2002

Where Land Meets Water: Understanding Wetlands of the Great Lakes

Environment Canada

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Where Land Meets Water

Understanding Wetlands of the Great Lakes

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Walter B. Fechner

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Foreword

In August 2000, Quebec City, Canada was the picturesque setting for a gathering of hundreds of wetland scientists, educators, students, engineers, industry representatives, and environmental leaders from around the world. The Quebec 2000: Millennium Wetland Event was organized to improve understanding and sustainability of the world's wetlands through the promotion of coordinated national and international wetland science, policy, conservation, management, and regulation. Delegates from as far away as Japan, Brazil, Poland, and Israel joined together to hear about and discuss the latest innovations, challenges, and directions in wetland science.

One of the hundreds of symposia presented during this week-long event was 'Conserving Coastal Wetlands of the Great Lakes', co-chaired by Environment Canada and the United States Geological Survey and involving presenters and participants from many different interests within the Great Lakes basin and around the world. This session included discussions of water level variation and the geological foundation of Great Lakes coastal wetlands, ecosystem and plant diversity within these wetlands, wetland restoration and protection, and community involvement in wetland monitoring programs. While the discussions focused on Great Lakes coastal wetlands specifically, the conservation message and scientific information presented during this session have wide-ranging applicability to freshwater wetlands throughout the basin and around the world.

This publication summarizes the current state of knowledge about Great Lakes coastal wetlands based on the information presented at the Millennium Wetland Event symposium. Information on wetland development and classification, summaries of wetland vegetation communities, and details of the fish and wildlife species that use Great Lakes coastal wetlands as habitat are all found within the following pages. Wetland conservation initiatives and some of the challenges of performing wetland science in such a large and diverse environment are also highlighted.

We hope you will find this information both interesting and useful when visiting your local wetland and undertaking your own wetland conservation projects and scientific studies.

Canadian Wildlife Service

Douglas A. Wilcox

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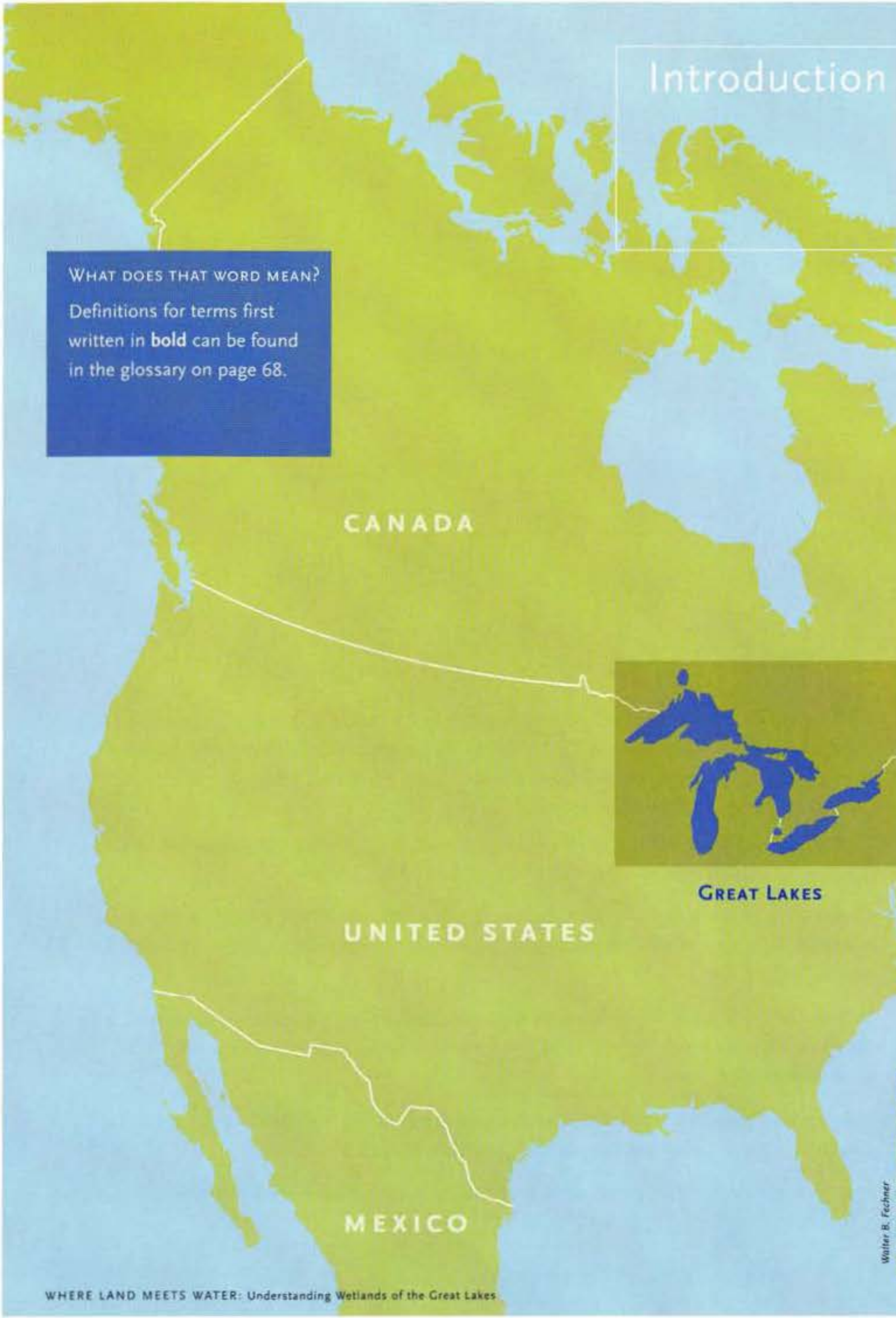


WHAT DOES THAT WORD MEAN?
Definitions for terms first written in **bold** can be found in the glossary on page 68.

Wetlands are some of the most ecologically diverse and productive **ecosystems** on Earth, providing **habitat** to thousands of species of wildlife. In the Great Lakes, more than two-thirds of all lake fish species spawn in coastal wetlands and numerous **endangered** and threatened birds, reptiles, and amphibians use coastal wetlands for all or part of their life cycles.

Until recently, the value of wetlands to wildlife and to human society went largely unnoticed, and Great Lakes basin wetlands were drained, filled in, or paved over to make way for human activities. As a result, during the past two centuries, over two-thirds of southern Ontario's original wetland area has been lost. That number reaches 90 percent and higher in areas such as parts of southwestern Ontario and the Lake Erie shoreline in Ohio. Unfortunately, it took these massive losses for society to begin to recognize the many values of wetlands.

Growing scientific awareness of wetlands' importance has prompted an increase in conservation efforts, including a strong focus on the protection and rehabilitation of Great Lakes coastal wetlands. As outlined here, a broad array of government and non-governmental groups are involved in Great Lakes wetland habitat conservation. These range from municipal governments, non-governmental organizations, community groups, and private sector interests to regional, state, and provincial jurisdictions and federal governments of both Canada and the United States. With two federal governments, eight states, one province, and numerous local governments and groups involved, this mix of jurisdictions and perspectives makes the wetland conservation process highly dynamic and complex.

This publication is designed to support the efforts of individuals and groups involved in coastal wetland conservation. It provides an overview of Great Lakes coastal wetland **hydrology**, **ecology**, and classification, as well as current efforts to protect and conserve these valuable ecosystems.

Walter B. Fechner

PRIOR TO 1850, an extensive coastal marsh and swamp complex existed in western Lake Erie, Ohio. This was part of the vast Black Swamp complex that was 160 kilometres long and 40 kilometres wide. Over the next hundred years, most of the wetlands were lost to clearing, draining and filling to provide agricultural land.

Coastal Wetlands of the Great Lakes

Most people have heard of marshes, swamps, and bogs, but what are *Great Lakes coastal wetlands*? Briefly, they are wetlands that are directly influenced by the waters of one of the Great Lakes. While they share many of the same functions and values as inland wetlands, it is the impact of the large lakes that differentiates coastal wetland hydrology and vegetational structure from that of their inland counterparts.

Coastal wetlands provide habitat for a wide range of species residing in the Great Lakes basin and play an essential role in water quality improvement. They help regulate stream flow, improve water clarity by reducing nutrients that lead to algal growth, settle sediments from upstream **erosion**, and decrease contaminant concentrations through sedimentation and uptake by plants and animals. As a result, coastal wetlands are essential to maintaining Great Lakes water quality – a critical issue for the millions of people in Canada and the United States who drink this water.

MARSHES REPRESENT the typical wetland to most people, yet they account for only about 10 percent of the *area* of wetlands in southern Ontario. However, they are the most prevalent wetland type in *numbers* found on the Great Lakes shoreline. Coastal marshes account for at least 90 percent of the number of provincially and regionally significant wetlands found on Great Lakes shores in Ontario, with swamps making up the majority of the remaining 10 percent. Coastal wetlands can also be bogs and fens, but these are less common, especially in southern regions of the Great Lakes.

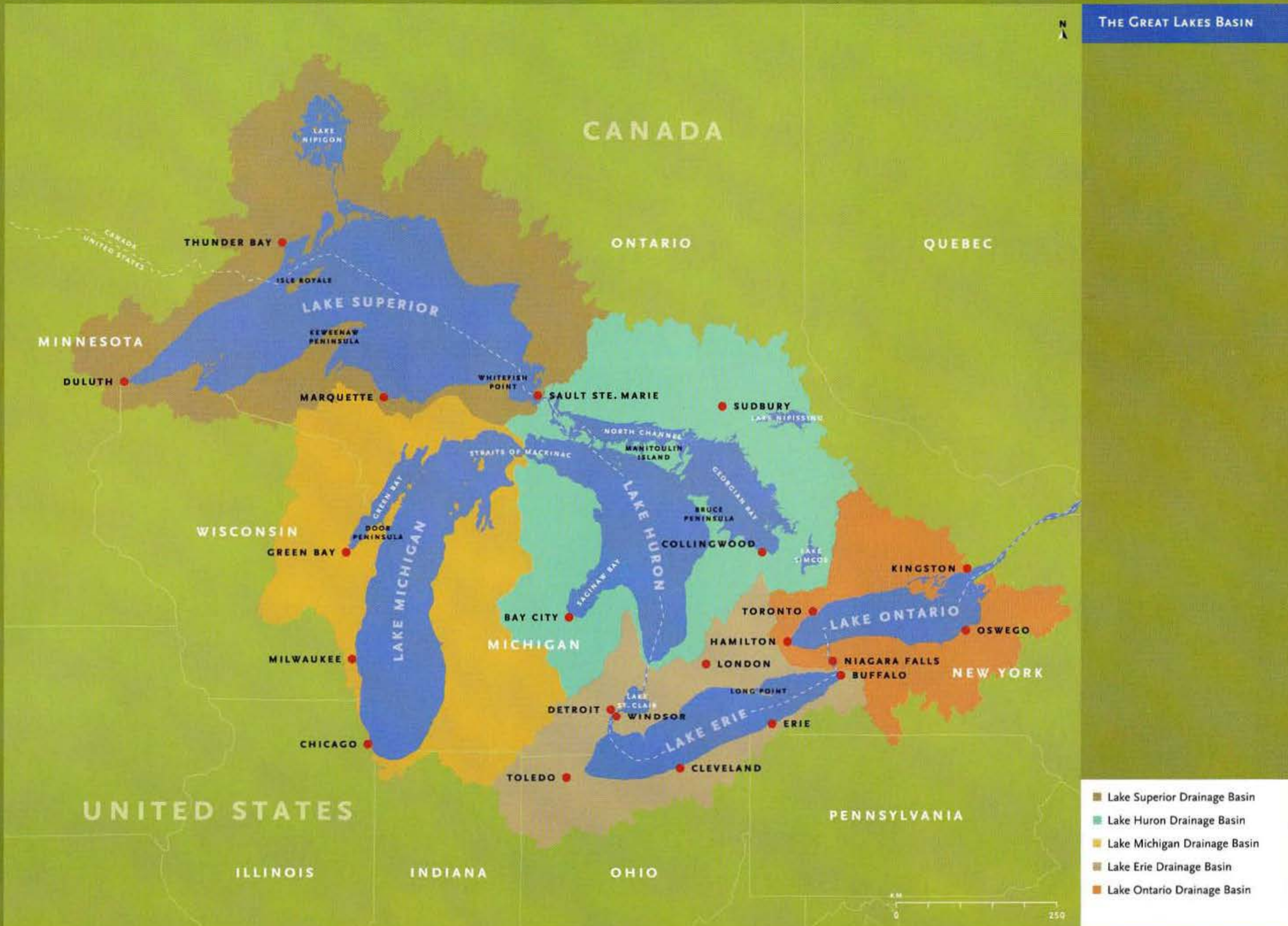
WETLANDS DEFINED

Wetlands can be defined as lands that are seasonally or permanently covered by shallow water, as well as lands where the **water table** is close to or at the surface. This presence of water has caused the formation of **hydric soils** and allows the dominance of **hydrophytic** or water-tolerant plant species.

Most people do not distinguish between a swamp and a marsh or a bog. However, coastal marshes, wooded swamps, and boreal bogs are unique ecosystems. Each forms a complex array of distinctive sub-types that support different species of **flora** and **fauna**. In the Great Lakes basin, there are four broad types of wetlands.

- **Swamps** are wetlands dominated by trees and shrubs, with periodic standing water, limited drainage, and often neutral or slightly **acidic organic** soils.
- **Marshes** are wetlands that are almost always flooded and are characterized by a mixture of emergent, floating, and submerged aquatic vegetation such as reeds, sedges, pondweeds, and water lilies.
- **Bogs** are peat-accumulating wetlands that trap precipitation as the major water source. They typically have acidic organic soils, and often contain *Sphagnum* mosses and **ericaceous** shrubs.
- **Fens** are peat-accumulating wetlands with groundwater as the dominant water source and support a variety of plant species, including orchids, sedges, and grasses.

Large coastal wetland complexes often encompass more than one of the four wetland types.



THE GREAT LAKES BASIN
N
CANADA
ONTARIO
QUEBEC
LAKE NIPIGON
CANADA
UNITED STATES
THUNDER BAY
ISLE ROYALE
LAKE SUPERIOR
KEWEENAW PENINSULA
MINNESOTA
DULUTH
WHITEFISH POINT
MARQUETTE
SAULT STE. MARIE
SUDBURY
LAKE NIPISSING
NORTH CHANNEL
MANITOULIN ISLAND
STRAITS OF MACKINAC
GREEN BAY
DOOR PENINSULA
WISCONSIN
GREEN BAY
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
BRUCE PENINSULA
COLLINGWOOD
LAKE SIMCOE
SAGINAW BAY
BAY CITY
MICHIGAN
KINGSTON
TORONTO
LAKE ONTARIO
OSWEGO
HAMILTON
MILWAUKEE
LONDON
NIAGARA FALLS
BUFFALO
NEW YORK
LONG POINT
LAKE ST. CLAIR
DETROIT
WINDSOR
LAKE ERIE
ERIE
CHICAGO
CLEVELAND
TOLEDO
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Lake Superior Drainage Basin
Lake Huron Drainage Basin
Lake Michigan Drainage Basin
Lake Erie Drainage Basin
Lake Ontario Drainage Basin


Part 1
Glenn Barrett

Walter B. Fechner

Dragonfly

The Science of Great Lakes Coastal Wetlands >

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Sora

Buttonbush

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Evolution and Classification

Wetlands from the Rock Up

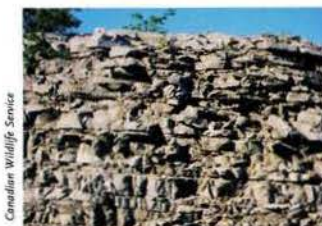
Igneous, **metamorphic**, and **sedimentary** rock occurs throughout the Great Lakes. Their spatial variability defines the physical and chemical conditions for wetland establishment and development throughout the basin. Harder and sometimes more chemically resistant igneous and metamorphic rock occurs in the northern and northwestern areas of the basin, whereas the more physically and chemically erodable sedimentary rock occurs in the southern areas.

The Great Lakes basin was created by several glaciations over the past two million years. Ice scoured the bedrock surface and deposited the scoured debris in numerous glacial landforms (e.g., **moraines** and **drumlins**) or in sheets of glacial deposits. The most recent glaciation set the current configuration of the basin. The Great Lakes lowlands contain numerous glacial landforms and deposits. The Canadian Shield contains sparsely scattered till deposits that are essential for wetland function in the northern Great Lakes (see map).

The Great Lakes lowlands contain the most numerous and well-developed wetlands because of an abundance of suitable sites, which are associated with glacial and coastal landforms and protected **embayments**. The many drowned river-mouths and deltas formed since the glacial retreat created suitable areas for wetlands. Starting with the retreat of the glaciers, waves, currents, and other coastal processes have redistributed glacial deposits and eroded bedrock headlands. These processes have reformed the coast, creating numerous shallow and sheltered areas with suitable hydrologic conditions to support wetland communities.

In contrast, the rugged Lake Superior, northern Lake Huron and Georgian Bay, northeastern Lake Ontario, and much of the St. Lawrence River shorelines are dominated by erosion-resistant igneous and metamorphic bedrock. These shorelines lack the shallow protected waters and fine-textured lake and river bottoms that support broad coastal wetlands. As a result, many northern Great Lakes coastal wetlands are located behind protective barrier beaches or at stream mouths within or downstream from the sparsely distributed pockets of till left by the glaciers.

DELINEATION OF PRECAMBRIAN IGNEOUS and metamorphic rock that makes up the Canadian Shield, and Paleozoic sedimentary rock that underlies the more southern Great Lakes-St. Lawrence Lowlands and Interior Plains.



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SEDIMENTARY ROCK

Greg Grabas

THE IGNEOUS AND METAMORPHIC ROCK of the Canadian Shield forms the northern and northwestern portion of the Great Lakes basin. It is characteristically colourful, with rocky outcrops and rugged terrain. The granite of the Shield also extends southward beneath the sedimentary rocks that cover the southern and eastern portions of the basin.

Tamarack

Canadian Wildlife Service

Climate, the Great Divider

As anyone who has traveled the extent of the Great Lakes basin knows, the climate of this broad region varies enormously. From the temperate, relatively balmy peach and grape growing regions of Lakes Ontario and Erie to the boreal conditions of the north shore of Lake Superior, a north-south climatic gradient has a major impact on the ecology of Great Lakes coastal wetlands. The length of the growing season and the annual amount of solar energy for wetland plant growth varies widely across the region.

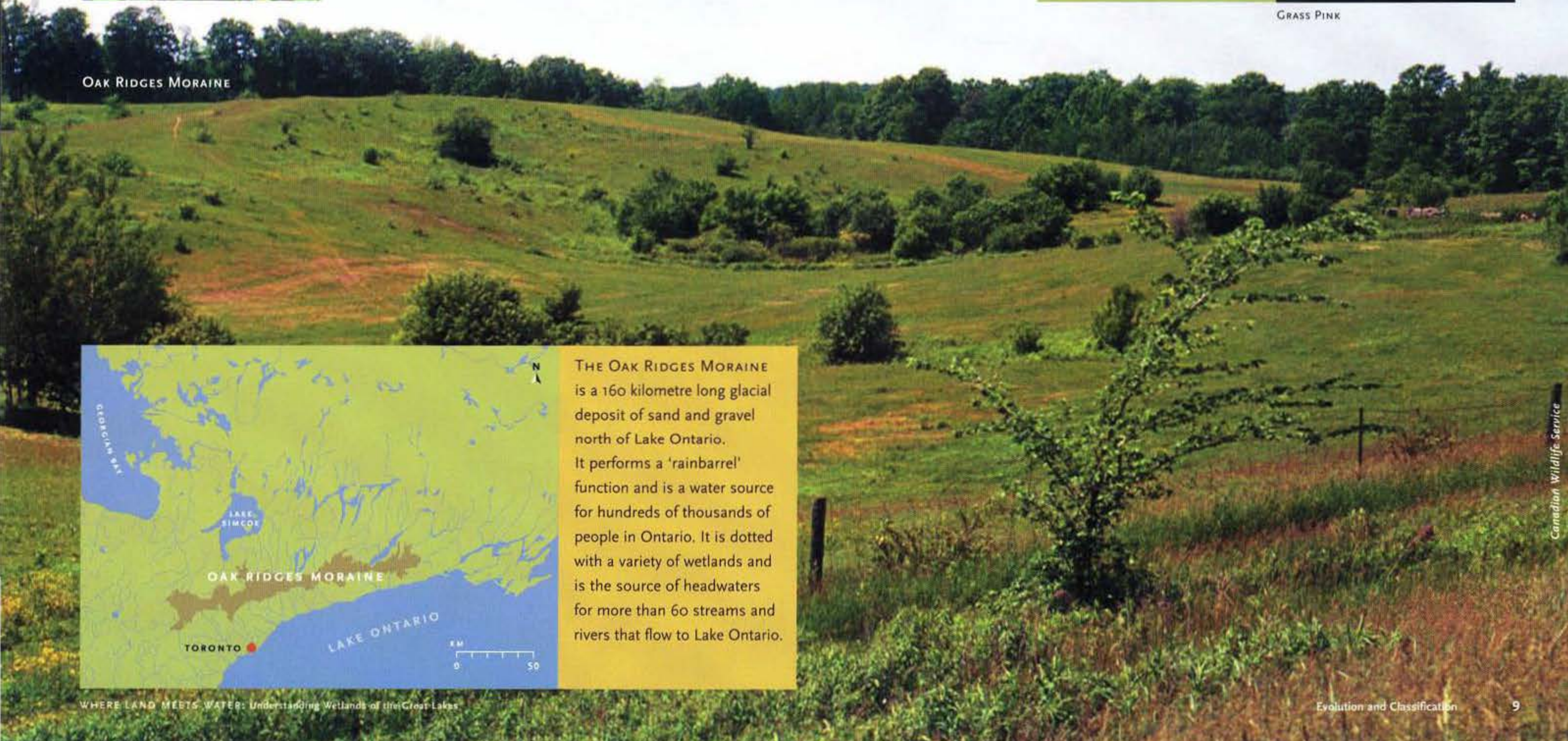
The differences in latitude create distinct vegetation communities. Lake Erie wetlands are rich in marsh species at the northern edge of their range – species that rarely occur along the other Great Lakes. These include Swamp Rose Mallow and American Water Willow. In comparison, the northern portions of Lakes Huron, Michigan, and Superior are habitat for a mix of boreal plant species such as Bog Rosemary, Leatherleaf, Black Spruce, and Tamarack.

The moderate climate of Lake Erie allows its coastal wetlands to support the largest diversity of plant and wildlife species in the Great Lakes. For example, over 300 species of plants have been identified including at least 37 considered significant by the Ontario Natural Heritage Information Centre.

Douglas A. Wilcox

Grass Pink

Oak Ridges Moraine



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The Oak Ridges Moraine is a 160 kilometre long glacial deposit of sand and gravel north of Lake Ontario. It performs a 'rainbarrel' function and is a water source for hundreds of thousands of people in Ontario. It is dotted with a variety of wetlands and is the source of headwaters for more than 60 streams and rivers that flow to Lake Ontario.

Classes of Great Lakes Coastal Wetlands

One of the ongoing discussions among scientists who study coastal wetlands is how to best define and explain the wide variety of Great Lakes coastal wetlands. The broad types of swamp, bog, fen, and marsh do not fully describe the diversity of coastal wetland relationships with the lakes.

The degree of lake protection provided to wetlands is largely shaped by local geology and geography. For instance, the bare Precambrian granites of the Canadian Shield that form much of Lake Superior's shoreline result in far less erosion and sediment accumulation than the softer, sedimentary rocks and till along much of the Lakes Erie and Ontario shorelines. As a result, features such as sand bars, **sand spits**, and **barrier beaches** are more common in the lower lakes.

