Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy

April 2011

02:002987.IE10.03-B3278

002987_IE10_03-B3278

Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy

April 2011

April 2011

To our biodiversity conservation partners:

The attached Lake Ontario Lakewide Management Plan (LaMP) report, **Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy, April 2011,** is the result of years of stakeholder consultation, solicitation of expert opinions, and consideration of existing biodiversity conservation program goals and objectives. The results of this broad stakeholder consultation process were summarized in the report **The Beautiful Lake, A Binational Biodiversity Strategy for Lake Ontario, April 2009,** which identifies twenty-six shorelines and watersheds of greatest value to Lake Ontario's biodiversity. The attached LaMP implementation strategy lists the key recommendations provided in **The Beautiful Lake** report to be formally adopted by the LaMP. The LaMP will work to promote these actions, report on progress, identify resource needs and recommend additional actions as necessary to conserve Lake Ontario's biodiversity.

The key elements of the Lake Ontario LaMP's Binational Biodiversity Conservation Strategy are: 1) the integration of action priorities into existing programs and "place-based" planning activities especially within key watersheds, an activity best done by local governments and organizations and; 2) regional coordination of lakewide scale biodiversity monitoring and restoration activities. Given the enormous amount of work needed to restore and protect Lake Ontario's biodiversity, the LaMP recognizes that the key to success lies in our ability to build and foster cooperative partnerships throughout the Lake Ontario basin. To that end, we ask that you consider the strategies and key steps outlined in this report as you plan and undertake activities to restore and protect Lake Ontario's biodiversity.

Sincerely,

Kevin Guérin
Management Committee Co-Chair
Lake Ontario Lakewide Management Plan
Environment Canada

Mario Del Vicario
Management Committee Co-Chair
Lake Ontario Lakewide Management Plan
U.S. EPA Region 2

Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy

Lake Ontario Lakewide Management Plan

April 2011

Prepared by Lake Ontario LaMP Work Group and Technical Staff

Michael Basile
U.S. Environmental Protection Agency
Buffalo, New York

Barbara Belasco
U.S. Environmental Protection Agency
New York, New York

Gavin Christie
Fisheries & Oceans Canada
Toronto, Ontario

Rick Czepita
Environment Canada
Toronto, Ontario

Conrad DeBarros
Ontario Ministry of the Environment
Kingston Ontario

Marie-Claire Doyle
Environment Canada
Burlington, Ontario

Sandra E. George
Environment Canada
Burlington, Ontario

Heather Hawthorne
Ontario Ministry of the Environment
Kingston, Ontario

Steve LaPan
New York State Department of
Environmental Conservation
Cape Vincent, New York

Audrey LaPenna
Ontario Ministry of Natural Resources
Picton, Ontario

Frederick Luckey
U.S. Environmental Protection Agency
New York, New York

Alastair Mathers
Ontario Ministry of Natural Resources
Picton, Ontario

Bruce Morrison
Ontario Ministry of Natural Resources
Picton, Ontario

Tom Stewart
Ontario Ministry of Natural Resources
Picton, Ontario

Betsy Trometer
U.S. Fish & Wildlife Service
Amherst, New York

Don Zelazny
New York State Department of
Environmental Conservation
Buffalo, New York

Tracey Tomajer
New York State Department of
Environmental Conservation
Albany, New York

Acknowledgements

The development of the Lake Ontario Lakewide Management Plan's biodiversity conservation strategy was funded by the U.S. Environmental Protection Agency, the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem, The Nature Conservancy, and The Nature Conservancy of Canada.

Special thanks to David Klein, The Nature Conservancy, and Daniel Krauss, Nature Conservancy of Canada for soliciting and coordinating the input of over 150 experts representing 53 agencies, conservation authorities, universities, and non-governmental organizations (NGOs) on behalf of the LaMP. The final report that summarized stakeholder and biodiversity expert input, **The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario,** completed in 2009 helped to guide the development of the LaMP's biodiversity conservation strategy.

Cover photo of Prince Edward County, Ontario shoreline courtesy of Wasyl Bakowsky, Ontario Natural Heritage Centre.

Table of Contents

Section **Page**

Acknowledgements i

1. The Beautiful Lake 1

2. Lake Ontario's Biodiversity 5

3. Developing the Strategy 7

4. Implementing Biodiversity Conservation Action Recommendations 11

5. Priority Lake Ontario Biodiversity Conservation Action Needs 19

6. Next Steps 25

7. References and Background Literature 27

Appendix

A Lake Ontario Biodiversity Maps 33
Migratory Fish – Condition 35
Coastal Wetlands – Biological Significance 37
Coastal Wetlands – Condition 39
Nearshore Zone – Condition 41
Lake-to-Tributary Connectivity 43

List of Tables and Figures

Table **Page**

1 Ten Things Every Resident of the Lake Ontario Basin Should Know 2

2 New York Priority Action Sites: Biological Importance and Recommended Actions..12

3 Ontario Priority Action Sites: Biological Importance and Recommended Actions..14

4 Binational Priority Action Sites: Biological Importance and Recommended Actions..17

Figure **Page**

1 Lake Ontario Natural Land Cover 3

2 Lake Ontario LaMP Biodiversity Conservation Priority Action Sites..............................9

1. The Beautiful Lake

Lake Ontario is the last lake in the chain of Laurentian Great Lakes and is shared by Ontario and New York. It is the smallest of the Great Lakes, with a surface area of 18,960 square kilometers (km^2), but has the highest ratio of watershed area to lake surface area. It is a deepwater system, with an average depth of 86 meters and a maximum depth of 244 meters, second only to Lake Superior. Approximately 80% of the water flowing into Lake Ontario comes from Lake Erie through the Niagara River. The remaining flow comes from Lake Ontario basin tributaries (14%) and precipitation (7%). About 93% of the water in Lake Ontario flows into the St. Lawrence River; the remaining 7% is lost via evaporation. Lake Ontario has over 3,900 kilometers (km) of shoreline, dominated by bedrock shores and bluffs. While the western portion of the Lake Ontario coast has been heavily urbanized, most of the basin is dominated by agricultural and rural lands (Figure 1).

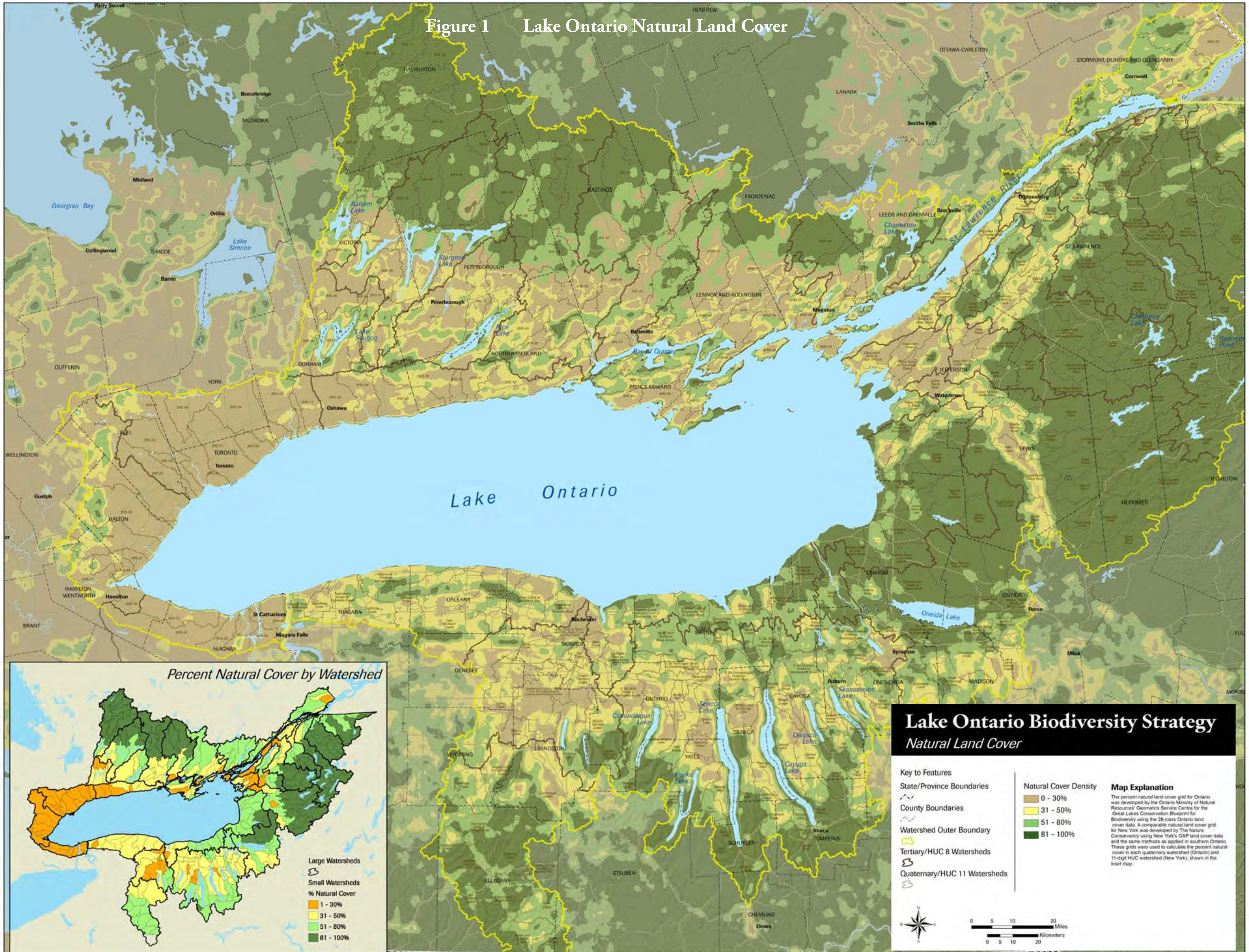
The name "Ontario" comes from a native word, possibly "Onitariio" or "Kanadario", loosely translated as "beautiful" or "sparkling" water or lake. (Government of Ontario 2008)

Lake Ontario and its watershed support a rich diversity of plants and animals. The physical environment supporting this biodiversity is rich and variable - there are island archipelagos, sand and cobble beaches, sand dunes often interspersed with rich wet meadows and fens, productive shallow embayments, numerous and varied tributaries, and a bedrock geology deriving from both Precambrian and Paleozoic periods. Native fish populations of walleye, yellow perch, and other species continue to be an important resource despite numerous threats. American eel is present in Lake Ontario and its tributaries, but has declined to the extent that it is now listed as Endangered in Ontario. Lake Ontario once supported lake trout and Atlantic salmon, and programs have been established to restore these species. Islands provide nesting habitat for colonial nesting bird species like black tern, Caspian tern, ring-billed gull, and the coast and nearshore areas provide migratory stopover habitat for birds, insects, and bats. The central and eastern Lake Ontario coastal dunes, marshes, and barrier beaches are ecologically very significant. Rare dune ecosystems can be found at Presqu‘ile and Sandbanks Provincial Parks and on Wolfe Island. Globally rare alvars can be found along the coast.

