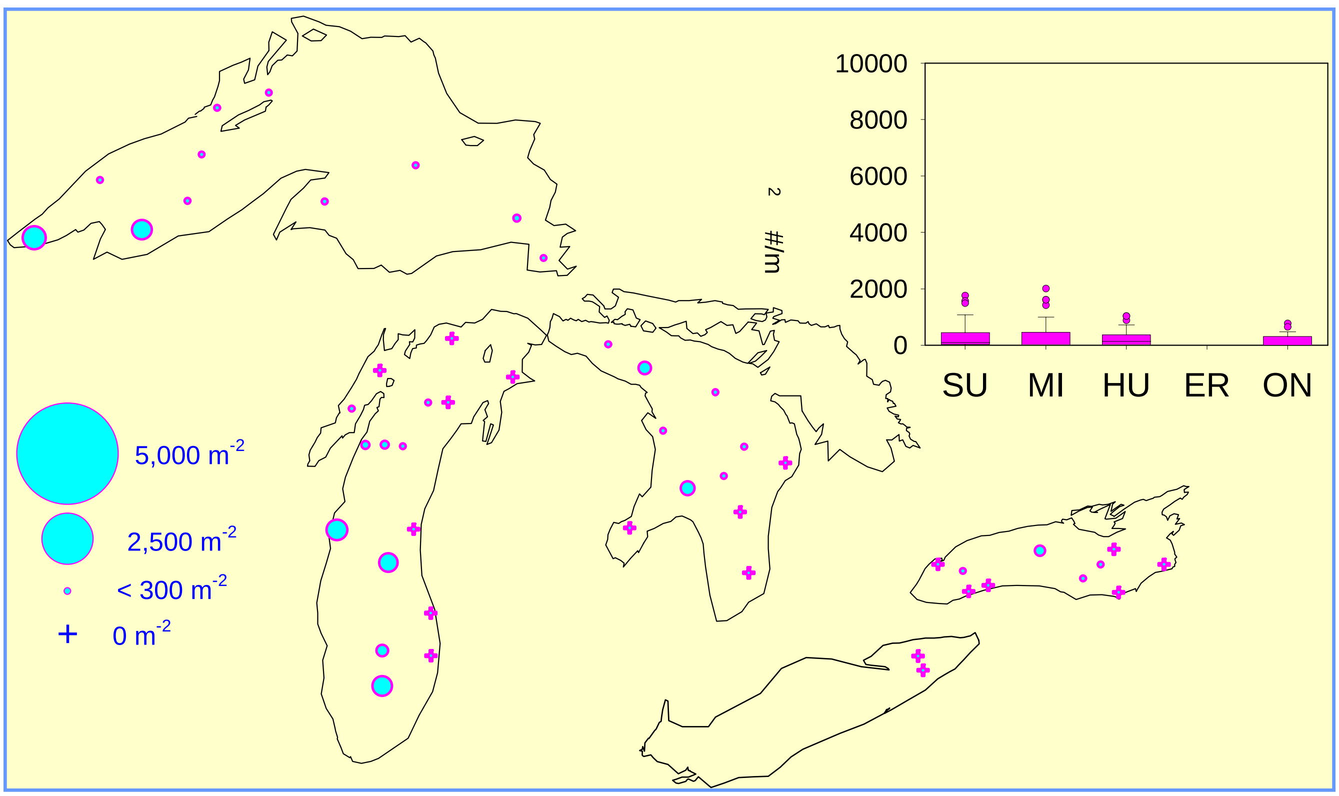


Figure 4-2. Diporeia density in the Great Lakes 2004

Source: David Rockwell, Environmental Scientist, MIRB-GLNPO; Dr. Richard Barbiero, Ph.D., Senior Environmental Scientist, CSC; Thomas Nalepa, Research Biologist, GLERL, NOAA; Dr. Mary D. Balcer, University of Wisconsin-Superior

Changes to these communities may be occurring due to the presence of contaminants and/or nutrients in the water, sediment, and increasing competition from invasive species such as the spiny water flea (*Bythotrephes cederstroemi*) and the zebra mussel (*Dreissena polymorpha*).

The abundance and types of phytoplankton are highly variable within the lake, depending on the time of year, area of the lake, and availability of phosphorus and other nutrients. They are generally found throughout the open lake waters to the depths of light penetration. The amount of phosphorus in the lake is an important man-induced change to phytoplankton communities, especially in nearshore areas. In addition, studies indicate that increased salinity and other (possible climate) environmental changes in Lake Michigan are enabling nonindigenous animals and algae to adapt more readily to the Great Lakes environment.

Zooplankton communities include many different invertebrates and comprise the bulk of the planktivorous fish diet. Because most zooplankton feed on phytoplankton, their abundance and geographic occurrence are similarly dependent upon water temperature, seasonal changes, and food availability. Zooplankton colonize open waters from the surface to the lakebed. Research conducted in the past 15 years indicates that zooplankton populations, such as *Daphnia*, may be experiencing changes induced by *Bythotrephes*, an exotic species.

The *Diporeia spp.*, also known as scuds, sideswimmers, beach hoppers, and sand fleas, belong to the group of invertebrates called amphipods and are about 0.5 inch long. *Diporeia* have inhabited Lake Michigan since the Great Lakes were formed 5,000 to 10,000 years ago, and they are environmentally sensitive, thriving only in clean, cold, well-oxygenated water. *Diporeia* are eaten by a variety of Great Lakes fish and provide an important energy source because they contain high amounts of fat.