There are a variety of coastal wetland classification systems, each an attempt to more accurately reflect the **hydrogeomorphic** diversity of all coastal wetlands. The following classification is currently the closest to consensus among different groups working in the Great Lakes basin. Within this classification, there are three broad systems, each based on the current, predominant hydrologic influence on the wetland. Further, within the hydrologically-based systems, Great Lakes coastal wetlands can be classified based on their **geomorphic** features and shoreline processes.

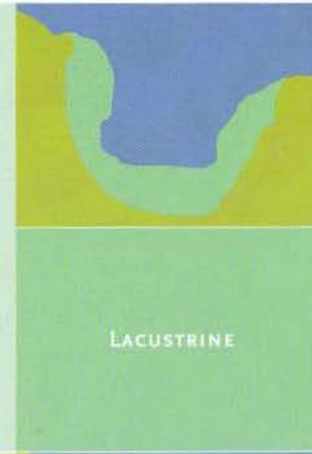
Ontario Ministry of Natural Resources

AN EXPANSIVE DELTA that harbours a complex of lacustrine and riverine wetlands exists where the St. Clair River enters Lake St. Clair. Some of the largest coastal wetlands in the Great Lakes are found in the St. Clair Delta, including over 10,000 hectares in the Walpole Island First Nation. As the surrounding **topography** is almost flat, water level fluctuations greatly affect their extent and position.

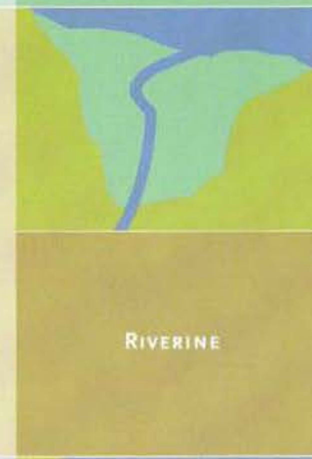
THE LOW SAND BANKS of the western and northern shores of Green Bay, Lake Michigan are fronted by numerous open lacustrine or fringe wetlands of bulrush.

Patricia Chow-Fraser

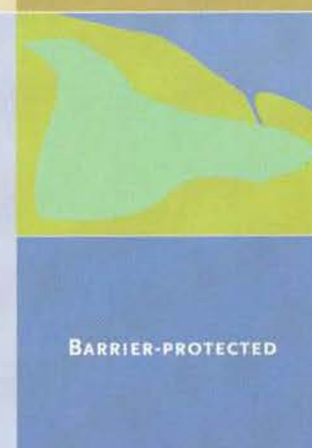
Lacustrine (lake-influenced) system wetlands are controlled directly by waters of the Great Lakes and are strongly affected by lake level fluctuations, nearshore currents, **seiches**, and ice scour. Geomorphic formations, such as embayments and sand spits, along the shoreline provide varying degrees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



Riverine (river-influenced) system wetlands occur in rivers and streams that flow into or between the Great Lakes. The water quality, flow rate, and sediment input are controlled in large part by their individual drainage basins. However, water levels and **fluvial** processes in these wetlands are also 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 by bars and channel morphology. Riverine wetlands within the Great Lakes also include those wetlands found along large connecting channels between the Great Lakes, such as the St. Marys and St. Clair Rivers, with very different dynamics than smaller **tributary** rivers and streams.



Barrier-Protected system wetlands may have originated from either coastal or fluvial processes. However, due to nearshore processes, the wetlands have become separated from the Great Lakes by a barrier beach or a series of **beach ridges**. These wetlands are protected from wave action but may be periodically or continuously connected directly to the lake by a channel or inlet crossing the barrier. When connected to the lake, water levels in these wetlands are determined by lake levels, while during isolation from the lake, groundwater and surface drainage from the basin of the individual wetland provide 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.



Ted Cline

Open Embayment

Protected Embayment

Ted Cline

Open Lacustrine wetlands are directly exposed to nearshore processes with little or no physical protection by geomorphic features. This exposure results in little accumulation of organic sediment, limiting vegetation development to relatively narrow nearshore bands. Exposure to nearshore processes results in variable **bathymetry**, ranging from relatively steep profiles to more shallow sloping beaches. These wetlands can be found along open *shoreline* areas or in wide *bays* that, due to their geographic location, are exposed to the full force of winds and waves.

Protected Lacustrine wetlands are also lake-based systems; however, they are characterized by increased protection by *bay* or *sand spit* formation. This protection results in increased organic sediment accumulation and more extensive vegetation development than this type's open lacustrine counterpart.

Rouge Park Alliance

Open Drowned River-Mouth

Barred Drowned River-Mouth

Douglas A. Wilcox

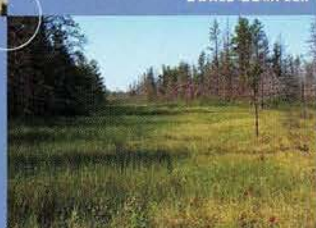
Drowned River-Mouth wetlands develop where tributary streams slow as they enter the Great Lakes and deposit large amounts of fine sediment. These wetlands may be *open* to the lake or *barred* by barrier beaches and protective dunes across the mouth of the inflowing river. The water chemistry of these wetlands can be affected by both the Great Lakes and river water, depending on Great Lakes water levels, season, and amount of precipitation.

Connecting Channel wetlands include all wetland types found on the major rivers that connect the Great Lakes. These include the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence Rivers.

Delta wetlands are formed of **alluvial** materials, both fine and coarse, which support extensive wetlands that extend out into the Great Lake or connecting river. These are extensive wetlands, typically with well-developed organic soils.

Maggie Young

Barrier Beach Lagoon



Swale Complex

Douglas A. Wilcox

Barrier Beach Lagoon wetlands form behind a sand barrier. Because of the barrier, there is reduced mixing of Great Lakes waters and the exclusion of coastal processes within the wetlands. Multiple **lagoons** can form, and water discharge from upland areas may also contribute significantly to the water supply.

Swale Complexes are wetlands that occur between recurved fingers of sand spits or between **relict** beach ridges. For many of these complexes, only the first couple of swales are directly connected to the lake, but in some the connection continues for hundreds of metres. Groundwater often supplies water to swales further from the lake. Organic soil depths are quite variable, as is the vegetation, which ranges from **herbaceous** to swamp forest.

The Rise and Fall of Great Lakes Coastal Wetlands

Great Lakes coastal wetlands are driven by one key factor – the rise and fall of lake water levels. Since 1860, the Canadian and United States governments have tracked Great Lakes water levels, and the record is one of constant change. These natural fluctuations impact a broad range of wetland characteristics, ranging from water chemistry to plant community composition. In fact, this 'water level stress' is essential to maintaining coastal wetland **biodiversity**.

Fluctuating water levels are an important part of coastal wetland development and function. When you see this symbol throughout this publication, water levels are being discussed with reference to other aspects of coastal wetlands.

Water level changes can be broken down into three distinct groups depending on their duration.

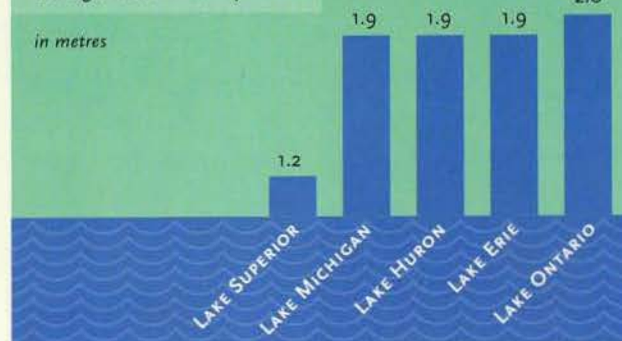
Temporary fluctuations are generally caused by wind and atmospheric pressure-driven 'tides' known as seiches. As frontal weather systems cross a lake surface, differences in pressure and associated winds can cause the surface of the lake to tilt as water builds up at one end of the lake and lake levels drop at the opposite end. Lasting generally less than one day, this phenomenon can temporarily change the shoreline lake level by as much as a metre or more. In deep lakes, this rarely causes water level differences greater than 0.5 metres; in shallower systems such as Lake Erie, seiches of up to five metres have been observed.

Seasonal fluctuations are of longer duration and reflect the yearly hydrologic (water) cycle in the Great Lakes basin. Low levels are predominant in late fall and winter as warm lake water below, and cool air above, cause increased evaporation from the lake surface. Highest levels are generally found in the early summer as cold winter snowmelt water drains into the lakes and evaporation is reduced. The seasonal range between low levels in the winter and high levels in the summer runs between 30 and 50 centimetres.

Multi-year fluctuations are changes in water levels from year-to-year and are caused by basin-wide, continental, or global changes in climate that result in different amounts of precipitation and evaporation over a number of years. For example, extreme low-water levels in the 1960s and 1998/1999 that left many cottagers' docks and boats high and dry were caused, in part, by below normal amounts of rain and snow in the preceding years. Similarly, high water levels in the early 1970s and mid-1980s were caused by above average precipitation.

BEFORE AND AFTER natural low water levels at Port Sheldon marsh on Lake Michigan. Exposure of the seed bank allowed regeneration of emergent plant communities.

RANGE OF WATER LEVELS in each of the Great Lakes during the 20th century



AN ICE JAM IN A CONNECTING CHANNEL may reduce the flow of water to a trickle. This happened on March 29, 1848 when Niagara Falls ran dry. Strong winds, currents and waves had jammed hundreds of thousands of tonnes of ice into the eastern end of Lake Erie between Fort Erie and Buffalo blocking the flow of water into the Niagara River for nearly 30 hours.

NIAGARA FALLS

Courtesy of Great Lakes National Program Office

The most noticeable effect of changes in water levels is on plant life, which in turn will impact the animal life that relies on wetlands as habitat. The duration, frequency, timing, and magnitude of water level fluctuations are critical for wetland plant communities. The variability of these factors may greatly alter wetland structure and function. Unpredictable and variable water levels tend to result in greater overall plant diversity in coastal wetlands. Wetlands that exist with these water level changes are known as pulse-stable systems – their plants and animals are adapted to and depend on a highly changeable wetland environment.

Low water levels occurring as part of multi-year or seasonal fluctuations can expose wetland bottom sediments, which allows the seeds contained there (in the **seed bank**) to germinate. Sometimes, if one plant type gets a foothold in early colonization, its density may be great enough that it dominates an area for the long term. In most cases though, early colonizing species or communities are later lost through competition with other plant types or through changes in water level.

Gradual, long-term changes in lake levels may result in the expansion and contraction of wetland area. High water levels can eliminate large areas of wetland by flooding out available space, while low water levels that expose large areas of mud flats with an extensive seed bank will allow wetlands to expand in the direction of the new water's edge.

Water level changes have an impact on almost all other **abiotic** factors that influence wetlands, including currents, wave action, **turbidity**, **pH**, temperature, and nutrient content. For example, low water levels will result in faster warming of wetland water, which may result in unsuitable habitat for certain fish species. Further, high water levels may dilute nutrient and contaminant concentrations to decrease local toxicity to plants, fish, and wildlife.

BLUE-JOINT SEEDLINGS emerge from the exposed mudflats of Button Bay in Lake Ontario. A healthy seed bank is essential in maintaining wetland vegetation diversity.

CONFLICTING INTERESTS IN LAKE ONTARIO

Effective coastal wetland conservation depends on understanding and maintaining natural water level fluctuations. This has been a significant challenge since 1960 with the creation of the St. Lawrence Seaway and associated hydropower and shipping infrastructure (Figure 1). These structures allow Lake Ontario's outflow to be regulated to suit a broad range of human needs, from electricity production to Great Lakes shipping. However, what has been good for Great Lakes shipping and recreational boating appears to have stressed coastal wetlands. In contrast to previously well-adjusted, pulse-stable systems, stable water levels from year to year during the growing season have resulted in less diverse shoreline plant communities and more rapid **succession** of wetland area to upland (drier) ecosystems.

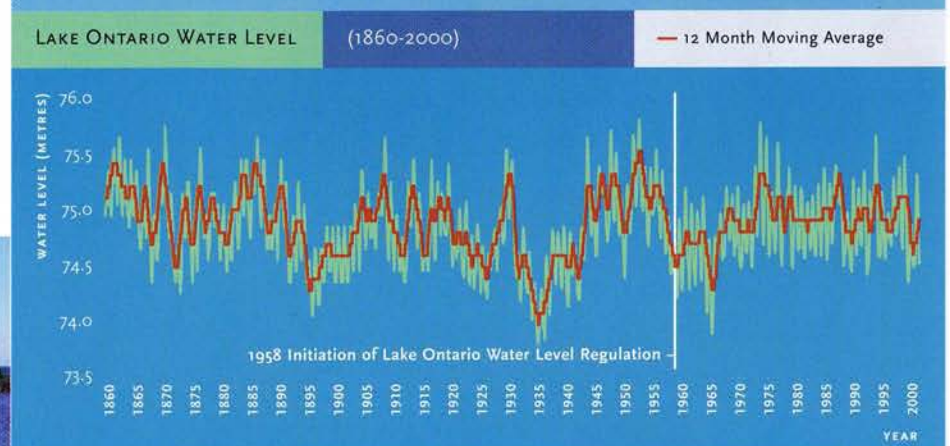
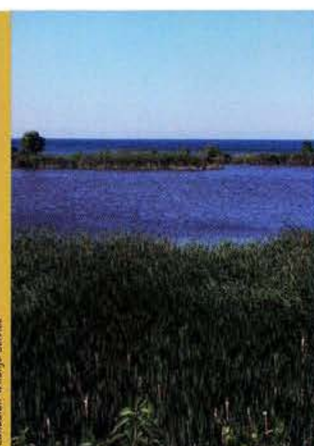


Figure 1 LAKE ONTARIO WATER LEVEL from 1860 to 2000. In 1958, lake wide regulation of lake levels was implemented and annual fluctuations were dampened.

TOPOGRAPHY AND BATHYMETRY play major roles in moderating the extent to which water level fluctuations impact a wetland's plant community. For example, Saginaw Bay and the Lake St. Clair marshes are dramatically altered by water level fluctuations because the gentle slope of the **lakeplain** creates potential for the exposure of extensive, fertile mud flats following a decrease in water levels. Thus, the area favours colonizing plants adapted to the cyclical exposure of the sediments. In contrast, the more abrupt offshore slope of a northern, open embayment marsh may result in the exposure of unsuitable, bedrock **substrate**, which limits wetland migration potential.



Water level changes over millennia

While many people who call the Great Lakes shorelines their home may be disturbed by what seems like abnormally low water levels in some years, they are in fact part of a normal long term cycle. In order to further understand the variability in Great Lakes water level fluctuations, it is helpful to examine the historical record of lake level change.

Lake levels have been recorded since the 1860s, which has allowed scientists to monitor trends in water level fluctuations. However this geologically 'short' record does not allow prediction of trends in lake level longer than a decade or two. To extend the existing water level record, analyses of shorelines from ancestral lakes have uncovered trends from over 4,000 years worth of water level changes in the Great Lakes. Using techniques such as measuring the elevations of **remnant** beaches and completing **radiocarbon dates** of ancient wetland remains; two dominant time-scales of water level variation were revealed (Figure 2).

- Shorter-term fluctuations with a water level variation range of between 0.5 to 0.6 metres occur about every 33 years.
- Longer-term fluctuations with a water level variation range of 0.8 to 0.9 metres occur about every 160 years.

An even longer-term change in lake levels also occurs in the data. Between 4,500 and 3,400 years ago, lake levels in the ancestral lakes predating the modern Great Lakes fell a little more than four metres. Modern Lake Michigan and its hydrologic counterpart, Lake Huron, came into existence after this drop.

These historic water level fluctuations are a natural behaviour of the lakes, driven by natural climate variability. The trends illustrate the potential magnitude of changes that might be expected in the future should human influence not overwhelm these natural signals.

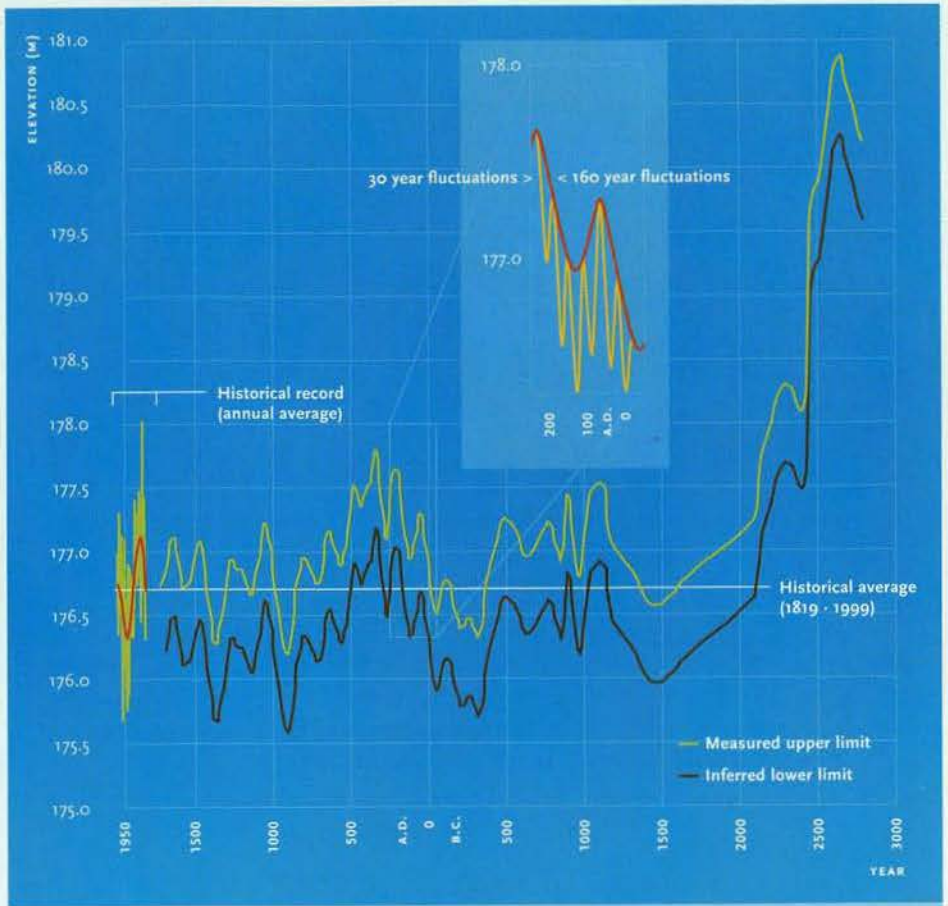
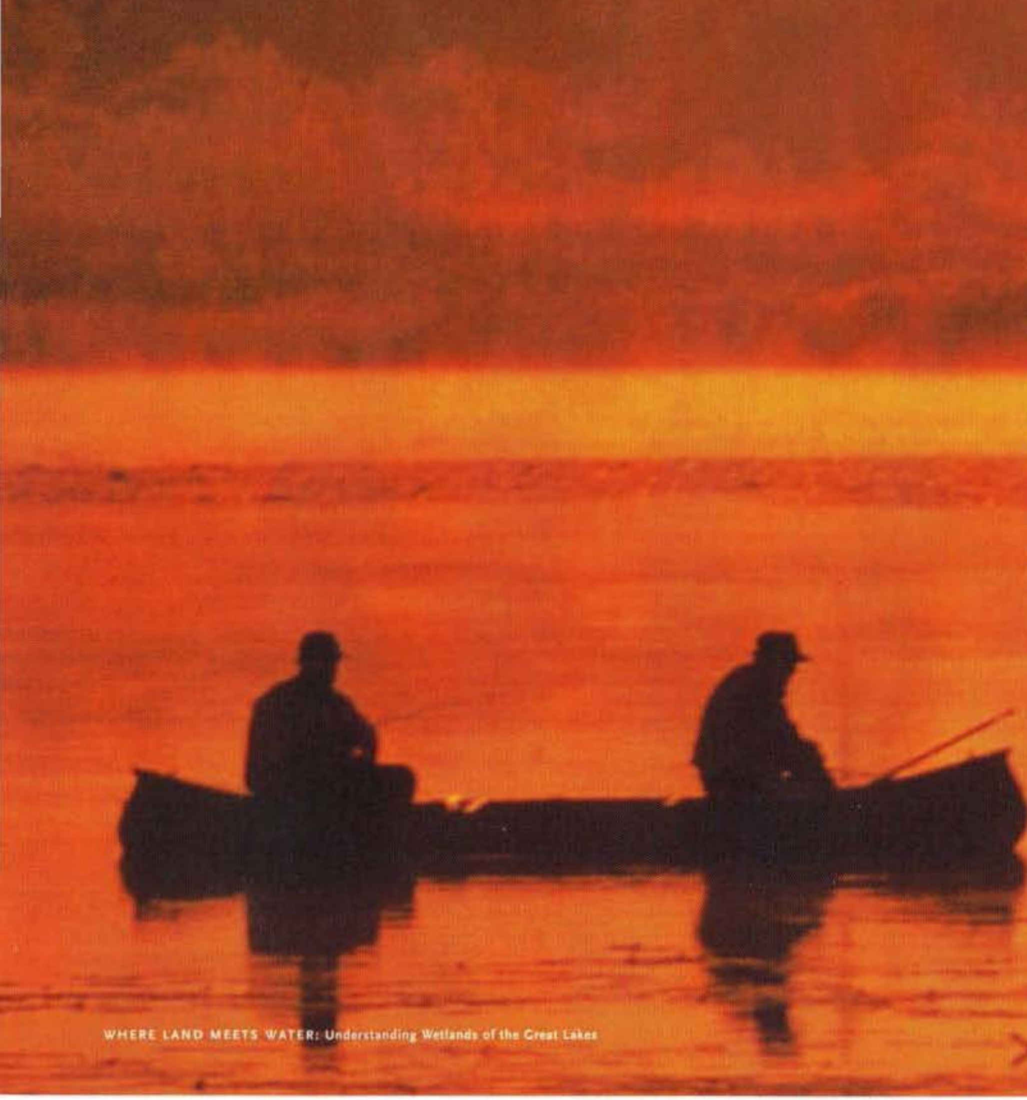


Figure 2 Great Lakes water levels over the past 5,000 years, from 1950 to 3000 B.C. At the maximum, the water levels were almost 5 metres higher than they are today.

Inset: the two dominant cycles of variability of 30 and 160 years uncovered through geologic prediction techniques.

Ecological Functions and Values of Great Lakes Coastal Wetlands

Functions and values are terms often used interchangeably when discussing wetlands. In fact, they have very different meanings. Functions include biological, chemical, and physical processes that occur naturally within a wetland, such as nutrient cycling and groundwater recharge. Assessing a wetland's ecological functions is important in guiding management decisions, as it provides a framework for evaluating the beneficial roles of wetlands. Values, on the other hand, are estimates of the worth or importance of wetland functions to humans. Values include recreation, flood control, and water quality improvement.

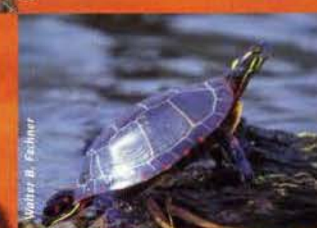


Courtesy of Great Lakes National Program Office

Lesley Dunn

CRANBERRY

Douglas A. Wilcox



Walter B. Fechner

PAINTED TURTLE

Two familiar functions and values are the improvement of lake water quality (both a function and a value) and provision of habitat for fish and wildlife (a function). Coastal wetlands help to improve lake water quality by absorbing and cycling nutrients and other contaminants, and by facilitating sediment deposition prior to upstream runoff entering lakes. When streams and rivers pass through coastal wetlands, plants and wetland topography slow the water speed, and suspended sediments settle out of the water column. These sediments often have attached agricultural and urban fertilizers and pesticides. By preventing such contaminants from reaching lake water, wetlands are providing an important human-use value. Unfortunately, this **biogeochemical** function of wetlands often also results in the degradation of the wetland itself.