The lake's water quality and ecology have undergone major changes in the last two centuries. Today, over 10 million people live in the basin. The Canadian population in Lake Ontario is the most rapidly expanding population in the Great Lakes basin. The population in this region has grown by over 40% in the last two decades and it is projected that the population in the western end of Lake Ontario will grow by an additional 3.7 million people by 2031 (Environment Canada and United States Environmental Protection Agency 2008). Many residents of the basin remain unaware of biology and ecological services provided by Lake Ontario (see Table 1). The lake provides drinking water to almost 8 million people and has supported substantial commercial and recreational fisheries. The character of the fisheries has been radically altered from the effects of historic over-fishing, habitat alterations, invasive species such as alewife, dreissenid mussels and round goby, extensive stocking of non-native trout and salmon, fluctuations in nutrient loading, and contaminants from industrial, agricultural, and residential sources around the basin. Since Lake Ontario is the lower-most Great Lake, it is further impacted by human activities occurring throughout the Lake Superior, Michigan, Huron, and Erie basins.

Table 1	Ten Things Every Resident of the Lake Ontario Basin Should Know
1.	Lake Ontario is the 14^{th} largest lake in the world; it is a deep, coldwater ecosystem that supports lake trout and whitefish.
2.	A critical link in the Lake Ontario food chain is a small freshwater shrimp.
3.	American eel lives in Lake Ontario in its tributaries, but spawns in the Atlantic Ocean.
4.	There are almost 100 species of native fish in Lake Ontario.
5.	It is one of two Great Lakes with water levels that are regulated through dams in outlet rivers (the other one is Lake Superior).
6.	Over 8 million people get their drinking water from the lake.
7.	Only the western portion of the watershed is highly developed, most of the basin is characterized by rural landscapes.
8.	The western part of Lake Ontario is the fastest growing area in the Great Lakes basin.
9.	The open lake is significantly cleaner than it was 20 years ago.
10.	Improving the health of the lake improves the quality of life for people in the basin.

Figure 1 Lake Ontario Natural Land Cover



2. Lake Ontario's Biodiversity

Lake Ontario contains a rich and diverse array of species, communities, and ecosystems that include aquatic, terrestrial, and wetland biomes. This project identified seven biodiversity targets within Lake Ontario. These biodiversity targets represent and encompass the full array of biodiversity found in Lake Ontario. Each biodiversity target includes a suite of nested species and communities with linked conservation needs. For example, by conserving islands in Lake Ontario, the needs of colonial nesting waterbirds will be met. Additional detail and maps of these biodiversity targets is provided in Appendix A.

Benthic and pelagic offshore system: This target represents the deepwater ecosystem in Lake Ontario, including the open waters and bottom of the lake in permanently cold water greater than 20 m in depth. This zone once supported an abundant and diverse fish community dominated by lake trout, lake whitefish, and deepwater sculpin. The Atlantic salmon was once the top predator in this system.

Native migratory fish: Many of Lake Ontario's fish depend on migration for part of their life cycle. This includes species that migrate to rivers (e.g., walleye), coastal wetlands (e.g., yellow perch and Northern Pike) and even the Atlantic Ocean (American eel). Protecting these migratory species requires protecting all of the habitats they utilize during their life cycle.

Coastal wetlands: Lake Ontario has over 35,000 hectares/86,450 acres of coastal wetlands. These wetlands have a hydrologic link to Lake Ontario as their water levels are directly related to the water level in the lake. Wetlands also provide a critical link between land and water, and they support a high diversity of species.

Nearshore zone: This zone occurs from the 20-meter depth contour to the high water mark along the coast. These shallow waters are the most productive zone of the lake and often include rich beds of aquatic vegetation that support fishes and waterfowl. Dynamic sand and cobble beaches also occur in this zone.

Coastal terrestrial systems: This biodiversity target includes a wide diversity of natural habitats that occur from the line of wave action to 2 km inland. This zone is over 3,900 km long, and supports sand dunes, alvars, and coastal forests and provides important stop-over habitat for migrating birds.

Rivers, estuaries and connecting channels: There are hundreds of streams and rivers that flow into Lake Ontario. These systems and their associated riparian areas provide habitat for many fish and other aquatic species, and have a significant influence on the diversity and health of nearshore waters.

Islands: Lake Ontario has almost 2,000 islands. These islands provide nesting habitat for colonial waterbirds and often contain unique assemblages of plants and animals due to their degree of isolation from other terrestrial systems. Islands in the eastern basin and the upper St. Lawrence River provide "stepping stones" in the linkage between Ontario's Algonquin Park and the Adirondacks in New York.

3. Developing the Strategy

There has been a long-running spirit of cooperation between Canada and the U.S. to protect and manage Lake Ontario. Lakewide Management Plans (LaMPs) developed out of the 1987 amendments to the Great Lakes Water Quality Agreement signed by the United States and Canada provide a framework to assess, restore, protect, and monitor the ecosystem health of the lake. The LaMP is used to coordinate the work of all the government, tribal, and non-government partners working to improve the lake ecosystem. The LaMP process requires public consultation to ensure that the plan adequately addresses the public's concerns. The stated goals of the 2004 update to the Lake Ontario LaMP (LaMP 2004) were:

- The Lake Ontario Ecosystem should be maintained and, as necessary, restored or enhanced to support self-reproducing diverse biological communities;

- The presence of contaminants shall not limit the uses of fish, wildlife, and waters of the Lake Ontario basin by humans and shall not cause adverse health effects in plants and animals; and

- We as a society shall recognize our capacity to cause great changes in the ecosystem and we shall conduct our activities with responsible stewardship for the Lake Ontario basin.

It was within this context that in 2006 the LaMP Management Committee initiated a process to create a biodiversity conservation strategy for Lake Ontario that was bi-national in scope (LaMP 2004). The LaMP tasked the Nature Conservancy of Canada and The Nature Conservancy (U.S.) to support the coordination of partners to develop the strategy.

The Binational Biodiversity Conservation Strategy (Strategy) was prepared through the participation and input of 150 experts from over 50 agencies, universities, and organizations. These experts participated in four bi-national workshops that focused on developing different sections of the Strategy. The purpose of these workshops was to assemble Lake Ontario experts from Canada and the U.S. and develop consensus on the scope and goals of the Strategy, identify and assess the health of biodiversity targets, identify and rank threats to biodiversity, and to develop both basin-wide and place-based conservation strategies:

- Workshop 1 (June 21 - 22, 2006): defined project scope and identify biodiversity targets and health

- Workshop 2 (October 5 - 6, 2006): identified and described threats to the biodiversity targets

- Workshop 3 (February 28 - March 1, 2007): identified strategies

- Workshop 4 (December 5 - 6, 2007): refined place-based strategies and implementation steps

The project scope identified by workshop participants was "to develop bi-national strategies for conserving and restoring the biological diversity of Lake Ontario, including its coastal habitats, pelagic and benthic zones, tributaries, and connecting channels." Since the focus of this project is to foster bi-national action to address the biota of Lake Ontario, the scope for recommended actions included the watersheds of tributaries to the extent that they affect the biodiversity of the lake, including the Niagara and St. Lawrence rivers.

Goals identified for this project were to:

- Reach a consensus on the key threats to biodiversity;
- Develop a bi-national action agenda of strategies to abate these threats;
- Identify priority action sites for implementation of strategies;
- Identify a suite of indicators of the health of biodiversity targets; and
- Achieve greater integration of efforts toward common goals.

The final report, **The Beautiful Lake, A Binational Biodiversity Conservation Strategy for Lake Ontario,** hereafter referred to as **The Beautiful Lake***,* completed in 2009, includes detailed summaries and maps of key components of Lake Ontario's biodiversity, such as coastal wetlands, forests and tributaries, is available on-line at: http://www.epa.gov/greatlakes/lakeont/reports/lo_biodiversity.pdf.