***Diporeia spp.*,**
Photo courtesy of GLERL

The numbers and density of these amphipods is decreasing in Lake Michigan. The change between 1997 and 2004 is dramatic (see Figure 4-1 and 4-2). While scientists have not yet determined the exact cause of the disappearance of the amphipods, they suspect it is linked to the introduction of zebra mussels to Lake Michigan in 1989, severely limiting the food available to *Diporeia*.

In addition, zebra mussels appear to be having a significant impact on benthic (bottom-dwelling) community structures and plankton abundance. Zebra mussels, which can attach themselves to any hard surface in the lake, have reached densities higher than 16,000/m^2 in southern Lake Michigan. Negative impacts of their presence include increased food competition (at the expense of fish fry) for nearshore fish species (such as yellow perch), increased biomagnification of contaminants in fish eaters feeding on organisms that eat benthic organisms, and possible zebra mussel-induced mycrocystis blooms, which affect taste and odor in the water.

The Great Lakes National Program Office is supporting sampling activities aboard the Research Vessel Peter Wise Lake Guardian.

Fish Population Decreased in 2007

The quantity of fish food in Lake Michigan hit a record low for the second straight year in 2007. Data collected by the U.S. Geological Survey's Great Lakes Science center indicates that the volume of alewife, bloaters, and other small preyfish eaten by salmon, lake trout, and whitefish fell from 61 kilotons in 2006 to 30 kilotons in 2007. This is 92 percent below the 400 kilotons recorded in 1989.

There is speculation that this may be driven by the explosion of quagga mussels now found in Lake Michigan. Quagga mussels, an invasive species, now make up 98 percent of the mussels in Lake Michigan. Quagga mussels consume the plankton that are at the base of the food chain. Unlike zebra mussels, they can survive and thrive at lower depths. As the quagga mussel population has grown, the zebra mussel population has decreased.

The reduction in preyfish population is leaving less food for salmon and whitefish. The states that surround Lake Michigan stocked fewer salmon. There

Hersey Dam Removed in Muskegon River Watershed

The Hersey Dam, located at the confluence of the Hersey and Muskegon Rivers, was removed in 2007, restoring the natural course of the River. The river, which is a cold-water trout stream, now allows fish and other aquatic life in the lower Hersey and Muskegon rivers to move freely between the two waterways.

The first Hersey Dam was built a mile from where the Hersey flows into Muskegon River in 1858. The dam once powered a sawmill and grain mill, but it disrupted the river's natural flow, blocked fish passage, and increased water temperatures. The river is now a fast-flowing river. Willow trees have been planted on the banks to help provide shade to keep the temperature of the river cooler.

Two dams have been removed from the Muskegon River's main branch since the 1960s: the Newaygo Dam in 1969 and the Big Rapids Dam in 2001. Removal of the Newaygo Dam played a major role in the lower Muskegon River becoming the state's most productive salmon stream.

Sturgeon River Dam Removed

The dam site before removal

The dam site after removal

A Wisconsin Power and Light dam located on the Sturgeon River near Loretto was removed in its entirety in 2006 and the river brought back to its original grade. The penstock, power generating house and all electrical poles, wiring, and other associated items are gone. All of the concrete was removed and more than 80,000 cubic yards of sediment behind the dam and that collected in the slack water below for three years was disposed of in an adjacent upland swale and then topsoiled, seeded and mulched. This is among the largest dams completely removed in the State of Michigan.

is also speculation that the reduction in preyfish has been caused by too many salmon chasing too few preyfish.

Great Lakes Fishery Commission Lake Michigan 2007 Report and Environmental Objectives

Lake Michigan once supported the largest lake trout fishery in the world before lake trout were driven to extinction after the introduction of sea lamprey in the 1940s and 1950s, coupled with overfishing and habitat degradation. In the mid-1980s, two lake trout refuge areas were established in regions where the most productive native lake trout spawning habitats occurred in Lake Michigan. Stocking efforts were concentrated in these areas and regulations prohibited fishing for lake trout within these refuges. Stocking programs have successfully built lake trout spawning stocks to historic levels at which natural reproduction occurred; however, current spawning success has been very limited.

Lake Michigan has a number of offshore reefs which are mainly concentrated in the Northeastern and central regions. The widespread availability of deepwater reef habitats structured the historical fish community, which was predominantly deepwater species such as Lake trout, whitefish, and ciscos. However, with the extinction of native lake trout populations, today these reefs are not being utilized for spawning as much as they could be. The nearshore reefs in Lake Michigan are located along the northern, western and eastern shores as well as in Green Bay, and have been subjected to degradation by sedimentation and the invasion of exotic species. These reefs historically supported reproduction of lake trout, lake whitefish, yellow perch, walleye, and smallmouth bass. Man-made structures such as breakwalls, piers, industrial water intake and discharge structures, and artificial reefs also are utilized as spawning reefs (Fitzsimons 1995).