Great Lakes coastal wetlands are also essential spawning and nesting habitat for hundreds of species of birds, fish, and amphibians. The Great Lakes sport and commercial fisheries rely on coastal wetland nurseries for their existence.

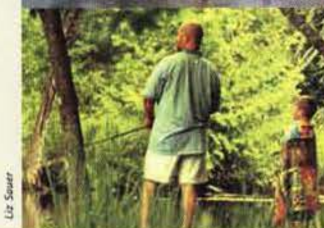
One of the highly visible values of wetlands is recreation: fishing, hunting, or observing nature and wildlife, most commonly birds. Due to their ecological diversity, wetlands are also commonly used as areas for nature study and scientific teaching and research.


Dragonfly

Walter B. Fechner


Great Blue Heron

Walter B. Fechner



Liz Sauer

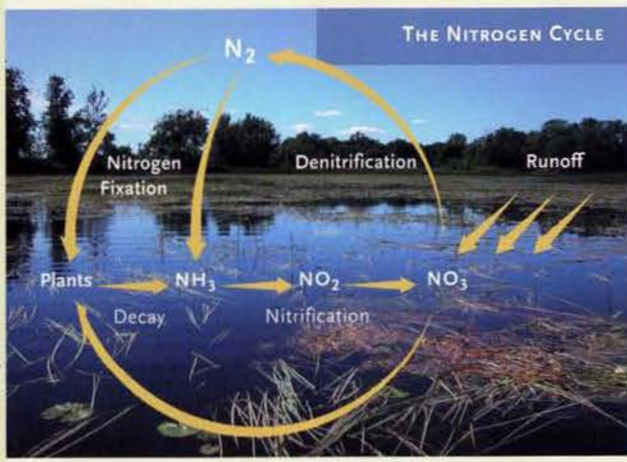
SELECTED FUNCTIONS AND VALUES PROVIDED BY WETLANDS

Functions

- Groundwater recharge, and stream baseflow maintenance
- Nutrient (nitrogen, phosphorus, carbon, sulphur), sediment, and contaminant cycling and storage (e.g., Figure 3)
- Food web production and export
- Biological productivity
- Provision of habitat for plants, fish, and wildlife (through community structure)

Values

- Water quality improvement
- Flood storage
- Water supply
- Erosion protection
- Non-consumptive recreation – bird-watching, nature study, and photography
- Recreational fishing and hunting
- Commercial fisheries



Canadian Wildlife Service

Figure 3 A SIMPLIFIED REPRESENTATION OF THE NITROGEN CYCLE. Nitrogen enters wetlands through nitrogen fixation of atmospheric nitrogen (N_2) by plants, lightning and industrial processes, and also from runoff of nitrates (NO_3) from agricultural fields. Plants use nitrogen for growth and release it back to the wetland as ammonia (NH_3) as they decay. Biogeochemical processes occurring in wetlands encourage the transformation of NH_3 to NO_3 to N_2. These processes of nitrification and denitrification eliminate excess nitrogen from wetlands that can cause excess algal growth and be toxic to amphibians.

BY PROVIDING WATER STORAGE, wetlands prevent the type of downstream flooding shown here.

Toronto and Region Conservation Authority

What is a Wetland Worth?

Qualitative descriptions of wetland values do not adequately explain the significant contributions of wetlands to national economies. Functional wetland ecosystems provide protection from flooding, nurseries for fish species, and clean air, water, and soil – all of high economic value.

Placing an economic value on wetlands and other natural features is a concept that is gaining increased attention among ecologists and economists alike, prompting the development of ecological economics. Valuing wetlands can help set priorities for agencies that deal with wetland management and direct funding for conservation actions. An important example of the usefulness of wetland valuation is in environmental assessment (EA) processes. In this context, knowing the monetary value of a natural feature assists EA decision-making through comparison to other economic factors of a proposed project.

Common Yellowthroat

Eric Dresser

At Point Pelee on Lake Erie, the area's wetlands were found to have an annual recreational value of more than $4 million (CDN), thanks in large part to the birdwatchers who flock to this famous avian migratory stopover.

Canadian Wildlife Service

While wetland valuation is an excellent idea in theory, it proves to be quite challenging in practice. Market values of some wetland products are available in terms of goods produced, such as cranberries or peat. The challenge is that a wetland's greatest worth to people is often in its societal or public value, an abstract idea that is difficult to conceptualize and quantify for many people. In some ways, the economic benefits received from wetlands are comparable to the benefits received from public education and health care. Unfortunately, this value is often realized only after a wetland has disappeared, when consequences such as flooding and well-water contamination emerge. This type of unforeseen problem is the driving force behind valuing wetlands – to support better-informed management decisions by recognizing the potential costs of wetland loss.

Acknowledging wetlands' broad societal value is an important step but it still leaves the challenge of deciding on an accepted dollar value for the benefits of this natural resource. Three primary methods exist for estimating a wetland's worth.

- The first is *direct use value*, estimated by surveying people's willingness to pay for benefits provided by the wetland (for example, to retain a recreational area).
- The second method is *indirect use value*, using mathematical models to estimate wetland values based on the market demand for wetland goods and services (for example, the amount spent or distance traveled by people visiting a wetland for recreational purposes).
- Finally, *proxy value* can be determined by assessing the values of other goods and services that approximate the values of wetland benefits. For example, what would it cost to build a water treatment facility to duplicate the water filtering capacity of a major Great Lakes coastal wetland? The answer to this question is likely millions of dollars.

A 1972 study from outside of the Great Lakes basin, in the Charles River Watershed in Massachusetts, found that the loss of 3,400 hectares of wetland near Boston would result in $17 million (U.S.) in flood damages per year. This value is equivalent to each hectare of wetland providing $5,000 worth of flood control each and every year. The study was completed 30 years ago, making that value even more considerable today.

Consideration of the economic values of natural systems, including wetlands, is emerging as a useful tool to demonstrate the value of wetlands in terms people can understand – dollars. Yet, given the complexity and variety of valuation methods, wetland valuation faces significant challenges and limitations.

Glenn Barrett

Black Duck

Walter B. Fechner

Enabling Agricultural Wetland Conservation

Ironically, wetlands have vast value for society, but they can have negative commercial value for individual landowners. In many cases, a wetland owner is not compensated for maintaining wetland function. The result is the unfortunate belief among many landowners that a wetland is worth much more to them as dry, productive land.

Various programs attempt to overcome this situation. In Ontario, the Ducks Unlimited program Land CARE targets agricultural regions, providing financial incentives and technical assistance for farmers to increase agricultural productivity, conserve their soil and water resources, and improve habitat, including wetlands. Similarly, in the United States, the Wetlands Reserve Program is an opportunity for farmers to receive financial incentives for retiring marginal agricultural areas in order to enhance adjacent wetlands.

In Canada, the Ecological Gifts Program supports landowners who donate ecologically sensitive areas, including wetlands. Land donations are assessed at fair market value and landowners receive enhanced income tax benefits.

www.on.ec.gc.ca/ecogifts

Coastal Wetland Ecology

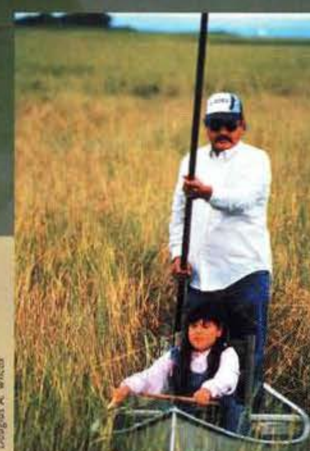
Plants and Plant Communities

Any Great Lakes resident who has explored the natural shorelines of the lakes has likely come to recognize, and may also be able to identify, many wetland plants. Cattails, water lilies, and grasses thrive in the wetland environment and represent the traditional marsh to many people. Wetland plants are classified into categories by their adaptation to growth in water.

Canadian Wildlife Service

Fragrant White Water Lily

Wild Rice is an annual aquatic grass that grows in the shallows of lakes and rivers throughout eastern and north central North America, including Great Lakes coastal wetlands. The light green colour of Wild Rice easily allows it to be distinguishable from stands of cattails, bulrushes, and other emergent vegetation. Wild Rice has been an important North American aboriginal food for at least 1,000 years.



Douglas A. Wilcox

Canadian Wildlife Service

Diverse vegetation communities are found throughout coastal wetlands of the Great Lakes. Detailed information on these communities is available in *Great Lakes Coastal Wetlands: Abiotic and Floristic Characterization*, found at

www.epa.gov/glnpo/ecopage/wetland/

These plant categories are general because most wetland plants, by necessity, can tolerate a range of water depths. There are five basic growth-forms (Figure 4).

- **Floating** plants are those that may be rooted under water but have leaves that float on the surface, such as Yellow Pond Lily, and those that float freely, such as duckweeds.
- **Submerged** plants are rooted under the water and grow entirely underwater such as Wild Celery and Coontail. Submerged and floating plants are often grouped as aquatic wetland vegetation.
- **Emergent** plants have roots that might be under water, but grow and flower above the water's surface. Common examples include cattails and bulrushes.
- **Wet meadow** zone plants represent the transition between the wetland and terrestrial environment. Flooding is seasonal with soils flooded in spring and moist to dry by summer. Species are less tolerant of prolonged flooding and include Jewelweed, grasses, and sedges.
- **Shrub** zone plants are woody plants less than six metres tall that grow above the water line where conditions allow. This area is still influenced by periodically flooded conditions. Plant types include shrubs and small trees such as willows, dogwoods, Buttonbush, Leatherleaf, and Bog Rosemary.

Climate, bedrock, land use, and the impact of the lake vary markedly between regions around the Great Lakes shoreline. As a result, each coastal wetland evolves as a unique community of plant species, with different types of plants determined by these local physical conditions.

Distinct plant communities have been identified for coastal wetlands of the Great Lakes based on restricted geographic areas containing wetlands with similar wetland vegetation and physical conditions. Each community supports key plant species that seem to prefer certain environments to others.

An example of a vegetation community is the *Lake Ontario Lagoon Marshes*, characterized by barrier-beach wetlands, with a unique set of wetland species in the emergent and wet meadow and shrub zones due to dampened water level fluctuations as a result of lake-wide regulation. High densities of submerged species such as Common Waterweed and Coontail are common, as well as shrub species such as Buttonbush and Dogwood.

In contrast, the *Northern Great Lakes Marshes* are located at the northern reaches of the Great Lakes. These wetlands are common along the St. Marys River and areas of Lake Superior and northern Lakes Michigan and Huron, and are characterized by low densities of bulrush and burreed in the emergent zone and Blue-joint Grass and Marsh Cinquefoil in the wet meadow areas.

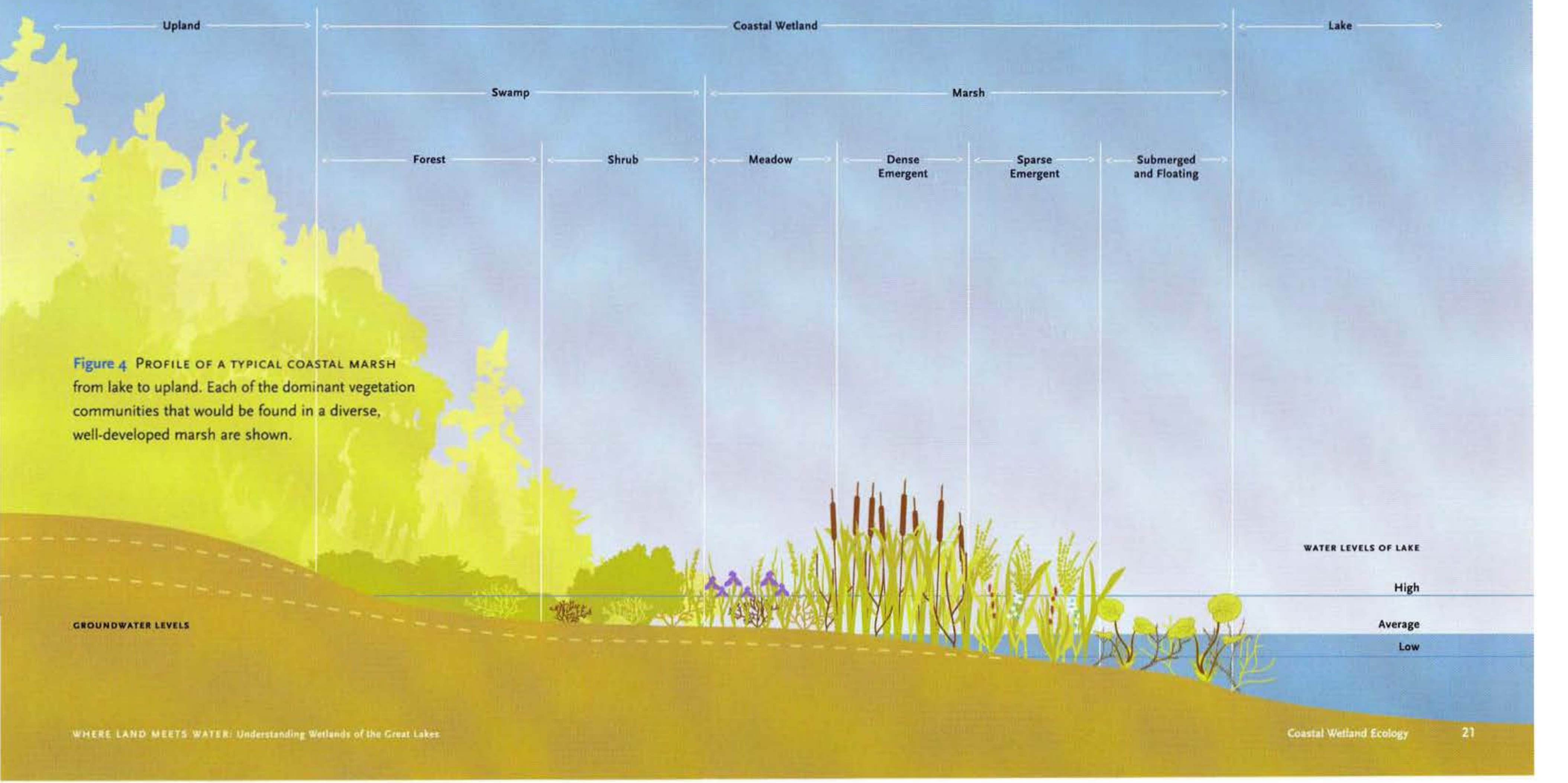


Figure 4 PROFILE OF A TYPICAL COASTAL MARSH from lake to upland. Each of the dominant vegetation communities that would be found in a diverse, well-developed marsh are shown.

Fish

Wetlands are notoriously difficult environments in which to study fish, as there is much cover in which fish hide from predators and avoid other disturbances. There are over 100 native Great Lakes fish species, many of which use wetlands for feeding, cover, spawning, and nursery habitat. Wetlands are habitat for cool-water and warm-water nearshore fish species such as Northern Pike, Walleye, and sunfish. In one study of fish in marshes along the north shore of Lake Ontario, 36 species were found to use the marshes, and 89 percent reproduced there. Northern Pike are a prime example: they spawn in flooded grasses in the shallow backwaters of marshes. Other fish, such as Walleye, spawn in rivers where the young drift downstream to nursery habitat provided by drowned river-mouth wetlands.

Fish that spawn in wetlands have one of two dominant reproductive strategies – those who leave and those who stay with the eggs. Spawners who leave immediately after depositing eggs (for example, Muskellunge) spawn in the early spring after the ice melts. This strategy takes advantage of the warmer shallow-water temperatures and high dissolved oxygen levels required for egg respiration. Other fish, such as Largemouth Bass, spawn in the late spring or early summer. In this case, the male remains with the eggs, fanning them in order to provide oxygen and guarding the eggs and juvenile fish from predators.

Some adult fish occupy Great Lakes marshes for much of the year, but seasonal use is more common. In the lower Great Lakes where the summers are hot and plant growth is extensive, decomposition of litter reduces the amount of dissolved oxygen in the backwaters of marshes to the extent that many species of fish cannot survive. In these marshes, fish tend to leave or move to the wetland's lakeward edge by mid-summer and return in the autumn when the rate of decomposition has slowed and oxygen levels increased.

Longnose Gar

Shawn Staton

Bowfin

Douglas A. Wilcox

Canadian Wildlife Service

Fishery biologists removing fyke net used for fish sampling.

Remarkable wetland fish

Some fish can remain in wetlands all summer long because they have remarkable physiological and/or behavioural adaptations to life in low oxygen conditions. Bowfin, intriguing remnants of an ancient line of fishes, gulp air from the surface. Gar, also primitive fish, lie at the surface of marshes where **diffusion** of oxygen from the atmosphere produces higher dissolved oxygen levels in the water. Yellow Perch move into marshes during the day when **photosynthesis** by plants produces oxygen and out of the marshes during the night when oxygen levels drop.

Douglas A. Wilcox

Pumpkinseed

Canadian Wildlife Service

Bullhead

Birds

Wetlands have been favorite destinations for birdwatchers for decades. Great Lakes coastal wetlands such as those at Point Pelee, Long Point, Lake St. Clair, and Presque Isle are among the richest wetland bird habitats in the Great Lakes basin. Many water, shore, and song birds rely on wetlands to fulfill important components of their **life history**, such as mating or feeding. Some species rely on wetlands entirely to fulfill all of their habitat requirements.

Wetlands are particularly important to birds as breeding and feeding habitat; however, wetland-dependent bird species are not well understood compared to many land birds, due to difficulties in accessing their habitats for study. As well, many species such as the King Rail are secretive by nature. Gaining understanding of wetland birds is essential to conservation of their habitat. At least 10 coastal wetland birds are currently considered at conservation risk in the Great Lakes basin, including the King Rail, Least Bittern, and Black Tern.

At least 42 of over 100 species of birds that use Great Lakes coastal marshes, typically nest there. The Red-winged Blackbird is probably the best known of these wetland nesters. To many people, the flash of the highly territorial male's bright red wing band is a welcome sign of spring. The abundance of plants, insects, fish, and amphibians provides food for a broad range of birds from the **omnivorous** Canvasback duck to the predatory Great Blue Heron. In addition, the importance of coastal wetlands as feeding habitat extends to the thousands of birds that use these wetlands for fall and spring migratory stopovers.

RED-WINGED BLACKBIRD

The Marsh Monitoring Program (MMP) is one of the key wildlife monitoring initiatives for coastal and inland marshes in the Great Lakes basin, and its success has been fueled by the energy and heart of volunteers. Established in 1995, the MMP is a volunteer-based binational program, coordinated by Bird Studies Canada in partnership with Environment Canada and the U.S. Environmental Protection Agency. Volunteers conduct regular surveys for marsh birds, frogs, and toads. More than 500 volunteers have taken part, contributing more than 6,000 hours of their collective time. The survey information collected has already identified several preliminary trends, including the significant decline of Black Tern populations in Great Lakes wetlands.

The MMP was designed to identify trends at a basin-wide scale, however the data are also useful at the local level to support the Remedial Action Plans underway in each of the Areas of Concern (AOC) around the Great Lakes basin. AOCs are the focus of rehabilitation efforts because of stress by pollutants, habitat loss, and habitat degradation. MMP survey routes are located in each of the AOCs that contain marsh habitat, and resulting data provided baseline information on the health of these wetlands. Combined with intensive local monitoring, MMP data are valuable for assessing the effectiveness of rehabilitation efforts.

MMP VOLUNTEER MONITORING BIRD CALLS IN WETLAND.

Canadian Wildlife Service

Since 1995, the Marsh Monitoring Program (MMP) – a volunteer-based wildlife study – has collected detailed population information on wetland birds. Initial results indicate that populations of Pied-billed Grebe, Blue-winged Teal, American Coot, and Black Tern (Figure 5) have experienced significant declines in the Great Lakes basin. Based on data recorded by MMP surveyors, the largest drop has been for Black Terns. Their numbers have decreased by an average of 19 percent annually from 1995 to 2001 (Figure 6). Similarly, numbers of Pied-billed Grebe decreased by an average of almost 12 percent per year.

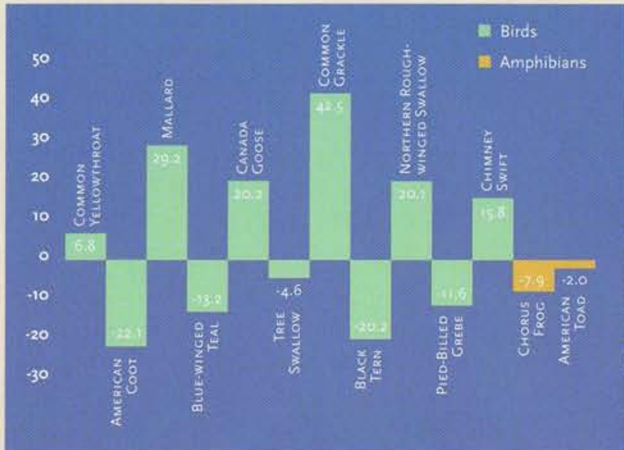
These population patterns are alarming, and the causes of the apparent declines remain unclear. Habitat-altering stresses, such as lake levels, contaminant trends, and **invasive species**, have been analysed with species population numbers to reveal some direct linkages. For example, many birds depend on a specific mix of emergent vegetation and open water habitats that usually result from periodic, wide fluctuations in water levels. Long-term reduction of water level extremes, particularly in Lake Ontario, may play a role in diminishing habitat suitability for these bird populations.

In contrast, some populations of birds found in coastal wetlands have increased. In recent years, there have been basin-wide increases for Canada Goose, Mallard, and Common Yellowthroat (Figure 7). Additional years of monitoring and more detailed analyses are required to understand how these patterns relate to broader trends in Great Lakes coastal and inland wetlands.

• Marsh Monitoring Program routes 1995-2001

The MMP is always looking for new volunteers to monitor their local Great Lakes marsh. To learn more about this innovative program, visit the website at

www.bsc-eoc.org/mmpmain.html



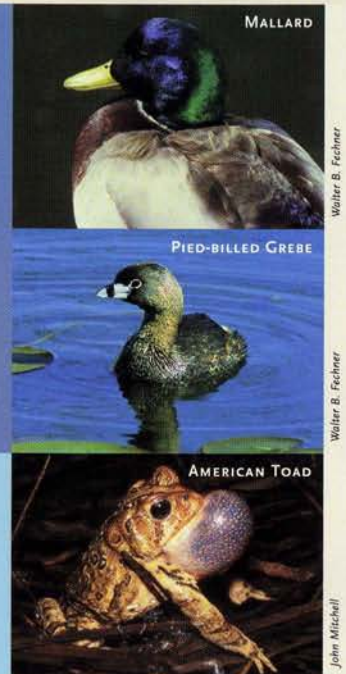
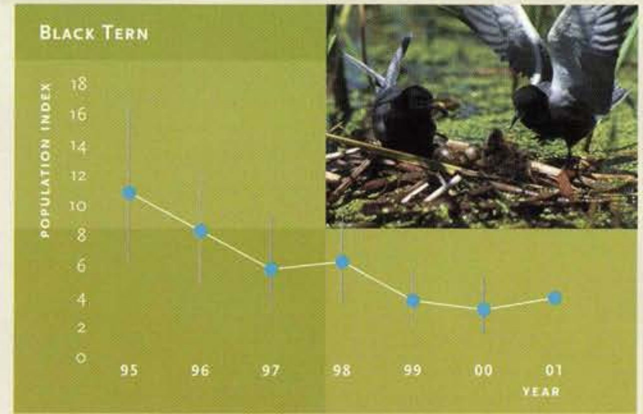


Figure 5 **Bird and amphibian populations** that showed significant positive or negative trends throughout the Great Lakes basin between 1995 and 1999. Values indicate the percent increase or decrease in population index over that time period.