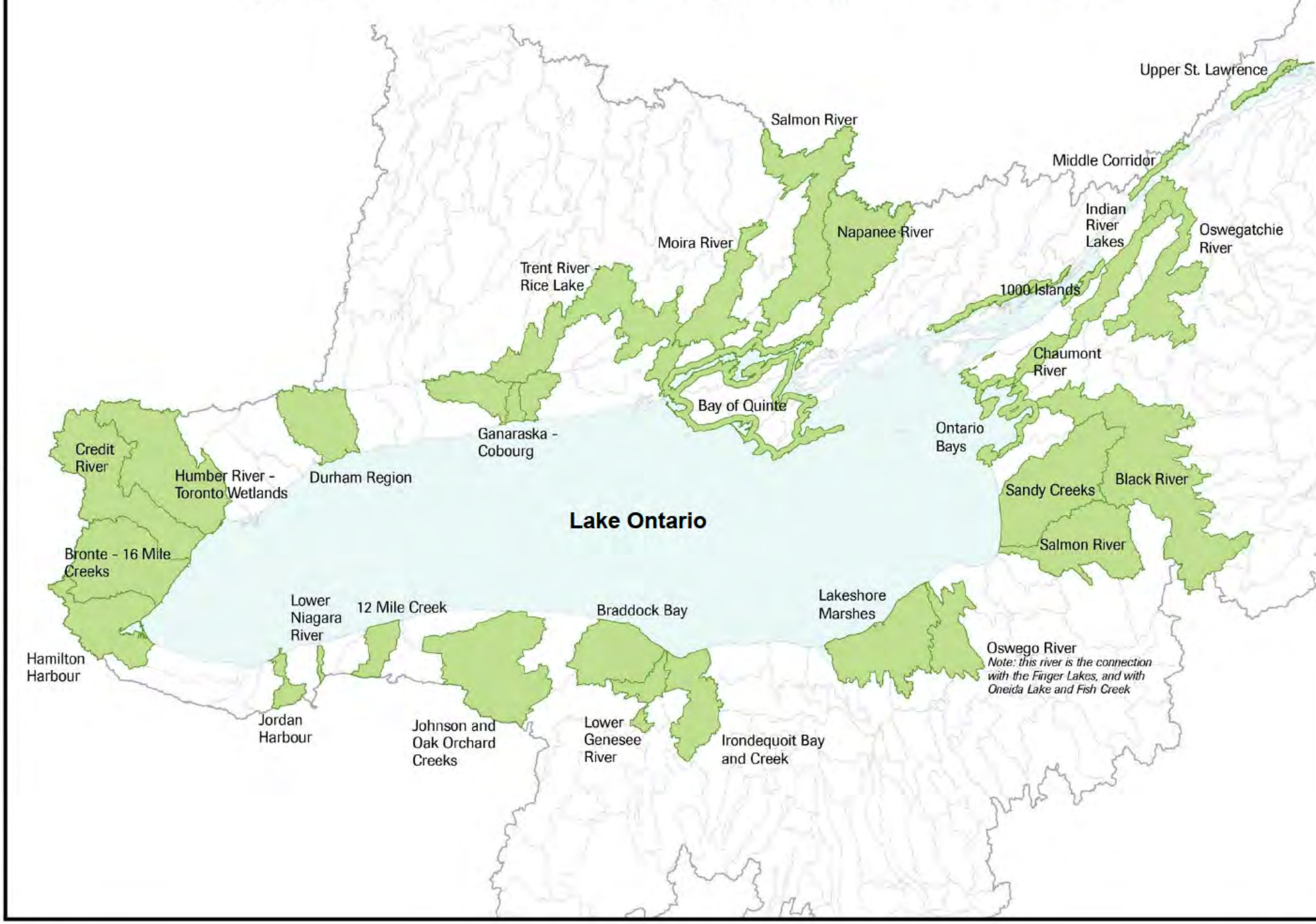
The Strategy identified broad categories of action recommendations. The LaMP selected the following five recommendations to be a focus of LaMP coordination and management activities with a special emphasis on implementing these actions at Priority Action Sites:

1. Conserve critical lands and waters
2. Reduce the impact of aquatic invasive species
3. Restore connections and natural hydrology
4. Restore native fish communities and native species
5. Restore the quality of nearshore waters

A significant achievement of the Strategy is the identification of 26 "Priority Action Sites," high value watersheds, tributaries, and coastal areas of critical importance to Lake Ontario's biodiversity. These Priority Action Sites, and specific recommended actions for each, are fully adopted by the LaMP (Figure 2 and Tables 1, 2 and 3) and will be integrated into LaMP coordination and management activities.

Given the broad range of perspectives included in the final report, **The Beautiful Lake***,* some of its recommendations are outside the scope or legal mandate of the LaMP agencies. However, stakeholders are encouraged to continue their consideration of all of the recommended actions.

Figure 2 Lake Ontario LaMP Biodiversity Conservation Priority Action Sites



4. Implementing Biodiversity Conservation Action Recommendations

The LaMP's primary role in conserving biodiversity is to promote and coordinate the implementation of conservation actions through LaMP stakeholders and its respective federal, state, provincial and tribal agencies, authorities, program plans, or strategies. Many government, private, and academic planning efforts are already established to protect and restore the Lake Ontario ecosystem. These existing efforts are being carried out on a variety of scales, lakewide, landscape, watershed or local. Rather than developing new, potentially duplicative planning processes, the LaMP will work with these existing efforts to see how they may help address the LaMP's 26 Lake Ontario "Priority Action Sites" (Figure 2) and five "Action Recommendations." Specific biodiversity action needs for New York, Ontario and Binational Priority Action Sites are summarized on Tables 2, 3 and 4.

The LaMP will develop a stakeholder consultation strategy to share its biodiversity conservation objectives with existing agencies, academics, environmental groups, municipalities and others, and to try to solicit partners in implementing biodiversity planning. It is only in those cases where no management strategy exists for a specific priority action area or coordination issue that the LaMP would seek to create a new management structure.

The LaMP will also coordinate with the Great Lakes Fishery Commission's Lake Ontario Lake Committee of fishery managers, and other applicable organizations, on regional biodiversity planning efforts including the restoration of self-sustaining native aquatic species, understanding and moderating the negative impacts of lake level control, reducing the impact of pollutants and excessive nutrients, limiting the influx of invasive species from outside the Lake Ontario basin and, supporting necessary monitoring efforts. Ideally the LaMP's broad programmatic view of the five categories of biodiversity action needs can help inform and guide local and regional efforts. The LaMP will periodically reconsider the status of biodiversity trends and planning efforts throughout the basin.

Table 2 **New York Priority Action Sites: Biological Importance and Recommended Actions**

Site	Biological Importance	Recommended Actions
Ontario Bays	Chaumont River and Black River empty into a series of bedrock shoreline embayments Extensive marshes are degraded with invasive plants, but Blanding's turtle and black tern are found here Embayments, river mouths, and Johnson Shoals are important for lake whitefish and lake herring Historical and active bald eagle nests found along the shoreline, and the site is a priority for the LaMP Bald Eagle Recovery Plan (2005)	Buffer wetlands and river mouths with protected land in natural cover Reduce sediment runoff into river mouths – rocky shoals are important for herring/whitefish spawning Restore populations of lake whitefish, lake herring
Black River	Large river system with historic importance for Atlantic salmon, lake sturgeon, and American eel	Promote and maintain riparian buffers
Sandy Creek Dunes and Embayments	Seventeen-mile barrier beach/dune ecosystem with sheltered lagoons, coastal fens, globally rare species and nesting black terns Historic bald eagle nest locations and includes LaMP eagle habitat conservation areas Sandy Creek has historic importance for Atlantic salmon, American eel, whitefish, lake herring	Dam mitigation/removal, but VHS is complicating factor Fish passage for low barriers on Sandy Creek and South Sandy Creek Land protection in active river areas and to buffer wetlands Reach out to private landowners Employ seasonal stewards to promote public education Reduce non-point loading from septic systems and upstream agriculture
Salmon River	River system goes deep into Tug Hill forest, and rich estuary was source of sediment to eastern shore beaches Historic importance for Atlantic salmon. Major spawning system for stocked and naturalizing Pacific salmonids	Protect source waters and conserve minimum flows Employ seasonal stewards to promote public education Wetland and upstream buffers for Salmon Creek
Oswego River	Keystone river system that connects the Seneca River, Finger Lakes, and Oneida Lake and tributaries, to Lake Ontario Historically provided access to spawning grounds for Atlantic salmon and feeding areas for American eel Historically important for lake sturgeon spawning, although the population appears extirpated	Evaluate current status of fish passage around dams including techniques to exclude lamprey Determine whether river mouth is currently suitable for stocking lake sturgeon

Table 2 **New York Priority Action Sites: Biological Importance And Recommended Actions (continued)**

Site	Biological Importance	Recommended Actions
Lakeshore Marshes	A series of small creeks and embayments, with diverse coastal wetlands Extensive submerged aquatic beds Embayments are possible restoration sites for lake herring This area has three historic bald eagle nesting locations, and is a priority recovery site	Protect lands buffering wetlands and riverine corridors Restore lake herring Complete and implement management plans on public lands – harbour management plan for Sodus Bay Reduce dominance of aquatic invasive plants Outreach to local governments – septic/sewer upgrades and best management practices (BMPs) for urban runoff
Irondequoit Bay and Creek	Large embayment formed by drowned mouth of ancient Genesee River Major streams have uninterrupted connectivity with Lake Ontario Possible restoration site for lake herring	Evaluate restoration potential for lake herring
Lower Genesee River	Active stocking site for lake sturgeon, with evidence of survival	Rochester Embayment Remedial Action Plan (RAP) is being implemented
Braddock Embayments	Extensive submerged aquatic beds Baymouth barrier beaches and shoreline bluffs with sand nearshore Tributaries to southern Lake Ontario bays: lakeplain wetland- and groundwater-fed streams Coastal ponds and embayments connected to the lake Extensive wetlands with diverse bird community – American bittern, sedge wren, black tern (population appears extirpated)	Reduce phosphorus loading to ponds through riverine buffers and BMPs Municipal sewage upgrades Screen culverts for mitigation to restore connectivity to the lake Wetland and upstream buffers for Salmon Creek Fish passage for low barriers on Sandy Creek
Western NY creeks – Johnson and Oak Orchard	Region is characterized by numerous short lakeplain streams Upper reaches of Oak Orchard watershed contain important stopover resources for migratory birds The lower reaches were previously important feeding grounds for the American eel High fish biodiversity High diversity of native mussels in upper reaches	Biological inventory of streams Floodplain and buffer protection for streams Complete watershed planning for Oak Orchard and Johnson creeks Explore fish passage for Lake Alice Dam, and dam on Johnson Creek Reduce non-point runoff into nearshore waters with buffer strips for creeks and BMPs
12-Mile Creek	High biological significance and species richness	Targeted land securement – stream buffers Influence management of private lands

Table 3 **Ontario Priority Action Sites: Biological Importance and Recommended Actions**

Site	Biological Importance	Recommended Actions/Comments
Jordan Harbour	Historic important feeding area for American eel Includes one of the largest wetland features in Niagara Peninsula region and provides key habitat for a number of waterfowl species	Floodplain and buffer protection for streams Targeted land securement Restoration of creek mouth
Hamilton Harbour	Includes Cootes Paradise, an extensive wetland system under restoration Former resource for American eel, whitefish, lake herring	Explore feasibility of restoring whitefish and lake herring Targeted land securement – stream buffers Reduce loading to nearshore through streamside buffers and BMPs Reduce sediment and phosphorus runoff from urban sources through three-prong approach Watershed planning for corridors and linkages for species movement in response to climate change Explore "soft engineering" approaches to shoreline hardening
Bronte/16-Mile Creeks	Bronte Creek – historic importance for Atlantic salmon	Restoration site for Atlantic salmon
Credit River	Main constituent of "Golden Horseshoe" region with high fish/mussel diversity Rattray Marsh is the last remaining baymouth bar coastal wetland between Oshawa and Burlington Source of all Pacific salmon raised for stocking in Ontario Historic importance for Atlantic salmon	Restoration site for Atlantic salmon Targeted land securement Restore stream buffers and wetlands to reduce peak flows Outreach to municipal governments – disconnect cross-connections between storm drains and sewer system Design standards for new developments to restore water balance Explore "soft engineering" solutions for shoreline hardening Reduce phosphorus loadings through BMPs and stream buffers Monitor nutrients at both watershed and sub-watershed scales

