Coastal Action Plan

FOR THE SOUTHEASTERN SHORES OF LAKE HURON

Lake Huron Centre for Coastal Conservation

WWW.LAKEHURON.CA | 2019

Recommended citation: TBD

The 2016-2019 Coastal Action Plan (for the southeastern shores of Lake Huron) was developed by the Lake Huron Centre for Coastal Conservation based in Goderich, Ontario. We gratefully acknowledge the efforts of the core writing team from the Coastal Centre, led by Hannah Cann. We would like to acknowledge the generous funding provided to this project from:

Ontario Trillium Foundation

Environment and Climate Change Canada

Ontario Ministry of the Environment, Conservation and Parks

These investments support positive, measurable change in Ontario communities along our coastline. Encouraging people to support a healthy and sustainable environment, this initiative is helping people connect with the environment and understand their impact on it, and has an impact on the lives of people in these communities.

This project would not be possible without the guidance, advice and support of the core Steering Committee made up of partners organizations within the conservation field:

Environment and Climate Change Canada (ECCC)

Ontario Ministry of the Environment, Conservation and Parks (MECP)

Ministry of Natural Resources and Forestry (MNRF)

Grey Sauble Conservation Authority (GSCA)

Saugeen Valley Conservation Authority (SVCA)

Maitland Valley Conservation Authority (MVCA)

Ausable Bayfield Conservation Authority (ABCA)

St. Clair and Region Conservation Authority (SCRCA)

Aamjiwnaang First Nation, Environment Office

University of Waterloo (UW)

Bruce Peninsula Biosphere Association (BPBA)

Ontario Parks (OP)

Additional efforts were generously provided by:

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)

OceanWise (Rhiannon Moore)

Parks Canada

Front Cover Photo Credit: TBD

Contents

CHAPTER 1: INTRODUCTION TO LAKE HURON'S SOUTHEASTERN SHORES

North America's coasts are dynamic areas, hosting many communities, and rare ecological habitats. Globally, ~37% percent of the world's population lives within the coastal zone initiating management for public safety and protection of sensitive ecosystems (UNEP, 2019). In Canada, Atlantic, Pacific, and Arctic Oceans are most commonly considered when thinking of the Nation's coast; however, a large population live on a 'fourth coast'. The Great Lakes are a system of five water bodies containing the largest source of surface fresh water on Earth. Lake Huron, the second-largest of the Great Lakes, is home to diverse ecosystem types, the largest inland island in the world, and diverse coastal communities. Lake Huron is the third largest freshwater lake in the world (59,588km^2) and has the longest shoreline of all the Great Lakes (6,190 km including islands). The sheer size of Lake Huron enables it to moderate local climates, re-shape shoreline, and provide many natural resources (ECCC & USEPA, 2018).

In the 1800's, Lake Huron was referred to as "La Mer Douce", translated as "the fresh-water sea". It built this reputation within newcomers to the shores of Lake Huron, as they could not fathom a lake its size made of fresh water. Appreciation and respect for this fragile resource was already deeply ingrained in the culture and lifestyle of First Nation and Métis communities. Lake Huron's expanse of water and shoreline became an integral part of the sustenance and culture of these early colonists, adopted from the long presence of First Nations and Métis in the Great Lakes basin. Lake Huron's basin (134,100 km^2) is home to more than 50 Indigenous communities on the Canada/U.S. borders (Figure 1). The deep-rooted culture and history of these nations is integral to the foundation of the coastal corridors communities, sense of place, and industry.

Lake Huron's coastal communities are popular for their beauty, health benefits, and recreation opportunities. "It is a source of inspiration, rejuvenation, and discovery to its visitors and residents" (ECCC & USEPA, 2018). Communities on Lake Huron's shoreline are vibrant with diverse economies all with an engrained history connecting them to the Lake.

Lake Huron has three distinct geological bases; (1) glacially derived overburden and till in the southern basin; (2) porous limestone bedrock of the Bruce Peninsula, and (3) tough granite of the Canadian Shield. These geological entities support coastal environments including sand dunes, alvars, bluffs, and freshwater coastal wetlands. Anthropogenic (human) influences ranging in severity by breadth, intensity, and location overlap these ecosystems. Some coastal environments can become "adversely affected by a lack of planning and coordination" when anthropogenic influences overlap sensitive areas (WCB, 1999, p.2). Establishment of Ontario's Conservation Authorities (CA's) in the 1940's has given aspects of planning and management on Lake Huron's shoreline from a natural hazard management perspective. Although shoreline policy and regulation exist, there is a notable challenge in the coordination and consistency of management. A mixture of approaches due to multiple overlapping jurisdictions and agencies affects the consistency of management. When projects are undertaken by these agencies and groups, small-scale efforts rarely require the amount of collaboration as large-scale projects and programs which may require many stakeholders to communicate and work together. A need to assist the collaboration and communication process was identified to rectify inefficiencies in coordinating projects and programs across Lake Huron's southeastern shores. The Coastal Action Plan for the Southeastern Shores of Lake Huron will unite grass-roots, local and regional initiatives within the coastal corridor to preserve and protect this resource for future sustenance, recreation, and enjoyment.

