State of the Lakes Ecosystem Conference 1996

Background Paper

THE LAND BY THE LAKES
Nearshore Terrestrial Ecosystems

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Notice To Readers

This Background Paper is one of a series of such papers that were prepared to provide a concise overview of the status of the nearshore conditions in the Great Lakes. The information they present has been selected as representative of the much greater volume of data. They therefore do not present all research or monitoring information available. The Papers were prepared with input from many individuals representing diverse sectors of society.

The Papers provided the basis for discussions at SOLEC 96. Participants were encouraged to provide specific information and references for use in preparing the final post-conference versions of the Papers. Together with the information provided by SOLEC discussants, the Papers have been incorporated into the 1997 State of the Great Lakes report, which provides key information required by managers to make better environmental decisions.

The Land by the Lakes:
Nearshore Terrestrial Ecosystems

1. Overview of the Land by the Lakes

1.1 Introduction

Over the past three decades, the citizens and governmental institutions of Canada and the United States have devoted their attention and resources to the restoration of the water quality and fisheries of the Great Lakes. The gradual shift to a holistic "ecosystem approach" highlights the growing recognition that shoreline areas—the land by the lakes—are integral parts of the Great Lakes system.

For purposes of this report for the State of the Lakes Ecosystem Conference (SOLEC) 1996, the extent of the land by the lakes, more technically known as the "nearshore terrestrial ecosystems" along the Great Lakes shoreline, is defined by the lakes themselves. The physical structure and living communities of the land along the lake's edge are as much a function of the lake's ecosystem as the fish in its depths. The actions of wave and wind shape the beaches, dunes, and shore bluffs. These land-forms and the local climatic effects of large water bodies determine the biological communities. These communities, in turn, sustain the amazing diversity of wildlife that enriches the Great Lakes basin. From narrow beaches weathered by wind and waves to inland contiguous forests or dune fields, nearshore terrestrial ecosystems are products of the lakes.

This report describes the land by the lakes and presents a snapshot of its quality. It focuses on the processes that shape the shore and on the unique ecological communities these processes create. It identifies the major human activities that are stressing these communities and the activities currently protecting and restoring them to health. It highlights both successes and areas needing further attention.

The report is not a rendering of every metre of shoreline; nor does it describe or evaluate stretches already altered by humans. (That subject is covered by the paper "Impacts of Changing Land Use" [Thorp and Rivers 1997]. Note that shoreline wetlands is the topic of a separate paper, "Coastal Wetlands" [Maynard and Wilcox 1997].) Our intention is to present a large amount of technical information about special lakeshore ecosystems, yet do so in an understandable language and format.

The objectives of this report are the following:

- To inform those living in the Great Lakes basin of important, special lakeshore ecological resources.
- To report on the current condition of these ecological resources.
- To encourage stewardship to protect them well in the future.

1.2 Report Structure

Section 2.0 of this report provides the ecoregional context of the land by the lakes. Section 3.0 introduces the nearshore environment, including the physical processes that shape it and how it relates to other Great Lakes systems. Section 4.0 describes 12 special ecological communities (sand beaches, sand dunes, bedrock and cobble beaches, unconsolidated shore bluffs, coastal gneissic rocklands, limestone cliffs and talus slopes, lakeplain prairies, sand barrens, arctic disjunct communities, Atlantic coastal plain disjunct communities, shoreline alvars, and islands) and the interactions of wildlife populations in those communities. Section 5.0 outlines the major stressors and sources of stress to special ecological communities. Section 6.0 provides background information on actions that people are taking to counter the stressors. Stressors and actions to counter them are not discussed in detail because the SOLEC 96 paper by Thorp and Rivers deals with both aquatic and terrestrial nearshore land-use issues more fully.

Section 7.0 identifies three tiers of indicators of ecosystem health, derived from the information in the previous sections. A letter grade from "A" through "F" indicates the quality of the shorelines of the 17 ecoregions and 12 special ecological communities, whereas a scale from "good" to "poor" characterizes four elements in the third tier. The ratings are subject to change on the basis of new information.

The report is supplemented by the Appendix in section 8.0, Characteristics of Lakeplain Ecoregions, which gives detailed descriptions of the physical features and biodiversity elements along the shoreline. Section 9.0 contains a glossary of terms used in this report, and section 10.0 the references used.

1.3 Conclusion

Our review of the factors contributing to shoreline physical structure and the diversity of living communities leads to the following conclusion: *The health of the land by the lakes, nearshore terrestrial ecosystems, is degrading throughout the Great Lakes*. In reaching this conclusion, we viewed the nearshore terrestrial environment from three perspectives: the ecoregions within the Great Lakes basin, the special ecological communities along the lakeshore, and the status of individual lakes.

The extent to which special ecological communities are represented and protected within the 17 ecoregions, and the rate of land-use change affecting these communities, determine the ecoregion ratings listed in section 7.1. At least half of the ecoregions are suffering moderate degradation. Strategies for managing these ecoregions should include protection of representative areas for the full range of nearshore biodiversity within parks or protected areas or through voluntary programs. Only a few of the ecoregions are fully represented now; over half have seriously inadequate representation, with a trend of moderate to severe degradation of shoreline health.

The quality of 12 special lakeshore ecological communities is rated on the basis of the percentage of the community remaining healthy, major stresses and sources of stress, processes and functions impaired by the stressors, species and communities endangered or threatened, and stewardship activities in place. Although most of these community types are undergoing some conservation activities, five of the communities are considered to be moderately or severely degrading. Shoreline alvars and lakeplain prairie communities are most at risk. The indicators of ecosystem health for special ecological communities are listed in section 7.2.

Each lake is also assessed according to four indicators: loss of communities/species, interruption of shoreline processes by lake-edge armouring, representation of biodiversity in lakeshore parks and protected areas, and gains in habitat protection in selected "biodiversity investment" areas. With several exceptions, four of the lakes are rated in the mixed/deteriorating or the poor category. Lake Superior receives a good rating in almost all categories. The indicators of overall ecosystem health for the land by the lakes are listed in section 7.3.

Given the findings that existing protection and restoration programs are inadequate to meet the continuing stresses to habitat and physical processes, a conservation strategy for Great Lakes coastal areas is urgently needed. This strategy should seek to involve all levels of governments and other stakeholders, reflect commitments to biodiversity conservation and sustainable development, and secure broad support from Great Lakes citizens. It should place special emphasis on protecting large core areas of shoreline habitat within the 20 Biodiversity Investment Areas identified on the figure in section 6.3.1.

1.4 Key Observations

The sum of information presented by this report leads us to several broad observations concerning the planning for the protection of nearshore areas.

1. Shoreline protection issues raise two distinct questions: (1) How do we protect the highest quality places, unique and rare in plant and animal life and physical characteristics, from alteration or destruction? (2) To what extent do we restore less healthy shoreline stretches to improve the quality of habitat for all who live there? To answer, we need to take a hard look at land-use policies and community vision statements at basinwide, lakewide, and local levels.

   This is not easy. Information about special ecological communities is largely not available to the public in a usable form. To complicate matters, information is often inconsistent and incomplete. For example, inventories of important ecological resources are incomplete for many parts of the basin. Where knowledge is available and understandable, seldom has a public process of developing a vision for the shoreline taken place. And seldom is there discussion about why special ecological communities need to be protected even where they are known.

   Stakeholders need to understand that information about special ecological communities is important and needed for proper decision making. This information must be easily obtainable.

2. From an ecological point of view, the Great Lakes shoreline is a particularly diverse and valuable habitat. Mapping of globally significant biodiversity elements carried out by The Nature Conservancy shows that 26 percent of the species and natural communities that are restricted to or have their best distribution in the Great Lakes basin occur along the coast; another 22 percent

occur on the adjacent lakeplain. On an acre-for-acre basis, shoreline sites are on average much richer in biodiversity than inland sites.

3. Any natural resource recovery strategy seeking to protect the highest quality places needs to address not just loss of shoreline habitats, but also their fragmentation. To sustain the full range of shoreline biodiversity, we need to protect and re-create large complexes of interconnected natural shoreline, particularly in the “Biodiversity Investment Areas” shown on the figure in section 6.3.1.

4. Ecological communities cannot be protected without preserving the processes that sustain them. In other words, we must not only save all the parts—the plants and animals indigenous to a community—but also preserve the physical processes that allow those plants and animals to function. This is especially vital in coastal areas, where the wind and wave sediment-transport processes are essential to sustaining special habitats.

5. The land by the lakes has been a favoured location for human use for thousands of years, but the intensity of that use has increased greatly over the last two centuries. Much of the habitat destruction and other impacts to the ecosystem associated with human use took place during the removal of original forests for European settlements, farmlands, and logging or industrial operations. In recent years, some sections of the shoreline have partially recovered their ecological health, while others have been impacted by expanding urban centres or other intensive uses. Human use of the Great Lakes shoreline is almost certainly going to continue to intensify in the future, and conservation strategies must address these modified shorelines as well as those in a more natural state.

6. Shoreline processes are distinctive and dynamic. Many work on a time line of seasons as well as centuries. Change is a fundamental characteristic of shoreline ecosystems. By trying to prevent natural changes (e.g., by armouring shorelines to prevent erosion or by seeking to stabilize fluctuating water levels), humans destroy the special processes and habitats that make shorelines distinctive and diverse. In addition to recognizing that human uses impact the shoreline, we need to acknowledge that natural changes also occur, and include them in our planning processes.

7. We can not view acquisition of land by public agencies as the sole tool for protecting high quality natural areas. A combination of appropriate planning and stewardship tools is less onerous and often effective in tackling unique shoreline situations.

8. Stewardship of nearshore terrestrial ecosystems invites participation by all citizens. If we all work to understand how we influence ecological systems, we are more likely to preserve healthy natural communities. Everyone has the opportunity to understand and act for the benefit of all life.

9. Insufficient knowledge and information is hampering conservation efforts in several areas. Further research and analysis are needed to

   a. identify the effects of human-induced water-level changes on the functioning of shoreline natural ecosystems;

b. increase understanding of the long-term effects of artificially high levels of beach/dune erosion or nourishment on the biodiversity in adjacent natural ecosystems;
c. establish the effects of the stressors identified in this report on the 12 special lakeshore community types, and their responses to those stressors, both individually and synergistically;
d. assess the representation of coastal biodiversity within ecoregions and ecodistricts, to help identify candidate areas for protection or restoration; and,
e. establish a consensus among the scientific community on ecoregional classification methodology that includes human social and economic needs in its development and a connection to water quality.

1.5 Moving Forward

Participants at SOLEC 96 endorsed the following next steps at discussions of the Land by the Lakes paper.

1. Overwhelmingly, SOLEC 96 conference participants wanted practical suggestions on what can be done to protect significant ecosystems in biodiversity investment areas. They suggested additional case studies on stewardship activities and an expansion of biodiversity investment area information.

   An addendum to this paper will be available for distribution at SOLEC 98. Each biodiversity investment area will be described in terms of significant ecosystems, stressors affecting the ecosystems as well as the ecosystem services provided, and brief case studies of the protection and restoration activities underway.

2. An analysis of the current status of the 12 significant ecosystems, key threats, management measures, and targets was recommended as a future action step by SOLEC 96 conference participants.

   The Nature Conservancy's Great Lakes Office is compiling known threats to the current status of sand dunes, alvars, lakeplain prairies, bedrock shores, and sand barrens communities. Results of the analysis will be available for SOLEC 98. The balance of the significant ecosystems still need to be analyzed.

3. The information in this paper, the biodiversity investment area description, and the analysis of the significant ecosystems needs to be integrated into Lakewide Management Planning (LaMP) and Remedial Action Plan (RAP) processes as well as other Great Lakes programs and structures.

   This final paper, the biodiversity investment area description, and the analysis of the significant ecosystems will be mailed to all LaMP and RAP coordinators. All information will be on Internet through the Great Lakes Information Network/Great Lakes National Program Office Home Page. Integration is up to each organization and agency, however, it is hoped the information compels changes in policies and strategies.

4. SOLEC 96 conference participants suggested the development of a communication or "sales" strategy for this paper, based on an analysis of the ecosystems to be protected and the consequences of no action, to help persuade communities to buy in to protection of significant ecosystems.

In addition to Internet posting and a mailing to all LaMP and RAP coordinators, this paper, the biodiversity investment area description, and the analysis of the significant ecosystems will be available for distribution through the Council of Great Lakes Mayors and the Council of Great Lakes Industries in the United States, and the Association of Municipalities of Ontario in Canada. These organizations are able to reach a broad audience of decision makers.

2. The Ecoregional Context

The Great Lakes basin landscape varies tremendously in its geology, landforms, climate, vegetation, wildlife, and land uses. Thus, classification of the landscape by region is appropriate. Ecoregions are large landscape areas defined by climate, physical characteristics of the landscape, and the plants and animals that are able to live there. Ecoregions contain many different physical settings and biological communities, which occur in predictable patterns.

2.1 Why Consider Ecoregional Context?

Landscape characteristics strongly influence the immediate nearshore area. The physical character of the lakeshore and physical processes such as shoreline erosion are largely determined by the make-up of the rocks and overburden of the adjacent landscape. Sediments and other materials carried into the nearshore area from tributary streams are a factor of the landscape character and land uses within their watersheds. The suitability of the regional landscape for human uses can also greatly affect the nature and degree of stresses along the Great Lakes coast. Where agriculture and industry are intense, for example, the demand for human use of the lakeshore is greater than in the low-population forested areas further north.

The nature of the regional landscape is of interest for other reasons as well. The lakeplain area of the Great Lakes, once the bed of ancestral, larger versions of today's lakes, contributes strongly to biodiversity within the Great Lakes basin (see Figure 1). The Nature Conservancy estimates that these lakeplains contain 22 of the globally significant biodiversity elements that are restricted to or have their best examples within the Great Lakes basin—a much higher proportion than in inland areas (The Nature Conservancy Great Lakes Program 1994). Many of these significant features, such as lakeplain prairies and savannahs or raised dune systems, are strongly linked to landforms created by the Great Lakes at some point in the fairly recent past (i.e., since the last glaciation).

In assessing the adequacy of protection for natural areas along the current Great Lakes coast, we must consider how the lakeshore area fits within the context of broader regional landscapes. In Ontario, as in all Canadian jurisdictions, the federal and provincial governments are committed to completing a system of protected areas representative of both land-based and marine natural regions (Hummel 1995). This approach, spearheaded by World Wildlife Fund Canada's Endangered Spaces Campaign, recognizes that biological diversity is an expression of landscape diversity, and sets out a process to identify "enduring features" based on landform characteristics (Iacobelli et al. 1994). Representation of these enduring features is used as a central criterion to evaluate natural areas for protection (Noss 1995).

As part of a gap-analysis methodology to assess the adequacy of representation, this approach lays out a landscape matrix for each ecoregion, showing different shoreline types such as cobble-boulder shoreline or sand beach (Iacobelli et al. 1994). Thus, it is important to examine how Great Lakes nearshore landscape features contribute to representation within the broader landscape, as well as how specific features are protected at a finer scale.

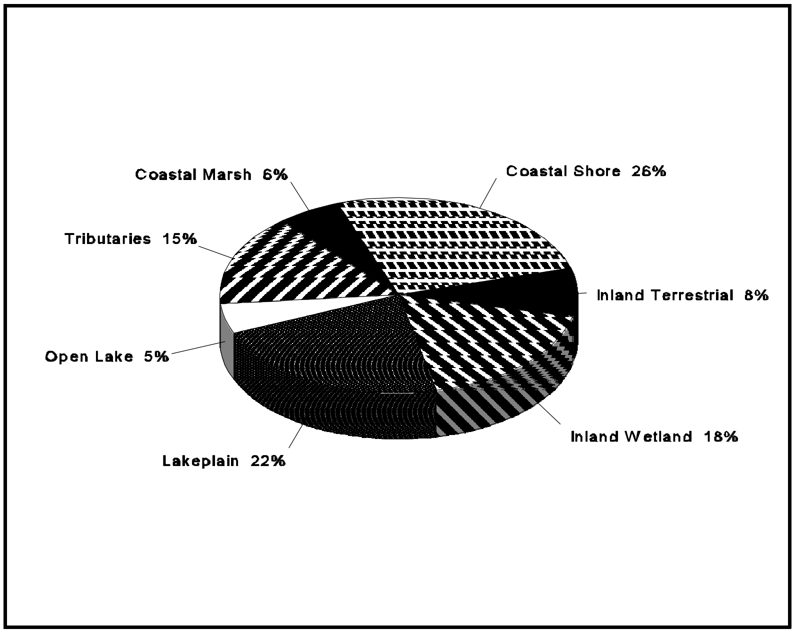

Figure 1. Significant Biodiversity Features Strongly Associated with Great Lakes Systems
Source: The Nature Conservancy Great Lakes Program 1994

2.2 Classification Systems for Great Lakes Ecoregions

To understand the ecological complexity within natural landscapes, Canadian and U.S. agencies have developed classification systems, resulting in a hierarchy of landscape units. Unfortunately, due to differences in methodologies or emphasis during application of these systems, the mapping of units differs significantly. To provide a coherent overview of landscapes related to the Great Lakes shoreline, this report uses descriptions based on the most recent systems, which attempt to bring together all earlier versions. The major land classification systems that are in broad use in the Great Lakes basin are also described.

Within Ontario, most of the land classification done to date is based directly or indirectly on a system developed by Angus Hills. This system was based on an analysis of climate and landform patterns, and divides the province into six site regions, 65 site districts, and correspondingly more detailed strata of landscape units, land types, site types, and site phases (Hills 1961). This system provides the basis for many aspects of forest management and provincial park planning in Ontario (Perera et al. 1995). For example, protection targets for parks are based on representation within Hills' site regions and site districts (Beechey 1980). Hills' mapping has been subject to numerous modifications over the years, most recently in 1993 (Burger 1993).

A second important system of land classification was done by the Canadian Committee on Ecological Land Classification (Wiken 1979) and applied to Ontario through mapping of ecoregions and ecodistricts (Wickware and Rubec 1989). This system has a similar hierarchy to Hills' but uses different terminology to describe ecosections, ecosites, and ecoelements. Although the mapping of site regions and ecoregions has the same broad pattern, many differences exist in the details, such as the placing of Manitoulin Island or the north Superior shore.

More recent work is under way to develop a strategic framework to "ecoregionalize" Ontario on the basis of an analysis of net primary productivity (Perera et al. 1995). At the federal level, two agencies have collaborated on an Ecological Stratification Project to review and integrate concepts based on biophysical land classifications, forest classifications, ecological classifications, and soils information (Ecological Stratification Working Group 1996). The resulting mapping of ecoregions and ecodistricts is intended to become the Canadian standard for years to come and will form the framework for state-of-the-environment reporting in future.

In the United States a number of classifications have been used to identify ecological regions. Beginning with Bailey's (1976) furtherance of the work of Crowley (1967), largely based on climate at the coarser hierarchical levels, the U.S. Department of Agriculture Forest Service has developed a map depicting a new revised hierarchical classification of ecoregions of the United States. In this classification system, Bailey's boundaries have been slightly modified (Albert 1995). The U.S. Environmental Protection Agency (USEPA) has also developed an ecoregional classification scheme, generally based on the spatial coincidence of all geographic phenomena that affect or reflect differences in the health/integrity/quality of ecosystems and ecosystem components (Omernik 1987, 1995). Rather than ecoregions being based primarily on a single characteristic at a particular hierarchical level, as is the case with Bailey's approach, the USEPA approach hypothesizes that the relative importance and number of factors useful for depicting ecoregions varies from one area to another, regardless of the scale or hierarchical level. To date the only Great Lakes states that detailed ecoregion mapping (at a scale comparable to the recent Forest Service maps) has been developed for using this approach are Indiana and Ohio. Work is presently underway for Wisconsin.

A federal interagency effort is currently underway to develop a common classification of ecological regions. This work is supported by a memorandum of understanding that was signed in 1996 by all of the U.S. resource management agencies (including the U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, U.S. Environmental Protection Agency, U.S. Geological Service, Bureau of Land Management, and Natural Resources Conservation Service). At the international level work has recently been completed to compile a map of ecological regions of North America (Commission for Environmental Cooperation 1997). This project has incorporated the work of Wiken in Canada as well as Omernik in the United States.

The Upper Midwest and Northeast GAP Analysis Projects are federal and state partnerships that use Landsat Thematic Mapper satellite imagery and other sources of information to determine the portion of biological diversity lying inside protected areas. The Michigan, Minnesota, and Wisconsin portions of the

Superior, Michigan, Huron, and Erie Lakes basins are the first in the region for which an Arc/Info land-cover map using a single land-cover classification scheme will be created (Great Lakes National Program Office 1996).

The Upper Great Lakes Biodiversity Committee requested a classification system for the ecosystems of Michigan, Minnesota, and Wisconsin. The committee is composed of individuals from federal, state, tribal, industry, colleges and universities, and conservation organizations. Its purpose is to maintain and restore biodiversity on a regional scale. Michigan Natural Features Inventory staff undertook the classification project. The outcome was the *Regional Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification*, published in 1994. Its aim is to "Distinguish appropriately sized ecosystems—useful and functional land units that differ significantly from one another in abiotic characteristics as well as in their related biotic components." The classification is hierarchical, presenting the landscape as "a series of ecosystems, large and small, nested within one another in a hierarchy of spatial sizes" (Albert 1995).

The Appendix (section 8) of this report, "Characteristics of Lakeplain Ecoregions," briefly describes the Great Lakes shoreline and the adjacent lakeplain. In most cases, the ecoregion boundaries extend well beyond the former glacial lakes shorelines. Canadian ecoregions are presented in sections 8.1 through 8.8. The descriptions are based on the recent work of the Ecological Stratification Working Group (1996), which represents both federal and provincial interests. United States ecoregions, sections 8.9 through 8.17, are compiled from Dennis Albert's *Regional Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification* (1995), the USDA Forest Service's *Ecological Subregions of the United States: Section Descriptions* (1994), and the USDA Forest Service's *Map Unit Tables: Ecological Units of the Eastern United States* (1995).

Ecoregional classification provides an important tool for organizing information across the Great Lakes basin, and for increasing understanding of ecological patterns and connection. The scientific community in both Canada and the United States should be encouraged to continue their efforts to reach broad consensus on ecoregion classification methodologies, so that expanded use of this tool can be achieved. As well, because of the close connections between the character of regional landscapes and human activities, ongoing efforts should be made to correlate social and economic characteristics with ecoregional mapping.

3. Where Land and Water Meet

The land by the Great Lakes uniquely and dynamically intersects with life on land and in water. The effects of the lakes—waves, wind, ice, currents, temperature, and rising and falling lake levels—constantly shape the 16,000 km (10,000 miles) of shoreline. Five hundred river mouths empty into the lakes at the shore, each with differing water chemistry and biological components (Ashworth 1987). Rains, snowmelt, and winds carry soils and other materials to the water, and waves carry them along the shore, depositing them some distance away. The ever-changing shoreline, in turn, buffers inland systems and interacts with coastal marsh systems. The shoreline harbours plants and animals that have adapted to a severe microclimate with frequent harsh storms, as well as those that thrive in sheltered areas where the seasonal temperature extremes are moderated by the presence of the lakes.

3.1 Changing Shapes and Structures

Basinwide, many factors act to change the shape and structure of Great Lakes shorelines, some acting very slowly, and others at a faster rate (Tovell 1987). Over millennia, a gradual tilting of the crust underlying the lakes moves water onto new ground. Climate affects temperature and precipitation on a large scale. On an annual or seasonal scale, wave action, wind, and ice cause erosion, and water-level fluctuations contribute to erosion processes.

3.1.1 Crustal Tilting

The earth's crust underlying the Great Lakes basin continues the uplifting movement that began when the Wisconsin glacier started its retreat 18,000 years ago. The lands along the north and east shores of each lake are rising, a process called "isostatic rebound." As a result, the water levels at the western and southern shores of each lake outlet are rising at a faster rate than the levels at the eastern and northern ends of the lakes. This is particularly pronounced in Lakes Ontario and Superior. Duluth, at the far western end of the basin, is experiencing high water levels in comparison with eastern Lake Superior (Great Lakes Commission 1986). Although perceptible changes in the shoreline as a result of crustal tilting will only occur slowly, the transformation of the shoreline from its present state is inevitable.

3.1.2 Climate

Global climate change alters basinwide temperature and precipitation patterns. Advancing and retreating glaciers carved out the lakes and the lake basin. Water levels changed in response to the melting ice. The results of the glacial retreat can be seen along the varied and rugged shoreline, and in abandoned former shorelines inland from today's lakes. In the Indiana Dunes National Lakeshore at the southern end of Lake Michigan, for example, a series of dune ridges marks the progression of the lake's water level. The youngest dunes are found closest to the shore, formed between 4,000 years ago and the present (Hill et al. 1991).

In the last ice age the spruce and fir forests that are today in northern Canada followed the retreating ice at a rate of about one kilometre per year. The climate was warming at a rate of one or two degrees every 1,000 years (Schneider 1989). As the ice retreated, new plant and animal species colonized and interacted, contributing to the rich natural heritage that remains now (The Nature Conservancy 1995).

Today, warm, moist air from the Pacific Ocean and Gulf of Mexico collides with cold, dry arctic air over the Great Lakes basin. Due to their sheer size and volume, the lakes moderate the effects of both systems by acting as a heat or cold "sink." As a result, shoreline temperatures differ from the temperatures of inland areas (Brown et al. 1974). For example, summer temperatures near the shoreline at Duluth, Minnesota, can be as much as 17 degrees Celsius (30 degrees Fahrenheit) colder than inland temperatures recorded at Duluth International Airport (Collins 1996). In the fall, the difference is less pronounced, but reversed, with the relatively warmer lake waters moderating the air temperature near the lakeshore. In addition to modifying temperatures in the basin, the lakes influence weather patterns, precipitation, and wind velocity and direction (Eichenlaub 1979).

Global warming resulting from human activities poses the threat of increased temperatures and changing precipitation rates. Shorelines could change quickly, submerging or exposing ecosystems accustomed to harshness and variability but unable to cope with rapid, permanent changes. An abrupt change in climate (i.e., a change over decades) could prevent ecosystems that now survive in small, isolated areas from adapting (Botts 1996). According to one source, geomorphic responses to temperature and precipitation changes are expected to be great, though our understanding of the physical mechanisms involved is incomplete (Wendland 1996).

3.1.3 Erosion

Storms and seiches produce wave, longshore current, wind, and ice action, eroding exposed rock from bluffs or sand from beaches. Wind and the tidal effects of the sun and moon generate waves. When conditions are stormy, waves often strike the shore head-on. Usually, they strike obliquely, leaving a cuspate or non-uniform beach pattern (Hill 1993).

Longshore currents are generated by obliquely striking waves. They move at an angle to the shore carrying sediment eroded from bluffs and beaches and from the banks of streams and tributaries to distant shores (Hill 1993). But as well as eroding sand from beaches and dunes, waves and longshore currents are also constructive forces, depositing sand to form dunes, beaches, sandbars, shoals, or spits (Hill 1993).

Sand beaches may be erosional, transitory, or depositional. Erosional beaches lose more sand than is deposited by waves or wind. Transitional beaches collect and lose sand so that there is no net gain or loss. Depositional beaches receive more sand than is lost over time (Environment Canada 1994c).

Wind also erodes sand dunes and beaches. High velocity winds cause grains of sand to bounce along and collide with other sand grains by a process known as “saltation.” Eventually, a ridge of sand is formed parallel to the shore. Strong winds and human disturbance cause blowouts, or saucer-shaped gaps in dunes (Hill 1993).

Ice, too, erodes sand and rocky bluffs. At the shoreline, freezing waves churn with sand and build up, becoming ice shelves in the lake. During spring thaw, ice and sand break off and float free of the shore. Over time, water freezing and thawing in the fissures of rocky bluffs cracks off chunks of rock.

Groundwater and surface water runoff erode the nearshore. Groundwater seeps through the permeable layers of a bluff causing it to slump. Surface runoff, propelled by rain, snowmelt, and irrigation, removes soil from upland to nearshore areas (Great Lakes Basin Commission 1980).

The rate of change caused by these processes at any shoreline site is influenced by a host of factors, such as shoreline substrate, degree of exposure to wave action, natural or artificial barriers to alongshore sand movement, water-level changes, the degree of winter ice cover, shoreline armouring, natural and artificial disturbances (e.g., road building, vegetation clearing). On the rocky shorelines of the upper Great Lakes, erosion is very slow. On the unconsolidated shorelines of much of the lower lakes, the effects of wave erosion can often be seen after a single severe storm.

These dynamic physical processes produce a distinctive set of shoreline habitats along the lake edge. To some degree, the maintenance of these habitats depends directly on the continuation of the natural shoreline rhythm of constant change. For example, unconsolidated bluff habitats depend on continued lake erosion at their toe to periodically “freshen” their face; otherwise they gradually stabilize as wooded hillsides. Sand dune habitats associated with dynamic beaches rely on occasional erosion and renewal to maintain their specialized flora. Sand spits and barrier beaches that create sheltered wetland habitats depend on a steady supply of wave-carried sediments to repair storm damage. Consequently, erosion is both a natural process that nourishes or depletes natural ecosystems of sand, and a threat when natural rhythms are disrupted.

3.1.4 Lake-Level Fluctuations

Great Lakes water levels, which may rise or fall by as much as 1 to 2 metres (5 to 6 feet) over a period of years, are affected by the amount of water entering and leaving the basin (Great Lakes Commission 1986). Lake-level fluctuations contribute to erosion, sediment transport, and sand dune maintenance (The Nature Conservancy 1994). Great Lakes water levels fluctuate on average 30 to 46 centimetres (12 to 18 inches) yearly. Making additional information on climatic fluctuations available to local planners would be useful.

Three types of water-level fluctuations occur. First, water may be temporarily displaced as a result of high winds or atmospheric pressure. This short-term fluctuation is called a “seiche.”

Second, the volumes of the lakes change seasonally as a result of storm actions, runoff, evapotranspiration, or groundwater flow. Runoff, all water flowing through streams and rivers that goes into the lakes, contributes to the rising and falling of Great Lakes levels in the short-term. The marshes and lakeplains of the basin act as sponges. When they are saturated, runoff occurs in greater volume and frequency. Between 1940 and 1985, precipitation in the Great Lakes basin increased by 6 percent and runoff increased by 14 percent (Great Lakes Commission 1986).

Third, long-term water-level fluctuations are due to precipitation and temperature, and evapotranspiration changes in the watershed (Center for the Great Lakes 1985). Precipitation is the primary factor affecting long-term Great Lakes water levels. Between 1900 and 1940, low precipitation created unusually stable lake levels, spurring shoreline development. After 1940, higher precipitation showed that the water levels of the lakes vary depending on seasonal as well as long-term precipitation fluctuations (Great Lakes Commission 1986).

To a lesser extent than precipitation, the combination of temperature and evapotranspiration affects Great Lakes water levels. In general, as the temperature cools, evapotranspiration slows. An increase in precipitation along with a decrease in temperature and lower evapotranspiration results in an increase in runoff (Great Lakes Commission, 1986).

3.2 Relationship with Other Systems

The relationship of nearshore terrestrial ecosystems with other Great Lakes systems—open lake, coastal marsh, lakeplain, tributary and connecting channel, inland wetland, and inland terrestrial—is one of interdependence. Nearshore terrestrial ecosystems perform functions that help to sustain other Great Lakes systems. They buffer coastal marsh, lakeplain, and inland wetland and terrestrial systems, protecting them from severe wave and wind action generated by the lakes. Sand dunes, bars, and spits, for example, shelter coastal marsh and lagoon habitats. Sand beaches are the staging ground for transferring sand inland to create dunes. Nutrients, algae, and coarse, woody debris that collect on nearshore beaches provide food for birds, fish, amphibians, mammals, and microscopic organisms. The nearshore ecosystems provide important habitat for aquatic invertebrates with short adult life cycles, and are spawning areas for amphibians. They are critical habitats for migratory birds (The Nature Conservancy Great Lakes Program 1994).

The other systems interact with nearshore ecosystems in many ways. Sediment and nutrients from tributaries are carried by longshore currents and waves to nourish sand beaches and dunes, and coastal marshes. Lakeplains and inland wetlands act like sponges, dampening the range of lake-level fluctuations. Lakeplains and coastal marshes together provide rich habitat for birds and fish. Inland terrestrial ecosystems are the refuges from lake storms and habitat for many terrestrial species.

Together, all systems make up a complex Great Lakes ecosystem, of which nearshore terrestrial ecosystems provide a dynamic and rich component.

3.3 Classifying the Shoreline

Since Great Lakes shorelines differ so much from place to place, management agencies often use classification systems to describe the character of the coastal environment. These classification systems are based either on the physical nature of the shore or on some combination of physical habitat and characteristic vegetation communities.

3.3.1 Physical Shoreline Types

While an enormous amount of descriptive information has been compiled over the years about Great Lakes shoreline characteristics, only recently has much attention been directed to the ecological processes that sustain shoreline environments. Much of the earlier work divided the shoreline into “reaches” of fairly uniform character, and described the physical shoreline type within each reach as a basis for programs to prevent or mitigate shoreline hazards to people and property. Information on shoreline biological resources, particularly wetland habitats, was often collected independently and was seldom integrated with the physical classifications.

One example of this early work is the *Coastal Zone Atlas* prepared by Environment Canada and the Ontario Ministry of Natural Resources (1976), which provides information on recession rates, shore damage estimates, ownership, value, land use, physical characteristics, and protection works for the area from Severn Sound to the St. Lawrence.

Charles Herdendorf (1988) from Ohio State University supplied a classification system for Great Lakes nearshore and coastal areas based on their geological origins. This system categorizes shoreline features on the basis of coastal processes, limnetic (pelagic) processes, stream processes, glacial processes, solution processes, eolian (wind) processes, gravity processes, tectonic processes, mineralization processes, rock-forming processes and fossilization (Bowes 1989).

A more recent set of studies carried out under the International Joint Commission Water Levels Reference Study applies a classification system to the Great Lakes. On the Canadian side, this involved a total of 1,973 shoreline reaches, varying from 1 to 5 kilometres (0.5 to 3 miles) each, from Severn Sound on Georgian Bay to the St. Lawrence River (Geomatics International 1992b). This information, which is available in Geographic Information System (GIS) format, is arranged in a three-tiered classification system.

The Ontario Ministry of Natural Resources has developed (in draft) a somewhat different approach as technical background for the application of the province's Great Lakes Shoreline Policy (Ontario Ministry of Natural Resources 1993). This approach identifies shoreline reaches as bedrock/cohesive or dynamic beaches, and then classifies them according to controlling nearshore substrate, general shoreline type, surficial nearshore substrate, planform (configuration), and exposure (Sullivan 1996). General mapping to apply this approach has not been completed; instead, this classification will be applied during development of local shoreline management plans or to determine the acceptability of shore protection measures on specific sites.

Case Study: *The Waterfront Regeneration Trust*

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The Waterfront Regeneration Trust, an Ontario agency with responsibilities related to the north shore of Lake Ontario, has adopted an integrated approach to shoreline classification (Shoreline Management Work Group 1996). This approach draws on the work of G.L. Boyd on the Lake Huron coast, which demonstrated that the dominant factor controlling the development of coastal features is the composition of material in the surf zone (Boyd 1992). Rapid long-term bluff erosion occurs only when this surf zone is composed of fine-grained till, which allows the formation of a steep "concave profile" in the nearshore area. Where erodible bedrock such as shale or limestone forms the controlling substrate in the shoreline area, or where cobble-boulder tills provide a buildup of stony materials, a shallow-water shelf develops in the nearshore area. This shelf protects the shoreline from rapid erosion in all except high-water periods (Shoreline Management Work Group 1996).

Using this analysis of shoreline processes, the Waterfront Regeneration Trust identified nine shoreline units along the north shore of Lake Ontario, which formed the basis for recommended treatment approaches. In the Lake Ontario Greenway Strategy, which integrates shoreline management information with community, economic, and environmental considerations, these shoreline units are matched with 13 terrestrial landscape units (Waterfront Regeneration Trust 1995a). Information on significant natural habitats, degree of forest cover, patterns of change, and regeneration goals is provided for each landscape unit (Waterfront Regeneration Trust 1995b). The resulting integration of aquatic, shoreline process, and terrestrial features facilitates improved decision-making on shoreline issues.

The recently published environmental sensitivity atlases for each of the Great Lakes and connecting channels contain very detailed information on shoreline characteristics and features (Environment Canada 1993a,b, and 1994a,b,c,d,e; Research Planning Inc. 1985a,b,c,d, and 1993). While this atlas series, produced by Environment Canada and the United States National Oceanic and Atmospheric Administration (NOAA), was designed primarily to assist in responses to oil spills, much of the shoreline information is also of interest to resource managers. Each atlas provides a description of shoreline types, associated biological resources and human-use resources, as well as information related to spill countermeasures. The information is maintained in digital form for ease of updating.

3.3.2 Classification of Vegetation Communities

Over the last five years, classification of vegetation communities has advanced considerably. Much of the recent work relates to a hierarchial system of communities within ecozones and ecoregions. Forest types and other vegetation communities are classified according to their structure and their relationship to the range of physical characteristics of the ecoregion—for example, identifying the types of conifer forest communities that occur on dry ecosites within the Lac Temiscamingue ecoregion.

Shoreline vegetation communities are a subset of this classification system. For the two site regions in Southern Ontario, for example, the Ontario Natural Heritage Information Centre (Bakowsky and Lee 1996) has listed the vegetation communities for each of the following shoreline ecosites:

Beach/Bar

- Open Sand Beach/Bar Ecosite
- Gravel/Shingle/Cobble Beach/Bar Ecosite
- Bedrock Beach/Bar Ecosite

Sand Dune

- Dune Grassland Ecosite
- Dune Shrubland Ecosite

Dune Savannah Ecosite

Bluff

Shale/Clay Bluff Ecosite

A number of other terrestrial and wetland vegetation communities also occur along the Great Lakes shoreline, but are listed within other community series, such as Great Lakes Coastal Meadow Marsh Ecosite and Granite Cliff Face Ecosite. Each of the communities have subnational (provincial) rarity ranks to help define their significance.

In the more northern ecoregions, most efforts to date have concentrated on classifying forest ecosites, with initial work now under way on wetland systems (Sims and Uhlig 1992). Field guides to these ecosites give a general description and illustration of each type, together with a characterization of soils, moisture and nutrient regimes, and vegetation strata—from canopy trees to mosses and lichens (Racey et al. 1995). While specific shoreline features such as sand dunes, beaches, cliffs, and talus have been classified as ecosites, they have yet to be described.

In Canada, relatively little biological inventory work has been carried out to systematically examine Great Lakes nearshore terrestrial environments. However, a considerable amount of data is available from specific sites and regional studies—for example, a study of waterfront natural areas along the north shore of Lake Ontario (Brownell 1993) and a series of University of Waterloo studies on the Long Point area of Lake Erie (Lawrence and Nelson 1993). As well, some of the Site District Life Science studies in Ontario, such as one covering the eastern coast of Georgian Bay (Brunton 1991), provide a good overview of significant natural habitats along the shoreline.

An excellent, although now somewhat dated, overview of significant natural areas along the Canadian Great Lakes shoreline was done by Paul Smith (1987a,b). This study did not involve new field work, but is rather a compilation of past inventories and assessments, and a review of the protection status of individual areas.

At least one other study, oriented primarily to the physical characteristics of the shoreline and erosion monitoring, gathered data on vegetation at each study site (Boyd 1981); however, this information is too general to be useful in identifying community types.

Unfortunately, very few of the studies done in the past on the physical characteristics of the shoreline area establish links to the corresponding vegetation communities. Given the large extent of physical data available, studies that analyse the relationship of vegetation and wildlife communities to each physical shoreline type could be helpful.

In the United States, several studies are completed or under way. One report, *Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities*, is intended as a strategic framework for biodiversity conservation in the basin. It identifies key biodiversity resources and discusses kinds of protection measures that can be taken to conserve these resources (The Nature Conservancy Great Lake Program 1994).

The surveys published by the Michigan Natural Features Inventory in *Bedrock Shoreline Surveys of the Keweenaw Peninsula and Drummond Island in Michigan's Upper Peninsula* resulted in discoveries of new sites of rare plants and high-quality bedrock beach as well as demonstrated the urgency for conservation actions to protect the shoreline (Albert et al. 1994).

Another Natural Features Inventory report, *A Survey of Lakeplain Prairie in Michigan* inventoried and characterized tallgrass prairie on Michigan's glacial lakeplain. The identification of new lakeplain rare prairie plant and animal occurrences resulted from extensive surveys (Comer et al. 1995).

Also in Michigan, the Lake Superior Watershed was surveyed for "ecosystems necessary to maintain the full complement of the native biota and functional ecological relationships on the landscape" (Soule 1993). Descriptions of 18 critical habitat sites were inventoried and mapped, and conservation concerns outlined.

Another Lake Superior study in draft, *Preliminary Summary of Important Habitat Data in the Minnesota Portion of the Lake Superior Basin,* identifies over 130 sites and subsites that have important habitat features. The report observes, "A systematic and comprehensive ecological inventory is needed in the region" (Collins 1995).

The Nature Conservancy's Midwest Regional Office prepared *Significant Areas of Biological Diversity in the Great Lakes Basin*, a document that maps 66 sites that are biologically significant throughout the Great Lakes basin. Core areas delineate areas of biodiversity; ecosystem areas outline the geographic scope of ecological processes supporting these areas. The document is significant in scope, detailing site information that includes conservation already in place (The Nature Conservancy 1995).

Several other projects to fill in the gaps of vegetation classification are under way. The Nature Conservancy is undertaking an inventory of biodiversity of New York State's Great Lakes shoreline. The Ohio Department of Natural Resources, together with The Nature Conservancy, is conducting a plant community inventory of the Lake Erie drainage within Ohio.

The Nature Conservancy, in cooperation with the Great Lakes State Heritage Programs and the Natural Heritage Information Centre in Peterborough, Ontario, is compiling species occurrence information (Great Lakes National Program Office 1996).

A basinwide database exists for recording occurrence of natural communities and rare species of plants and animals. Although this can be helpful in setting conservation priorities, it does not address all the aspects of biodiversity nor of ecosystem health.

4. Special Lakeshore Communities

Great Lakes basin residents are privileged to live in a wonderfully diverse ecosystem. From the towering cliffs of Lake Superior's north shore to sandy beaches along southern Lake Michigan and eastern Lake Ontario to the prairie/coastal marsh environs of Lakes Huron and Erie, diversity in plant and animal life abounds.

This area is the crossroads for many species and communities. Species come together at the limits of their ranges. Prickly pear cactus grows in the Indiana Dunes National Lakeshore. Tallgrass prairies extend to Walpole Island in the St. Clair River. Arctic lupine grows on the shores of Lake Superior. The eastern deciduous forest meets the northern boreal forest here.

This section describes the characteristics of some of the special plant and animal communities that inhabit the Great Lakes shoreline.

4.1 Sustaining Wildlife Populations

The lands close to the shore of the Great Lakes offer a distinctive environment for wildlife, in many ways different from the adjacent inland areas. This coastal area has a more moderate climate and unusual physical structures such as sand spits, islands, or bluffs, which meet the needs of a diverse range of wildlife species. As well, the coastal area plays an important role for migrating wildlife, which respond to the water barriers and food resources presented by the Great Lakes.