Table 3 **Ontario Priority Action Sites: Biological Importance and Recommended Actions (continued)**

Site	Biological Importance	Recommended Actions/Comments
Humber River – Toronto wetlands	Historic importance for Atlantic salmon Isolated wetlands in highly urbanized area	Restoration site for Atlantic salmon Targeted land securement Work with private landowners to restore natural cover Restore stream buffers and wetlands to reduce peak flows Outreach to municipal governments – disconnect cross-connections between storm and sewer Design standards for new developments to restore water balance Explore “soft engineering” solutions for shoreline hardening
Durham region	Highly diverse coastal wetlands Historic importance for Atlantic salmon	Restoration site for Atlantic salmon Reduce phosphorus loading to wetlands and nearshore through BMPs and stream buffers Restore stream buffers and wetlands to reduce peak flows Reduce dominance of aquatic invasive species – carp
Ganaraska-Cobourg Creeks	Historic spawning site for lake sturgeon; judged to be suitable for stocking (Draft Lake Sturgeon Rehabilitation Plan) Historic site for Atlantic salmon	Priority site for restoration of Atlantic salmon Targeted land securement Reduce sediment and phosphorus runoff from urban sources Mitigate barriers to sediment transport – “soft engineering” of shoreline hardening

Table 3 Ontario Priority Action Sites: Biological Importance and Recommended Actions (continued)

Site	Biological Importance	Recommended Actions/Comments
Trent River – Rice Lake	Major river system Mouth of the river just upstream from Bay of Quinte to Rice Lake has historic importance for American eel Potential spawning and nursery stream for lake sturgeon, with existing remnant population	Inventory and prioritization of barriers (dams and locks) that are barriers to fish passage (locks present 38 barriers to fish movement) Design operational guidelines for dams requiring recertification Retrofit existing dams with screens on turbine intakes Seek restoration of more natural flows through dam management Explore removal of selected dams Partners for such a project could include appropriate conservation authorities, Parks Canada, Ministry of Natural Resources, Department of Fisheries and Oceans (DFO), other federal agencies
Presqu'ile and Prince Edward shoreline	Extensive barrier beach system with sheltered embayment wetlands; one of two such barrier beach systems remaining in Lake Ontario Area of high waterfowl use and high density of breeding pairs of waterfowl Priority area for restoration of bald eagle, with seven priority sites identified Designated an Important Bird Area	Targeted land securement – buffers for Sandbanks Provincial Park and Wellers Bay Complete watershed planning Reduce phosphorus loading through BMPs and buffers
Bay of Quinte	Lengthy embayment with extensive embayment and river mouth wetlands Important spawning resource for whitefish, Herring Historic importance for American eel Prince Edward Bay important resource for lake sturgeon	Need a specific strategy to combat spread of common reed (*Phragmites australis*) Reduce sediment and phosphorus runoff from urban sources
Napanee River	Restoration site for lake sturgeon	Priority site for restoration of lake sturgeon

Table 4 Binational Priority Action Sites: Biological Importance and Recommended Actions

Site	Biological Importance	Recommended Actions/Comments
Lower Niagara River	Important spawning and nursery area for lake sturgeon	Continue efforts to restore Lake sturgeon (United States Geological Survey and United States Fish and Wildlife Service are leading this effort)
1,000 Islands	Bays, fringe wetlands, and diverse tributaries SAR, including historic bald eagle nesting locations Colonial waterfowl nesting areas Raptor staging and migration areas	Targeted land securement – mature forests and stream buffers Restoration of natural vegetation (made difficult by the shallow overburden on pre-Cambrian rock Watershed planning – designed to address recreational and tourism pressures

5. Priority Lake Ontario Biodiversity Conservation Action Needs

Conserve Critical Lands and Waters

Lake Ontario's watersheds and shorelines are highly diverse in their character and ecological value. The shorelines often reflect the impacts from the demands of large urban centers, suburban residential development, second home development, transportation routes, industry, and agriculture. These land uses have had the typical effects of removing, altering, and fragmenting the landscape's original natural cover, affecting the natural physical and hydrology processes, and changing freshwater and coastal environments. The key challenges include how to respond to the causes and impacts of habitat degradation, and where to focus conservation efforts so they may have the greatest benefit to native biodiversity.

This proposed bi-national approach to conserving critical lands and waters in the Lake Ontario watershed includes land securement in priority areas, aided by targeted conservation funding, watershed planning, and management of public and private lands for the benefit of biodiversity.

Priority Action Sites for Conservation Activities: New York's Comprehensive Wildlife Conservation Strategy (CWCS) has identified three action zones for the watershed of Lake Ontario, encompassing the southwestern shoreline west of Rochester, the southeastern zone including the watersheds of Oswego, Salmon, and Black Rivers, Sandy Creek, and the upper St. Lawrence River. Aquatic resources are most threatened in the northwestern and southwestern portions of the lake ecosystem, such as Durham region, Credit River, Humber River, Bronte/16-Mile Creek, and Jordan Harbour in Ontario, and Johnson-Oak Orchard Creeks and Braddock Bay in New York. Least-altered areas, such as Sandy Creek, Salmon River, and Lakeshore Marshes in New York, and the Napanee watershed, Bay of Quinte, and Thousand Islands shoreline in Ontario should also be given special attention.

Examples of actions needed:

- Evaluate the status of integrated watershed planning/plans and their implementation throughout the basin;

- Promote links among local plans with government, academic or private efforts having similar biodiversity conservation goals;

- Create strategies and incentives to advance planning and implementation where critical assistance is required; and

- Develop inventories and identify repositories of integrated planning efforts among the lake's watersheds that support the LaMP's biodiversity conservation goals and objectives.

Reduce the Impact of Aquatic Invasive Species

In Lake Ontario, aquatic invasive species (AIS) have altered the native food web in fundamental ways. Examples include re-routing the flow of nutrients in the aquatic food web by zebra and quagga

(Dreissenid) mussels negatively impacting native benthic communities; predation on larval native fish by exotic Alewife, rainbow smelt, and round goby and; parasitism on top predators by sea lamprey.

While international shipping through the St. Lawrence Seaway remains the primary vector for new AIS vectors include: canals, trade in live animals and plants, and recreational boating. Several conservation authorities, including Credit Valley Conservation, noted that illegal stocking of fish into storm water management ponds represents an increasingly significant vector of AIS, and recommended guidance documents to educate local residents on the negative impacts of such stocking.

Artificial connections linking Lake Ontario with other catchments have been a vector for the introduction of AIS since the 19th century. Most recently, the blue-back herring was introduced to Lake Ontario and the Great Lakes basin via the New York Oswego-Erie Canal, which connects the Lake Ontario drainage with the Hudson River. The potential of future invasive species introductions via the Hudson to Oswego/Erie Canal connection and the Rideau Canal to Ottawa River remains a particular concern.

Examples of actions needed:

- Identify options to help prevent the spread of AIS between Lake Ontario and other watersheds, such as permanent barriers, cargo transfer stations, small watercraft lifts and cleaning stations without interrupting the transport of goods or recreation;

- Review existing inventories of species involved in live trades and apply risk assessment procedures to identify those which pose the highest risk of ecosystem damage;

- Consider approaches to prevent introductions via the boating pathway by finding support for boat washing stations and inspection stations on major transportation routes and water access points;

- Inventory all boat landings and major water access points that may provide pathways for AIS to enter to Lake Ontario and identify those with the highest probability of new invasions;

- Consider the feasibility of developing a basinwide rapid response framework to coordinate inter-jurisdictional response to early detection of AIS plants for high risk areas, such as the Welland Canal, New York Oswego/Erie Canal, and Hamilton Harbour.

Restoring Connections and Natural Hydrology

Hydrologic alteration due to dams on Lake Ontario tributaries and the St. Lawrence River have been identified as a serious threat to biodiversity. In particular, artificial lake level controls and shoreline development have had an array of effects including the inhibition of longshore sediment transport due to shoreline armoring (nearly 40% of the western lakeshore has been hardened); the loss of wetlands (60 to 90% of the original wetlands have been lost from the Greater Toronto Area); isolation of remaining wetlands and limitations in their ability to migrate up- and down-slope in response to long-term natural changes in lake levels.

Dams and barriers (e.g., culverts at road-stream crossings) also alter hydrologic rhythms that sustain riparian and coastal habitats. These barriers restrict access by fish to spawning and nursery habitats, alter the thermal regime of streams, and interrupt movement of sediments. Several thousand dams are in place on Lake Ontario tributaries, with over 110 in-stream barriers, such as dams and weirs, identified in the Humber River watershed alone.

Several recent initiatives provide opportunities to address some of the threats to biodiversity posed by dams and barriers:

- Methods for reducing the impacts of dams and barriers are being developed in both New York and Ontario. Several Conservation Authorities have inventoried and categorized barriers in specific watersheds, and are developing decision support tools to prioritize dams for mitigation. In New York, priority dams have been identified by an U.S. Environmental Protection Agency (EPA)-funded New York Rivers United project carried out in cooperation with New York State fishery managers. A province-wide project to inventory dams in Ontario will include a registration program by 2012. These studies may provide a starting point for selecting actions such as dam removal or installation of fish passage devices to help reduce the impact of dams on fish;

- Many dams in Ontario are being retrofitted for hydropower, and the licensing procedures provide an opportunity to improve connectivity between tributaries and the lake; and

- A comprehensive bi-national database of the dams in the watershed, describing current use and ownership, does not exist, but efforts in both countries may be combined to produce this important source of information.

Several participants in past Lake Ontario biodiversity conservation workshops cautioned that invasive pests and pathogens like the sea lamprey and VHS complicate the issues of connectivity, fish passage, and dam removal. Conservation Ontario notes: "Not all dams and barriers are a problem. Many are needed to help separate native and non-native species – being able to partition streams may be a key management tool for programs like the Atlantic salmon recovery project." Clearly, decisions about fish passage or dam removal need to be assessed on the basis of local conditions.

