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Conservation Guidelines for Michigan Lakes and Associated Natural Resources

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Abstract–The Michigan Department of Natural Resources, Fisheries and Wildlife divisions, have developed guidelines for protecting and restoring the natural resources of Michigan lakes. These guidelines follow the department's ecosystem-based approach to natural resource management that combines ecological, social, and economic considerations toward achieving the goal of conserving and sustaining natural resources. The guidelines were developed to support department staff in managing public trust lake resources, and also as reference information for other organizations and individuals interested in Michigan lakes. Background material provided includes descriptions of basic ecological features and processes of lakes, important natural resources including habitat requirements, and lists of aquatic plants, mollusks, crayfish, amphibians, reptiles, birds, and mammals that reside in Michigan lakes. Descriptions of stresses and threats to lake ecology include the cumulative effects of small modifications to habitats, artificial drainage, water quality and pollutants, dams and lake-level control, non-indigenous species, shoreline development, dredging and filling bottomlands, vegetation alteration, swimmer's itch control, and boating and shipping activities. The guidelines recommend a watershed approach for protection and management of ecosystem integrity and natural resources of lakes, with development of comprehensive resource assessments and management plans.

Introduction

The Michigan Department of Natural Resources (DNR) is responsible for managing fish and wildlife populations and their habitats, thus protecting the public trusts in these resources in Michigan. Among these resources, lakes are some of the most productive and biologically diverse ecosystems that exist. A vast array of aquatic organisms including plants, crayfish, fish, mollusks, and amphibians, as well as many reptiles, birds, and mammals, depend on lakes and their associated wetlands and uplands for survival. However, most lakes in Michigan, including the Great Lakes, have been subjected to

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significant biological and ecological changes as a result of human influences. These changes can degrade lake quality, resulting in losses of fish and wildlife species, lost recreational opportunities for citizens, and, ultimately, a lower quality of life for Michigan residents.

Michigan has an obligation to preserve and protect its resources as prescribed by Article 4, § 52 of the Michigan Constitution. The Michigan Legislature has implemented this constitutional mandate by establishing the Michigan Department of Natural Resources (Natural Resources and Environmental Protection Act, 1, Act 451, Part 5, § 324.501), and established duties for the department (Act 451, Part 5, § 324.503):

> The department shall protect and conserve the natural resources of this state; provide and develop facilities for outdoor recreation; …prevent and guard against the pollution of lakes and streams within the state and enforce all laws provided for that purpose with all authority granted by law; and foster and encourage the protection and propagation of game and fish. The department has the power and jurisdiction over the management, control, and disposition of all land under the public domain, except for those lands under the public domain that are managed by other state agencies to carry out their assigned duties and responsibilities.

Under the public trust doctrine, Michigan holds all fish, amphibians, reptiles, mussels, mammals, birds, and other wildlife in trust for the benefit of the people of Michigan.

There are many factors that the DNR must consider in fulfilling its obligations under the public trust doctrine. This is especially true for Michigan lakes. Human developments in and around lakes continue to increase and alterations to fish and wildlife habitat are also expanding. Both commercial and residential land uses are significant factors influencing lake management, including activities related to home and septic tank construction, dredging and filling of bottomland (including beach sanding), dock and marina construction, shipping on the Great Lakes and connecting waterways, artificial lake levels maintained by dams, and removal of vegetation within and around the lake. Michigan lakes are used by many recreational interests in addition to lakeshore property owners (riparians). Swimming, boating, sunbathing, relaxation, scuba diving, sightseeing, fishing, hunting, trapping, and wildlife viewing are some of the reasons people are attracted to lakes.

A goal of the DNR is to promote optimum recreational use of public trust resources for Michigan citizens. However, with such highly diverse interests and activities associated with Michigan lakes, this can be a difficult goal to reach. Lake alterations prescribed to improve one type of recreational use often reduce the system's ecological integrity or recreational opportunities for other users. Conservation of biodiversity and ecological integrity require planning and management when alterations are proposed to a lake system. A thorough knowledge of, and proper planning for lake resources management will help to insure that ecological integrity is conserved and that sustainable populations of fish and wildlife remain available for current and future generations of Michigan citizens.

