Lake Michigan wetlands: classification, concerns, and management opportunities

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Introduction

The wetlands that border Lake Michigan are an extremely important component of the lake ecosystem. Wetlands are considered to be among the most productive and ecologically diverse habitats on earth, with attributes of both upland and aquatic ecosystems. Although wetlands comprise only a small fraction of the total area of Lake Michigan, they provide habitat for thousands of species of plants and animals and perform environmental functions that affect the whole lake (Wilcox, 1995; Environment Canada, 2002). However, unlike open waters of the lake that have been studied for nearly a century, wetlands have been studied for only a few decades. The numerous forms of degradation and assault on wetland resources have been documented, but few are understood thoroughly. Management of wetlands and the problems they face has thus not progressed quickly, and debates still occur regarding descriptions of wetlands. In this paper, I will review the status of wetland classifications used for Lake Michigan and the other Great Lakes, as well as the major management concerns and opportunities presented by Lake Michigan wetlands.

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Classification of wetlands

Wetlands in the Great Lakes basin can be classified into several general categories: marshes, swamps, and peatlands. They each have widely accepted definitions. Marshes are periodically or continually flooded wetlands characterized by non-woody emergent vegetation that is adapted to living in shallow water or moisture-saturated soils. Swamps are wetlands dominated by trees or shrubs that occur in a variety of flooding regimes, with standing water present during most or just a small part of the year. Peatlands are wetlands in which plants are produced faster than they can decay and partially decomposed plant material (peat) accumulates.

Great Lakes coastal wetlands differ from inland wetlands in that they are shaped by large lake processes, including waves, wind tides (seiches), and especially long- and short-term fluctuations in water levels. Since most woody vegetation cannot tolerate the flooding regimes of the Great Lakes, swamps in coastal areas usually occur at elevations above the influence of lake levels or in basins isolated from the lake. Some woody vegetation may invade marshes during extended low water phases of the lakes but dies during high water years. Peatlands may be found in coastal areas on Lake Superior and in northern portions of lakes Michigan and Huron. Peatlands are generally found above or isolated from the influence of lake also, but in some areas, they may form floating mats that adapt to lake-level changes. Because marsh vegetation can tolerate water-level changes and often requires these changes to maintain diversity, marshes are easily the most common type of coastal wetland in the Great Lakes.

Great Lakes wetlands can also be classified based on geomorphological setting, which reflects the influence of lake processes, especially exposure to waves. Such a classification system was developed during early studies related to lake-level fluctuations and Great Lakes wetlands (ILERSB, 1981). The eight classification categories included open shoreline, unrestricted bay, shallow sloping beach, river delta, restricted riverine, lake-connected inland, barrier beach, and diked (Figure 1). However, some of these categories share similarities, and they can intergrade or occur in hybridized complexes, such as a restricted riverine wetland discharging into a lake-connected wetland. Keough et al. (1999) recognized the common features of wetland geomorphic types across this continuum and grouped them into three broad categories based on physical and hydrologic characteristics: open coast wetlands, drowned-river-mouth and flooded delta wetlands, and protected wetlands (Figure 2). Further discussions among wetland scientists working in the Great Lakes (D. Albert, J. Ingram, T. Thompson, and D. Wilcox) resulted in agreement on a means to combine features of these two approaches to classifying wetlands. The new classification system contains three broad categories (lacustrine, riverine, and barrier-protected), each based on the modern-day, predominant hydrologic influence on the wetland, and then further