Priority Action Sites for Dam Removal and/or Fish Passage Projects: Sandy Creek, Oswego River, Hamilton Harbour watershed, Credit River, and Durham Region are all target areas for dam and barrier mitigation; fish passage is a priority in Braddock Bay, Oak Orchard-Johnson Creek, and Trent River-Rice Lake.

Examples of actions needed:

- Monitor and assess key Lake Ontario and Upper St. Lawrence environmental indicators to support adaptive management in response to water level regulation;

- Identify opportunities to better connect coastal wetlands to the lake through culvert modifications or other options;

- Update inventories of abandoned and unused dams that could be mitigated to provide upstream passage for Lake Ontario fish. Develop a proposed removal strategy for each candidate dam listing relevant parties that need to be involved, necessary government approvals and removal cost estimates; and

- Periodically update the current database and map of barriers to lake-to-tributary connectivity.

Restore Native Fish Communities and Native Fish Species

Like all the Great Lakes, the fish community of Lake Ontario has been highly altered by over-fishing, damming of tributaries, pollution of nearshore waters, and the impacts of invasive species. A former top predator, the Atlantic salmon, which ascended high into the tributaries to spawn, is now extirpated from the lake as a result of degradation of spawning areas (including dams), non-native species impacts, over-harvesting, and sea lamprey predation. Active restoration program for Atlantic salmon, supported by public and private funds, is progressing in a number of tributaries in Ontario.

Another top predator, the lake trout, is only present in the lake today because of targeted management programs including stocking, although some natural reproduction has apparently resumed at low levels. Lake sturgeon reproduction is re-occurring in several areas, and active restoration efforts are underway in both Ontario and New York but overall the abundance of this species is very low in Lake Ontario. Many of the native coldwater coregonid prey fish species (e.g., lake herring, whitefish, and bloater) are gone or severely diminished from the lake. The lake whitefish still persists in low levels in the Kingston Basin, and small lake herring populations remain along the eastern shores. American eel were once an important component of the nearshore food web in Lake Ontario and provide an important commercial fishery, but their abundance has declined precipitously in the last two decades and American eel have recently been listed under Ontario's Endangered Species Act.

Opportunities exist to restore parts of the native fish community and restoration of native species and communities is both a LaMP priority and a goal of the Great Lakes Fishery Commission's Lake Ontario Committee.

Today, several challenges impede efforts to restore portions of the native food fish community. Non-native species such as the round goby, alewife, sea lamprey, water fleas, and dreissenid mussels all pose threats to native species restoration. Invasive species interfere biochemically with the reproduction of top predators (alewife), depress fry survival through predation (alewife and goby); parasitize the adult fish (lamprey); replace and prey upon native food resources (water fleas); and alter energy and nutrient flows through the lower levels of the web (mussels).

Intentional and controlled stocking of non-native Pacific salmonids and brown trout has been used effectively as a technique to control alewife populations and to provide a more diverse range of top predators in the food web. Fishery managers and scientists have noted that the interplay between alewife populations, Pacific salmonids, and native species is very complex and the challenges of restoring native species, particularly top predators, should not be underestimated. Restoration of native prey fish, such as the lake herring, whitefish, and deepwater ciscoes, is needed to set the stage for increased natural recruitment of native predators like the lake trout.

Examples of actions needed:

- Evaluate the progress towards restoration of native prey fish, Atlantic salmon, American eel, lake trout and lake sturgeon;
- Inventory and monitor the effectiveness of native fish stocking/re-introduction;
- Develop options to better engage a broad and diverse spectrum of stakeholders in restoration of native species; and
- Conserve watersheds, embayments, and coastal wetlands of particular importance to supporting the life-cycles of native fish species (Table 2).

Restore the Quality of Nearshore Waters

Non-point source pollution of tributaries and nearshore waters from urban, suburban, and agricultural sources can lead to algal blooms that alter water chemistry, decrease oxygen levels, and may combine with actions of invasive mussels to alter chemical and species composition in the littoral zone. This is an issue of particular importance in the urban settings of the western basin, but research in New York has revealed high nutrient levels in nearshore waters adjacent to rural settings as well.

The population of the western basin of Lake Ontario is projected to grow by 3.7 million by 2031. In anticipation of the environmental issues, including increased non-point and stormwater runoff, which are likely to occur as a result of this rapid population growth, provincial policies in Ontario are emphasizing low impact development and accelerated natural heritage system planning, among other initiatives.

Priority Action Sites for Non-Point Source Nutrient Control Actions: The urban watersheds Jordan Harbour, Hamilton Harbour, Bronte/16-Mile creeks, Durham Region, Ganaraska/Cobourg, and Trent River/Rice Lake are priority sites for implementation of urban non-point controls. The rural watersheds 18-Mile Creek, Salmon Creek, Oak Orchard Creek in New York; and Humber River, Credit River, and 16-Mile Creek in Ontario are the watersheds requiring the greatest amount of restoration effort.

Examples of actions needed:

- Promote beneficial shoreline management practices that seek to balance economic and biodiversity benefits;
- Promote soil erosion control, riparian buffer planting and conservation actions along streams, coastal zones and wetlands; and
- Promote concepts and methods of low impact development through outreach to developers.

6. Next Steps

The Lake Ontario LaMP Work Group and Public Involvement Committee will develop a stakeholder consultation strategy to engage partners to implement integrated, multi-scale planning and biodiversity conservation actions in identified priority action areas. The consultation will be targeted to local governments, non-governmental organizations, colleges and universities, and others. The key objective is to ensure that biodiversity conservation efforts are well integrated with existing government conservation efforts on multiple scales. The LaMP will build on and improve the coordination of existing efforts and strategies wherever possible rather than creating new management structures.

It is acknowledged that this strategy is by no means complete given the scale of biodiversity issues facing Lake Ontario. However, it begins to address the major opportunities to improve the management of the ecosystem. The strategy will also allow the LaMP opportunity to leverage as many existing resources and programs as possible to make implementation effective and efficient. This strategy will be periodically reviewed and the list of Priority Action Sites and recommended actions revised as needed to ensure it is meeting the LaMP's ecosystem goals and objectives.

7. References and Background Literature

Baird & Associates. Flooding Performance Indicator: Methodology and Shared Vision Model Application. IJC Plan Formulation and Evaluation Group, Windsor, ON: International Joint Commission, 2005.

Barko, J.W. Ecological effects of water level decreases in the Great Lakes. Vicksburg, Michigan: US Army Engineer Research and Development Center, 1999.

Brazner, J.C. and E.W. Beals. "Patterns in fish assemblages from coastal wetland and beach habitats in Green Bay, Lake Michigan: a multivariate analysis of abiotic and biotic forcing factors." Canadian Journal of Fisheries and Aquatic Sciences, 1997: 54: 1743–176.

Brinson, M.M., A.E. Lugo, and S. Brown. "Primary productivity, decomposition and consumer activity in freshwater wetlands." Annual Review of Ecology and Systematics, 1981: 12:123–161.

Center for Watershed Protection. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, MD: Center for Watershed Protection, 1998.

Chow-Fraser, P. "Development of the Water Quality Index (WQI) to assess effects of basin-wide land-use alteration on coastal marshes of the Laurentian Great Lakes." In Coastal wetlands of the Laurentian Great Lakes: health, habitat and indicators, by T.P., Stewart, P.M., Munawar, M. and Edsall, T.A. (Eds) Simon, in press. CRC Press, 2006.

CJS Consulting. A Revised Geomorphic, Shore Protection and Nearshore Classification of the Canadian and United States Shorelines of Lake Ontario and the St. Lawrence River. Consulting. International Joint Commission, 2002.

Committee to Review the Lake Ontario-St. Lawrence River Studies. Review of the Lake Ontario-St. Lawrence River Studies. Washington, D.C.: THE National Academies Press, 2006.

Crewe, T.L. and S.T.A. Timmermans. Assessing biological integrity of Great Lakes coastal wetlands using marsh birds and amphibian communities. Technical report, Project # WETLAND3-EPA-01, Downsview, ON: Environment Canada, 2005.

Dave, G. "Assessment and monitoring of ecosystem health in the sea: A description of the Swedish monitoring system for coastal marine areas." Aquatic Ecosystem Health & Management, 2001: 12:263-274.

Dermott, R. "Sudden disappearance of the amphipod Diporeia from eastern Lake Ontario, 1993-1995." Journal of Great Lakes Research, 2001: 27:423-433.

Dodd, C.K. and L.L. Smith. "Habitat destruction and alteration: historical trends and future prospects for amphibians." In Amphibian Conservation, by R.D. Semlitsch (ed), 94-112. Washington, D.C.: Smithsonian Institution, 2003.

Dove A. and G. Warren. Phosphorus Concentrations and Loadings: Indicator #111 (in State of the Great Lakes 2007). Environment Canada and U.S. Environmental Protection Agency. 2007 70-73.

Eastern Ontario Model Forest. Methods & Rationale for Assigning Woodland Value. June 2003. http://woodlandvaluation.eomf.on.ca/ (accessed July 2006).

Edsall, T.A. and M.N. Charlton. Nearshore Waters of the Great Lakes. Background paper, State of the Lakes Ecosystem Conference 1996, 1997.

Edsall, T.A., E.L. Mills, and J.H. Leach. "Exotic species in the Great Lakes." In Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems, by G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds) E.T. LaRoe, 442-444. Washington, D.C.: National Biological Service, 1995.

Environment Canada and Central Lake Ontario Conservation Authority. Durham Region Coastal Wetland Monitoring Project: year 2 technical report. ECB-OR, Downsview, ON: Environment Canada, 2004.

Environment Canada and Ontario Ministry of Natural Resources. The Ontario Great Lakes Coastal Wetland Atlas: A Summary of Information (1983-1987). Downsview, ON: Environment Canada, 2003.

Environment Canada and United States Environmental Protection Agency. State of the Lakes 2007. April 28, 2008. http://www.epa.gov/solec/sogl2007/ (accessed November 7, 2008).

Environment Canada. How much habitat is enough: a framework for guiding habitat rehabilitation in Great Lakes Areas of Concern. Downsview, ON: Environment Canada, Canadian Wildlife Service, 2004.

Environment, Ministry of the. Surface Water Monitoring and Assessment: 1997 Lake Ontario Report. Toronto, ON: Ministry of the Environment, 1999.

Farrell, J.M. “Reproductive success of sympatric northern pike and muskellunge in an Upper St. Lawrence River bay.” Transactions of the American Fisheries Society. American Fisheries Society, 2001. 130:796-808.