Natural resource managers, regulators, and private citizens often have different viewpoints on lake conservation issues due to different training, experience, and personal values. The guidelines provided in this document were developed to assist lake stakeholders in understanding and incorporating the scientific principles of ecosystem management into decisions that will influence Michigan lakes. Stakeholders with varying interests must understand the importance of maintaining the ecological integrity of lakes and maintaining the natural diversity and abundance of plants and animals, while remembering that social needs and recreational pursuits are part of ecosystem management.

Information in this document: (1) identifies the general goals of the Michigan DNR fisheries and wildlife management programs, (2) provides a brief description of the ecosystem features of watersheds and lakes used in management assessments and planning, (3) reviews the most common stresses and threats to Michigan lakes, and (4) provides guidelines for resource conservation of lakes and associated wetland communities.

Natural Resources of Lakes and Management Considerations

The animal and plant resources associated with Michigan lakes are vast and provide significant recreational benefits, commercial benefits, and ecological services for the citizens of the state. In 2001, there were an estimated 16.6 and 0.6 million days of fishing and migratory bird hunting at lakes, with associated economic values of $712.3 million and $39.1 million (U.S. Department of the Interior 2002). An estimated 1.1 million people participated in wildlife viewing away from home (non-residential) and associated with a waterbody; this wildlife viewing had an estimated value of $276.4 million. These values do not include the many other recreational and commercial uses of lakes.

Fish, mammals, and birds are often the focus of natural resource users and management considerations. However, algae, higher aquatic plants (aquatic macrophytes), and numerous species of small animals form the base of the food chain, and the plants provide habitat necessary to support lake ecosystems. Many species of plants and animals found in lakes are severely reduced in abundance compared with historical levels. This trend suggests diminished ecological integrity of lakes and loss of biodiversity that may affect the continued viability of fish and wildlife species associated with Michigan lakes.

The Michigan Natural Features Inventory presently lists 2,279 higher plant species found in Michigan (Penskar et al. 2001). Approximately 41% of these may be found growing on water-saturated soils. Approximately 18% (499 obligate wetland species) have a greater than 99% probability of growing in water or on saturated soils (Appendix 1). The obligate wetland species include 38 non-indigenous species, 10 extirpated species, and 92 species that are threatened, endangered, or of special concern. Of the 499 obligate species, 141 species grow submerged in water or have floating-leaves, including 8 non-indigenous species, 2 extirpated species, and 24 species that are threatened, endangered, or of special concern. The remaining obligate species grow with part of the plant below the water and the remaining portion emerging above the water (emergent plants), or grow on saturated soils with no standing water.

Mollusks, crayfish, and fish live within the waters of lakes. Michigan has 121 species of mussels and snails that live in lakes including 10 non-indigenous species and 9 threatened, endangered, or special concern species (Appendix 2). There are 7 species of crayfish including one non-indigenous species (Appendix 3). Lakes in Michigan contain 154 species of fish, including 25 non-indigenous species and 23 species that are threatened, endangered, or of special concern (Appendix 4). Five species have been extirpated and are extinct.

Many amphibians, reptiles, birds, and mammals require or use Michigan lakes. Twenty-four species of amphibians (Appendix 5) and 25 species of reptiles (Appendix 6) use Michigan lakes, including 4 amphibian and 8 reptile species that are threatened, endangered, or of special concern. Birds (Appendix 7) and mammals (Appendix 8) may require lake environments all or part of the year. There are 87 species of birds and 19 species of mammals commonly associated with Michigan lakes.