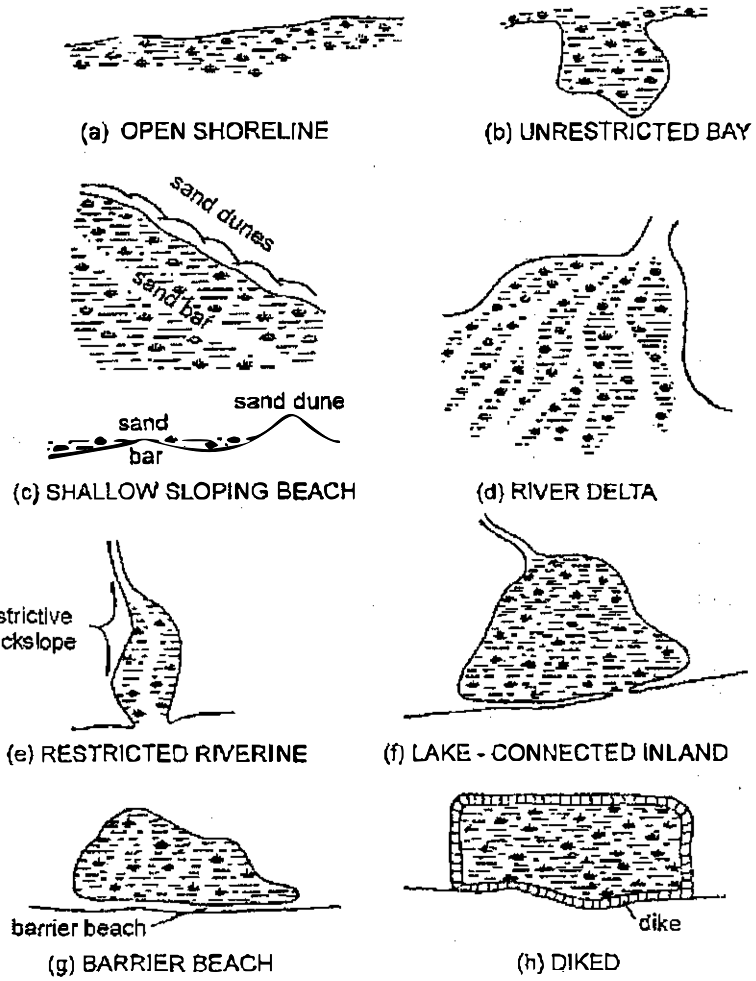

Fig. 1. Geomorphological setting of Great Lakes coastal wetlands as described by the International Lake Erie Regulation Study Board (ILERSB, 1981).

classifies each category based on geomorphic features and shoreline processes, as summarized below (Environment Canada, 2002).

Lacustrine (lake-influenced) wetlands are controlled directly by waters of the Great Lakes and are strongly affected by lake-level fluctuations, nearshore currents, seiches, and ice scour. Geomorphic formations along the shoreline provide varying degrees of protection from coastal processes, which leads this class to be subdivided into open lacustrine (open shoreline, open embayment) and protected lacustrine (protected embayment, sand-spit embayment) wetlands.

Riverine (river-influenced) wetlands occur in rivers and creeks that flow into or between the Great Lakes. They can be subdivided into drowned-river-mouth (open, barred) wetlands, connecting channel wetlands, and delta wetlands based on the landscape and geographic position of each wetland. The water quality, flow rate, and sediment input in tributary drowned-river-mouth wetlands are controlled in large part by their individual drainages. However, water levels and fluvial