The 2000 Lake Michigan LaMP adopted the Great Lakes Fishery Commission Lake Michigan Environmental Objectives. For example:

- Benthivore Objective. *Maintain self-sustaining stocks of lake whitefish, round whitefish, sturgeon, suckers, and burbot. The expected annual yield of lake whitefish should be 1.8-2.7 million kg (4 to 6 million lb).*Lake whitefish spawn throughout Lake Michigan. Spawning reefs are located along the northwestern, northeastern and eastern shores with concentrations in Grand Traverse Bay, Beaver Island, Millecoquins Point and the Door County peninsula. Round whitefish spawning reefs are found in the northern half of the lake around the Manitou Islands, Grand Traverse Bay, Ludington, and the Door County peninsula.
- Physical/Chemical Habitat Objective. *Achieve no net loss of the productive capacity of habitat supporting Lake Michigan's fish communities. High priority should be given to the restoration*

States and Federal Government Develop New Plan for Lake Michigan Lake Trout

Michigan DNR, Wisconsin DNR, the Great Lakes Fishery Commission, and the U.S. Fish and Wildlife Service developed a revised plan for the lake trout in Lake Michigan. Over the past 40 years efforts to restore the lake trout populations in Lake Michigan have met with limited success due to inadequate levels of stocking, inappropriate stocking practices, excessive fishing mortality, and interactions between lake trout and native and non-native species. Based on an analysis of these impediments, the Lake Michigan lake trout plan was revised. The goals are to reestablish a diversity of lake trout populations composed predominantly of wild fish and sustain desirable fisheries. By 2035, the states plan to have wild fish comprise 75% or more of the population of age-10 and younger in specific deep and shallow-water habitats.

The plan shifts stocking to priority areas of limited geographic extent that have the best reproductive habitat and where fishing is minimized. In these limited areas, hatchery-reared fish will be concentrated to provide a sufficient density of adults for successful reproduction and to reestablish lake trout as a dominant local predator. Morphotypes introduced from Lake Superior into deep, offshore waters are expected to augment the population of lean lake trout in shallow water.

Continued control of fishing and increased control of sea lamprey populations are needed to achieve the population densities required for sustained natural reproduction. Assessment of progress towards achievement of the goal and the results will be reviewed annually and reported.

More information is available at: http://dnr.wi.gov/fish/lakemich/managementreports.htm.

and enhancement of historic riverine spawning and nursery areas for anadromous species. Nearshore spawning reef habitats are important to the reproductive success of lake trout, lake whitefish, yellow perch and walleye populations and offshore spawning reef habitats for lake trout in Lake Michigan. High quality reef habitats are required for natural reproduction of lake trout.

Degradation of water quality affects the biological productivity of Lake Michigan's ecosystem. Nutrification, sedimentation and contamination are functions of natural as well as human activities and contribute to changes in the food web. Land use changes, point and non-point discharges, and air emission deposition jeopardize the water quality of the lake.

Lake Trout
Courtesy of the Ontario Department of Fisheries and Oceans

The availability of nutrients in the water column plays an important role in the lower trophic level of the food web. Nutrients are necessary for regulating the planktonic communities and maintaining the lake's production. Increased nutrient levels can result in eutrophication leading to an unbalanced ecosystem. Increases in nutrients lead to an increase in aquatic plant and algae production, a depletion of the water's dissolved oxygen content resulting from plant decay and oxygen uptake during algal blooms. In addition, increased turbidity from algae reduces the amount of light penetrating the water and decreases the growth of submergent vegetation which can result in a loss of habitat for fish and other aquatic organisms.

Phosphorus has the greatest potential to affect the lake's ecosystem by acting as a catalyst for eutrophication. Regulation of phosphorus through decreasing point sources from major water treatment plants, and bans on phosphorus in detergents have been a successful management strategy to control eutrophication . Since 1981, phosphorus loadings in Lake Michigan have been below target loads set by the GLWQA of 5600 metric t/y , while chloride, nitrogen and silica concentrations increased from both increased loadings and biological cycling.

In **nearshore waters**, zebra mussels (and more recently quagga mussels) are thought to have changed the dynamics of phosphorus cycling and increased water clarity, which along with increased tributary loadings of phosphorus from agriculture and urban areas is stimulating blooms of Cladophora, a benthic algae. The consequences of algal blooms for fisheries are potential degradation of nearshore spawning and nursery habitat and harm to social concerns including tourism and angling nearshore.

Sedimentation of nearshore habitats is a water quality issue attributed to natural forces, but exacerbated by human activities. The expansion of urban development around the lake increases surface runoff and magnifies erosion in concentrated patterns. Agricultural practices such as tilling and overgrazing expose large areas of soil to wind and water erosion. Sedimentation can cloud water clarity, which reduces the growth of submerged aquatic vegetation, degrades fish spawning areas and food sources, and acts as a medium to transport and retain pollutants.

Contaminants in the lake basin pose serious threats to the health of the Lake Michigan ecosystem. The various activities occurring in the Lake Michigan basin such as urban, industrial and agricultural land uses have left a legacy of contaminants in the lake. The most severely degraded areas in the lake are identified as Areas of Concern (AOCs). The GLWQA defines AOCs as areas that fail to meet the objectives of the agreement including impaired beneficial use of the area's ability to support aquatic life.

Dams played a major role in the development of the Great lakes for lumber mills, hydroelectric power, navigation, and flood control. While thousands of the dams remain, many of the benefits they originally provided do not. As the original use is lost, so often is the funding source for maintenance. Sixty percent of dams are in private hands, 21 percent belong to local governments, and the rest to federal and state governments and utilities. Concern over aging dams as well as their acting as barriers to fish passage upstream highlighted the need to adapt dam management practices.

In the Great Lakes, the ability to identify linkages between climate, aquatic ecosystems, fish population dynamics and fisheries has improved tremendously

The Lake Michigan Toolbox
WildLink Program Helps Landowners Keep Space Open for Wildlife
Climate Change Adaptation

The WildLink Program is overseen by the Conservation Resource Alliance and assists volunteer land owners in managing private-property corridors used by wildlife for travel between one large parcel of land (such as state-owned wildlife areas) to another. Its aim is to preserve the rural character of northwestern Michigan for outdoor recreation, hunting and wildlife watching in natural surroundings.