The ecosystem-based approach to natural resources management combines ecological, social, and economic considerations toward achieving the goal of conserving and sustaining natural resources. This management process forms a comprehensive strategy aimed at protecting and enhancing

sustainability, diversity, and productivity of natural resources. The Ecological Society of America described eight elements of ecosystem management (Christensen et al. 1996a) that have been endorsed by the Michigan Department of Natural Resources:

1. Ecosystem management regards intergenerational sustainability as a precondition.
2. Ecosystem management establishes measurable goals for sustained resources.
3. Ecosystem management relies on research performed at all levels of ecological organization.
4. Ecosystem management recognizes that biological diversity and structural complexity strengthen ecosystems against disturbance and supply the genetic resources necessary to adapt to long-term change.
5. Ecosystem management avoids attempts to freeze ecosystems in a particular state of configuration, because change and evolution are an inherent component.
6. Ecosystem processes operate over a wide range of spatial and temporal scales, and their behavior is greatly influenced by surrounding systems. Thus, there is no single appropriate scale or time frame for management.
7. Ecosystem management values the active role of humans in achieving sustainable management goals.
8. Ecosystem management acknowledges that current knowledge of ecosystem functions are provisional and subject to change. Management approaches must be viewed as hypotheses to be tested by research and monitoring programs.

Listed below are several Department of Natural Resources general fisheries and wildlife goals important to management of lake resources in Michigan. These goals are included in the Strategic Plans for Fisheries and Wildlife divisions:

- Ensure that Michigan's fish and wildlife are managed to maintain viable populations within healthy, sustainable ecosystems.
- Provide a variety of opportunities for fishing, hunting, trapping, and other forms of related recreation, education, observation, and appreciation.
- Identify, restore, conserve, and protect natural communities and associated threatened and endangered species.
- Foster and contribute to public stewardship of natural resources through a scientific understanding of fish, fishing, and fisheries management.
- Provide information and educational assistance to enable people to understand and appreciate wildlife, wildlife habitats, natural resource management, and human-wildlife interactions.
- Continuously improve natural resources conservation through scientific research, employee education and training, open public participation, and responsive management.
- Help ensure that Michigan's natural resources are managed through a cooperative, ecosystem-based approach involving both public and private partners.
- Permit and encourage economically efficient and stable commercial fisheries that accommodate Native American fishing rights and do not conflict with recreational fisheries.

Other agencies have responsibilities associated with protecting natural resources in Michigan waters. These include several federal agencies and the Michigan Department of Environmental Quality. The federal government has regulatory authority over dredging and filling activities in federally navigable waters, generally including the Great Lakes, various rivers, and inland lakes connected to the Great Lakes. In 1994, many regulatory responsibilities of the Department of Natural Resources were transferred to the newly created Department of Environmental Quality under the Natural Resources and Environmental Protection Act, Public Act 451. Some of these responsibilities included regulation of surface water quality, dredging and filling activities in lakes and wetlands, and regulation of the aquatic nuisance control program (aquatic plants and swimmer's itch).

Part 309 of Public Act 451 allows the establishment of lake boards. With participation from local governing bodies, lake boards may make lake improvements. Lake improvements may be made in lakes or adjacent wetlands, and lake boards may take steps necessary to remove undesirable accumulated materials from the bottom of a lake or wetland by dredging, ditching, digging, or related work. Special assessment districts can be established to provide funding for lake improvement projects. Part 307 of Public Act 451 allows a county board to petition the court to establish an artificial, regulated inland lake-level (create a dam). Special assessment districts may be established to provide funding for normal inland lake-level projects.

Other stakeholder groups also affect or influence natural resource management of Michigan lakes. Typical groups include watershed councils, fishing and hunting organizations, environmental groups, and lake associations.

Characteristics of Michigan lakes

Michigan lakes vary in size from the very large Great Lakes to very small bodies of water. Some may contain water only periodically, such as vernal ponds. Some lakes are isolated, having no tributaries or outlet streams, with small watersheds. Lakes with tributary streams generally have larger watersheds, some of which encompass the largest river watersheds in the state. The Great Lakes collect all tributaries of the state and have very extensive watersheds.