Different types of migrating wildlife react differently to the lakes. Songbirds and monarch butterflies tend to concentrate at spits and island chains along the shore, waiting for favourable weather to cross the open water or renewing their fat reserves. Bird observatories at Long Point on Lake Erie and Thunder Cape on Lake Superior have contributed greatly to our understanding of bird movements and population trends by regularly monitoring these important migration corridors. Hawk Ridge Nature Reserve in Duluth, Minnesota, is one of the nation's premier raptor observation and banding areas. Professional hawk counting has been conducted here for many years.

Beach areas and open wetlands along the Great Lakes shore are also very important to migrating shorebirds, in both spring and fall. As well, offshore waters are vital stopover areas for diving ducks, loons, and grebes. These species often mass in the open waters of the lakes in early spring, feeding heavily as they wait for ice to thaw in areas to the north.

Most species of hawks avoid crossing the open waters of the Great Lakes and instead make use of updrafts along the shore bluffs to make their way along the shore. Several hawk watch sites are staffed by volunteers who monitor the spring and fall passage of birds of prey. Some species of hawks and owls concentrate during the winter in areas immediately north of Lakes Erie and Ontario, taking advantage of the milder conditions and lower snow cover there.

The Great Lakes is one of the richest habitats for breeding birds in North America. Twenty-five years of data-gathering by the U.S. Fish and Wildlife Service and Canadian Wildlife Service have found the highest breeding-bird diversity in the forests and other habitats around the Great Lakes (Crispin 1996).

The milder conditions of the Erie lakeplain (or Carolinian Canada zone) also support a significant number of breeding birds that occur nowhere else in Canada. This pattern is repeated elsewhere along the Great Lakes shore—38 of the 58 birds at risk in Ontario are strongly oriented towards shoreline areas (Austen et al. 1994). Some of these birds, such as great black-backed gulls (*Larus marinus*) and caspian terns (*Hydroprogne caspia*), prefer nesting on large water bodies. Others, such as barn owls (*Tyto alba*) and white-eyed vireos (*Vireo griseus*), appear to be responding to local climatic factors influenced by the lakes.

The islands of the Great Lakes, together with some of the less disturbed sand spits and peninsulas, are important nest areas for colonial birds, such as ring-billed gulls (*Larus delawarensis*), double-crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and several others. These settings provide both isolation from human disturbance and reduced natural predation levels. Shoreline wetland areas are important sites for the colonial black tern (*Chlidonias niger*), and Great Lakes bluffs are preferred sites for large colonies of bank swallows (*Riparia riparia*).

A number of reptile and amphibian species are also strongly associated with Great Lakes shoreline areas, with southeastern Georgian Bay and the islands of western Lake Erie being particularly known for their outstanding diversity of herptiles. Several snake species, including the Lake Erie water snake (*Natrix sipendon insularum*), blue racer (*Coluber constrictor foxi*), fox snake (*Elaphe vulpina*), and eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), are found largely within a few kilometres of the shoreline.

Populations of insects and other terrestrial invertebrates are probably also influenced by the Great Lakes, but the distribution of many types is poorly known. Some more visible species, such as Karner blue butterflies (*Lycaeides melissa samuelis*), show a strong preference for habitats associated with Great Lakes dune communities. Recent research on land snails has identified a number of previously unknown species associated with limestone alvars (Grimm 1996). However, considerably more inventory work is necessary before the role of invertebrates in shoreline biodiversity can be assessed with accuracy.

There are more than 75 mammal species in the Great Lakes basin (Kurta 1995). This large number reflects the Great Lakes as a transition area. A few species important to nearshore ecosystems are described below.

Several species of moles and shrews till the soils of tallgrass prairies and sand barrens, and voraciously eat insects. The eastern mole (*Scalopus aquatious*) lives in prairie and oak savannahs. The starnose mole (*Condylura cristata*) inhabits wet prairies and swamps. The shorttail shrew (*Blarina brevicauda*) is found in most Great Lakes habitats, including the sand dune areas of Lake Michigan (Burt 1972).

Bats are insect eaters. Populations of the little brown bat (*Myotis lucifugus*), the keen bat (*Myotis keenis*), and the silver-haired bat (*Lasionycteris noctivagans*) are widespread throughout the region. The Indiana bat (*Myotis sodalis*) is endangered and found in the southeast portion of the basin (Burt 1972).

Larger mammals that prey on insects and rodents are found in prairies and pine and oak barrens. They include the red fox (*Vulpes fulva*) and the coyote (*Canis latraus*) (Burt 1972). White-tailed deer (*Odocoileus virginianus*) are prolific throughout the region and in most habitats, including urban areas. They are economically important to humans because of the amount of money spent each year by hunters. In sensitive ecosystems such as coastal sand spits, high deer populations may damage rare plants to the point of extirpation. Moose inhabit the boreal forest region and strongly influence plant communities through herbivory. Mink (*Mustela vison*) and otters (*Lutra canadensis*) are considered indicators of water quality in some nearshore areas.

In a few cases, the climatic effects of the Great Lakes appear to influence mammal distributions. For example, woodland caribou (*Rangifer caribou*) have long since disappeared from most parts of the Great Lakes basin, but remnant populations persist along exposed sections of the Lake Superior shore at Pukaskwa, Slate Islands, and a few other areas.

4.2 The Rare and the Beautiful

A 1994 report, *The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities,* identified 131 globally imperilled species and natural communities in the Great Lakes basin. “Imperilled” means vulnerable to extinction throughout its range. Nearly 30 percent of these rare species live, rest, or feed in nearshore terrestrial ecosystems. Each species requires habitat of a different size and composition to maintain a viable population (The Nature Conservancy Great Lakes Program 1994).

Several plant and animal species are endemic to the Great Lakes. Their existence and evolution result from the physical processes of the lakes. The Michigan monkey flower (*Mimulus glabratus var. michiganensis*) is found in cold seeps and streams and at the base of bluffs in northern Michigan. The Kirtland’s warbler (*Dendroica kirtlandii*) inhabits the jack pine barrens of the northern lower peninsula of Michigan (The Nature Conservancy Great Lakes Program 1994). The dwarf lake iris (*Iris lacustris*) and ram’s head lady’s slipper orchid (*Cypripedium arietinum*) live on the shores of Lakes Michigan and Huron (Guire 1963). Moonwort (*Botrychium acuminatum*) is a dune plant found on Lake Superior (The Nature Conservancy Great Lakes Program 1994). The Lake Huron locust (*Trineratropis huroniana*) and the lakeside daisy (*Hymenoxis acaulis var. glabra*) grow on the shores of Lake Huron and Lake Erie. The federally endangered Pitcher’s thistle (*Cirsium pitcheri*) is found on beaches and dunes on Lakes Huron, Michigan, and Superior (McEachern et al. 1989).

Other globally imperilled species include the piping plover (*Charadrius melodus*), which has been declining by 7 percent annually in the Great Plains (Ryan 1993). Houghton’s goldenrod (*Solidago houghtonii*) grows in interdunal areas on the shores of Lakes Michigan and Huron (Guire 1963). The federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) inhabits oak savannahs and barrens (The Nature Conservancy Great Lakes Program 1994). The prairie white-fringed orchid (*Platanthera leucophaea*) is a tallgrass prairie endangered species (The Nature Conservancy 1995).

As described in the next section, entire communities may be critically imperilled. These include tallgrass prairies, oak savannahs, alkaline shoredunes/cliffs, and alvars.

Species and communities may be rare for several different reasons. First, many species and communities reach the limit of their ranges within the Great Lakes basin—for example, species of the boreal forest, tallgrass prairie, and eastern deciduous forest. Second, species and communities may be rare because they occupy habitats of very limited distribution created by the lakes, such as sand dunes. Third, species and communities become rare when stressors such as habitat destruction and alteration of hydrology affect them. It is vital to understand the underlying cause of rarity for each of the species or communities of concern, so that appropriate management responses can be developed, and reasonable targets set for their restoration.

4.3 Special Ecological Communities

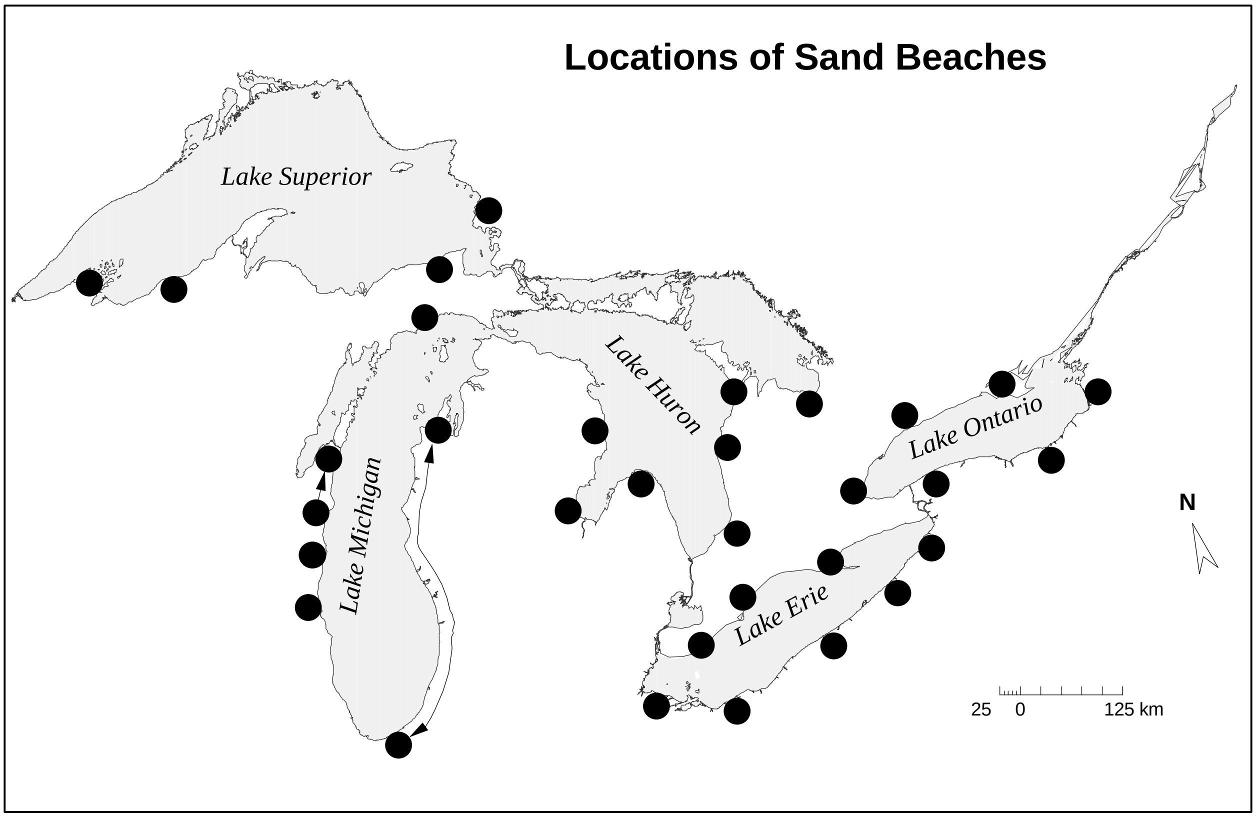
The following significant ecological communities have a special status along the Great Lakes shore. For purposes of this paper, significant ecological communities are places having unique physical features and habitats supporting biodiversity, unique plant and animal life. Most are directly dependent on lake processes for their existence and do not occur elsewhere within the basin. They support many of the wildlife habitat functions and rare species described in the previous two sections. Taken together, they contribute strongly to the biodiversity within their ecoregions and the Great Lakes basin as a whole.

4.3.1 Sand Beaches

Figure 2. Sand Beaches

Sand beaches form when waves and wind deposit sand eroded from other places on exposed shoreline. The sand settles until storms or ice transport it elsewhere or until the wind lifts and deposits it inland to form dunes. Beaches are rich areas for migrating shorebirds that feed on algal mats and for a variety of microfauna (Whillans 1987).

On the *psalmolittoral beach,* land and water constantly interact. Its inhabitants include microscopic protozoans, algae, microcrustaceans, and insect larvae. Next to the psalmolittoral beach lies the *lower beach*. Waves scour the sand, devoid of vegetation, most heavily during summer storms. Scavenger beetles, flies, and spiders visit here. The *middle beach* collects driftwood and debris deposited by winter and summer storms and ice. Tiger beetles, ground beetles, flies, spiders, other insects, and shorebirds feed here.



Vegetation is sparse and hardy. The drought-tolerant sea-rocket (*Cakile edentula*), an annual herb, colonizes early. The *upper beach* is vegetated with biennials and perennials such as wormwood (*Artimesia campestris*), Pitcher's thistle (*Cirsium pitcheri*), beach pea (*Lathyrus maritimus*), and evening primrose (*Oenothera rhombipetala*). Butterflies, beetles, spiders, and ants frequent this drier sand habitat (Peloquin, no date).

A category of organisms called "meiofauna" inhabit beaches. These organisms, less than 2 millimetres long, include *Rotifera*, *Nematoda*, *Tardigrada*, *Copepoda*, and *Oligochaeta*. The abundant and diverse *Rotifera* concentrate near the shore. *Nematoda*, common in submerged sands, tolerate some pollutants well.

Tardigrada colonize sand beaches 1 to 2 metres from the shoreline in bays and coves that are protected from waves. The presence of *Harpacticoid copepoda*, a *Crustacea*, indicates environmental degradation due to organic or silt loading. *Oligochaeta* live in the top few centimetres of wet sand and tend to be less dense at polluted sites (Whitman et al. 1992).

Sand beaches are found all over the Great Lakes basin—over 500 in the United States alone. However, definitions of sand beaches vary, especially in the documentation of beach closings due to high coliform bacteria counts. High coliform bacteria counts are often due to combined sewer overflows and constitute a major health threat. Chicago/Northwest Indiana beaches, for example, close periodically in the summer after large storms. This problem is not limited to urban areas. In addition to affecting recreational opportunities for millions of citizens, the biological impact on plant and animal communities on the beach is detrimental (Jacobson 1996).

Artificial shoreline structures and hardening of the shorelines in Lakes Erie, Michigan, and western Lake Ontario have interrupted the important process of longshore sediment transport that naturally erodes and replenishes sand beaches. This is also a problem in western Lake Superior, although the percentage of shoreline affected is less than for the other lakes. Tons of sand are brought in to artificially replenish beaches each year primarily for recreational purposes.

Shoals, sandbars, and spits protect lagoons and coastal marshes from wave and wind action. *Shoals* are sandy elevations offshore, which may be partially or fully submerged. *Sandbars* are offshore shoals built up by wave, current, or wind action. While home to some microscopic organisms, shoals and sandbars are transitory, with no permanent populations of plant or animal life. *Spits* are narrow points of land extending into a body of water. Spits protect inland areas, particularly coastal marshes, from wave and wind action. Established spits, such as Long Point on Lake Erie or Oak Point on Lake Superior, may house complex plant and animal communities.

4.3.2 Sand Dunes

Sand dunes form where sand grains from 1/16 to 2 millimetres in size are abundant, wind blows frequently, and there is a place for sand to be deposited. As saltation occurs—sand grains bouncing and colliding with other grains—over time, dunes actively move. Abundant and easily erodible quartz from the rocks of the Canadian Shield is the primary mineral component of sand (Sleeping Bear Dunes National Lakeshore 1991).

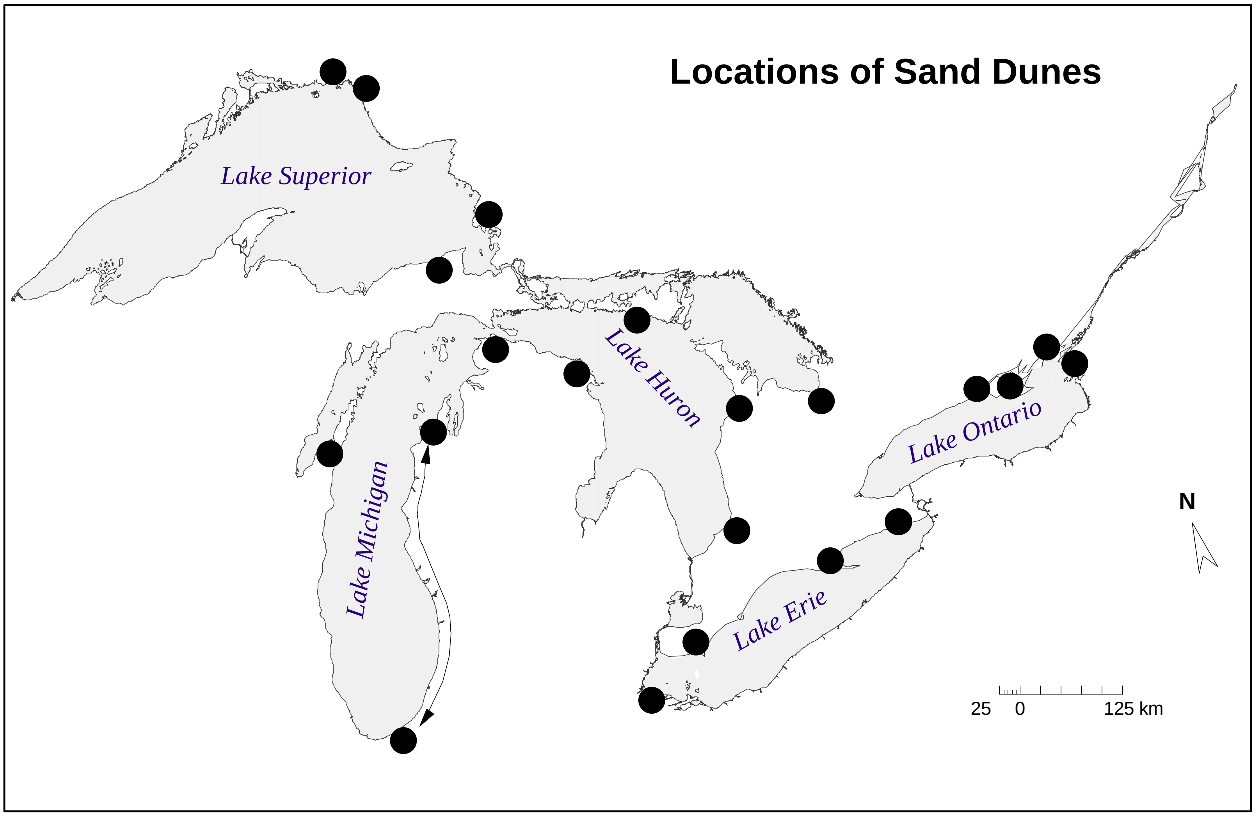


Figure 3. Sand Dunes

Foredunes, sand dunes closest to the beaches, begin to grow as vegetation such as marram grass (*Ammophila breviligulata*) forces the winds to drop sand, which piles up. As a foredune grows, other grasses such as sand reed (*Calamovilfa longifolia*) and little bluestem (*Andropogon scoparius*) and shrubs and trees such as cottonwood (*Populus deltoides*), trembling aspen (*Populus tremuloides*), sand cherry (*Prunus pumila*), dogwood (*Cornus stolonifera*), and willows (*Salix spp*.) gain a foothold. Numerous animals find shelter and food among the trees and shrubs (Hill 1993).

Blowouts occur most frequently in the foredune area. Wind or humans treading heavily and wearing away vegetation create gaps in the dune (Hill 1993). As a break in the side of a dune is excavated by the wind, sand and vegetation quickly erode, leaving a saucer-shaped depression.. Serious blowouts begin as a result of human activities (Wilhelm 1990).

Interdunal areas lie protected from wind and waves behind the foredunes. These areas include unique sand dunes and globally imperilled communities called *pannes* or interdunal wetlands— calcareous, wet, interdunal depressions—which form near the water table. Vegetation in these areas may include asters (*Aster ptarmicoides*), sedges (*Carex garberi*, *Carex viridula*), lobelias (*Lobelia kalmii*), with jack pines (*Pinus banksiana*) and cottonwoods (*Populus deltoides*) at the edges (Wilhelm 1990). Pannes are found on the northern and eastern coasts of Lake Michigan, the northern and southern shores of Lake Huron, at one location on the north coast of Lake Ontario, and at one location on Lake Superior (Hiebert 1986).

Parabolic, longitudinal, and transverse dunes form as a result of vegetational patterns and wind direction and are characterized by their unique shapes.

Backdunes occupy inland areas. Their size and shape are more stable than those of foredunes due to the well-established vegetation that prevents wind erosion except in extreme weather. Successive ridges of backdunes contain different plant communities. At the Indiana Dunes National Lakeshore in southern Lake Michigan, for example, the first ridge of backdunes is dominated by jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), juniper (*Juniperus communis*), and an understorey of plants that includes poison ivy *(Rhus radicans*). The second line of backdunes supports an oak community characterized by black oak (*Quercus velutina*), white oak (*Quercus alba*), and basswood (*Tilia americana*). Furthest inland is the beech-maple dune community with a forest of beech trees (*Fagus grandifolia*) and maple trees (*Acer rubrum*), well-developed soil, a complex plant understorey, and diverse populations of mammals, reptiles, and amphibians (Hill 1993).

Several unusual dune types are found in the Great Lakes. *Perched dunes* rest on a plateau of glacial sediment. *Falling dunes* form as sand migrates off perched dunes and builds on an adjacent lowland. *De-perched dunes* form on lowland areas beyond plateaus. Sleeping Bear Dunes National Lakeshore, Lake Michigan and Grand Sable Dunes National Lakeshore, and Lake Superior have stunning examples of all three dune types, some several hundred feet high (Sleeping Bear Dunes National Lakeshore 1991).

Dune and swale or *ridge and swale* community complexes are found in several places throughout the Great Lakes, notably along Lakes Michigan and Erie shorelines. They were formed as the ancestral Great Lakes receded (Sleeping Bear Dunes National Lakeshore 1991). In the south, the dunes or ridges stretch parallel to the Lake Michigan shore and are rich in oak savannah species. The wet swales between these ridges support rich prairies and sometimes rare coastal plain marsh communities. In the north, ridges are typically dominated by red and white pine and other conifers, and the swales by white cedar swamps or sedge meadows.

4.3.3 Bedrock and Cobble Beaches

Exposed rock along the lakeshore forms a *bedrock beach*. In Lake Superior large areas of granite, basalt, sandstone, and shale are exposed. Acidic bedrock beaches intergrade into coastal gneissic rocklands in Georgian Bay. Limestone bedrock beaches may support alvar habitats.

Bedrock beaches are shaped by wave and ice erosion. Cracks in the rock contain plant life, and seasonal pools form in low areas carved into the rock. The following four communities are found, correlating to their distance from the lake (Albert et al. 1994):

- *Low, wet bedrock beaches* lie closest to the lake. On the Keweenaw Peninsula, Lake Superior, low, wet bedrock beaches contain mosses, which are restricted to the cracks in the rocks. Little lichen (lichens are a combination of algae and fungi) and other vegetation grow here because of the harsh weather conditions.
- *Intermediate bedrock beaches* remain moist. Herbs and woody species are more abundant. Crustose, loose foliose, and fruticose lichens are infrequently found.
- *Intermediate/dry bedrock beaches* lie further from the lake. Crustose and appressed lichens cover 50 to 90 percent of the bedrock surface. Loose foliose and fruticose lichens are still not abundant. Mosses and vascular plants are sparse.
- *High/dry bedrock beaches* are covered with diverse species of lichens, though loose folios and fruticose lichens predominate. A variety of bryophytes, herbs, and woody plants also live here.

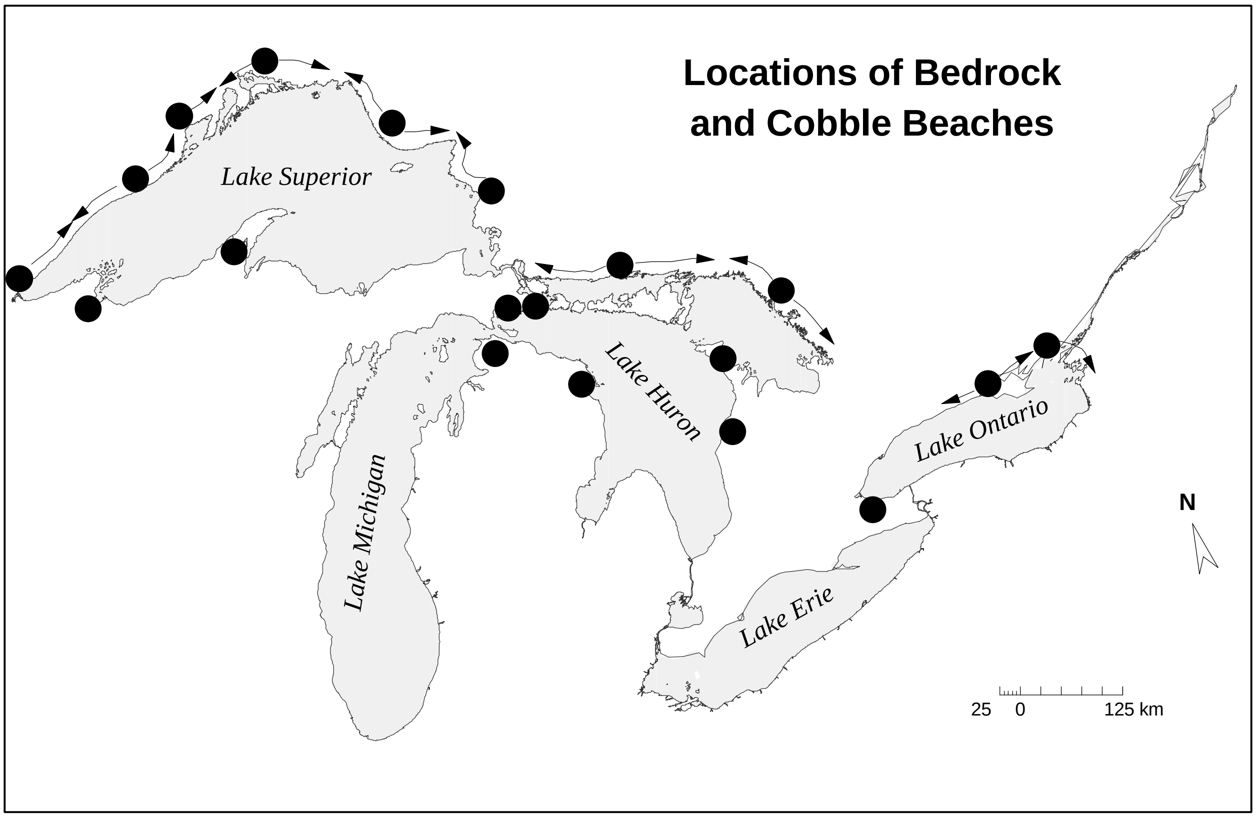


Figure 4. Bedrock and Cobble Beaches

Perched meadows are found in carved out areas of the bedrock along with seasonal pools of water. The meadows contain a variety of tuft-forming grasses such as wild oat-grass (*Danthonia intermedia*) and downy oat-grass (*Trisetum spicatum*), sedges such as *Carex scirpoidea* and *Carex richardsonii*, herbs such as butterwort (*Pinguicula vulgaris*), pearlwort (*Sagina nodosa*), and reclining goldenrod (*Solidago decumbens*), and woody plants such as the shrub *Castilleja septentrionalis*. To date, perched meadow communities have not been the subject of intensive study (Albert et al. 1994).

Bedrock glades are thin-soiled plant communities that lie between the bedrock beaches and forests. Generally, they comprise a few trees, scattered shrubs or thickets, and a grassy, sedge turf on exposed bedrock. Bedrock glade vegetation includes shrubs such as shadbush (*Amelanchier sanguinea*) and low shadbush (*Amelanchier spicata*), bearberry (*Arctostaphylos uva-ursi*), bush honeysuckle (*Dierville lonicera*), juniper (*Juniperus communis*), and creeping juniper (*Juniperus horizontalis*), and trees such as balsam fir (*Abies balsames*), paper birch (*Betula papyrifera*), and jack pine (*Pinus banksiana*) (Albert et al. 1994).

Cobble beaches are common along rocky shorelines. Cobbles are rock chunks made up of limestone or other durable rock. Little vegetation is present due to exposure to severe wave and ice action (The Nature Conservancy 1993). Cobble beaches are favourite places to look for agates (Albert et al. 1994).

Although there is a possibility the animals inhabiting bedrock beaches, glades, and cobble beaches are unique because of the special habitat requirements, little is known about the fauna of these communities. During the surveys conducted on the Keweenaw Peninsula, researchers observed, “No special animals were noted during shoreline surveys” (Albert et al. 1994).

4.3.4 Unconsolidated Shore Bluffs

South of the Canadian Shield, bluffs of unconsolidated clay, till, or other sediments occur frequently along the Great Lakes shoreline. These bluffs are relatively low in height and may be partially protected by a beach deposit at their toe. In some sections of shoreline, however, the bluffs reach heights of 85 metres (279 feet) or more, and provide a specialized habitat for plants and wildlife, as well as a geological record of scientific interest.

Actively eroding bluffs are a source of the sediments that are carried by wave action and deposited in beach areas. On the erodible portions of the Great Lakes, approximately 49 million metric tons of sediment are supplied annually by bluff erosion, out of a total supply of 60 million metric tons (Canada/Ontario 1981).

The Scarborough Bluffs on Lake Ontario provide the most complete and interesting record of Pleistocene geology in North America, if not the world (Coleman 1933). Layers of clay and till, with fossil remains of historic plants and animals, provide evidence of conditions before the last glaciation. In places, wave erosion at the toe of the Scarborough Bluffs has created distinctive formations called “needles” along the face of the bluff, which are noted for their scenic value.

Further east on Lake Ontario, shore bluffs in the Bond Head and Port Granby area display unusual habitats in groundwater seepage zones, sometimes called “hanging fens.” Together with a number of rare plants, these bluffs support large populations of such uncommon wildflowers as Indian paintbrush (*Castilleja coccinea*), yellow lady’s-slipper (*Cypripedium calceolus*) and queen lady’s-slipper (*Cypripedium reginae*) orchids. Large colonies of bank (*Riparia riparia*) and rough-winged swallows (*Stelgidoperyx ruficollis*) nest in these bluff areas (Brownell 1993).

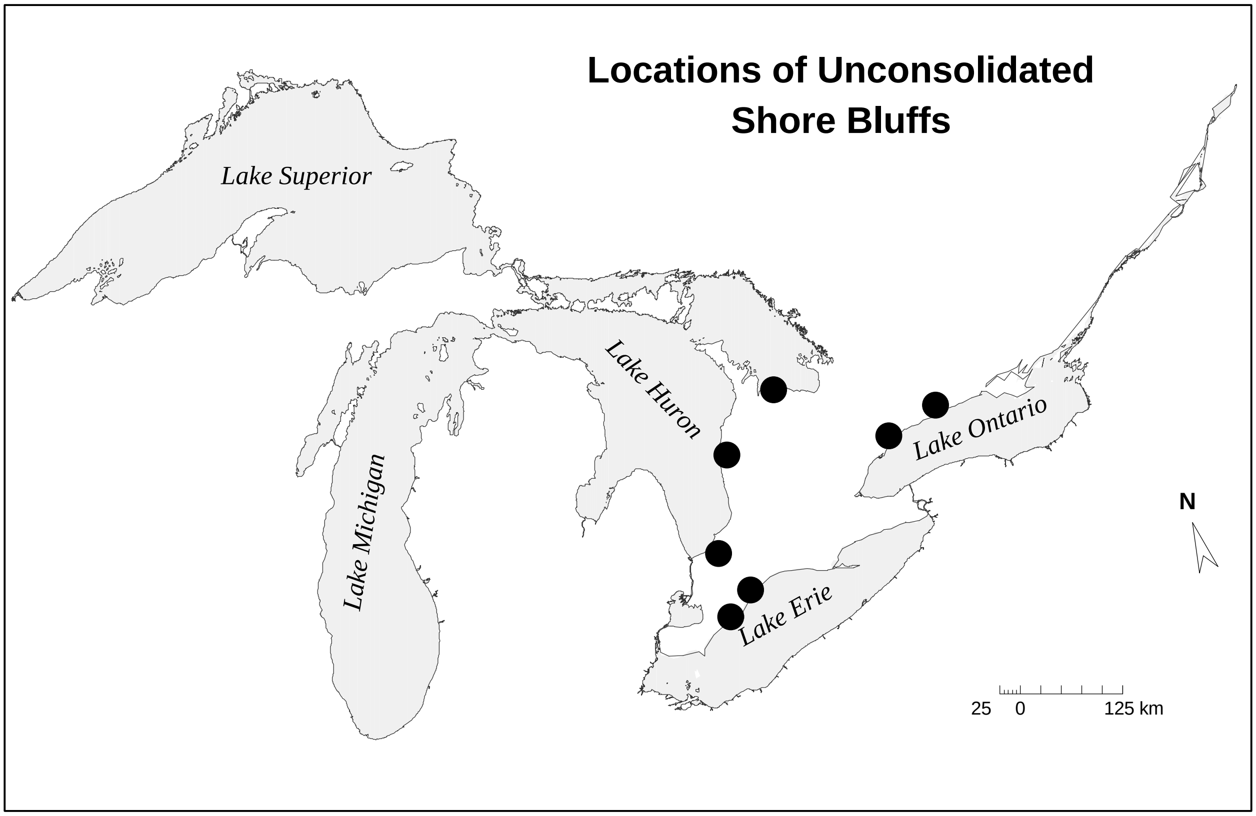


Figure 5. Unconsolidated Shore Bluffs

Extensive areas of shore bluff are found along the north shore of Lake Erie, with the best examples along an 8.5-kilometre (5-mile) stretch of largely undeveloped shoreline known as the Elgin and Kent County Shoreline (Lindsay 1984). This area has for many years been a nesting site for bald eagles (*Haliaeetus leucocephalus*). On Lake Huron, the best example of clay shore bluff has been designated as the Eighteen Mile South Shorecliff earth science Area of Natural and Scientific Interest (ANSI) (Environment Canada 1994a).

Also of interest are the Claybanks, near Cape Rich on Georgian Bay. Here, the current Georgian Bay shoreline cuts into abandoned shore bluffs left by Lake Algonquin and other previous lake levels, and sections of shale are included within the bluffs. In part because this area, including the surrounding landscape, has been protected from agricultural use by its status as a military training area since the 1940s, it has an exceptional diversity of natural habitats and significant species (Jalava et al. 1995).

Shore bluffs can become concentration points for migrating hawks in autumn, as many birds of prey follow the lakeshore to take advantage of rising air currents. At Hawk Cliff, on the north shore of Lake Erie, bird-watchers annually count a wide range of raptors, and band hawks to discover more about their migration. This effort has been under way since 1969 (Duncan 1989).

In most cases, the physical barriers presented by bluffs and their potential for ongoing erosion have discouraged development in their vicinity. A major exception is the Scarborough Bluffs, which are within an urban area and have residential development along much of their rim. As a result, over 70 percent of the bluff toe has been armoured, and sections of the bluff are evolving into wooded hillsides. Development activities are also intruding into natural habitats at the rim of several other shore-bluff areas, lowering their ecological value and creating a potential demand for future shoreline stabilization projects.

4.3.5 Coastal Gneissic Rocklands

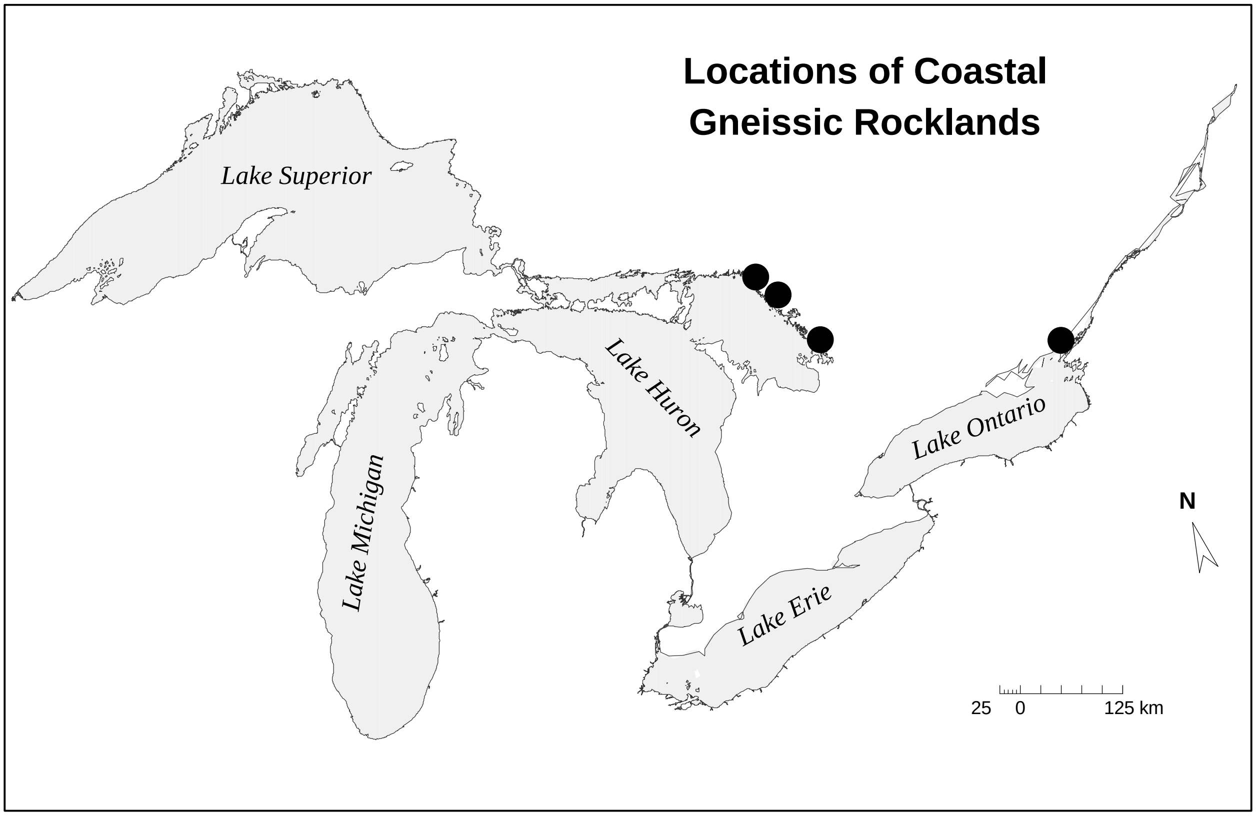


Figure 6. Coastal Gneissic Rocklands

Along the island-studded eastern coast of Georgian Bay, and in the Thousand Islands area at the eastern end of Lake Ontario, the ancient acidic rocks of the Algonquin Arch are exposed. These areas have been scoured and shaped by the glaciers, and then wave-washed by glacial lakes, leaving very little surface sediments. The exposed rockland is mostly gneiss, a banded metamorphic rock originally derived from granite. Smooth rocky shores rise gently from the water, into islands and backshores with low, undulating terrain.

These conditions create a distinctive set of habitats strongly related to the Great Lakes. As described by Ian Macdonald (1986), the coastal gneissic rocklands along Georgian Bay are *characterized by the predominant influence of the coastal environment on the landform and vegetation features, notably the presence of the typically barren islands and near backshore rocklands, the occurrence of restricted lacustrine features, such as beach features, the presence of concentrations of species which have the coastline as their major habitat, and the generally colder than normal microclimatic conditions which are due to the presence of the large water-body of Georgian Bay*.

Much of this rockland supports open communities of white pine, mixed pine-oak forest, and dry oak barrens (Geomatics International 1992a). Shoreline and wetland vegetation associations, including several plant species with western or northern affinities, are frequent in more sheltered areas (Macdonald 1986). In the Kingston area, the Frontenac Axis rockland area supports the only occurrence in Ontario of pitch pine (*Pinus rigida*) associations.

Several threatened species are strongly associated with coastal rockland habitats, notably prairie warblers (*Dendroica discolor*) (Austen et al. 1994) and eastern massasauga rattlesnakes (*Sistrurus catenatus catenatus*). Reptile and amphibian diversity appears to be strong within these habitats, which include a number of uncommon to rare species such as five-lined skinks (*Eumeces fasciatus*) and map turtles (*Graptemys geographica*).

While several sections of coastal rockland are currently protected within national and provincial parks, the growing popularity of these scenic islands and backshores for cottage development and boating presents a threat to the ecological integrity of many parts of this habitat type.

4.3.6 Limestone Cliffs and Talus Slopes

On the upper sections of the Bruce Peninsula, the Georgian Bay shoreline is dominated by limestone bedrock cliffs, terraces, talus slopes, and boulder beaches associated with the Niagara Escarpment (Jalava et al. 1995). The escarpment face rises up to 120 metres (394 feet) above the shoreline, with vertical shore cliffs, sea caves, karst and crevice formations in some sections. Most of the cliffs are bare of vegetation except for occasional clumps of ferns and herbs in fissures and solution holes, and groves of stunted white cedars (*Thuja occidentalis*), which have some trees of several hundred years old (Larson 1992).

Talus slopes are formed by large blocks of rock, up to 10 metres (33 feet) in diameter, that have broken away from the cliff face. These slopes are often covered with white cedar and mixed forests, with lush moss carpets and fern beds on the shaded talus blocks.

The Georgian Bay shore in the vicinity of these features sustains a rich assemblage of shore communities on shore terraces, cobble beaches and lagoons, shelving bedrock and talus (Jalava et al. 1995). The extensive cobble beach shores have a progression of plant communities, ranging from unvegetated in the wave-wash area, through herb, shrub, and mixed forest communities in sections further from the shore. The shores of shelving bedrock and talus support sparse open communities with such specialized plants as rand’s Goldenrod (*Solidago glutinosa*) and bird’s-eye primrose (*Primula mistassinica*).