Farrell, J.M., R. Casselman, and J.M. Klindt. Update of the Strategic Plan for Management of the St. Lawrence River Muskellunge Population and Sportfishery Phase III: 2003-2010. Albany N.Y.: New York State Department of Environmental Conservation, 2003.

Farrell, J.M., J. Toner, and J. Mead. Muskrat house abundance within Upper St. Lawrence River tributary wetlands: evaluation of responses to water level regulation plans. Windsor, ON: International Joint Commission, 2005.

Findlay, C.S., J. Lenton, and L.G. Zheng. "Land-use correlates of anuran community richness and composition in southeastern Ontario wetlands." Ecoscience, 2001: 8:336–343.

Great Lakes Environmental Indicators (GLEI) Collaborative. 2006. http://glei.nrri.umn.edu/default/ (accessed August, 2006).

Johannsson O.E., L.G. Rudstam, G. Gal, and E.L. Mills. "Mysis relicta in Lake Ontario: population dynamics, trophic linkages." In The state of Lake Ontario: past, present, and future, by Munawar M. (ed), 257–288. Burlington, ON: Ecovision World Monograph Series, Aquatic Ecosystem Health and Management Society, 2003.

Jude, D.J. and J. Pappas. "Fish utilization of Great Lakes coastal wetlands." Journal of Great Lakes Research, 1992: 18(4):651-672.

Klindt, R.M. and R. Adams. Lake sturgeon spawning activity in the lower Black River: Section 21 In 2005 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. Albany, NY: New York State Department of Environmental Conservation, 2006.

Lake Ontario Biodiversity Conservation Strategy, Workshop 1. Kingston, ON, June 21-22, 2006.

Lake Ontario Biodiversity Strategy Conservation Strategy Working Group. The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario. April 2009. Prepared in cooperation with the U.S. – Canada Lake Ontario Lakewide Management Plan. http://www.epa.gov/greatlakes/lakeont/reports/lo_biodiversity.pdf

Lake Ontario Lakewide Management Plan. Lake Ontario Lakewide Management Plan. December 4, 2007. http://binational.net/lakeontario_pub_e.html (accessed November 7, 2008).

LaMP. Lake Ontario Lakewide Management Plan 2004. April 22, 2004. http://www.epa.gov/greatlakes/lakeont/2004update/index.html (accessed November 7, 2008).

Lougheed, V.L. and Chow-Fraser, P. 2002. Development and use of a zooplankton index to monitor wetland quality in Canadian marshes of the Great Lakes basin. Ecological Applications 12 (2): 474-486.

Lougheed, V.L. and P. Chow-Fraser. 1998. Factors that regulate the community structure of a turbid, hypereutrophic Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55: 150-161.

Lozano, S.J., J.V. Scharold and T.F. Nalepa. "Recent declines in benthic macroinvertebrate densities in Lake Ontario." Canadian Journal of Fisheries and Aquatic Sciences, 2001: 58(3): 518–529.

McNair, S.A. and Chow-Fraser, P. 2003. Change in biomass of benthic and planktonic algae along a disturbance gradient for 24 Great Lakes coastal wetlands. Canadian Journal of Fisheries and Aquatic Sciences, 60: 676-689.

Meixler, M. S., K. A. Arend and M. B. Bain. 2005. Fish community support in wetlands within protected embayments of Lake Ontario. Journal of Great Lakes Research 31 (S1): 188-196.

Mills E.L., K.T. Holeck, and H. MacIsaac. (2007) Non-native Species - Aquatic: Indicator #9002 (in State of the Great Lakes 2007). EC and USEPA. pp. 353-357.

Mills, E.L, R. Dermott, M. Munawar, S. Millard, O. Johannsson, and L. Rudstam. Status of the Lake Ontario Food Web in a Changing Ecosystem: the 2003 Lake Ontario Lower Aquatic Food Web Assessment (LOLA). Chicago, IL: U.S. Environmental Protection Agency, 2003a.

Mills, E.L., J.M. Casselman, R.M. Dermott, J.D. Fitzsimons, G. Gal, K.T. Holeck, J.A. Hoyle, O.E. Johannsson, B.F. Lantry, J.C. Makarewicz, E.S. Millard, I.F. Munawar, M. Munawar, R. O'Gorman, R.W. Owens, L.G. Rudstam, T. Schaner, and T. Stewart. "Lake Ontario: food web dynamics in a changing ecosystem (1970–2000)." Canadian Journal of Fisheries and Aquatic Sciences, 2003b: 60: 471-490.

Morrison, B.J., and S.R. LaPan (eds). The state of Lake Ontario in 2003. Special Publication 07-01, Ann Arbor, MI: Great Lakes Fishery Commission, 2007.

New York Department of Environmental Conservation: A 25-Year Plan for the Great Lakes, June 1992 New York Ocean and Great Lakes Ecosystem Conservation Council, Report to New York State Governor and Legislature, April 2009 www.nyoglecc.org

New York State Department of Environmental Conservation 2007 Annual Report of the New York State Department of Environmental Conservation's Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee: Executive Summary.

Ouyang, D, J. Bartholic, and J. Selegean. "Assessing Sediment Loading from Agricultural Croplands in the Great Lakes Basin." The Journal of American Science, 2001: 1(2)14-21.

Owens, R.W., R. O'Gorman, T.H. Eckert, and B.F. Lantry. "The offshore fish community in southern Lake Ontario, 1972-1998." In The state of Lake Ontario: past, present, and future, by M. Munawar (ed), 407-442. Burlington, ON: Ecovision World Monograph Series, Aquatic Ecosystem Health and Management Society, 2003.

Quinte Conservation. Climate Change Adaptation Options for Coastal Zone Management in the Great Lakes Basin: Minutes of Workshop, 2004.

Reid, R. Status and Trends in Fish and Wildlife Habitat on the Canadian Side of Lake Ontario. Downsview, ON: Environment Canada, 2001.

Reschke, C., R. Reid, J. Jones, T. Feeney, and H. Potter. Conserving Great Lakes Alvar: Final Technical Report of the International Alvar Conservation Initiative. Chicago, IL: The Nature Conservancy, 1999.

Ritters, K.H., and J.D Wickham. "How far to the nearest road?" Frontiers in Ecology and Environment, 2003: 1(3): 125-129.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. "Habitat area requirements of breeding forest birds of the Middle Atlantic States." Wildlife Monographs, 1989: 103:1-34.

Rubbo, M.J. and J.M. Kiesecker. "Amphibian breeding distribution in an urbanized landscape." Conservation Biology, 2005: 19:504–511.

Stanfield, L. and B. Kilgour. "Effects of percent impervious cover on fish and benthos assemblages and instream habitats in Lake Ontario tributaries." American Fisheries Society Symposium. Bethesda, MD, 2006. 48: 577-599.

Tate, D.P. Assessment of the Biological Integrity of Forest Bird Communities: A Draft Methodology and Field Test in the Severn Sound Area of Concern. Severn Sound RAP Technical Report, Downsview, ON: Canadian Wildlife Service, 1998.

The Nature Conservancy. Conservation Action Planning. November 3, 2006. http://conserveonline.org/workspaces/cbdgateway/cap/index_html (accessed November 7, 2008).

Toner, J. 2006. Muskrat house abundance and cattail use in upper St. Lawrence River tributary wetlands: modeling the effects of water level regulation. M.S. thesis. SUNY College of Environmental Science and Forestry. Syracuse, NY.

Toronto and Region Conservation Authority and Ontario Ministry of Natural Resources. Humber River Fisheries Management Plan. 2005.

U.S. Army Corps of Engineers. Great Lakes Water Levels. July 2005. http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/ (accessed September 2006).

Walsh, M.G., D.E. Dittman and R. O'Gorman. "Occurrence and food habits of the round goby in the profundal zone of Southwestern Lake Ontario." Journal of Great Lakes Research, 2007: 33, 83-92

Watkins, J.M., R. Dermott, S.J. Lozano, E.L. Mills, L.G. Rudstam, and J.V. Scharold. "Evidence for remote effects of dreissenid mussels on the amphipod Diporeia: analysis of Lake Ontario benthic surveys, 1972-2003." Journal of Great Lakes Research, 2007: 642-657.

Wolter, P. Land Cover - Land Conversion: Indicator #7002. State of the Lake Ecosystem Conference 2006, 2007.