Wild Link focuses on parcels which fall within ecological corridors, or pathways of habitat. These privately owned corridors provide the critical connections between larger protected public properties.

The program, funded by the U.S. Fish and Wildlife Service, assists land owners in outlining a five to ten-year voluntary program for developing or modifying land use in order to keep wildlife corridors open for animal movement which may become critical to survival in a future with climate change.

More information available at:
www.rivercare.org/wildlink/wildlink.php

The Lake Michigan Toolbox
Great Lakes Basin Landscape Ecology Metric Browser

USEPA designed a Great Lakes Basin Landscape Ecology Metric Browser. The principal focus of this project is the mapping and interpretation of landscape scale (i.e., broad scale) ecological metrics among hydrologic units and within 1 km, 5 km, and 10 km regions of coastal land in the Great Lakes Basin (GLB). Much is still unknown about the ecological relationships between human activities, surface water quality, and the biological characteristics with the GLB. This browser is an important step toward understanding the distribution of these phenomena and the analyses of their interrelationships.

The browser is designed to present some key ecological metrics to the GLB public and research communities at a landscape scale and will be updated as additional analyses are completed. For additional information regarding the topic of landscape ecology, visit the following web site: www.epa.gov/nerlesd1/land-sci/intro.htm. This is the initial presentation of landscape metrics for the GLB; for current applications of these metrics and results from other related topics in the Great Lakes, visit the following web site: www.epa.gov/nerlesd1/land-sci/wetlands.htm

through collaborative relationships and expertise between state and federal research and management agencies, and universities. The availability of extensive time series data on fish community abundances and harvests now permits characterization of natural variability and prediction of future climate impacts. Hydrodynamic circulation models now available for Lake Michigan permit understanding of how lake circulation patterns may retain or advect fish larvae away from favorable nursery areas, with implications for fish recruitment and movement. Studies of land-use patterns, watershed dynamics and fisheries habitat allow prediction of direct and indirect effects of climate change on tributary habitats and their adfluvial fish populations.

Information and Research Needs include:

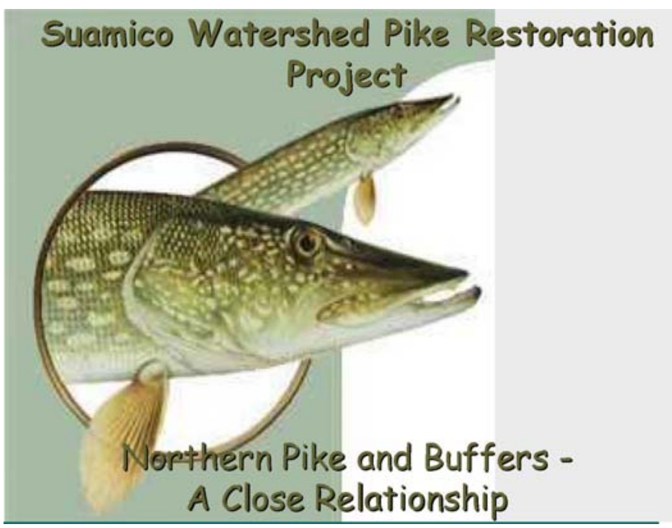
- Understand and predict climate change impacts on fish habitats, fish vital rates, and fisheries harvest over multiple spatial scales, ranging from tributaries to open-lake habitats, and incorporate that knowledge into fisheries management policies.
- Quantify historic natural population variability of young-of-year or yearling fish abundances on annual and decadal time scales, and relating the variability to historic climate patterns.
- Use regression and simulation models to predict climate change impacts on key lake fishes across multiple spatial scales.

Lake Sturgeon

Lake sturgeon, formerly a dominant nearshore species, continues to be the object of increased study and recovery effort. The previous state-of-the-lake report indentified at least eight known remnant populations, the largest spawning runs of several hundred fish and the smallest with few or unknown spawners annually. Several indications suggested lake wide abundance, though low, was increasing. Despite these positive signs, lake sturgeon continues to be considered rare, endangered, threatened, a species of greatest conservation need, or a resource

Suamico Watershed Pike Habitat Restoration Project

The intent of the Suamico Watershed Pike Habitat Restoration Project of the Brown County Land Conservation Department is to create, enhance or restore high quality spawning and rearing habitat for Northern Pike (a predator fish that resides in the Bay of Green Bay as an adult) as well as enhancing and protecting critical wetland habitat in an area where over 70% of such habitat has been lost. To accomplish this, the project will create approximately 12-14 acres of new spawning marshes capable of producing in excess of 20,000 young of the year Northern Pike per acre. The project plans to remove several major stream impediments in order to open access to an additional 3-4 miles of stream to spawning Pike. The project will establish buffers along shallow headwater streams which have been highly degraded by agricultural runoff creating sediment and nutrient related problems. Local and national conservation groups such as Ducks Unlimited, Trout Unlimited and the Nature Conservancy will promote the importance of the project on both a local and national level. The project will work to educate local government and citizens regarding the simplicity and effectiveness of vegetative buffers in protecting streams and will encourage local government to enact local ordinances for their perpetual protection.



conservation priority by one or more of the state, tribal, and/or federal agencies with responsibilities for the lake's fishes.