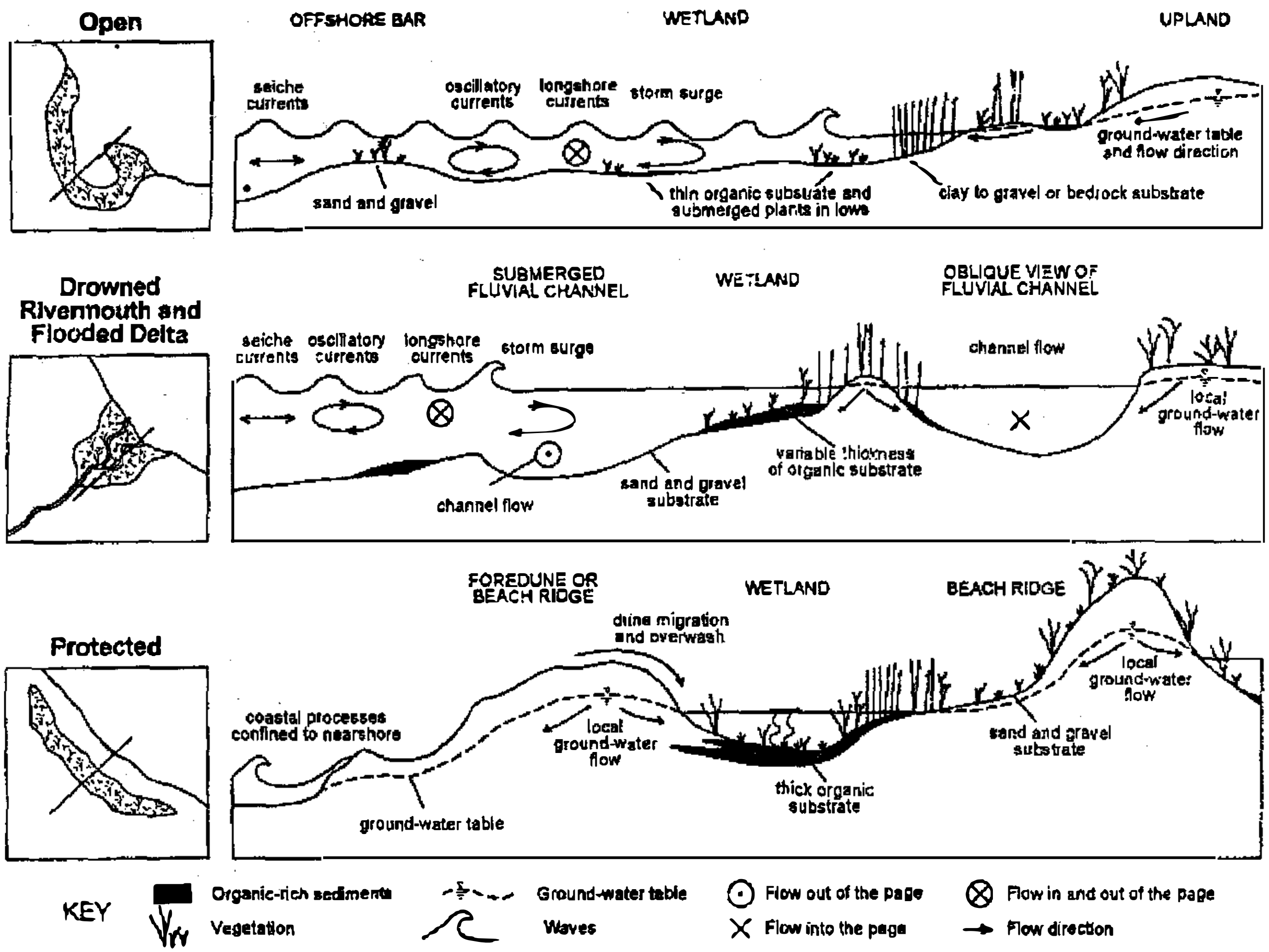

Fig. 2. A continuum of hydrogeomorphic types of Great Lakes wetlands: open coastal, drowned river mouth and flooded delta, and protected, as described by Keough et al. (1999), with illustrations of various physical and hydrologic processes shown as general profiles (not to scale). Specific sites may have features of more than one type.

processes in these wetlands are determined by the Great Lakes because lake waters flood back into the lower portions of the drainage system. Protection from wave attack is provided in the river channels. Riverine wetlands within the Great Lakes also include those wetlands found along large connecting channels between the Great Lakes and the extensive delta wetlands at the mouth of the St. Clair River.

Barrier-Protected wetlands may have originated from either coastal or fluvial processes. However, due to coastal processes, the wetlands have become separated from the Great Lakes by a barrier beach (barrier beach lagoon) or a series of beach ridges (swale complexes). These wetlands are protected from wave action but may be periodically connected directly to the lake by a channel crossing the barrier. When connected to the lake, water levels in these wetlands are determined by lake levels, while during isolation from the lake, ground water and surface drainage to the basin of the individual wetland provides the dominant source of water input. Inlets to protected wetlands may be permanent or temporary due to nearshore processes that can close off the inlet from the lake.

Most of the geomorphic wetland types occur in Lake Michigan, some in greater numbers than others. Examples include the following sites that are shown in Figure 3 with an inventory of other wetlands 16 hectares (40 acres) or more in area (Table 1) (Hoagman, 1997): Open Shoreline Lacustrine – Trails End Bay (#2), Big Stone Bay (#3); Open Embayment Lacustrine – Ogantz Bay (#96), Big Bay de Noc (#98); Protected Embayment Lacustrine – North Bay (#60), Epoufette Bay (#91); Sand-Spit Embayment Lacustrine – Little Tail Point (#78), Portage Bay (#86); Open Drowned River-Mouth Riverine – Pigeon River (#41), Mink River (Rowley Bay) (#61), Sturgeon River (#97); Barred Drowned River-Mouth Riverine – Betsie River (#21), Manistee River (#24), Pere Marquette River (#33), Pentwater River (#35), Muskegon River (#39); Delta Riverine – Oconto River (#81), Peshtigo River (#82); Barrier Beach Lagoon Barrier Protected – Arcadia Lake (#22), Bar Lake (#23); and Swale Complex Barrier Protected – Sturgeon Bay embayment (#4), Calumet dunes region (#47), Baileys Harbor embayment (#57), Thompson/Manistique embayment (#105), Seul Choix Bay embayment (#106), Pointe aux Chenes embayment (#116).

Management problems and restoration options associated with Lake Michigan wetlands

Drainage

Ditches are often constructed in an attempt to drain wetlands for agricultural, urban, or industrial land uses. In extreme cases and at higher elevations, wetlands

Table 1. List of selected coastal wetlands of Lake Michigan over 16 ha in area (modified from Herdendorf et al. (1981) and Hoagman (1998).