Appendix A Lake Ontario Biodiversity Maps

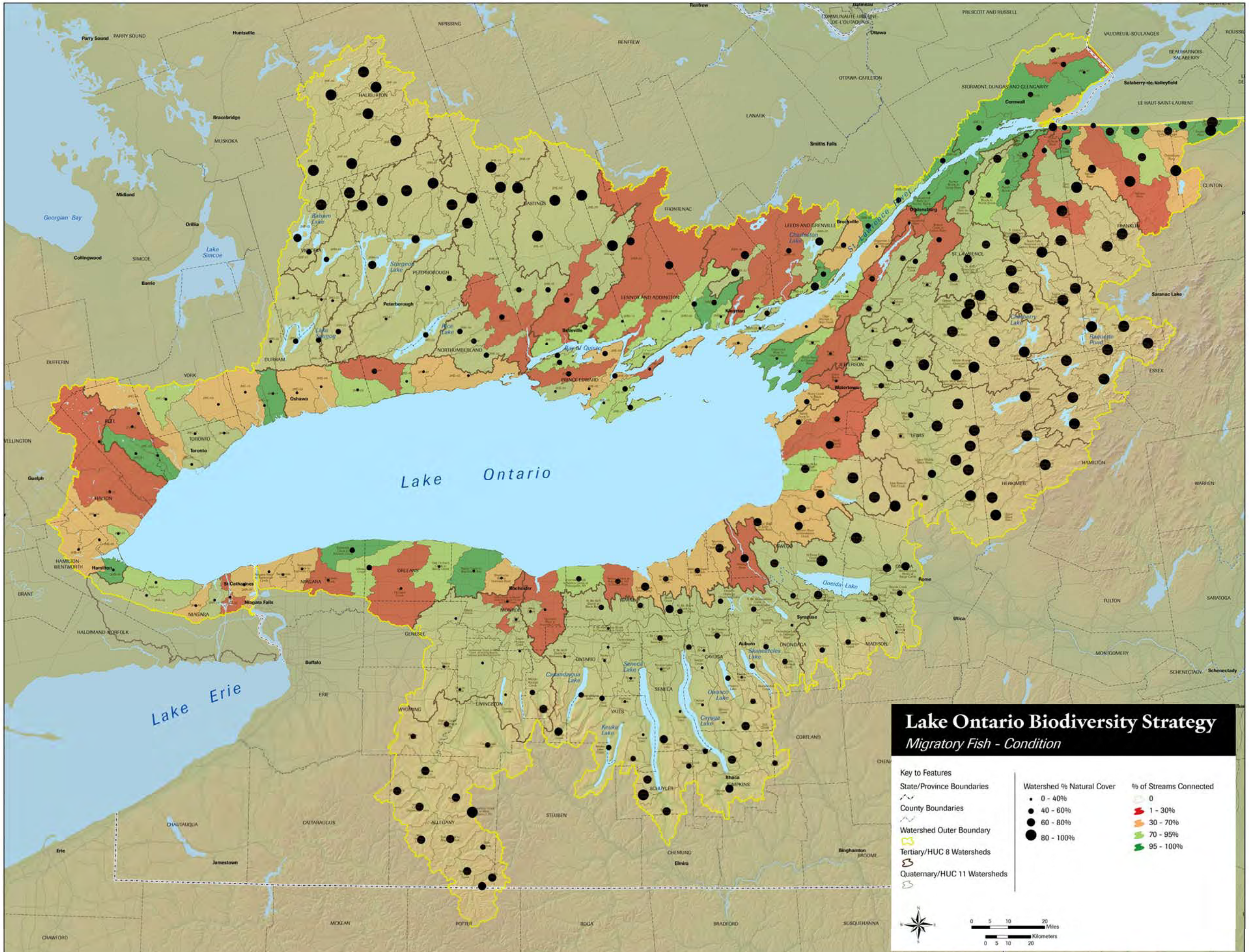
Migratory Fish – Condition

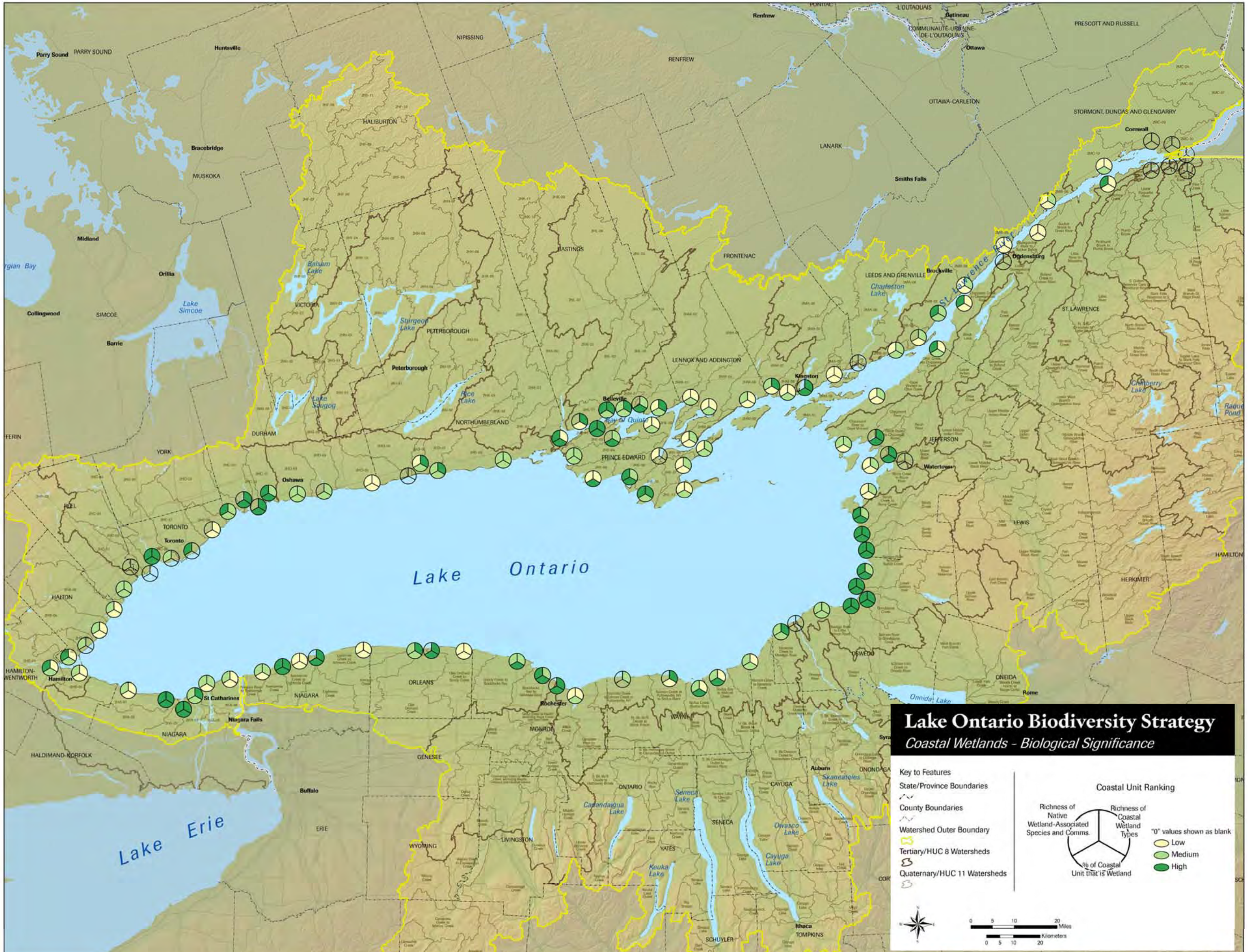
Coastal Wetlands – Biological Significance