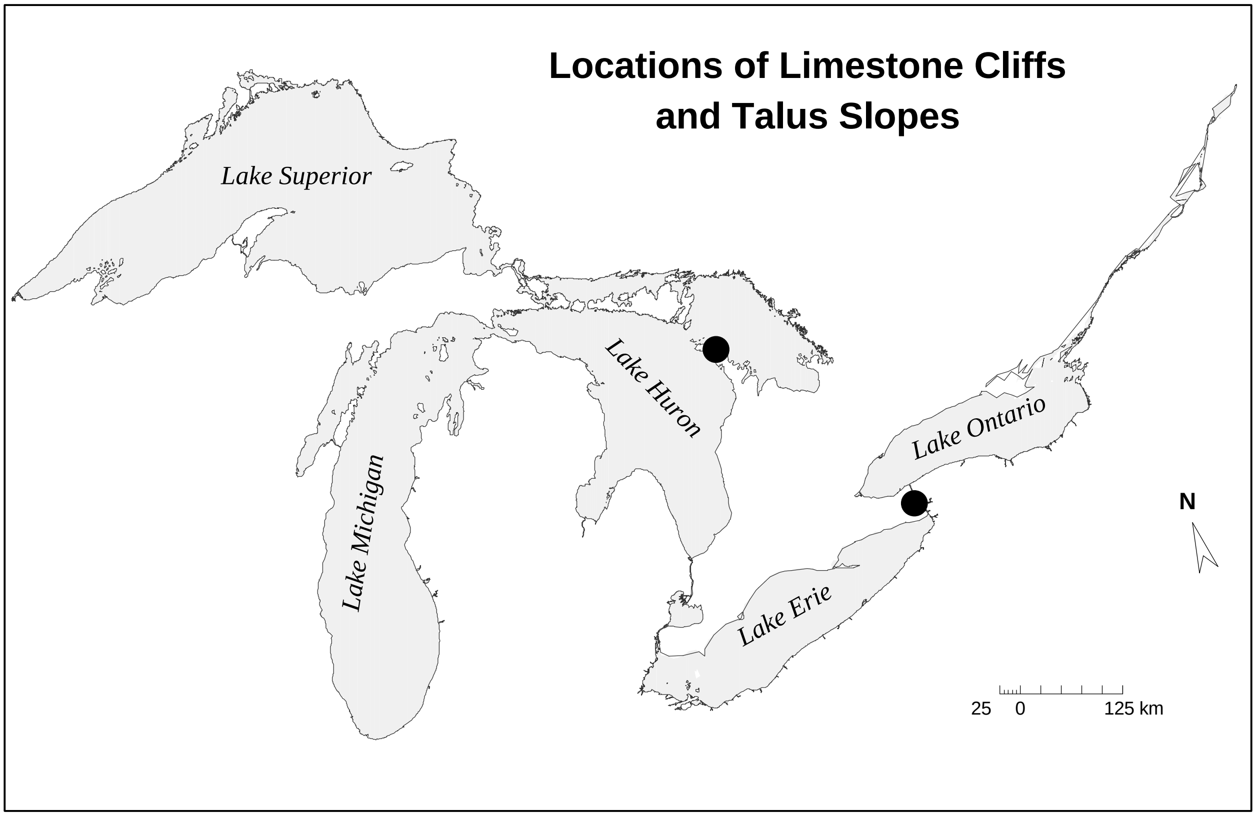


Figure 7. Limestone Cliffs and Talus Slopes

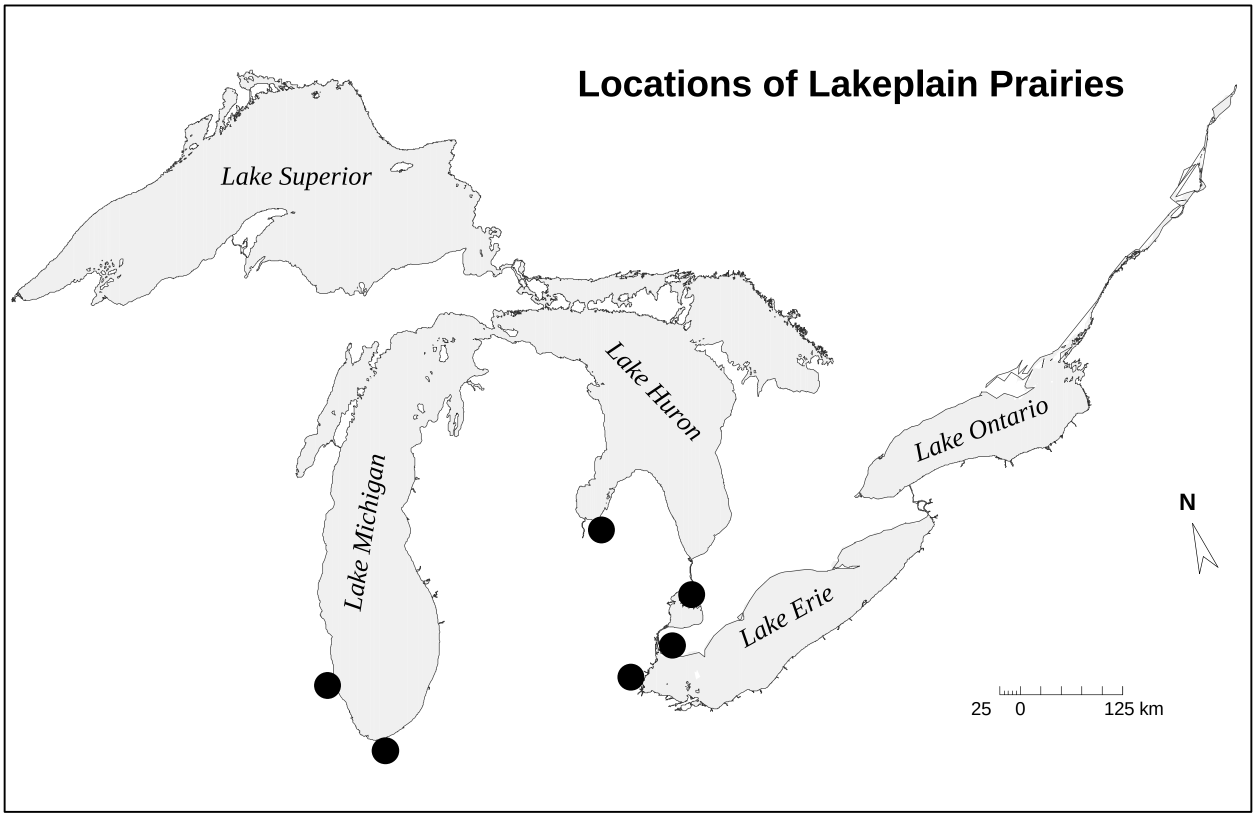
Relict shoreline features from previous higher lake levels also frequently occur, particularly cobble beach and raised dune formations, sea caves, and sea stacks or "flowerpots" (Ontario Ministry of Natural Resources 1976).

The vegetation communities associated with this mix of habitat types contain many rare and unusual species, including many with western or northern affinities. As well, the extensive forests that are associated with the limestone cliff and talus slope areas, and with the shallow limestone rim areas above the cliffs, provide the extensive habitat conditions needed by a number of forest interior birds.

While some sections of this shoreline are at risk from future cottage development, for the most part the difficult terrain and past acquisition by public agencies has reduced the threat to their integrity.

A smaller section of limestone cliff and talus communities occurs along the lower Niagara River, where the erosive force of the river has created a 90-metre (295-foot) deep gorge in the Niagara Escarpment bedrock. This site is recognized as a very significant natural area, with "an exceptional number of vascular plants and the highest concentration of significant flora in the Niagara Escarpment Plan Area" (Jalava et al. 1995). The Niagara Gorge is also renowned as a site for large concentrations of migrant and wintering gulls. The provincially endangered northern dusky salamander (*Desmognathus fuscus fuscus*) has its only known occurrence in Ontario in seeps within the talus slopes of the Niagara Gorge.

Although publicly owned, the Niagara Gorge and its environs have experienced a serious decline in its historic biodiversity over the past 100 years. Such provincially endangered wildlife as timber rattlesnakes (*Crotalus horridus horridus*), along with breeding bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*), has been lost. The list of vascular plant species has declined from 565 known species to 480 species, with 64 percent of the rare plant species having disappeared (Jalava et al. 1995). These losses are attributed to changes in forest composition following logging and fires, development of formal parkland, and the construction of hydro-electric facilities and associated works. In recent years, efforts to better protect natural habitats within the Gorge and to restore water quality and wildlife habitats



have slowed the rate of loss of species.

4.3.7 Lakeplain Prairies

Figure 8. Lakeplain Prairies

Lakeplain prairies consist of rich and deep soil on which a variety of tallgrasses and flowers grow. The grasses, which look like an ocean when the winds sweep through, may reach 3.6 metres (12 feet) in height. The roots of some prairie plants reach as far below the ground as the plant above. Few trees and shrubs grow there. The lakeplains on which the tallgrass prairies grow were formed from sediments deposited as the Wisconsin glacier receded 10,000 years ago.

Before European settlement, the tallgrass prairie peninsula spread from the west and extended through the southern Lake Michigan basin in northeastern Illinois and northwest Indiana throughout the southern part of Michigan to the southeastern part of the province of Ontario. In Michigan alone tallgrass prairie originally covered 63,990 hectares (158,000 acres). About 80 percent was located along the shore and inland in the region of Lake St. Clair, Detroit River, and Lake Erie; 18 percent in the Saginaw Bay Watershed; and about 1 percent in Berrien County of southwest Michigan (Comer et al. 1995).

The type of vegetation growing in lakeplain prairies varies according to climatic conditions influenced by proximity to a Great Lake, and soil composition and moisture. As with coastal marshes, lakeplain prairies depend on the water-level fluctuations of the lakes. The deep root systems of lakeplain prairies enable them to hold water, acting—much as marshes do—like sponges in flood conditions. By killing trees and shrubs, periodic fires and fluctuating water levels help prairies maintain their open, treeless condition. Organic material such as leaf litter is eliminated, allowing new growth. Birds and other species use coastal and inland prairies as refuges from flooding as well as habitat for nesting and feeding (The Nature Conservancy Great Lakes Program 1994).

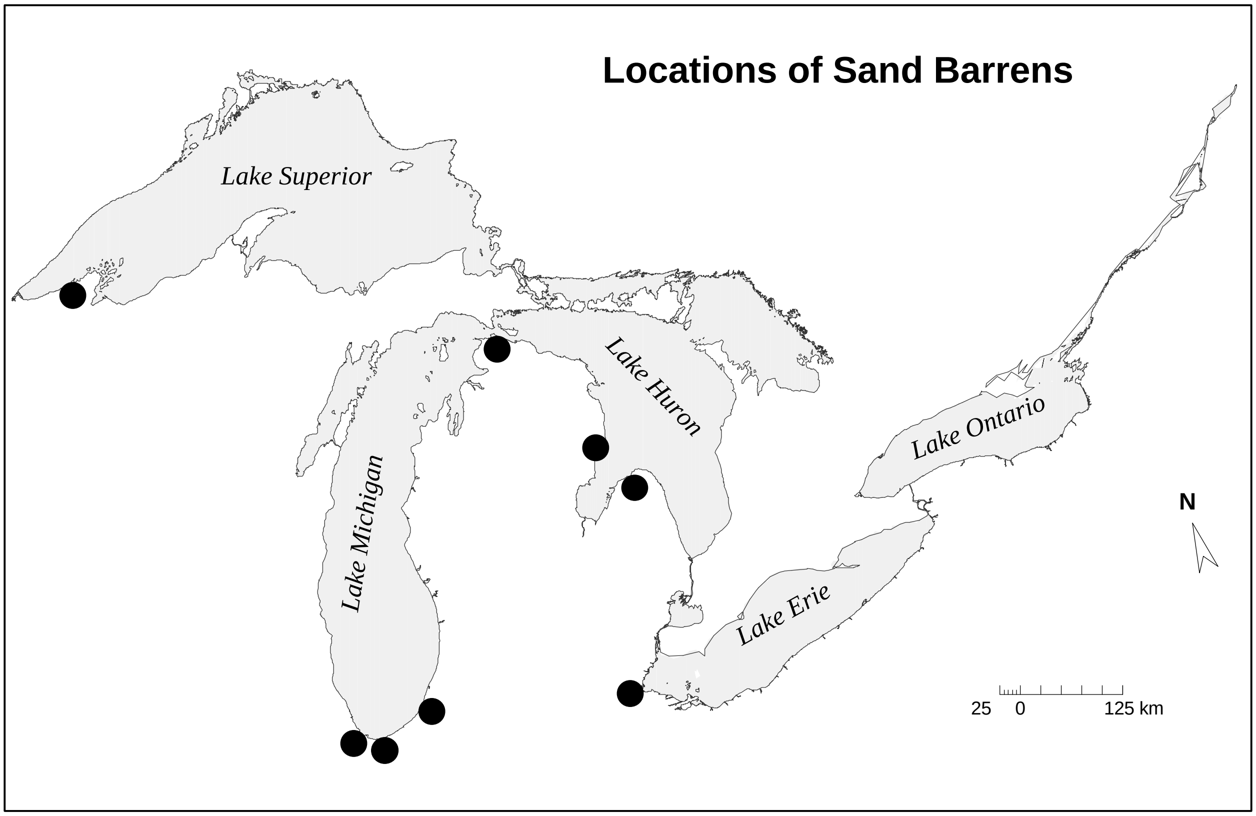
Wet tallgrass prairies are found at the shoreline or growing contiguously with coastal marshes. Vegetation includes grasses such as blue joint grass (*Calamagrostis canadensis*) and prairie cordgrass (*Spartina pectinata*), sedges such as *Carex stricta* and *Carex aquatilus*, red osier dogwood (*Cornus stolonifera*), and shrubby cinquefoil (*Potentilla fruticosa*) (Comer et al. 1995).

Mesic to dry mesic (dry) tallgrass prairies lie inland at the edges of the wet prairies. Plant species include big bluestem grass (*Andropogon gerardii*), little bluestem grass (*Andropogon scoparius*), Indiangrass (*Sorgastrum nutans*), switch grass (*Panicum virgatum*), tall coreopsis (*Coreopsos tripteris*), mountain mint (*Pycnanthemum virginianum*), blazing star (*Liatris spicata*), and Ohio goldenrod (*Solidago ohioensis*) (Comer et al. 1995).

Little is known about native lakeplain prairie fauna because the fragments of remaining prairie do not contain a complete representation of species from pre-European settlement times. Certainly the bison and elk that roamed the Michigan prairies during explorer Antoine la Mothe de Cadillac's time in the early 1700s are gone, along with other large mammals. Muskrat lodges are, however, still found in marsh/wet prairie areas. Prairie ant mounds and crayfish chimneys lie inconspicuously among tallgrasses (Comer et al. 1995). The king rail (*Rallus elegans*) is sometimes spotted in the wetter areas (Comer et al. 1995). Insects abound, including grasshoppers (*Orthoptera*), true bugs (*Hemiptera*), leafhoppers, spittlebugs, planthoppers, and treehoppers (*Homoptera*).

Of interest is *Papaipema sciata*, a moth borer dependent on Culver's root *(Veronicastrum virginicum*), a plant found in lakeplain prairies. One severe storm could potentially eradicate an entire population. However, if a prairie is rich and sustainable, one storm may only serve to set back the moth. *Papaipema* may be a useful indicator of good lakeplain tallgrass prairie (Comer et al. 1995).

In the mid-1800s most of the lakeplain tallgrass prairie in the Great Lakes basin was converted for agricultural use (Comer et al. 1995). Today, residential and industrial development impinge on the remnants and thus tallgrass prairies are globally imperilled. Of Michigan's 63,990 hectares (158,000 acres), 433 hectares (1,068 acres) of degraded prairie remain, in fragmented, tiny parcels in Wayne and St. Clair Counties, the Saginaw Watershed, and in the southwest part of the state. Less than 1 percent of the original prairie peninsula acreage still exists within the Great Lakes basin. Some of the best examples are found along Saginaw Bay, western Lake Erie, and the St. Clair River Delta in Michigan; at Walpole Island and the Windsor Ojibway Prairies in Southern Ontario; at Chiwaukee Prairie in southeast Wisconsin; at Markham Prairie in northeast Illinois; at Hoosier Prairie in Indiana; and at a few acres in Lucas County, Ohio (Comer et al. 1995).



4.3.8 Sand Barrens

Figure 9. Sand Barrens

Sand barrens are defined here as areas of deep sands with scattered, sometimes scrubby, oak and pine trees and a ground layer of sedges and forbs. “Savannah” is sometimes used interchangeably with “barrens.” Barrens, however, are differentiated by their poor, sandy soils and frequent and intense fires (Botts et al. 1994). Barrens are closely associated with other ecosystems—savannahs, dunes, and prairies in particular. They are dynamic, sometimes open-canopied with prairie-like vegetation, at other times denser and more like woodlands.

Before European settlement a large portion of the midwestern United States, probably more than 11 million hectares (27 million acres), was oak savannah. It’s estimated that 17 to 22 percent is left, though in varying degrees of degradation. No information exists specifically for oak barrens of Great Lakes coasts. It is estimated that pre-European jack pine barrens of northern Wisconsin covered 930,000 hectares (about 2.3 million acres). Today less than 1 percent remains (Boyce and Mladenoff 1995). Timber harvesting methods, conversion to agriculture, fragmentation, and fire suppression are sources of stress to oak savannahs and oak and pine barrens (Botts et al. 1994).

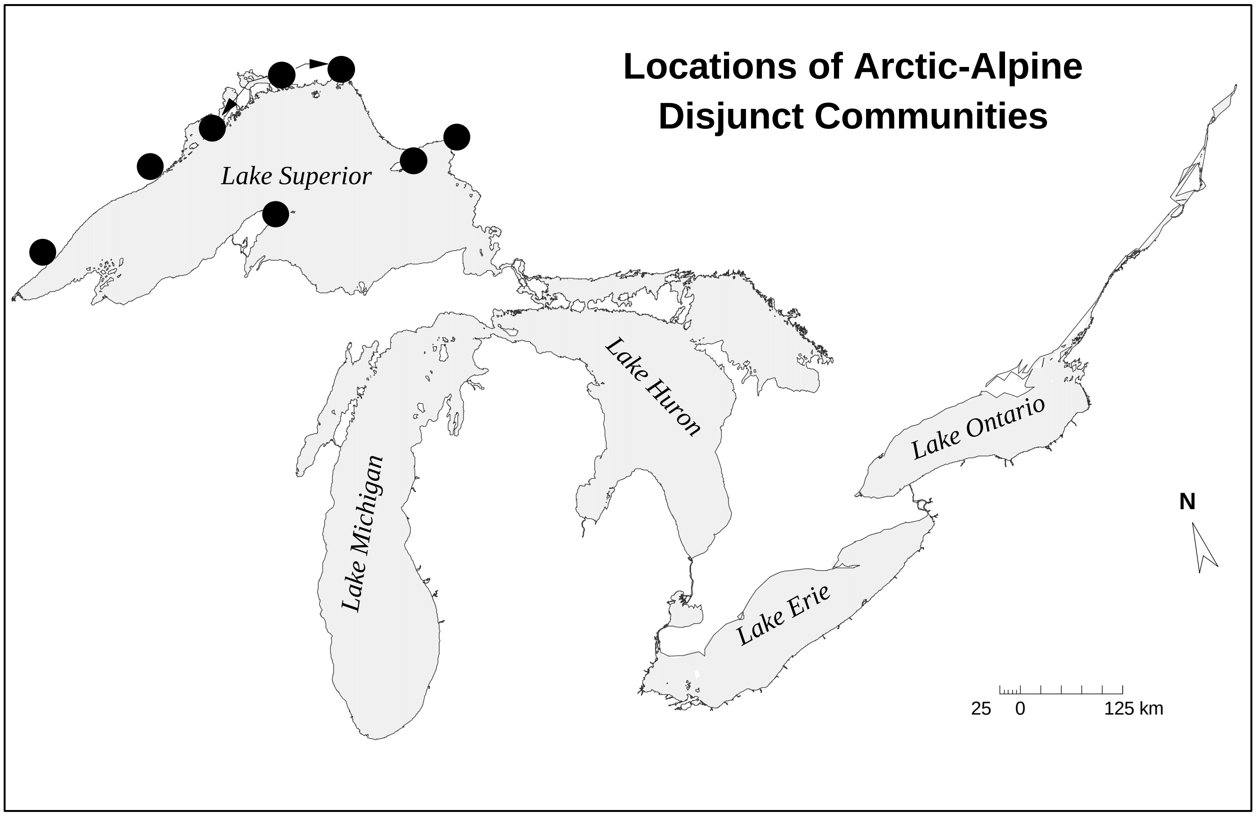
In the Great Lakes, pine and oak barrens are found associated with sand dunes, areas of sandy glacial outwash, and tallgrass prairies. White (*Pinus strobus*) and jack pines (*Pinus banksiana*) dominated the first backdunes before European settlement, though land surveyors did not always distinguish between the two species (Cole 1987). White pines were heavily logged throughout the Great Lakes basin in the 1800s. As a result, some jack pine, but little white pine, remain. Pine communities also contain junipers (*Juniperus communis*), shrubs such as sand cherry (*Prunus pumila*), and forbs such as sand cress (*Arabis lyrata*). The endangered Kirtland’s warbler (*Dendroica kirtlandii*) is a jack pine barren species.

Dune ridges and backdunes inland from pine communities are dominated by black and white oak (*Quercus velutina* and *Q. alba*). The oak communities have a lush understorey of grasses, including tallgrass prairie species like big and little bluestem (*Andropogon gerardi* and *A. scoparius*), sedges such as Pennsylvania sedge (*Carex pensylvanica*), and forbs such as lupine (*Lupinus perennis*), hoary puccoon (*Lithospermum canescens*), and yellow lady’s-slipper orchid (*Cypripedium calceolus*).

Little is known about the frequency of fire in barrens communities before European settlement (Boyce and Mladenoff 1995). All oak communities in the Midwest, however, are fire dependent (Botts et al. 1994). The suppression of fire has had a damaging effect on oak communities. Woody species such as European buckthorn have moved in, shading the ground layer and preventing oak regeneration. Fire suppression may also be detrimental to human communities. The buildup of woody debris invites accidental or lightening-induced uncontrolled fires which may damage property. Controlled or managed burns are preferred to protect property and assist oak communities.

A range of animals inhabit oak barrens and savannahs. A list can be found, along with Natural Heritage Inventory rankings, in Appendix D of Botts et al. (1994). Pine barren fauna is not well documented.

Today, pine and oak barrens in Great Lakes nearshore ecosystems are found in northern Wisconsin, on southern and eastern Lake Michigan, on the north and west shores of Lake Erie, and in the northern part of Michigan’s lower peninsula.



4.3.9 Arctic-Alpine Disjunct Communities

As the Wisconsin glacier retreated, the climate around the Great Lakes gradually changed. Plants and animals that had adapted to cooler, wetter weather followed the glacier's retreat northward as the southern part of the basin gradually became warmer and drier. Some of these plants remain in isolated areas on the north shore of Lake Superior and the Susie Islands (Givens and Soper 1981). These plants belong to rare *arctic-alpine disjunct communities*, so called because they are isolated from their primary range. In addition, individual plant species such as bearberry (*Arctostaphylos uva-ursi*) survive in sand communities such as those at the southern end of Lake Michigan in the Indiana Dunes National Lakeshore, Illinois Beach State Park, and southwestern Michigan.

Figure 10. Arctic-Alpine Disjunct Communities

The plants of arctic-alpine disjunct communities on the shores of Lake Superior survive by warming themselves with the heat that radiates from the ground. Photosynthesis takes place in the two months or so during the year when their root systems are not frozen. Energy is accumulated in the form of carbohydrates.

Along the shore, the plants adapt to wind and waves. Over 400 species of lichen, including reindeer moss, survive on the rocks. Two lichen species, *Coccocarpia cronia* and *Umbilicaria torrefacta*, are found only on the Susie Islands in western Lake Superior (Johnson 1984).

Just inland, mosses, cranberries, and insectivorous plants live in bog forests of black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), red pine (*Pinus resinosa*), northern white cedar (*Thuja occidentalis*), and mountain ash (*Sorbus americana*). Sedges form a thick, grass-like mat. Peat is formed from dead plant matter that does not readily decompose because of the cold and lack of oxygen (Johnson 1984; Givens and Soper 1981).

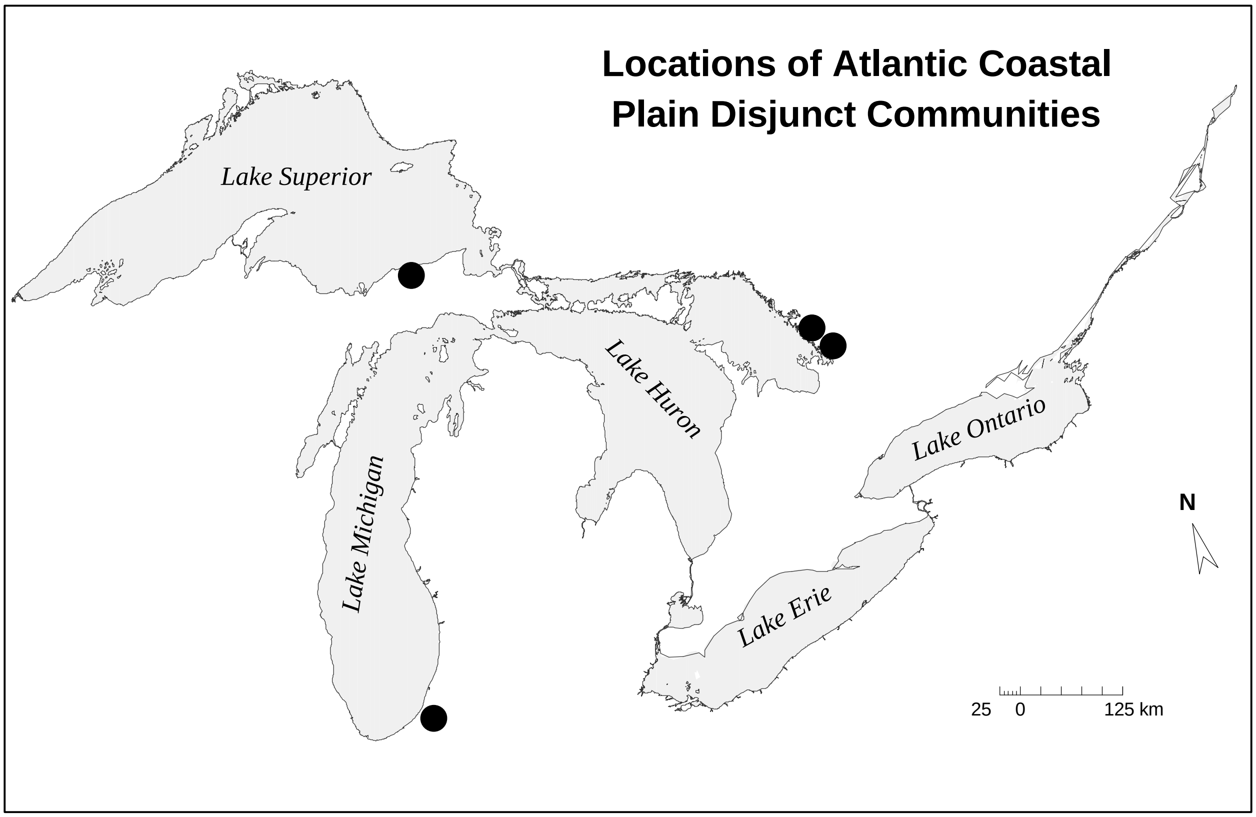
Other arctic-alpine disjunct vegetation includes rock cranberry (*Vaccinium vitis-idaea*), bearberry (*Arctostaphylos uva-ursi*), insectivorous round-leafed sundew (*Drosera rotundifolia*), butterwort (*Pinguicula vulgaris*), onion and garlic (*Allium schoenoprasum var. sibericum*), Norwegian witlow grass (*Draba norvegica*), northern eyebright (*Euphrasia husoniana*), alpine bistwort (*Polygonum vivifarum*), and arctic lupine (*Lupinus arcticus*) (Johnson 1984).

Arctic-alpine disjunct communities on the rocky shores and cliffs along the north shore of Lake Superior are generally protected from disturbance because they are inaccessible and the climate is harsh, though the area is attractive to tourists. Recently, however, second-home development has begun to encroach. Recreational use (marina development) and trampling of vegetation also has the potential for significant vegetative impact. Some communities have protected status on properties owned by the state of Minnesota, The Nature Conservancy, Parks Canada, and Ontario Parks.

4.3.10 Atlantic Coastal Plain Disjunct Communities

Figure 11. Atlantic Coastal Plain Disjunct Communities

In a few lakeplain areas around the Great Lakes, there are whole communities of plants whose normal distribution lies in a band along the Atlantic coast of the eastern United States. These species, which are called disjuncts, occur only on sandy or peaty shores with fluctuating water levels. These specialized habitats appear to be relict fragments of previously more extensive sandy shores associated with higher lake levels in the past. Coastal plain species are thought to have migrated into the Great Lakes basin some 11,000 years ago, when a drainage channel down the Hudson River connected with the Atlantic coastal



plain (Keddy 1981).

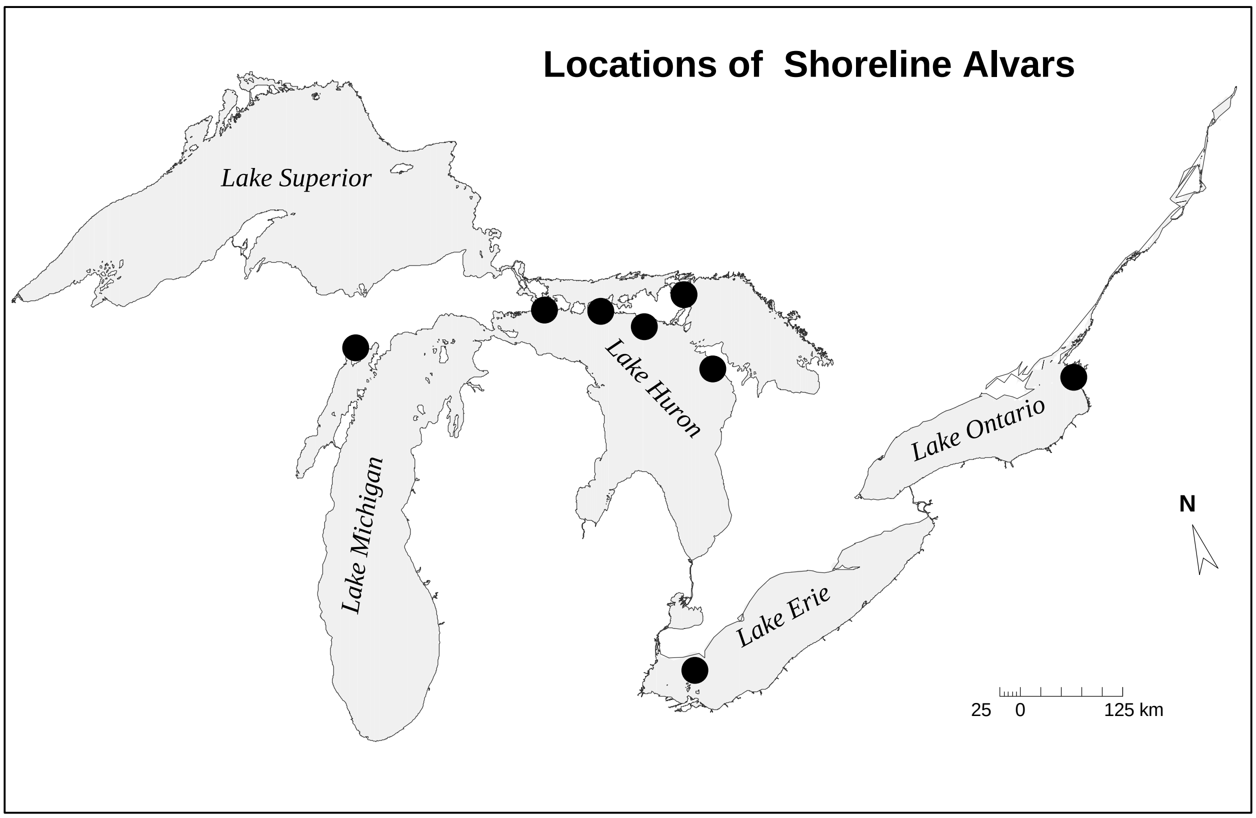
Atlantic coastal plain communities are concentrated around the southern end of Lake Michigan (Peattie 1922) and extend northward into Michigan as well (McLaughlin 1932). A major concentration of these disjunct communities also occurs on the inland lakes of the Muskoka District, between the former Lake Algonquin shoreline and the current Georgian Bay coast. Twenty-three species have been identified as characteristic coastal plain plants, with the richest concentrations occurring on low-nutrient inland lakes (Keddy and Sharp 1989). A number of less rich sites are also known from the sites on the Georgian Bay coast (Geomatics International 1992a; Macdonald 1986), but the scarcity of sandy habitats along the modern coast may limit the distribution of coastal plain plants.

Some of the plant species associated with this habitat type are separated from their main range by 500 to 1,000 kilometres (310 to 620 miles) or more, and many are listed as rare or threatened at a state/provincial level. For example, one of the most widespread Atlantic coastal plain plants, Virginia meadow beauty (*Rhexia virginica*), is classed as threatened in Wisconsin, potentially threatened in Ohio, and rare in Michigan and Ontario (Keddy and Sharp 1989). While a few of the richest sites around the Great Lakes are protected within reserves or by planning designations, most are vulnerable to shoreline recreational developments or other disturbances. Stabilized water levels are also a threat to these communities, since they depend on periodic flooding to prevent shrub growth.

4.3.11 Shoreline Alvars

Figure 12. Shoreline Alvars

Alvars are naturally open areas of thin soil over limestone or marble bedrock, which host a distinctive vegetation community, including a considerable number of rare plants. Within North America, alvar systems occur only within the Great Lakes basin, where they are scattered in an arc from Michigan's Upper Peninsula through Southern Ontario to northwestern New York State (The Nature Conservancy 1994). While alvar grasslands and savannahs occur at several hundred sites of varying quality, a smaller number



are located on or near Great Lakes shorelines in areas of gently sloping limestone bedrock (Catling and Brownell 1995). Other major alvar areas include the Carden Plains and Napanee Plains of Southern Ontario and Jefferson County, New York. The alvars of the Marblehead Peninsula in Ohio were largely destroyed by quarrying (Crispin 1996).

Alvar sites undergo periodic flooding followed by drought, and their very shallow soils are subject to high surface temperatures in mid-summer. Alvars have been described as "a habitat for the hardy" (Schaefer 1995), since plants that thrive there must be able to withstand harsh conditions. Trees are scattered and often stunted or deformed. Claudia Schaefer (1996) noted the presence of stunted conifer trees 400 to 500 years old at several coastal alvar sites along the Bruce Peninsula.

Alvar habitats support several types of bedrock pavement, grassland, and savannah communities, most of which are considered by The Nature Conservancy to be globally rare. These communities support an unusual blend of boreal and prairie species, which appear to be relicts of the cold period following the last glaciers, and of the warmer, drier period that followed (The Nature Conservancy 1994). Among the 54 vascular plant species strongly associated with alvars in Ontario, 17 are provincially rare (Catling 1995). One species, lakeside daisy (*Hymenoxys acaulis*), occurs nowhere else in the world except on Great Lakes alvars and several isolated places in Illinois (DeMauro 1993).

Alvars are home to an unusual set of wildlife species as well, including the loggerhead shrike (*Lanius ludovicianus*) and a large number of distinctive invertebrates such as leaf-hoppers and land snails (Grimm 1996).

The largest concentrations of coastal alvars are located along the western shore of the Bruce Peninsula, the southern shore of Manitoulin Island, and Drummond Island. Most of these sites are on private land, and their quality is seriously threatened by expanding cottage developments and to a lesser extent by quarrying. Plant collection, such as the "harvesting" of stunted trees by bonsai collectors, is also a threat in some areas.

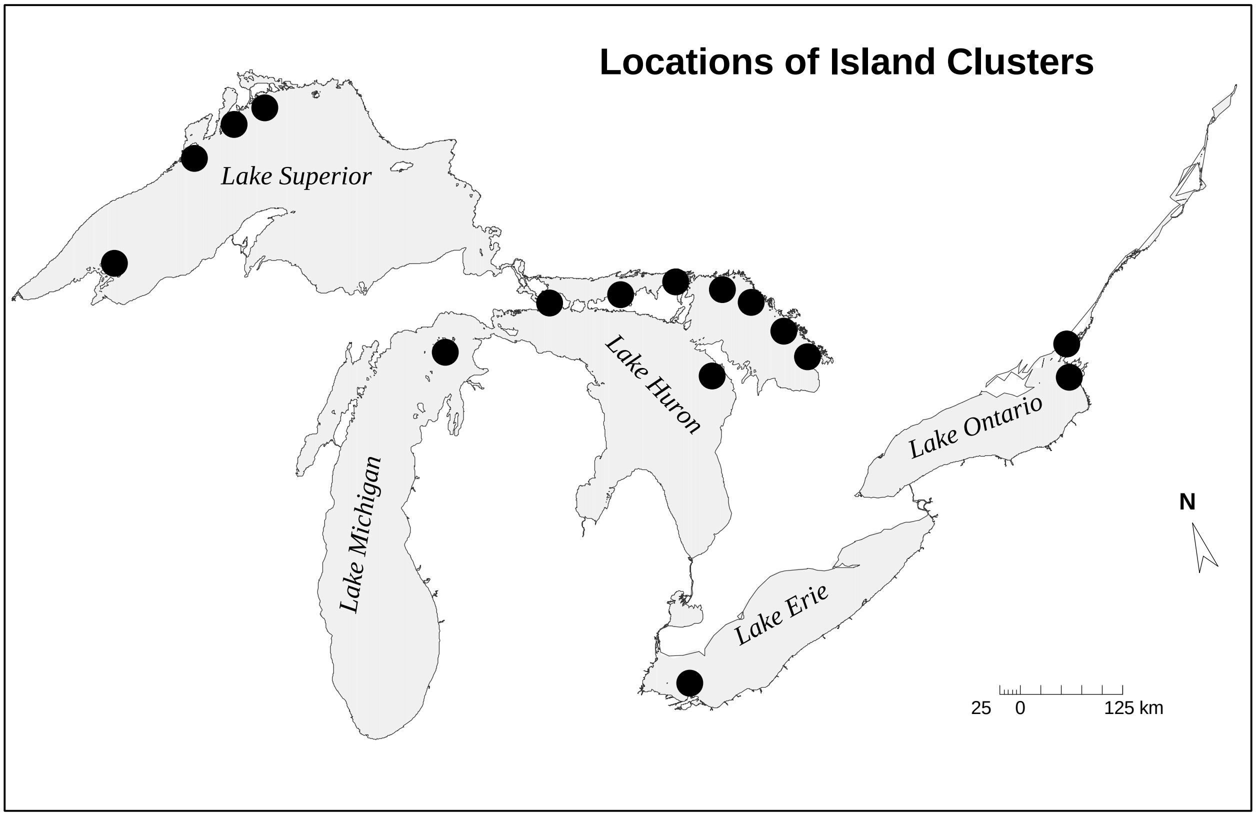
4.5.12 Islands

While the Great Lakes are perhaps best known for their large, deepwater habitats, they also host a surprising number of islands—up to 35,000 by one estimate (Vigmostad 1996). Other authors are more conservative in their counting. Paul Smith (1989) gives island totals in Canadian waters as 1,720 in Lake Huron, 615 in Lake Superior, 50 in Lake Ontario, and 29 in Lake Erie. However, there is broad agreement that Great Lakes islands are distinctive and important habitats, with a unique set of natural values.

In part, those values are related to the geological origins of many islands. While most islands in the upper lakes are based on ancient rocks, because of changing lake levels and other factors, they are relatively young landscapes. The Slate Islands in Lake Superior, for example, present an array of metamorphic rocks that suggest either that the islands are the eroded stump of an ancient volcanic cone or that they are the remnants of the crater from a meteorite impact (Snider 1989). However, some of the Slate Islands emerged above the surface of the lake only 3,000 years ago, as the lake bottom slowly rebounded from the weight of the glaciers (Smith 1989).

Figure 13. Island Clusters

The limestone islands in the western basin of Lake Erie are also relatively young. At one time, when lake



levels were lower, they formed a continuous peninsula across the lake. The rock outcrops of today's islands are the remains of hills on that peninsula (McKeating 1989). Other islands, such as those in Batchawana Bay on Lake Superior, are composed of sands deposited there by lake currents since the last glaciation. Excellent examples of sand beach and dune systems are found in many islands. Two of the least-disturbed sand dune complexes in North America are found on Great Duck Island, in the middle of Lake Huron (Hilts 1989).

Island ecosystems are greatly affected by their isolation, which tends to simplify wildlife communities and provide protection from predators. As a result, Great Lakes islands are the primary nesting sites for great multitudes of gulls, cormorants, terns, herons, and egrets (Blokpoel and Tessier 1996). The waters of Lake Superior have served as a barrier to colonization of many species on the Slate Islands, including the large predators of the adjacent shore, and moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*). In this environment, caribou (*Rangifer caribou*) have done exceedingly well, with population densities at the highest levels recorded anywhere in North America (Snider 1989). Not far away, Isle Royale has good populations of both moose and wolves (*Canis lupus*) and has acted as a natural laboratory for the documentation of the complex relationships between these species.

Islands set in large bodies of water have their climate considerably moderated, allowing native plants to thrive in unusual places. The vegetation and wildlife of the western Lake Erie islands, for example, is similar to that found much further south, with such species as shellbark hickory (*Carya laciniosa*), American lotus (*Nelumbo lutea*), and carolina wrens (*Thryothorus ludovicianus*) (McKeating 1989).

Island habitats not only contribute strongly to biodiversity within the Great Lakes basin, but also retain more of their natural heritage, since their isolation helps discourage environmentally destructive developments. Some island clusters are protected in national and provincial parks, or given status as wildlife sanctuaries to protect bird colonies. However, the growth of recreational boating and cottaging is affecting many Great Lakes islands. In some areas such as southern Georgian Bay, island cottages are considered premium real estate. Holistic strategies to deal with these pressures are only in their beginning stages.

5. Land under Stress

No part of the Great Lakes basin still displays the full integrity of primeval nature. (Regier 1987)

It is not the intent of this paper to argue that humans should be kept out of nature, away from sensitive ecological systems. It is, however, important to look at human-induced stresses in order to understand the impacts we have on other species and the roles we might play in living with the land, treading lightly on it. This section and the one following look at human impacts on significant ecosystems. This section focuses on negative impacts, those human activities which are the sources of stress resulting in damage to ecosystem processes and species. Section 6.0 focuses on positive actions humans are taking or may take to preserve the integrity of significant ecosystems as stewards of the landscape.

All nearshore terrestrial ecosystems are under stress. For purposes of this report, *stress* is defined as "Those human impacts which are damaging, or have the potential for damaging, an ecosystem component or natural process" (The Nature Conservancy 1996). The following are the major categories of stress to nearshore ecosystems: direct alteration of habitat, alteration of hydrology, alteration of physical processes, alteration of biological structure, and alteration of chemical regime (The Nature Conservancy Great Lakes Program 1994). All these categories of stress change ecosystems. The type of stress, intensity of stress, and combinations of stressors to nearshore terrestrial ecosystems vary greatly, as do the ecological responses and resulting impacts in specific locations.

"*Sources* are the causes of stresses" (The Nature Conservancy 1996). Perhaps the greatest sources of stress to coastal ecosystems stem from activities of the humans who congregate there. It is estimated that half of the world's population lives near a coast. "People have often favored coastal locations for settlement because, among other benefits, these areas tend to contain the greatest biological productivity" (Turner et al. 1996). Indigenous plant and animal species and communities are specifically adapted to natural stressors, which have become important factors in maintaining the features of those communities. Human-induced stresses introduce ecological "wild cards" to which these features are not adapted and may be unable to adapt.

It should be noted that some species do adapt to human-induced stresses. White tailed deer, for example, are prolific in northeastern Illinois. The result is an unsustainable deer population eating suburban backyard vegetation and rare plants from local nature preserves.

Another example is phragmites, an introduced plant species which quickly colonizes wet, roadside ditches and other disturbed landscapes. The concern is that this species quickly spreads into the edge areas of adjacent richer ecological communities. The result is often an impoverished ecosystem established at the expense of a rich assemblage of interacting species.

The point here is that individual species do not constitute complete ecosystems. Because some species are adapted to human-induced stressors does not guarantee a healthy, sustainable, community of plants and animals interacting on a landscape rich in habitats, and performing functions necessary for ecosystem integrity. The success of individual species adaptations, though interesting, pales in comparison to species lost as a result of disrupted ecosystems.