Trend (%/yr) = - 18.7 (-24.1, -12.9)

Figure 6 **Annual population index** for the Black Tern as detected on Great Lakes basin MMP routes, 1995 through 2001.*

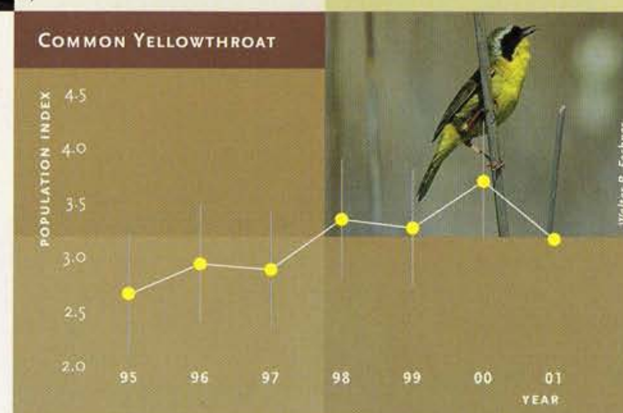
Bird Protection on the Global Stage

Important Bird Areas

The Important Bird Areas (IBA) program is an international initiative that strives to conserve significant sites for birds throughout the world. The program was launched in 1985 in Europe, where it has gained protection for more than 65,000 square kilometres of critical habitat. Canada and the United States launched their IBA programs in 1996, and more than 2,000 potential sites have been identified in the two countries. Twenty-nine of the 71 Canadian-recognized Important Bird Areas in southern Ontario include freshwater marsh habitat.

IBAs are assessed under four main categories: sites with significant numbers of threatened species; sites with species with restricted ranges; sites with species that are largely restricted to a unique or threatened community type; and sites where birds congregate in large numbers when breeding, in winter, or during migration. IBAs are identified as globally, continentally, or nationally significant.

Visit www.ibacanada.com
or www.audubon.org/bird/iba/
for more information.



Trend (%/yr) = + 4.0 (1.2, 6.9)

Figure 7

Annual population index for the Common Yellowthroat as detected on Great Lakes basin MMP routes, 1995 through 2001.*

* Population indices are based on counts of individuals inside the MMP station boundary and are defined relative to 2001 values; vertical bars indicate 95 percent confidence limits around annual indices. The estimated annual percent change (trend) is indicated for each species and the lower and upper extremes of 95 percent confidence limits are enclosed in parentheses.

Amphibians

The call of a frog is a familiar sound evocative of spring or summer evenings spent near a pond or wetland teeming with life. Great Lakes coastal wetlands are essential habitat for 13 species of frogs and toads. **Amphibians** depend upon the essential mix of land and water that wetlands provide, playing an often unseen, yet critical, role in the coastal wetland food web. Many wetland fish eat tadpoles, and adult frogs are prey for wading birds, such as the Black-crowned Night-Heron. In turn, adult frogs feast on wetland insects, especially as they emerge *en masse* from their aquatic larval stages to their adult, airborne forms.

Based on population surveys by the Marsh Monitoring Program from 1995 to 2001, Great Lakes wetland amphibian populations show a mix of growth and decline. Five species showed general population increases: Bullfrog, Northern Leopard Frog, Spring Peeper, Green Frog, and Wood Frog. Three species experienced general declines during this period: the American Toad, Grey Treefrog, and most notably, the Chorus Frog whose population has dropped an average of almost eight percent per year in the Lakes Huron and Michigan basins (Figure 8). More telling trends are likely to be revealed as continued monitoring strengthens statistical relationships.

GREEN FROG

Two rare wetland amphibians are considered to be at risk of **extirpation** in some areas of the Great Lakes region – the Blanchard's Cricket Frog and Fowler's Toad. The Blanchard's Cricket Frog is a small, non-climbing member of the tree-frog family at the northern edge of its range in southern Canada. In Canada, it has only been found at Point Pelee National Park (last observed in 1920) and Pelee Island (last observed in 1977). Although common in the eastern United States, the Fowler's Toad is rarely seen in Great Lakes wetlands, found only in isolated areas around Lake Erie.

A PRESSING THREAT to coastal wetland amphibians and reptiles is automobile traffic. Many frogs, toads, snakes, and turtles are killed crossing roads as they return to coastal wetlands to breed. In some areas, warning road signs alert motorists to highly used crossing areas.

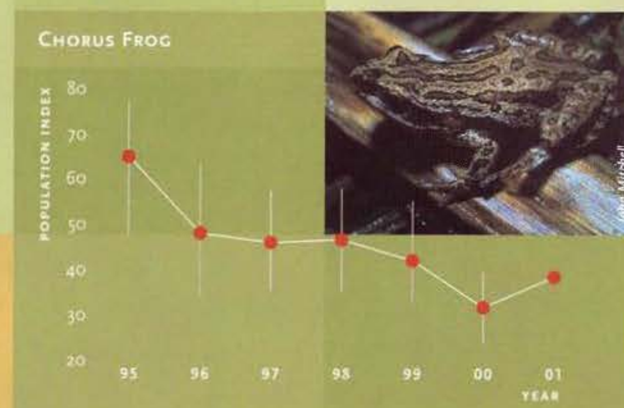
PAINTED TURTLE

NORTHERN WATER SNAKE

Sun, Scales, Swamps

Visit a coastal wetland on a sunny summer day and there is a good chance you will see sunbathers – turtles and snakes. Coastal wetlands are habitat for about a dozen species of **reptiles**. The most common include the Snapping Turtle, Painted Turtle, Eastern Garter Snake, and Northern Water Snake. These reptiles are crucial wetland predators, and in turn, their eggs provide food for wetland mammals. Coastal **shoreline hardening** – the construction of breakwalls and retaining walls – is particularly damaging to turtle reproduction because they require soft sandy areas in which to dig holes to deposit their eggs.

SNAPPING TURTLE



Trend (%/yr) = - 3.5 (-5.3, -1.5)

Figure 8
ANNUAL POPULATION INDEX for the Chorus Frog as detected on Great Lakes basin MMP routes, 1995 through 2001.*

Mammals

Although better known for their bird, fish, and amphibian life, Great Lakes coastal wetlands support a diversity and abundance of mammals. These range from one of North America's largest land animals, the Moose, to some of the smallest mammals, such as the Water Shrew.

Two of the best-known wetland mammals are the Beaver and the Muskrat. Both not only live in wetlands but play a key role in shaping and even creating them. Beavers in particular are ecosystem engineers – their dam-building activity is responsible for the creation and maintenance of many inland wetlands. Similarly, Muskrats thrive in cattail marshes and can clear large areas of vegetation, for food and to build their cone-shaped shelters. In the process, they increase the area of open water and create a more structurally diverse wetland as habitat for other animals.

Northern Great Lakes coastal wetlands, particularly bogs, are an important food source for Moose, who eat aquatic plants as an essential source of salt and other nutrients. Among the larger wetland animals, many small mammals are found, including the Southern Bog Lemming and several species of mice. These, in turn, are a key food source for mammalian predators, such as the American Mink and Red Fox.

Wetland loss and disruption have an impact on mammal populations due to loss of habitat and prey species. For example, the states of Illinois, Ohio, and Indiana, have listed the River Otter as endangered due to low populations. Reintroduction of the River Otter appears to have been successful in restoring viable populations in many areas. Populations continue to be monitored to ensure the success of this wetland mammal.

Eric Dresser

MINK

Eric Dresser

SNOWSHOE HARE

Eric Dresser

BEAVER

Glenn Barrett

MOOSE

A review of aquatic habitat, plants, and animals (birds, fish, invertebrates, amphibians, and reptiles) in Canada, is available at

www.aquatic.uoguelph.ca

Invertebrates

Wetland **invertebrates** (animals without backbones) are best known by one bloodsucking representative, the mosquito. But these small animals – from tiny plankton to larger insects, mollusks, sponges, crayfish, and snails – are the largest and most diverse group of coastal wetland creatures. Like amphibians, many invertebrates have two distinct life stages: a larval (the immature form of the animal) aquatic one and an adult one that is aerial or terrestrial.

Many larvae and some adults are **benthic** or bottom dwellers, feeding on decaying plant material and bacteria. For example, midges, a type of small fly, begin life as bottom-dwelling blood worms, named for their dark-red colouring. The water column and aquatic vegetation support invertebrates such as the predatory Giant Water Bug. A wetland's water surface is also rich in invertebrates, such as Water Striders and microscopic animals such as hydras, relatives of corals that cling to the underside of wetland plants. The air above wetlands is alive with adult dragonflies and mayflies.

Given their large numbers and diversity, invertebrates play a critical role in coastal wetland food webs. Since many are herbivores, they are often the food link between wetland plants and larger animals such as birds, fish, amphibians, and mammals.

Canadian Wildlife Service

Invertebrates and Wetland Health

Invertebrates are excellent **indicators** of coastal wetland health since they occupy a wide range of habitats and are relatively easy to collect and study. As a result, their role is emerging in the ecological monitoring of coastal wetlands. For example, the presence of certain dragonflies, damselflies, and mayflies can be a quick indicator of a healthy and productive emergent plant community within a coastal marsh.

BIOLOGIST COLLECTING INVERTEBRATES FOR ANALYSIS OF WETLAND HEALTH.

Eric Dresser

MAYFLY ON THISTLE

Eric Dresser

SKIPPER

Eric Dresser

SPIDERWEB

Canadian Wildlife Service

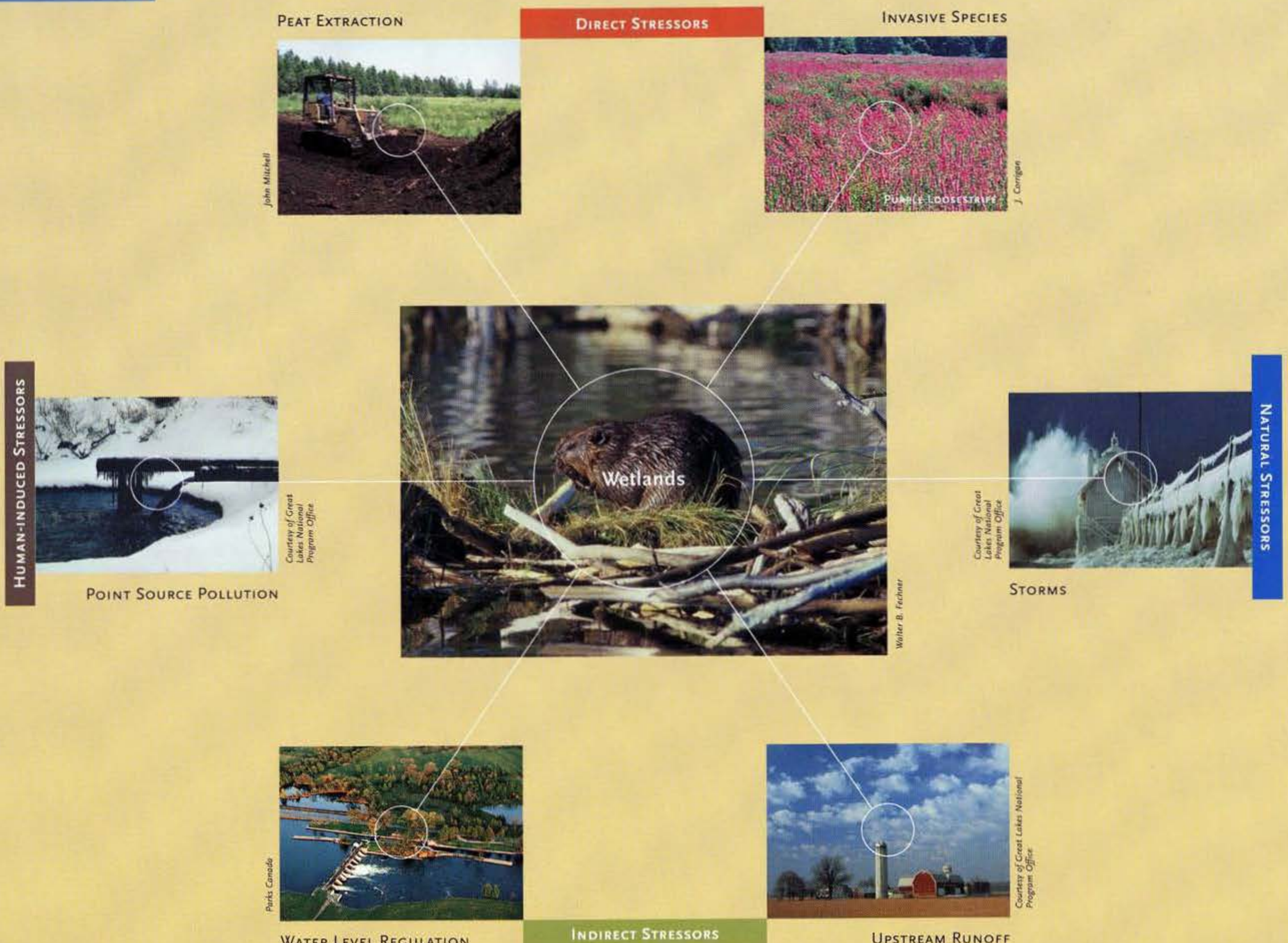
DRAGONFLY EXOSKELETON

Wetlands Under Stress

Like many ecosystems, coastal wetlands of the Great Lakes are, by nature, stress-dependent systems. In fact, species diversity is largely driven by natural habitat changes over time. To assess the human impact on coastal wetlands and develop rehabilitation efforts, it is necessary to distinguish between natural changes and those that are **anthropogenic**, or caused by people.

Biologists refer to the pressures that change wetlands as stressors. Stress, of course, is not always a bad thing. In human lives, there is both 'bad stress', an adverse condition or circumstance that disturbs normal physiological or psychological functioning, and 'good stress', the physiological response to changes in surroundings that keeps humans alert and energized. Similarly, coastal wetlands experience both positive and negative stress. Forces such as water level fluctuations stress wetlands as part of a natural cycle allowing exposure and germination of seeds during periods of low water. In contrast, the pressure of draining and filling wetlands, and receiving agricultural and urban runoff, are negative stressors resulting in a loss of area and quality of wetland habitat.

Canadian Wildlife Service


Direct Stressors
Peat Extraction
John Mitchell
Invasive Species
Purple Loosestrife
J. Corrigan
Human-induced Stressors
Point Source Pollution
Courtesy of Great Lakes National Program Office
Wetlands
Walter B. Fechner
Natural Stressors
Storms
Courtesy of Great Lakes National Program Office
Indirect Stressors
Water Level Regulation
Parks Canada
Upstream Runoff
Courtesy of Great Lakes National Program Office

Canadian Wildlife Service

HIGH LEVELS OF SUSPENDED SEDIMENT increase water turbidity and decrease light penetration.

Eric Dresser

MUSKRAT

Natural Stressors

Four of the most commonly cited and important natural stressors of coastal wetlands are water level fluctuations, sedimentation and turbidity, ice and storms, and invasive species.

The major stressor affecting Great Lakes wetlands is water level fluctuations, a vital link in the maintenance of wetland diversity. The potential impacts of water level variability are discussed in detail beginning on page 12.

Another major stressor is the constant change in the amount, location and movement of sediments. Natural changes in sediment location and movement are often directly linked to changes in water levels and shoreline currents. Sediments can form barrier beaches and sand spits that protect wetlands; their erosion can expose wetlands to wave attack.

If deposited in excess into existing wetlands, sediments can bury wetland plant communities. Elevated suspended sediment concentration in the water column increases water turbidity. Following heavy rainfall and during spring melt when runoff is extensive, large quantities of particulates may be flushed into the wetland from upstream. High turbidity decreases light penetration, limiting photosynthesis in plants and potentially causing die-off of some fish species due to lack of oxygen in the water column.

The impact of ice on coastal wetlands is closely linked to changes in water levels. If the water levels drop in the winter, ice can form in the bottom sediments and freeze them, allowing them to be carried away with receding ice. Winter storms can also cause shoreline ice to erode protective barriers and destroy wetland vegetation.

Natural stressors of Great Lakes wetlands also include some native plants and animals. Invasive emergent plants such as cattails can stress wetlands by forming large, single species stands of vegetation that greatly reduce faunal diversity. The Muskrat is a **keystone** mammal in wetlands of the Great Lakes, as well as much of North America. Muskrats can substantially alter wetland habitat by cutting emergent vegetation, such as cattails and bulrushes, for food and shelter. The unvegetated pools around Muskrat houses and platforms, formed by cutting activity, create open areas within the wetland. Beavers also use wetlands of the Great Lakes and have similar habitat-altering effects.

Human-induced Stressors

Human-induced stress is generally more harmful to overall wetland health because it tends to be more persistent and of greater magnitude than natural stress. For more than 200 years, Great Lakes coastal wetlands have been filled, drained, and converted to allow urban, agricultural, and industrial use of these areas.

Physical alteration

One of the most common stressors to coastal wetlands is direct, large-scale physical alteration. Ranging from vegetation removal to filling or draining a wetland, these actions occur on all of the lakes but most notably in the highly populated areas of Lake Ontario and the lakeplains of western Lake Erie, Lake St. Clair, and Saginaw Bay on Lake Michigan. A 1982 study estimated that Lake Ontario's heavily populated Canadian shoreline between Niagara Falls and Toronto has lost coastal marsh area ranging from 73 to 100 percent in urban areas such as Toronto. In Ohio, over 90 percent of the state's original wetlands have been drained, making wetland loss the second leading cause of wildlife endangerment in the state after general habitat destruction.

Lake level regulation

After physical alteration, the greatest human impact on coastal wetlands is a result of regulation of lake levels, particularly of Lake Ontario. As a result, wetland plant diversity has significantly decreased across the entire lake. Lake Superior is also regulated, but the range of fluctuations and the cyclic nature of high and low lake levels have not been changed significantly, minimizing the effect on wetland communities.

Shoreline hardening at Maumee Bay, Toledo, Ohio on Lake Erie

Courtesy of Great Lakes National Program Office

Shoreline modification

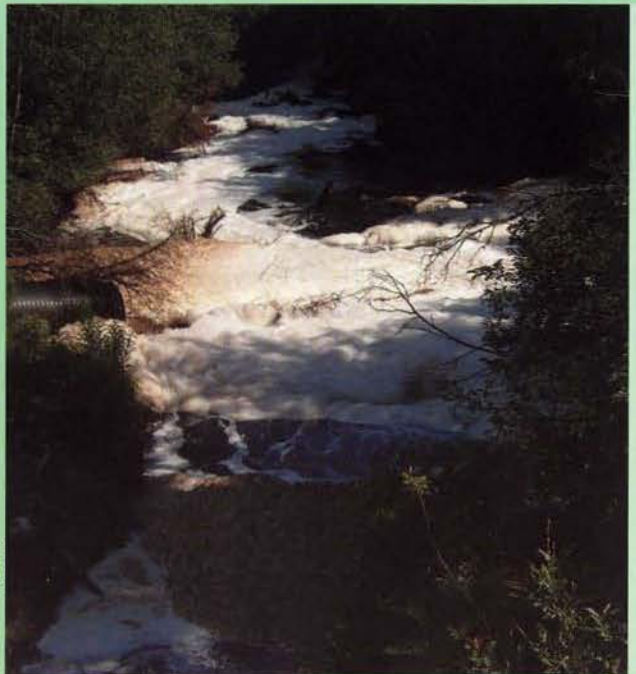
Great Lakes shorelines are heavily used for agricultural, urban, industrial, and recreational activities. Affected shorelines are 'hardened' by the construction of breakwalls, **groynes**, and retaining walls to resist erosion and flooding. Studies show that as much as 75 percent of Great Lakes basin shorelines have been hardened in some areas. Hardening is most evident in the lower lakes and connecting channels. For example, 69 percent of the St. Clair River shoreline has been hardened significantly.

Shoreline hardening damages coastal wetlands and coastal processes in general by changing sediment movement and availability. Some shoreline erosion is necessary to maintain many coastal wetlands, as the eroded sediment supplies the material for protective bars, beaches, and spits.

Graham Bryan

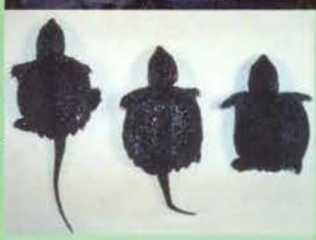
Toronto, Ontario, Canada

Encroachment of urban areas is a major cause of wetland loss in the Great Lakes basin.



Canadian Wildlife Service

Pulp mill effluent discharged into local stream.



Canadian Wildlife Service

Hatchling Snapping Turtles showing tail deformities (right and center) and normal tail (left).

Water quality

A major health issue for people who live in the Great Lakes basin, water quality is also critical for coastal wetland health. The range of water quality issues includes nutrient enrichment, the accumulation of toxins, increased turbidity, and changes in water temperature.

Nutrient enrichment, the addition of nutrients such as phosphorus and nitrates from agricultural and residential runoff and sewage discharge, is one of the most widespread water quality issues in the lower Great Lakes. Excessive levels of nutrients damage wetlands by dramatically increasing some plant growth, particularly that of algae or **phytoplankton**. Excessive growth allows algae to shade-out submerged and emergent vegetation and can cause massive die-off of certain principal species. It also produces a significant amount of organic material that will eventually decompose and use up valuable oxygen.

Toxic chemicals also stress wetland biological systems, especially the faunal communities. Through the processes of **bioaccumulation** and **biomagnification**, the impact of toxic chemicals is greatest on species at the top of the food web – predatory birds, fish, and mammals. Animal health and reproduction can be damaged by contaminants and affected sediments may be toxic to fish eggs and benthic organisms. Fish-eating birds of the Great Lakes are known to experience thinning of eggshells and deformities. Although levels of DDT and PCBs (polychlorinated biphenols) have declined significantly since their use was restricted in the 1970s, the effect of the continuing discharge of other persistent toxic chemicals on the water quality of ecosystems is not well understood.

In recent years, the impacts of synthetic chemicals known as endocrine disruptors are becoming apparent. This family of chemicals blocks, mimics, or otherwise interferes with naturally produced hormones, the body's chemical messengers, that control how an organism develops and functions. While use of endocrine disrupting chemicals such as DDT and PCBs has been restricted or banned, many others are still in wide use across the Great Lakes basin and make their way into coastal wetlands through urban and agricultural runoff, and municipal effluent. These include organochlorine pesticides still in use in North America, natural hormones produced by livestock, synthetic steroids found in contraceptives, and components of plasticisers and surfactants released in industrial effluent.

Effects that are being reported in wildlife range from crossed-beaks in birds and abnormally formed reproductive organs in reptiles, to abnormal mating and parenting behaviour and altered male to female ratios among various populations, including Herring Gulls in contaminated areas of the Great Lakes. Health effects are not limited to wildlife – these chemicals may also impact humans. It has been suggested that among other reproductive and developmental effects, they may be responsible for declining sperm counts, increased breast cancer, and increased testicular cancer in young men. Research is underway in both Canada and the United States to test these findings.

More information can be found at
www.epa.gov/endocrine and
www.ec.gc.ca/eds

Exotic species

Exotic, or non-native, species have threatened the Great Lakes ever since Europeans settled in the region in the 19th century. To date, more than 140 exotic aquatic organisms of all types – including plants, fish, algae and mollusks – have become established in the Great Lakes, many of them in wetlands.

Eurasian Water Milfoil, introduced accidentally from Europe in the 1940s, is a stringy, submerged plant that quickly proliferates in North American waterbodies. Highly invasive, it aggressively competes with native plant communities and reduces biodiversity. Similarly, large stands of Purple Loosestrife are a common occurrence in many Great Lakes wetlands. It was introduced from Europe in the early 1800s as a garden plant. Its attractive appearance is deceiving – it is extremely invasive and out-competes desirable native species, which in turn makes habitat less desirable for many birds, insects, and other wildlife that rely on the native habitat.