Communities in Lake Huron's coastal corridor include: five First Nations, cities (Sarnia) towns (Goderich, Kincardine), coastal villages (Grand Bend, Port Elgin, Tobermory), and smaller hamlets and cottage communities

(Port Albert, Camlachie, Oliphant). These communities host life-long lakeside dwellers, to newly retired individuals, seasonal residents, and tourists. The diversity of people sharing one lake and one shoreline creates a stratification of influences on coastal management decisions.

1.1 WHAT IS THE PURPOSE OF THE COASTAL ACTION PLAN?

Lake Huron's southeastern coastal corridor is home to thousands of permanent and seasonal residents. Visitors interact with the lake through fishing, swimming, boating and other recreational activities. Communities within the coastal corridor recognize Lake Huron as key to their economic development. While most beaches are safe for recreational use, many are not free from water quality advisories and nuisance algae. Sand beaches and dunes, bluffs, gullies, river mouths, nearshore waters, wetlands, alvars, islands and woodlands are all coastal ecosystems that provide valuable ecosystem services, and support many rare species in the coastal fringe. To maintain healthy ecosystem function, wildlife populations, adapt to climate change and maintenance water quality, environmental restoration, protection and enhancement efforts are required. There are significant regional threats to Lake Huron's biodiversity and water quality, including pollution, shoreline development and alteration, invasive species, and climate change.

Figure 1 - First Nations communities and reserves on Lake Huron (Gov. Canada, 2011)

The Coastal Action Plan for the Southeastern Shoreline of Lake Huron (CAP) will create a unified vision for conservation and stewardship efforts for the coastal corridor between Sarnia and Tobermory Ontario. This action plan will enable a coordinated approach to address common issues and goals of communities along the coastal corridor. The CAP intends to unite the shoreline's diverse portfolio of local and regional governance, landowners and visitors under one common strategy for conservation, restoration, and efficient land-use. The CAP will become a framework to recommend, coordinate, and encourage locally, provincially, and federally driven action to address critical stressors and threats along the Lake Huron shoreline. It will engage local communities, First Nations, Métis, conservation organizations, and the various levels of government to enhance partnerships for conservation efforts along the coast. The CAP will develop a list of environmental management strategies by identifying coastal ecosystems and the threats and stressors that negatively impact them.

"an action plan is a 'heroic' act: it helps us turn our dreams into a reality. An action plan is a way to make sure [a] vision is made concrete. It describes the way [the shoreline] will use its strategies to meet its objectives. An action plan consists of a number of action steps or changes to be brought about in [the] community" (University of Kansas, 2017b).

The CAP recognizes that the coastal corridor is a prime area for residents and seasonal visitors, requiring a balance between ecological integrity and necessity of maintaining coastal economies. This action plan, like many plans that have come before it, attempts to determine:

- What actions need to occur to ensure our coast is resilient towards changes and threats, and sustainably managed for the future;
- Who will carry out these changes, whether it is partnerships between landowners and municipalities, or policy towards development and industry along the coast;
- When will these changes need to occur (long vs. short term);
- What threats and stressors are higher priority based on location and natural sensitivities affected;
- What resources may be required to complete these projects or eradicate these issues. Resources include money, time, partnership programs, and community engagement.

The CAP will serve two purposes; (1) A baseline study combining work done by partner agencies into a cohesive analysis of the coastal corridor to formulate best management practices and future efforts; (2) A reference resource for agencies and organizations completing conservation and restoration efforts.

MISSION STATEMENT

“**The challenge is not one of how to prevent any human-induced change, but rather one of deciding how much change will be allowed to occur, where, and the actions needed to control it.” (USDA, 1985).**

Our vision for the coastal corridor is “the ribbon of life”: a fringe of land and water that is resilient to ecological and human induced changes protecting the ecological health and processes that occur here, while supporting the vibrant network of coastal communities and their economies.

1.2 VISION: A HEALTHY RESILIENT COAST, VALUED BY ALL

Lake Huron’s coastal corridor is ‘the ribbon of life’ represented by the Huron Fringe corridor – the land and water margin that runs from Sarnia to Tobermory along the southeastern shores of Lake Huron. It is a living coast in terms of the special ecology occurring here and the ample opportunities for people to engage in an active, healthy lifestyle and a vibrant economy. It links communities along the coast, building on the shared experience of coastal marine heritage. Landscapes across Southern Ontario are comprised of remnants of what were, prior to European settlement, large deciduous forests and wetlands. Remaining ecosystems have environmental significance and potential to provide human benefits that need preservation and enhancement.

The new vision seeks to engage the coastal community to think in a holistic, broader ecosystem perspective while making stewardship decisions at the local or grass-roots levels. This vision promotes the adoption of natural heritage policies into local Official Plans and Zoning bylaws which, in turn, supports elements of this vision. This vision anticipates the increased use and stress placed on the coastal environment in the coming years; and recognizes the valued and importance of the coastal corridor to municipalities for property tax base, tourism, recreational revenues and other economic factors (economic pillars of agriculture, manufacturing, tourism and recreation, heritage and culture, etc.). It seeks to inform communities about how to invest in infrastructure (natural and human-made) that will enable greater numbers of people to use the shores without compromising environmental integrity.