5.1 Direct Alteration of Habitat

Stresses that directly alter nearshore terrestrial ecosystem habitats include *converting land to agricultural, residential, industrial, or recreational use; mining and timber harvesting; removing parts of ecosystems from the landscape;* and *paving or armouring the shoreline*. These activities may result in habitats being destroyed, species and communities being eliminated, and remaining populations—often not allowed to live and develop under normal conditions—being compressed into small, fragmented areas (The Nature Conservancy Great Lakes Program 1994).

Land Development

Converting land to agricultural, residential, industrial, or recreational uses can destroy ecosystems. When a piece of land is cleared of its original components—living and non-living things—then replaced with a structure, a parking lot, or a lawn, habitats are irrevocably altered. Whatever life is not exterminated must move or adapt to a diminished habitat. Few species with specific niches in the original ecosystem are capable of adapting.

Those species, usually animals, that do move when land conversion takes place are relegated to tiny fragments of their original territory, sometimes great distances from each other. Great distance, of course, is relative to the species. Squirrels and foxes move quickly and can cover much ground. To an insect, however, the edge of a parking lot is the end of the world. Habitat fragmentation makes it difficult for individuals within a species to interact. Thus, the flow of genetic information that is necessary to sustain populations is inhibited. In addition, fragmentation constrains the migration of species.

The above discussion has dealt with outright destruction of habitat, such as with a bulldozer. Other land conversions are more subtle but can be just as devastating. Preserving areas as parks, then opening them to diverse recreational uses may also result in incremental damage culminating in the destruction of ecosystems. An increase in foot traffic and off-road vehicles may destroy vegetation, opening areas to erosion. In dune areas, a lack of vegetation creates blowouts. A footpath or a two-inch tire tread track may be a barrier that prevents plants and animals from moving from one place to another, thus fragmenting ecosystems. Raking beaches for sunbathers eliminates the algal mats that shorebirds feed on (Whillans 1987).

Resource Extraction

Mining alters habitats. The extraction of minerals, sand, and gravel disrupts groundwater flows, impairs surface water quality, and destroys vegetation. For example, in southern Lake Michigan, whole dunes were sand mined for use in industry. The result was the elimination of dune and swale habitat.

Removing parts of ecosystems from the landscape can also cause major alterations to habitats. For instance, “mining” cobbles or boulders for use in another place reduces the shelter needed by some animals. Bonsai collectors taking dwarf plants from alvars reduces the vegetative diversity of these sensitive areas. Butterfly collectors removing rare animals from rare habitats depletes species already in jeopardy.

Armouring

Shoreline armouring is the installation of artificial shoreline structures designed to prevent erosion and protect properties from being washed away (Ashworth 1987). Paving or armouring the shoreline, in addition to interrupting natural physical processes, destroys critical habitat. Concrete chunks and other riprap or sheet piling destroys soil, sand, and rock habitat, replacing it with non-friendly surfaces that plants and animals are ill-prepared to inhabit.

Other

From the mid- to the late 1800s the Great Lakes basin was logged. First the white pines were cleared, then maple, oak, and walnut. Whole forest systems were eliminated. Stream banks eroded because their protective vegetative covering was cleared along with the timber. This caused severe runoff and the destruction of fish-spawning habitats downstream. Waterfalls and other obstructions along the north shore of Lake Superior were dynamited to provide better passage for logs in streams on their way to Lake Superior.

Today, converting aspen/fir forests to young stands of pure aspen reduces the habitat quality for species that need mixed forests—for example, boreal owls require older stands of aspen, spruce, and fir.

All nearshore terrestrial ecosystems are under severe stress from direct alteration of habitat. People want to live, work, and play near the water. Industry needs water for manufacturing and transportation, so proximity to the lakes is essential. How we use the land by the lakes has a critical effect on stress to ecosystems.

5.2 Alteration of Hydrology

Changes in the levels and natural fluctuations of the lakes and the water table have profound effects on coastal communities. These are physical process stressors but are considered here separately because of their importance to terrestrial communities. For example, natural lake-level and water-table fluctuations are part of the processes that sustain dune communities and lakeplain prairies. Dune communities require natural lake fluctuations to remove and replenish sand, and rejuvenate habitats. Lakeplain prairies depend on both natural lake- and water-table fluctuations to maintain soil moisture.

Human-induced water diversions and dredging of connecting channels alter lake levels. The diversion of water into and out of the Great Lakes is regulated by control structures at five locations throughout the Great Lakes: Ogoki, Long Lac, Chicago, Welland Canal, and New York State Barge Canal. Since the early 1900s, water levels in Lakes Michigan and Huron have dropped 25 centimetres (10 inches), in part as a result of dredging of the St. Clair River (Great Lakes Commission 1986). More recent studies show that the drop in Lakes Michigan and Huron caused by St. Clair/Detroit River dredging is in the order of 41 centimetres (16 inches) (Levels Reference Study Board 1993).

Water levels on Lakes Superior and Ontario are partially controlled by dams at their outlets. The operation of these dams has reduced the range of fluctuation of lake levels.

The results of lake-level and natural fluctuation alterations are severe for sand beach and sand dune communities, lakeplain tallgrass prairies, and coastal marshes. Plant and animal species may be eliminated, productivity decreases, and organic matter and nutrient flushing is decreased because habitat is greatly altered. (The Nature Conservancy 1994).

Irrigation, mining, and land drainage alter the water table. This causes drought-like conditions that kill species not adapted to dry conditions (The Nature Conservancy 1994).

5.3 Alteration of Physical Processes

Increased sedimentation, the removal of fire, and *the interruption of the transport of sediments by longshore currents* are the primary stresses that alter nearshore terrestrial ecosystem physical processes. Sand beach and sand dune communities, tributary streams and wetlands, lakeplain prairies, and oak barrens are most affected.

Increased Sedimentation

While sediments clearly play an important ecological role along the lakeshore, in excessive quantities they can cause ecological problems as well. Where poor agricultural, logging, or development practices have increased soil erosion near watercourses, there is an increase in the amount of sediment flowing to the mouths of rivers and streams, as well as an increase in suspended sediments.

When agricultural, logging, and development practices increase soil erosion, sedimentation occurs. This results in an increase in the amount of sediment flowing to the mouths of rivers and streams as well as an increase in suspended sediments. An increase in the amount of sediment alters the composition of river mouths and the amount and content of sediment available for transport to adjacent shorelines. Suspended sediment blocks light and reduces submergent vegetation in both streams and adjacent coastal marshes. This, in turn, eliminates spawning habitat for certain fish species (The Nature Conservancy Great Lakes Program 1994).

Fire Suppression

Fire is a natural disturbance that lakeplain prairies, barrens, and some forests require to function. Fire keeps out woody plants and invasive species and returns nutrients to the soil. Humans prevent fires out of fear of destruction of human lives and property and out of ignorance of the role of fire in maintaining ecosystems. This results in an increase in woody and invasive species and a reduction in native plant species and native animal habitat (The Nature Conservancy Great Lakes Program 1994).

Longshore Transport Disruption

The transport of sediments by longshore currents replenishes sand beaches, dunes, and coastal marshes. Shoreline hardening/armouring, jetties, breakwaters, causeways, bridges, marinas, and other artificial coastal structures interrupt the natural sediment nourishment process (Burnett 1991). Sand is prevented from eroding in one place and depositing in another. Sand starvation is thus a severe problem throughout the Great Lakes (The Nature Conservancy Great Lakes Program 1994). Without sand, beaches and dunes are washed away and coastal marsh communities are inundated.

The positive effects of shoreline armouring include protecting property against wind and wave damage, and providing microhabitats for invertebrates, plants, and fish (Burnett 1991). Whereas “soft” coastal shoreline protection structures such as sand, rock, or rubble may nourish beaches and assist habitats (School of Civil Engineering 1986), “hard” coastal protection structures such as vertical sheet piling is hostile to wildlife (Burnett 1991). Lakes Erie and Michigan, and the western part of Lake Ontario are, for the most part, armoured (Ashworth 1987).

The western part of Lake Ontario has the “world’s highest concentration of large, artificial coastal spits (Whillans 1987).” These artificial structures are barriers that stop sand from travelling by way of longshore currents. Sand is deposited in particular places as a result of the position of the structures, not the natural current. In some areas, sand beaches must be artificially replenished every year to make up for the loss in sediment from longshore transport. This is done primarily for recreational purposes with little consideration for sand and coastal marsh communities.

5.4 Alteration of Biological Structure

The biological structures of ecosystems are altered when *changes occur in the food web* (Mills et al. 1993). This can happen in several ways, including the introduction of non-native or “exotic” plant and animal species. When this happens the new species competes for food and space with native species. Exotics are often opportunistic, moving in when an ecosystem is disturbed and before native species have time to recover. In general, exotics have no enemies in their new environment so they can quickly dominate competitive interactions and become very abundant.

Exotics enter the Great Lakes in several ways. Some are intentionally released, such as certain game and ornamental species. Others are introduced unintentionally, the result of activities such as removing previously existing barriers. For example, the construction of canals allowed fish such as the sea lamprey to move past waterfall barriers.

Human modification of Great Lakes landscapes has created the right conditions for exotic species to become established. In the mid-1800s, deforestation and farming practices contributed to the increase in stream turbidity, allowing exotics that liked those conditions to get a foothold. The water in the lakes around power plants and industries on shore is warmer, providing habitat for exotics that could not survive in normally colder lake waters. Adaptable species of exotic marine algae can survive because road salt and industrial waste have contributed to make waters three times more saline than in the 1850s (Mills 1993). Human disturbance of ecosystems has resulted in a reduction of ecosystem resilience and the establishment of new plant communities at the expense of native species (Bowles 1990).

In all, about 139 exotic plant and animal, terrestrial and aquatic species are problematic in the Great Lakes basin (Mills 1993). Sand dune and oak savannah shoreline exotic trees and shrubs include purple willow (*Salix purpurea*), crack willow (*Salix fragilis*), white willow (*Salix alba*), glossy buckthorn (*Rhamnus frangula*), and black alder (*Alnus glutinosa*). The glossy buckthorn is a pest species threatening the ground vegetation and is a contributing factor in preventing oak regeneration in oak savannahs (Mills 1993).

In addition to exotics, introduced diseases such as Dutch elm and white pine blister rust alter the biological structure of ecosystems. If one species in a forest community cannot recover from a disease, the birds and other animals that feed and nest there must adapt to other sources.

5.5 Alteration of Chemical Regime

Chemicals play an important role in ecosystem health. *Toxic chemicals*, however, have adverse effects on animal and plant populations if they occur in harmful concentrations. Changes in water chemistry, in particular, have resulted in death, chronic impairments, reproductive failure, and the inhibition of growth in wildlife. Toxic chemicals that alter the chemical regimes of nearshore ecosystems come from point source discharges from industries and municipalities, non-point sources from agricultural runoff, silviculture, commercial, and residential activities, and contaminated sediment releases (The Nature Conservancy Great Lakes Program 1994).

Early on, much dumping of toxic wastes into the lakes took place. Many industries, mills, and factories were built on the shores of the Great Lakes to take advantage of the fresh water supply and easy transportation. In the 1800s the shores of the Great Lakes were stripped of trees, such as the white pine, for lumber for growing communities. Decaying wood left on shore or in the nearshore waters reduced oxygen and often produced hazardous chemicals. Wetlands and lakeplain prairies were drained for agriculture in the mid-1800s. This was followed by the introduction of chemicals to control agricultural pests in the mid-1900s (Keating 1987).

In heavily populated areas the salt used to de-ice roads in the winter may change the chemical balance of nearshore terrestrial as well as aquatic ecosystems. It is estimated that nearshore waters are now three times as salty as in the mid-1800s (Mills 1993). The impact on terrestrial ecosystems is, however, unknown.

Although a change in the acid-base balance of systems may affect plants and surface water, at this time, the effect of such a change on nearshore terrestrial ecosystems is unknown (The Nature Conservancy Great Lakes Program 1994).

At present, water-chemistry changes affect the animals that feed in many of the coastal marshes and nearshore aquatic environments of the Great Lakes and nest or live in nearshore terrestrial ecosystems. Several chemicals bioaccumulate in the fatty tissue of some animals and are transmitted to subsequent generations, causing deformities and reproductive problems. Pesticides that are known to bioaccumulate are no longer in use in the Great Lakes basin, although they may persist in sediments for a long time, posing a continued threat to wildlife and humans.

Some lichen species are sensitive to sulphur dioxide and other atmospheric pollutants. For example, it is estimated that 83 percent of the lichens that inhabited the Indiana Dunes National Lakeshore 100 years ago died from severe air toxic pollution (Wetmore 1986).

Large tankers cross the Great Lakes daily, transporting numerous materials from all parts of the world. An accident could result in an oil or other toxic substance spill, which would damage ecosystems in the vicinity.

6. What Actions Are Needed?

> *If we are to have an accurate picture of the world—even in its present diseased condition, we must interpose between the unused landscape and the misused landscape a landscape that humans have used well.*
> (Wendell Berry, *Turn of the Crank,* 1995)

Considerable progress has already been made in protecting the nearshore terrestrial environment, but that task is far from complete. The ongoing degradation of nearshore ecosystems and the processes necessary to maintain them weaken the fabric of life of natural communities. When species or whole communities are lost or diminished, we and future generations are deprived of untapped and intrinsically valuable resources, and our options for decision-making in the future are limited (The Nature Conservancy Great Lakes Program 1994).

Future stewardship of lakeshore lands must be oriented towards the goal of “protecting and restoring ecosystem health,” as part of broad international efforts to restore health to the Great Lakes ecosystem as a whole. Generally, “health” implies that the components of ecosystems function within some normal range of fluctuations, they can withstand external stressors, and they remain capable of continual self-organization and development (Francis 1996).

In the case of nearshore terrestrial ecosystems, this goal must include the protection and restoration of coastal biodiversity and the underlying shoreline processes that are essential to maintaining the character of the shore. Biodiversity includes a range of levels, from landscapes, through community associations, species, and genetics (Skibicki and Nelson 1994). Thus, biodiversity conservation on the Great Lakes shore could include both broad landscape features, such as Lake Erie sand spits, and individual species or subspecies, such as piping plovers or the Lake Erie subspecies of water snakes.

To effectively improve ecosystem health on the land by the lakes, future management actions and planning for human uses of the land and natural resources must respond to the stressors identified in section 5.0. In some cases, existing programs are under way. For example, progress in restoring air quality or reducing the level of toxins in the Great Lakes ecosystem will yield benefits for nearshore terrestrial ecosystems as well. In these cases, the relationship of these stressors to nearshore terrestrial health is an additional reason for maintaining vigorous progress in the future.

Most existing programs, however, do not take care of the most important sources of stress for the land by the lakes—direct alteration of habitat and alteration of physical processes. To meet these challenges, a conservation strategy for coastal areas is needed that is actively fostered by governments at all levels, that reflects governmental commitments to biodiversity conservation and sustainable development, and that is broadly supported by Great Lakes citizens.

This strategy should have two components:

1. A concerted international effort to complete a core set of protected areas along the Great Lakes coast, based both on representative examples of enduring features of the full range of coastal landscapes and on protection of special lakeshore biodiversity elements and communities; and

2. Development of coordinated shoreline management measures in areas between the core protected areas to ensure that ecological processes are sustained and that shoreline areas with human uses also contribute to biodiversity conservation.

Many current stewardship activities contribute to the strategy proposed above. They form the foundation for future work. This section outlines some of the major actions needed and provides a very brief overview of categories of activity currently under way.

Case Study: ***Maeqtekuahkihkyak Pemaenakuau - Keepers of the Forest***
The Menominee Forest-Based Sustainable Development Tradition

Menominee Tribal Enterprises, Doug Cox, Menominee Forestry Center, P.O. Box 670, Keshena, WI 54135, 715-799-4937

The Menominee People have long recognized the need for balance among environment, community, and economy both in the short term and for future generations. Menominee culture and traditions teach us never to take more resources than are produced within natural cycles so that all life can be sustained. Chief Oshkosh, an early Tribal Chief, first presented the idea of cutting across the reservation at such a rate that there would always be timber ready to cut.

These cultural and traditional beliefs are the foundation of the management practices and principles of today's Menominee Tribal Enterprise operations. The concept of sustainability in the management of our forest allows us to experience a traditional quality of life from an intact, diverse, productive and healthy forest ecosystem on the Reservation.

Menominee Tribal Enterprises has been charged with the responsibility of managing the forest, which is held in trust by the Secretary of the Interior for the benefit of the Menominee people. The 140 year history of forest resource use and management stands as a practical example of sustainable forestry - forestry that is ecologically viable, economically feasible, and socially desirable. This refers not only to forest products and social benefits, but also to wildlife, site productivity, and other ecosystem functions. The Tribe has learned from previous generations how a forest ecosystem interacts. We understand that the whole resource is needed to protect any part.

The Menominee Forest stands as a monument to the foresight of our ancestors who recognized the bounty they inherited. Today, because they acted as responsible stewards of these resources for future generations, we enjoy, cherish, and are sustained by the resources so wisely planned for and managed by them.

6.1 Get the Facts

An enormous amount of data has been collected about the characteristics of the Great Lakes shoreline area, usually with a specific, relatively narrow, purpose in mind. Rather than continue the tradition of endless re-collection of basic data, it would be useful to make the best use of available data, examine current data sources to determine which sources could be adapted for other uses, identify gaps, and propose common data standards.

For example, a substantial amount of detailed, relatively recent mapping on physical shoreline characteristics is available in digital form. However, the inventory of biological communities along the shoreline is incomplete, with classification systems now available or in progress, but relatively little mapping being carried out. Since lakeshore biological communities are strongly associated with physical landform characteristics, it may be possible to create links to the existing maps as a first attempt at locating significant biological communities. Other geographically based linkages between biological resources, physical resources, and land use are also needed.

The Waterfront Regeneration Trust has suggested that agencies collecting data along the shoreline coordinate their efforts in future to standardize the data they gather. This means collecting the data in a consistent fashion with a common approach and then entering it in a format that will allow it to be used and compared in monitoring and analysis (Shoreline Management Work Group 1996). The benefits of this standardized approach include increased abilities to:

> *improve collective knowledge about the entire ecosystem;*
> *compare data for research and monitoring;*
> *focus efforts on important issues and shore areas;*
> *jointly prepare and implement plans;*
> *facilitate joint ventures;*
> *assess cumulative effects of shoreline and lakebed alterations; and*
> *facilitate the conversion of data into computer and GIS applications.* (Shoreline Management Work Group 1996)

Gaps in ecological information exist—for example, in basinwide comprehensive inventories of plants and animals. Invertebrates, mosses, liverworts, lichens, and fungi, in particular, have not been well inventoried anywhere.

Gaps of a geographical nature also exist. The plants of the northern Lake Superior and southern Lake Ontario basins, for example, are not well inventoried (The Nature Conservancy 1995; The Nature Conservancy Great Lakes Program 1994). In the Lake Superior basin surveys need to be done for rare plants, insects, birds, reptiles, and amphibians to determine the relationship between rare species and natural communities (Soule 1993; Collins 1995).

Little is known about the effects of stressors on ecosystems. A recent report by the Great Lakes National Program Office reviewed protection and restoration activities funded by the office and stated, “Quantifiable effects, with the exception of outright destruction, are not known. Cumulative effects of stressors on individual species or communities are not known. How much is enough in terms of area needed for ecosystems to maintain their integrity is not known. The effects of stressors on ecosystem processes and functions are not generally known” (Great Lakes National Program Office 1996).

Federal, state, and local governments and their natural resource agencies and departments do not have the staff to inventory, document, assess, and monitor all ecosystems on publicly owned lands. Many are now relying on citizens to help gather facts within programs and standards coordinated by government agencies and non-governmental organizations. Citizens all over the Great Lakes basin are collecting data on everything from birds to coyotes. The local plant expert is often a lifelong and knowledgeable resident. Although we will never know everything about nearshore terrestrial ecosystems, all pieces of information add to the total picture.

The Great Lakes State Heritage Programs and the Natural Heritage Information Centre in Ontario are helpful to resource managers and for biodiversity analyses. The Programs and Centre were developed under the leadership of The Nature Conservancy in cooperation with state and provincial governments and local agencies. They have provided a linked basinwide database for occurrences of rare species and ecological communities, which contributes greatly to assessing conservation priorities.

Case Study: *Long Point Bird Observatory*

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The Long Point Bird Observatory (LPBO) takes advantage of its location on the north shore of Lake Erie to collect a wealth of information about North American birds and their movements. By the end of 1995, LPBO had banded over 500,000 birds, including 260 species. The recapture or recovery of songbirds with individually numbered leg bands at sites across the continent has added greatly to our understanding of bird migration and biology.

The success of LPBO is related in part to its use of Long Point, a 40-kilometre (25-mile) long sand spit reaching out into Lake Erie, which acts to funnel bird migration. More recently, LPBO has been involved in helping to sponsor similar banding and bird monitoring activities at the Thunder Cape Bird Observatory on the end of the Sibley Peninsula on Lake Superior.

Another important success factor for LPBO has been its extensive use of volunteers. Throughout the Great Lakes basin, volunteers are involved in monitoring the bird population through breeding-bird surveys, marsh and woodland bird surveys, loon surveys, feeder watches, and other programs. Hundreds of volunteers also participate annually in the Baillie Birdathon sponsored by the LPBO, which raises funds for research and conservation projects.

LPBO and other non-government sector organizations have added immensely to our understanding of the importance of Great Lakes shoreline habitats to the feeding, staging, and breeding activities of many species of birds.

6.2 Plan for Protection and Recovery

The shorelines of the Great Lakes basin are vastly altered from what they were in pre-European settlement times, with virtually all the alterations resulting in some degree of environmental deterioration. However, some areas are still in good to excellent condition, and thoughtful planning can prevent damage. Getting the facts and assessing what remains, the quality of remnants, and stressors to those remnants precede developing a plan to protect remnants and recover entire ecosystems.

Placing key shoreline habitats in parks or protected areas should become part of any plan for nearshore terrestrial ecosystems. On other public or private lands where human uses will continue to dominate, management measures to sustain ecological processes and restore biodiversity must be introduced. Just as past international efforts have had considerable success in restoring Great Lakes water quality and aquatic ecosystems, future management of shoreline areas should plan for their recovery to an improved state of health.

Planning for protection and recovery can take place at several levels. The Lakewide Management Planning (LaMP) process offers an opportunity to extend coastal area management to a broader context. Lake Erie LaMP, for example, involves two federal governments and their many agencies, the government agencies of several states and Ontario, local governments, industries, environmental organizations, and interested private citizens, all working together to develop and work towards a vision for the Lake Erie basin. The complex effort will take years. As a result, present and future residents will participate in improving the integrity of Lake Erie ecosystems as well as their own quality of life.

Coordinated planning can also take place at a regional level—such as the Lake Ontario Greenway Strategy described previously, which handles shoreline management issues along most of the north shore of Lake Ontario (Waterfront Regeneration Trust 1995a). The U.S. National Wildlife Federation has done some interesting work on a regional basis on approaches to terrestrial biodiversity conservation in the western part of the Lake Superior basin.

Recovery activities for areas most affected by water-quality problems are under way through Remedial Action Plans (RAPs), which include a terrestrial habitat component. RAP projects have included such strategies as construction of nesting islands for terns and construction of snake hibernaculums.

Locally based planning works best when projects involve a variety of partners, including local citizens, governments, businesses, and industries, collectively tackling the most significant ecosystems and stressors (The Nature Conservancy Great Lakes Program 1994). This requires both a historical perspective of the ecosystem and a vision for future conditions. What does the community want the shoreline to be like in 1, 5, 10, 50, 100, or 500 years? What is realistically achievable in terms of ecosystem processes, functions, and species and community elements? How will the vision be achieved? Who will participate?

Whether on a local or regional scale, ecosystem recovery planning is often too complex to be done by one agency. The Midwest Oak Ecosystems Recovery Plan is a multi-agency, multi-organizational effort begun in 1993 and continuing today. The plan is being continuously implemented, with reports on regional activities and science updates presented at biennial conferences.

At the species level, recovery plans may be developed for individual endangered species. In the United States, endangered species recovery planning is the responsibility of the U.S. Fish and Wildlife Service and federal, state, and private partners. Recovery planning includes identifying key parcels to enlarge or add to existing preserves and addressing the management of the entire ecosystem (Botts et al. 1994). In Canada, endangered species recovery plans are usually developed by a cooperative effort of federal, provincial, and non-governmental agencies.

Case Study: *Chicago Wilderness, Lake Michigan*

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It seems unlikely that some of the world's unique natural communities are nestled in and around the third largest metropolitan area in the United States. But while most of the rich lands of the corn belt were converted to farm land, fragments of wild nature survived around the southern end of Lake Michigan from Chiwaukee Prairie in southeast Wisconsin to a six-county area in northeastern Illinois that extends from the City of Chicago to the Indiana Dunes National Lakeshore in Indiana. Today, within Chicago Wilderness—more than 81,000 hectares (200,000 acres) of prairies, woodlands, dunes, beaches, streams, and wetlands—live many rare plants and animals that need help and protection.

You can find Chicago Wilderness everywhere—in forest preserves, conservation areas and parks, along greenways and waterways, and some backyards that can be home to native plants and animals. To save this natural legacy and make it an integral part of our everyday lives that contributes to our well-being, a group of 34 organizations that are already active in conservation efforts in the Chicago region have joined forces. By combining their skills and resources, these organizations are collectively working to protect and restore these precious natural areas.

Teams of scientists, educators, land managers, and dedicated citizens are actively pursuing conservation projects, including restoring damaged woodlands and wetlands, managing prairies, and monitoring populations of plants and animals in the area. The group is committed to helping interested residents better understand how they can play a direct role in caring for the nature around them.

Case Study: ***The Humber River Habitat Strategy, Toronto***

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As part of efforts to improve water quality and habitat conditions within Canadian Areas of Concern, habitat targets for upland systems have been developed and tested. As shown in the table below, these targets are intended to measure the degree of upland habitat rehabilitation that may be needed before the beneficial uses associated with fish and wildlife can be considered restored.

This approach has been tested in the five sub-watersheds of the Humber River, which drains into the Metro Toronto Area of Concern. GISs have been used to develop habitat mapping and to measure progress towards the targets. The sub-watersheds vary widely in their natural area cover, from only 4 percent of the land area to 48 percent. However, even the sub-watershed with the highest degree of natural cover falls short on targets for interior habitat, owing to the high degree of forest fragmentation in Southern Ontario.

These targets for upland habitats help to guide decisions on the degree of effort needed in rehabilitation programs and on priority opportunities for specific restoration projects. Additional targets will be developed for aquatic habitat needs along shorelines, streams, and wetlands. Further information is available in the interim report, “Identifying Habitat Rehabilitation Targets and Priorities in Great Lakes Areas of Concern: Upland Systems,” released by the Canada-Ontario Agreement RAP Steering Committee.

Habitat Targets:

Parameter	Target	Rationale
Percent forest cover in watershed	>30	Will support most bird species expected within range.
Size of largest forest patch (minimum of 500 m wide)	100 ha	Will support most bird species expected within range.
Percent of watershed that is forest cover 100 m or farther from edge	>10	Will support most forest-interior bird species within range.
Percent of watershed that is forest cover 200 m or farther from edge	>5	Will support most forest-interior bird species within range.
Percent of riparian habitat that is vegetated along first to third order streams	>75	Should maintain high stream integrity assuming no other major problems; may maintain cold water.
Percent of riparian habitat with at least 30 m wide buffers	>75	Should maintain high water quality and stream integrity.
Percent of watershed that is impervious	<15	Potential to maintain cold-water streams.

6.3 Preserve and Restore Large Tracts

Preservation through Acquisition

Both the United States and Canada have established a system of federal designations such as national parks both to protect areas for the enjoyment of their citizens and to preserve pieces of the landscape for future generations. States and provinces support parks and wilderness areas. Local land preservation organizations are active. Some special ecological communities are already being protected at all levels. The key to preservation in the future is continued efforts and good stewardship.

In the United States, over 100 different federal designations exist for resource protection, including the National Park System, Wildlife Refuges, National Forests, Research Natural Areas, Wild and Scenic Rivers, Experimental Ecological Areas, and Wilderness Areas. The Wilderness System is intended to prevent public access except by foot in large unfragmented tracts. Canada has a similar, but more limited, array of designations.

Most publicly owned U.S. federal and Ontario provincial land is multi-use—that is, managed for recreation, preservation of natural features, and use of renewable and non-renewable resources such as timber and minerals. As such, these lands are usually not managed to protect biodiversity as much as to protect the public interest in extractable resources. The five Canadian National Parks on the Great Lakes shore are, however, managed by policies that give priority to ecological protection, although reconciling recreational use is often a management challenge.

State and provincial natural resource agencies manage millions of acres throughout the Great Lakes basin. Although regulations governing mission and management differ, the combined effect is a vast network of areas set aside for natural resource values and recreation. Some states and provinces also manage extensive nature preserve systems, which often represent the best examples of ecological community types within their boundaries.

Many municipalities and local governments also own large tracts of land and manage them for biodiversity as well as for recreation. The City of Superior, Wisconsin, for example, manages more than 2,025 hectares (5,000 acres) of forest on the St. Louis River. Cook County, Illinois, home of the City of Chicago, has a 27,135-hectare (67,000-acre) Forest Preserve District with a mission to “restore and restock” the biodiversity for future generations. Ontario conservation authorities also hold large acreages of significant natural areas, which are managed for watershed protection, conservation, and recreation.

In Ontario, Areas of Natural and Scientific Interest (ANSI) have been identified to represent both life and earth science features of significance. ANSIs on provincial Crown lands are managed to maintain their natural features. On private lands, landowners and municipalities are encouraged to recognize and protect ANSIs through the municipal planning process.

Private organizations acquire and preserve land as well. The Nature Conservancy, for example, buys land specifically to preserve biodiversity. Private hunting clubs may preserve large tracts of land for members. Small not-for-profit organizations, such as the Shirley Heinze Foundation in northwest Indiana, buy small parcels and lots, piecing together a landscape that provides additional habitat for plants and animals also found in nearby Indiana Dunes National Lakeshore. The Federation of Ontario Naturalists' nature reserve system covers several significant coastal sites.

Case Study: *Sandy Pond Beach, Community-based Conservation*

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"Welcome to Sandy Pond Beach Natural Area," proclaims the visitors brochure. Beach users from near and far received that message last year as they anchored their boats in the sandy shallows along this mile-long stretch of globally rare Great Lakes dunes and sparkling white sand beach. An estimated 30,000 visitors shared the beach last year with the ecologically unique dunes and rare plants and birds the site supports. The dunes are better for the experience, and bird-watchers reported that the migrating shorebirds and rare terns continued to use the site in great numbers.

During 1995, The Nature Conservancy (TNC) and the New York State Department of Environmental Conservation (DEC) joined to develop a management plan for the site. By encouraging people to stay on the beach, the TNC and DEC provided ecologically sensitive access between Sandy Pond and the Lake Ontario beach. In addition, they defined a protected bird sanctuary on the damp sand flats adjacent to the Sandy Pond channel. Visitors responded positively by respecting protected areas.

TNC, DEC, and the volunteer Friends of Sandy Pond Beach share management responsibilities. DEC provides insurance, law enforcement, and site maintenance. TNC hired a dune steward and supplied building materials, signs, interpretive kiosks, and a brochure. The Friends helped to construct the dune walkovers, install the signs, plant 9,000 beachgrass plants, and share beach watch duties with the dune steward.

In July 1996, all parties joined together to dedicate the recent beach/dune access improvements at Sandy Pond and at Lakeview Wildlife Management Area, Deer Creek Marsh Wildlife Area, and Southwick Beach State Park, all part of the 27-kilometre (17-mile) stretch of Lake Ontario shoreline that is considered the eastern Lake Ontario "megasite." The celebration brought dignitaries and press to join the managers in recognizing the progress made in meeting the needs of both people and ecologically unique and sensitive dune habitats.

Restoration to Repair Damage to Ecosystems

Preservation of ecosystems within park or protected area boundaries, though difficult, is possible with good management. Stresses from outside the boundaries, however, may greatly influence the management of natural resources within parklands. Restoring the processes that allow special communities to function and species to flourish is needed to counteract stressors. “Ecological restoration is the process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems” (Society for Ecological Restoration, 1995). This is the on-the-ground collection of activities that reverses the process of ecosystem degradation and deals with stressors head-on.

Restoration activities may include removing exotic species, conducting prescribed burns, collecting and planting native seeds, constructing walkways or paths through sensitive areas, and repairing erosion prone areas. Citizen stewards provide people power to assist resource managers. Activities bring citizens into contact with land management issues and solutions, establishing responsive and creative caring for the land.

There are numerous examples of citizens restoring ecosystems across the Great Lakes basin. The residents of Minnesota Point in Duluth, Minnesota, for example, feel a particular affinity with Hearding Island, off the bay side of the spit. Owned by the Minnesota Department of Natural Resources, the island is a favourite place for bird-watching and canoeing. To restore the habitat, residents are assisting in planting white pine trees and removing the invasive tansy (*Tanacetum vulgare*) (Great Lakes National Program Office 1996).

Stewardship means that everyone takes responsibility for ecosystem preservation, not just a few organizations. The following case study illustrates one restoration activity—removing an exotic species—that is being undertaken by a state natural resource agency, a non-governmental organization, and several federal agencies.

Case Study: *Restoration of Great Lakes Coastal Habitats, Lakes Michigan and Huron*

Significant open dune, interdunal wetlands and alvar grassland communities, as well as threatened and endangered plants and animals, are being protected and maintained in four Michigan nature preserves by a partnership of The Nature Conservancy, Michigan Department of Natural Resources, U.S. Fish and Wildlife Service, the National Park Service, and citizens. Dudley Bay takes in a 5-kilometre (3-mile) shoreline parcel that contains high quality bedrock beach, northern fen communities, and dwarf lake iris populations. Coastal dunes and swales possess occurrences of Pitcher’s thistle and Houghton’s goldenrod. Grass Bay houses healthy populations of Houghton’s goldenrod, the Lake Huron tansy, and dwarf lake iris. Point Betsie is dominated by coastal dunes that provide habitat for Pitcher’s thistle, the Lake Huron locust, and fascicled broomrape. Maxton Plains is a high-quality alvar community on Drummond Island that supports a diverse assemblage of rare species, including Hill’s thistle and the tawny crescentspot butterfly.

The exotic plant baby’s breath (*Gypsophila paniculata*) is a hardy, diffusely branched, perennial herb with a deep penetrating root system that enables the species to overwinter and survive periods of drought. Single plants produce as many as 14,000 pepper-like seeds that can be wind-dispersed. This exotic plant has the potential to alter the habitats of native plant populations because it overwhelms native vegetation and inhibits sand movement. Three removal methods of this exotic plant are being tested in the four nature preserves. They include cutting the tap root as far below the surface of the ground as possible to inhibit resprouting, cutting the tap root at ground surface and treating the cut surface with herbicide, and cutting the tap root at ground surface and burning the cut surface.

Volunteers are assisting in the weed-removal work. In addition to directly restoring significant habitats, volunteers will learn more about the natural processes that form them and the species that inhabit them.

6.3.1 Shoreline Biodiversity Investment Areas

While much has been accomplished in acquiring and restoring significant tracts of shoreline, the job of protecting significant natural resources is clearly not complete. As outlined in Table 6 and the Appendix (section 8), only 9 of the 17 ecoregions have good or excellent existing representation within parks and protected areas. Many outstanding natural areas remain in private ownership.

In both Canada and the United States, although important sites are still being acquired to protect features, communities, and species, the trend is towards a multi-faceted management approach that includes private landowners as participants. Ecoregions are assessed for their representative and biodiversity values, then various tools are employed to protect the resources.

From an ecological point of view, not all sections of Great Lakes shoreline warrant the same degree of attention. Some areas, although small in size, may be critically important as habitats for nesting colonial birds or as hosts to imperilled plant communities. Other areas may serve an important regional function as sources of sediment to nourish nearby beaches or sand spits. These priority shoreline areas often occur in clusters, usually with a diversity of features, communities, and species. Protecting shoreline sites within these cluster areas is an investment that provides an extra bonus for biodiversity.

In general, it appears that many of the sand beach shorelines have been secured by public ownership, largely because of their recreational values. Scenic bedrock shores and islands are also often included within parklands, but the sloping limestone shores that support alvars are infrequently represented. Areas of unconsolidated shore bluff, which are often important source areas for sediment, are rarely represented within public ownership, although some are partially protected through land-use policies.

The following map and tables identify priority shoreline biodiversity investment areas, lake by lake and by ecoregion (described in the Appendix, section 8). The identification of these areas does not mean there are no other significant areas of biodiversity in the basin. Numerous other high quality, but smaller, areas exist. The 20 Biodiversity Investment Areas (see Figure 14), however, are clusters of shoreline areas with exceptional biodiversity values that present key opportunities to create large protected areas that will preserve ecological integrity and, ultimately, help protect the health of the Great Lakes themselves.

This map is intended to draw attention to those sections of shoreline with the greatest concentrations of biodiversity values, on the basis of existing information. While various initiatives to protect these values are underway, as listed in the current protection column of Tables 1 to 5, this mapping is not intended as a regulatory program.

Figure 14. Shoreline Biodiversity Investment Areas

Table 1. Shoreline Biodiversity Investment Areas: Lake Superior

Coastal Area/Ecoregion	Identified by	Special Features	Current Protection	Stressors
1. Northwestern Lake Superior (Lake Nipigon Ecoregion)	- Smith 1987a,b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Parks Canada 1995	- Landform representation - Arctic-alpine flora - Bird colonies - Coastal wetlands - Bedrock beaches	- Several provincial parks - Crown land guidelines	- Recreational use and developments - Logging
2. Eastern Lake Superior (Abitibi Plains and Lake Timiskaming Lowland Ecoregions)	- Bowes 1989 - Wildlands League 1995	- Landform representation - Arctic-alpine flora - Bird colonies - Rare species - Coastal dunes - Bedrock beaches	- National park - Several provincial parks - Crown land guidelines	- Recreational use and developments
3. Grand Sable Dunes (Northern Continental Michigan, Wisconsin, Minnesota Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Perched sand dunes - Boreal forest - Rare species	- National lakeshore	- Recreational use
4. Keweenaw Peninsula (Northern Continental Michigan, Wisconsin, Minnesota Ecoregion)	- Soule 1993 - Albert et al. 1994 - TNC 1994 - TNC 1995	- Landform representation - Bedrock beaches - Cliffs	- State and county parks - MI Nature Association - TNC	- Second-home development - Logging - Mining
5. Bad River Watershed / Bayfield Peninsula (Northern Continental Michigan, Wisconsin, Minnesota Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Estuarine marsh - Sand spit - Sand beaches/dunes - Bogs, swamps - Bird nesting, loafing and staging area - Apostle Islands	- Bad River tribe - Wisconsin DNR - TNC - National Park Service - Federal park	- Exotic species - Logging - Toxic landfills - Point source discharges - Water diversion - Recreation

6. Lake Superior Highlands / Isle Royale (Northern Minnesota Ecoregion)	- TNC 1994 - TNC 1995 - Collins 1995	- Landform representation - Arctic flora - White pine forest - Upland white cedar forest - Waterbird nesting - Globally rare species - Islands	- Federal parks - State parks	- Second-home development - Logging - Recreational use - Acid rain

Table 2. Shoreline Biodiversity Investment Areas: Lake Michigan

Coastal Area/Ecoregion	**Identified by**	**Special Features**	**Current Protection**	**Stressors**
1. Michigan Islands (Northern Lacustrine-Influenced Lower Michigan Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Sand beaches/dunes - Cobble beaches - Bogs - Rare/endemic species - Colonial nesting birds - Migratory bird stopover	- National wildlife research area - State environmental areas	- Potential for toxic chemical spill from ships - Development
2. Chicago Wilderness (South Central Great Lakes and Southwestern Great Lakes Morainal Ecoregions)	- TNC 1994 - TNC 1995 - Chicago Biodiversity Council 1995	- Landform representation - Tallgrass prairie - Oak savannah - Wetlands - Sand beaches/dunes - Migratory birds/rookeries - Significant rare species representation	- Federal and state parks/designations - Forest Preserve Districts - TNC - Other not-for-profit	- Urban, industrial development - Shoreline armouring - Point and non-point source pollution - Hazardous waste - Exotic species - Habitat destruction/ fragmentation
3. Door County Peninsula (Northern Lacustrine-Influenced Upper Michigan and Wisconsin Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Sand beaches/dunes - Fish spawning - Migratory bird staging area	- State parks - State conservation areas	- First and second-home development - Erosion - Runoff - Toxics - Altered hydrology

4. Green Bay Western Shore (Northern Lacustrine-Influenced Upper Michigan and Wisconsin Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Colonial nesting birds - Marshes	- State conservation area - Wisconsin Stream Anti-degradation Rules Protection	- Habitat fragmentation - Point source pollution - Water-level fluctuations

Table 3. Shoreline Biodiversity Investment Areas: Lake Huron

Coastal Area/Ecoregion	Identified by	Special Features	Current Protection	Stressors
1. Mackinaw-Manitoulin (Manitoulin-Lake Simcoe Ecoregion)	- Smith 1987a,b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Parks Canada 1995 - Bowes 1989	- Landform representation - Alvar communities - Sand dune communities - Bird colonies - Exceptional biodiversity - Endemic plant communities	- A few small nature reserve parks	- Cottage developments - Quarrying - Lack of ecological information base
2. Eastern Georgian Bay (Algonquin-Lake Nipissing Ecoregion)	- Smith 1987b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Bowes 1989	- Landform representation - Atlantic coastal plain communities - Coastal gneissic rocklands flora/fauna - Bird colonies - Island archipelago	- National park - Several provincial parks and ANSIs - Crown land guidelines	- Cottage and marina development - Recreational boating - Water quality
3. Bruce Peninsula (Manitoulin-Lake Simcoe Ecoregion)	- Smith 1987b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Parks Canada 1995 - Bowes 1989	- Landform representation - Alvar communities - Limestone islands, cliffs, and talus slopes - Unconsolidated shore bluffs - Bedrock beaches	- National park - Several provincial nature reserve parks and ANSIs - Niagara Escarpment Plan	- Cottage developments - Logging
4. Saginaw Bay (Southern Lower Michigan Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Lakeplain wet prairie - Wet-mesic prairie - Marsh - Oak savannah - Rare species - Breeding bird habitat - Migratory bird stopover	- State wildlife areas - State environmental area	- Habitat fragmentation - Pollution - Agriculture - Development

5. Misery Bay (Northern Lacustrine-Influenced Lower Michigan Ecoregion)	- TNC 1994 - TNC 1995	- Landform representations - Karst formations - Wet meadows - Cliffs - Fens - Conifer swamps - Marsh - Rare species - Migratory hawk and passerine bird stopover	- State forest - Michigan State Nature Association - Largely private - State environmental areas	- Development

Table 4. Shoreline Biodiversity Investment Areas: Lake Erie/Lake St. Clair

Coastal Area/Ecoregion	**Identified by**	**Special Features**	**Current Protection**	**Stressors**
1. Long Point (Erie and Ontario Lakeplain Ecoregion)	- Smith 1987b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Bowes 1989	- Landform representation - Coastal wetlands - Sand beaches/dunes - Exceptional biodiversity	- National wildlife area - Provincial parks	- Disruption of sediment - Water quality - Marinas
2. Presque Isle (Lake Erie Lowland Ecoregion)	- TNC 1994 - TNC 1995	- Landform representation - Sand spit - Sand beaches/dunes - Rare species and communities - Migratory bird stopover	- State park	- Urban runoff - Recreational use - Exotic species
3. Western Lake Erie/Oak Openings (Lake Erie Lowland and Erie and Ontario Lakeplain Ecoregions)	- TNC 1994 - TNC 1995 - Smith 1987a,b - Wildlands League 1995	- Landform representation - Black oak savannah - Coastal plain marsh - Dry sand prairie - Sand beaches - Sand dunes - Estuarine marsh - Boreal flatwoods - Rare species - Migratory bird corridor/colonies - Coastal wetlands - Alvar flora	- Canadian National park - Several provincial nature reserves and ANSIs - Toledo Metroparks - U.S. National Wildlife Refuge - TNC - State environmental areas	- Water-level changes - Agriculture - Development - Industry - Pollution - Breakwalls - Exotic species

4. Lake St. Clair/Detroit River (Lake Erie Lowland and Southern Lower Michigan Ecoregions)	- TNC 1994 - TNC 1995 - Smith 1987a,b - Wildlands League 1995 - Bowes 1989	- Landform representations - Mussel species - Delta marsh - Tallgrass prairie - Oak savannah	- Canadian Wildlife Sanctuary - Walpole Island First Nation Reserve - State parks - State environmental areas	- Exotic species - Pollution - Agriculture - Development

Table 5. Shoreline Biodiversity Investment Areas: Lake Ontario

Coastal Area/Ecoregion	Identified by	Special Features	Current Protection	Stressors
1. Eastern Lake Ontario (Manitoulin-Lake Simcoe, Frontenac, and Erie and Lake Ontario Lakeplain Ecoregions)	- Smith 1987a,b - Wildlands League 1995 - TNC 1994 - TNC 1995 - Parks Canada 1995 - Bowes 1989	- Landform representation - Coastal wetlands - Coastal gneissic rockland flora - Bird colonies - Island clusters - Raptor/waterfowl flyway - Fishery resources - Barrier beaches/dunes	- National park - Several provincial parks and ANSIs - National wildlife area	- Cottage developments - Erosion - Water-level fluctuations

6.4 Involve Private Landowners

Land acquisition or fee title ownership can protect ecosystems within property boundaries. This is an expensive ecosystem protection measure. A major drawback is that legislation or jurisdictional boundaries separate ecosystems from most human activities. Protecting ecosystems, and their processes and functions, only within fences is not sustainable, nor does that approach contribute fully to the quality of life for humans and other organisms. A solution is to look at all landscapes, public as well as private, as part of ecosystems. Without outright public acquisition, the challenge is how to protect the integrity of Great Lakes shoreline ecosystems while taking private property rights into account.