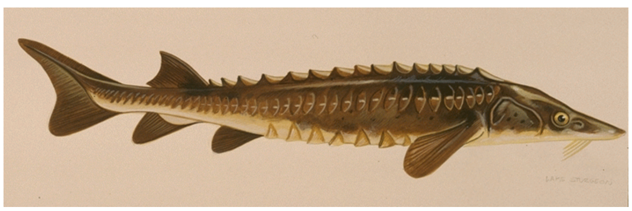
Recent mark-recapture estimates and direct counts indicate annual spawning runs of 199-577 adults in the lower Peshtigo River, 23-52 adults in the lower Manistee River, 24-49 adults in the lower Fox River, and 15-23 adults in the lower Muskegon River. Though spawning-run size in the lower Menominee River has not been estimated, the resident population during summer was estimated at 457-1,329 fish in 1991, and spawners are thought to number in the hundreds each spring. Gill-net assessments and sightings suggest that annual spawner abundance in the lower Oconto, lower Manistique, lower Grand, and lower Kalamazoo rivers is less than 25 fish per river. Sightings and sampling also suggest that adults may periodically spawn in the lower St. Joseph and Millecoquins rivers, and possibly on some shoals. Populations also persist in two sections upstream of dams on the Menominee River, in Indian Lake upstream of the lower dam on the Manistique River, and possibly upstream of the lower dam on the St. Joseph River. A large, self-sustaining population exists in the Lake Winnebago system upstream of the lower Fox River. Although fish from these systems can move downstream to Lake Michigan, they cannot return upstream beyond the first dam on each river.

Since 2000, production of sturgeon larvae has been documented in the lower Fox, Oconto, Peshtigo, Menominee, Manistee, Grand, and Muskegon rivers, and fall young-of-year (YOY) have been documented in the Menominee, Manistee, Oconto, and Peshtigo rivers. A single larvae has been collected in each of the St. Joseph and Kalamazoo rivers. The largest catches of drifting larvae and YOY have consistently come from the Peshtigo and Manistee rivers.

Populations of lake sturgeon are genetically structured, with differences occurring geographically. Sturgeon populations in the Menominee, Peshtigo, Oconto, lower Fox, and Wolf rivers, and all of Green Bay were genetically more similar to each other than to populations in the Manistee and Muskegon rivers, which in turn were more similar to each other than to populations in Lake Huron tributaries. Small populations do not lack genetic diversity nor do they exhibit higher levels of genetic drift or inbreeding compared to larger populations. The significant differences in allele frequency at microsatellite loci and in mitochondrial DNA among populations, including those in relatively close proximity, indicate that populations are reproductively isolated and that spawners exhibit a high degree of fidelity to their river of origin. Tag returns also indicate that spawners return to the same river repeatedly to reproduce.

Spawning populations are composed primarily of fish less than 35 years of age and 175-cm total length, although fish exceeding 50 yrs of age and 200 cm have been collected. As expected, sex ratios of spawning fish are highly skewed toward males, particularly in rivers with younger fish. Open-water assessments targetting all sizes of sturgeon are dominated by fish less than 1,000-mm TL and younger than 12 years, suggesting recruitment to spawning may improve. Observations of increased numbers of spawning fish in some tributaries, and reports of increased encounter rates by commercial and recreational fishers and in agency assessments, suggest recruitment has improved in at least some areas of the lake during the 1980s and 1990s. If true, spawner abundance in some rivers may continue to increase in the near future as juveniles reach maturity.

Recaptures of marked sturgeon from the open waters of central and southern Green Bay indicate a population (fish ≥122 cm) of 920-4,455 (95% CI). In a population of this size a loss of more than 100 adult fish/yr could be excessive. The recreational harvest in the lower Menominee River has increased steadily over the past 20 years, reaching a high of 150 fish (125-cm minimum length) registered during the 2003 season. While increasing harvest could be indicative of increasing abundance, effort also is increasing. Other sources of mortality are from injury of fish released alive by recreational and commercial fishermen and fish struck by boat propellers or killed when passing through or around hydropower facilities. Each summer since 2001, dead lake sturgeon have been reported washed up on beaches from numerous areas around the lake. As many as 21 fish were reported in 2003, primarily from central Green Bay. Other fish have been recovered near Michigan City, Indiana, and Manistee and Petoskey, Michigan. It is uncertain what proportion of this die-off is being observed or reported. At the time of recovery, no obvious cause of death has been apparent, but laboratory examination of fresh specimens recovered from Green Bay found enough ***Clostridium botulinum*** in ingested prey items to suspect type-E botulism. Similar die-offs in Lake Erie and Lake Ontario since 2000 have been associated with type-E botulism .



Lake Sturgeon
Figure Courtesy of the Ontario Department of Fisheries and Oceans

More Sturgeon than Thought Found in the Muskegon, Manistee, Grand, and Kalamazoo Rivers

Sturgeon have been in the planet's waters for 100 million years. The fish, which can grow to eight-feet long and weigh 300 pounds, were a dominant Great Lakes fish for thousands of years before the presence of logging, dam construction and excessive fishing eliminated about 99 percent of the fish from Lake Michigan and its tributaries.

Scientists estimate that there are between 1,000 and 3,000 sturgeon in Lake Michigan, down from 11 million thought to live in the lake in 1800. Biologists hope to restore its population by improving fish habitat in large rivers -- such as the Muskegon, Manistee, Grand and Kalamazoo — where sturgeon spawn and once were abundant.

Research by University of Georgia scientists indicated that there are far more juvenile sturgeon in the Muskegon River than previously believed.

Biologists from WDNR, MDNR and the USFWS have conducted regular surveys of the sturgeon population in the Menominee River for years, the largest population in Lake Michigan. WNDR has active management involving the harvest fishery and stocking in that system. Researchers from Purdue University and the University of Alaska working with USFWS and WNDR have conducted annual recruitment surveys of young sturgeon in the Peshtigo River from 2003-2007, indicating recent substantial annual production.