Of concern along Lake Huron’s coastal corridor is the Huron Fringe; a narrow band of ecosystems bordering the shores of Lake Huron from Sarnia to Tobermory. The name ‘Huron Fringe’ refers to the physiographic region in which the coastal lands and waters intersect and create a band of coastal ecosystems. These niche habitats are an important migratory corridor and provide numerous ecosystem services including climate modification, water purification, and habitat for many plant and animal species. Included within the coastal corridor are locally rare coastal ecosystems like dunes, coastal wetlands, alvars, bluffs and estuaries. Areas of the coastal corridor that have been identified as environmentally significant include the Kettle Point to Grand Bend corridor, documented as an Important Birding Area (IBA), Eighteen Mile Shore and Point Clark Woodland (candidate ANSI's), Blair's Grove Oak Savanna, Inverhuron-MacGregor Park corridor, and the Bruce Peninsula (Biosphere Reserve).

Aligning the needs for habitat and healthy ecosystems with the wants of anthropogenic development is the harmony sought by the CAP. The vision of a cohesive coastal corridor on Lake Huron seeks to foster coordinated best management practices to ensure healthy and resilient coastal environments, that are valued by all and align with community heritage and local needs. The CAP intends to lead this initiative to connect fragmented ecosystems along the coast. The effects of threats and stressors are not in isolation to the ecology of ecosystems, and encompass social ramifications, historical significance, and economic prosperity of the communities along the shoreline. The CAP intends to identify stressors in order to recommend tailored actions to the different communities and ecosystems they overlap. Working cooperatively among grass-roots, local governance and regional governance is imperative to the success of the application of the recommendations and best management practices given in this plan.

Understanding how and why the diverse stakeholders use the Lake Huron coastal fringe is imperative to effectively managing this area now and in the future. Mitigating a range of interests is a challenging task anywhere, but in the small fringe of water-and-land, there are many 'players' vying for the same resources but for different uses. Understanding how communities rely on the coastal corridor for their economies, identity, and values plays a vital role in the implementation of recommendations made in this plan.

Reasons people come to, and care about Lake Huron's coast, as well as their vision for the future of Lake Huron's coastal corridor were analyzed in depth to prepare a plan that would be realistic, optimistic, and customized to coastal communities across the shoreline. These values and recommendations provide a tangible set of goals and best management practices to ensure local stakeholders are encouraged to see actions through to improve the resiliency and ecological integrity of their area.

2.1 OBJECTIVES

The objectives of the Coastal Action Plan embrace three domains of objectives; Process ('improve the process'), Community-Based Action ('acting as a community'), and Behavioural Change ('elicit behavioural and societal change'). Combining these three objectives enable the whole dynamic system encapsulated within the coastal corridor to receive recommendations in this Plan.

Table 1: Summary of The Coastal Action Plan's Objectives.

OBJECTIVES	DESCRIPTION

PROCESS	Create a unified strategic vision for the Lake Huron coastal corridor using a multi-discipline stakeholder engagement approach to address cross-jurisdictional environmental issues. Establishing baseline data and comparing this to indicators and thresholds will determine the 'state' of ecosystems within the coastal corridor. This data can be used by grass-roots, local, and regional governance to improve the resiliency and sustainability of their jurisdictions. This objective provides groundwork for collaboration to implementation strategies necessary to achieve action towards sustainability and resiliency in the coastal corridor.
COMMUNITY-BASED ACTION	Facilitating collaboration across the coastal corridor and encouraging grass-roots, local, and regional governance to work together towards the CAP's objectives. Fostering knowledge and information sharing to increase awareness of environmental ecosystems and threats within the coastal corridor. Citizens actively engaging in management and regulatory decisions, understanding interdependence between the health of ecosystems, the economy, ecological services, and socio-cultural heritage of the coastal communities.
BEHAVIOURAL CHANGE	Cooperation and collaboration will encourage adoption of best management practices. Recommendations made in this plan will foster grass-roots changes and eventual policy influence. Improving networks to distribute fiscal support and human resources will be paramount in tackling societal changes. "These objectives look at changing the behaviors of people (what they are doing and saying) and the products (or results) of their behaviors. For example, a neighbourhood improvement group might develop an objective for having an increased amount of home repair taking place (the behavior) and of improved housing (the result)." (University of Kansas, 2017b).

1.3 OUTCOMES

The Coastal Action Plan aims to improve understanding of threats and stressors affecting coastal environments and provide place-based priorities for protection, restoration and enhancement actions to be implemented collaboratively. Approaching this by ecosystem type allows communication between land managers and landowners who have a connection and experience living within respective ecosystem types. Outcomes of the plan include recommended actions prioritized by impact, timeframes, challenge, and importance for the ecosystems and communities in the study area.