One way is to negotiate management agreements that protect ecosystems. These agreements generally encourage conservation activities designed to protect resources (The Nature Conservancy 1994). DuPont Corporation, for example, owns a large tract of land in northwest Indiana on the southern shores of Lake Michigan that is ecologically important to the region. The corporation is negotiating an agreement with The Nature Conservancy to conduct periodic controlled burns to manage exotic species and encourage the growth of native vegetation. The property is an important piece within a fragmented and polluted landscape, and the agreement will thus contribute greatly to the ecological health of the entire region.

Conservation easements are legal agreements “by which a landowner voluntarily restricts or limits the type and amount of development that may take place on his or her own property” (The Nature Conservancy 1992). The many variations of easements are governed by the states and the province of Ontario; however, the holder of a conservation easement must be a qualified conservation organization or government agency. The holder of the easement has the right to enforce restrictions and limit right of access for inspection, scientific data collection, and active management. The landowner retains all rights other than those specified in the easement, continues to pay taxes on the property, and makes sure restrictions are not violated. Many easements are perpetual—that is, they are transferred along with property ownership (The Nature Conservancy 1992).

One form of non-binding agreement is for landowners to agree to systematically document rare species and communities on their properties so they can be included in local inventories. Registering is voluntary, however, some fear it may lead to government regulation or property condemnation if an endangered species is discovered (The Nature Conservancy Great Lakes Program 1994).

In Ontario, private land stewardship programs have been carried out in a number of areas to encourage landowners to recognize significant natural areas, to provide management information, and to raise awareness of assistance programs. Landowners of provincially significant ANSIs and wetlands who agree to maintain habitats in their natural state can qualify for a provincial rebate on their property taxes. Increasingly, community-based groups are also undertaking land trust activities, such as acquiring natural lands through donation or purchase.

Conserving ecosystems on private lands may not entail formal agreements. Many citizens take great care to preserve the natural integrity of their properties. Land conservancies and trusts promote landowner awareness of and care for ecosystems. One goal of the Grand Traverse Bay Watershed Initiative in Michigan, for example, is “To promote resource-protective local land use decisions” (Grand Traverse Bay Watershed 1995). Another example is the interest in native plant gardening in Chicago and Toronto. In Chicago, private landowners grow native plants in their yards, blurring the lines between private yards and adjacent Forest Preserve District lands. In Toronto, a community group will link the backyards in several square blocks and plant native species to promote recognition of the region’s natural heritage (D’Alessandro 1996).

Case Study: ***Habitat Development on Industrial and Private Property: The St. Clair River Waterways for Wildlife Program***

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Corporations own about 25 percent of the privately owned land within the United States. National programs to preserve and protect our natural resources for future generations should and do involve the corporate sector. The Wildlife Habitat Council (WHC), with its corporate and conservation members, is demonstrating that corporations can—and are willing to— act voluntarily to preserve and protect the environment. WHC is a non-profit, non-lobbying organization established in 1988 as a joint venture between the corporate and conservation communities. The council encourages and helps corporations to develop and establish voluntary wildlife management programs on corporate lands. WHC members currently manage nearly 121,500 hectares (300,000 acres) of property for wildlife at more than 350 sites internationally.

Through the Waterways for Wildlife program, WHC is working with Detroit Edison, Ontario Hydro, Terra International, Consumers Power, Ford Motor Company, and other corporate and conservation groups to establish and implement an international watershed management plan for the St. Clair River, which flows between Michigan and Ontario. The Waterways for Wildlife project is designed to promote voluntary cooperative habitat enhancement efforts initiated by WHC member corporations along river corridors. These successful efforts are used as models to encourage participation from neighbouring public and private land managers.

The St. Clair River Waterways for Wildlife program will focus on engaging corporate and private landholders to manage their properties to achieve the project objectives identified by the general program participants. (The plan incorporating these objectives was due for release during the summer of 1996.) Although just beginning, the St. Clair River Waterways for Wildlife program has achieved some notable early results, including engaging conservation, corporate, and natural resource agencies in joint discussions regarding habitat enhancement activities in the watershed; coordinating a joint reforestation effort on the Darcy McKeough Floodway Channel between the St. Clair Region Conservation Authority and Detroit Edison; establishing an international steering committee of conservation organizations and corporations to spearhead the project; becoming partners with the Rural Lambton Stewardship Network and the Ontario Ministry of Natural Resources on several restoration and management projects; and aiding Detroit Edison in the expansion of its wildlife management program at the Belle River Power Plant and other properties in the St. Clair River basin.

Through the Waterways for Wildlife program for the St. Clair River, project participants are protecting and enhancing habitat along the river, using scarce financial resources more efficiently, contributing to the long-term health and viability of the river, and providing productive habitat for riparian, upland, and prairie-associated wildlife.

6.5 Make Use of Legislation and Regulations

The United States and Canada are both signatories to the International Convention on Biological Diversity. Canada has prepared a National Biodiversity Plan. Legislation that deals with issues of ecosystem preservation is, however, often piecemeal and indirect.

In the United States, the Lacey Act of 1900, the Migratory Bird Treaty Act of 1918, the Migratory Bird Conservation Act of 1929, the Bald Eagle Protection Act of 1940, and the Endangered Species Act of 1972 were designed to protect individual species. The Clean Water Act of 1977 is broader in intent, requiring a coordinated land use and water cleanup. The main objective is to restore and maintain the “chemical, physical, and biological integrity of the Nation’s waters.” It seeks to secure “water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water.” In addition, it contains wetlands licensing provisions.

Other U.S. laws have ecosystem components. The National Environmental Policy Act of 1969, signed into law on January 1, 1970, encourages protection of the environment and understanding of ecological systems and natural resources. The Federal Water Pollution Control Act Amendments of 1972 declares as a national goal that all waters of the United States be made clean enough for fishing and swimming. One of the purposes of the Clean Air Act Amendments of 1990 is to "preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value."

States enact legislation appropriate to their circumstances. Michigan's Shorelands Protection and Management Act of 1970, for example, regulates sensitive coastal areas, particularly those with a high erosion risk and sensitive wildlife populations (Michigan Natural Resources Commission 1982). Many states have endangered species and natural areas dedication laws that are powerful in preserving special ecological communities.

Case Study: ***Michigan's Shorelands Protection and Management Act***

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In Michigan, the Shorelands Protection and Management Act, 1970 PA 245 (now recodified as Part 323, 1994 PA 451) provided statutory authority to designate the shoreline property, found necessary for the maintenance and preservation of fish and wildlife as Environmental Areas (EA). EA designation required permits for any vegetation alteration, fill, development, etc., within the EA boundaries [Note that this statute was enacted prior to Michigan's Wetlands Protection Act, 1979 PA 203 and affords additional protection of habitat by regulating the cutting of vegetation - unlike PA 203 and Section 404 of the Clean Water Act.]

EA designations typically focused on large coastal wetland embayments and undisturbed/non-fragmented areas of shoreline. Upland habitats were also included where they were found to also contribute to necessary fish and wildlife habitats (i.e. nesting, cover, feeding, etc.).

This program, called the EA Program, has been successful in maintaining large tracts of coastal wetland and upland in their natural state especially given that 404 and Michigan's Wetland Statute exempts the cutting of vegetation. Therefore, if statutes are available and the political climates allow, designations similar to this found in Michigan can greatly increase protection of valuable aquatic and terrestrial nearshore biota.

Unfortunately, only 275 linear miles of Michigan's shoreline is designated as EA and no new designations have been formally adopted since 1986. Studies and surveys are being conducted of Lake

Michigan's drowned river mouths to provide documentation for future efforts to designate more EAs in Michigan.

Local governments operate under state statutes but are authorized to plan and zone. Zoning is a potential tool for protecting ecosystems either by prohibiting certain uses or by setting appropriate protective standards for permitted uses.

On the Canadian side of the Great Lakes, there is considerable equivalent legislation, with more than 20 pieces of legislation dealing with some aspect of land use and management in the nearshore area. The federal role is largely administered by Environment Canada and the Department of Fisheries and Oceans, using such legislation as the National Parks Act, Migratory Birds Convention Act, Canada Wildlife Act, Fisheries Act, and the Canada Water Act.

The Ontario Ministry of Natural Resources has primary provincial responsibility for shoreline management, primarily through the Lakes and Rivers Improvement Act and the Public Lands Act. In Southern Ontario, most shoreline management planning and licensing activities have been delegated to watershed-based Conservation Authorities, which operate under the Conservation Authorities Act.

Ontario municipalities, at both the local and regional level, have an important role in land-use planning and control under the Planning Act. Municipalities can establish development setbacks from shorelines, and can identify significant natural areas or hazard lands in their Official Plans and zoning documents. Through provincial policy, municipalities are required to have regard for significant wetlands and ANSIs in their planning decisions.

Legislation is generally reactive in nature, and the protection it affords varies, depending on the situation. Generally, however, action through legislation tends to be costly and slow (The Nature Conservancy Great Lakes Program 1994).

6.6 Educate to Build Support

People visit our spectacular western parks in large numbers. Unbroken tracts of forest, challenging mountain peaks, roaring rivers, and the attraction of wild animals appeal to vacationers seeking interesting sights and solitude. The treasures of the Great Lakes basin coastline are unique and spectacular in their own right. The wild and rugged cliffs along the north shore of Lake Superior, unusual plant and animal species of Lake Huron's coastal alvars, steep sand dunes on Lake Michigan's eastern shore, thousands of migratory birds over Lake Erie's Long Point, and beautiful sand beaches on Lake Ontario's eastern shore rival any scenic vista in North America.

Education about shoreline ecosystems and their important functions is needed for all citizens. A translation of information into a common language would help the dissemination of important facts. Whether they're individual citizens or school-age children in a classroom, people need information to make wise decisions about ecosystems.

Education is a diverse enterprise. In the Chicago area, for example, The Nature Conservancy launched the Mighty Acorn Program to teach children about the biodiversity of the region and to involve them in protection and restoration activities as part of an overall school curriculum. Students, teachers, parents, volunteers, and volunteer stewards or land managers "discover" tallgrass prairies and oak savannahs in the Forest Preserve Districts and actively help to manage these areas. Recently, a contingent of U.S. Environmental Protection Agency staff joined the Mighty Acorns Program to help combine ecological issues and pollution concerns.

Several efforts are taking place to promote "regional ecosystem" thinking, which can be helpful in building support for Great Lakes habitat restorations. Parks Canada has sponsored regional ecosystem studies around national parks, with extensive local involvement. A similar initiative is under way in the Apostle Islands–Chequamegon area on the southern shores of Lake Superior. These initiatives help people to see their local natural areas in a broader context and to appreciate connections to broader issues.

Case Study: *Ojibway Prairies and Savannahs, City of Windsor*

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The success of the Ojibway Prairie Complex in Windsor, Ontario, has not been achieved without its challenges. Perhaps the greatest challenge currently facing the complex is changing the public's perception of nature and protecting the fragile prairie environment while still providing public access.

Neighbours enjoy the natural surroundings but their tolerance for wildlife can be tested when mosquitos interrupt a backyard barbecue or skunks, opossums, or raccoons upset a garbage can. The perception that everything, including nature, must be "neat," "clean," and contained within certain boundaries has led to some negative reactions. In response, Windsor's Department of Parks and Recreation and the Ontario Ministry of Natural Resources initiated public relations and education programs aimed at local residents. Their efforts paid off. People are beginning to understand that nature isn't always as tidy as they expect. Attitudes are changing as people realize the true value and beauty of natural areas and, in particular, the tallgrass prairie of the Ojibway Prairie Complex.

The urban setting brings other difficulties. Intensive human activity in and around Ojibway places a strain on the parklands. As I've said, "Our goal is to make the Complex well known enough to keep it protected, but protected enough to keep it well known. In order to make Ojibway well known we need the people. The problem arises when too many people want to use Ojibway and end up degrading the park."

The Ojibway Nature Centre offers opportunities for neighbours to learn about the prairies. Day camps for children, naturalist field trips, bird-watching tours, and seasonal festivals offer the public a special opportunity to take part in nature-oriented activities and enjoy the outdoors in any season.

7. How Will We Know What We've Achieved?

Biological diversity not only underpins the ecological integrity of the Great Lakes, but is an accurate and sensitive barometer of an ecosystem's health. (Soule 1993)

The information presented in the preceding sections brings us to a critical juncture. What does it all mean? How can we use it to better our Great Lakes coastal environment?

According to the United States Intergovernmental Task Force on Monitoring Water Quality, an indicator is a "measurable feature which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality, or reliable evidence of trends in quality." The International Joint Commission (1996) further clarifies:

An indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. It is a sign or symptom that makes something known with a reasonable degree of certainty. An indicator reveals, gives evidence. Its significance extends beyond what is actually measured to a larger phenomenon of interest. . . . Environmental indicators communicate information about the environment and about the human activities that affect it.

The development of appropriate indicators for the health of nearshore terrestrial ecosystems involves consideration of four key questions:

1. *What is happening in the environment?*
2. *Why is it significant?*
3. *Why is it happening?*
4. *What are we doing about it?*

(International Joint Commission 1996)

The following sections offer three sets of environmental indicators for nearshore terrestrial ecosystems that are based on the background information in previous sections of this report. The indicators inevitably involve some degree of judgement, which is open for discussion and revision where necessary. However, we present the indicators in a systematic way, using known facts and figures and relevant information, balancing what is known and observed, and connecting the actions of humans with specific landscape results.

First, we present the status of nearshore terrestrial ecosystems within each ecoregion described in section 3.0 and the Appendix, section 8. Second, we summarize each significant ecological community described in section 4.0. The information presented in sections 5.0 and 6.0 has also been used for both sets of indicators. Finally, we describe a lake-by-lake look at four suggested Great Lakes basinwide indicators. This hierarchial approach is intended to provide an appropriate context for each indicator and to focus attention on the most significant elements of the nearshore ecosystem.

In assessing indicators, the time scale being considered is primarily the current period, including the recent few years. On a longer time scale, the nearshore ecosystem of almost all Great Lakes shorelines has changed dramatically through the large-scale clearing of trees, construction of harbours and breakwalls, stonehooking and lakefilling, and many other activities. Particularly in the lower Great Lakes, natural communities in today's nearshore terrestrial area are remnants of what existed in pre-European settlement times. The proposed indicators consider the extent and health of those remnants and the trends affecting them as they exist today.

In general terms, the suggested indicators measure two desired outcomes, as modified from those proposed by the Indicators for Evaluation Task Force (International Joint Commission 1996):

1. Maintenance of the ability of nearshore terrestrial biological communities to function normally within the context of a dynamic lakeshore environment.

2. Maintenance of the diversity of nearshore terrestrial biological communities, species, and genetic variation within species.

7.1 Status of Ecosystem Health for Ecoregions

In the past, most Great Lakes information has been collected either for the area as a whole or for political jurisdictions. For terrestrial environments, including shorelines, a third framework for analysis is particularly relevant—that of the ecoregion. Within Canada, the newly revised ecozones and ecoregions are being used to prepare the 1996 national State of the Environment Report, particularly with respect to forestry and agricultural information (Ecological Stratification Working Group 1996). Future monitoring activities will also be related closely to this framework. Since the nature of Great Lakes shorelines is closely linked to the characteristics of the ecoregion, it would be worthwhile and efficient to assess future progress in protecting or restoring nearshore terrestrial habitats on an ecoregion, as well as lake-by-lake, basis.

Ecoregions and ecodistricts (the next level down in a hierarchial system; each ecoregion typically has 4 to 10 ecodistricts—princes, sections, and subsections in the United States) are also used to identify gaps in representation of ecological diversity and to evaluate candidate areas for protection (Gauthier et al. 1995). The same landscape units can be employed to identify gaps in representation along the Great Lakes shore. This report provides a very rudimentary start at such a gap analysis, but a more detailed theme study, preferably at an ecodistrict level, is needed to adequately review all existing information. Since work is currently under way to develop a set of aquatic natural regions and classification of community types for the Great Lakes (Recchia 1996; Higgins and Lemmert 1996), a coastal theme study could incorporate representation aspects from both terrestrial and aquatic perspectives.

The following table attempts to characterize the quality of Great Lakes coastal ecoregions. Representation of significant natural communities and rate of land-use change affecting these communities suggest indicators. Refer to the Appendix, section 8, for descriptions of each ecoregion.

The first four categories in Table 6 identify some of the key natural communities and features occurring within each ecoregion, and provide a rough assessment of how well they are represented within existing protected areas. That assessment is based partially on the length and diversity of shoreline included within protected areas, and partially on how well the significant communities are represented.

The next four categories provide an estimate of the degree to which the shoreline edge and the shoreline watersheds are affected by land uses involving extensive changes from natural conditions. These estimates are a snapshot of current conditions, even though the original impact to the natural ecosystem (from land clearing, for example) may have occurred many years ago.

The Rate of land use change category estimates how quickly the land uses near the lakeshore in the bioregion are changing now, approximately over the past two decades.

The next category looks at how government agencies, citizens groups, industries, or others are responding to ecological stresses along the lakeshore, through Lakewide Management Planning programs, Remedial Action Plans, or other initiatives.

The Trend in shoreline health category attempts to draw together the representation information, the cataloguing of land use stresses, the rate of change and the planning/restoration responses to an overall comparative rating for the ecoregions.

Finally, using all of the above factors, we gave each ecoregion an overall rating of nearshore terrestrial habitat health. The only region we rated “A”, in good condition with regard to the quality of the shoreline, is Abitibi Plains (Figure 15). We gave the following seven ecoregions a “B” or pretty good rating: Lake Nipigon, Lake Timiskaming, Algonquin-Lake Nipissing, Northern Lacustrine-Influenced Lower Michigan, Northern Lacustrine-Influenced Upper Michigan and Wisconsin, Northern Continental Michigan, Wisconsin, and Minnesota, and Northern Minnesota (Figure 16). The shoreline of the following five ecoregions are considered to be “C” or fair: Thunder Bay-Quetico, Frontenac Axis, Southern Lower Michigan, South Central Great Lakes, Southwestern Great and Lakes Morainal (Figure 17). Lastly, the shorelines of four ecoregions are rated “D” or poor (Figure 18).

Because of the varying nature of the ecoregions and their relationship to the Great Lakes, this approach works better in some regions than others. In the ecoregions along the north shore of Lake Superior, for example, land uses and stresses are fairly consistent across the coastal areas of each ecoregion. But in some of the more southerly ecoregions, particularly those which front on more than one of the lakes, this degree of generalization may mask important internal differences.

Some SOLEC 96 conference participants were concerned the ecoregional ratings are overly generalized. Future refinements to this approach, perhaps using a more detailed ecodistrict scale and incorporating quantitative data wherever possible, would be valuable.

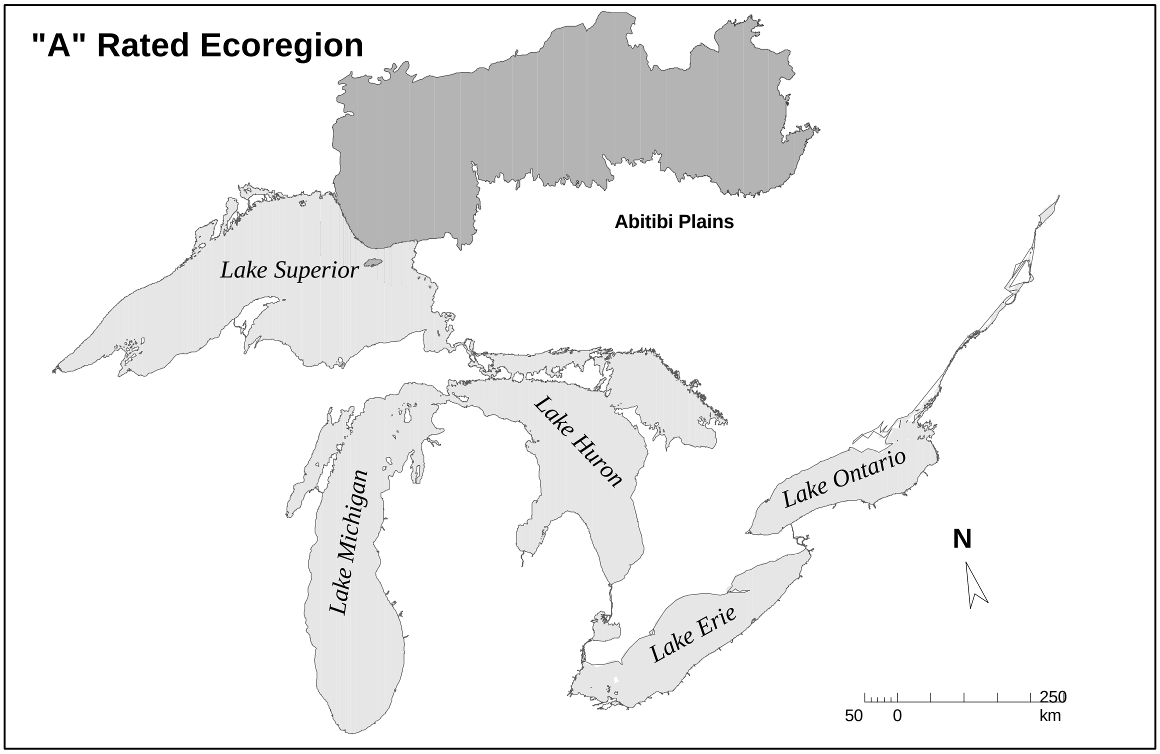


Figure 15. “A” Rated Ecoregions

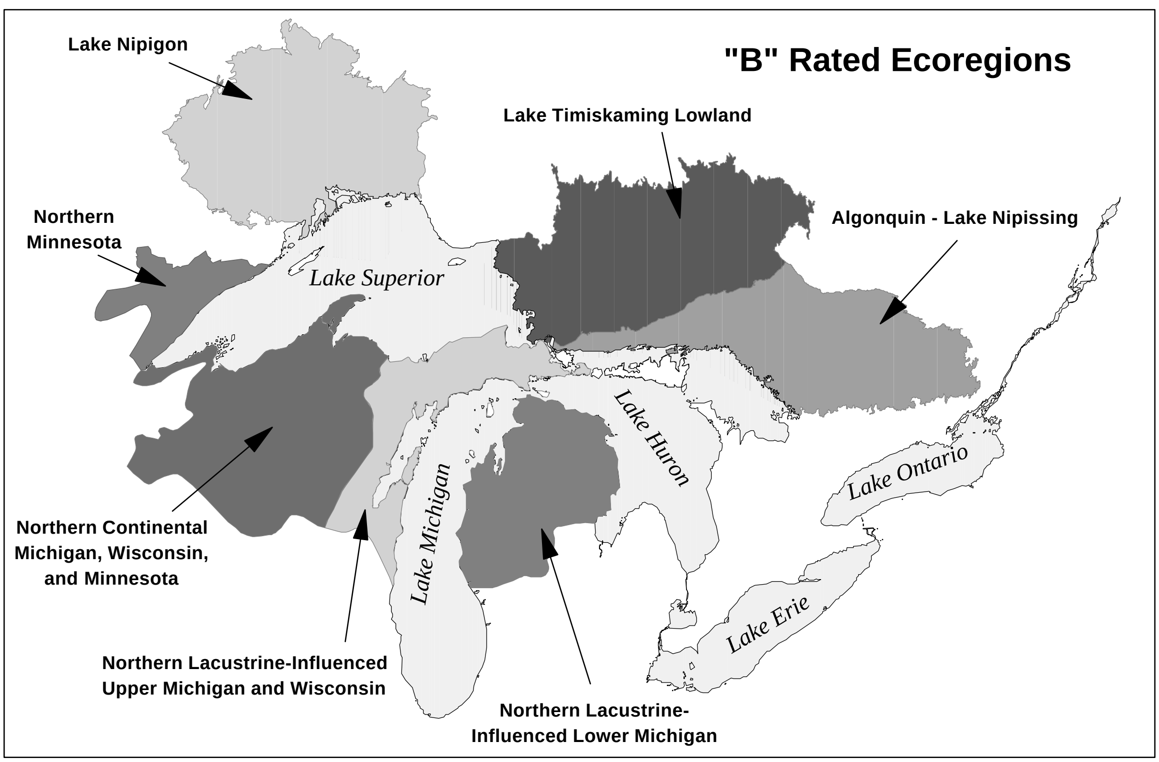


Figure 16. “B” Rated Ecoregions

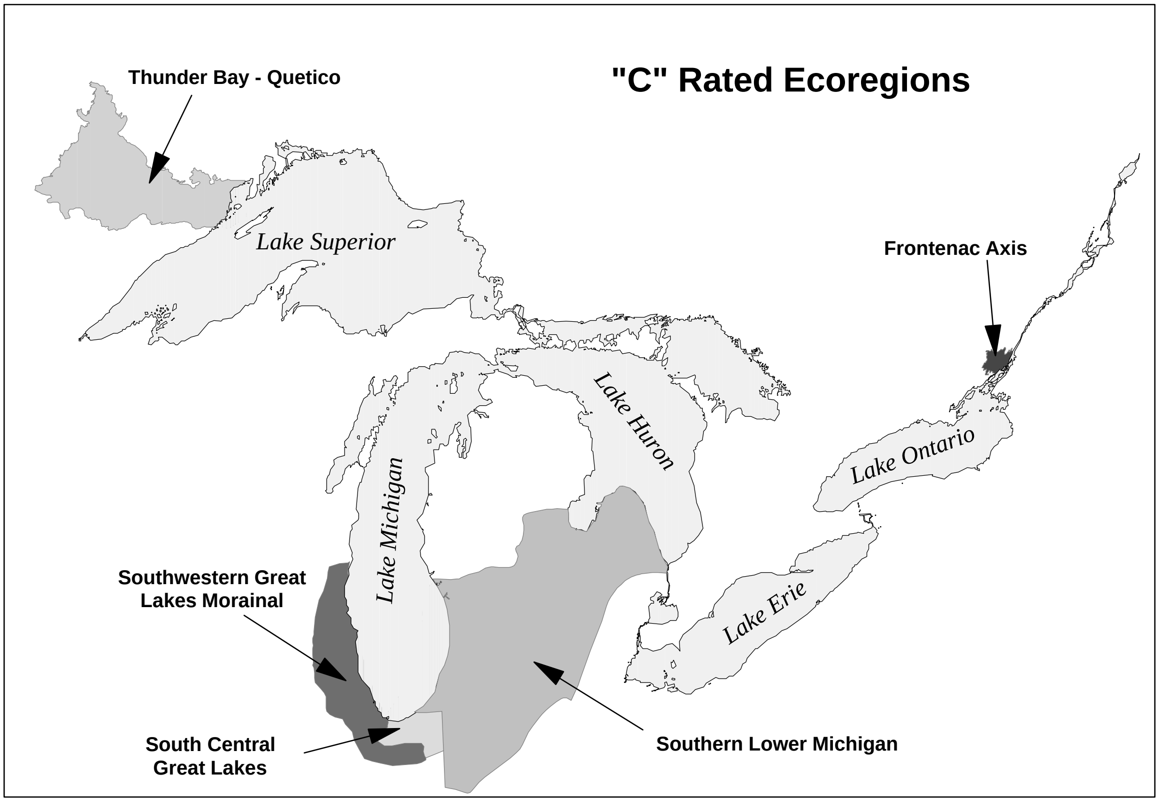


Figure 17. "C" Rated Ecoregions

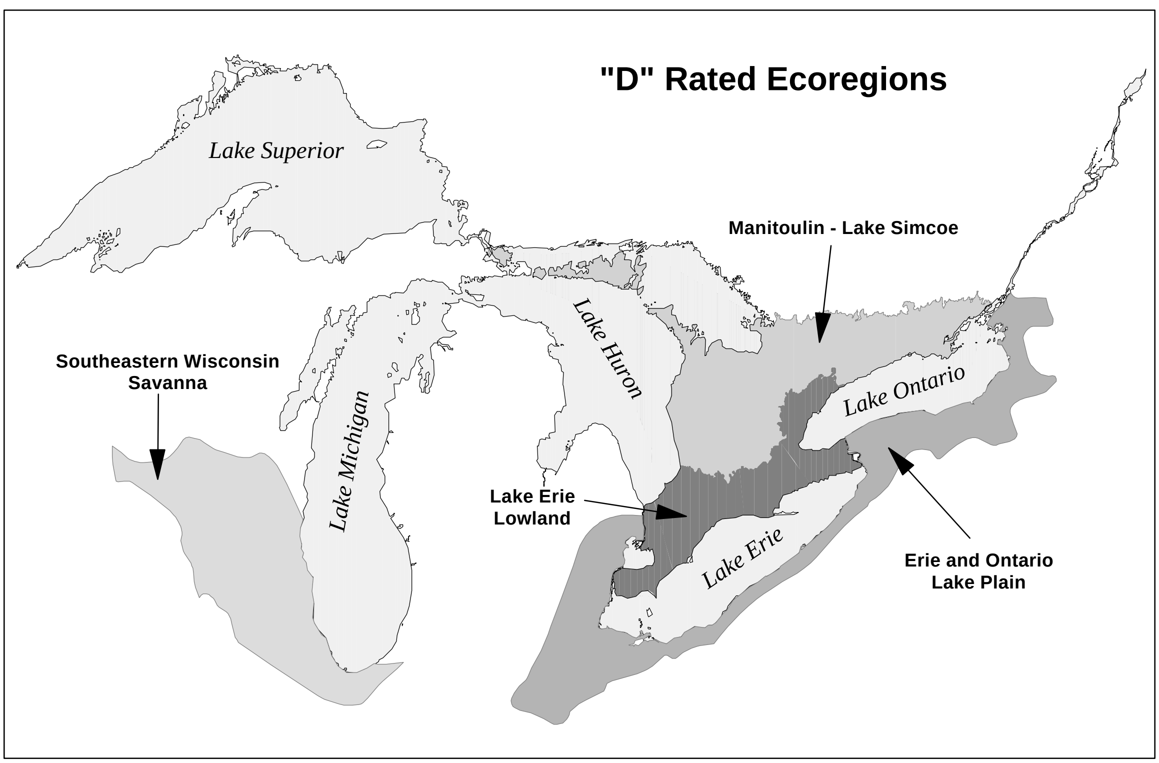


Figure 18. "D" Rated Ecoregions

Table 6. Status of Ecosystem Health for Great Lakes Coastal Ecoregions

	Thunder Bay–Quetico	**Lake Nipigon**	**Abitibi Plains**	**Lake Timiskaming Lowland**
Characteristic shoreline types	- Bedrock, cobble	- Bedrock, cobble	- Cobble/boulder	- Bedrock, cobble, sand beaches
Significant natural communities	- Arctic disjuncts - Islands - Cobble/gravel beaches	- Cobble/gravel beaches - Arctic disjuncts - Islands	- Cobble/gravel beaches - Arctic disjuncts	- Sand beaches - Dune systems - Cobble/gravel beaches
Existing representation in parks/protected areas	Poor–moderate	Good	Excellent	Good
Priority unprotected features	- Delta wetlands - Bird colonies - Geological sites	- Islands/headlands complex - Geological sites - Offshore aquatic		- Geological sites
Urban area within shoreline watersheds	Low–moderate	Very low	Very low	Very low
Agriculture within shoreline watersheds	Low	Very low	Very low	Very low
Residential/cottage/ marina shoreline use	Low–moderate	Low	Very low	Low
Lake edge armoured against erosion	Low	Very low	Very low	Very low
Rate of land-use change	Moderate	Low	Very low	Low
Planning/restoration activities under way	- Thunder Bay RAP	- Nipigon Bay RAP - Jackfish Bay RAP - Peninsula Harbour - National Marine Conservation Area planning		
Trend in shoreline health	Moderately degrading	No change	No change	No change
Overall rating of nearshore terrestrial habitat health	**C**	**B**	**A**	**B**

Table 6. Status of Ecosystem Health for Great Lakes Coastal Ecoregions (continued)

	Algonquin–Lake Nipissing	**Manitoulin–Lake Simcoe**	**Lake Erie Lowland**	**Frontenac Axis**
Characteristic shoreline types	- Bedrock	- Bedrock, cobble/boulder, sand beach, shore bluff	- Unconsolidated bluffs, sand beaches and spits	- Bedrock
Significant natural communities	- Coastal gneissic rockland - Islands	- Sand beaches - Dune-panne systems - Unconsolidated bluff - Alvar - Atlantic coastal plain disjuncts - Islands	- Sand beaches/spits - Dune-panne systems - Unconsolidated bluffs - Prairie/savannah - Alvar - Wetlands - Limestone islands	- Islands - Gneissic rocklands
Existing representation in parks/protected areas	Good	Moderate–good	Moderate	Good
Priority unprotected features	- Geological sites - Bird colonies	- Alvars - Shore bluffs - Offshore aquatic	- Prairie/savannah - Wetlands - Shore bluffs	- Islands - Wetlands
Urban area within shoreline watersheds	Low	Moderate	Very high	Low–moderate
Agriculture within shoreline watersheds	Low	High	Very high	Low
Residential/cottage/ marina shoreline use	Moderate–high	High	Very high	High
Lake edge armoured against erosion	Very low	Low	Very high	Low
Rate of land-use change	Moderate–low	High	Very high	Moderately high
Planning/restoration activities under way	- St. Marys River RAP - Spanish Harbor RAP - Severn Sound RAP	- Collingwood Harbour RAP - Port Hope RAP - Bay of Quinte RAP - Lake Ontario Greenway Strategy	- St. Clair River RAP - Detroit River RAP - Wheatley Harbour RAP - Niagara River RAP - Hamilton Harbour RAP - Metro Toronto RAP - Lake Ontario Greenway Strategy	
Trend in shoreline health	No change	Moderate–severely degrading	Severely degrading	Moderately degrading

Overall rating of nearshore terrestrial habitat health	**B**	**D**	**D**	**C**

Table 6. Status of Ecosystem Health for Great Lakes Coastal Ecoregions (continued)

	Erie /Ontario Lake Plain	**Southern Lower Michigan**	**South Central Great Lakes**	**Southwestern Great Lakes Morainal**
Characteristic shoreline types	- Sand beaches and dunes - Unconsolidated bluffs	- Sand beaches and dunes	- Sand beaches and dunes	- Sand beaches and dunes - Tallgrass prairies - Oak savannahs
Significant natural communities	- Sand beach - Sand dune - Oak savannah - Alvar - Unconsolidated bluffs - Wetlands	- Sand dunes - Tallgrass prairies - Oak barrens	- Sand dunes - Sand beaches - Oak savannahs - Tallgrass prairies - Wetlands	- Sand beaches - Sand dunes - Tallgrass prairies - Oak savannahs - Wetlands
Existing representation in parks/protected areas	Poor–moderate	Poor–moderate	Moderate	Poor–moderate
Priority unprotected features	- Alvar - Sand dune - Wetland	- Wet prairie - Coastal marsh - Sand dunes - Oak savannahs	- Oak savannah - Wetland - Tallgrass prairie	- Tallgrass prairie - Oak savannah
Urban area within shoreline watersheds	High	Low–moderate	High	High
Agriculture within shoreline watersheds	High	High	Low	Low
Residential/cottage/ marina shoreline use	High	High	High	High
Lake edge armoured against erosion	High	Moderate	High	High
Rate of land-use change	High	Moderate	High	High
Planning/restoration activities under way	- Federal/state parks - Eastern Lake Ontario Megasite (TNC/DEC) - Cuyahoga RAP - Buffalo River RAP - Toledo Oak Opening Project (TNC)	- White Lake RAP	- Chicago Wilderness - Lake County, IN RAP - Federal/state parks	- Chicago Wilderness - State park - Forest Preserve Districts
Trend in shoreline health	Severely degrading	Moderately degrading	Severely degrading	Severely degrading
Overall rating of nearshore terrestrial habitat health	**D**	**C**	**C**	**C**

Table 6. Status of Ecosystem Health for Great Lakes Coastal Ecoregions (continued)

	Northern Lacustrine-Influenced Lower Michigan	**Southeastern Wisconsin Savanna**	**Northern Lacustrine-Influenced Upper Michigan and Wisconsin**	**Northern Continental Michigan, Wisconsin, and Minnesota**	**Northern Minnesota**
Characteristic shoreline types	- Bedrock/cobble shore - Sand beach/dune	- Sand beach - Tallgrass prairie	- Sand dunes, spits, and ridges - Bedrock/cobble	- Bedrock shore - Sand dunes	- Bedrock shore
Significant natural communities	- Bedrock shores - Pine barrens - Cobble beaches - Sand dunes	- Tallgrass prairies - Oak savannahs - Wetlands	- Alvar - Sand dunes - Wetlands - Bedrock and cobble beaches	- Bedrock beaches	- Bedrock beaches - Arctic disjunct populations
Existing representation in parks/protected areas	Good	Poor	Good	Good	Good
Priority unprotected features	- Sand dune - Pine barrens	- Tallgrass prairie - Wetlands	- Red pine forests - Wetlands	- Bedrock beaches - Sand dunes - Arctic disjuncts	- Bedrock beaches - Arctic disjunct populations
Urban area within shoreline watersheds	Low	High	Low	Low	Low
Agriculture within shoreline watersheds	High	Moderate	Moderate	Low	Low
Residential/ cottage/ marina shoreline use	Moderate	High	Moderate–high	Moderate	Moderate
Lake edge armoured against erosion	Low	High	Low	Low	Low
Rate of land-use change	Moderate	High	Moderate	Low-moderate	Low-moderate
Planning/ restoration activities under way	- Land conservancies	- Chiwaukee Prairie Preserve restoration	- Federal/state parks - Northern Lake Huron Bioreserve (TNC)	- Federal/state parks	- Federal/state parks - St. Louis River RAP
Trend in shoreline health	No change	Severely degrading	Moderately degrading	No change	Moderately degrading

Overall rating of nearshore terrestrial habitat health	**B**	**D**	**B**	**B**	**B**

7.2 Status of Ecosystem Health for Special Great Lakes Ecological Communities

The 12 special ecological communities discussed in section 4.0 are rated according to a number of factors. The potential indicators attempt to incorporate known environmental changes, the stressors causing these changes, their ecological effects, and stewardship activities being carried out.

Note that the first category, Percent remaining in a healthy state, is an estimate of how much of each community remains intact from its original, pre-European settlement, extent. The other categories relate to current stresses, impacts, and activities, which affect the future of the special communities as they exist now.

The Trend category in particular relates to current or recent trends, over roughly the past two decades. For many of the communities, trend information is incomplete, and the ratings have been assigned on the basis of comments and reviewed by individuals knowledgeable in the field. A more complete analysis of the current and former distribution of these special lakeshore communities and trends affecting their future and management needs would be very valuable.