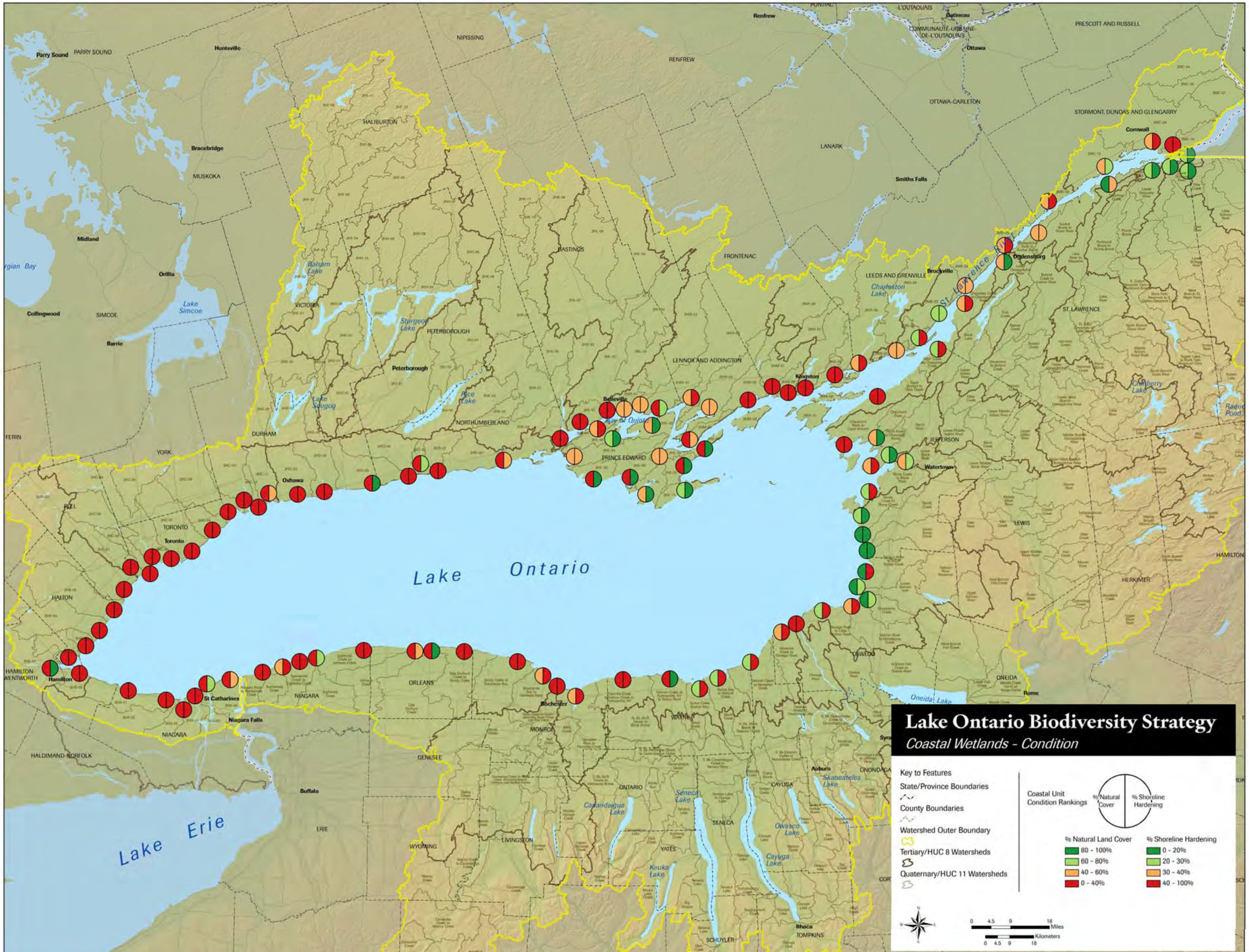
Coastal Wetlands – Condition

Nearshore Zone – Condition

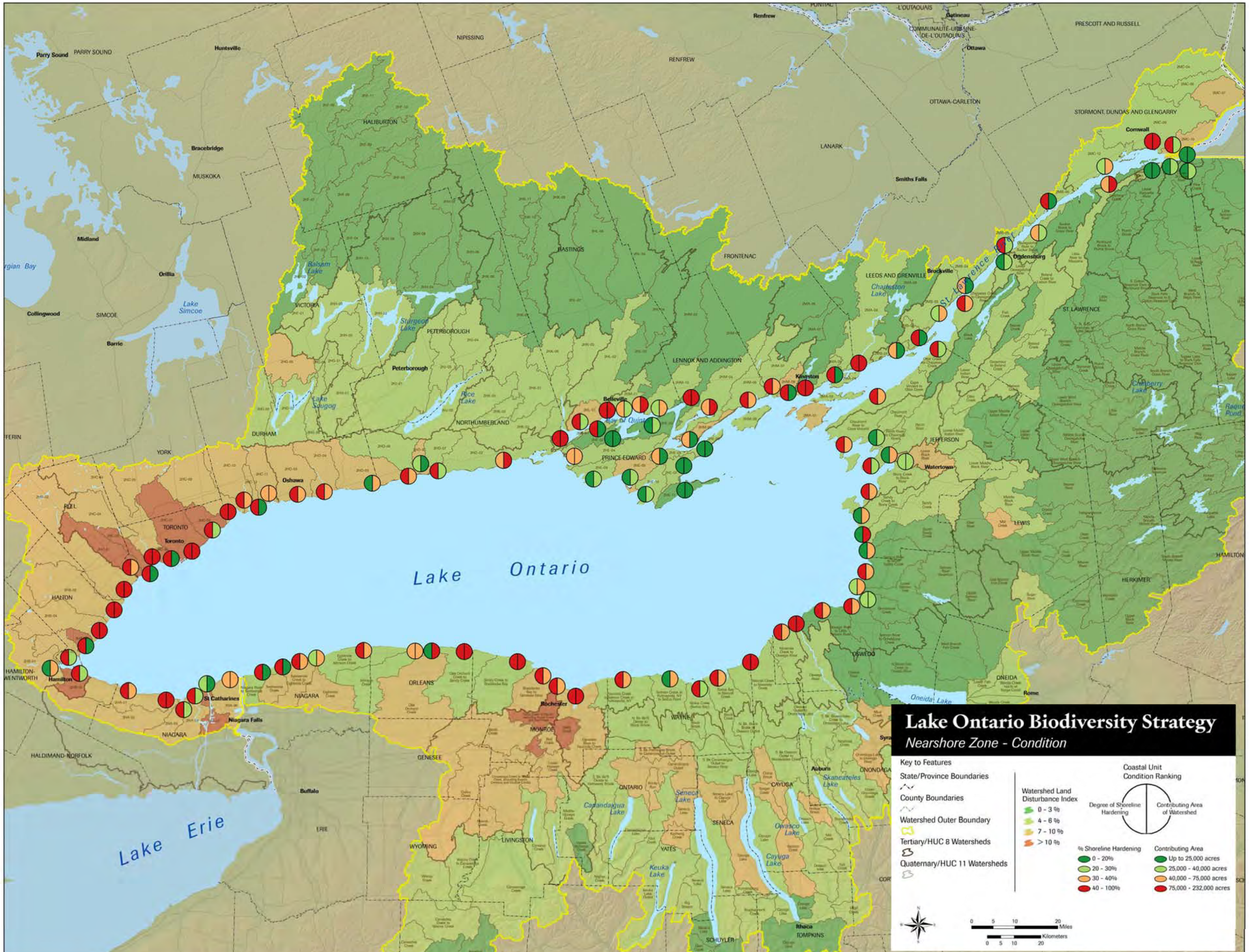
Lake-to-Tributary Connectivity

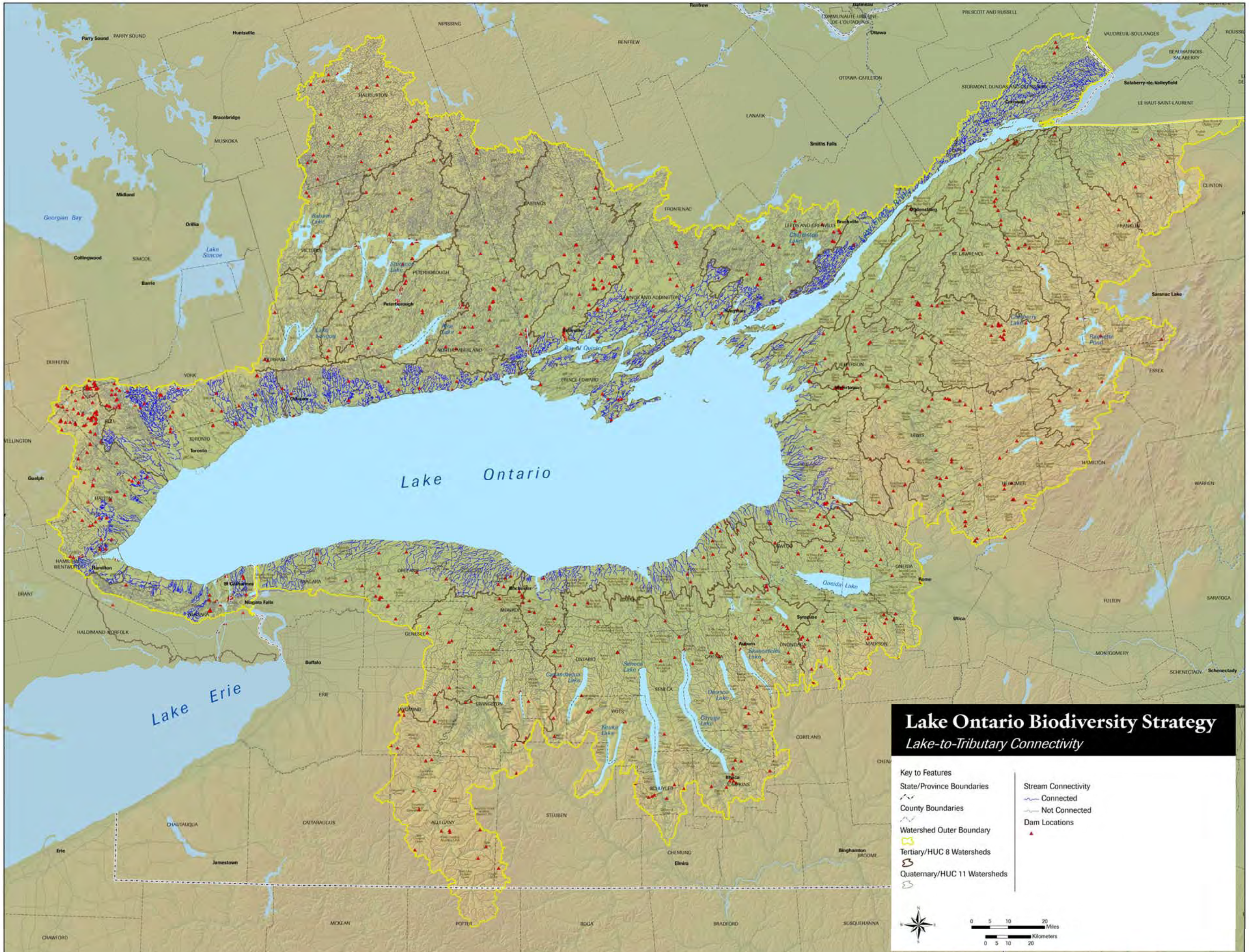

Lake Ontario Biodiversity Strategy
Migratory Fish - Condition
Key to Features
State/Province Boundaries
County Boundaries
Watershed Outer Boundary
Tertiary/HUC 8 Watersheds
Quaternary/HUC 11 Watersheds
Watershed % Natural Cover
0 - 40%
40 - 60%
60 - 80%
80 - 100%
% of Streams Connected
0
1 - 30%
30 - 70%
70 - 95%
95 - 100%
Miles
Kilometers
Lake Ontario
Lake Erie
Georgian Bay
Lake Simcoe
Oneida Lake
Toronto
Hamilton
Kingston
Rochester
Syracuse
Buffalo
Ottawa


Lake Ontario Biodiversity Strategy
Coastal Wetlands - Biological Significance
Key to Features
State/Province Boundaries
County Boundaries
Watershed Outer Boundary
Tertiary/HUC 8 Watersheds
Quaternary/HUC 11 Watersheds
Coastal Unit Ranking
Richness of Native Wetland-Associated Species and Comms.
Richness of Coastal Wetland Types
% of Coastal Unit that is Wetland
"0" values shown as blank
Low
Medium
High
Miles
Kilometers
Lake Ontario
Lake Erie



Lake Ontario Biodiversity Strategy
Coastal Wetlands - Condition
Key to Features
State/Province Boundaries
County Boundaries
Watershed Outer Boundary
Tertiary/HUC 8 Watersheds
Quaternary/HUC 11 Watersheds
Coastal Unit Condition Rankings
% Natural Cover
% Shoreline Hardening
% Natural Land Cover
80 - 100%
60 - 80%
40 - 60%
0 - 40%
% Shoreline Hardening
0 - 20%
20 - 30%
30 - 40%
40 - 100%
0 4.5 9 18 Miles
0 4.5 9 18 Kilometers
Lake Ontario
Lake Erie
Lake Simcoe
St. Lawrence River
Oneida Lake
Toronto
Hamilton
Oshawa
Belleville
Kingston
Brockville
Ogdensburg
Cornwall
Watertown
Oswego
Rochester
St Catharines
Niagara Falls
Buffalo
Peterborough
Barrie
Orillia
Ottawa
Smiths Falls


Lake Ontario Biodiversity Strategy
Nearshore Zone - Condition
Key to Features
State/Province Boundaries
County Boundaries
Watershed Outer Boundary
Tertiary/HUC 8 Watersheds
Quaternary/HUC 11 Watersheds
Watershed Land Disturbance Index
0 - 3 %
4 - 6 %
7 - 10 %
> 10 %
Coastal Unit Condition Ranking
Degree of Shoreline Hardening
Contributing Area of Watershed
% Shoreline Hardening
0 - 20%
20 - 30%
30 - 40%
40 - 100%
Contributing Area
Up to 25,000 acres
25,000 - 40,000 acres
40,000 - 75,000 acres
75,000 - 232,000 acres
0 5 10 20 Miles
Kilometers 0 5 10 20
Lake Ontario
Lake Erie
Toronto
Hamilton
St Catharines
Niagara Falls
Rochester
Oswego
Kingston
Belleville
Oshawa
Watertown
Ogdensburg
Brockville
Cornwall
Buffalo
Peterborough
Oneida Lake
Lake Simcoe


Lake Ontario
Lake Erie
Lake Ontario Biodiversity Strategy
Lake-to-Tributary Connectivity
Key to Features
State/Province Boundaries
County Boundaries
Watershed Outer Boundary
Tertiary/HUC 8 Watersheds
Quaternary/HUC 11 Watersheds
Stream Connectivity
Connected
Not Connected
Dam Locations
0 5 10 20 Miles
0 5 10 20 Kilometers