The Rusty Crayfish is a crustacean whose population has expanded beyond its limited territory in the central United States, and is now found in every Great Lakes state and in many parts of Ontario. Perhaps the crayfish's most serious impact is destruction of submerged aquatic vegetation while feeding. This reduces plant diversity and abundance, and then impacts nesting, shelter provision, and erosion protection for shoreline areas. The Rusty Crayfish is extremely aggressive, potentially displacing native crayfish species through competition. This exotic species is also less likely to become prey for fish compared to native crayfish. Instead of attempting to swim away like native species, Rusty Crayfish put up their claws in defense, which deters predators.

Global changes seen locally

Human-accelerated, global climate variability could have a major impact on Great Lakes coastal wetlands. Global climate models (GCMs) predict that a doubling of carbon dioxide concentrations in the atmosphere could increase the surface air temperatures in southern Ontario between 3.4 and 9.1 degrees Celsius in winter and between 2.7 and 8.6 degrees Celsius in summer. This magnitude of temperature change will likely create atmospheric and hydrologic conditions that will significantly impact the water levels of the Great Lakes. While estimates vary, some studies show that lake levels may drop from 0.2 metres in Lake Superior to 1.6 metres in Lakes Huron and Michigan.

As illustrated throughout this report, Great Lakes coastal wetlands are especially sensitive to any fluctuation in water levels. The rate of the water level change, the magnitude of the change, the role of groundwater supply, the composition and presence of a healthy seed bank, and the offshore bathymetry of individual wetlands will determine the impact on the biodiversity and area of wetland vegetation.

A change in wetland vegetation will affect the fish and wildlife species that depend on wetlands. Reduction in the proportion of open water in wetlands and an increase in dense emergent and wet meadow vegetation means a loss of optimum habitat for some species of fish, waterfowl, and other marsh birds.

In addition, the predicted increase in air temperature may greatly affect plant growing seasons and distribution. Certain plant species that are adapted to the current climate may not find suitable climatic conditions in the coming century. In general, as temperatures rise, plant communities are likely to shift north to follow their preferred climatic range.

Despite an uncertain future, coastal wetlands are resilient and stress-tolerant systems. Given the right combination of space to move, timing, and species adaptation, the diversity and area of Great Lakes coastal wetlands will survive well into the 22nd century.

Jeff Gunderson, University of Minnesota Sea Grant Program

Rusty Crayfish

NOAA, Great Lakes Environmental Research Laboratory

Turning the Tide

Coastal Wetland Rehabilitation

There is now a global movement to protect and rehabilitate wetlands after decades of thinking of wetlands as wastelands. It is a change in perspective that is due to the growing awareness of wetlands' enormous ecological and societal values. From Vietnam's Mekong Delta to South American coastlines and the Florida Everglades and back to the Great Lakes, work is underway to protect and rehabilitate wetlands of all kinds.

Wetland rehabilitation starts with changes in how we think

One of the biggest challenges to successful wetland rehabilitation is conceptual. Coastal wetlands are not static entities – they are dynamic systems that are always changing. What is ultimately important is not what the wetland looks like after a summer of rehabilitation work, but rather how it functions over decades. Similarly, the end point of a Great Lakes wetland rehabilitation effort is not a specific one-time mix of plants and animals. Rather, it is a range of end points representing the many different stages of wetland succession that would occur naturally.

Wetland Vocabulary

Rehabilitation	*Revival of the functions or values of a degraded wetland.*
Restoration	*Modification of the existing function and structure of a wetland's habitat so that it is similar to historical conditions.*
Creation	*The conversion of a persistent upland vegetation community or ephemeral shallow water area into a permanent wetland where no previous wetland existed.*
Enhancement	*Activity that addresses the stresses or limitation on one or more wetland functions or values.*

Patricia Chow-Fraser

Patricia Chow-Fraser

Canadian Wildlife

THERE ARE THREE GENERAL PHILOSOPHICAL GUIDELINES FOR WETLANDS REHABILITATION.

1. **Understand wetland ecological and hydrologic principles.** For example, successful restoration efforts involve researching the historical conditions that previously shaped and maintained a coastal wetland.
2. **Design for function not form.** The goal is to produce a self-sustaining wetland, not a static one. This is one of the primary concerns with the permanent use of **dikes**. While dikes may create what look like coastal wetlands in the short term, they do not behave like them over the long term unless pump stations and gates are incorporated creatively into the design, or they are hydrologically reconnected to the lake.
3. **Give them time.** Wetlands evolve over years and decades. As such, wetlands rehabilitation and creation takes patience. The success of any rehabilitation effort takes many years to assess.

Techniques

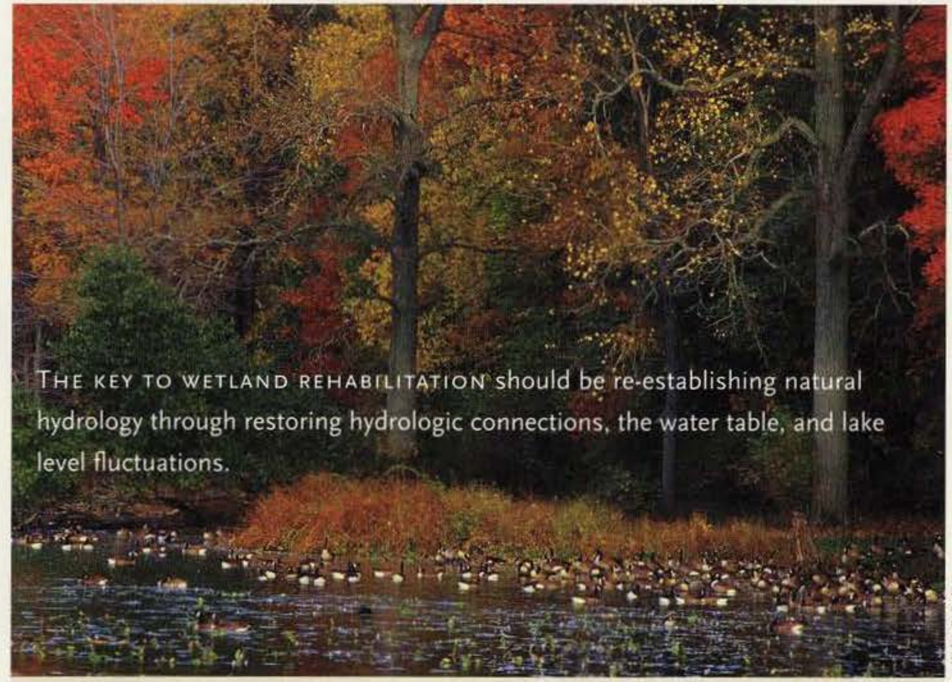
Wetland rehabilitation techniques are loosely grouped into four categories: hydrologic, sediment-related, contaminant, and biological. The particular techniques used in a rehabilitation effort will vary depending on the condition of the existing wetland and its classification.

Hydrologic techniques

Wetland hydrology is the single most important overall factor affecting the composition and structure of wetland vegetation in Great Lakes coastal wetlands. Proper restoration of wetland hydrology involves re-establishing hydrologic connections to the lake or inland water body, and maintaining the historic water budget. In some cases, temporary water control measures are required to ensure vegetation establishment. Construction of dikes and creating channels through dense vegetation are most often used to regulate hydrology. Both have advantages and disadvantages.

Diking a wetland involves modifying the existing hydrologic connection between the wetland and its water source by a human-made barrier, designed to alter the inflow or outflow of water and to protect the wetland from lake forces. The hydrology of the wetland is then regulated using pumps. Diking has been used extensively to manage wetlands on the lower Great Lakes. For example, at least 31 percent of Lake Erie's marshes are diked, including 77 percent of Ohio's coastal marshes. Once diked, periodic drawdowns of one to two years' duration allow the consolidation of sediments, germination of the seed bank, and curtail the growth of unwanted species such as Eurasian Water Milfoil in the wetland. The opposite condition, flooding, is used to control undesirable emergent plants such as Purple Loosestrife. Dikes have been used effectively to manage waterfowl habitat along the Great Lakes shores.

Dikes, however, may remove the hydrologic connection with the lake and eliminate fish access and nutrient and sediment transport if proper mitigative measures, such as fishway construction, are not implemented. Although pumping can be used to mimic natural processes, such as drawdowns, the dikes can limit wetland development, including preventing the lakeward expansion of wetland plants during low lake levels. The dikes also alter coastal sediment transport required to maintain protective wetland barriers, require ongoing maintenance, and are difficult and costly to remove.



Walter B. Fechner

BEFORE AND AFTER DEWATERING USING AQUA DAMS IN COOTES PARADISE IN HAMILTON, ONTARIO, CANADA.

Royal Botanical Gardens

Bagged water

Aqua Dams offer an intriguing alternative to dikes. Comprised of synthetic bags of water, they create temporary water-control structures that allow dewatering of wetland areas to stimulate the growth of the seed banks. Although not yet widely used in the Great Lakes basin, they hold considerable potential for temporary hydrologic control in wetlands.

CHANNELIZATION IN SAWGUIN CREEK MARSH, BAY OF QUINTE, LAKE ONTARIO

Ducks Unlimited Canada

A second technique – restoring historic channels through dense wetland vegetation – involves dredging wetland sediment and vegetation to positively influence water level, stream velocity, duration of flooding, and sedimentation. This technique is often used in wetlands that have become dominated by plants such as cattail and can be used to flush or direct turbid water through a wetland. Disadvantages include damage to adjacent vegetation and temporarily increased turbidity while work is underway.

SEDIMENT-RELATED TECHNIQUES

Sediment management in wetland ecosystems and adjacent shoreline areas is a highly complex challenge due to competing requirements in wetlands. On one hand, movement and deposition of sediment is essential to maintain the protective sand spits and barrier beaches that shelter coastal marshes from the Great Lakes' powerful waves. On the other hand, too much sediment input from upstream can lead to high levels of turbidity in the water column which may bury aquatic vegetation and habitat, causing a decline in general wetland health.

The requirement for natural deposition of sediment to protect wetlands is often disrupted by human-made shoreline structures. A common cause is the hardening of shorelines by breakwalls or revetments (sloped walls). These structures reflect wave energy along the shore or into the **littoral** zone where unnatural erosion can occur.

Recreating the conditions that initiate and sustain sediment supply and transport is one of the technical challenges in coastal wetland restoration. It involves strategic construction and placement of human-made structures like those that may have caused the problem originally. Replacement of protective bars may be required when human activities interfere with either the erosion or deposition of sediment. However, this must be done with caution and only after their potential effect along the whole of a shoreline is understood and controlled. Misplaced structures could exacerbate rather than relieve problems by redirecting forces.

For example, groynes – low walls in the water running perpendicular to shore – are designed to increase sediment deposition in sediment-deprived areas and prevent erosion. However, when designed improperly, they can cause excessive erosion on the down-current side and excessive deposition up-current. If sediment is in short supply, groynes will not be able to supply it to the wetland and may even impoverish adjacent areas.

Douglas A. Wilcox

ARMORING OF THE SHORELINE OF EASTERN LAKE ONTARIO WITH ROCKS AND CONCRETE ALTERS COASTAL PROCESSES.

Courtesy of Great Lakes National Program Office

SHORELINE EROSION

The second sediment-related rehabilitation concern in wetlands, elevated turbidity, is often a result of their position in the landscape. Many coastal wetlands occur at the mouths of rivers that drain large areas of upland. For example, the Grand River in southern Ontario drains an area of 7,000 square kilometres of agricultural, urban, and forested land. Following periods of intense precipitation or during spring snowmelt, large amounts of sediment are swept into local streams and make their way to the lake through coastal wetlands. Water slows as it enters the wetland and much of this sediment is deposited. This provides a positive filtration function for the adjacent lake, however it can create significant problems in the wetland itself.

Throughout all watersheds, best management practices should be adopted to reduce soil erosion and runoff. This will help alleviate sedimentation of waterways and deposition into receiving wetlands at watershed outlets. In agricultural areas, buffer strips and settling ponds have been shown to greatly reduce sediment loadings. Efforts should be made to retire marginal crop area, keep livestock out of rivers and streams, and plant trees and shrubs to stabilize riverbanks. In urban areas, runoff from construction sites is one of the most common sources of sediment. Measures should be taken to limit erosion in the first place, by planting vegetation on exposed soils, and efficiently finishing construction projects. Where erosion is unavoidable, installation of silt fences and settling ponds, and the use of diversion dikes should be attempted.

Contaminant techniques

Rehabilitation of a wetland degraded by contaminants is a considerable task. Toxic chemicals and excess nutrients threaten the ability of wetlands to support wildlife by interfering with naturally occurring processes of filtration, leading to contamination and **eutrophication**, and subsequently to a general decline in wetland health. As with many other rehabilitation challenges, prevention is critical. Control of contamination at the source is by far the most effective rehabilitation method for both nutrients and toxic chemicals.

Unfortunately, contaminant source control is not always possible. By nature, wetlands process nutrients and toxic chemicals to some degree. The microbial community on the roots of aquatic plants and in the adjacent soils is essential in aiding the decomposition of organic matter, nutrient cycling, and energy transfer in wetlands. Healthy nutrient cycling in wetlands means that nutrients are less likely to accumulate. Microbial activities such as **denitrification** of nitrate to harmless nitrogen gas, which is then released to the atmosphere, are essential in controlling nutrient concentrations.

Carp activities increase water turbidity in coastal wetlands.

Douglas A. Wilcox

Canadian Wildlife Service

Canadian Wildlife Service

Collecting water samples for nutrient analysis.

Great Lakes Sustainability Fund

Clam shell dredge modified to reduce sediment resuspension during operation.

Purple Loosestrife

Canadian Wildlife Service

Highly specific insects are being used to battle the spread of Purple Loosestrife, an undesirable, exotic invader of wetlands. Three beetles have been released for use as biocontrol agents in all Canadian provinces and 27 American states. One insect is a weevil (*Hylobius transversovittatus*) that attacks the root system and the two others are leaf-feeding beetles (*Galerucella calmariensis* and *G. pusilla*). In high densities, these insects cause defoliation of mature plants, death of seedlings, and the prevention or destruction of flowering spikes. Recent results from Ontario, Minnesota, and Michigan release sites indicate that the *Galerucella* beetles can have a dramatic impact on Purple Loosestrife infestations is as little as three years.

Wetlands can also process some toxic chemicals as microbes break them down, and chemical degradation occurs. However, if a large, historical deposit of contaminants exists in a wetland, something more needs to be done. Several options are available. First, persistent chemicals can be removed from wetlands by harvesting contaminated plants, although plant uptake typically accounts for only a small proportion (i.e., one-twentieth) of the contaminants processed by a wetland. A second option is dredging the contaminated sediments, a technique that has been used experimentally on some Great Lakes wetlands. Some scientists warn that this technique might do more harm than good by resuspending contaminants in the water column. A third option is to cap the contaminated sediments with clean soil, fill, or clay. Finally, in some cases, highly specific chemicals can be injected into sediments that are known to bind with contaminants and prevent their release or promote their breakdown. In many cases, it is a combination of the above techniques that will be most successful and limit further wetland impact during contaminant rehabilitation.

Biological techniques

Biological wetland rehabilitation often involves a three-pronged approach aimed at altering the wetland's animal and plant life. This is a combination of changing the habitat to support desired plants and animals, removing undesired plants and animals, and introducing beneficial species.

The most effective way to change a coastal wetland's plant and animal community is to alter the habitat's physical conditions. For example, increasing the ratio of open water to vegetation in a densely covered wetland, or increasing the range of water depths in most wetlands will increase overall plant diversity and satisfy habitat requirements for the greatest number of species.

In many cases, wetland managers also take a more direct approach to reducing unwanted plants and encouraging the growth of desired ones. The application of herbicides is a common remedy to remove unwanted garden and agricultural weeds. Although they can be effective in some wetland scenarios, the use of herbicides is often avoided as they may be toxic in an aquatic setting and destroy desirable vegetation along with the undesirable. In small, confined areas, unwanted vegetation may be removed manually rather than with herbicides. In large areas, mechanical techniques for removing emergent plants such as late-season burning and ploughing, and using specially designed aquatic combines for removing submerged vegetation such as Eurasian Water Milfoil, are also used. However, like herbicides, these large-scale methods can harm desirable species. In addition, a note of caution: if a plant reproduces **vegetatively**, broken-off segments of the plant can take root and cutting will only encourage its spread.

Eric Dresser

CANADA GOOSE

Control of wildlife considered to be nuisances, such as Common Carp, Mute Swans, and Canada Geese, can be permitted with approval from appropriate authorities. Birds can be discouraged by modifying preferred nesting habitat, oiling eggs, and placing lines and other obstructions to flight.

There are a variety of ways to directly add plants to a wetland. One way is to transplant **tubers**, roots, and seedlings from a nearby donor wetland, taking care that the donor wetland is not damaged in the process. Another option is to grow the plants in greenhouses and then transfer them to the wetland. This approach may involve classroom **propagation** programs, in which students grow plants as part of a rehabilitation effort. Seeding generally has the lowest chance of success since the conditions required for seed germination and young plant survival are rarely present in disturbed wetlands.

Canadian Wildlife Service

CONCEPTUAL REPRESENTATION of an ideal ratio of upland area to wetland area. A wetland is surrounded by three times as much upland.

Douglas A. Wilcox

Planting the Seed: A Guide to Establishing Aquatic Plants is a detailed how-to guide on adding plants to a wetland. *Planting the Seed* offers guidance on developing a plant list, obtaining plants and planting, and more. Available at

www.on.ec.gc.ca/wildlife/publications-e.html

IT'S NOT ONLY THE WETLAND THAT COUNTS...

Conserving a wetland usually also means protecting a significant portion of the surrounding upland forests and fields, an area known as the adjacent lands. These areas may provide hunting and nesting habitat for area-dependent raptors such as Northern Harrier and Short-eared Owl that may nest either in grasslands or marshes. Further, many turtles nest in upland areas up to 300 metres from the wetland margin. The amount of adjacent natural vegetation is important to the long-term survival and ecology of marshes in particular. One research study found that disrupting the adjacent upland areas could reduce wetland biodiversity to the same extent as losing half of the wetland itself. In addition to providing essential habitat for species, these areas act as **buffers** that filter out excess nutrients and sediments from upland sources that might otherwise run into the wetland.

Most properties managed for coastal wetland conservation now include adjacent upland. The recommended ratio of upland habitat to marsh area is three to one. This means that in an ideal situation, a 100 metre square marsh would be bound by at least a 300 metre square upland area. A larger upland area supports a healthier wetland community.

Case Studies

Wetlands are complex ecosystems, defined by their local hydrology, geomorphology, and climate. Each wetland requires a rehabilitation strategy that is sensitive to local conditions. While similar projects can provide a comparative guide, individual wetlands are often so unique that experience with one is inadequate as the only basis for decisive action on another. Rather, each rehabilitation project is better seen as an experiment, with the sum of the results providing context for future actions.

Taking this experimental perspective into account, many wetland rehabilitation projects often follow the principles of what is known as *adaptive resource management* (ARM). This is a long-term management technique based on a three-step process of taking action, monitoring the results, and adjusting the activity as necessary. A simple common definition of ARM is 'learning from doing', and it brings together resource managers and researchers with a common desire to improve management performance on a reasonable time-scale. The technique is in contrast to conventional management that emphasizes immediate objectives and seeks precise predictions. Unanticipated project results are often uncovered and welcomed as part of ARM.


Keith Discipline


Douglas A. Wilcox

Rehabilitating a wetland is far from an exact science; yet, with increased communication among scientists and practitioners, each new effort can add important information on how these ecosystems respond to human intervention.


Douglas A. Wilcox

Pitcherplant

Case Study 1

Reclaiming Paradise at Cootes

Cootes Paradise is struggling to live up to its name. Today, the mostly marsh, 250-hectare wetland at the west end of Lake Ontario is managed for multiple purposes within the Hamilton Harbour Remedial Action Plan. The wetland is separated from the lake by a natural peninsula, Hamilton Harbour, and a baymouth bar. Several creeks feed into this coastal wetland.

By the mid 1900s, this area was in trouble. Plant diversity decreased from 24 species to 10 between 1949 and 1970, and aerial photos revealed that 85 percent of emergent vegetation disappeared between 1934 and 1985. Plant loss during high water years was a natural occurrence. However, low water years did not result in natural recovery, and lake level regulation eventually eliminated low water years. There appeared to be three key problems: water level manipulation, the activities of Common Carp, and the deposition of sediment.

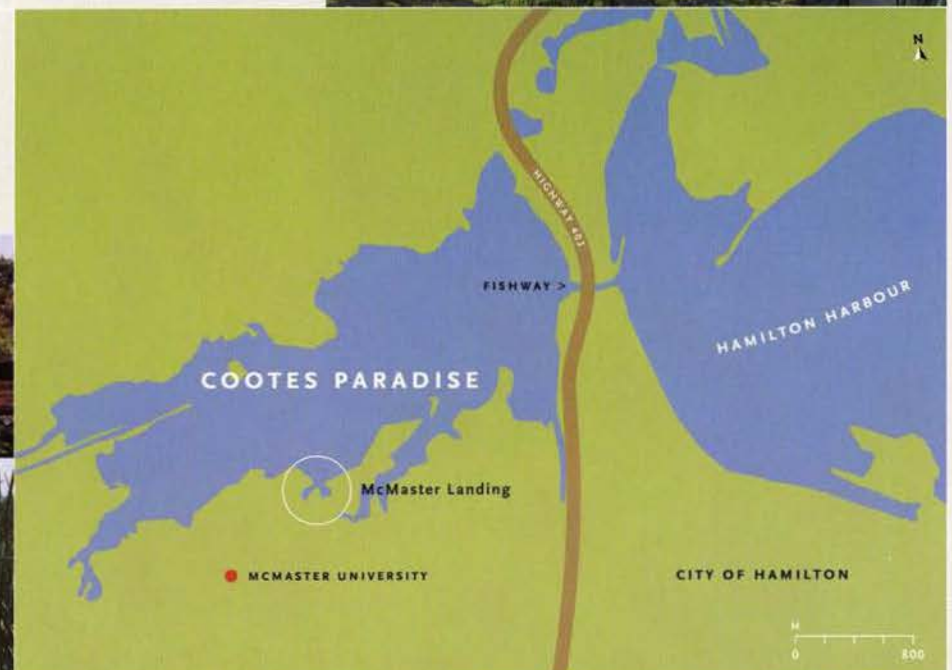
Patricia Chow-Fraser

PLANTING EXCLOSURES AT MCMASTER LANDING IN 1994.

Patricia Chow-Fraser

MCMASTER LANDING REVEGETATED IN 2002.

Patricia Chow-Fraser



COOTES PARADISE'S LOCATION in a highly urban and industrialized watershed makes rehabilitation a significant challenge. Efforts in the 1990s have been successful and the wetland is on the road to recovery.

TURBID WATER IN MCMASTER LANDING DUE TO CARP ACTIVITIES AND WATERSHED RUNOFF.

FISHWAY INSTALLED IN 1997 TO EXCLUDE CARP RESULTS IN DECREASED TURBIDITY.

CARP EXCLUSION AND LOW WATER LEVELS IN 1999 RESULT IN REGROWTH OF VEGETATION IN MCMASTER LANDING.

Restoration took place in a step-by-step manner, with each step first undertaken on a small experimental basis prior to broader application. The steps included installation of a **fishway** to exclude Common Carp, reduction of inflowing sediments through settling tanks and land stewardship, naturalization of the shoreline, and planting of vegetation. Some 10,000 aquatic plants were cultivated in school classrooms and transplanted into the wetland. Volunteers planted tens of thousands of other plants.

The result? Plant density is now as high as 60 stems per square metre, with Coontail and three species of pondweed responding most dramatically. The numbers of young fish increased three-fold in 1998, compared to 1994 through 1996.

As a result of the various projects, ecosystem improvements at Cootes Paradise have allowed the wetland to begin to reclaim its health – and its name.