No.	Name of Wetland	Hectares	No.	Name of Wetland	Hectares	No.	Name of Wetland	Hectares
1	Mackinaw City	56	40	Little Pigeon Creek	17	79	Charles Pond Area Complex	69
2	Trails End Bay	149	41	Pigeon River	36	80	Pensaukee River Complex	198
3	Big Stone Pond	75	42	Macatawa River	27	81	Oconto Marsh	3792
4	Little Sucker Creek	105	43	Black River	28	82	Peshtigo River	2040
5	McGeach Creek	216	44	Grand Mere Lakes Complex	103	83	Cedar River Complex	630
6	Whisky Creek	232	45	Galien River	178	84	Henderson Lakes	102
7	Banks Township Complex	35	46	Indiana Dunes	163	85	Ford River Complex	157
8	Torch Lake Township #3	260	47	Lake Calumet Complex	428	86	Portage Marsh	527
9	Milton Township #2	91	48	Illinois Beach State Park Complex	847	87	Escanaba City	20
10	Paradine Creek	35	49	Point Beach State Forest	603	88	Whitefish River Complex	259
11	Traverse City Complex	74	50	Carlton Township	16	89	Squaw Point	295
12	Bowers Harbor	28	51	Kewaunee River Complex	146	90	Deepwater Point Complex	107
13	Lee Point	24	52	Threemile Creek	65	91	Peninsula Point	23
14	Suttons Bay	42	53	Rocky Point Complex	563	92	Wedens Bay	20
15	Good Harbor Bay #1	36	54	Lilly Bay	170	93	Granskog Creek Complex	295
16	Good Harbor Bay #2	67	55	Whitefish Bay Complex	62	94	Sand Bay Complex	73
17	Port Oneida	110	56	Kangaroo Lake Complex	66	95	Martin Bay Complex	208
18	North Manitou Island Complex	28	57	Baileys Harbor-Ephraim Swamp	2044	96	Ogontz Bay Complex	712
19	Beaver Island Complex (North)	31	58	Toft Point	40	97	Sturgeon River	2710
20	Beaver Island Complex (South)	1495	59	Cana Island Complex	32	98	Big Bay De Noc Complex	3867
21	Betsie River	154	60	North Bay	870	99	South River Bay	45
22	Arcadia Lake	146	61	Rowley Bay Complex	219	100	Sucker Lake	118
23	Bar Lake Complex	480	62	Europe Lake Complex	33	101	Portage Bay Complex	432
24	Manistee River	3705	63	Washington Island Complex	109	102	Delta County Border	43
25	Little Manistee River	98	64	Sister Bay	24	103	Point O'Keefe Complex	43
26	Filer/Grant Townships	59	65	Tennison Bay	24	104	Little Harbor Complex	56
27	Big Sable Point	28	66	Juddville Bay	32	105	Stony Point Area	1762
28	Rupert Bayou	110	67	Horseshoe Point Complex	110	106	Seul Choix Point Complex	2361
29	Big Sable River	142	68	Egg Harbor Township	53	107	Seiners Point Complex	23
30	Hamlin Lake Complex	43	69	Sand Bay Area	49	108	Point Patterson Complex	599
31	North Bayou	71	70	Sand Bay Complex	28	109	McNeil Creek	149
32	Piney Ridge Area	43	71	Little Sturgeon Bay Complex	127	110	Garfield Township Complex	82
33	Pere Marquette River	2532	72	Keyes Creek	28	111	Lower Millecoquins River Area	42
34	Bass Lake Complex	67	73	Point au Sable	45	112	Millecoquins Point Complex	35
35	Pentwater River	110	74	Whitney Slough	185	113	Mattix Creek	594
36	Stony Creek	157	75	Atkinson Marsh Complex	206	114	Pacquin Creek	168
37	Flower Creek	32	76	Dead Horse Bay Complex	130	115	Epoufette Complex	37
38	White River	1579	77	Long Tail Point Complex	66	116	Pointe Aux Chenes Complex	1229
39	Muskegon River	2449	78	Little Tail Point Complex	85	117	West Moran Bay	522

may be completely lost. However, many lake-connected wetlands have also been ditched in failed attempts at land-use conversion. Examples on Lake Michigan include the lower reaches of the Betsie River (Figure 3; #21) and Arcadia Lake (Figure 3; #22). During higher lake-level stages, these ditches are at lake level and no dewatering occurs; however, the channels they create change the character of wetland habitat and likely alter flow paths of water through the wetland. During lower lake-level stages, the ditches may cause localized reductions in the water table and thus alter habitat conditions. In addition, spoil banks created when the ditches were constructed present localized areas of higher elevation and may be sites for colonization by invasive plant species.

Wetlands drained by ditching can be addressed by filling in the ditches, blocking them at their outlets, and redirecting flow away from them. However, these actions must be handled carefully because they can involve both surface and ground water, may affect upstream lands in private ownership, and may not result in pre-ditching conditions due to burning or subsidence of dried wetland sediments or potential loss of the pre-ditching seed bank (Wilcox and Whillans, 1999).

Filling and dredging

Prior to enactment of wetland protection laws, wetlands were sometimes used for landfills, filled to create upland for development, and dredged to create marinas, harbors, and boating channels. These types of actions virtually eliminate wetlands. Examples of wetland landfills in Lake Michigan include portions of the lower Little Manistee River (Figure 3; #25) and the lower Pere Marquette River (Figure 3; #33). Wetlands filled to create uplands include broad areas along the south shore of Lake Michigan, extending from Indiana to Chicago. Wetlands in this region were also dredged to create harbors and marinas.

Wetlands that have been dredged or filled may not be suitable for restoration as wetlands, but options exist for handling contaminants in wetlands or landfills. The contaminated sediments may be left buried, flooded, and out of biological contact, and in certain cases, natural remediation processes such as biodegradation, chemical degradation, and advection and transport of sediments may occur (Wilcox and Whillans, 1999). Clean sediments may also be deposited over the contaminated sediments to diminish risks associated with the sites (USEPA, 1994a; Passino-Reader et al., 1999). Active sediment remediation is another alternative in some cases. Non-removal remediation technologies either isolate the sediments from the surrounding environment by capping or containment or treat the contaminants *in situ* by immobilization, chemical, or biological processes. Removal technologies are more widely used and consist of two general types—mechanical dredges and hydraulic dredges. Material removed may be pretreated by dewatering or physical separation (Wilcox and Whillans, 1999).