Annual spawner abundance is also monitored in each river where remnant populations persist (Fox, Oconto, Peshtigo, Menominee). The Manistee River, Michigan also has nearly a decade of good assessment data on adults and recruitment of young, and ongoing rehabilitation work.

Though sea lamprey-related mortality has not been quantified for sturgeon, eighty-two of 212 fish collected in 2003 from the open waters of Green Bay bore 128 marks. Type A-IV and B-IV (healed) marks were most common and amounted to 37 per 100 fish, indicating that sea lampreys commonly attached to sturgeon. Marking rates were 6 per 100 fish for AI-AIII marks, which indicate more recent attachments. The relationship between sea lamprey marking and mortality is currently being researched. The sensitivity of young lake sturgeon to the chemical TFM used to treat rivers for larval lamprey has led to the implementation in 1998 of a "sturgeon protocol" that reduces the concentration of TFM and defers treatments until after July 1 in rivers where YOY sturgeon are known or suspected to occur.

Management

Substantial portions of the sturgeon's historic spawning and rearing habitats are impounded or blocked by dams, and no effective passage exists around these barriers. Passage, however, is being designed into a replacement for the Manistique River dam and for several dams on the Menominee River. Passage for native fish species, including lake sturgeon, will also be provided as a condition of operation of a new barrier to be constructed on the Cedar River. Careful regulation of flow over dams and through hydropower facilities is also necessary to ensure that river segments below dams remain useable by sturgeon.

In 2000, recreational harvest of sturgeon from Lake Michigan waters was banned, except in the Menominee River where harvest from a fall recreational fishery was reduced by increasing the minimum size limit from 50 inches to 70 inches (TL) in even numbered years, creating essentially a catch-and-release fishery.

In 2004, the Little River Band of Ottawa Indians began on the Manistee River a long-term rearing program where wild-caught larvae are transferred into a streamside rearing facility for several months to enhance early survival and then released back, typically in late summer . The goal is to increase early survival while not diminishing imprinting to the river.

In 2003, the Wisconsin DNR initiated reintroduction of lake sturgeon into sections of the Milwaukee and Manitowoc rivers having an unimpeded connection to Lake Michigan. Hatchery-reared larvae from egg-takes in the Wolf River were stocked into the Manitowoc (N = 119,793) and Milwaukee (N = 64,000) rivers in the spring of 2003. In 2004, fingerlings (N = 2,000) and juveniles (N = 200) were stocked into the Milwaukee River, and will be stocked in both rivers in 2005. In addition, 6-8 adults were transferred from the Wolf River into the Milwaukee River in each of these years. Details of these stocking programs spurred significant debate among the agencies and institutions involved with lake sturgeon management and research. Concern focused on the need to maintain and ensure genetic diversity in Lake Michigan populations and on the potential risks posed to remnant populations if stocked fish were to stray and spawn in non-target rivers. In 2003, the LMC formed the Lake Michigan Lake Sturgeon Task Group

The Lake Michigan Toolbox
Milwaukee Pilot Project Offers Wetland Data Tools

In the last few decades, scientists have confirmed the critical role wetlands play in urban as well as rural areas. Not only do they provide habitat to a wide diversity of valuable plants and animals, wetlands reduce flooding, protect surface water quality, and provide scenic beauty and open space. Many of the wetlands in the Milwaukee River Basin have been destroyed, filled in, or drained to create farm fields, cities, and roads. The Milwaukee River Basin Wetlands Assessment Project seeks to understand the consequences of these losses and examine options for future planning. Questions the project will consider include: What wetland resources do we have left and how do they benefit us? Where can former wetlands be restored for the most benefit for people and wildlife in the basin?

The Milwaukee River Basin Wetlands Assessment Project is a pilot project that will develop tools to improve planning wherever wetland resources are a concern. It will provide governments, conservation organizations, and other decision makers tools to better understand where wetland restorations are most likely to improve habitat or water quality. These tools are a way of analyzing the relative level wetlands in small catchments provide wildlife habitat and water quality treatment (through sediment trapping/ nutrient) to protect downstream waters. They relate more to "ecosystem services" than to wetland biological integrity.

The project is spearheaded by the Wisconsin Department of Natural Resources through a grant from the U.S. Environmental Protection Agency. More information is available at: http://search.wi.gov/cs.html?url=http%3A//dnr.wi.gov/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf&charset=iso-8859-1&qt=url%3Adnr.wi.gov+%7C%7C+milwaukee+river+basin+wetlands+assessment+project&col=noquery+query&n=2&la=en

(LSTG) and charged it with reviewing stocking proposals and developing a rehabilitation plan for lake sturgeon. Initial work on this plan resulted in draft *Guidelines for Genetic Conservation, Propagation and Stocking of Lake Sturgeon in Lake Michigan*. The agencies agreed to follow these guidelines when stocking fish in the future and began work to develop streamside facilities as means of rearing lake sturgeon in a manner that all agencies could accept for stocking into the Milwaukee, Manitowoc, Cedar, and Whitefish rivers beginning in 2006.

Michigan DEQ Report Outlines Impacts of Beach Maintenance

A report released in March 2006 by the Michigan Department of Environmental Quality found negative impacts to coastal areas where "beach grooming" had occurred. The report, developed by a team of scientists from Michigan State University and Grand Valley State University, compared groomed beaches with similar, nearby natural beaches, allowing the researchers to measure how fish populations, other animals, and marsh plants are affected.