CARP'S PARADISE

Common Carp – a freshwater fish first imported to North America from Eurasia in the 19th century as a potential food fish – can be a major problem for wetlands. Carp displace emergent and submerged vegetation while feeding and, to some extent, spawning. Their diet consists of molluscs, insects, worms, crustaceans, algae, and other aquatic plants (dead or living) and seeds. During feeding, carp suck in and expel water, mud and debris; in doing so, aquatic plants become uprooted, nutrients are released, and sediments are resuspended, causing an increase in water turbidity. High turbidity can reduce aquatic plant growth by limiting light penetration through the water column.

The restoration of Cootes Paradise illustrates a successful remedial strategy for dealing with this introduced species. Beginning in 1991, studies were performed to judge the carp's role in the degradation of the wetland. Experimental exclosures, including Aqua Dams, were used to assess the effects of carp on plant survival.

The results of these studies led to the construction of a fishway at the harbour entrance to the wetland, which allowed passage of all fish except carp. Operation of the fishway involves handling, tagging, and monitoring fish passing into the wetland. In 1997, the first full year of operation, roughly 82 percent of the fish handled were carp and their goldfish relatives. Some 97,000 carp attempted to enter the wetland. Through the use of this restrictive fishway, the wetland's population of adult carp was reduced to between 2,000 and 3,000 – significantly better than the target of 6,000.

Canadian Wildlife Service

COMMON CARP

Case Study 2

An innovative dike for Metzger Marsh

For much of the past 50 years, the viability of Metzger Marsh was eroding like the baymouth barrier beach that had shielded it from the physical forces of Lake Erie. Eighteen kilometres east of Toledo, Ohio, the marsh had suffered extensively from human activity. Attempts had been made to dike and farm the wetland, and the inflow of Cedar Creek had been diverted to Lake Erie. Hardening of the adjacent shoreline gradually eliminated the flow of sediments that fed the protective barrier beach. In 1973, high water levels intensified the barrier's gradual erosion, and it was eliminated.

These primarily hydrologic changes dramatically reduced the marsh's biodiversity. Aerial photos show that vegetation covered 58 percent of the marsh in 1940. By 1993, only 10 percent of the wetland sustained the emergent plants that made up most of the original vegetation.

A comprehensive plan was developed to restore the marsh's role as prime wetland habitat. To achieve this, it would be necessary to replace the baymouth protective barrier beach, maintain hydrologic connection to the lake, and revegetate the marsh.

BEFORE

Douglas A. Wilcox

METZGER MARSH BEFORE RESTORATION, SHOWING LARGE AREAS OF OPEN WATER AND LITTLE EMERGENT VEGETATION.

AFTER

Douglas A. Wilcox

METZGER MARSH AFTER RESTORATION, SHOWING EMERGENT VEGETATION THAT GREW FROM THE SEED BANK WHEN IT WAS EXPOSED TO THE AIR DURING DRAW DOWN OF WATER LEVELS.

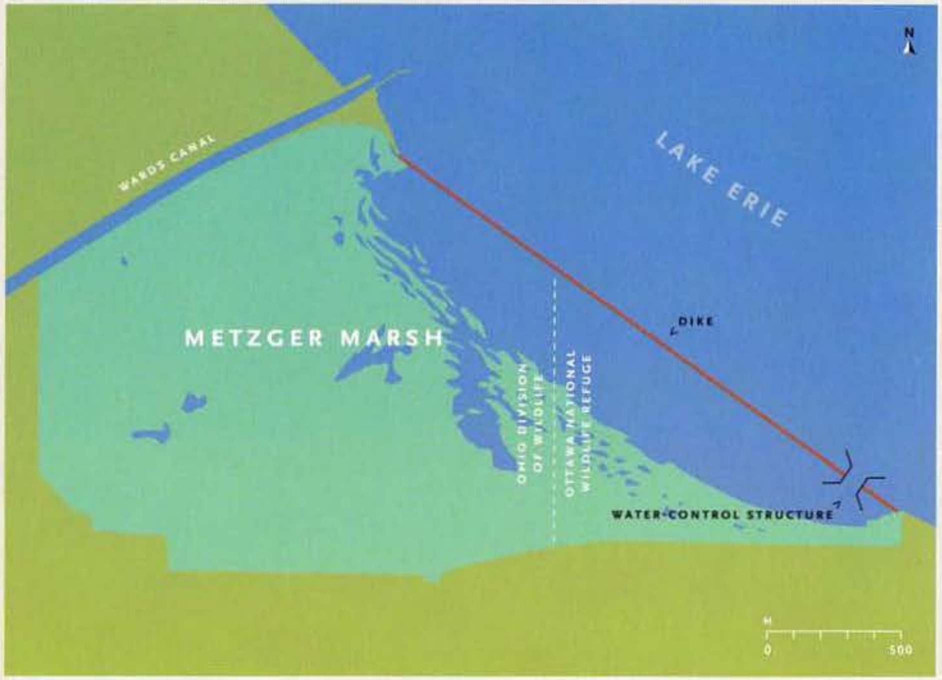
PHRAGMITES

Canadian Wildlife Service

ONE UNEXPECTED RESULT of the controlled drawdown of Metzger Marsh water levels was the invasion of *Phragmites* (Common Reed), willows, and Cottonwood. This invasive vegetation was chemically controlled with herbicides. The *Phragmites* was sprayed with glyphosate, and the unwanted trees with 2,4-D. Both of these herbicides are non-persistent and bind tightly to soil particles so will not leach into the water table.

The long-lost baymouth barrier beach was replaced by a dike in 1995. The dike included five gates to permit drawdown of the water level to mimic a low lake level and stimulate the growth of emergent vegetation; the gates were then opened after revegetation to re-establish natural water level cycles. During 1996, the first year of drawdown, vegetation returned to 73 percent of the wetland. Subsequently, 80 percent of the marsh was covered with vegetation, including sedges, Pale Smartweed, Rice Cut Grass, Nodding Beggar's Tick, Narrow-leaved Cattail, Softstem Bulrush, and Broad-leaved Arrowhead. These diverse species repopulated the marsh from the seed bank. To augment this natural regeneration, researchers planted tubers of Wild Celery – a species particularly attractive to waterfowl.

Based on the Cootes Paradise experience with carp, before Metzger Marsh's five dike gates were reopened to the lake in 1999, they were fitted with a fishway with bars spaced five centimetres apart. This spacing permits the passage of small fish but not the large carp that are most destructive to wetland vegetation. Lift baskets were also installed to allow other large fish species to be transported into the marsh. The fish gates continue to operate and while some carp still get in, they do little damage to the incredible revegetation of the marsh.



- Wetland vegetation
- Upland

Douglas A. Wilcox

METZGER MARSH AERIAL VIEW

Case Study

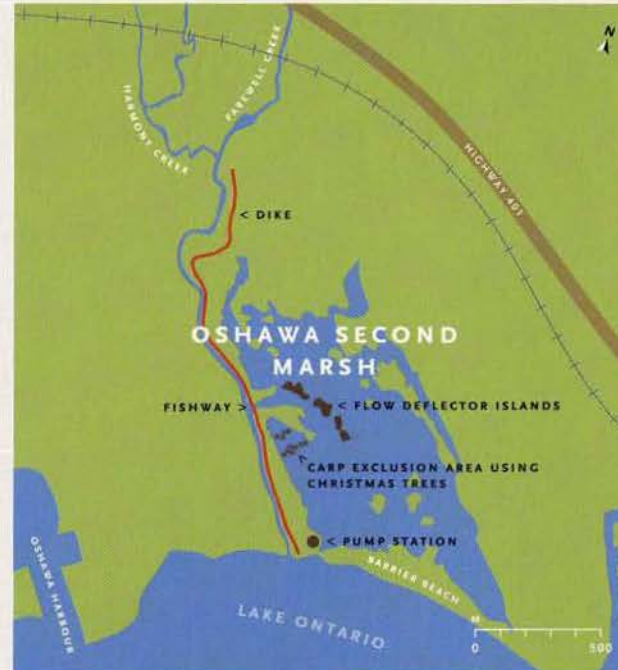
3

A second chance for Second Marsh

Located in the city of Oshawa, Ontario on the north shore of Lake Ontario, Oshawa Second Marsh was once a healthy, well-vegetated wetland, with a robust and diverse wildlife community. A barrier beach protects this 123-hectare wetland from the lake.

Beginning in the early 1970s, the marsh experienced major human disruption. In 1974, the Oshawa Harbour Commission blocked the western outlet to raise water levels in the marsh, to permit heavy equipment to drill boreholes in preparation for harbour development. The following spring, large clumps of vegetation floated out to Lake Ontario during record high water levels following severe winter conditions. Although these events are frequently referred to as the primary events that "killed-off" the marsh, the wetland was already severely stressed by this time as a result of lake-wide water level regulation, the arrival of carp, and changing land use in the watershed. By the 1980s, the formerly diverse vegetation was reduced to a narrow fringe of cattail.

The City of Oshawa, the marsh's owner, led the development of a marsh management strategy in partnership with a number of agencies and groups. As a key component of these efforts, a citizens' group was appointed to help coordinate the wetland rehabilitation. The goal was to use natural techniques, as much as possible, to restore the wetland community of plants and animals that had existed prior to 1970.



Oshawa Second Marsh on Lake Ontario, Oshawa, Ontario

Canadian Wildlife Service

Fishway construction at Oshawa Second Marsh, in winter

Canadian Wildlife Service

CHRISTMAS ON THE MARSH

The Oshawa Second Marsh restoration project has shown that Christmas trees can shelter more than gifts. Recycled Christmas trees are being used to protect emerging vegetation from Canada Geese and Common Carp. The trees are arranged in cells resembling a palisade formation. Along with biodegradable stabilization mats and soil, the trees are also being used to create habitat islands in the marsh.

John Mitchell

COMMON TERN

Walter B. Fechner

GREAT BLUE HERON

An ARM approach to rehabilitation was initially led by Environment Canada from 1994 to 1996. The western channel through the barrier beach was reopened, and a blocked riverine inflow was cleared. To recreate the historic water flow, four deflector islands were built where such islands had previously existed. The deflector islands were made from solid sand cores anchored by tree root-wads. At the same time, 11 habitat islands were placed in the marsh. Materials for the habitat islands varied. Some were filled with soil and rocks; others floated on logs in fixed locations. Nesting Common Terns unexpectedly occupied one island, resulting in the re-design of an island specifically for terns.

Carp needed to be excluded from parts of the marsh to protect new vegetation. A link fence was placed down the middle of the marsh, but carp regularly breached this barrier, leading to its removal two years later. Log barriers were constructed, but these too were ineffective. Of the techniques tried, the most successful way to protect the new plants from carp and geese, which graze tender, young plants, was the use of discarded Christmas trees. These were arranged in protective cells to shelter the new shoots.

To bolster natural revegetation, volunteers planted more than 3,000 classroom-cultivated aquatic plants with limited success. In 1999, low water levels provided ideal conditions for monitoring natural recovery. Over that summer, emergent vegetation expanded by 30 percent. However, low water levels occurred too late in the year and few plants survived through winter. The limited success of these non-intrusive techniques demonstrated that more proactive hydrological techniques would be required.

In 2001/2002, Ducks Unlimited Canada led a project to divert the sediment-laden Harmony Creek around Second Marsh to the lake, and manage water levels to promote vegetation regeneration. As part of the project, the construction of a fishway between the lake and the marsh allows marsh access for most fish, but excludes large carp that destroy submerged vegetation and cause increased turbidity. The rehabilitation efforts appear to be working. Preliminary results from the summer of 2002 show turbidity levels in Second Marsh have dropped significantly from previous years. This improvement in water quality facilitates submerged vegetation growth, which will be further encouraged by a draw down of the marsh in 2003.

The long-term solution calls for better watershed management through a local landowner stewardship program and perhaps re-opening the marsh to the lake and creek once the vegetation has recovered.

Visit www.secondmarsh.com for more information.

Part 2

John Mitchell

Walter B. Fechner

RED-BREASTED MERGANSER

Douglas A. Wilcox

Wetland Conservation: National to Backyard Efforts

Douglas A. Wilcox

Canadian Wildlife Service

THIRTY YEARS AGO, it would have been difficult to imagine the broad range of legislation, programs, and activities that currently exist in North America to conserve wetlands. The most striking feature of wetland conservation efforts is the complexity and number of players: from national governments to community groups, private wetland owners, and concerned individuals who enjoy spending time in their local wetland. It is a mix with inherent hurdles that requires effective coordination and communication among those involved and makes for dynamic and innovative wetland conservation initiatives. This section outlines many of the challenges to effective wetland conservation and management, provides an overview of the programs and legislation in place to encourage wetland conservation, and describes a handful of the hundreds of conservation success stories that have been completed and are underway in wetlands found in every corner of the Great Lakes basin.

Buttonbush

Canadian Wildlife Service

State of the Lakes Ecosystem Conference (SOLEC): Wetland science without borders

American and Canadian Great Lakes coastal wetland scientists in governments and universities have very close ties and often work together on policy development and research. One of their important meeting places is the State of the Lakes Ecosystem Conference (SOLEC), held every two years by the governments of Canada and the United States.

SOLEC was established by the American and Canadian governments in 1994 to provide independent reporting on the state of health of the Great Lakes basin ecosystem. Recent efforts have focused on developing easily understood indicators to represent the health of various Great Lakes ecosystems, including nearshore and open waters, nearshore terrestrial, and coastal wetlands. Another major thrust has been the development of the Biodiversity Investment Areas concept. Biodiversity Investment Areas are broad coastal areas (aquatic, wetland, and nearshore) that contain clusters of exceptional biodiversity and should be protected.

For more information about SOLEC, visit www.on.ec.gc.ca/solec or www.epa.gov/glnpo/solec

Jurisdictional Complexities: Turning Challenges into Opportunities

Coastal wetland management is a challenge for a single government, but put more than a dozen interested agencies together and things get complicated. Jurisdiction of Great Lakes coastal wetlands involves the Canadian and United States federal governments, the province of Ontario, eight U.S. states: New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota, several of North America's largest cities, including Toronto and Detroit, plus a myriad of local government agencies.

The Great Lakes are a shared resource of enormous economic, health, and recreational importance to millions of Americans and Canadians. Competing uses for the Great Lakes shoreline include the simultaneous needs for navigation, hydroelectric power production, recreational boating, and private shoreline property. These competing interests make securing land for coastal wetland conservation a difficult but essential binational priority. Coastal wetlands are an area where there is shared concern and responsibility – with the awareness that what happens on one side of the border can influence the entire Great Lakes ecosystem.

Along with this multi-jurisdictional responsibility come both opportunities and challenges for Great Lakes coastal wetland management and conservation. With so many jurisdictions comes a proportional increase in the number of guidelines, policies, and agencies involved in wetland conservation. This complexity greatly increases the amount of time required for reaching consensus on new binational agreements and programs, implementing these programs, and interpreting program results. For example, the State of the Lakes Ecosystem Conference (SOLEC) is developing a suite of ecosystem health indicators that will have basin-wide application. Hundreds of representatives from all five Great Lakes are participating in the process. Since each party has the opportunity to review the proposed indicators and offer perspectives from their respective agencies, incorporation of every idea in a manner that satisfies the different jurisdictional requirements becomes very challenging.

On an even more fundamental level, jurisdictions often have their own wetland classification schemes for assessing wetland type. This is one of the crucial aspects of any inter-jurisdictional wetland monitoring program. In order to set up comparable programs so that resulting data will be useful, the wetland types as identified by researchers must mean the same thing in both Canada and the United States. The wetland types outlined in this report on pages 10 and 11 represent the most recent classification as agreed upon by a multi-partner Geomorphic Classification Committee of the binational Great Lakes Coastal Wetlands Consortium.

Despite the inherent challenges, the opportunities arising from the diversity of opinions and expertise of the many wetland scientists doing research in the Great Lakes basin do not go unnoticed. The importance of communication and collaboration between scientists is becoming increasingly recognized in the wetlands community. Every research program, community conservation effort, and graduate student project produces results that may be useful to an unknown colleague hundreds of kilometres away. The establishment and use of binational, interactive, wetlands databases and collaborative projects provides the opportunity for the wetland community to share information more easily.

In order to facilitate and coordinate some of the wetland conservation efforts of the various jurisdictions, the Canadian and United States federal governments, along with Great Lakes states and the province of Ontario, have worked together to establish international agreements and related management organizations. The International Joint Commission is one of the central Canada-United States coordinating bodies for transboundary water issues. One of the Joint Commission's key roles is to oversee the implementation of the Canada-United States Great Lakes Water Quality Agreement. The Agreement expresses each country's commitment to restore and maintain the chemical, physical, and biological integrity of the Great Lakes basin ecosystem.

Canadian Wildlife Service

Great Lakes Wetlands Consortium – Looking for indicators of wetland health

The Great Lakes Wetlands Consortium is a group of American and Canadian scientists, policy makers, and others dedicated to monitoring the condition of Great Lakes coastal wetlands. Emerging from the SOLEC indicators process, the Consortium was brought together by the Great Lakes Commission with funding from the U.S. Environmental Protection Agency, to validate and enhance the SOLEC coastal wetland indicators and to assess the ecological integrity of Great Lakes coastal wetlands. It is also designing a long-term program to monitor Great Lakes coastal wetlands, including creating a binational database accessible to scientists, decision makers, and the public. To date, more than 100 groups and individuals have contributed to the project. The Great Lakes Commission hopes to have a fully state- and province-supported binational monitoring program in place by 2004.

A fresh look at the criteria for regulating Lake Ontario's water level

Determining the criteria that should be used to decide how water level and flow of Lake Ontario and the St. Lawrence River should be regulated is being addressed by a binational study launched by the International Joint Commission (IJC) in 2000. The five-year study will consider, develop, evaluate, and recommend updates and changes to the 1956 criteria for Lake Ontario-St. Lawrence River water level and flow regulation. It will also assess how water level fluctuations and control affect all human and environmental interests associated with this water system, including coastal wetlands.

The IJC study provides a major opportunity to improve the understanding of past water-regulation impacts on coastal wetlands. The new knowledge will be used to develop and recommend water level regulation criteria with the specific objective of maintaining coastal wetland diversity and health.

For more information on the IJC study, go to

www.ijc.org

Canadian Wildlife Service

Lakewide Management Plans

The Governments of Canada and the United States, along with provincial, state, and municipal governments, and non-governmental organizations, have come together to ecologically restore each of the five Great Lakes. The 1987 Protocol to the Great Lakes Water Quality Agreement called for Lakewide Management Plans (LaMPs) to "embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses".

There are currently four LaMP processes – in Lakes Ontario, Erie, Superior, and Michigan. There is also a Lake Huron Initiative, led by the state of Michigan, which has performed many of the preliminary tasks associated with developing a binational program for Lake Huron. Conservation and rehabilitation of wetlands is integral to the work of the LaMPs to improve degraded fish and wildlife populations and restore lost fish and wildlife habitat.

For more information, visit

www.great-lakes.net/lakes/ref/lamps.html

On the continental scale, Mexico enters the web of jurisdictions with its involvement in the North American Waterfowl Management Plan (NAWMP). With so many Great Lakes bird species migrating to warmer climates in the winter, wetland conservation in Mexico is also critical. Created in 1986, NAWMP is a trilateral agreement between the United States, Canada, and Mexico. The goal is to conserve and restore 2.4 million hectares of waterfowl habitat in North America. The treaty is jointly administered by the U.S. Fish and Wildlife Service, the Canadian Wildlife Service of Environment Canada, and the Mexican government, and it is based on the principle of joint ventures between public and private agencies, organizations, and individuals interested in conservation.

The North American Bird Conservation Initiative (NABCI) builds from the success of NAWMP and is a coordinated effort among Canada, the United States and Mexico with a goal to maintain the diversity and abundance of all North American birds. Launched in 1998. NABCI coordinates conservation efforts for shorebirds, landbirds, waterfowl and waterbirds. Many species within each of these four groups of birds rely on wetlands to fulfill a part of their life cycles. Given the early stage of this initiative, the impact of NABCI in conserving bird populations has yet to be realized.

Walter B. Fechner

Sandhill Crane

For more information, visit

northamerican.fws.gov/NAWMP/nawmphp.htm, www.nawmp.ca and www.nabci.org

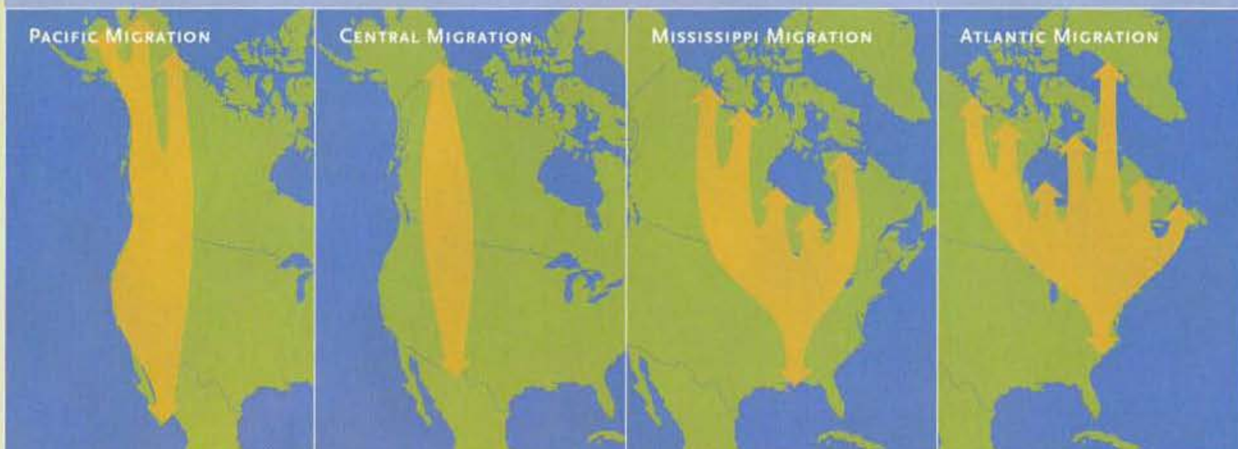
NAWMP on the ground

The Eastern Habitat Joint Venture (EHJV) and Upper Mississippi River/Great Lakes Region Joint Venture (UMR/GLR JV) are two of 14 habitat 'joint ventures' established across the continent to ensure the implementation of NAWMP. In Ontario, the EHJV is a partnership of the federal government, the provincial government, Ducks Unlimited Canada, The Nature Conservancy of Canada, and Wildlife Habitat Canada. In the Great Lakes region of the United States, private landowners, state government agencies, the U.S. Fish and Wildlife Service, and the National Fish and Wildlife Foundation are all partners in the UMR/GLR JV. The Great Lakes-St. Lawrence region is one of the priority focus areas for NAWMP, and partners under both joint ventures are working to conserve, enhance, and manage priority wetland and upland habitats.

Extensive programs are applied on a broad scale to influence land use policies and promote ecologically sound and sustainable land use practices. Intensive programs are tailored to secure, create, restore, or rehabilitate balanced habitat conditions for waterfowl and other wetland wildlife. In the United States, the UMR/GLR JV has protected, restored, or enhanced over 358,000 hectares of wetland and associated uplands, while in Ontario, EHJV partners have legally protected over 115,000 hectares of valuable habitat.

Mallards taking flight

Eric Dresser



< Migratory bird flyways in North America

The Ramsar Convention:
A global wetlands conservation treaty

The Convention on Wetlands of International Importance, more commonly known as the Ramsar Convention, has spearheaded international cooperation on wetlands conservation. Initiated in Ramsar, Iran in 1971, there are presently 131 Contracting Parties to the Convention, with 1,150 wetland sites, totaling 96.3 million hectares designated on the Ramsar List of Wetlands of International Importance. In the year 2000, there were 36 Ramsar sites in Canada, totaling 13 million hectares, and 17 U.S. sites, totaling two million hectares. Five of these sites are located in the Great Lakes basin: St. Clair, Long Point, Point Pelee, Matchedash Bay, and Minesing Swamp, all in Ontario.