Michigan's political boundary encompasses an area of 96,791 mi^2 (Sommers 1977), with roughly 40% (38,575 mi^2) covered by the Great Lakes, and over 1,300 mi^2 (1.3%) covered by inland lakes. There are 62,798 inland lakes with a surface area of at least 0.1 acres or larger, 1,148 lakes exceeding 100 acres, 98 lakes exceeding 1,000 acres, and 10 lakes over 10,000 acres (Breck 2004). Houghton Lake is the largest inland lake in the state, encompassing 20,044 acres. The Great Lakes rank among the 15 largest lakes in the world and contain about one-fifth of the world's supply of fresh water. The Great Lakes contain 95% of the surface freshwater in the United States. Lake Superior is the largest of the Great Lakes with a maximum depth of 1,333 feet and it contains over 50% of the water in the Great Lakes (Michigan State University 1987).

This document focuses on lakes and areas immediately adjacent to lakes (riparian areas). Various ecological zones are typically used to describe areas within and adjacent to lakes. Each zone provides habitat (or partial habitat) for many organisms. These zones include the pelagial, profundal, littoral, and the upland portions of the lake's watershed (Figure 1). The pelagial zone is the open water area of the lake. The profundal zone lies below the pelagial zone and includes the bottom area where rooted plants do not grow. The littoral zone delineates the area of the lake where rooted aquatic plants (macrophytes) grow (maximum of 5–25 feet deep depending on the lake) shoreward to where the land is unaffected by lake water at the high water mark. The lake's watershed may contain various types of wetlands, other lakes, groundwater sources, and tributary streams. The shoreline or riparian area of a lake is a transition zone between the lake and uplands, and is also referred to as the shoreline ecotone. All of these zones include habitat components for organisms dependent on the lake to survive or reproduce.

Lakes form in many ways and their geomorphology plays a significant role in the ecological functioning of individual systems. The study of lake features, such as the shape of the basin and type of sediment on the bottom, is known as lake morphology. Much of the way a lake functions, including its recreational potential, can be deduced from the lake's morphology. Most of the natural lake depressions in Michigan resulted from glacial activity. Many are called "kettle" lakes, formed by the melting of remnant blocks of ice that had been buried in glacial till deposits. Some formed from glacial scouring. A relatively small number of lakes, known as "karst" lakes, were formed by the dissolution of sedimentary rock. Some natural impoundments were formed by earth movements blocking stream channels. Beaver continue to create and abandon many small impoundments on

streams, especially across the northern two-thirds of the state. Humans have formed many unnatural impoundments and reservoirs through purposeful damming of rivers. Reservoirs, by definition, have 50% or greater of their maximum depth maintained by a man-made dam. It is important to understand the processes that formed the lake in order to deduce how the lake and surrounding landscape should function.

Glacial terrain is characterized by a landscape of hills and depressions. Lakes can be present in many different parts of the landscape and can have complex surface and ground-water flow systems associated with them. Although rivers often drain parts of these landscapes, many areas of glacial terrain do not contribute runoff to rivers. Instead, surface runoff from precipitation falling on the landscape accumulates in these depressions, contributing to the presence of a lake. Because of the lack of stream outlets, the water balance of these "closed" types of lakes and wetlands is controlled largely by precipitation, evaporation, and ground water. The interaction between a lake and its ground water supply usually cannot be observed and is therefore more difficult to understand. It is determined to a large extent by the lake's position with respect to local and regional ground-water flow systems. Lakes interact with ground water in three basic ways: some receive ground-water inflow throughout their entire bed; some have seepage loss to ground water throughout their entire bed; but perhaps most lakes receive groundwater inflow through part of their bed and have seepage loss to ground water through other parts. Lake sediments often have significant organic, relatively impermeable deposits that affect the exchanges of water, minerals, and nutrients.

Bathymetric maps provide details about the terrain, or shape, of the lake's underwater landscape. A bathymetric map can be used to calculate several measurements that are crucial to understanding how the lake system functions, including surface area, volume, maximum length, mean width, maximum width, mean depth, maximum depth, shoreline length, shoreline development, slope of the bottom, and proportion of the basin in littoral and profundal zones.