Table 7. Status of Ecosystem Health for Special Great Lakes Ecological Communities

	Sand beach	**Sand dune**	**Bedrock beach/cobble beach**	**Unconsolidated shore bluff**
% remaining in a healthy state	Unknown	Unknown	Unknown	>75%
Major stresses	- Alteration of physical processes - Habitat alteration - Hydrological changes - Biological changes	- Habitat alteration	- Habitat alteration	- Alteration of physical processes - Habitat alteration
Sources of stress	- Primary-home development - Second- home development - Industrial development - Armouring the shoreline - Recreational impacts - Combined sewer overflows	- Blowouts - Sand mining - Primary-home development - Second-home development - Recreational impacts	- Primary-home development - Second-home development - Recreational impacts - Cobble mining	- Shoreline armouring - Recreational lakefills - Bluff-top developments
Processes/functions impaired	- Beach erosion - Beach nourishment	- Saltation process interrupted - Impaired protection for inland systems	- Reduces shelter for plants and animals - Fragment dispersal and migration corridor	- Wave erosion - Sediment transport - Inland progression
Species/communities threatened/ endangered	- Pitcher's thistle - Piping plover	- Pitcher's thistle - Karner blue butterfly - Houghton's goldenrod - Interdunal pannes	- Arctic disjunct plants - Bedrock glade	- Shorecliff seeps - Forested shorecliff - Shorecliff barrens
Stewardship activities in place	- Numerous federal, state/provincial, and local parks - Sand replenishment - Coastal Zone Management planning - Michigan shoreline protection legislation - Pitcher's thistle recovery plan - Piping plover recovery plan	- Numerous federal, state/provincial, and local parks - Pitcher's thistle recovery - Karner blue recovery	- Inventory work on the Keweenaw - Federal, state/ provincial, and local parks	- Conservation areas and municipal parks - Shoreline management plans

	Sand beach	Sand dune	Bedrock beach/cobble beach	Unconsolidated shore bluff
Trend	Moderately degrading	Moderately degrading	Moderately degrading	Moderately degrading
Overall rating of Natural Community Health	**C**	**D**	**D**	**C**

Table 7. Status of Ecosystem Health for Special Great Lakes Ecological Communities (continued)

	Coastal gneissic rocklands	Limestone cliffs/talus slopes	Lakeplain prairies	Sand barrens
% remaining in a healthy state	>75%	>75%	<1%	Unknown
Major stresses	- Habitat alteration	- Habitat alteration	- Habitat alteration - Alteration of physical processes - Alteration of hydrology	- Habitat alteration - Hydrological changes - Alteration of physical processes
Sources of stress	- Second-home development - Marinas	- Second-home development - Recreational trampling	- Agricultural practices - Primary-home development - Draining of adjacent wetlands - Shoreline armouring	- Timber harvesting methods - Conversion to agriculture - Fragmentation - Fire suppression - Introduction of exotics
Processes/functions impaired	- Vegetation growth - Faunal life cycles and movements	-Vegetation growth	- Vegetation growth - Natural hydrological development - Periodic fire - Dispersal and movement of biota	- Vegetation growth
Species/communities threatened/ endangered	- Prairie warbler - Eastern massasauga rattlesnake	- Northern dusky salamander - Peregrine falcon - Rockshore	- Prairie white-fringed orchid	- Karner blue butterfly - Oak savannah - Kirtland’s warbler

	Coastal gneissic rocklands	Limestone cliffs/talus slopes	Lakeplain prairies	Sand barrens
Stewardship activities in place	- Two federal parks, several provincial parks - Severn Sound RAP - Private land stewardship	- Federal park (Canada) - Niagara Parks Commission - Niagara Escarpment Plan - Recent inventory work on Bruce Peninsula	- Ojibway Provincial Park - Algonac State Park, MI - Chiwaukee Prairie, WI - Forest Preserves, IL	- Oak ecosystems recovery plan - Karner blue recovery plan - Recent inventory work - Private land stewardship
Trend	Moderately degrading	Moderately improving	Severely degrading	Moderately degrading
Overall rating of Natural Community Health	**C**	**B**	**F**	**D**

Table 7. Status of Ecosystem Health for Special Great Lakes Ecological Communities (continued)

	Arctic-Alpine disjunct communities	Atlantic coastal plain communities	Shoreline alvars	Islands
% remaining in a healthy state	Unknown	Unknown	Unknown	Unknown
Major stresses	- Habitat alteration	- Habitat alteration - Hydrological changes	- Habitat Alteration - Alteration of hydrology - Alteration of biological structure	- Habitat alteration - Alteration of physical processes - Alteration of chemical regime
Sources of stress	- Second-home development - Recreational trampling and development	- Second-home development - Shoreline armouring - Recreational grooming - Water-level stabilization	- Second- home development - Quarrying - Plant collecting - Lake-level fluctuation - Road establishment - Introduction of exotics	- Second-home development - Recreational trampling - Shoreline armouring - Introduction of exotics
Processes/ functions impaired	- Vegetation growth	- Annual water-level fluctuations - Vegetation growth on sandy/peaty substrates	- Ice/wave scour and drought - Vegetation growth - Dispersal movement of flora and fauna	- Vegetation growth - Loss of sediment supply - Loss of isolation

	Arctic-Alpine disjunct communities	Atlantic coastal plain communities	Shoreline alvars	Islands
Species/ communities threatened/ endangered	- Arnica - Norwegian draba - Purple crowberry - Black crowberry - Knotty pearlwort - Encrusted saxifrage - Nodding saxifrage - Northern spikemoss - Small false asphodel - Alpine bilberry - Butterwort - Alpine bistwort - Smooth woodsia - Parmelia stictica	- Alkaline shoredunes pond/marsh - Virginia meadow beauty - Carey's smartwood - Panic grass - Water-wort - White-fringed orchid - Yellow-eyed grass	- Lakeside daisy - Alkaline scrub grassland - Rockshore, Great Lakes alkaline - Ram's head orchid	- Bird colonies - Woodland caribou - Dunes and beaches - Bedrock and cobble shores
Stewardship activities in place	- State/provincial parks - Private preserves - Beginning inventories	- Several federal parks - Recent inventory work (Georgian Bay) - Private land stewardship (Georgian Bay)	- Federal park (Canada) - Several provincial parks - Private conservation areas - Recent inventory work	- Federal parks - Provincial/state parks - Private land stewardship - Colonial bird monitoring
Trend	No change	Moderately degrading	Severely degrading	Moderately degrading
Overall rating of Natural Community Health	**B**	**C**	**F**	**C**

7.3 Status of Overall Ecosystem Health for the Land by the Lakes

We make the following four suggestions for indicators of ecosystem health for the nearshore terrestrial environment. While reporting on a lake-by-lake basis provides a useful summary of the status of each, a more detailed breakdown of reporting for each ecoregion, as noted previously, would yield additional benefits. The development of additional indicators to more fully include nearshore lands should be based as much as possible on existing monitoring programs, on information that is specifically oriented to the nearshore area, and on relatively simple and easily understood measures. Where possible, quantitative measures such as the length of shoreline armoured against erosion should be used as a basis for these indicators.

The first two indicators relate to current environmental effects along the nearshore, whereas the latter two document progress in protection programs.

1. Retention of significant ecological communities and species.

Tracking of this indicator could begin with the 12 significant lakeshore communities identified in section 4.0. At a more detailed level, communities and species that are considered significant because of their rarity value have been identified at the global and provincial/state level by the Natural Heritage Inventory Programs and the equivalent Ontario Natural Heritage Information Centre (The Nature Conservancy Great Lakes Program 1994). While mapping programs are never fully complete, many of these elements have been geographically located along the Great Lakes shore.

2. Retention of natural shoreline processes (un-armoured shoreline).

Relatively recent baseline information on the percentage of shoreline "protected" along each of the Great Lakes and connecting channels is available (Geomatics International 1992b). While the degree of impairment to natural shoreline processes is highly site-specific, depending on location and design, the figures showing the percentage armoured provide a useful first approximation.

3. Representation of coastal biodiversity within protected and adequately stewarded areas.

Effective use of this indicator will require baseline inventories to summarize the significant elements of biodiversity occurring with the nearshore area, preferably organized on an ecoregion/ecodistrict framework. The classification systems of ecological communities currently under development will considerably assist in this task (Bakowsky and Lee 1996; Racey et al. 1995; The Nature Conservancy 1996). A "gap analysis theme study," included as part of the baseline, can identify which biodiversity elements are already represented by viable occurrence within protected areas and which require additional action and investment.

4. Gains in biodiversity investment habitats protected through public ownership or policy.

Progress in protecting the biodiversity investment areas identified in section 3.3 is particularly important for the future health of lake-edge terrestrial habitats. This indicator can track gains through the creation of new parklands or other protected areas, the development of land-use policies that will result in improved protection of the significant elements within these priority areas, or private stewardship initiatives.

Table 8. Status of Overall Ecosystem Health for the Land by the Lakes

INDICATORS	**STATUS OF INDICATORS**			**TREND**		
	Good	**Mixed**	**Poor**	**Improving**	**Stable**	**Deteriorating**

1. Retention of shoreline species/communities						
Lake Superior	*				*	
Lake Michigan		*				*
Lake Huron		*				*
Lake St. Clair–Lake Erie		*				*
Lake Ontario		*				*
2. Retention of natural shoreline processes (un-armoured shoreline)						
Lake Superior	*				*	
Lake Michigan		*				*
Lake Huron		*			*	
Lake St. Clair–Lake Erie			*			*
Lake Ontario			*			*
3. Representation of biodiversity in lakeshore parks and protected areas						
Lake Superior	*			*		
Lake Michigan		*			*	
Lake Huron		*		*		
Lake St. Clair–Lake Erie		*			*	
Lake Ontario		*			*	
4. Gains in biodiversity investment areas						
Lake Superior		*		*		
Lake Michigan		*		*		
Lake Huron		*			*	
Lake St. Clair–Lake Erie			*		*	
Lake Ontario		*			*	

Lake Superior is rated highly for three of the four indicators since its lightly developed shoreline and extensive parks system have kept its nearshore terrestrial ecosystems in generally excellent condition. At least one important initiative within a biodiversity investment area is underway with the proposal for a Canadian National Marine Area designation, but this future potential is not yet fulfilled.

Lake Huron received a mixed status for all four indicators, with trend ratings in all three categories. This reflects the strong system of protected areas along its shores and relatively little shoreline armouring in most areas. However, some of the special natural communities such as shoreline alvars are at risk, and new initiatives are needed to protect the natural features in biodiversity investment areas, notably Mackinaw-Manitoulin.

Lake Michigan also received mixed status for all four indicators, with trend ratings in all three categories. Stewardship work in Chicago Wilderness, Door County, and the Traverse Bay-Leelanau areas has increased significantly in recent years, bringing resources and attention to the importance of protection. Nevertheless, development and shoreline armouring to protect homes and businesses from high lake levels are increasing.

Lake St. Clair and Lake Erie received the lowest ratings overall, with two of the four indicators in the poor category. In large part, this reflects the intensity of urban, industrial, and agricultural land use along its shores, and the very high percentage of the shoreline of both lakes which have been armoured. Protected areas, while significant in themselves, are mostly relatively small and isolated from each other. With a few notable exceptions, the Lake Erie nearshore offers few opportunities for short-term gains within biodiversity investment areas.

Lake Ontario rates mostly in the mixed category, with either stable or deteriorating trends, largely because of the intensive urbanization along much of its shores. It received one poor rating, related to the extent of shoreline armouring in place, and the known negative effects taking place due to the interruption of natural shoreline processes. While the protected areas system along this lake is fragmentary, the eastern end of Lake Ontario offers excellent future opportunities for significant gains within this biodiversity investment area.

8. APPENDIX: Characteristics of Lakeplain Ecoregions

8.1 Thunder Bay–Quetico

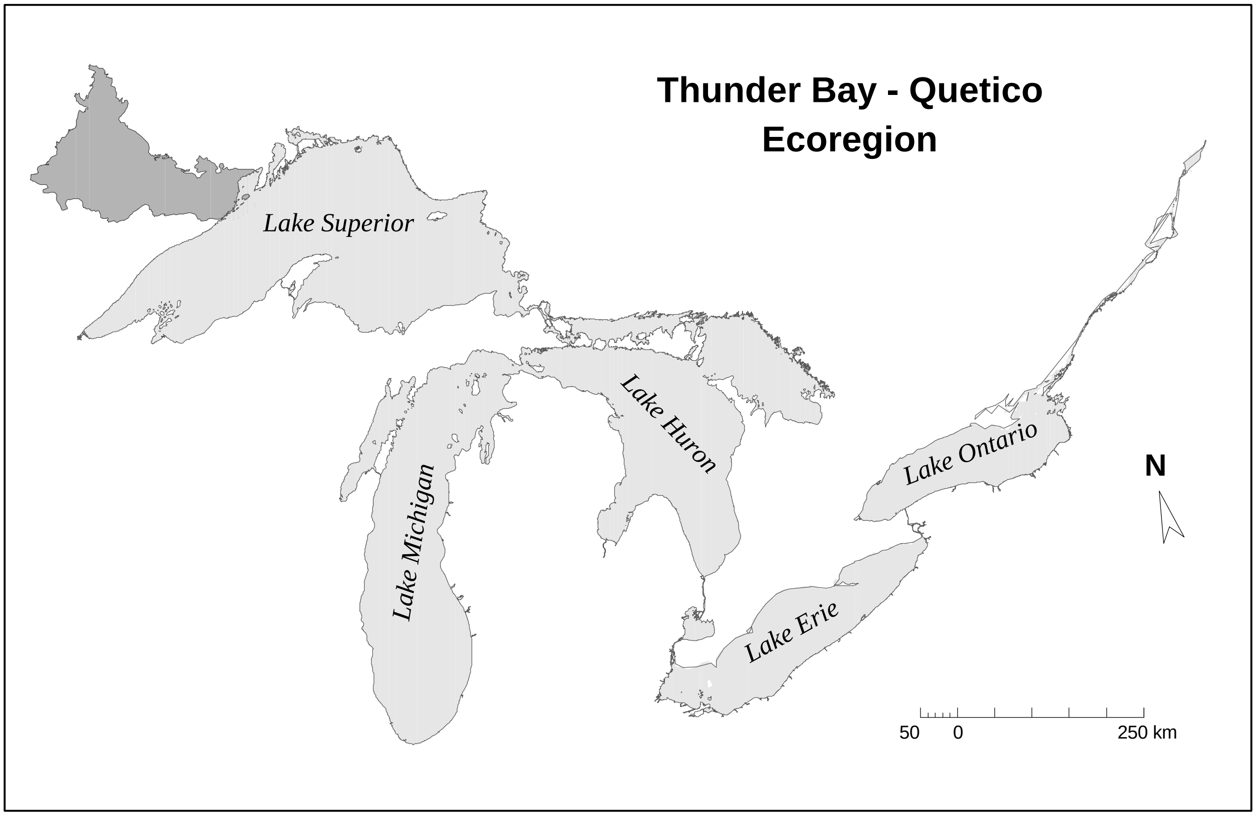


Figure 19. Thunder Bay–Quetico Ecoregion

Stretching westward from Thunder Bay, this ecoregion has warm and somewhat dry summers, with cold, snowy winters. Generally the topography of this ecoregion is moderately broken, with an overburden of shallow sandy-loamy soil materials and some areas of deep silts and clays from former lake floors. Just south of Thunder Bay, several prominent mesa hills create steeper topography. Coniferous boreal forest are typical of much of the ecoregion, but it also contains a number of species that are typical of more southern regions, such as red and silver maple and yellow birch. Forestry and tourism are the most extensive land uses, with the area close to the Superior shoreline heavily influenced by the industrial and commercial centre of Thunder Bay.

8.1.1 The Lake Superior Shoreline within Thunder Bay–Quetico Ecoregion

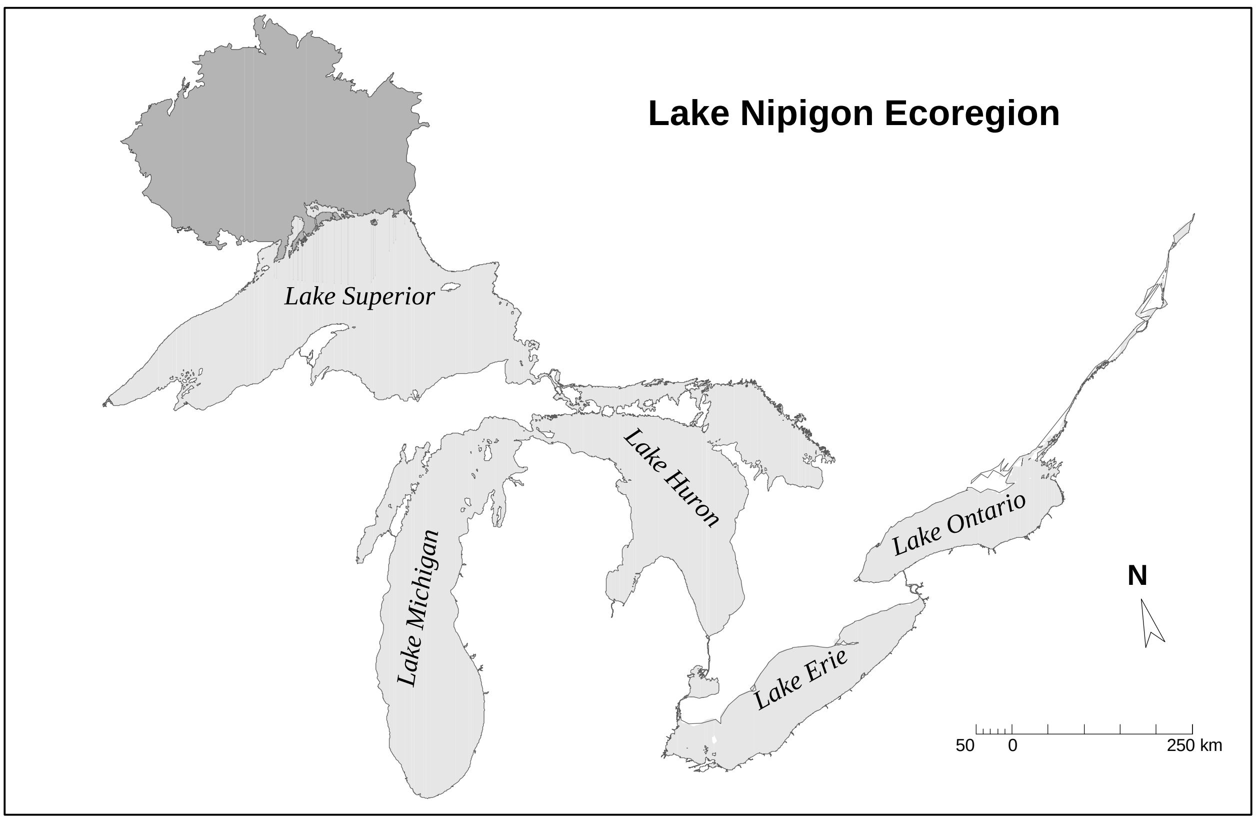
The Lake Superior coast within this ecoregion is characterized by rocky shores with many bays and islands. Cobble and mixed shore types are common, with a few cliffs and beaches. Shoreline marshes occur infrequently in sheltered bays and as remnants along the large delta at the mouth of the Kaministikwia

River. Some of the shoreline has been armoured, primarily for port facilities and other urban uses in the City of Thunder Bay.

Protected areas along the shoreline within this ecoregion include the following:

Provincial parks	1 natural environment, 2 nature reserves
Conservation areas	4 small recreation areas
ANSIs (outside parks)	2 geological ANSIs

Several additional shoreline sites are documented as ecologically significant (Smith 1987a), but currently have no formal protection status. These include three small coastal wetland areas, several offshore islands with bird colonies, and beach areas along the north end of Thunder Bay with rare flora and fauna. Other areas have been identified as having significant geological values, including the Kaministikwia River delta and two shoreline areas with limestone and chert bedrock cliffs (Bowes 1989).



8.2 Lake Nipigon

Figure 20. Lake Nipigon Ecoregion

This ecoregion extends from the northwest shore of Lake Superior to encompass the area around Lake Nipigon. Summers are warm and rainy, and winters cold and snowy. Its terrain is mostly hummocky Precambrian bedrock, with frequent outcrops of acidic rock and glacial deposits of coarse tills, sands, and silts. Along the Superior shore, the topography is more broken, with frequent bedrock knobs and cliffs, and with prominent mesas created by the erosion of softer sedimentary rocks underlying a resistant cap of basalt. Most of the ecoregion is covered with mixed forests of white and black spruce, balsam fir, jack pine, trembling aspen, and paper birch. The primary land use is commercial forestry, and the nearshore area is largely undeveloped, but sees considerable recreational use.

8.2.1 The Lake Superior Shoreline within the Lake Nipigon Ecoregion

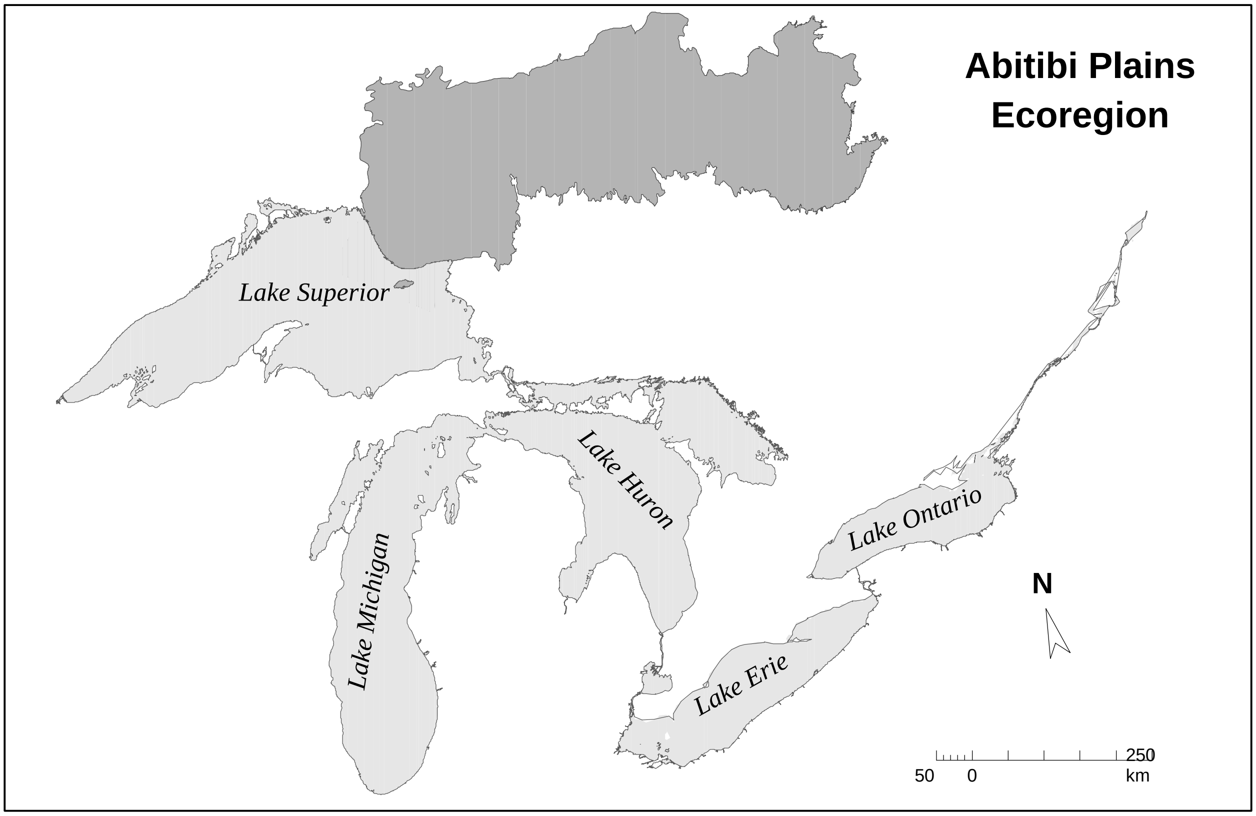
This complex shoreline includes narrow peninsulas and sheltered bays, together with many rocky islands and areas of exposed coast that are subject to some of the harshest wind and wave action anywhere on the Great Lakes. Although mesas and areas of high backshore are frequent, most of the shoreline is of a pebble-cobble-boulder type, with a few sections of narrow beach in more sheltered bays. Very little of the shoreline has been armoured.

Protected areas along the shoreline within this ecoregion include the following:

Provincial parks	3 major natural environment parks—Sleeping Giant, Slate Islands, Neys; 8 nature reserves; 1 provincial wilderness area (Agate Island)
Conservation areas	2
ANSIs (outside parks)	3 ecological; 2 ecological/geological

Despite this degree of protection already in place, much of this section of shoreline is identified as a region requiring further attention (Smith 1987a,b). It is a highly scenic and attractive landscape, with a multitude of islands, headlands, and botanical and geological features of interest. At least 12 additional sites have been identified as environmentally sensitive areas (Environment Canada 1993a), most of them on coastal islands. Shoreline rock formations in the Marathon area have also been identified as a priority for protection (Bowes 1989).

The Nature Conservancy has recognized the Black Bay area within this ecoregion as an area of exceptional biodiversity (The Nature Conservancy Great Lakes Program 1994). This ecoregion also corresponds to an interesting and diverse aquatic region immediately offshore, part of which is being considered by Parks Canada as a potential National Marine Conservation Area (Parks Canada 1995).



8.3 Abitibi Plains

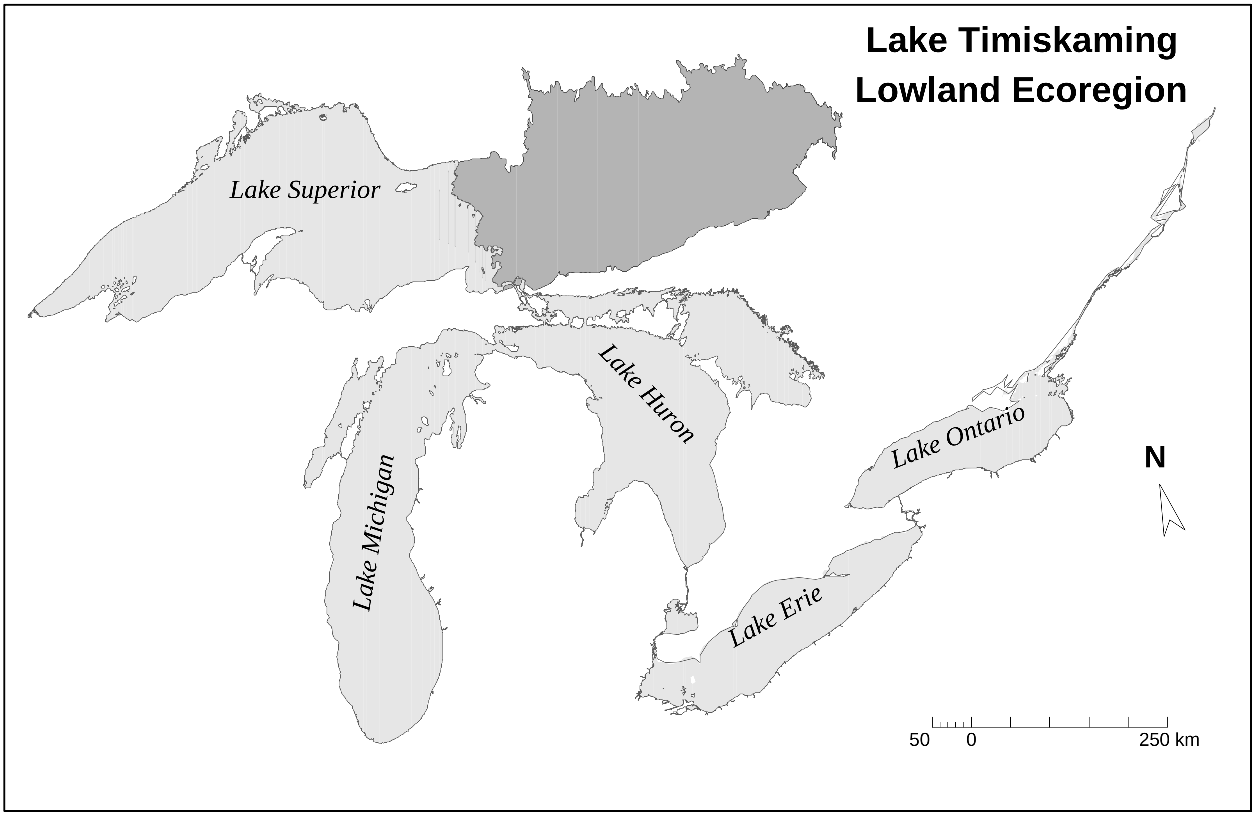
The western end of this extensive ecoregion borders the northeast shore of Lake Superior. Much of the ecoregion is characterized by fine-textured, level to undulating lacustrine deposits with large areas of organic wetlands. Near Lake Superior, however, bedrock outcrops are more common. Summers are warm, and winters cold and snowy. Forest cover comprises mostly mixed boreal stands of white spruce, balsam fir, paper birch, and trembling aspen. Major land uses include forestry, mining, and power generation.

Figure 21. Abitibi Plains Ecoregion

8.3.1 The Lake Superior Shoreline within the Abitibi Plains Ecoregion

Most of the shoreline along this ecoregion is rocky, with areas of cobble-boulder beach and sections of high backshore, but few cliffs. Almost the entire shoreline is classed as “high-energy,” since it is exposed to waves and wind from the full 500-kilometre (310-mile) long expanse of Lake Superior. There is very little fine sediment to form sand beaches. Almost none of the shoreline has been artificially hardened.

Examples of the terrestrial nearshore area of this ecoregion are very well represented in the following protected areas:



National park	Pukaskwa National Park
Provincial parks	Michipicoten Island natural environment park, plus 1 small provincial wilderness area.

Several small geological features in the Michipicoten Bay area have been identified as being worthy of future protection (Bowes 1989), but in general this ecoregion's coastal area is well-represented within Pukaskwa National Park.

8.4 Lake Timiskaming Lowland

Figure 22. Lake Timiskaming Lowland Ecoregion

This ecoregion takes in the southeastern shore of Lake Superior, and extends eastwards into Quebec. It has warm summers and cold, snowy winters, with a strong snowbelt effect east of Lake Superior. It is characterized in the Lake Superior area by massive, acidic bedrock areas forming undulating terrain with broadly sloping uplands and lowlands. While much of the ecoregion has characteristic boreal mixed forests, the warmer areas along the Superior shore contain sugar and red maple, yellow birch, and red and white pine. Major land uses include forestry, mining, hydro-electric power generation, and recreation.

8.4.1 The Lake Superior Shoreline within the Lake Timiskaming Lowland Ecoregion

Along the Superior shore, the undulating pattern of the backshore terrain creates a mix of bedrock cliffs, cobble-boulder exposed shores, and sandy beaches and dunes. In general, the more northern sections of shoreline are straighter, more exposed, and rockier, whereas towards the south there is a pattern of large sheltered bays, with abundant sand in some sections. Almost none of the shoreline has been armoured.

Examples of the terrestrial nearshore area of this ecoregion are very well represented in the following protected areas:

Provincial parks	2 major natural environment parks—Lake Superior and Michipicoten Island; also 1 provincial wilderness area, 1 nature reserve, and 2 recreation parks.
Conservation areas	1— Shore Ridges Conservation Area
ANSIs (outside parks)	2 geological, 2 ecological, and 2 with both geological and ecological values

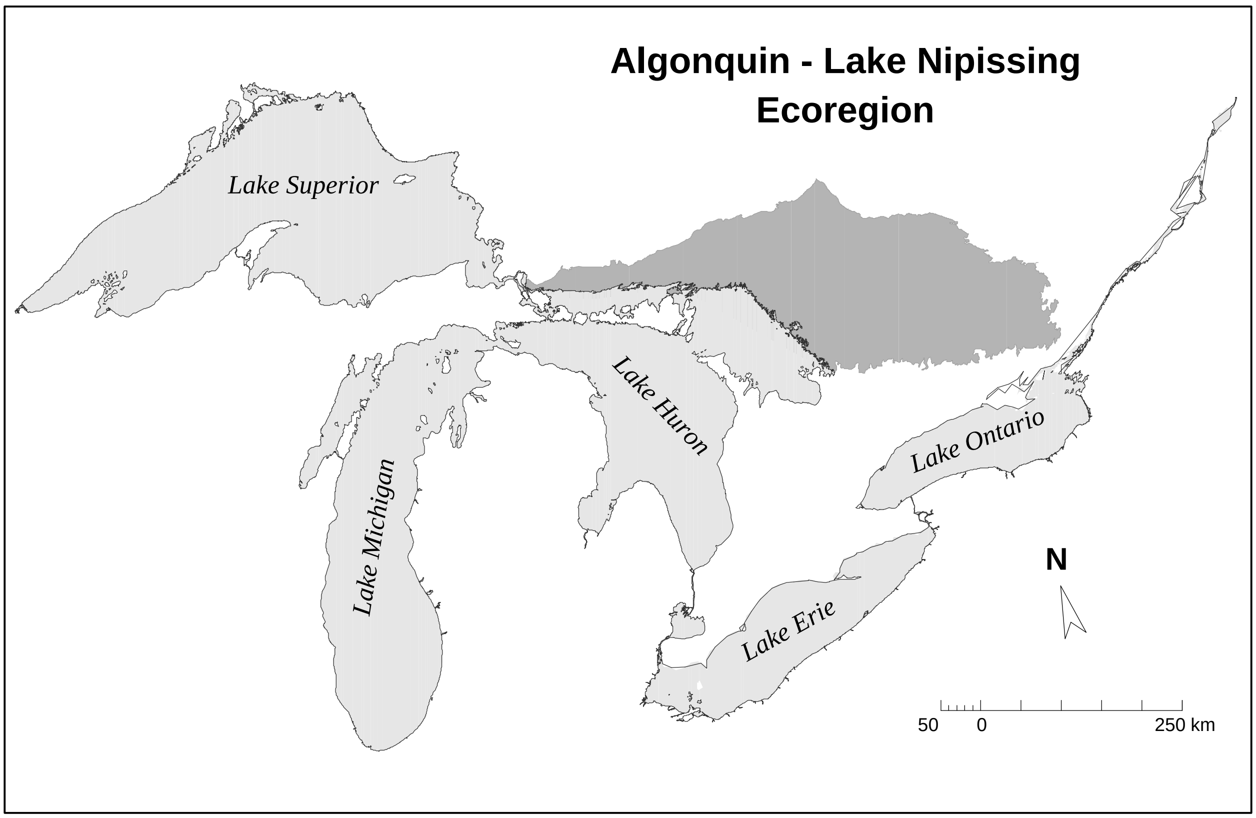
Four small areas currently lacking protection have been identified as environmentally sensitive or geologically significant (Environment Canada 1993a; Smith 1987a; Bowes 1989). The Lake Superior Park coast and Batchawana Bay–Goulais Bay areas have been identified as ecological hot spots (Smith 1987a); the first of these is fully within park boundaries, whereas the latter is partially protected.

8.5 Algonquin–Lake Nipissing

Figure 23. Algonquin–Lake Nipissing Ecoregion

The Algonquin–Lake Nipissing ecoregion includes the Lake Huron north channel shoreline, and the entire eastern shore of Georgian Bay, as well as the upland areas of the Algonquin dome to the east. In many areas along the shore, the massive acidic bedrock is exposed in ridges and hummocks. Further inland, some sections are covered with a discontinuous veneer of glacial tills. The ecoregion is largely forested with tolerant hardwoods and mixed forest, including sugar maple, yellow birch, eastern hemlock; white pine and red oak associations are common on drier, shallow rock sites. Winters are snowy, particularly east of the Georgian Bay coast. Major land uses include forestry, mining, and tourism, with commercial centres in Sault Ste. Marie and Sudbury.

8.5.1 The Lake Huron Shoreline within the Algonquin–Lake Nipissing Ecoregion



The north shore of Lake Huron and the eastern shore of Georgian Bay are extremely complex in configuration, with an extensive archipelago of bedrock islands and many sheltered bays and fjords. Most of the acidic Precambrian bedrock is exposed through past glacial scouring and wave action, with outcrops of a diverse array of gneisses and other rock types, including the white quartzite hills of Killarney. Very little sediment is present, except in a few pockets such as the Mississagi River delta. Very little of this shoreline has been armoured.

Examples of the terrestrial nearshore area within this ecoregion are represented in the following areas:

National parks	Georgian Bay Islands National Park
Provincial parks	Killarney wilderness park, 3 natural environment parks (La Cloche, Killbear, Massasauga Wildlands), 1 waterway park (a large area at the French River mouth), 3 nature reserves.
ANSIs (outside parks)	2 geological, 3 ecological

Despite the breadth of this representation, this section of Great Lakes shoreline includes a wealth of natural heritage values, and some other shoreline areas that have been identified as ecologically significant remain unprotected. The Federation of Ontario Naturalists included on its lists of Great Lakes ecological hot spots the Lake George–St. Marys River area, the eastern section of the North Channel, the French River mouth, and southeastern Georgian Bay (Smith 1987b). The Nature Conservancy also highlighted southeastern Georgian Bay as an area supporting significant biodiversity (The Nature Conservancy Great Lakes Program 1994). In his review of Great Lakes natural heritage areas, Paul Smith (1987a) identified Manitoulin Island and the North Channel as a region requiring further attention, along with a large number of island bird colonies. The north shore area from Killarney westwards into the north channel has also been identified as a priority area because of its geomorphological significance (Bowes 1989).

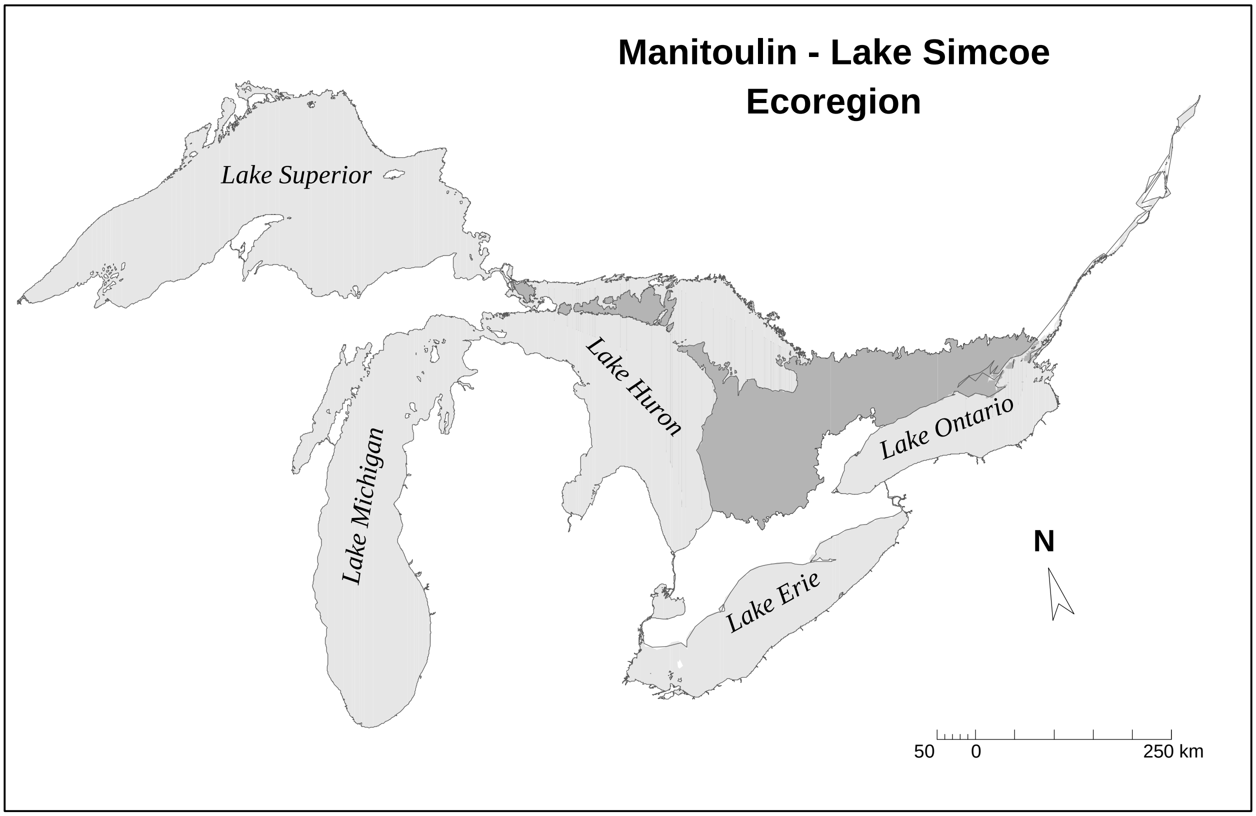
8.6 Manitoulin–Lake Simcoe

This ecoregion includes the shorelines of southern Georgian Bay, the Bruce Peninsula, Manitoulin Island, much of eastern Lake Huron, and the north shore of Lake Ontario from Oshawa to Kingston. Summers are warm and winters mild. The terrain is based on palaeozoic limestone bedrock and a variety of deep glacial deposits. The resulting rich soils are extensively used for mixed agriculture, with relatively little natural cover remaining. Along the Niagara Escarpment, particularly on the Bruce Peninsula and Manitoulin Island, and in eastern sections of the ecoregion in the Prince Edward County area, the limestone bedrock is close to the surface, with considerable remaining forest cover and significant clusters of natural habitat values. Hardwood and mixed forests of sugar maple, beech, and eastern hemlock are characteristic of this ecoregion.

Agriculture is the dominant land use, with small urban centres in such areas as Kitchener-Waterloo and Barrie, and recreation and tourism activity along much of the lakeshore.

Figure 24. Manitoulin–Lake Simcoe Ecoregion

8.6.1 The Lake Huron Shoreline within the Manitoulin–Lake Simcoe Ecoregion



The Great Lakes shoreline within this ecoregion shows considerable diversity. Areas of sloping limestone bedrock shoreline are common along the Bruce Peninsula and on the south shore of Manitoulin Island. Bedrock cliffs and talus slopes occur along the northern end of the Bruce Peninsula, with cobble-boulder beaches in some areas as well. In parts of Georgian Bay and the lower Lake Huron shore, there are bluffs of unconsolidated glacial materials, and large sand beaches. Relatively little of the shoreline has been armoured, although some shoreline hardening has taken place in the vicinity of shoreline towns to provide harbour facilities or to protect urban development.

Examples of the terrestrial nearshore areas of this ecoregion are represented in the following parks and protected areas:

National parks	Bruce National Park Fathom Five National Marine Park

Provincial parks	3 natural environment parks (Black Creek, Awenda, MacGregor Point), 8 nature reserves (mostly on the Bruce Peninsula), and 5 recreation parks.
Provincial wildlife areas	1— Matchedash Bay
Conservation areas	7, mostly small areas
ANSIs (outside parks)	12 geological, 8 ecological, 2 with both geological and ecological values.

The Bruce Peninsula and Manitoulin Island are well-known as ecological hot spots (Smith 1987a,b; The Nature Conservancy Great Lakes Program 1994). While some important shoreline natural habitats are unprotected, the Bruce Peninsula has been the subject of considerable protection effort. Manitoulin Island has received far less attention to date. A number of shoreline sites on both Manitoulin and the Bruce have been identified as having priority geomorphological values, together with sites on Cockburn Island, the Penetang Peninsula and nearby Christian and Beckwith Islands, and the Sauble Beach area (Bowes 1989). Parks Canada (1995) has also highlighted southern Manitoulin, the Main Channel–Western Bruce peninsula area, and Sauble Beach as potential sites for national marine conservation area status.

At least nine other specific sites have been identified as having significant values, but little or no current protection (Smith 1987a; Environment Canada 1994b). Most of these are shoreline wetland sites, together with several bluff sites along the southern Lake Huron coast.