Development of Geographic Information System (GIS) maps showing the bio-physical and cultural information necessary to conduct a spatial analysis of the coast will prompt a better understanding of sensitive coastal environments, human use of the coast, spatial distribution of threats and stressors and determine what information and resources communities need to better manage and care for Lake Huron's coast. Communicating this information to partners and the public, the broader Lake Huron community will learn how to actively embrace and adopt a coastal stewardship ethic that will improve the environmental, economic and social well-being of Lake Huron's southeastern coastal corridor. Developing a spatially-based action plan requires identifying "the most efficient locations for conservation actions to meet ecological goals while sustaining or enhancing human well-being values within the coastal and nearshore areas" (Annis et al., 2017).

Figure 2 - CAP Outcomes & Expected Products

Recommendations made through the CAP are built on studies previously done within the coastal corridor and Great Lakes Basin. These studies “recognize that incorporating human values into conservation planning increases the chances for success by garnering broader project acceptance.” (Annis et al., 2017). Employing community-based action techniques by including the public and partners in conversations about the Coastal Action Plan from the beginning will increase community uptake of the recommended actions made in this Plan. Anticipated emerging issues and barriers to implementation by reviewing past documents and studies done in this area will determine how successful work previously done was and adapt recommendations from there. Three outcomes will come from this Coastal Action Plan:

OUTCOME 1:

Measurable improvements to the ecological integrity of Lake Huron’s coastal corridor through a coordinated, collaborative approach to conservation and stewardship by grass-roots, local, and regional governance.

- Create a Coastal Action Plan for the southeastern shoreline of Lake Huron that:
    - Incorporates broad community input in a regional planning process;
    - Improves the understanding of threats and vulnerabilities to the coastal environment;
    - Provides clearly defined regional strategies and objectives;
    - Provides place-based priorities for protection, restoration, and enhancement actions to be implemented collaboratively;
    - Establishes a framework for monitoring and evaluation.

OUTCOME 2:

Increased public awareness and understanding of the coast of Lake Huron, its dynamic nature, ecological significance and enhanced capacity to enable community members to be active stewards in their daily lives.

- Improve public awareness of coastal conservation issues;
- Prepare a public-oriented document compiling information from the planning process to communicate coastal conservation priorities and to promote opportunities for participation.

OUTCOME 3:

Support grass-roots, local, and regional governance efforts towards ecological integrity, sustainability and resiliency in the coastal corridor.

- Support existing environmental groups and initiatives, while encouraging the establishment of local stewardship groups where there are gaps along the coastal corridor;
- Outline stewardship resources, incentives, and best management practices to enable stewardship activities, and identify gaps in these programs;
- Develop a foundation for sustainably building a coastal corridor for healthy, active living.

A visual representation of the outcomes of this Plan as well as the expected products is illustrated in Figure 2. Adaptively managing the CAP’s recommended actions (Figure 2) and facilitating partnerships is key to the success of the program. In future renditions of this report, analysing what has been done to meet and exceed recommendations made, and how work has been completed across the coastal corridor. These three questions will be referenced when completing the review or progress of the Coastal Action Plan:

1. “Are we doing what we said we would do?
2. Are we doing it well?
3. Is it what we are doing advancing the mission?” (University of Kansas, 2017b).

Monitoring the progress after 3-5 years of the plan’s lifespan will enable an adaptive management strategy.

1.3.1 EXPECTED PRODUCTS:

1. **Coastal Action Plan Technical Document:** to be distributed to grass-roots, local governance, and regional governance agencies.
2. **Coastal Action Plan Public Document:** A short, public-oriented document summarizing the CAP providing an overview of conservation and stewardship priorities. To be distributed to individuals, landowners, and general information sessions.
3. **Communication Products:** social media, webinar, and e-news coverage, factsheets and video clips explaining the interconnections of the coastal environment.

1.4 PROJECT SCOPE

The southeastern shore of Lake Huron is a diverse corridor of ecological, economic, and cultural entities. This area is of interest because of its distinct and diverse ecological habitats, socio-economic value, and historical importance. The Coastal Action Plan will focus on this ribbon of life of nearshore waters and boarding lands between Sarnia and Tobermory.