The study showed that clearing vegetation through a coastal marsh alters the chemical and physical conditions of nearshore waters, reducing or eliminating habitat for Michigan's important game fish including yellow perch, smallmouth bass, and largemouth bass.

According to the Michigan DNR, approximately 90% of the 200 fish species living in the Great Lakes rely on coastal wetlands during some part of their life cycle. The report found negative impacts to several important game fish including yellow perch, smallmouth bass, and largemouth bass. The study also found that beach grooming destroyed stands of important plants and helped invasive species colonize the groomed areas.

In light of this research, MDEQ Director Steven Chester has recommended to the Legislature that the provisions created through 2003 wetlands legislation be allowed to expire according to the sunset dates in the law.

More information is available at: www.michigan.gov/deq/0,1607,7-135-3313_3687-10202--,00.html.

Progress Towards Sustainability Recommendations for Fish

Lakewide abundance and distribution of lake sturgeon in Lake Michigan remains low and restricted compared to historic levels. Although some populations appear to be self sustaining and possibly increasing in abundance, the long-term status of other populations remains questionable. Research and assessment efforts during the last five years represent progress in meeting the fish community objective of maintaining self-sustaining stocks, but the objective of enhancing the lake-wide population will require a larger effort. Existing agency rehabilitation plans and the current draft of the LSTG rehabilitation plan provide additional objectives and strategies for maintaining and enhancing self-sustaining stocks of lake sturgeon. Specific strategies include inventorying populations and habitats so that areas for protection and rehabilitation can be prioritized; augmenting remnant populations and re-establishing others; determining effects of exotic species, contaminants, and diseases on lake sturgeon; and implementing public education. A long-term commitment of additional resources will be required to implement and evaluate these strategies. With the eventual approval of a lake sturgeon rehabilitation plan, it will be appropriate to incorporate more specific objectives and strategies for lake sturgeon into a future revision of the lake's fish community objectives.

Land Use Changes

The Lake Michigan basin is seeing changes in land use over the last several years. According to the National Land Cover database, land is used primarily for agriculture. However, according to the Coastal Change Analysis Program overseen by NOAA, development is encroaching on the farmland. Forest land has decreased by a small amount, but this decrease is being more than offset by an increase in tree farming as evidenced by an increase in shrubland. Wetlands saw a slight increase between 1996 an 2001, indicating that wetland restoration and protection programs have had an effect.

Wetland Restoration

Wetland restoration programs have seen a significant increase in activity. The Great Lakes Regional Collaboration set a goal of increasing the net acreage of wetlands Great Lakes basin-wide by 1.1 million by 2020. Michigan set a target acreage for its portion of the Lake Michigan basin at 89,750. Wisconsin has set a target statewide of an increase in 30,000 acres. Both states have developed programs that encourage wetlands restoration using state and private programs.

A wetland restoration project tracking database and pilot collection system maintained by NRCS, USFWS, and WDNR is working to help track wetland loss. This project involves collecting a uniform set of data to track wetland restoration projects done by the major organizations responsible for wetlands. The project also involves establishing a geospatial database that contains the tracking data. The objective in this project is to plug a major gap in reporting wetland "gains" achieved through voluntary restoration projects and to resolve the problem of double and triple counting the acres involved when these players

Charter Township of Garfield in Grand Traverse County, Michigan
Riparian Vegetative Buffers

The Garfield Township Planning Commission began examining riparian vegetative buffers based on recommendations in the Mitchell Creek Watershed Study. Vegetated buffers along streams and lakes provide widely recognized environmental benefits. After initial investigations by the Planning Commission the one hundred foot buffer recommendation of the Mitchell Creek Study was determined to be excessive in the context of Garfield Township's suburban landscape.

In March 2006 Garfield Township adopted a thirty five foot vegetative buffer requirement which provides maintenance of ground cover in its natural state, prohibits clear cutting of vegetation, and regulates fertilization of stream bank vegetation.

Existing - Lawns and grading near edges of creeks.

Preferred - natural state vegetative buffers provide full to partial shading, and woody materials contributing to the vegetative "tea" for a healthy fishery.

collaborate on a restoration project. Many wetland losses are not known because we have no way of accounting for illegal losses or loses which do not require a permit. The project will report wetland losses and gains that are captured through the wetland permit tracking and compensatory mitigation databases to generate an overall status report on known wetland activities.

Buffer Strips

Stream bank buffer strips not only provide buffers against nonpoint pollution, they also protect aquatic and stream bank habitat and provide for more natural flow of streams.

Well managed riparian buffers generally support larger populations of wildlife because the buffer provides many habitat requirements. In a stratified forest, different habitat zones exist vertically, including at the soil-air interface, intermediate zones, and at the canopy. Plants in these areas includes herbs and shrubs at lower levels, and intermediate height and taller trees which reach up to the canopy. Included with the leaf litter and rotting logs at the soil-water interface are insects. These organisms are a food source for reptiles, amphibians, small field mammals, and birds. The herbs and shrubs provide habitat for insects, birds, and mammals. The intermediate zone and the canopy serve as habitat for birds, bats, squirrels, opossums, and raccoons. Bird habitat may be highly stratified, and birds generally show a preference for certain layers that differ in habitat characteristics and food sources (See Chapter 7 for information).

The Great Lakes Regional Collaboration set goals for the Great Lakes basin at 1.1 million new acres of buffer strips. The states are beginning to set targets for buffer strips for Lake Michigan streams.