Location of the designated Ramsar sites located within the Great Lakes basin

For more information visit www.ramsar.org

Green Heron

Walter B. Fechner

Nearly 70 percent of southern Ontario's wetlands have been lost, an area roughly the size of Lake Ontario. This number increases to highs of 90 to 100 percent in various counties in the province's southwest. Similarly, in the contiguous United States 60 to 90 percent of all wetlands have been lost.

No Net Loss: A Fundamental Guiding Policy for Wetland Conservation

'No net loss' is the cornerstone concept guiding wetland conservation efforts in Canada and the United States. It means that wetland managers operate on the minimum principle that there should be no further decrease in the total area and/or healthy functioning of wetlands in either country. This, of course, does not mean that some wetlands will not be lost. What it does mean is that when a wetland is destroyed, measures should be taken to compensate for this loss.

In the United States, the 'no net loss' initiative arose from a 1987 National Wetlands Policy Forum. The forum proposed one overall objective: "To achieve no overall net loss of the nation's remaining wetlands base and to create and restore wetlands, where feasible, to increase the quantity and quality of the nation's wetland resource base."

In Canada, 'no net loss' was first incorporated into the federal *Fisheries Act* to protect fish habitat and subsequently became the central principle in the 1991 Federal Policy on Wetland Conservation. Under this policy, 'no net loss' of wetland functions applies to all projects that affect wetlands on federally regulated lands or any non-federal wetlands when a project requires an environmental assessment under the *Canadian Environmental Assessment Act*.

Recognizing that land use issues are complex, the 'no net loss' concept uses a three-step harm-reduction process to achieve its goal.

1. **Avoid**. The first step is to make every effort to avoid damaging wetlands.
2. **Minimize**. When total avoidance is impossible, professional wetland managers must be involved to minimize a project's impact.
3. **Compensate**. This step of last resort allows for damage to wetlands as long as there is restoration of another wetland or creation of a new one.

The success of 'no net loss' policies has been varied. The concept has had a significant impact on the planning and practice of U.S. federal agencies responsible for wetland management. It has also changed the practice of environmental assessment in Canada. In this sense, 'no net loss' has represented a major shift in thinking about wetlands management.

Federal Government Wetland Policies and Legislation

Wetland conservation and protection includes the full gamut of legislative and regulatory initiatives, as well as rehabilitation, monitoring, and education programs. In the United States, there are about 20 major federal laws, directives, and regulations, as well as policy and technical guidance documents for the management and protection of wetlands. Most are independently administered by separate government agencies, the four central ones being the U.S. Army Corps of Engineers, Fish and Wildlife Service, Environmental Protection Agency, and the Natural Resources Conservation Service.

The cornerstone U.S. legislation guiding wetland management is the *Clean Water Act*. Although the Act doesn't directly mention wetlands, a series of U.S. Supreme Court rulings has asserted that the legislation does cover them. The crucial *Clean Water Act* regulation protecting wetlands is Section 404. This section requires that anyone who wants to discharge dredged or fill material into waters in the U.S. must receive a permit from the Army Corps of Engineers. Examples of activities included under the law are fills for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming and forestry. However, normal farming and forestry practices, such as plowing, seeding, and harvesting are exempt from the requirement.

Canada has several federal policies and acts that offer protection to wetlands. The Federal Policy on Wetlands Conservation was developed in the early 1990s with the overall goal to conserve Canada's wetlands so as to sustain their ecological and socio-economic values. The two key commitments include 'no net loss' of wetland functions on federal lands and waters and the enhancement and rehabilitation of wetlands in areas where continuing loss and degradation of wetlands has reached critical levels. This policy applies to *federal* lands and waters. Federal lands include national parks, military bases, and land housing federal government buildings. The rest of Ontario's wetlands are covered under provincial legislation as discussed on page 58.

The key federal act is the *Fisheries Act*, which contains provisions for pollution prevention, conservation, and protection of fish habitat. This legislation provides protection to wetlands through their function of providing fish habitat.

GREAT EGRET

Walter B. Fechner

A RECENT U.S. SUPREME COURT RULING determined that isolated, inland wetlands are no longer protected by Section 404 of the *Clean Water Act*. In response to this action, individual states are incorporating regulations equivalent to the former wetland protection of Section 404 into their own wetland policies in order to maintain a high level of protection for these valuable wetlands. Like their coastal cousins, isolated inland wetlands provide important stopover habitat for migrating waterfowl.

The Great Lakes Wetlands Conservation Action Plan

The Great Lakes Wetlands Conservation Action Plan (GLWCAP) is the largest and most diverse Canadian coastal wetlands conservation effort and acts as an umbrella plan for a broad array of efforts. Announced in 1994, GLWCAP is a cooperative program of the federal and Ontario governments, as well as non-governmental groups, to protect, rehabilitate, and create wetlands on the Canadian side of the Great Lakes basin. Implementation of the plan is coordinated by representatives from the Canadian Wildlife Service of Environment Canada, the Ontario Ministry of Natural Resources, the Nature Conservancy of Canada, the Federation of Ontario Naturalists, and Ducks Unlimited Canada.

GLWCAP is part of a 25-year strategic plan to protect wetlands on the Canadian side of the Great Lakes basin. To maximize its efforts, the first phase of the program (1994 to 2000) focused on the most threatened wetlands in the Canadian Great Lakes basin – coastal marshes between Sarnia and Cornwall, Ontario. Eight strategies for working towards this goal guided the first phase of the Plan and also form the basis of the second phase, which is currently in development:

- increase public awareness and commitment to protect wetlands;
- improve wetland science, data collection and monitoring;
- secure wetlands as protected sites;
- create, **reclaim** and rehabilitate wetlands;
- strengthen legislation, policies, agreement and compliance;
- strengthen local planning and commitment to wetland conservation;
- improve coordination and planning among government and non-governmental organizations; and,
- evaluate the program.

The action plan has had a broad range of successes. GLWCAP partners succeeded in protecting more than 5,300 hectares through acquisition and rehabilitated more than 12,000 hectares of wetlands, double the target set for the initial six-year phase. Coastal wetlands acquired included Pigeon Marsh, portions of the Long Point Wetland Complex, and the Brockville Long Swamp Fen, among other locations. Coastal wetland rehabilitation work included projects at Cootes Paradise in Hamilton Harbour and Oshawa Second Marsh.

Wetland securement projects (1994 – 2001). The securement of these areas is thanks to the partners of the Great Lakes Wetlands Conservation Action Plan and the Eastern Habitat Joint Venture.

Canadian Wildlife Service

Big Sandy Bay: a secured wetland

The protection of Big Sandy Bay is one of the many success stories of the first phase of the Great Lakes Wetlands Conservation Action Plan. Located at the southwestern tip of Wolfe Island on the eastern end of Lake Ontario, Big Sandy Bay is a large wetland complex that has been nominated as a globally significant Important Bird Area due to its role in the migratory routes of waterfowl, particularly Canada Goose, Greater Scaup, and Canvasback. Fifty-six hectares of this combined provincially and privately-owned wetland were purchased in 2000 by GLWCAP and EHJV partners. Through this securement, Big Sandy Bay will retain its important role in bird migration across eastern Lake Ontario.

White-tailed Deer

Walter B. Fechner

U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency: Working together for wetlands protection

The U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) jointly administer Section 404 of the *Clean Water Act*, an authority requiring permits for any filling of wetlands associated with waters of the United States. EPA has the authority to object to permits proposed for issuance by the Corps if a determination is made that the permit as proposed does not conform to the wetland guidelines. Unlike the other Great Lakes states, the State of Michigan administers the program in most state waters.

EPA has independent enforcement authority for filling of wetlands without a permit. The focus of this program has been to restore wetlands illegally filled, mitigate lost area at a minimum 2:1 ratio if the wetland filled is not restorable, and require the creation, restoration, and protection of wetlands, buffers, and riparian (shoreline) areas.

Wisconsin Coastal Management Program

To balance competing uses of its Great Lakes coast, Wisconsin's coastal management program encourages wetland protection and awareness; solutions to runoff pollution, primarily from agriculture; greater public access to the shoreline; solutions to erosion; and resolving water quality threats from failing septic systems. The coastal program works with existing programs in six state agencies to ensure the state's coastal policies are met in decision-making processes. The Wisconsin Coastal Management Council, appointed by the governor and representing local governments, state agencies, Native American tribes, and interest groups, guides the program.

Provincial and State Wetland Protection

Each U.S. state has the jurisdictional ability to protect wetland ecosystems as they see fit. While the federal *Clean Water Act* Section 404 permit process is the common regulation applied in each state, each also has a parallel wetland-related regulatory framework that may add further requirements or categories. For example, Minnesota regulates not only for dredging and filling, but also for drainage projects through excavation or ditches. Development projects that impact wetlands must adhere to both the federal and state regulations. All of the Great Lakes states are also involved in non-regulatory conservation programs, including binational initiatives such as the Lakewide Management Plans.

The Ontario government has a range of policies and programs that support coastal wetland conservation and rehabilitation throughout the province. Some of these extend beyond the minimum 'no net loss' policy, and approach a 'no loss' policy. For example, the Province's overarching land use legislation is the *Planning Act*, under which Natural Heritage Policies are enunciated as part of the government's Provincial Policy Statement (1995). The Natural Heritage Policies state that "Natural heritage features and areas will be protected from incompatible development." These 'features and areas' include provincially significant wetlands, fish habitat, and significant portions of the habitat of endangered and threatened species, all considerations that apply to many coastal wetlands.

The Natural Heritage Policies' strength comes from the fact that these policies must be incorporated into new and updated municipal official plans that set the rules for local planning and development. The Policies state that:

- "Development and site alteration will not be permitted in significant wetlands south and east of the Canadian Shield", and
- "Development and site alteration may be permitted in significant wetlands on the Canadian Shield [but only] if it is demonstrated that there will be no negative impacts on the natural features or ecological functions for which the area is identified."

The result has been a societal change in Ontario over the past 10 years, so that wetland protection is now widely accepted as a standard part of community planning and stewardship.

Areas of Concern around the Great Lakes Basin

It's a RAP: Working together for Great Lakes restoration and protection

Remedial Action Plans (RAPs) are developed by all levels of government with citizen involvement to restore and protect environmental quality at each of the identified Areas of Concern (AOC) in the Great Lakes basin. RAPs were formalized through the Great Lakes Water Quality Agreement between Canada and the United States in 1987. Initiatives arising from the action plans typically include habitat restoration and protection, public involvement, and outreach.

Because all AOCs include coastal areas of the five Great Lakes, many of them contain wetland habitat. In others, local RAPs are attempting to re-establish wetland habitat where it once existed. Many RAPs have successfully implemented programs to restore degraded wetland habitat such as the Hamilton Harbour RAP (Cootes Paradise Restoration) on Lake Ontario and the Black River RAP in southwestern Lake Erie.

For more information on Great Lakes RAPs, visit

www.great-lakes.net/envt/pollution/rap.html

Walter B. Fechner

The Grand River Conservation Authority, which encompasses the Grand River watershed of 7,000 square kilometres and drains into eastern Lake Erie, recently held a Wetlands Forum. They sought federal, provincial, and municipal government advice and input from planners, drainage managers, and scientists on how better to protect the remaining 35 percent of wetlands that once existed in the watershed. This input will be used to develop the Wetlands Management Policy for the Grand River watershed.

Local and Non-Governmental Initiatives

While project funding and guidelines often come from federal, state, or provincial agencies, many wetland conservation efforts are driven by non-governmental organizations and local groups that have a personal, vested interest in maintaining the health of local wetlands.

In Ontario, Conservation Authorities are independent, local agencies set up to manage renewable natural resources on a watershed basis, primarily water quantity. Through the lands they manage and own, as well as the educational programs they deliver, Conservation Authorities provide opportunities for citizens to understand the value of their natural surroundings and the economic and social benefits of protecting that environment. One of the many specific objectives of all Conservation Authorities is to protect, manage, and restore Ontario's woodlands, wetlands, and natural habitats. Ontario's 38 Conservation Authorities own more than 138,000 hectares of land in the province. Twenty-five Authorities have direct connection with the Great Lakes, thereby influencing many existing coastal wetlands, particularly on Lakes Ontario and Erie. Like all agencies working on the Great Lakes, Conservation Authorities work with provincial and federal governments, local municipalities, and other community organizations to achieve their conservation goals.

In addition to local organizations, national non-governmental organizations (NGOs) such as Ducks Unlimited and the Nature Conservancy contribute significantly to wetland conservation in the Great Lakes basin.

Ducks Unlimited Inc. in the United States and Ducks Unlimited Canada combine to make North America's largest non-governmental wetlands conservation organization. Founded in the late 1930s, both organizations are private, non-profit groups dedicated to the conservation of wetlands for the benefit of North America's waterfowl, wildlife, and people. Ducks Unlimited works to conserve wetlands on two main fronts: buying wetlands, often in conjunction with other groups and government agencies; and working with individual and public landowners to develop long-term agreements to protect and rehabilitate wetlands. Wetland education and research are also important aspects of the organization's mandate.

In Canada, Ducks Unlimited Canada is an important partner in the Great Lakes Wetlands Conservation Action Plan, while in the United States, Ducks Unlimited's Matching Aid to Restore States Habitat (MARSH) program facilitates the acquisition and enhancement of waterfowl habitat on a state by state basis. This reimbursement program provides matching funds and grants to public and private agencies and organizations within each state. MARSH projects develop, maintain, restore, and preserve wetland and associated upland habitat in the United States. Projects protecting or restoring habitats within North American Waterfowl Management Plan Joint Venture priority areas receive first consideration.

The Nature Conservancy of Canada (NCC) is another important partner in GLWCAP. NCC is Canada's only national charity dedicated to preserving ecologically significant areas through outright purchase, donations and conservation easements. Since 1962 NCC has secured a long-term future for more than 1,000 properties, comprising 686,000 hectares of woodlands and seashores, internationally significant wetlands, threatened prairies, and a host of other precious natural places.

NCC, in partnership with The Nature Conservancy in the United States, the Ontario Ministry of Natural Resources, and other partners, are collaborating on a project to establish a conservation blueprint for the Great Lakes ecoregion. The project's main objectives are to rank the area's biodiversity-conservation targets in both aquatic and terrestrial ecosystems and map the distribution of this biodiversity, including identifying areas of special biodiversity significance. This major initiative will bring together a wealth of geographically-referenced conservation data for the entire Great Lakes basin, including coastal wetlands.

Canadian Wildlife Service

DuPont Provincial Nature Reserve

The creation of the DuPont Provincial Nature Reserve is an excellent example of how public and private partnerships can work to protect and preserve Great Lakes coastal wetlands. The 610-hectare reserve, located one kilometre east of the village of Morrisburg, Ontario was created under the Ontario Parks Legacy 2000 Program through a partnership between the Nature Conservancy of Canada (NCC), the Canadian Wildlife Service of Environment Canada, the Ontario Ministry of Natural Resources, and DuPont Canada Incorporated.

Through a combination of land purchase by NCC on behalf of the project partners and land donation from DuPont Canada Incorporated, the newly created reserve protects a rich and diverse habitat, including a provincially significant coastal wetland complex. Prominent features of the site include a lowland swamp, Riverside Marsh, and Hoasic Creek – a spawning and nursery habitat for numerous species of fish. The site is also one of the largest nesting areas for Great Blue Herons in southeastern Ontario and contains more than 360 species of vascular plants, including the provincially rare Lizard's Tail and Lake Cress and the regionally rare Small Yellow Water Lily and Water Pimpernel.

Despite the volume of wetland conservation legislation and policies, international, national, and local cooperation, and genuine concern for wetland health expressed by many individuals and organizations in the Great Lakes basin, wetlands continue to be lost and degraded at an alarming rate. Continued vigilance and improved outreach by those involved in wetland conservation are required by all parties; to encourage governments to improve wetland protection legislation and policies, enforce existing policies, and to educate the public, municipalities, and resource managers of the benefits of conserving wetlands.

Barb Crosbie

Dollars for Wetlands

Without external funding, few of the key local and non-governmental organization wetland rehabilitation projects would get off the ground. A variety of government and non-governmental programs exist in both Canada and the United States that offer financial support for the rehabilitation, conservation, and securement of wetlands around the Great Lakes. There are many other generous organizations that are helping in the conservation of Great Lakes coastal wetlands, some of which have already been discussed in this report. The following list merely provides a sampling of the potential funding sources.

The **Great Lakes Aquatic Habitat Network and Fund** (www.glhabitat.org) is a joint networking and funding body promoting U.S. Great Lakes basin aquatic habitat conservation and protection. A project of the Michigan-based Tip of the Mitt Watershed Council, the network involves organizations in all eight Great Lakes states, as well as the province of Ontario. Each state or provincial partner provides consultation, information, and financial resources to grassroots environmental organizations. The funding program includes both one-time grants of up to $3,500 (U.S.) and ongoing grants of $500 (U.S.) for eligible projects. Now in its sixth year, the program has funded more than 200 initiatives, including numerous coastal wetland conservation projects.

The **Coastal Zone Management Program** (CZM) (www.ocrm.nos.noaa.gov/czm/) is administered at the U.S. federal level by the Coastal Programs Division (CPD) within the United States National Oceanic and Atmospheric Administration. The CPD is responsible for advancing national coastal management objectives and maintaining and strengthening state and territorial coastal management capabilities. It supports states through financial assistance, mediation, technical services and information, and participation in priority state, regional, and local forums. The CZM's unique state-federal partnership leaves day-to-day management decisions at the state level in the 33 states and territories with federally approved coastal management programs, including six of the eight Great Lakes states. Currently, 152,530 U.S. national shoreline kilometres (99.9 percent) are managed by the program.

The **U.S. Environmental Protection Agency's Great Lakes National Program Office** (www.epa.gov/glnpo/fund/) annually invites submissions of proposals for innovative projects furthering protection and clean up of the Great Lakes ecosystem. In 2002, a total of $2.9 million (U.S.) was awarded to Great Lakes projects pertaining to contaminated sediments, pollution prevention and reduction, ecological (habitat) protection and restoration, invasive species, habitat indicator development, and strategic or emerging issues. Assistance (through grants, cooperative agreements, and interagency agreements) is available for activities in the Great Lakes basin and in support of the Great Lakes Water Quality Agreement. State pollution control agencies, interstate agencies, other public or nonprofit private agencies, institutions, and organizations are eligible: "Preference is given to U.S. organizations over foreign organizations; however, proposals for coordinated, binational projects are encouraged."

The following criteria are applied to all proposals for ecological (habitat) protection and restoration projects. Projects should:

- have biological importance on a regional or global scale;
- test new techniques or approaches to protection or restoration;
- identify and report on demonstrated environmental results;
- incorporate an education or outreach component;
- create new partnerships; and,
- impact a significant number of hectares of aquatic, wetland, riverine, and terrestrial habitat.

Walter B. Fechner

Pied-billed Grebe

Eric Dresser

EcoAction (www.ec.gc.ca/ecoaction) is an Environment Canada funding program that provides financial support for habitat rehabilitation and other environmental projects developed by local community groups. Usually, these projects rely heavily on volunteers and focus on developing the community infrastructure for the projects and hands-on learning for participants. Coastal wetland-related projects over the past five years include naturalization projects along the Bay of Quinte and Toronto shorelines.

The **Wetland Habitat Fund** (WHF) (www.wetlandfund.org) was established in 1997 to provide private landowners with financial assistance for projects that improve the ecological integrity of Ontario's wetlands. The WHF is supported financially by Wildlife Habitat Canada, the Ontario Ministry of Natural Resources, the Canadian Wildlife Service, and the U.S. Fish and Wildlife Service. Projects that enhance wetland habitat diversity and benefit waterfowl may be eligible for funds to a maximum of $5,000 (Canadian) or 50 percent of the total project cost. As of September 2000, 299 projects had been approved for WHF financial assistance, including 75 that have already been completed. The types of projects include fencing to restrict cattle access, open water cell creation, tree and native grass buffer plantings, water level-control structures, and barrier island construction.

The **Great Lakes Sustainability Fund** (http://sustainabilityfund.gc.ca) provides financial support to initiatives that are essential to the rehabilitation of key habitats in AOCs of the Canadian Great Lakes basin. Projects can include habitat rehabilitation, contaminated sediment remediation, stewardship, and control of urban and rural runoff. The fund is administered by Environment Canada and has supported projects in coastal wetlands such as Cootes Paradise and Oshawa Second Marsh.

The Canadian federal government's **Ecological Gifts Program** (www.on.ec.gc.ca/ecogifts) supports the permanent conservation of environmentally sensitive areas, including wetlands. Under this program, private and corporate donors receive a federal income tax benefit. The land is donated to a government body or conservation organization, which then issues a tax receipt. To date in Ontario 100 properties, covering 4,500 hectares, have been certified under the Ecological Gifts Program – nearly half contain wetland habitat.

Canadian Wildlife Service

Donor Don Bucknell admires gnarled tree in woodland surrounding Mud Lake wetland Ecological Gift.

Conclusions and Wetland Conservation Priorities

GREEN FROG

Walter B. Fechner

Wetland science and conservation in the Great Lakes have come a long way. The social and economic values of wetlands are gaining widespread recognition across Canada and the United States by the public and governments alike, while researchers are uncovering new insights into the complex, interwoven nature of wetland hydrology and ecology. Further, government funding, programs, and policies such as 'no net loss' are contributing to conservation and rehabilitation of wetlands throughout the Great Lakes basin. Despite these advances, overall wetland losses continue. These losses highlight that there is more that can and should be done to increase our understanding and protection of Great Lakes coastal wetlands. The following list outlines some of the priority areas of wetlands research and conservation that continue to need attention.

1 **Agree upon a binational coastal wetland classification system.** Cooperative work between United States and Canadian wetland scientists must continue to attempt to reach agreement on a widely accepted, standardized coastal wetlands classification system. This will help to ensure a common vocabulary, comparable wetland studies between jurisdictions, and an assessment of basinwide trends.

2 **Develop a binational, accessible, computerized database for Great Lakes coastal wetlands.** This should include a wetland inventory incorporating information such as the location and area of each wetland, geomorphic classification, vegetation communities, species information, landowner or wetland researcher contact information, and responsible jurisdiction.

3 **Continue existing monitoring programs and expand coastal wetland monitoring.** The success of the Marsh Monitoring Program (MMP) has highlighted the need for detailed population and habitat information for coastal wetlands. It is expected that the MMP will continue and increase its coverage; however, further integrated and intensive monitoring efforts are required. For example, monitoring of exotic species, mammals, invertebrates, and abiotic factors such as water levels, shoreline hardening, and contaminant trends, are required to provide the necessary baseline data to identify emerging trends and to inform wetland managers.

4 **Enhance funding for Great Lakes wetlands research.** Continued monitoring of Great Lakes wetlands has alerted scientists to emerging issues, such as climate change, water level regulation, and human alteration of coastal processes, that may have significant impact on coastal areas. These research areas should receive continuous dedicated funding for multidisciplinary studies. Similarly, ongoing issues such as determining the functions and economic values of wetlands and understanding the distribution and abundance of endangered species remain important areas to direct research-related dollars.

5 **Prioritize wetland rehabilitation and securement efforts.** Previous coastal wetland rehabilitation and securement efforts have taken place largely on an opportunistic basis – given available funding and local initiative. While this has resulted in the protection of some wonderful places and development of important wetland rehabilitation initiatives, there is now the opportunity to focus more closely and coordinate efforts based on areas of greatest need or where there can be the greatest impact.

6 **In areas of heavy historical loss and degradation of wetlands, implement a program of restoration of wetland function at the landscape scale.** This action would involve identifying the functions lost and restoring/creating appropriate wetlands, not necessarily in the same location as in the past, but somewhere on the regional landscape. For example, wetlands filled along shorelines can be replaced when other lake-fill projects are undertaken.