1.4.1 PHYSICAL SCOPE

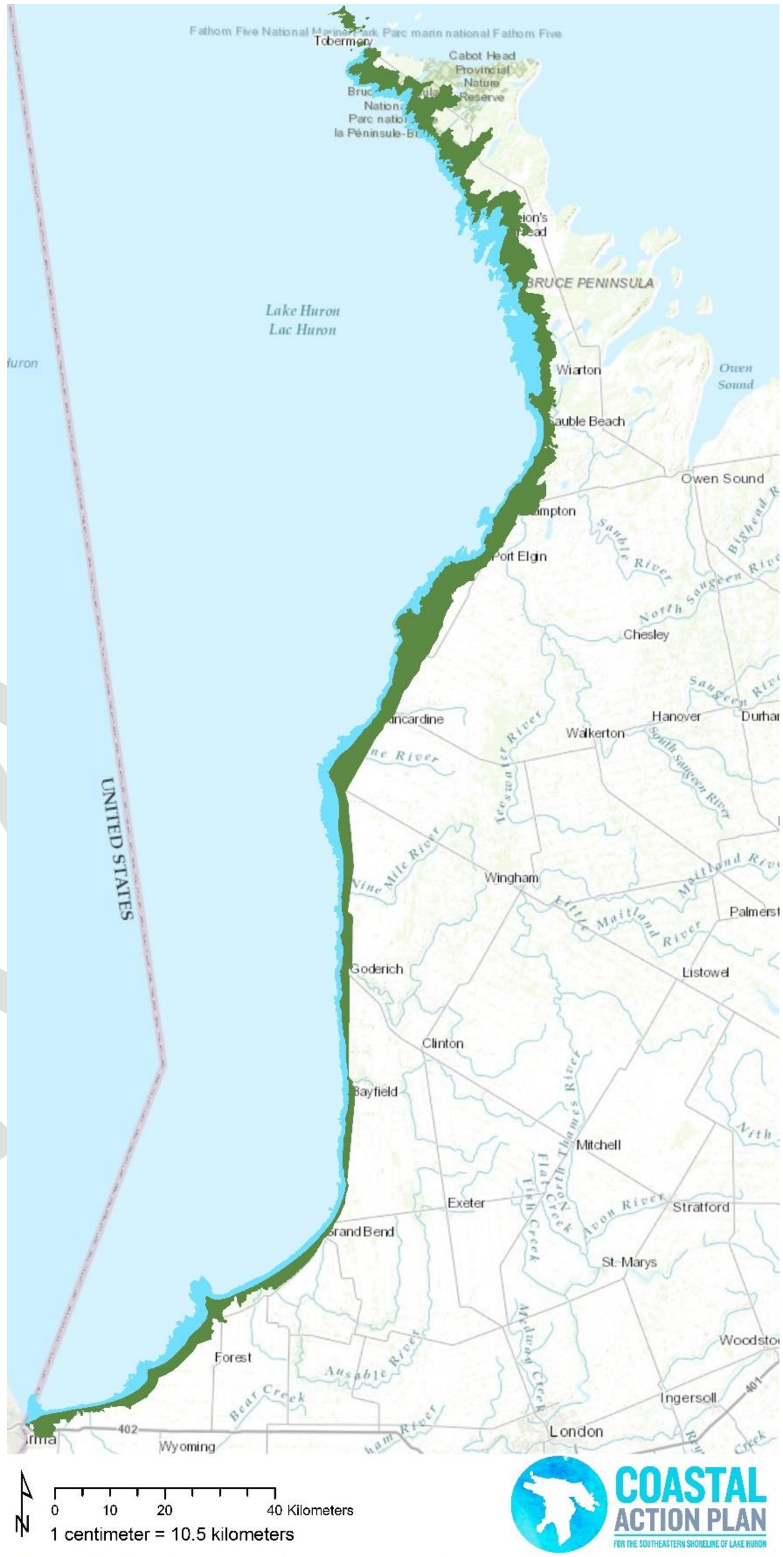


Figure 3 - The coastal corridor of the southeastern shoreline of Lake Huron.

Coastal environments are commonly defined as the land area within 2 km of the shoreline, as well as the nearshore waters <6m deep. This CAP focuses on the southeastern shoreline of Lake Huron- a vast stretch of continuous coast. The shoreline within this zone is ~946-kilometres long including islands. The physical scope follows the ecologically defined boundary of the Huron Fringe and is expanded to stretch from Sarnia to Tobermory Ontario. This coastal corridor encompasses 10 ecosystem types, including; sand beaches and dunes, bluffs, gullies, cobble beaches, wetlands, woodlands, river mouths, islands, nearshore, alvars and bedrock. The narrow corridor of specialized ecosystems includes some of the rarest habitat types in the world, and is an important migratory corridor for birds, fish, and herpetofauna. This coastal corridor provides extensive water purification services, as well as habitat for rare plants and animals. Beautiful coastal ecosystems like those existing on Lake Huron's southeastern shores attract significant tourism annually and have become renowned for the "west coast lifestyle" of residents, many of which are retirees living in converted cottages and homes.

The CAP includes nearshore waters abutting the shoreline spanning offshore to a depth of 6m derived using provincial bathymetry layers. This area of shallow nearshore waters is at the highest risk for contamination and manipulation due to actions undertaken on shore. Figure 3 shows a map of the coastal corridor including the nearshore waters, extending from Sarnia to Tobermory Ontario.

1.4.2 SOCIO-POLITICAL SCOPE

The in-depth landscape analysis will occur through areas called Assessment Units. There have been 11 assessment units derived across the coastal corridor. Assessment Unit boundaries were formed using littoral cell nodes determined in the Flood Damage Reduction Program (FDRP) mapping completed in the 1980's. These boundaries were cross referenced with work being completed with Environment and Climate Change Canada on a Nearshore Framework for the Great Lakes, and Lake Huron in particular. Assessment Units 'disregard' political jurisdictions of municipalities, federal and provincial districts, and Conservation Authority (CA) boundaries; and intend to analyze the coastal corridor using this ecologically-derived boundary. Using this method places the call for action on multiple stakeholders in each Assessment Unit, and will encourage communication, and collaborative action fulfilling the recommendations made in the CAP.