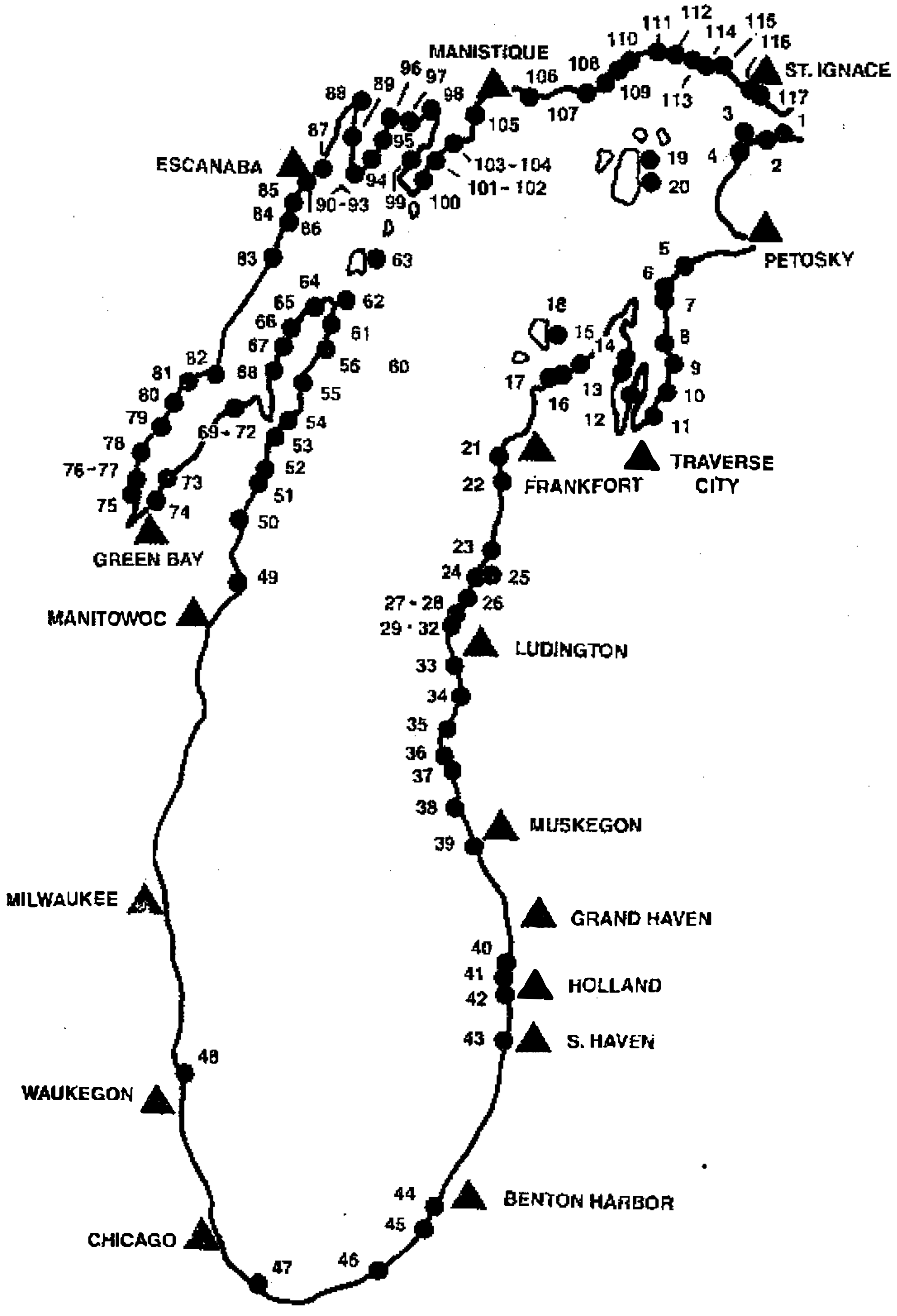

Fig. 3. Map of selected coastal wetlands of Lake Michigan over 16 ha in area (modified from Hoagman (1998).

Shoreline modification

A common response to the threat of flooding and erosion along the shoreline of Lake Michigan is to construct revetments or break walls along the shore and breakwaters that parallel the shoreline at depths of 3 to 5 m (e.g., harbors in Chicago and Milwaukee; Richardson, 1995). Shoreline modification may cause degradation of coastal wetlands. By reducing or altering localized erosion, these structures also reduce the supply of sediments that naturally nourishes the shoreline and replaces eroded sediments (Silvester and Hsu, 1991). Sand spits that shelter protected lacustrine wetlands may thus be lost; barrier beach lagoons and swale complexes may lose the protection of a barrier beach. Hard shoreline structures also shift wave energy further downshore and may locally accelerate erosion of beaches and wetlands elsewhere. When revetments are constructed along the gently sloping shore of a wetland, a "backstopping" effect can result. Wave energy can scour sediments from in front of the revetment, leaving an abrupt boundary between upland and deep water and no migrating, sloping shoreline with the required water depths for various wetland plant communities (Maynard and Wilcox, 1997).

Shoreline modifications will likely never be removed completely, thus allowing sediment supplies that nourish barrier beaches and sand spits to be restored. However, improved designs to replace existing structures have been promoted in Lake Ontario (Hamilton Region Conservation Authority, 1995). The typical vertical retaining walls are replaced by armorstone, with aggressive-rooting tree species planted above them. Offshore stone and anchored tree roots reduce incident energy. Sloping stone revetments along the shore are replaced by two low revetments, one offshore and one at the toe of the bluff. Wetland and aquatic plants are planted between them, and the shore is stabilized with native trees and shrubs. Beach nourishment has also been used in an attempt to supplement sediment supplies. However, application of sand to a beach seldom results in a natural slope, and the wave climate quickly modifies it, resulting in an initial loss of as much as 30 to 50% of the sand. Continued erosion may result in a loss of 80 to 90% of the beach width after 15 to 24 months. The use of coarser material to reduce transport by waves has also not proven successful (Silvester and Hsu, 1991).