7 **Review and strengthen international and binational agreements, and strengthen the complementary provincial/state and local legislation and policies.** When provided the opportunity to review wetland agreements, guidelines, legislation, and policies, governments, non-governmental organizations, and citizens groups should take the opportunity to do so. This will serve to raise the profile of wetlands and strengthen these guidance documents from a multi-stakeholder perspective.

8 **Review and enhance the effectiveness of private wetland stewardship programs, particularly on agricultural land.** Most wetlands are found on private land. There are now a range of government and non-governmental programs that support the stewardship of wetlands by private property owners and communities. These programs should be compared and evaluated for their overall effectiveness and coordinated where possible. Stronger incentives should be provided where needed to encourage individuals to conserve sensitive wetlands.

9 **Increase awareness of the values of wetlands, including economic values.** This will encourage an understanding and appreciation of wetland values and foster conservation and rehabilitation by land-management decision makers.

These nine priorities complement one another, as they support the common goal of improving our understanding and conservation of Great Lakes coastal wetlands. A binational inventory of Great Lakes coastal wetlands that includes their type and status in combination with a monitoring program, review of policy, stewardship, securement, and rehabilitation initiatives is critical to advancing coastal wetland science and conservation. Only with this information can Great Lakes basin-level coastal wetland goals and objectives be set and a comprehensive conservation strategy developed that identifies the roles of various initiatives in reaching objectives.

Addressing these priorities will also involve reflection on the strengths and weaknesses of previous initiatives. In so doing, the need to increase coordination and cooperation between various government agencies and non-governmental groups will likely emerge as a vital area in which to build on previous initiatives and organizational strengths. Now and in the future, multi-partner coordination will help to avoid duplication of research and take advantage of the breadth of knowledge held by wetlands scientists in all Great Lakes jurisdictions. This cooperation will improve conservation and rehabilitation efforts in Great Lakes coastal wetlands, efforts that support the countless wetland functions and values upon which humans, fish, and wildlife have come to rely.

CATTAILS

Canadian Wildlife Service

A Final Thought

Humankind has not been gentle to the coastal wetlands of the Great Lakes. The wetlands and the lands that drain into them have suffered significant abuse since European settlement. Despite this abuse, wetlands have shown remarkable resiliency. To ensure wetlands persist into the future, conservation efforts must be enhanced to relieve wetlands of their many stressors and curtail ongoing habitat loss.

Great Lakes coastal wetlands continue to be among the richest habitats in North America. These natural assets simultaneously provide clean water, habitat for abundant wildlife, and outstanding recreational opportunities for canoeing, nature appreciation, birdwatching, hunting, and fishing, which contribute millions of dollars to the economy.

With some extra care, these vital areas will be around for future generations to enjoy.

Eric Dresser

Appendices >

Glossary of Terms

SHOWY LADY'S SLIPPER

Eric Dresser

Abiotic – non-living components of an ecosystem (e.g., climate and soil).

Acidic – water or soil having a pH of less than 7.

Alkaline – water or soil having a pH of greater than 7.

Alluvial – pertaining to material or processes associated with transportation and/or subaerial deposition by concentrated running water.

Amphibian – animals that live first in water, then on land (e.g., frogs, salamanders).

Anthropogenic – caused by humans.

Barrier beach – a sedimentary landform essentially parallel to the shore, the crest of which is above normal high water level. Lagoons and wetlands often occur on the inland side of these beaches.

Barrier-protected wetlands – wetlands that may have originated from either coastal or fluvial processes and that due to nearshore processes, have become separated from the Great Lakes by a barrier beach or a series of beach ridges.

Bathymetry – the science of measuring water depth to understand the topography of the sea or lake floor. This is the equivalent of topography or elevation for land measurements.

Beach ridge – a low, essentially continuous mound of beach or beach-and-dune material heaped up by the action of waves and currents on the backshore of a beach, which is beyond the present limit of storm waves. These ridges roughly parallel the relict or present shoreline.

Benthic – relating to the bottom of a body of water.

Bioaccumulation – increase in concentration of pollutants such as pesticides or heavy metals from the environment to the first organism in a food chain.

Biodiversity – the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

Biogeochemical – geochemical properties of a substance in relation to the local animal and plant life.

Biomagnification – the process whereby there is an increase in concentration of a pollutant from one link in a food chain to another. The substances become concentrated in tissues or internal organs as they move up the chain.

Bog – peat-accumulating wetland with precipitation as the dominant water source, typically acidic and normally dominated by *Sphagnum* mosses.

Buffer – areas or strips of land in permanent vegetation, designed to intercept pollutants, and sediment. Buffers include riparian buffers, filter strips, windbreaks, and living snow fences.

Creation – the conversion of a persistent upland vegetation community or ephemeral shallow water area into a permanent wetland where no previous wetland existed.

Denitrification – the process by which nitrates and/or nitrites are reduced to nitrogen gases through bacterial action.

Diffusion – the movement of suspended or dissolved particles (or molecules) from a more concentrated to a less concentrated area.

Dike – a human-made barrier built around a wetland designed to control water levels within the enclosed area.

Drumlin – an elongated hill or ridge of glacial drift.

Ecology – the study of the relationships between organisms and their environments.

Ecosystem – a dynamic complex of plants, animals, and micro-organisms and their non-living environment interacting as a functional unit.

Embayment – a bay.

Endangered – rare species that are at varying risks of extinction in a region/country. Includes formal designations such as extinct, extirpated, endangered, threatened and of special concern.

Enhancement – activity that addresses wetland stresses or limitations in order to improve one or more wetland functions or values.

Ericaceous – plants of the heath family such as Bog Rosemary, Leatherleaf, and laurels, which usually prefer acid substrates.

Erosion – the detachment and movement of the soil and rock from the land surface by water, wind, ice, or gravity.

Eutrophication – a process whereby an excess of nutrients in a water body results in excessive growth of organic matter, especially algae. This reduces the dissolved oxygen content of the water and can cause the loss of other organisms. Eutrophication can be a natural process or it can be accelerated by an increase of nutrient loading to a water body by human activity.

Exotic species – organisms (plant or animal) introduced to a habitat where they are non-native. They are often severe agents of habitat alteration and degradation and are a major cause of loss in biological diversity. Often referred to as introduced, alien, or nonindigenous species, they include Purple Loosestrife, Rusty Crayfish, and Eurasian Water Milfoil.

Extirpated – species that no longer occur in the wild in the region, but they occur elsewhere.

Fauna – animals, collectively.

Fen – peat-accumulating wetlands with groundwater as the dominant water source, and a variety of plant species, including sedges and grasses.

Fishway – a human-made structure built to either permit or prevent specific species of fish from entering a body of water.

Flora – plants, collectively.

Fluvial – processes that deposit sediments due to the action of flowing water.

Geomorphic – of or resembling the earth or its shape or surface configuration.

Groyne (or jetty) – a man-made structure extending into the water perpendicular to the shoreline in order to trap sand and sediment on the updrift side.

Habitat – the environment occupied by individuals of a particular species, population, or community, including everything required during the life cycle, such as food, water, space, shelter, and breeding places.

Herbaceous vegetation – non-woody vegetation, including ferns, sedges, emergent, submerged, and floating plants.

Hydric soils – soils that are formed under saturated or flooded conditions that during the growing season, develop anaerobic conditions in the upper part.

Hydrogeomorphic – of or pertaining to a synthesis of the geomorphic setting, the water source and its transport, and hydrodynamics.

Hydrology – the science dealing with the properties, distribution, and circulation of water both on and under the surface.

Hydrophytic plants – vegetation adapted to growing in water or in hydric soils.

Igneous – rock formed by the cooling and solidification of magma.

Indicator – a measurable parameter or value that reflects the condition of an environmental component and provides scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality.

Invasive species – plant or animal species (native or exotic) with tendencies to expand quickly, especially in disturbed areas, and that dominate or out-compete other local species. Often, invasive species are introduced to an area due to human activities.

Invertebrate – any type of animal that lacks a back bone (e.g., worms, arthropods, mollusks).

Keystone species – a species whose presence is essential in the functioning of the entire ecosystem of which it is a part. The effect is disproportionate to their abundance, and their removal initiates changes in ecosystem structure and often loss of diversity (e.g., Beaver, Muskrat, Great Blue Heron, and *Sphagnum* moss). Different species will be considered 'keystone' in different locations.

Lacustrine wetlands – wetlands directly controlled by the waters of an adjacent lake. They are strongly affected by lake level fluctuations and nearshore currents.

Lagoon – a term used to describe an enclosed or partially opened aquatic system. Often found in coastal areas.

Lakeplain – the old lake bottom of the ancestral Great Lakes.

Life history – the developmental history of an individual or a group.

Littoral – a coastal region, a shore.

Marsh – a wetland that is almost always flooded and characterized by a mixture of emergent and submersed aquatic vegetation.

Metamorphic – rock formed from pre-existing sedimentary or igneous rock, but which has been altered by heat and/or pressure.

Moraine – an accumulation of gravel, and stone carried and deposited by glaciers.

Omnivorous – eating both animal and plant materials.

Organic – soils that have a high percentage of organic material (often 12 to 18 percent peat or muck depending on clay content).

pH – a measure of the acidity of a water or soil on a logarithmic scale of 1 – 14, where 7 is neutral, less than 7 is acidic, and greater than 7 is alkaline or basic.

Photosynthesis – the manufacture by plants of carbohydrates and oxygen from carbon dioxide mediated by chlorophyll in the presence of sunlight.

Plankton – small, passively floating or weakly mobile aquatic plants (phytoplankton) or animals (zooplankton).

Propagation – reproduction of plants.

Radiocarbon dating – a method of dating wood, plant, or bone artifacts through evaluating the decay of organic carbon isotopes.

Reclaim – to bring into or return to a suitable condition for use.

Rehabilitation – improvement of the functions or values of a degraded wetland.

Relict – a plant, animal, or geological feature that has survived in a considerably changed environment.

Remnant – remaining.

Reptile – cold-blooded, air-breathing vertebrates with scales or plates (e.g., snakes, turtles).

Restoration – modification of the existing function and structure of a wetland's habitat so that it is similar to historical conditions.

Riverine wetlands – wetlands that occur in or along rivers and streams that flow into or between the Great Lakes.

Sand spit – a point of land projecting into a water body and along the coast line behind which coastal wetlands often form.

Sedimentary – rock formed from deposition or precipitation of materials; these are usually consolidated and often formed in distinct layers.

Seed bank – seeds stored in wetland soils.

Seiche – oscillations or local rises and falls in the water level of a water body due to atmospheric pressure and wind.

Shoreline hardening – the installation of artificial shoreline structures such as concrete docks, jetties, berms, and breakwalls designed to prevent erosion and protect properties from being washed away. In the process, natural vegetation and habitat is eliminated.

Substrate – the base upon which an attached species is growing.

Succession – the sequence of vegetation types in an ecosystem beginning when vegetation is first established or disturbed.

Swamp – a wetland dominated by trees and shrubs, with standing water, limited drainage, and often neutral or slightly acidic soils.

Topography – the elevational pattern of the soil surface, including its relief and the position of its natural and manmade features.

Tributary – any river or stream that connects with a larger river or stream before reaching its final outflow.

Tuber – a swollen underground stem or root found in certain plants. It enables the plant to survive the winter or dry season and is also a means of propagation.

Turbidity – the degree of cloudiness of water due to suspended silt or organic matter.

Vegetative reproduction – reproduction of a plant involving asexual processes such as cuttings, stolons, and tubers.

Water table – the surface below which the soil is saturated with water.

Wetland – lands that are seasonally or permanently covered by shallow water, including lands where the water table is at, or very close to, the surface, where the presence of abundant water has caused the formation of hydric soils, and has favoured the dominance of either hydrophytic or water-tolerant plants.

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Selected Species List: Common and Scientific Names

Great Blue Heron

Eric Dresser

Plants

American Water Willow (*Justicia americana*)

Black Spruce (*Picea mariana*)

Blue-joint Grass (*Calamagrostis canadensis*)

Bog Rosemary (*Andromeda glaucophylla*)

Broad-leaved Arrowhead (*Sagittaria latifolia*)

Bulrush (*Scirpus spp.*)

Burreed (*Sparganium spp.*)

Buttonbush (*Cephalanthus occidentalis*)

Cattail (*Typha spp.*)

Common Reed (*Phragmites australis*)

Common Waterweed (*Elodea canadensis*)

Coontail (*Ceratophyllum demersum*)

Cottonwood (*Populus fremontii*)

Dogwood (*Cornus spp.*)

Duckweed (*Lemna spp.*)

Eurasian Water Millfoil (*Myriophyllum sibiricum*)

Jewelweed (*Impatiens capensis*)

Lake Cress (*Armoracia aquatica*)

Leatherleaf (*Chamaedaphne calyculata*)

Lizard's Tail (*Saururus cernuus*)

Marsh Cinquefoil (*Potentille palustre*)

Narrow-leaved Cattail (*Typha angustifolia*)

Nodding Beggar's Tick (*Bidens cernua*)

Pale Smartweed (*Polygonum amphibium*)

Purple Loosestrife (*Lythrum salicaria*)

Rice Cut Grass (*Leersia oryzoides*)

Small Yellow Water Lily (*Nuphar luteum*)

Softstem Bulrush (*Scirpus validus*)

Sphagnum Moss (*Sphagnum*)

Spikerush (*Eleocharis spp.*)

Swamp Rose Mallow (*Hibiscus moscheutos*)

Tamarack (*Larix laricina*)

Water Pimpernel (*Samolus ebracteatus*)

Wild Celery (*Vallisneria americana*)

Wild Rice (*Zizania aquatica*)

Yellow Pond Lily (*Nuphar variegatum*)

Fish

Bowfin (*Amia calva*)

Common Carp (*Cyprinus carpio*)

Gar (*family Lepisosteidae*)

Largemouth Bass (*Micropterus salmoides*)

Muskellunge (*Esox masquinongy*)

Northern Pike (*Esox lucius*)

Sunfish (*family Centrarchidae*)

Walleye (*Stizostedion vitreum*)

Yellow Perch (*Perca flavescens*)

Birds

American Coot (*Fulica americana*)

Black-crowned Night-Heron (*Nycticorax nycticorax*)

Black Tern (*Chlidonias niger*)

Blue-winged Teal (*Anas discors*)

Canada Goose (*Branta canadensis*)

Canvasback (*Aythya valisineria*)

Common Tern (*Sterna hirundo*)

Common Yellowthroat (*Geothlypis trichas*)

Great Blue Heron (*Ardea herodias*)

Greater Scaup (*Aythya marila*)

Herring Gull (*Larus argentatus*)

King Rail (*Rallus elegans*)

Least Bittern (*Ixobrychus exilis*)

Mallard (*Anas platyrhynchos*)

Mute Swan (*Cygnus olor*)

Northern Harrier (*Circus cyaneus*)

Pied-billed Grebe (*Podilymbus podiceps*)

Red-winged Blackbird (*Agelaius phoniceus*)

Short-eared Owl (*Asio flammeus*)

Reptiles

Eastern Garter Snake (*Thamnophis sirtalis sirtalis*)

Painted Turtle (*Chrysemys picta*)

Northern Water Snake (*Natrix sipedon sipedon*)

Snapping Turtle (*Chelydra serpentina*)

Amphibians

American Toad (*Bufo americanus*)

Blanchard's Cricket Frog (*Acris crepitans blanchardi*)

Bullfrog (*Rana catesbeiana*)

Chorus Frog (*Pseudacris maculata*)

Fowler's Toad (*Bufo fowleri*)

Grey Treefrog (*Hyla versicolor*)

Green Frog (*Rana clamitans*)

Northern Leopard Frog (*Rana pipiens*)

Spring Peeper (*Pseudacris crucifer*)

Wood Frog (*Rana sylvatica*)

Mammals

American Mink (*Mustela vison*)

Beaver (*Castor canadensis*)

Moose (*Alces alces*)

Muskrat (*Ondatra zibethicus*)

Red Fox (*Vulpes vulpes*)

River Otter (*Lontra canadensis*)

Water Shrew (*Sorex palustris*)

Invertebrates

Damselfly (*family Coenagrionidae*)

Dragonfly (*family Aeshnidae*)

Giant Water Bug (*Abedus herberti*)

Mayfly (*order Ephemeroptera*)

Midge (*family Chironomidae*)

Rusty Crayfish (*Orconectes rusticus*)

Water Strider (*family Gerridae*)

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Brian Branfireun

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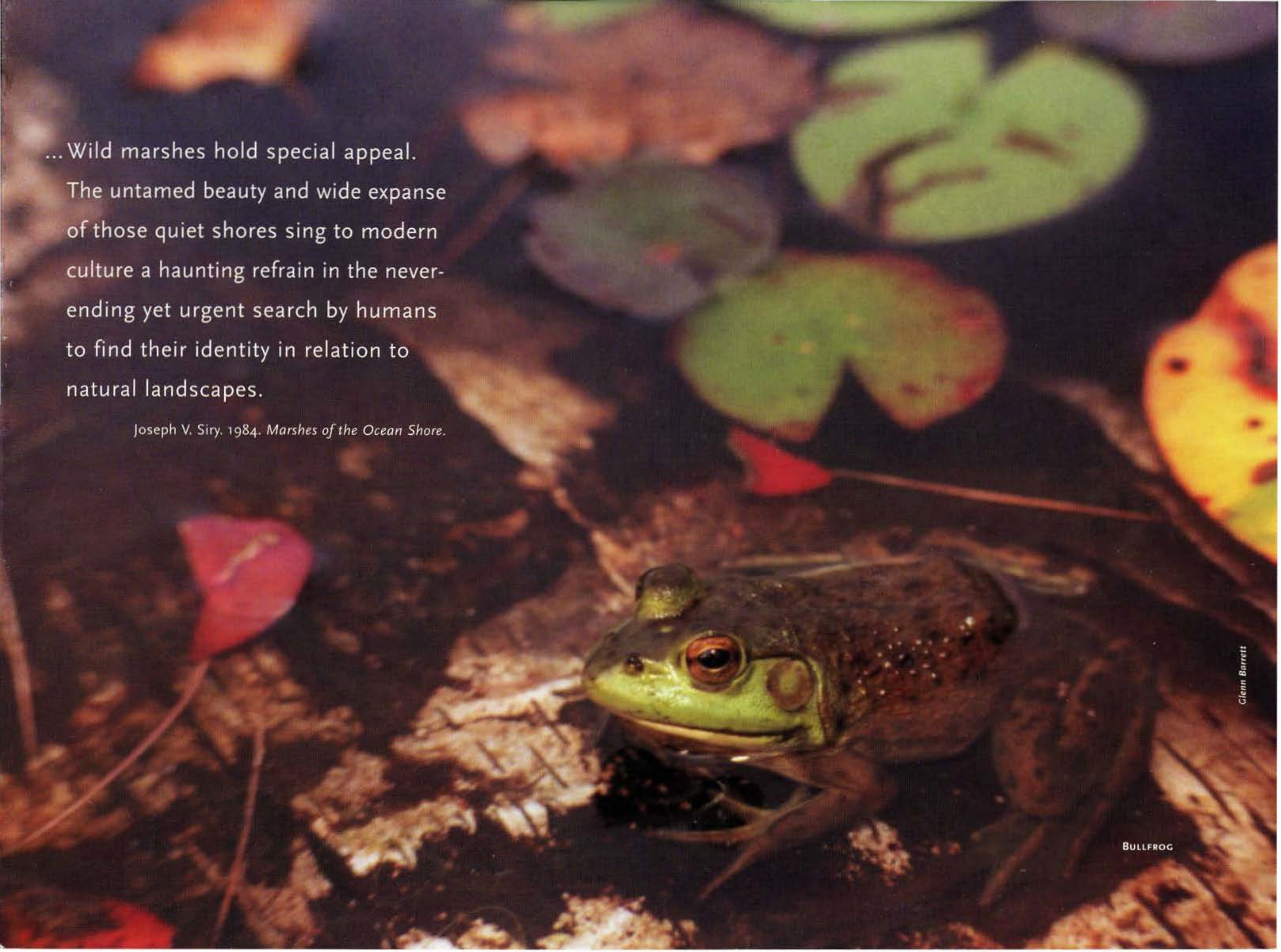


Glenn Barrett

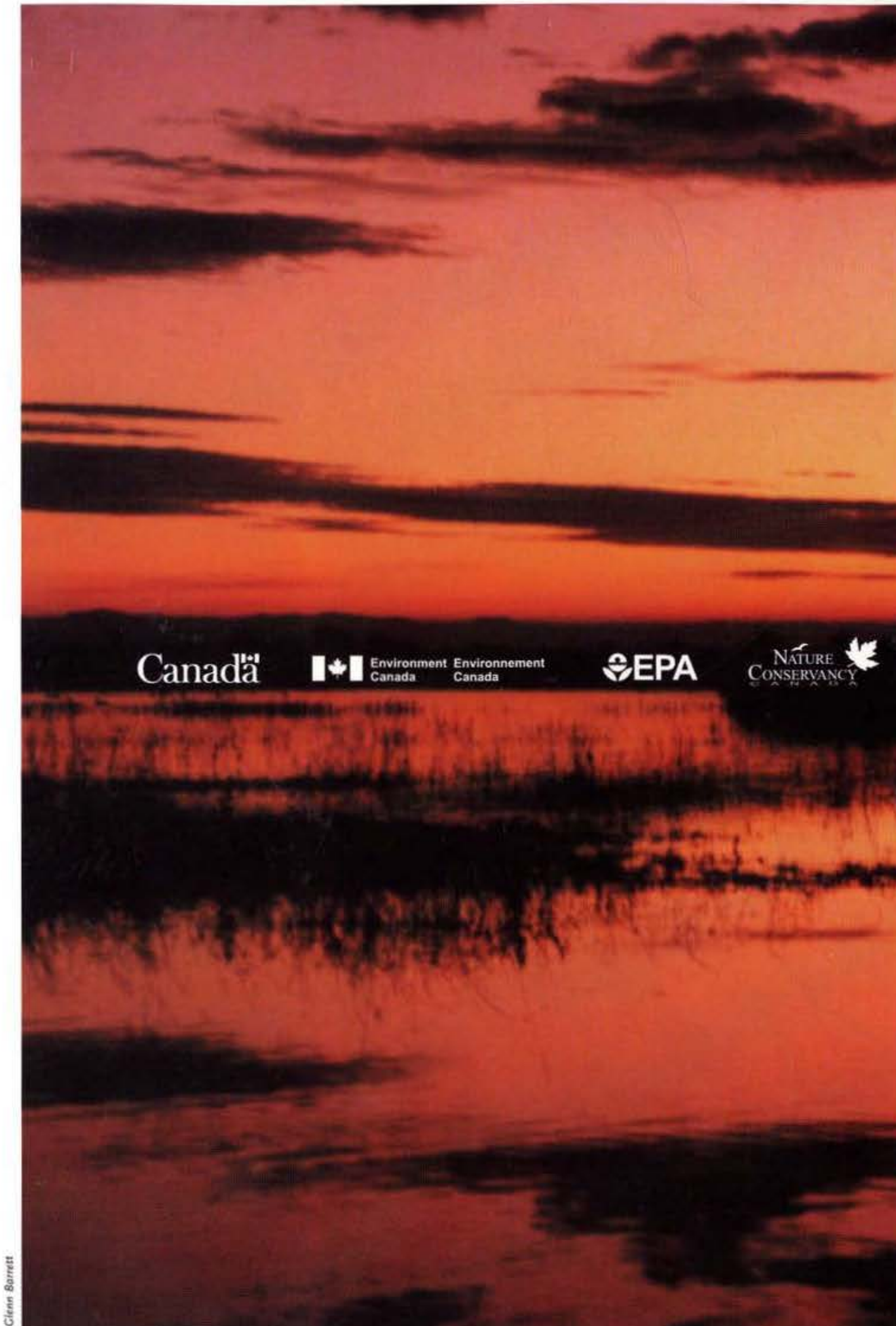
BULLFROG


Walter B. Fechner

American Bittern


Eric Dresser

Fragrant White Water Lily



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