1.5 COLLABORATION, ENGAGEMENT AND OUTREACH

The coastal corridor of Lake Huron is a patchwork of political boundaries and jurisdictions. Land management in coastal environments is challenging and complex due to nature's inability to adhere to political boundaries (NOAA, 2017). There are many types of land managers in the coastal corridor, ranging from individual landowners, to the federal government and everyone in between. For the purpose of this Plan, these land managers have been categorized into three groups; grass-roots, local governance, and regional governance. The responsibility of managing a healthy shoreline ecosystem is through a shared responsibility of all members of the community, as echoed in Huron County's Official Plan (Huron County, 2015a). The distribution of responsibility by shoreline land management is holistic, as reflected in this action plan. Local governance within the coastal corridor include four First Nations and Métis (Table 2), five CA's (Grey Sauble, Saugeen, Maitland, Ausable Bayfield, St. Clair Region); three Counties (Bruce, Huron, Lambton); and thirteen municipalities. Figure 4 represents the amount of shoreline each County manages, while Chart 2 illustrates the amount of shoreline managed by the individual shoreline municipalities.

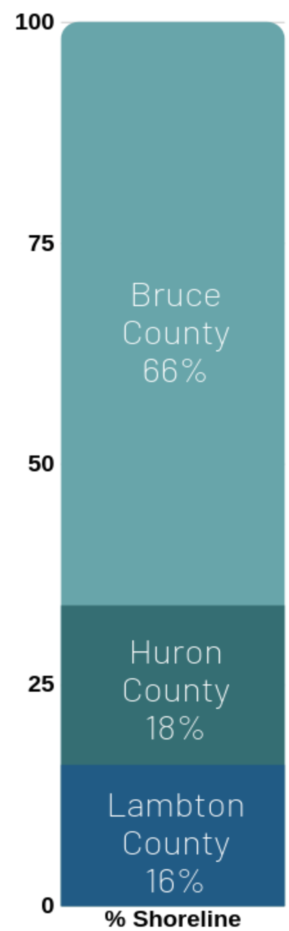


Figure 4 - County shoreline management on the southeastern shores

Table 2 - Indigenous communities within the Coastal Action Plan project scope.		
Community	**Population**	**Description**
Aamjiwnaang First Nation	2,300 members	*"Aamjiwnaang is known as 'the place at the spawning stream – where the water flows spiritually like a braid'… We are situated along the shores of the St. Clair River, within the boundaries of the City of Sarnia, Ontario." (AFN, 2018).*
The Chippewas of Kettle & Stony Point First Nation	2,108 members	*"**Kettle Point** also known as **Wiiwkwedong** is part of the **Anishinabek Nation.** Kettle Point is unceded territory located along Lake Huron… Stony Point is known as 'Aazhoodena'. Our land base consists of ~1,096 hectares… Kettle Point is named for its unusual spherical rock formations that erode from the underlying shale beds along the shore of Lake Huron. These rock formations known as "kettles" are unique to three locations within the entire world. It's the uniqueness of this First Nation that makes preservation of the Kettle Point lands a high priority, not only for its "kettles", but for the first peoples of this community and future generations to come" (KSPB, 2018).*
Saugeen Ojibway Nation	Unlisted	*"The Saugeen First Nation is located on the shores of Lake Huron at the base of the Bruce Peninsula… 2 miles northeast of Southampton and ~18 miles west of Owen Sound on Hwy 21." (SFN, 2018) "As Anishnabek peoples, we are subject to Anishnabek law and we are ever mindful of our duty under our law to be stewards of our land" (SON, 2018). "Our people have a long relationship with our land, including harvesting of resources, which remains important to our people. Fishing is of special importance, historically and today. In 1994, the Canadian Courts recognized that SON has an Aboriginal and treaty right (constitutionally protected) to our fishery in the SON territory. Certain parts of our land are particularly important to us as ceremonial and sacred sites. It is one of our most important laws that the places where our ancestors are buried should not be disturbed" (SON, 2018).*
Historic Saugeen Métis	Unlisted	*"The Historic Saugeen Métis (HSM) are a distinctive Aboriginal community descended from unions between European traders and Indian women. We are the Lake Huron watershed Métis with a unique Métis history and culture who lived, fished, hunted, trapped, and harvested the lands and waters of the Bruce Peninsula, the Lake Huron proper shoreline and its watersheds. HSM traded in a regional network since the early 1800s as far as the north shore of Lake Huron… The geographic scope of the contemporary community covers over 275-kilometres of shoreline from Tobermory to south of Goderich, and includes the counties of Bruce, Grey and Huron… Upon the decline of the fur trade in the early 1820s, Métis families from the Northwest joined these early Métis at Goderich. The community traded in a cohesive regional trading network that extended from the Upper Detroit River system to the northern shoreline of Lake Huron, to the historic Métis community of Killarney" (HSM, 2018).*

Table 2 provides a short summary of the First Nations along the southeastern shoreline of Lake Huron. The four First Nations living in and managing sections of the coastal corridor include: The Historic Saugeen Métis the Saugeen Ojibway Nation (SON), The Chippewas of Kettle and Stony Point, and Aamjiwnaang First Nation. SON is made up of the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation. SON's traditional territory lies between the Maitland River system (Goderich to Arthur), on the west by the Canada/USA border, and to the north lying between the Bruce Peninsula and Manitoulin Island (Saugeen Ojibway Nation, 2018). There are shared rights near Goderich where SON's territory overlaps with the territories of the Aamjiwnaang First Nation, Bkejwanong Territory (Walpole Island First Nation), and the Chippewas of Kettle and Stony Point.