The Lake Michigan Toolbox
Buffer and Shoreline Protection Ordinances in Wisconsin

River Hills Buffers

The River Hills Committee on the Environment is working to restore and protect the riparian buffers which in turn restore and protect the quality of all Village waterways. The Village has had a buffer ordinance since 1973. Because riparian buffers are the single most effective protection for our water resources, it is vital that all residents support the preservation of riparian areas along the Milwaukee River and our other Village waterways.

To be most effective river buffers should include native vegetation and be as wide as possible. Riparian strips of native vegetation, shrubs, and trees filter polluted runoff and provide a transition zone between water and human land use. Buffers are also complex ecosystems that provide habitat and improve the stream communities they shelter. Natural riparian buffers have been lost in many places over the years. Restoring them will be an important step toward improving water quality, riverbank stability, wildlife, and the aesthetics of our waterways in River Hills.

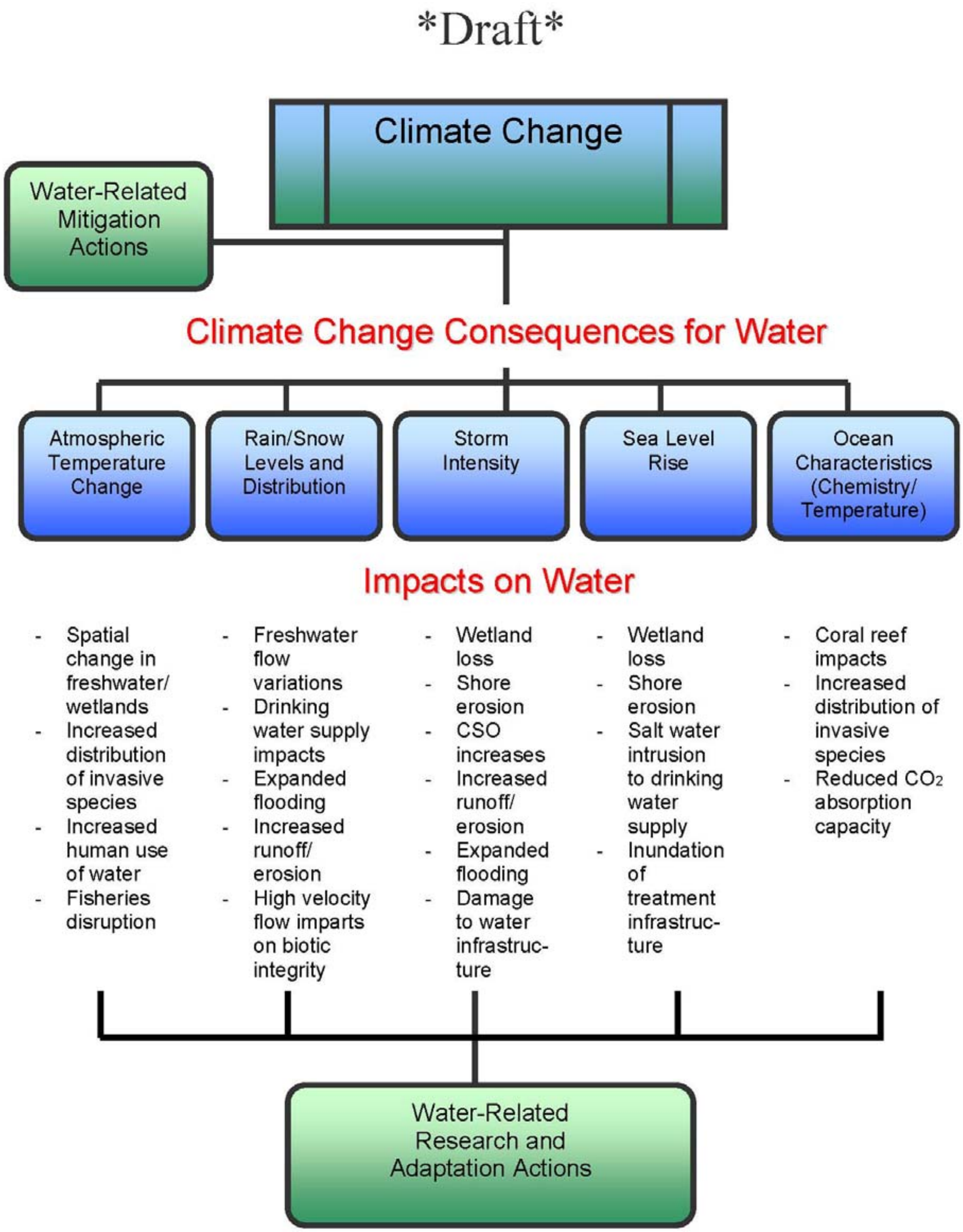
More information is available at www.riverhillswi.com.

Brown County Shorelands Ordinances

Brown County has two County Ordinances that include buffer strip requirements:

- Shorelands and wetlands ordinance (Chapter 22) (regulation can be used under this ordinance without cost share required and
- Agricultural shoreland management ordinance (Chapter 10) (regulation can only be used under this ordinance after cost share has been offered by the landowner)

More information is available at www.co.brown.wi.us/county_clerk/CountyCode/Chapter22.html and www.co.brown.wi.us/county_clerk/CountyCode/Chapter10.html.



DRAFT Chart: Consequences of Climate Change for Water from "Climate Change and the National Water Program" March 1, 2008 memorandum from USEPA Deputy Administrator Benjamin Grumbles to Office Directors: Office of Water, Water Division Directors: Regions 1 – 10 Great Waterbody Program Office Directors. More information is available at www.epa.gov/water/climatechange/.