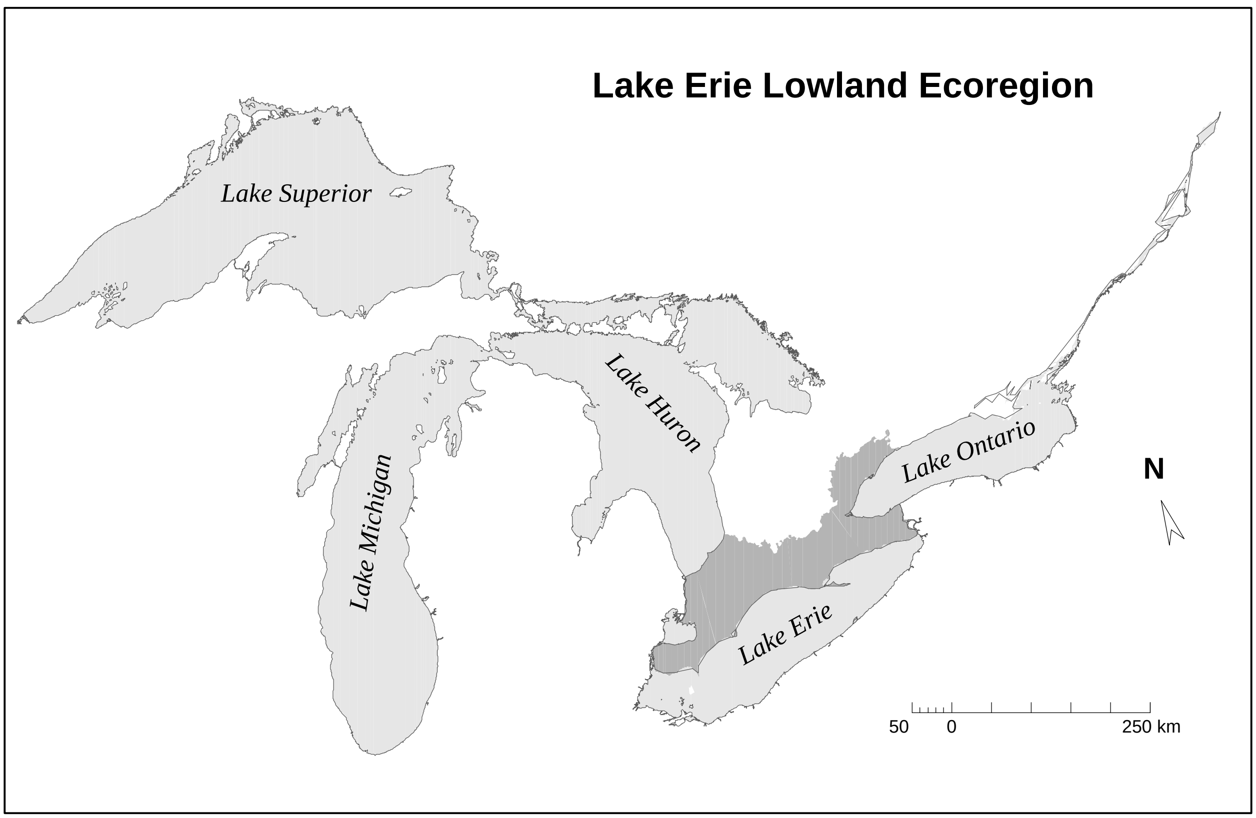
8.6.2 The Lake Ontario Shoreline Within the Manitoulin–Lake Simcoe Ecoregion

The western sections of this shoreline are relatively straight, with a mix of low bluffs, cobble beaches, and unconsolidated till higher bluffs. From the Presqu'ile peninsula eastwards, the shore character is controlled by low sloping limestone outcrops, and its nature changes to a very complex shore with frequent bays and islands. Baymouth sand bars and extensive associated wetlands are common here. Very little of the shoreline area is armoured, except for harbours and other urban areas.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Provincial parks	2 natural environment (Presqu'ile and Sandbanks), 1 nature reserve, and 2 recreation class parks.
National wildlife areas	2— Weller's Bay and Prince Edward Point
Provincial wildlife areas	1— Petre Point
Conservation areas	7, mostly small.
ANSIs (outside parks)	7 geological, 11 ecological, 2 with both geological and ecological values.

Despite these protected areas, many significant shoreline sites are unprotected within this ecoregion, including at least 19 wetland areas (Smith 1987a; Environment Canada 1993b). As well as these remnant marshes, Smith (1987b) identified the eastern Lake Ontario islands and Prince Edward County as ecological hot spots requiring attention. Prince Edward County has also been highlighted as an area of exceptional biodiversity (The Nature Conservancy Great Lakes Program 1994), and as having baymouth bar/spit complexes of geomorphological significance (Bowes 1989). Two sites along the shores of Prince Edward County—Weller’s Bay and Prince Edward Point—have also been identified for consideration as national marine conservation areas (Parks Canada 1995).



8.7 Lake Erie Lowland

Figure 25. Lake Erie Lowland Ecoregion

The Lake Erie Lowland ecoregion, which is also known as the Carolinian Canada area, has the mildest climate in Canada, with warm, humid summers and mild, snowy winters. Most of the region is covered in deep glacial deposits, with extensive areas of clay soils in the west, sand plains in the central area, and mixed tills to the east. The Niagara Escarpment crosses the ecoregion, providing a narrow band of exposed limestone bedrock. Shoreline areas along Lake St. Clair, Lake Erie, and western Lake Ontario include a number of sand spit formations, and once-extensive wetlands and savannahs that are now considerably reduced. The remaining forest is highly fragmented in most parts of the ecoregion, with many southern elements in hardwood associations dominated by sugar maple, beech, oaks, and hickories.

Agricultural use of much of the ecoregion is intense, with extensive areas of row crops, wine-growing areas, and specialty crops, including tobacco, fruit, and vegetables. Urban development is a major factor within the ecoregion, particularly in the Toronto-Hamilton-Niagara Falls "Golden Horseshoe" area, and in the Windsor-Sarnia area.

8.7.1 The Lake Huron–Lake St. Clair Shoreline within the Lake Erie Lowland Ecoregion

The southern coast of Lake Huron includes extensive beach deposits with dune systems in the Grand Bend area, low bluff areas, and considerable stretches of armoured shoreline. Lake St. Clair also has significant stretches of armoured shoreline, particularly along its south coast, with 57 percent having some degree of artificial protection (Geomatics International 1992b). This shallow lake has very low shore relief and extensive marshes, especially in the delta area at the north end of the lake. Many sections of marshland have been diked and are managed for waterfowl or used as farmland. The connecting channels of the St. Clair River and Detroit River have armouring along 77 percent and 100 percent of their shorelines, respectively (Geomatics International 1992b).

Examples of the terrestrial nearshore area of the ecoregion are represented in the following parks and protected areas:

Provincial parks	1 natural environment (Pinery), 2 recreation
National wildlife area	St. Clair National Wildlife Area
Conservation areas	5 small conservation areas
ANSIs (outside parks)	1 geological, 3 ecological

The primary area of this shoreline section without formal protection is Walpole Island and the associated marshlands, which have been identified as a very significant resource by a number of authors (Smith 1987a,b; The Nature Conservancy Great Lakes Program 1994; Bowes 1989). The Pinery–Kettle Point area on Lake Huron has also been identified as a significant area that is only partially protected (Smith 1987a; The Nature Conservancy Great Lakes Program 1994; Bowes 1989). First Nation lands exist on both these sites. Six other specific shoreline natural areas, most being wetlands, have been identified as needing attention (Smith 1987a).

8.7.2 The Lake Erie Shoreline within the Lake Erie Lowland Ecoregion

The Lake Erie shoreline is characterized by eroding bluffs of unconsolidated materials, with the highest bluffs in the central sections of the shoreline. Three large sand spit features have extensive beach-dune and marsh systems. In the shallow western basin, small limestone outcrops form a series of islands. A shelf of limestone bedrock and a deep limestone gorge are present along the Niagara River. Approximately 46 percent of the Canadian shore of Lake Erie is protected to some degree by artificial structures (Geomatics International 1992b).

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National parks	Point Pelee National Park
National wildlife areas	Long Point National Wildlife Area
Provincial parks	2 natural environment parks (Rondeau, John E. Pearce), 3 nature reserves, 8 recreation class parks
Conservation areas	11, mostly small
ANSIs (outside parks)	6 geological, 8 ecological

The Lake Erie sand spits are universally recognized as significant natural systems and, for the most part, have been brought into public ownership. Long Point was designated as a world biosphere reserve by UNESCO in 1987. Because of their dynamic nature, however, the sand spits are vulnerable to a loss of sediment supply from adjacent bluff areas of the shoreline. At least nine smaller natural areas in need of protection have been identified along the Lake Erie shoreline (Smith 1987a; Environment Canada, 1994d). Most of these are woodland areas associated with shore bluffs or valleys. As well, the western Lake Erie islands have been highlighted as priorities for future protection (Smith 1987a,b).

8.7.3 The Lake Ontario Shoreline within the Lake Erie Lowland Ecoregion

Much of the shoreline along the western end of Lake Ontario is characterized by low bluffs of unconsolidated materials, with a few shale bedrock outcrops. Shore protection works are widespread. A large baymouth bar across the entrance to Burlington Bay is a major exception. A former sand spit area forming Toronto Islands has been extensively armoured and modified. The Scarborough Bluffs rise more than 100 metres (328 feet) from lake elevation, but approximately 75 percent of this prominent shoreline feature has also been armoured at its toe.

Examples of the terrestrial nearshore area of the ecoregion are represented in the following parks and protected areas:

Conservation areas	19, including lakefill parks
Other parks	The Rouge Park, managed by an alliance of agencies; many small municipal parks
ANSIs (outside parks)	3 geological, 3 ecological, 2 with both geological and ecological values

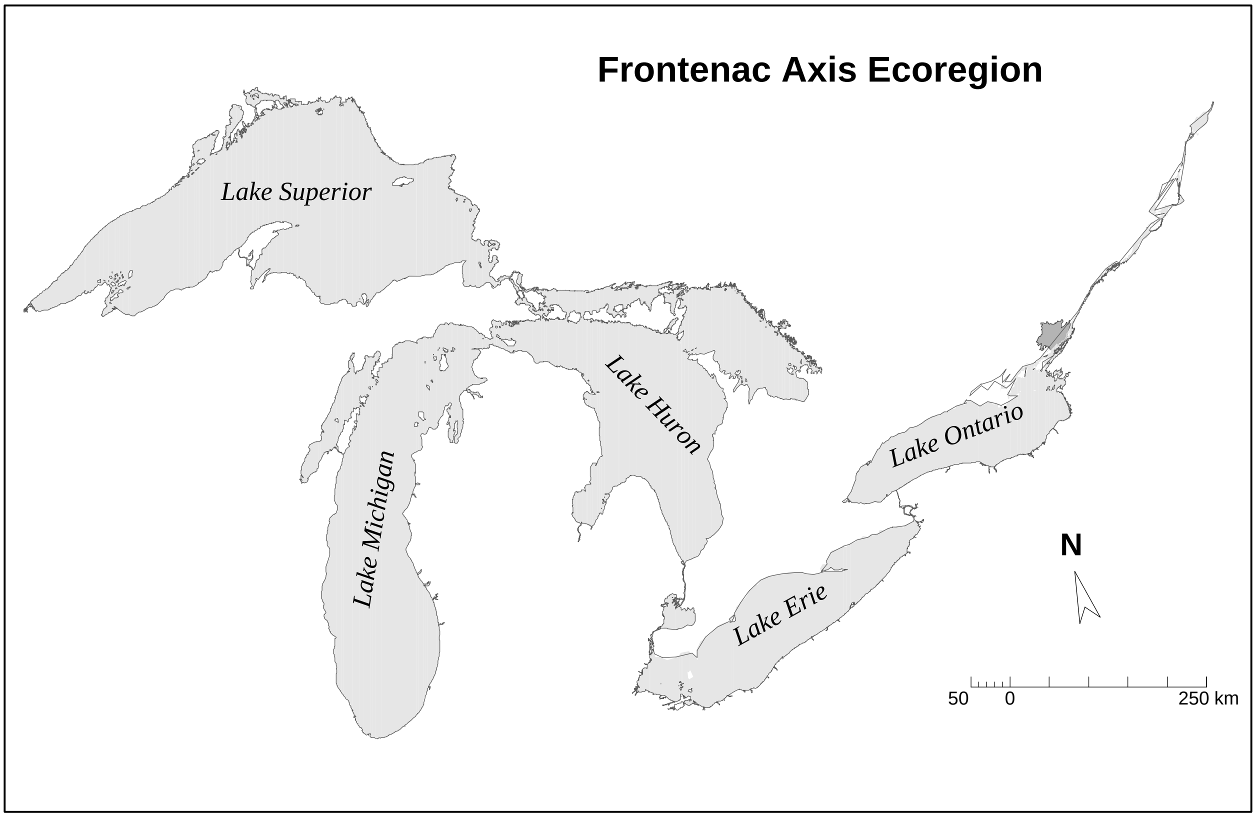
While a few small natural areas along this shoreline have been identified as needing protection, most shoreline natural habitats are already publicly owned or have been lost to urban development (Waterfront Regeneration Trust 1995a). Habitat restoration projects are underway in several areas, most notably Hamilton Harbour and the Toronto waterfront area.

8.8 Frontenac Axis

Figure 26. Frontenac Axis Ecoregion

This small ecoregion forms a northern extension of the Adirondacks area of New York state. It is characterized by shallow Precambrian rocks of metamorphic origins, with some areas of deeper clay soils. Forest cover is mixed, with sugar maple, eastern hemlock, and red oak among the more common species. One species unique to this area is pitch pine. Major land uses include mixed farming and dairying, recreation and tourism, and urban development.

8.8.1 The Lake Ontario–St. Lawrence River Shoreline within the Frontenac Axis Ecoregion



The shoreline forms a complex pattern of bays and islands, dominated by sloping bedrock shores. Small pockets of wetland occur in sheltered bays. Very little of the shoreline has been armoured.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

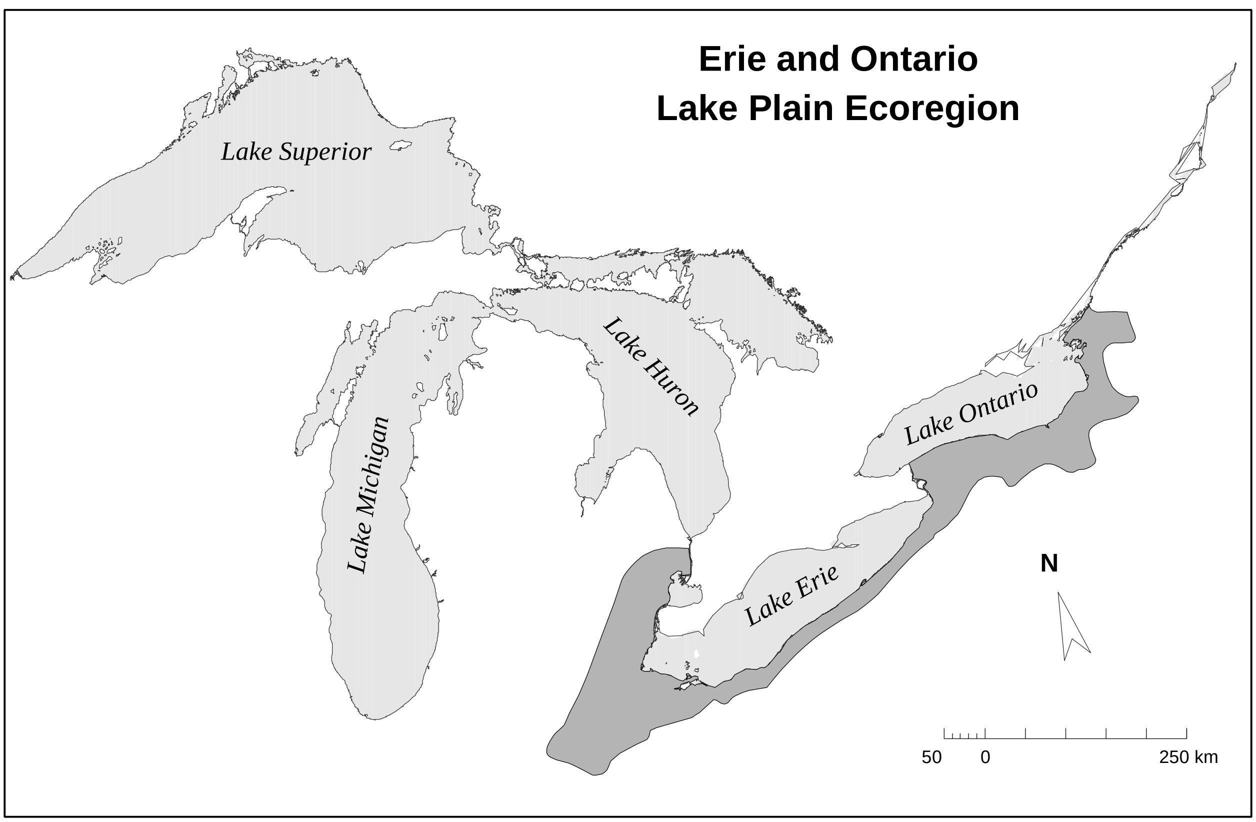
National parks	St. Lawrence Islands National Park
State parks	2—Wellesley Island and Grass Point
Other parks	Shoreline areas held by St. Lawrence Parks Commission
ANSIs (outside parks)	1 geological, 2 ecological, 1 with both geological and ecological values

Several islands and wetland areas have been identified as significant natural areas in need of protection (Environment Canada 1994e). This ecoregion is subject to intense recreational pressures, as well as commercial shipping.

8.9 Erie and Ontario Lake Plain

Figure 27. Erie and Ontario Lake Plain Ecoregion

This ecoregion extends along the southern end of Lakes Ontario and Erie from the St. Lawrence Seaway to Michigan. It consists of gently rolling glacial moraine landscape and flat lakeplain. Sand beaches and dunes as well as the wetlands and oak openings of the Maumee basin characterize the shoreline. Before European settlement, swamp forests, wet prairies, and marshes were flooded periodically.



Agriculture, farm woodlots, and residential and urban/industrial development are the major land uses. Draining the land for agriculture has had the most impact on the coastal environment.

8.9.1 Eastern Ontario Lake Plain

The Lake Ontario shoreline from the St. Lawrence River to Fair Haven, New York, is an irregular lowland with bays, sand dunes, beaches, and spits, wetlands, and unconsolidated bluffs. Forests of oak, hickory, and ash, white cedar forests, and alvars predominate. Agriculture and forestry are the major human land uses in the region. Numerous sand beaches dot the shoreline; however, it is not known whether any beaches outside the state parks are ecologically significant.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

New York state parks	Wellesley Island, DeWolf Point, Keewaydin, Grass Point, Cedar Point, Burnham Point, Lang Point, Westcott Beach, Southwick Beach, Selkirk Shores, Fair Haven Beach
New York state wildlife areas	Dexter Marsh, Lakeview, Deer Creek Marsh
The Nature Conservancy preserves	Sandy Pond

8.9.2 Erie/Ontario Lake Plain

This region extends from Fair Haven to just north of Buffalo, New York. It is lined with sand beaches, orchards, bays, and forests of oak-hickory-ash, chinquapin oak, and white cedar limestone woodlands. The landscape is both urban and agricultural. Land has been drained for the orchards. Numerous sand beaches dot the shoreline; however, it is not known whether any beaches outside the state parks are ecologically significant.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

New York state parks	Chimney Bluffs, Sodus Point, Hamlin Beach, Lakeside Beach, Golden Hill, Wilson Tuscorora, Four Mile Creek, Fort Niagara, Joseph Davis, Devil's Hole, Niagara Reservation, Buckhorn Island
New York state wildlife areas	Lake Shore Marshes, Braddock Bay

8.9.3 Lake Erie Plain

This region, which extends from Buffalo, New York, to Sandusky, Ohio, is an irregular lakeplain of lake silt-clay soils and oak-hickory-ash dry forest, northern hardwood forest, black oak-white oak woodland, and beechgrass dunes. Forestry, orchards, and agriculture are the major land uses today. Numerous sand beaches dot the shoreline; however, it is not known whether any beaches outside the state parks are ecologically significant.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National wildlife sanctuary	Old Woman Creek
New York state parks	Evangola, Lake Erie
Pennsylvania state parks	Presque Isle
Ohio state parks	Geneva, Headlands Dunes/Beach, Cleveland Lakefront
Ohio state natural preserves	Mentor Marsh, Lake Erie
Ohio reservations	Rocky River, Huntington
Ohio wildlife management areas	Resthaven, Willow Point

8.9.4 Maumee Lake Plain

This region extends from Sandusky, Ohio, into Michigan and inland to the reaches of what was called the Black Swamp in northwest Ohio. It overlaps with the Southern Lower Michigan Ecoregion. This old glacial lakeplain is characterized by red-maple-black ash swamps, northern hardwood forests, northern white cedar forests, and pine-heath woods. It is a predominantly urban area with land usages that include agriculture and forestry.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National wildlife refuge	Ottawa, Cedar Point
Ohio state parks	Kelley’s Island, East Harbor, Catawba Island, Oak Point, South Bass Island, Crane Creek, Maumee Bay
Ohio state wildlife areas	Magee Marsh, Metzger Marsh, Mallard, Toussant

Toledo metroparks	Toledo Oak Openings
Ohio state forests	Maumee
State experimental station	Crane Creek

8.9.5 Washtenaw–Maumee Lake Plain

Lake Erie moderates the climate of this region, which covers the area on the western shores of Lake Erie and along Lake St. Clair from the Ohio-Michigan state line to Port Huron, Michigan. Its productive, loamy soils made it a prime location for Native American and European settlements. In pre-European settlement times, the clay lakeplain was forested with wetlands. The sandy lakeplain supported oak barrens, wet prairies, and marshes. Water-level fluctuations maintained the wet prairies, marshes, and swamp forests, and fire was important in maintaining open conditions. Drainage of these lands for agriculture has left few high-quality remnants.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state natural areas	Dickinson Island
Michigan state game areas	Petersburg, Pointe Mouillee
Michigan state wildlife areas	Ford, St. Clair Flats, St. John's Marsh, Erie
Michigan state parks	Algonac, Sterling
Michigan state environmental areas	Stony Island, Grassy Island, Pointe Mouillee, Monroe, Maumee Bay
Michigan state recreation areas	Rochester-Utica, Proud Lake
Metroparks	Oakwoods, Lower Huron, Lake Erie, Stony Creek, Metro Beach, Willow
The Nature Conservancy preserves	Erie Marsh, Highland Cemetery
Michigan Nature Association preserves	American Lotus Plant Preserve, Sibley Prairie

Lakeplain prairie and oak-opening restoration and management are high priorities.

8.10 Southern Lower Michigan

This ecoregion extends across the southern half of the lower peninsula of Michigan and touches the shores of Lakes Erie, Huron, and Michigan. It comprises rolling hills and flat lakeplains of fertile soils. A long, warm growing season has made this area appealing for agriculture. Broad lacustrine plains are found along the lakes for as much as 80 kilometres (50 miles) inland along Lake Huron. Much of the Lake Michigan shoreline has a band of sand dunes. Before European settlement, this region was forested with oak-hickory or beech-sugar maples. Tallgrass wet prairies covered large areas of the lakeplains of Lakes St. Clair, Erie, and Huron. Extensive marshes, fens, and swamp forests were also present. Fire was important in maintaining the savannahs and prairies.

Most of the tallgrass/wet prairies have been converted to farmland. Oak savannahs have been degraded as a result of fire suppression. Heavy industrial and urban development has altered habitats in both communities. As a result, prairies and oak savannahs are rare and threatened.

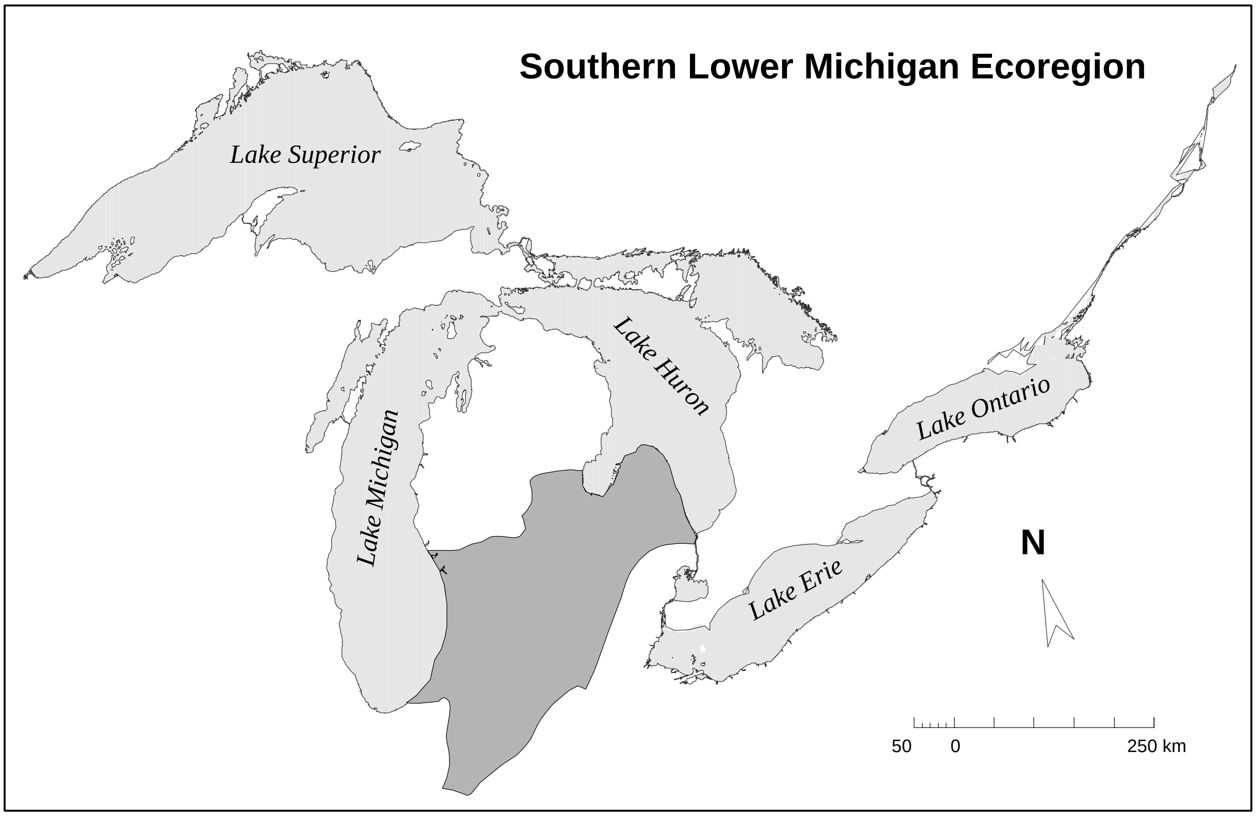


Figure 28. Southern Lower Michigan Ecoregion

8.10.1 Huron–Sandusky Lake Plain

Before European settlement, the coast of this clay lakeplain along the southern end of Lake Huron from Bay City to Port Huron, Michigan, was marsh with low beach ridges and sand spits with white and black oak. Oak savannahs were managed with fire by the early Native American settlers. The lands are now agricultural. A few wet prairies and marshes remain.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state game areas	Fish Point, Deford, Rush Lake, Sanilac, Vassar, Port Huron, Minden City, Cass City, Murphy Lake, Tuscola, Verona
Michigan state wildlife areas	Fish Point, Quanicassee, Wildfowl Bay,
Michigan state parks	Lakeport, Port Crescent, Sanilac Petroglyphs, Albert E. Sleeper
Michigan environmental areas	Fish Point, McKinley, Rose Island, Sebewaing, Thomas, Weale, Bay Port
Michigan Nature Association preserves	Jasper Woods Memorial and Red Wing Nature Sanctuaries, Ray Memorial Plant Preserve

This area has been substantially altered. Conservation measures to protect remaining wet prairie for waterfowl are recommended.

8.10.2 Saginaw Bay Lake Plain

This area extends from Bay City to Arenac County in Michigan. Marshes and wet prairies were characteristic of this poorly drained clay and sand lakeplain prior to European settlement. Distinctive prairies and oak savannahs, as well as white pine and hemlock dominated pre-European settlement vegetation. The rich, loamy soils and lake-moderated climate have resulted in agricultural development. This area is important for prairie and savannah communities, rare plant and animal species, and waterfowl.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National wildlife refuge	Shiawassee
Michigan state game areas	Crow Island, Gratiot-Saginaw, Tobico Marsh, Shiawassee River
Michigan state wildlife areas	Nayanquing Point, Quanicassee, Wigwam Bay
Michigan state parks	Bay City
Michigan state forests	Au Sable
Michigan environmental areas	Coryeon Point, Quinicassee, Pinconning, Nayanquing, Oil Fields

Extensive diking and draining of marsh and wet prairies have significantly altered this region. Conservation priorities include restoration of coastal marsh and wet prairie to improve rare plant and animal species and waterfowl habitat.

8.10.3 Allegan–Southern Lake Michigan Lake Plain

Along the southern Lake Michigan shoreline in southwest Michigan from White Lake to the Michigan–Indiana state line is a discontinuous band of sand dunes, 1.6 to 4.8 kilometres (1 to 3 miles) wide. Before European settlement, the dunes were eastern hemlock and beech forests along with white pine, red and white oak, and sugar maple.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forests	Manistee
Michigan state natural areas	Crooked Lake Marsh, Saugatuck,
Michigan state nature study areas	Warren Woods, Warren Dunes
Michigan state game areas	Grand Haven, Allegan, Muskegon
Michigan state parks	Warren Dunes, Grand Mere, Van Buren, Saugatuck, P.J. Hoffmaster, Holland, Muskegon
Michigan Nature Association preserves	Five Lakes, Wade Memorial, Barvicks Sand Dunes, Pepperidge Dunes, Beck Memorial
The Nature Conservancy and other privately owned preserves	Grand Beach, Ross, Hofma, Robinson, Sarrett Nature Center, Fernwood Nature Study Area

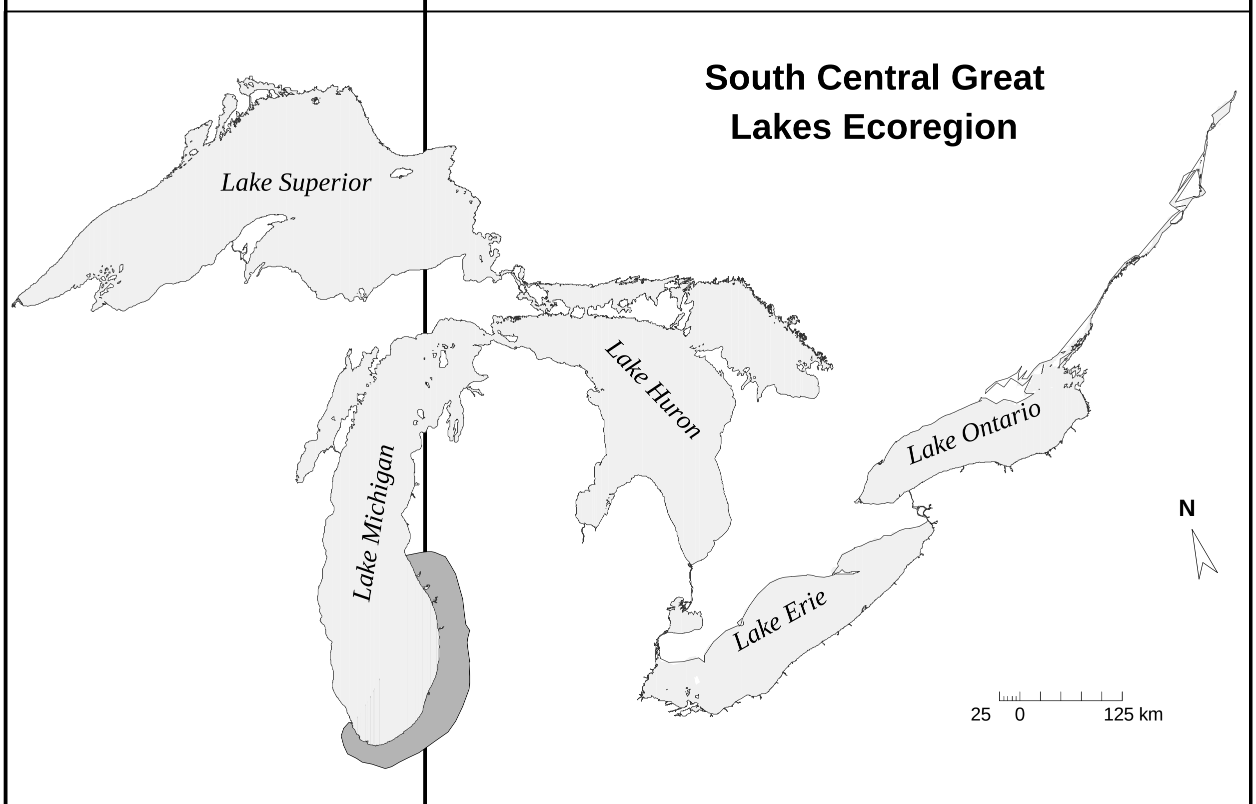
The shoreline is being destabilized by construction of marinas and breakwaters in other parts of the lake. This, plus residential development, sand mining, and off-road vehicle use, threaten important sand dunes, many already in protected state park status.

8.11 South Central Great Lakes

Figure 29. South Central Great Lakes Ecoregion

This region overlaps with the Southern Lower Michigan Ecoregion. It extends from Muskegon, Michigan, through northwest Indiana to the Calumet Region on the southeast side of Chicago. Formed by receding glaciers, this region is a combination of gently rolling lowlands and flat lacustrine plains. Lakeshore erosion and deposition contribute to a dune system. Oak-hickory covered dunes, sand beaches, tallgrass prairies, and wetlands characterize ecological communities. Industrial and urban development dominate the shoreline; however, the region is surprisingly rich in biological diversity and protected areas. The following are protected areas in Indiana and a small part of Illinois:

National lakeshore	Indiana Dunes
Indiana state parks	Indiana Dunes
Lake County, Indiana preserves	Gibson Woods, Oak Ridge Prairie
Indiana state nature preserves	Tolleston Ridges, Clark and Pine, Bongi, Hoosier Prairie, Moraine
The Nature Conservancy preserves	Ivanhoe



City parks	Whihala Beach - Hammond, Marquette Park - Gary
Forest Preserve District of Cook County, Illinois	Lake Powderhorn, Sand Ridge

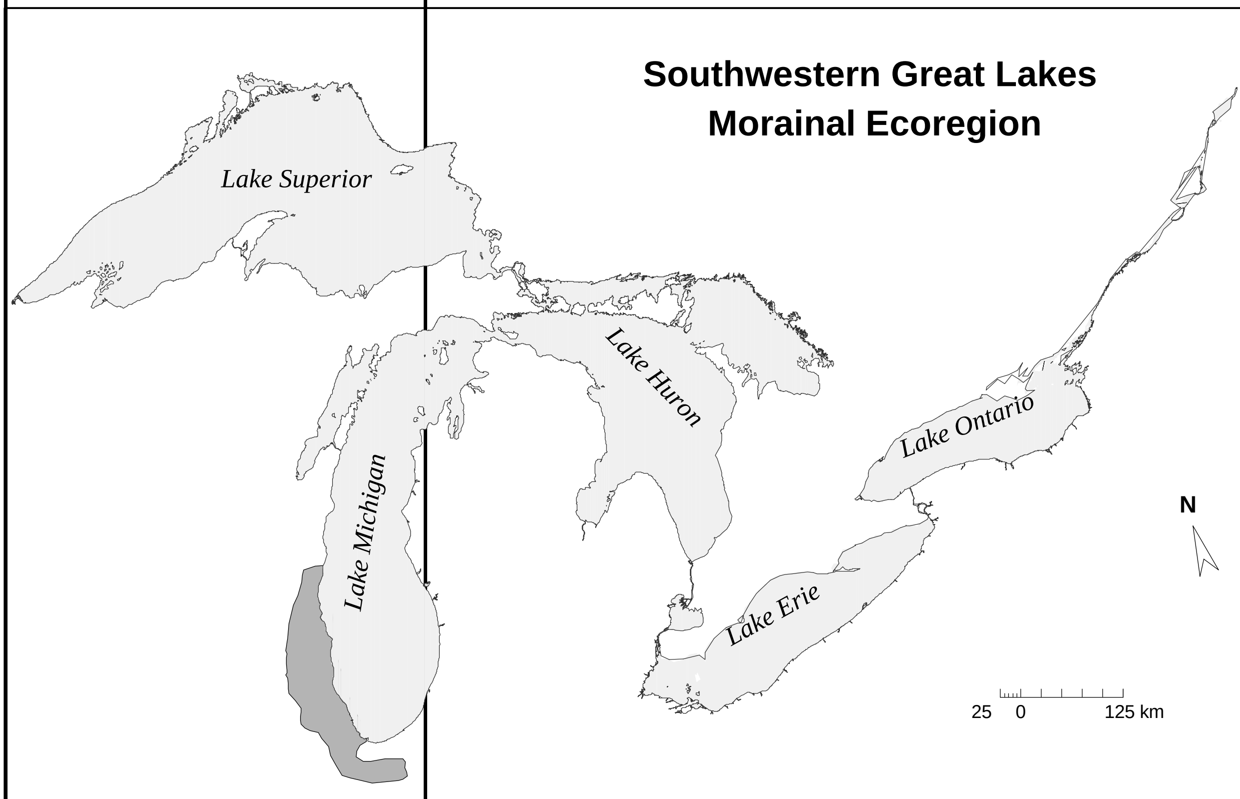
8.12 Southwestern Great Lakes Morainal

Figure 30. Southwestern Great Lakes Morainal Ecoregion

This region overlaps with the Southeast Wisconsin Savanna Ecoregion. It extends from Southeast Chicago to Milwaukee. It is flat, undulating topography resulting from glaciation. The lakeshore is largely hardened with artificially nourished beaches in Chicago and Milwaukee. Two outstanding natural areas, Chiwaukee Prairie in Wisconsin and Illinois Beach State Park, preserve remnant dune and swale, oak savannah, and tallgrass prairie communities. Inland from the lake are numerous ecological restoration sites within the Forest Preserve Districts of Cook and metropolitan collar counties. A movement called Chicago Wilderness has united 34 environmental organizations, agencies, and institutions to preserve high-quality ecosystems within a three-state area (Wisconsin, Illinois, Indiana).

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Illinois state park	Illinois Beach



Illinois county preserves	Forest Preserve District of Cook County, Forest Preserve District of Lake County

The Nature Conservancy preserve	Chiwaukee Prairie

8.13 Northern Lacustrine-Influenced Lower Michigan

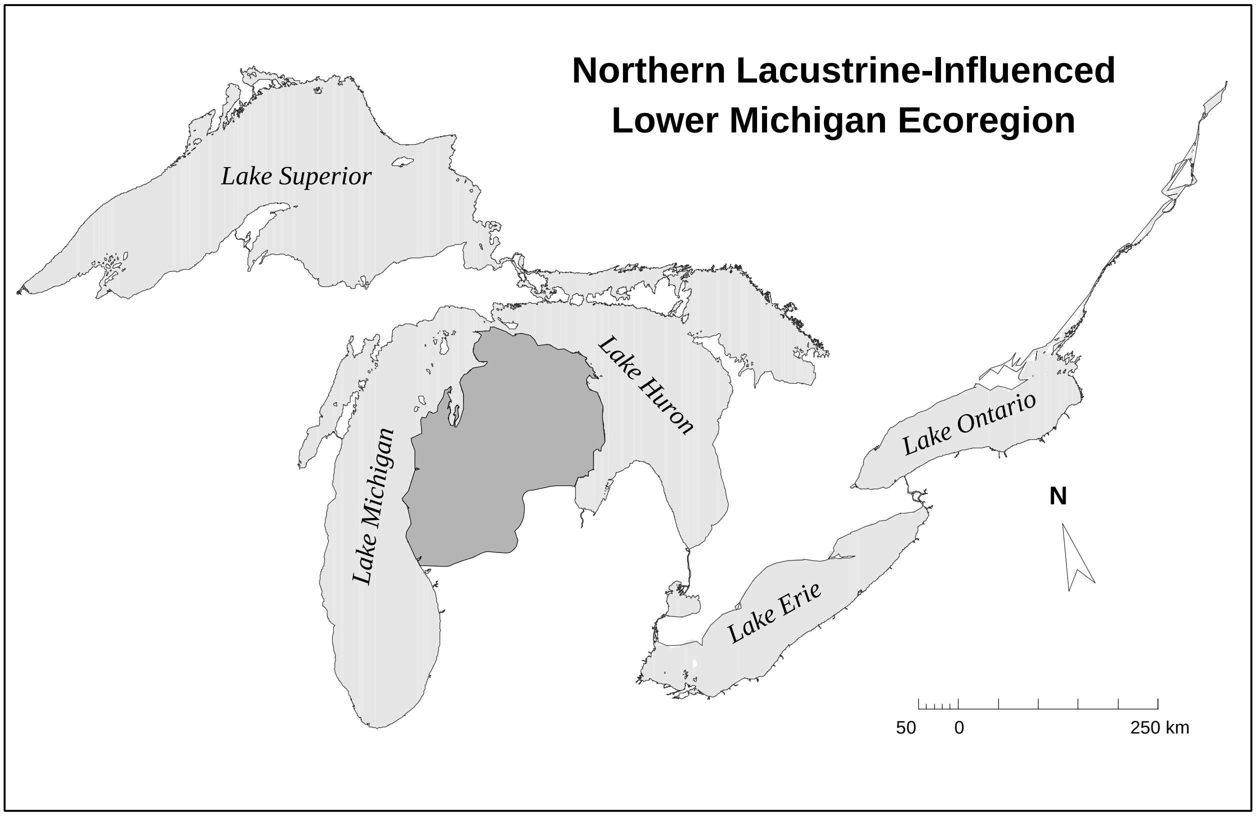


Figure 31. Northern Lacustrine-Influenced Lower Michigan Ecoregion

This ecoregion region extends across the upper half of Michigan's lower peninsula, touching the shores of Lakes Huron and Michigan. The shoreline climate is affected by the lake and is characterized by snow, summer and winter temperature extremes, a short growing season, greater summer precipitation, and risk of occasional spring freezes. Limestone bedrock is exposed along the Lake Michigan and Huron shores. Sand deposits are thick in most areas. Before European settlement, jack pine, white pine, and northern pin oak dominated large areas of this region. Much of the area has been logged, the eastern hemlock for the tanning industry. Orchards and vineyards exist in the southern part of the region. Primary- and second-home development as well as recreation are affecting sensitive ecosystems along the shoreline.

8.13.1 Arenac–Standish

This area extends from the Bay/Arenac County line to Oscoda, Michigan. Before European settlement, jack pine barrens dominated this area north of Saginaw Bay, with white pine, red pine, and black and white oak also occurring. Embayments along the Saginaw Bay shoreline were bog or shrub swamps with jack pine barrens. Swamp forests, marshes, and wet prairies dominated low-lying swales, whereas white pine and red oaks dominated the beach ridges. Presently, the wet areas are drained and the lakeplain areas are used as pasture or for row crops, timber, or recreation.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forests	Huron
Michigan state forests	Au Sable
Michigan state parks	Harrisville, Tawas Point
Michigan state wildlife areas	Wigwam Bay
Michigan state environmental areas	Rifle River, Pine River, White's Beach
Michigan Nature Preserve Association preserve	Frink's Pond

Conservation needs include the expansion of Kirtland's warbler habitat along the lower Au Sable River. The peatlands on the sand lakeplain require management for biodiversity.

8.13.2 Presque Isle–Cheboygan

This area extends from Oscoda to Wilderness State Park, Michigan, and includes Beaver Island. The shoreline of Lakes Michigan and Huron on the northern part of Michigan's lower peninsula consists of low foredunes, sand spits, beach ridges, and dune and swale. Limestone bedrock and cobble are found near Rogers City, Michigan. White pine, red pine, jack pine, and northern pin oak were common in pre-European settlement times. Residential development and limestone quarrying followed logging in the area.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Wilderness area and national wildlife refuges	Michigan Islands
Michigan state natural areas	Besser, Sturgeon Bay-Sucker Creek, Thompsons's Harbor, Waugoshance Point Nature Study Preserve, Wilderness State Park

Michigan state forests	Mackinac
Michigan state parks	Wilderness, Cheboygan, Thompson's Harbor, Onaway, Negwegon, P.H. Hoeft
Michigan state environmental areas and other preserves	Black River, Cuncan Bay, Jensen Harbor, Hat Island, Squaw Bay, Whitefish Bay, Wilderness, Grape, Sacajawea, Univ. of Michigan Biological Station, Beaver Island Wildlife Research Area
The Nature Conservancy preserves	Grass Bay, Squaw Bay
Michigan Nature Association preserves and other preserves	Grass Lake, Gull Island, Bird Island, Grass Island, Peter Nature Sanctuary

Much of the shoreline is state-owned, but several high-quality undeveloped areas remain unprotected.