Recent reports about Great Lakes management specify planning and coordination as paramount in the success of multi-jurisdictional projects. Coordinating among jurisdictions, collaborating with neighbours, working with other partners, coordinating funding, and planning across departments are all imperative methods to being the most efficient when tackling issues along the coast (Allan, Callewaert & Olsen, 2018). Coordination and cooperation among different agencies and organizations is essential to complete ecosystem-based projects being recommended through the lifetime of this plan. Some of the agencies we have engaged in the formation of the Lake Huron Coastal Action Plan and intend to continue relationships with into the implementation phase include:

REGIONAL

- Environment and Climate Change Canada
- Ontarion Ministry of Agriculture, Food and Rural Affairs
- Ministry of the Environment, Conservation and Parks
- Ministry of Natural Resources and Forestry
- Policy & Acts - (Great Lakes Water Quality Agreement, Provincial Policy Statement)

LOCAL

- First Nations
- Historic Saugeen Métis
- Conservation Authorities
- Municipalities
- Counties

GRASS-ROOTS

- Environmental Non-Profits
- Charities
- Associations & Clubs
- Recreation Groups
- Healthy Lake Huron

Ecosystem-based management is a strategy to manage resources cross-jurisdictionally with equal dedication across ecosystems. Suggested in the early 1980's, "*the main obstacle to implementation of an ecosystem approach in the Great Lakes basin is the lack of comparable policies in the political jurisdictions surrounding the Great Lakes… until recently, localized initiatives for the practical development of the concept have been lacking*" (Lawrence, 1995, p.2). The 1980's is now known for the rapid introduction of stressors including armouring, bluff clearing, and nutrient inputs. CA's and municipalities have since stepped-up regulations and developed new shoreline management plans controlling coastal development for human safety. The Great Lakes Shoreline Management Guide made before the introduction of the Lake-wide Action Management Plans (LAMP's), created goals and objectives, "for developing shoreline management plans, including land-use planning, economic evaluation of management alternatives, understanding of natural processes, and assessment of environmental impacts" (Lawrence, 1995, p.4). Although LAMP's are effective at completing these tasks with the wide-scope Federal lens, more opportunity exists for cooperating with partners at local levels to harmonize initiatives across the southeastern shores.

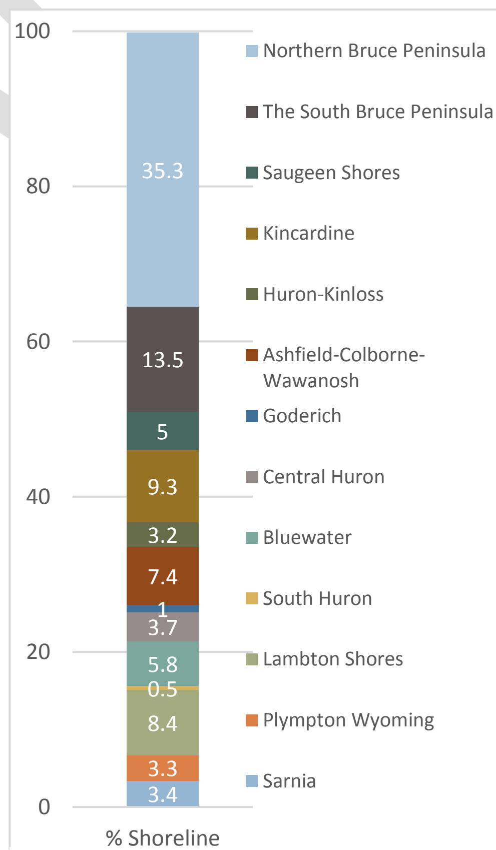


Figure 5 - % of shoreline managed by each municipality

The CAP is shaped by the steering committee, which has been fundamental in the plan's development, with representatives from organizations guiding the planning process and providing input, technical advice and expertise. The planning framework developed by the CAP Steering Committee and working group draws on many previous coastal planning works across North America to create the best framework for Lake Huron's coastal corridor. The steering committee is an important vehicle for building support for the implementation of the plan among their respective networks and creating a long-lasting conservation network in the future.