Headland control is another approach to restoring and maintaining a protective shoreline that shows promise. Headland control makes use of a naturally occurring landform in which crenulate- or J-shaped bays are formed between headlands. The shape of the bays keeps them in equilibrium. Energy inputs recycle sediments within bays because constructive waves arrive nearly normal to the beach and movement of sediment lacks a long shore component (Figure 4a). Thus, any eroded sediments remain within the compartment and are returned to the beach during low energy periods (Silvester and Hsu, 1991). On a straight shoreline or a recurved sand spit (Figure 4b), a series of headland structures could stabilize the existing

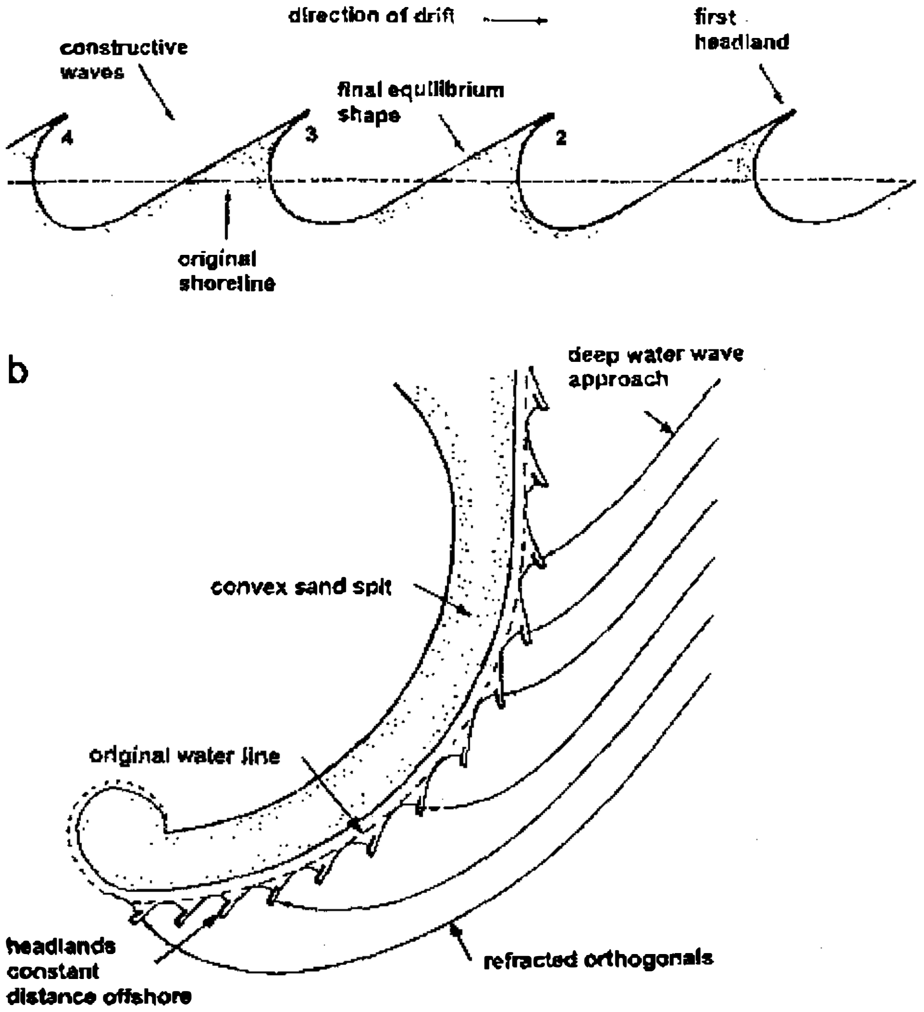

Fig. 4. Diagram showing use of headland control for accretion of beach a) along a straight shoreline, b) on a recurved sand spit (modified from Silvester and Hsu, 1991).

sand and slow or halt net erosion by eliminating the longshore component of sediment transport (Silvester and Hsu, 1991). Headland control has been used successfully along the ocean coast in different parts of the world. It has also been used successfully on Lake Ontario by the Toronto Harbour Commission to assist in land reclamation for recreational purposes and harbor development (Denney and Fricbergs, 1979).