Surface area is one of the most important morphological parameters of a lake because it not only describes the size of a lake, but also plays a major role in lake function. Bottom slope helps in predicting how a lake's surface area will be affected with changing water levels. Lake surface area can also be used to help predict the potential effects of wind on a lake. In general, lakes with more surface area are subject to larger waves during windy conditions which can result in extensive shore erosion. This is significant because larger waves have the ability to mix water at greater depths, in some instances reaching all the way to the bottom of the lake. The ability to create mixing at the bottom of a lake is extremely important because it can result in the re-suspension of sediments and the disturbance of submersed aquatic plants. Thermal stratification can also be prevented, affecting the level of oxygen present in bottom waters. As a result, other lake characteristics, such as water clarity and the availability of nutrients, can be affected.

Shoreline development refers to the length of a lake's shoreline relative to the length of the circumference of a circle of area equal to that of the lake. In other words, lakes with longer, irregularly shaped shorelines are considered to have more shoreline development, while circular lakes are considered to have less. (The use of the term development here does not refer to such human developments as cottages or seawalls, but rather to the shape of a lake's shoreline). Determining a lake's shoreline development is important because it reflects the potential for greater development of littoral communities in proportion to the surface of the lake. A greater amount of natural shoreline development provides more interface between the water and surrounding land (i.e., coves and peninsulas), often translating into more habitat for fish, birds, and other wildlife to raise their young. Irregular shorelines also absorb more wave energy and provide better substrates for plant growth.

Maximum length and width measurements are also important because they can be used to determine fetch, or the distance that wind can travel over water before intersecting a landmass. Fetch distances

can be used to predict the depth at which wave energy extends below the water's surface since the greater the fetch distance, the greater potential there is for large waves. Longer fetch and higher wind speed both create greater wavelengths and wave heights. The depth of wave impact can be estimated from the fetch distance and wind speed.

Large beds of aquatic plants can also alter sedimentation patterns in a lake in several ways. The plants themselves greatly reduce the amount of turbulence within the plant beds, resulting in an accumulation of fine particles in shallow areas that are dominated by plants. This can happen even though there may be deep areas within the lake. Plant beds can moderate the development of waves in a lake. Thus, shallow lakes filled with plants may not develop large waves and the fine sediments will be protected from re-suspension. Such plant-dominated lakes tend to appear clear due to a lack of turbulence that would otherwise keep fine particles and algae in suspension. Aquatic plants can significantly reduce erosion of the shoreline by waves.

The terms lacustrine and lentic are also used to describe lakes or water bodies that have still waters. Shallow lakes include basins that have never been preceded by a larger, deeper lake, and those basins that represent the terminal stages of deep lakes that have filled with sediment. Shallow water bodies can be separated into those that are permanent, containing some water at all times of the year, and those that are temporary, in which the basin periodically has no standing water (Wetzel 1975; Figure 2). Vernal lake, swamp, marsh (fen), bog, mire (bog or fen), and wetland are terms that have been used to describe shallow lakes or the shallow portions of lakes.

Wetlands have received significant attention in natural resource disciplines during recent years because of their importance to the ecological integrity of natural systems, and the significant losses of wetlands that have occurred through artificial drainage and filling activities. Classifications of wetlands have been made to aid in inventory, evaluation, and management (Cowardin et al. 1979). The broadest classification includes five systems: marine, estuarine, riverine, lacustrine, and palustrine. Only the latter three apply in Michigan. Numerous subsystems, classes, subclasses, and dominance types are used in classifying wetlands. Generally, wetland types are classified using floral characteristics, composition of substrate, water regime, and water chemistry. There are also specific legal definitions of wetlands for regulatory purposes. The portion of a lake that typically is referred to as a wetland includes the areas of the littoral zone containing emergent vegetation, normally at depths of 5 feet or less. The remaining portions are referred to as "deepwater habitats" in wetland classification systems, although the term "submerged wetland" is sometimes used to describe the portion of the littoral zone with submerged plants. Lakes always contain some wetlands, and sometimes lakes are entirely wetlands when emergent vegetation grows throughout the lake. In lacustrine systems, wetlands are often significantly affected by human development. This occurs because wetlands predominantly occur along the shoreline where most development occurs.