8.13.3 Presque Isle–Stutsmanville

This area lies between Wilderness State Park and Harbor Springs, Michigan. The Lake Michigan shoreline at the northwestern tip of the lower peninsula of Michigan consists of steep sand dunes. Before European settlement, this was northern hardwood forest and northern white cedar. The forests were logged and are now second growth northern hardwoods.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state forests	Mackinaw
Michigan state park	Wilderness
Little Traverse Conservancy preserves	M. Shrotleff, E. Johnson, Sims-Moffat

Second growth forests are maintained in the state forests and parks and conservancy preserves.

8.13.4 Manistee

This region, which lies between Leland and White Lake, Michigan, is on the eastern coast of Lake Michigan and includes islands with perched sand dunes. The lake significantly moderates the climate, resulting in conditions suitable for vineyards and orchards. Sleeping Bear Dunes National Lakeshore and other high dune areas are significant features of this region.

Large areas of the coast are federal and state parks. Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forests	Manistee
National lakeshores, natural areas, and other research areas	Sleeping Bear Dunes, Nordhouse Dunes, Michigan Islands
Michigan state parks	Charles Mears, Ludington, Silver Lake, Orchard Beach
Michigan state game areas	Betsie River, Manistee River, Muskegon, Pentwater
Michigan state forests	Pere Marquette
The Nature Conservancy preserves	Betsie River, Point Betsie, Lucia K. Tower
Other research areas	Beaver Islands Wildlife Research Area, High Island Environmental Area, Central Michigan University Biological Station

8.13.5 Leelanau and Grand Traverse Peninsula–Traverse City

This area lies between Petosky and Leland, Michigan. Low sand dunes and dune and swale ridges characterize this sandy lakeplain of peninsulas. Before European settlement, northern hardwood forest dominated the dunes. Today, land is used for orchards and pasture, with rapidly developing second-home development.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National lakeshore	Sleeping Bear Dunes
Michigan state parks	Fisherman Island, Leelanau, Young, Old Mission Peninsula
Michigan state forests	Pere Marquette, Mackinaw
Michigan state game areas	Petobego
County parks	Marion Island
Michigan Nature Association preserves	Green River, Cedar River
The Nature Conservancy preserves	Palmer-Wilcox-Gates, Skegemog Swamp, Oyster Bay Nature Preserve, Leffingwell Forest Preserve

As a result of its beauty, the area is being rapidly developed. Few high-quality natural areas remain.

8.14 Southeastern Wisconsin Savanna

The Southeastern Wisconsin Savanna Ecoregion is characterized by gently sloping moraines and end moraine ridges, calcareous soils, and lacustrine sand and clay. The soils are fertile and the growing season long. Limestone or dolomite cuestas underlie the Niagaran upland along Lake Michigan.

Before European settlement, oak savannah and tallgrass prairie dominated the areas close to the lake. Fire was frequent. Agriculture and development have altered land use, so that both community types are now rare.

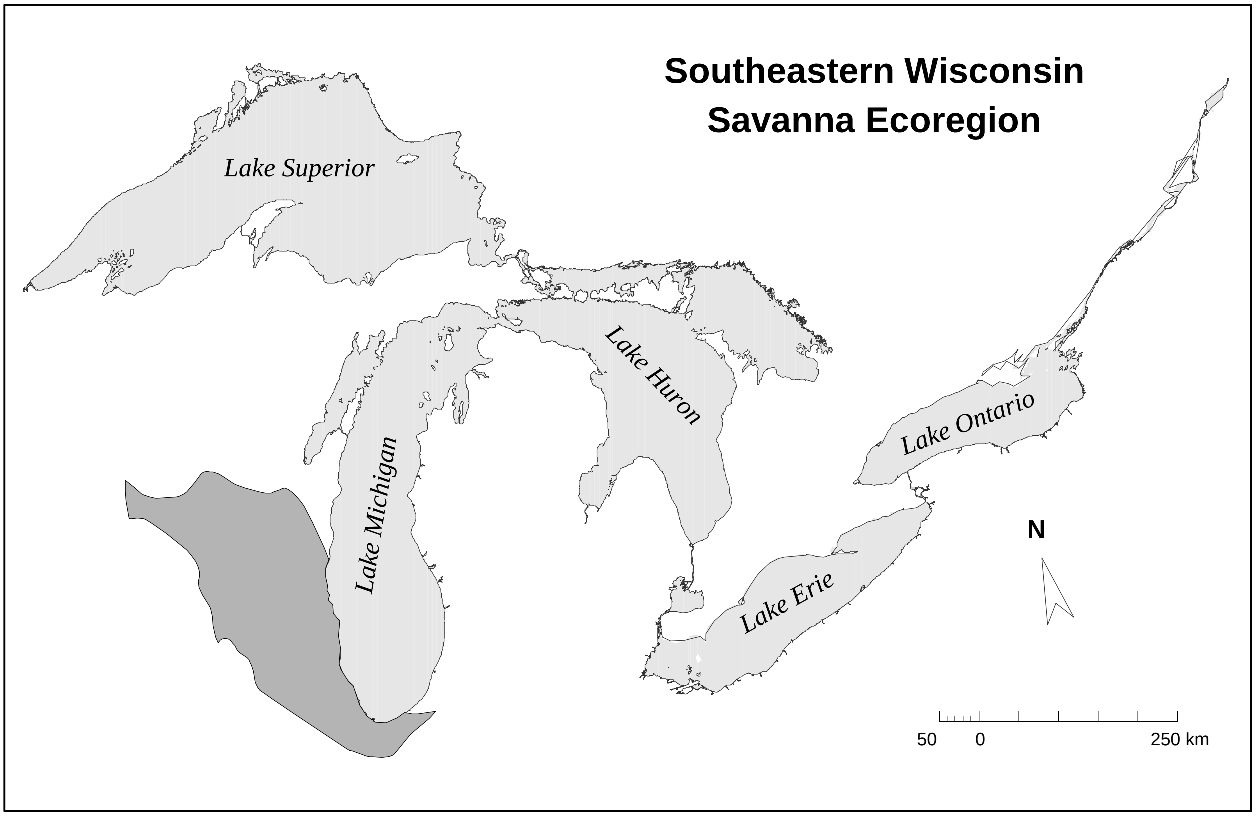


Figure 32. Southeastern Wisconsin Savanna Ecoregion

8.14.1 Southeastern Wisconsin Till Plain–Galena-Platteville

This area lies between the Illinois-Wisconsin state line and Racine, Wisconsin. Tallgrass prairie grows on the gently sloping Niagara cuesta along the Lake Michigan southeast shore. Rare communities include tallgrass prairie, oak savannah, and fens. The landscape is developed and the shoreline extensively armoured.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National wildlife refuge	Horicon Marsh
Wisconsin state natural areas	Ripon Prairie, Chiwaukee Prairie, Audubon Goose Pond, Renak-Polak Beech Maple Woods
The Nature Conservancy preserve	Chiwaukee Prairie

8.14.2 Southeastern Wisconsin Till Plain–Milwaukee

This area lies between Racine and Port Washington, Wisconsin. Sugar maple-basswood forest predominates in this area. Before European settlement white and black oaks were probably present. Marshes and sedge meadows were common. At present, the shoreline is developed and armoured. Inland, bogs and marshes remain but sites are fragmented and have been affected by urban growth.

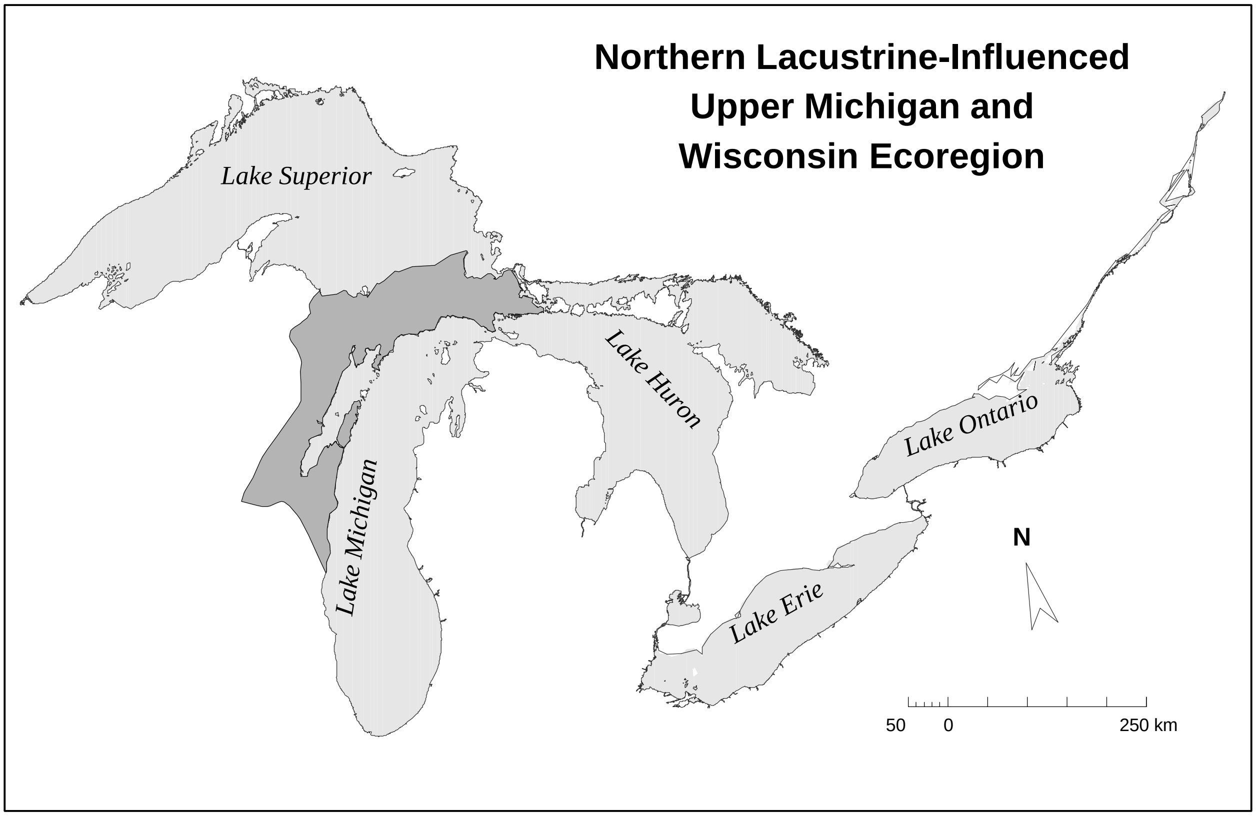
Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

State natural areas	Spruce Lake Bog, Sander’s Park Hardwoods, Oakfield Ledge, Mayville Ledge Beech-Maple Woods, Neda Mine, Vanderbloemen Bog, Cedarburg Beech Woods, Cedarburg Bog, Sapa Spruce Bog, Kurtz Woods, Riveredge Creek and Ephemeral Pond
The Nature Conservancy preserve	Zinn

8.15 Northern Lacustrine-Influenced Upper Michigan and Wisconsin

This ecoregion is characterized by peatland and swamp forest. Lake effect snow and rain is common on Lake Superior. Sandstone is exposed along the Lake Superior shoreline. Limestone and dolomite are exposed along the Lake Michigan shore. Most of the region is glacial lakeplain with common landforms at the shoreline that include transverse dunes, sand spits, beach ridges, and deltas. The rare alvar community is found here.

Before European settlement, the region was covered by northern hardwood forest, jack pine barren, white and red pine forest, conifer swamp, and hardwood-conifer swamp. Extensive marshes were found along the shoreline. Fire was an important disturbance in the jack pine barrens.



Intensive logging took place early, then agriculture followed. Second-home development pressures are stressing the shoreline. The Nature Conservancy has a major bioreserve project under way here.

Figure 33. Northern Lacustrine-Influenced Upper Michigan and Wisconsin Ecoregion

8.15.1 Niagaran Escarpment and Lake Plain–Green Bay Till Plain and Lake Plain

This area lies in Wisconsin, between Port Washington and Two Rivers on the Lake Michigan shore, and between the Door-Kewaunee County line and Oconto on the Green Bay shore. Lake Michigan influences the temperatures along this shoreline. Snowfall, however, appears not to be affected by the lake to a great degree. A flat cuesta underlies the Niagara Escarpment from Green Bay to the Door Peninsula. Most of the land is agricultural. Sand dunes and interdunal wetlands are found on the shoreline, but prairies and oak savannahs have long succumbed to the plough.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Wisconsin state forest	Point Beach
Wisconsin state park	Kohler-Andrae
Natural areas	Cedarburg bog, Cedar Grove Hawk Research Station, Wilderness Ridge, Maribel Caves, Two Creeks Buried Forest, Fairy Chasm, Kohler Park Dunes, Point Beach Ridges

8.15.2 Niagaran Escarpment and Lake Plain–Escanaba/Door Peninsula

This area includes the Door Peninsula, Wisconsin, and lies between Oconto in Wisconsin and Escanaba in Michigan. Beach ridge and swale topography forms a band along the Lake Michigan shoreline. Sandy beaches as well as bedrock and cobble beaches are common. Soils are sandy. Before European settlement, the shoreline was characterized by dune and swale topography with ridges of white or red pine, white spruce, balsam fir, and hardwoods. Jack pine barrens were also prevalent in limited areas. Windthrow is the most common natural disturbance. Fire and water-level fluctuations were also common.

Logging and agriculture changed the land early. Urban development is currently the major stressor to high-quality natural communities such as alvar, cobble beaches, sand dunes, and interdunal wetlands.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Hiawatha
Michigan state parks	Fayetete, Palms Book, Wells
Wisconsin state parks	Newport, Peninsula, Whitefish Dunes, Rock Island, Potawotami
Michigan state forests	Lake Superior, Escanaba River
Michigan state environmental areas	Portage Point, Rapid River, St. Vital Island, Fishdam River, Ford River, Round Island, Ogontz River
U.S. Fish and Wildlife Service	Spider, Gravel, Fish Islands
Wisconsin state wildlife areas	Mudlake
Wisconsin state natural areas	Peninsula Park Beech Forest, Peninsula Park White Cedar Forest, The Ridges Sanctuary, Sister Islands, Two Creeks Buried Forest, Seagull Bar, Toft Point, Newport Conifer-Hardwoods, Jackson Harbor Ridges, Mud Lake, Whitefish Dunes, Marshall’s Point, Moonlight Bay Bedrock Beach, Coffee Swamp
The Nature Conservancy preserves	Mink River Estuary
Michigan Nature Association preserves	Two Wilderness Islands, Garden Peninsula, Escanaba River

Proposed research natural areas	Nahma, Sturgeon River

8.15.3 Niagaran Escarpment and Lake Plain–St. Ignace

This area lies between Escanaba and St. Marys River and includes Drummond Island. The landscape shoreline is characterized by sandy lakeplain, exposed limestone bedrock on the Lake Huron shore, sand dunes, beach ridges and swales, and conifer-dominated wetlands. Before European settlement, coastal marshes were protected in embayments and coves. Beach ridges and swales, supported by forests of white pine, red pine, red oak, and other hardwoods, were found in the embayments. Parabolic dunes on the shore of Lake Michigan were dominated by northern hardwood forest. Wildfires and windthrows were common.

The forests have been logged, and residential development is increasing. Some land has been cleared for agriculture. The globally rare alvar community is found on Maxton Plains of Drummond Island and in Schoolcraft County. Dunes and ridges support populations of Pitcher's thistle and Lake Huron tansy. Dwarf lake iris, Houghton's goldenrod, and Michigan monkey-flower are found along the shoreline.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Hiawatha
National wildlife refuges	Seney
Michigan state forests	Lake Superior, Mackinaw
Michigan state parks	Detour, Mackinaw Island
Michigan state environmental areas	Little St. Martin Island, Voight Bay, Goose Island, Pointe Aux Chenes Bay, Mismer Bay, Carp River, St. Helena, Crow River, Scammon, Epuofette, Crow Island, Cedar Island, Paw Point, Search Bay, Lone Susan, Pontchartrain, Seiners Point, Naubinway Island, Scotty Bay, Seymour Bay, Duck Bay, Gravel Island
The Nature Conservancy preserves	Bois Blanc Island, Maxton Plains, Voight Bay, Dudley Bay-Trout Lake, Poe Point, Little LaSalle Island, Northern Lake Huron Bioreserve
Michigan Nature Association preserves	Purple Coneflower, Michigan Monkey-flower, Green Spleenwort, Rare Fern, Beaver Dam, Beavertail Point, Three Wilderness Islands, Carlton Lake Wetlands, Lake Huron Sand Dunes, Drummond Island, Harvey's Rocks
Proposed research natural areas (Hiawatha National Forest)	Summerby Swamp, Pointe aux Chenes Marsh
Wilderness areas (Hiawatha National Forest)	Horseshoe Bay, Round Island, Government Island

Michigan state natural areas	Maxton Plains, Snake Island, Mixed Forest Nature Study Area, North Shore, Northern Lake Michigan (proposed), Seiners Point (proposed), Little Brevoort Lake Scenic Area

8.15.4 Niagaran Escarpment and Lake Plain–Rudyard

This area lies between St. Marys River and Point Iroquois, Michigan. It is a broad, clay lakeplain, intensively formed. Ancient beach ridges and swales can be found, sometimes a distance from the shore. Forests have been cleared and swamps drained for agriculture. The wetlands along St. Marys River are important for waterfowl.

National forest	Hiawatha
Michigan state forest	Lake Superior
Michigan environmental areas	Frog Bay, Roach Point, Pickford, Shingle Bay, Kemps, Rock Island, Hiawatha, Sand Island, Birch Point, Winter, Round Island, Gem Island, Dike
Michigan Nature Association preserves and other preserves	Beaver Dam, Lapland Buttercup, Three Wilderness Islands, Carlton Lake Wetlands, Roach Point, Osborn Preserve

8.15.5 Luce–Grand Marais Sandy End Moraine and Outwash

This area lies between Point Iroquois and Au Train bay, Michigan. It includes the sand dunes of Grand Sable Dunes National Lakeshore, sand spits, and beach ridges. Small areas of jack pine exist within the dunes. Forests have been logged. Extensive remaining areas of red pine and wetlands are of concern.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National park	Pictured Rocks National Lakeshore
National forest	Hiawatha
Michigan state forest	Lake Superior
Michigan state parks	Tahquamenon Falls, Muskallonge Lake
Michigan state environmental areas	Tahquamenon Island, Williams Island
Research natural areas	Betsy Lake. Betsy Lake River, Grand Island, Au Train Gorge (proposed)
Wilderness areas	Rock River Canyon
State scenic site	Wagner Falls

The Nature Conservancy preserves	McMahon Lake, Swamp Lakes
Michigan Nature Association preserves and other preserves	Lake Superior, Twin Waterfalls, Whitefish Point Bird Observatory

8.15.6 Dickinson–Deerton

This area lies between Au Train bay and Marquette, Michigan. It is characterized by sandstone knobs, sand ridges and swales. Before European settlement, the beach ridges and swales were dominated by red and jack pine. Logging, recreation, and residential development are current land uses.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state forests	Escanaba River, Lake Superior
Michigan state scenic sites	Laughing Whitefish Falls
National forest	Hiawatha
The Nature Conservancy preserves	Laughing Whitefish Lake

8.16 Northern Continental Michigan, Wisconsin, and Minnesota

This ecoregion is typified by glacially scoured bedrock ridges and glacial features, including moraines, lake beds, and outwash channels and plains. In the past mining was important and led to early rapid development, but it is no longer a major industry. At present, most of the land is under public or private forest management. The original vegetation was northern hardwood forest. Red and white pine and red oak were common. Red oak forests occurred on the Keweenaw Peninsula, Isle Royale, and the Porcupine Mountains. Windthrows and fire were important natural disturbances.

Bedrock beaches and boreal vegetation are important. Forests are major breeding areas for migratory song birds.

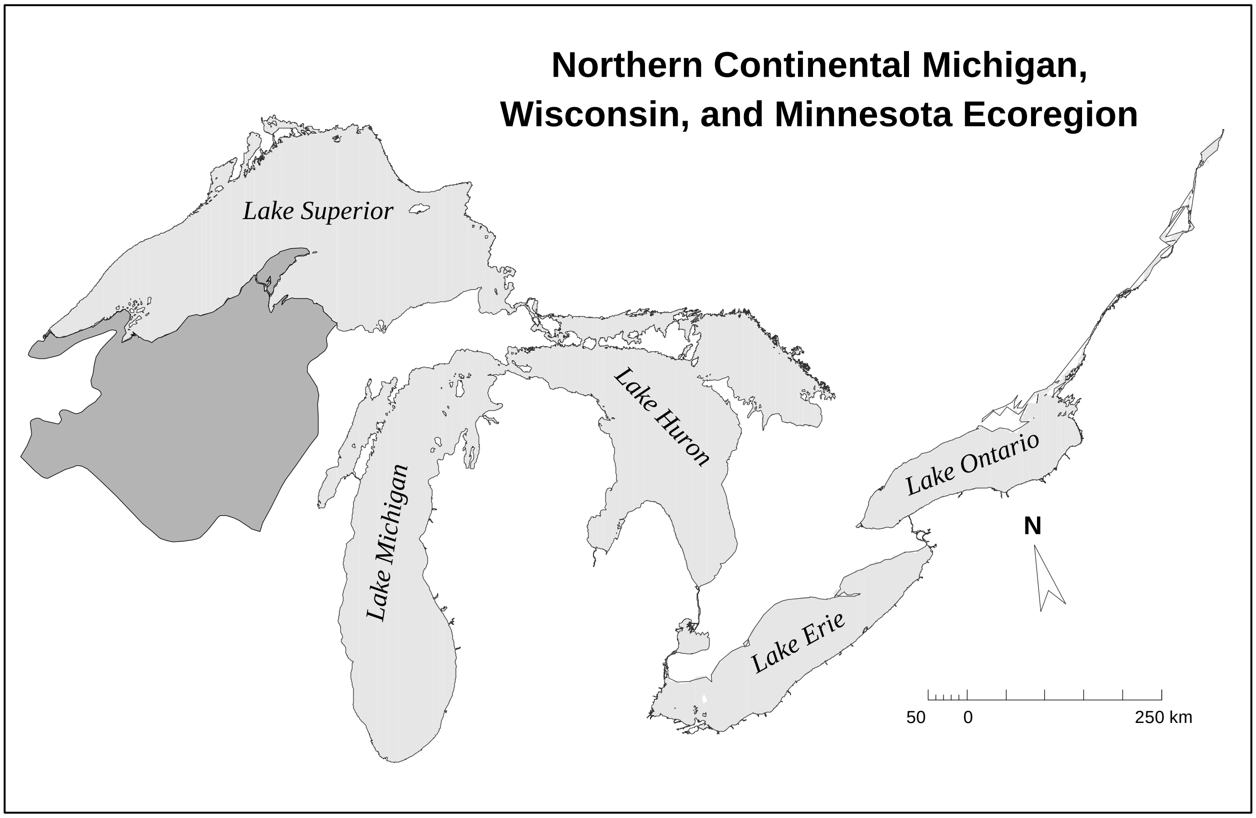


Figure 34. Northern Continental Michigan, Wisconsin, and Minnesota Ecoregion

8.16.1 Bergland–Gogebic-Penokee Iron Range

This area is from Laughing Fish Point, Michigan, to Oconto Bay, Wisconsin. This part of the Lake Superior shoreline and inland is characterized by volcanic bedrock ridges. Before European settlement, the ridges were of red and white pine, red oak, and paper birch. Now, tourist activities and forestry are important, with some copper and iron mining.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Chequamegon, Ottawa
Michigan state wilderness areas	Porcupine Mountains
Michigan state scenic sites	Presque Isle River, Union Springs
Michigan state parks	Porcupine Mountains, Lake Gogebic

Michigan state forests	Copper Country

8.16.2 Lake Superior Lake Plain

The Lake Superior Lake Plain area covers 320 kilometres (200 miles) of Lake Superior shoreline in Michigan, Wisconsin, and Minnesota. It is characterized by a short growing season and leached calcareous red loams and clays. Vegetation in pre-European settlement times was boreal forest, but logging, mining, and home development has now altered vegetation. Superior water-level fluctuations are critical natural disturbances that influence the coastal wetlands of the area. Shoreline cliffs and sand dunes are found, as well as the Kakagon Sloughs estuary in northern Wisconsin.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Ottawa, Chequamegon, Black River
National lakeshore	Apostle Islands
Michigan state parks	Porcupine Mountains
Minnesota state natural areas	Hemlock Ravine
Wisconsin state natural areas	Bark Bay Sloughs, Port Wing Boreal Forest, Big Bay Sand Spit and Bog, Apostle Islands Maritime Forest, Apostle Islands Maritime Cliffs, Apostle Islands Sandscape, Apostle Islands Critical Species Sites, Lost Creek Bog, Bibon Marsh
Michigan state forest	Copper Country
Minnesota state parks	Jay Cooke
Minnesota state forest	Nemadji
Minnesota municipal forest	Magney-Snively

8.16.3 Michigamme Highland

This area extends from Marquette to the Marquette-Baraga County line, Michigan. The climate on the Lake Superior shore in this area is harsh with extreme minimum temperature ranges and heavy snowfall. The topography is variable, with low rocky ridges, swamps, and high, exposed granite or sandstone ridges. Soil is sandy or minimal on bedrock knobs. Before European settlement, northern hardwoods dominated. Fire was an important natural disturbance of the area. Logging and mining were important land uses last century. Currently, recreation and development predominate. The bedrock ridges require more study.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Ottawa
National wilderness area	Huron Islands
Michigan state forests	Escanaba River, Copper Country,
Michigan state park	Craig Lake
Experimental forests	McCormick, Upper Peninsula
Michigan state environmental areas	Squaw Bay
Research natural areas	McCormick Tract
Michigan Nature Association preserves	Willow Creek, Braastad Memorial
Other	Huron Mountain Club Nature Reserve Area

8.16.4 Bergland–Baraga

This area lies between the Marquette-Baraga County line and Little Traverse Bay, Michigan. It has extreme temperature ranges and is characterized by large, broad ridges near Lake Superior. Land uses include mining, logging, development, and recreation. Hydrological changes have had a negative impact on wetlands.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Ottawa
Michigan state forest	Copper Country
Michigan state environmental areas	Pequaming

8.16.5 Keweenaw–Gay

This area lies between Little Traverse Bay and Bete Grise, Michigan. It is characterized by broad ridges and swamps, a sandy till plain and ground moraine. Northern hardwoods covered most of the area. Mining was important in the past. Recently, recreational activities and cottage development have taken place, and forest logging has been severe.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state forest	Copper Country
Michigan state environmental area	Traverse Island

8.16.6 Keweenaw–Calumet

This area lies between Bete Grise and Hancock, Michigan. The bedrock shoreline is characterized by northern hardwood forest, white pine forest, white pine, red pine, and red oak on bedrock forest, spruce-fir forest, and bogs. Steep slopes, high cliffs, and small sand dunes are found. Bedrock beaches are rich in boreal species. Original land uses included mining and logging, but currently, recreational activities and cottage development are taking place. Mining has degraded the shoreline. Sensitive bedrock shores are being developed.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

Michigan state forest	Copper Country
Michigan state park	Fort Wilkins
The Nature Conservancy preserve	Horseshoe Harbor
Michigan Nature Association preserves	Estivant Pines, Keweenaw Shore, Dan's Point Hylton Memorial, K.W. and T.S. Gunn Memorial, R. and M. Grinnel Memorial, Brockway Mountain, J.H. Klipfel

8.17 Northern Minnesota

This ecoregion is characterized by the glacial erosion of bedrock. The rugged Lake Superior shoreline holds cliffs and fast-flowing rivers with waterfalls. Before European settlement, conifers dominated the vegetation, with some hardwoods. Fire was an important natural disturbance. Heavy logging in the early 20th century changed the composition of the forest, replacing original red and white pines with jack and red pine plantations.

8.17.1 North Shore (Lake Superior) Highlands

This area from Duluth, Minnesota, to the Canadian border is rocky, with representations of northern hardwood forest, upland northern white-cedar forest, and forested bog. Arctic disjunct plant populations are found on the shoreline. Original white pine and red pine forests have been logged and replaced by trembling aspen-paper birch forests. Today, recreational activities and second-home development are major land use concerns.

Examples of the terrestrial nearshore area of this ecoregion are represented in the following parks and protected areas:

National forest	Superior
Minnesota state forests	Cloquet Valley, Finland, Grand Portage, Pat Bayle
Minnesota state parks	Cascade River, George Crosby-Manitou, Gooseberry Falls, Split Rock Lighthouse, Temperance River, Tettegouche, Judge Magney
Minnesota state waysides	Devils Track, Kodonce River, Ray Bergland
Minnesota state wildlife management areas	Canosia
Natural research areas	Marble Lookout, Schroeder
The Nature Conservancy preserves	Cathedral Grove, Langley River, Susie Islands, Congdon Park, McNair, Pigeon River

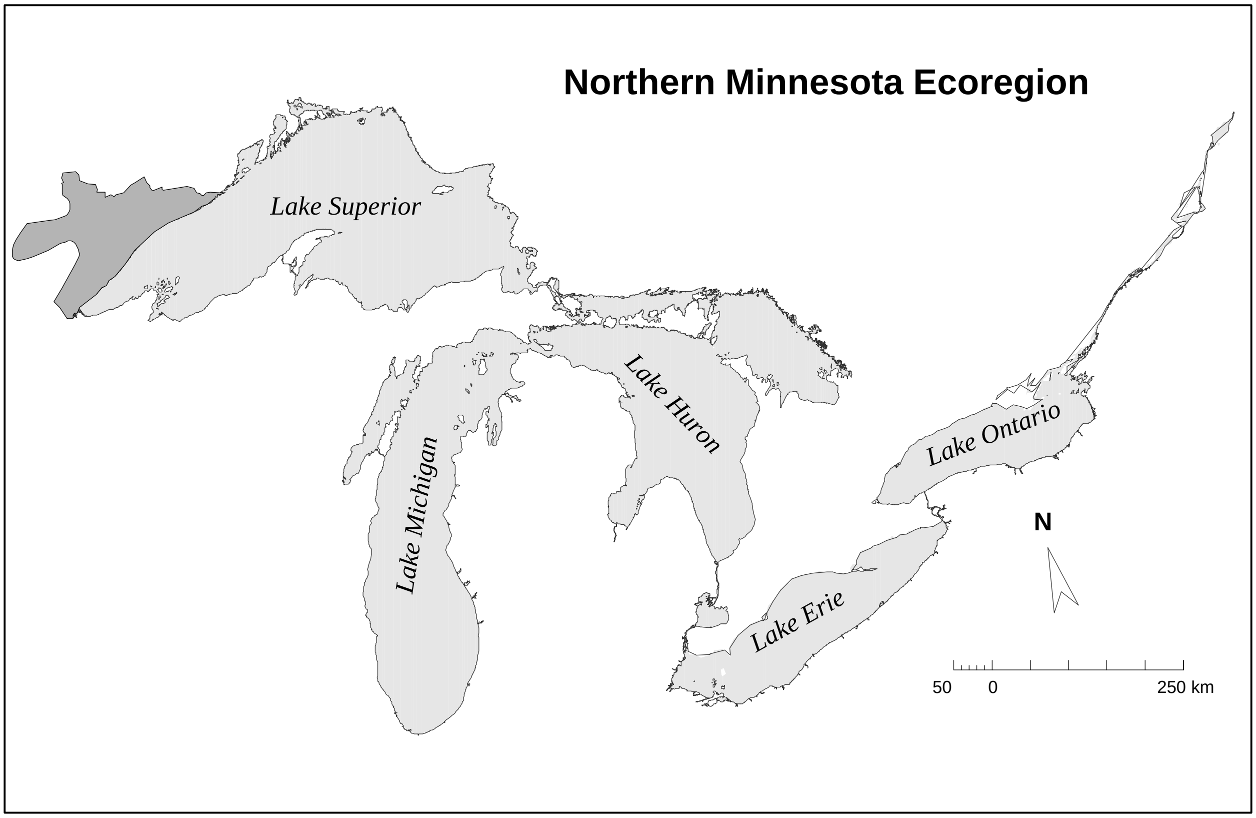


Figure 35. Northern Minnesota Ecoregion

9. Glossary

abiotic. Non-living.

acid deposition. Combination of wet deposits from the atmosphere, consisting of droplets of sulphuric acid and nitric acid dissolved in rain, sleet, and snow, and dry deposits from the atmosphere, consisting of particles of sulphate and nitrate salts. These acids and salts are formed when water vapour in the air reacts with the air pollutants sulphur dioxide and nitrogen dioxide.

alvar. Naturally open areas of thin soil over limestone or marble bedrock, which host a distinctive vegetation community—including a considerable number of rare plants.

ANSI. Area of Natural and Scientific Interest, defined by the Ontario Ministry of Natural Resources to represent the earth or life science features of a site district.

aquatic. Pertaining to water.

armouring (shoreline hardening). The installation of artificial shoreline structures designed to prevent erosion and protect properties from being washed away.

backdunes. Dunes inland from the lakes with well-established vegetation.

beach nourishment. Large quantities of sand added to the beach system to offset losses caused by wave erosion.

bedrock beach. The bare rock that is washed by the lake waves.

bedrock glade. Thin-soiled plant communities consisting of a few trees, scattered shrubs, or thickets and a grassy sedge turf on exposed bedrock that lie between the bedrock beaches and forests.

biodiversity. *See* **biological diversity.**

biological diversity. The spectrum of life forms and the ecological processes that support and sustain them. Biological diversity is a complex of four interacting levels: genetic, species, community, and landscape. “Biodiversity” is the shortened form.

biotic. Living or of life.

blowouts. Saucer-shaped gaps in dunes.

climate. Average of day-to-day weather conditions at a given place on earth over a fairly long period, usually 30 years or more. Also includes extremes in weather behaviour during the same period.

cobble beaches. Rock chunks made of durable rock generally 5 to 25 cm (2 to 10 inches) in diameter.

coliform bacteria. A normally harmless type of bacteria that resides in the intestinal tract of humans and other animals and whose presence in water is an indicator that the water may be contaminated with other disease-causing organisms found in untreated human and animal waste.

colonize. The successful establishment of a species in a habitat.

combined sewer. Sewer system that transports both storm runoff and sewage through one large pipe to a sewage treatment plant.

community. An assemblage of species living together in a particular area, at a particular time, in a prescribed habitat. Communities usually bear the name of their dominant plant species but include all the microbes, plants, and animals living in association with the dominant plant species at a given time.

community diversity. The variety and type of species present in a community, the complexity of their interactions, and the age and stability of the community. The community diversity of a region is influenced by the number of communities present, the degree of difference among the communities, and how the communities are distributed across the region.

conservation. Careful management of resources so as to obtain the maximum possible benefits from them for present and future generations.

cottage development. The building of second or recreational homes .

crustal tilting. The uplifting movement of the earth’s crust.

cuesta. An asymmetric landform that consists of a steep slope and a more gentle dip (or back) slope.

cuspate. A pattern of tooth-like points.

de-perched dunes. Dunes that form on lowland areas beyond plateaus.

depositional beaches. Beaches that receive more sand than they lose over time.

development. Changing the landscape through agriculture, industry, or building homes.

disjunct. Species that are isolated from their primary range.

diversity. Physical or biological complexity in a system. Usually a measure of the number of different species in an ecosystem.

dune. A hill or ridge of wind-deposited sand.

dune and swale (ridge and swale). Dunes or ridges that run parallel to a lake and on the ancestral lake bed; the dunes are dry and sandy, the swales are wetland areas.

ecological processes. Actions and events that link organisms and their environment—for example, nutrient cycling, carbon cycling, predation, and primary productivity.

ecological restoration. The process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems.

ecology. Study of living organisms and their relationships with one another and the environment.

ecoregion. Large landscape area defined by climate, physical characteristics, and the plants and animals that are able to live there.

ecosystem. A biotic community and its abiotic environment, considered together as a unit. Ecosystems are characterized by a flow of energy that leads to trophic structure and material cycling.

ecosystem diversity. The diversity in structure and function within an ecosystem. It is determined by the amount and complexity of linkages between the plants and animals of an ecosystem and their abiotic environment.

element. As used in this report, an individual plant, animal, or ecological community.

endemic. Found nowhere else in the world.

environment. All the biological and non-biological factors that affect an organism's life.

eolian. Deposited by wind.

erosion. Removal of soil by water or wind.

erosional beaches. Beaches that lose more sand than they receive through deposits of waves and wind.

evapotranspiration. Evaporation of water from soil, and transpiration of water from plants.

exotic. Non-native plant and animal species.

extinction. The disappearance of a species from part or all of its range.

falling dunes. Dunes that form as sand migrates off perched dunes and builds on an adjacent lowland.

fauna. Animal population of a particular area.

flora. Plant population of a particular region.

foliose. Leaf-like, made up of thin, flat lobes.

food chain. A specific nutrient and energy pathway in ecosystems proceeding from producer to consumer.

food web. Complex intermeshing of individual food chains in an ecosystem.

foredunes. Sand dunes closest to the beaches.

fragmentation. The breaking up of large and continuous ecosystems, communities, and habitats into smaller areas that are surrounded by altered or disturbed land or aquatic substrate.

function. The roles played by the biotic and abiotic components of ecosystems in driving the processes that sustain the ecosystem.

genetic diversity. The spectrum of genetic material carried by different organisms. Recombination gives genetic diversity the potential to increase or decrease over time.

global climate change. Alteration of temperature and precipitation patterns throughout the world.

global warming. The increase in temperatures as a result of human activities.

gneiss. A banded metamorphic rock originally derived from granite.

groundwater. Water that sinks into the soil, where it may be stored for long times in slowly flowing and slowly renewed underground reservoirs known as “aquifers.”

habitat. The place where an organism lives and its surrounding environment, including its biotic and abiotic components. Habitat includes everything an organism needs to survive.

herptile. A general term for amphibians and reptiles.

imperilled. Vulnerable to extinction throughout its range.

indicator. A measurable feature that singly or in combination provides manageable and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality.

interdunal areas. Areas such as pannes and ponds that are protected from wind and waves and lie behind the foredunes.

karst. Any region underlain by limestone and characterized by a set of landforms resulting largely from the action of carbonation or other processes.

lakeplain. The old lake bottom of the ancestral Great Lakes.

landscape. The surface of the earth, encompassing the water and vegetation upon it, as produced or modified by geologic, biotic, and cultural forces.

land-use planning. Process for deciding the best use of each parcel of land in an area.

longitudinal dunes. Long ridges of sand parallel to the prevailing wind; these dunes form where sand supplies are limited.

longshore current. A near-shore current that flows parallel to the shore.

lower beach. Slightly inland from the psalmolittoral beach.

meiofauna. Category of organisms less than two millimetres long.

natural resource. Anything obtained from the physical environment to meet human needs.

nearshore terrestrial ecosystems. The land area directly influenced by the presence of the lakes through physical processes or climate modification.

niche. How an organism fits into the ecosystem—where it lives, what it consumes, what consumes it, and how it interacts with all biotic and abiotic factors.

non-point source. Source of pollution in which wastes are not released at one specific, identifiable point but from a number of points that are spread out and difficult to identify and control.

nutrient. Element or compound needed for the survival, growth, and reproduction of a plant or animal.

oak opening. A savannah on rich, mesic soils with mostly bur or white oak.

pannes. Calcareous, wet, interdunal depressions that form near the water table in interdunal areas.

parabolic dunes. Dunes whose shape resembles a crescent except their tips point into the wind; they often form along coasts that have strong onshore winds, abundant sand, and vegetation that partly covers the sand.

perched dunes. Dunes resting on a plateau of glacial sediment.

perched meadows. Grassy areas found in carved out areas of bedrock along with seasonal pools of water.

point source (of pollution). Easily discernable source of pollution such as a factory pipe.

pollution. The human-induced introduction of many types of substances within and between air, land, and water components of ecosystems in quantities and at rates that adversely affect organisms, habitats, communities, ecosystems, or public health.

pond. Small, shallow impoundment of fresh water.

population. Group of individual organisms of the same species that occupy particular areas at a given time.

pre-European settlement (before European settlement). The period before the arrival of European settlers in America.

preservation. Protection of large areas of land from development.

protection. Safeguarding of valued habitats or resources from harmful activities.

psalmolittoral beach. The sandy area where the lake and the land constantly interact.

resource. Anything used by organisms to meet their needs, including air, water, minerals, plants, fuels, and other animals.

ridge and swale. *See* **dune and swale.**

runoff. All water flowing through streams and rivers that goes into the lakes.

salinity. Amount of dissolved salts in a given volume of water.

saltation. Sand grains colliding with other sand grains because of high velocity winds.

sand barrens. Areas of deep sands with scattered, sometimes scrubby, oak and pine trees and a ground layer of sedges and forbs.

sandbars. Offshore shoals built up by wave, current, or wind action.

sand beach. An area at the water's edge where sand is deposited by waves and wind action.

savannah (savanna). A community of grasses and other herbaceous plants with less than 50 percent tree cover.

sediment. Soil, particles, sand, and other mineral matter eroded from land and carried in surface waters.

seiche. Temporary displacement of water due to high winds or atmospheric pressure.

shoals. Sandy elevations offshore, which may be partially or fully submerged.

shoreline hardening. *See* **armouring.**

slump. Downward slipping of a mass of rock or unconsolidated material moving as a unit along a curved surface.

soil. Complex mixture of inorganic minerals (mostly clay, silt, and sand), decaying organic matter, water, air, and living organisms.

species. A group of individuals that can interbreed successfully with one another, but not with members of other groups. Plants and animals are identified as belonging to a given species on the basis of similar morphological, genetic, and biochemical characteristics.

species diversity. The variety of species in an area. It includes not only the number of species in the area but also their relative abundance and spatial distribution. Species richness (*see* next definition) is one component of species diversity, but not the only determinant.

species richness. The number of species in an area.

spit. An elongated ridge of sand that projects from the land into the mouth of an adjacent lake or bay.

stress. Impacts that are damaging or have the potential for damaging an ecosystem component or natural process.

substrate. The rock underlying surface soils.

surface runoff. Water flowing in streams and over the ground's surface during rainstorm or snowmelt.

sustainability. Long-term management of ecosystems to meet the needs of present human populations without interruption, weakening, or loss of the resource base for future generations.

tallgrass prairie. Rich and deep soils on which a variety of tallgrasses and flowers grow.

talus. An accumulation of rock debris at the base of a cliff.

talus slopes. Banks formed by large blocks of rock, up to 10 metres (33 feet) in diameter, that have broken away from the cliff face.

terrestrial. Pertaining to the land.

till. Unconsolidated sediment deposited directly by a glacier.

toxin. A chemical, physical, or biological agent that causes disease or some alteration of the normal structure and function of an organism. Onset of effects may be immediate or delayed, and impairments may be slight or severe.

transitional beaches. Beaches that collect and lose sand without net gain or loss.

transpiration. Escape of water from plants through pores in the leaves.

transverse dunes. A series of long ridges at right angles to the prevailing wind; these dunes form where vegetation is sparse and sand is plentiful.

unconsolidated bluffs. A steep bank or cliff made of clay, till, or other sediments.

urbanization. Development of towns and cities.

water diversion. Transfer of water from one watershed to another, usually involving dams and tunnels.

watershed. Land area that delivers runoff water, sediment, and dissolved substances to a major river and its tributaries.

water table. Top of the zone of groundwater saturation.

wetland. An area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and whose soils are indicative of wet conditions.

wildlife. Free, undomesticated species of plants and animals on earth.

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12. List of Figures, Tables, and Case Studies

All figures (except Figure 1) were produced by Geomatics Unit, Environment Canada