Changes in sediment budgets

Human activities have substantially altered the amount and particle size of sediments flowing into Lake Michigan since European settlement and, in turn, greatly affected the sediment budgets of coastal wetlands (Maynard and Wilcox, 1997). Elevated sediment loads can be caused by reduction of vegetated cover in watersheds entering coastal wetlands and by increases in land clearance, agricultural runoff, urbanization, construction activities, logging, and erosion along stream banks subject to increased flows. Excess sediment loads can prevent the germination of emergent plant species (Jurik et al., 1994) and, in some cases, can fill marshes. They can also smother fish spawning areas and submersed vegetation critical to many forms of wildlife, reduce dissolved oxygen concentrations, and affect the survival rate of invertebrate and fish eggs. Due to physical characteristics of sediments, increases in sediment loads can also have high associated nutrient loads and can be contaminated with industrial and farm chemicals (Boto and Patrick, 1978). Alterations of sediment budgets can result in increased turbidity, which reduces the availability of light to submersed plants and epiphytes, reducing photosynthesis and limiting growth. In some cases, human activities produce a lack of sediments in coastal wetlands. Dams constructed upstream on tributary rivers can trap sediment (Ligon et al., 1995) that may be essential to the maintenance of barrier beaches protecting wetlands.

Coastal wetlands of Lake Michigan occupy the shoreline that also serves as a transportation corridor connecting coastal cities and providing access for owners of private land along the coast. Roadways following the shoreline and crossing wetlands serve as stressors on the wetlands. A substantial percentage of the drowned-river-mouth wetlands on Lake Michigan are crossed by roadways. The hydrology of these wetlands is altered by constriction of the often broad river channel to passage under a narrow bridge placed along a roadbed causeway that partially dams the river and wetland. Flood waters slowed by the causeway dam and narrowed outlet deposit excessive sediments in the wetlands and raise the elevation of the substrate. This allows invasion of plant species that would otherwise not tolerate the hydrologic regime of the wetland. Water-level changes due to seiches are also dampened by the reduced connection with the lake. Barrier beaches are also commonly used for roadbeds, with similar hydrologic impacts to wetlands behind them and added alteration of the coastal processes that create and maintain them. In addition, roadways can contaminate wetlands with by-products of combustion and with road salt in winter (Wilcox, 1985a).

Excess sediment loads in wetland related to human activities can be addressed by management of sediment input from upland and nearshore sources. Examples include proper erosion control on agricultural lands, restoration of ditched wetlands, removal or proper management of dams on tributary rivers, and restoration of natural hydrology at wetland road crossings by increasing the width of bridge spans or adding additional bridges or culverts to the road bed (Wilcox and Whillans, 1999).

Water quality

The above-mentioned problems of pollutants, low dissolved oxygen, and turbidity, along with increased water temperatures and nutrient concentrations, comprise another major alteration to wetlands—decreased water quality (Maynard and Wilcox, 1997). Wetlands may be stressed by enrichment of nutrients from agricultural runoff, residential runoff, or sewage discharge. The trophic status of the water in a wetland has obvious importance in determining productivity and species composition. Plant communities in nutrient-enriched wetlands may differ from those in other areas. Nutrient enrichment also may cause excessive algal blooms that can reduce light available to macrophytes for photosynthesis. Excessive growth of macrophytes or algae can also result in depletion of dissolved oxygen when these plants die and decay; this is especially critical in shallow basins with little mixing, such as barrier beach wetlands. Oxygen depletion can also be caused by discharge of organic wastes into wetlands.

Toxic chemicals can stress wetland biological systems, especially the faunal communities. Through the processes of biomagnification and bioaccumulation, the impact of toxic chemicals has been greatest on faunal species at the top of the food web, such as predatory birds, fish, and mammals. Animal health and reproduction can also be affected by contaminants. Although levels of banned DDT, PCBs, and their metabolites will likely continue to decrease, the effect of the continuing discharge of other persistent toxic chemicals on the quality of the chemical regime of habitats is not well understood (Dodge and Kavetsky, 1995). Water-soluble metals from sediment pore water can reduce primary production by ultra and pico plankton. Increased salinity caused by road salt runoff can alter algal and macrophyte communities of wetlands, as well as faunal communities (Wilcox, 1985b).

The obvious approach for addressing water quality problems is to reduce or eliminate inputs of nutrients and contaminants through better management practices, better technology, construction of new treatment facilities, changes in the discharge permitting process, and locating and eliminating illegal discharges. Better management practices can be elevated to the watershed level to reduce siltation and inputs of nutrients and pesticides from agricultural runoff, as well as upstream loading from municipal and storm sewers and from roads and other developed lands. Specific practices could include livestock fencing, tree planting, erosion control, bank stabilization, buffer strips, reforestation, and rerouting of surface drainage systems and discharges away from wetlands (Wilcox and Whillans, 1999).

Non-indigenous and invasive species

Perhaps the most serious management problem affecting Lake Michigan wetlands is coping with species not native to the area and aggressive species of uncertain origin that compete with native biota (Maynard and Wilcox, 1997). Methods of introduction include intentional release, deposition of ship ballast, escape from cultivated or cultured populations, and migration along travel routes such as railroads, highways, and canals (which may also overcome natural physical barriers to aquatic travel). In many cases, introductions may not be successful in a healthy ecosystem. However, given the means and extent of wetland alteration in the Great Lakes, habitats and food webs have been sufficiently disturbed to allow many introduced species to thrive. Several of these species have the potential to cause considerable problems, including purple loosestrife (*Lythrum salicaria* L.), common reed (*Phragmites australis* (Cav.) Steudel, reed canary grass (*Phalaris arundinacea* L.), Eurasian watermilfoil (*Myriophyllum spicatum* L.), curlyleaf pondweed (*Potamogeton crispus* L.), common waterweed (*Elodea canadensis* Michx.), zebra mussel (*Dreissena* sp.), common carp (*Cyprinus carpio* L.), and mute swans (*Cygnus olor* Gmelin).

Management of non-indigenous and invasive species typically involves control measures. Weedy plant species most targeted in the Great Lakes include *Lythrum salicaria, Phragmites australis, Typha angustifolia* L. or *T.* x *glauca* Godr., *Phalaris arundinacea*, and *Myriophyllum spicatum*. As reviewed by Wilcox and Whillans (1999), control methods include physical harvesting or exclusion, chemical control, and biological control. Specific techniques include pulling by hand, harvesting, mulching with black plastic, burning, disking, cutting, flooding, herbivore control, use of heavy construction equipment, chemical control with herbicides, and biological control (Weller, 1981; van der Toorn and Mook, 1982; Kaminski et al., 1985; Balogh, 1986; Apfelbaum and Sams, 1987; Thompson et al., 1987; Madsen et al., 1988; Westerdahl and Getsinger, 1988; Cross and Fleming, 1989; Wilcox and Ray, 1989; Ball, 1990; Engel, 1990; Hutchison, 1992; Sojda and Solberg, 1993; Marks et al., 1994; Naglich, 1994; Boylen et al., 1996; Madsen, 1997).

Insects that might serve as potential biological control agents for *Phragmites australis*, *Typha*, *Myriophyllum spicatum*, and *Lythrum salicaria* were reviewed by Galatowitsch et al. (1999). Biological control by the root-boring weevil *Hylobius transversovittatus* Goeze and leaf-feeding beetles *Galerucella calmariensis* L. and *G. pusilla* Duff. has been tested and implemented for *Lythrum salicaria* (Blossey, 1993, Malecki et al., 1993; Blossey et al., 1994; Hight et al., 1995). Control of *Myriophyllum spicatum* by milfoil weevil *Euhrychiopsis lecontei* Dietz has been tested and implemented less extensively but shows promise (Newman and Biesboer, 2000).

Control of non-indigenous vertebrates is more difficult because they are mobile. The most common example of an attempt to control non-indigenous fauna in Great Lakes wetlands is use of dikes, fences, and grates to restrict access of large carp

(French et al., 1999; Wilcox and Whillans, 1999). Control methods are not available for zebra mussels in wetlands; however, populations in wetlands seem to be held in check naturally by warm waters in summer, ice and water-level decreases in winter, and drawdowns associated with frequent seiche action (Brady et al., 1995).

Climate change

Climate warming could alter the water-level conditions under which Lake Michigan wetlands were formed and maintained. The frequency and duration of water-level fluctuations could be modified (Baedke and Thompson, 2000). For instance, if seasonal distributions of water levels are altered by a climate change, there could be shorter periods of low water in winter; earlier rises of water level in the spring, and an earlier onset of seasonal water-level decline. Increased frequency and duration of low water levels would result in higher water and air temperatures, more evapotranspiration, less runoff, and reduced ice cover. Coastal wetland vegetation and faunal communities would change substantially, although the exact changes are not known for certain (Mortsch and Koshida, 1996).

Development of a wetland monitoring program to identify degraded wetlands

If management problems in wetlands of Lake Michigan are to be addressed, they must first be identified at specific locations. The lake is bordered by four different states, each with different programs for identifying and managing environmental problems. No cross-jurisdictional program or protocols for wetland monitoring are currently in place for Lake Michigan or any of the Great Lakes. However, with funding from the U.S. Environmental Protection Agency, the Great Lakes Commission recently formed the Great Lakes Coastal Wetlands Consortium to expand the monitoring and reporting capabilities of the U.S. and Canada under the Great Lakes Water Quality Agreement. The Consortium consists of scientific and policy experts from key U.S. and Canadian federal agencies, state and provincial agencies, non-governmental organizations, and other interest groups with responsibility for coastal wetlands monitoring. The Consortium is designing a long-term program to monitor Great Lakes coastal wetlands by developing indicators of wetland degradation as promoted by the State of the Lake Ecosystem Conference (SOLEC) process. The Consortium is providing scientific support for this monitoring program, creating a database that is publicly accessible; recruiting the leadership required to implement the long-term monitoring program, and developing a network of funds providers and agencies to support the monitoring program (http://www.glc.org/wetlands/).

Summary

Wetlands are an important component of the Lake Michigan ecosystem, but management concerns and actions have not been addressed as thoroughly as they have for open waters of the lake. A first step in addressing management opportunities is agreement on a classification system for wetlands. The latest development is a hydrogeomorphic system for Great Lakes wetlands with three major classes (lacustrine, riverine, barrier-protected) and several subclasses, most of which are represented in Lake Michigan. Major management concerns include drainage, filling and dredging, shoreline modification, changes in sediment budgets, water quality, non-indigenous and invasive species, and climate change. Many management options are available to address these concerns, but site-specific identification of the problems is first required. A consortium of scientific and policy experts from key U. S. and Canadian agencies, non-governmental organizations, and universities is developing a long-term monitoring program for Great Lakes wetlands to address this need.

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