1.6 METHODS OF ASSESSMENT

The Coastal Action Plan for the Southeastern Shoreline of Lake Huron (CAP) as implied by its name will recommend actions for the coastal corridor of Lake Huron. Executing the CAP's deliverables as well as future action for recommendations throughout the plan, a combination of the Conservation Action Planning (CAP) methodology developed by the Nature Conservancy (USA) widely adopted in many programs world-wide; as well as Community Based Participatory Action Research (CBPAR) methods commonly used for specific geographic areas and communities will be used. These methodologies are most appropriate because of their flexibility to be used at many different scales and across any type of ecosystem or geography. "*Its methods are science-based, focused, and efficient, and have evolved over decades of trial and error in an array of landscapes, cultures and political environments. CAPs are clear, achievable, measurable, and can quite easily be monitored. The CAP approach is collaborative and holistic, considering not only ecological, but socioeconomic and cultural factors as well*" (Carolinian Canada, 2018). These methods were most feasible for Lake Huron's coastal corridor and will (Chart 3);

Chart 1 - Methods of Assessment; *This CAP completes (blue), Post-plan action (green).*

Coastal Action Planning relies on understanding dispersals of ecosystems, cultural elements, ecosystem services, and stressors, to target priority areas for action within the coastal corridor (Allan et al., 2012, p.373). The CAP uses an adaptation of the Community Based Participatory Action Research (CBPAR) method, whereby it involves stakeholders to establish a research question, develop data, analyse findings, addresses practical concerns of the community, and suggests action to solve issues within the findings (Advancement Project, 2011). Table 3 shows the steps of the CBPAR method, how this Coastal Action Plan is interpreting these, and steps to be taken to fulfill these categories.

Table 3 - Coastal Action Planning Methods with CBPAR method

CBPAR Method	Lake Huron CAP	Steps taken

Establish research question	Improve ecological integrity, resiliency and sustainability in the coastal corridor	Conduct a literature review to determine current state of socio-ecological standards existing in the coastal corridor and identify gaps
Develop data	Map coastal ecosystem extents, threats and stressors	Determine floral, faunal and cultural elements of the coastal corridor. Map data using Geographical Information Systems (GIS).
Analyse findings	Determine BMP and indicators and thresholds in literature	With mapped data, determine landcover composition and shoreline ecosystem types, to determine areas with high concentration of potential threats and stressors.
Address practical concerns	Identify inconsistencies and limitations to meeting targets	Bring together stakeholders to plan more consistent levels of regulation, incentives, or activities, within the coastal corridor.
Suggests actions	Establish recommendations	Apply BMP's, and discipline accepted indicators and thresholds and determine realistic goals for coastal corridor. Determine potential for future projects across coastal corridor.

Adaptive management strategies will be the most effective method to completing recommendations within the CAP. In order to facilitate adaptive actions along the coast and preserve positive partnerships with other organizations, the following concepts for Great Lakes integrated coastal ecosystem management will be utilized;

CONCEPT (WHAT IS NEEDED)	ACTIONS (HOW THE CAP FULFILLS THE CONCEPTS)
1. Political and public commitment	Engaging public and partners in creation and feedback of plan development.
2. Visionary or strategic long-term perspective	Creating short to long term goals and recommendations.
3. Planning for uncertainty with flexible and proactive approaches	Adaptive management strategies, continuous commitment to communication among lakeshore stakeholders and individuals.
4. Ecosystem units as a basis for planning	Assessment unit analysis to determine state or health of coastal corridor sections.
5. Recognition of significant Great Lakes ecosystems	Analysing ten coastal ecosystem types and indicators that determine their state.
6. Consider threats in a land-use and environmental context	Analysing land-use types which cause or expedite stressors on coastal habitats without bias.
7. Mechanisms for cooperation and coordination	Partnership building among all individuals and partners includes; frequent meetings, Municipal forums, community workshops, and information sharing.
8. Adequate information and scientific basis	Ensuring data is current, shared, and backed by scientific ecological monitoring, indicators, and thresholds
9. Systems of evaluation, assessment, and monitoring	Determining most accurate and relative scientifically based indicators and thresholds are used to monitor ecosystem health.
10. Provisions for education, public awareness, and communication	Partner agencies combining forces to do community workshops, presentations, and information sessions, as well as social media engagement and education through scientific posts, videos, webinars, podcasts, newsletters, and blogs.
(Concepts adapted from Lawrence, 1995, p.13)	

Through this analysis, there is recognition that landscape planning at broad scales can present some challenges; Lake Huron has considerable regional differences, ecologically, population density, and economically, that can be masked by assessing the lake's biodiversity as a single entity. The most striking variation can be observed along the north-south gradient. Northern portions of the watershed, including Georgian Bay, tend to have lower population density and are substantially forested; Meanwhile, southern portions have higher population densities, more urban centers, and more agricultural and industrial activities. This results in a higher degree of ecological degradation and additional challenges to natural resource management in southern Lake

Huron. Where enough information is available, north-south variation or even finer scale stratifications while assessing status, threats, and conservation needs are used (Franks Taylor et al, 2010).

Development of biological indicators to monitor the status and trends of aquatic ecosystems have become routine for many environmental agencies, on the basis that the community of plants and animals will reflect the overall condition or quality of the habitat (Simon et al, 2006). The CAP identifies threats, stressors, and ecosystems, and the best management practices associated. This framework creates a direction for the CAP's future implementation and monitoring phases. Chart 3 illustrations the combination of CBPAR and CAP methodologies which will be used in this analysis.

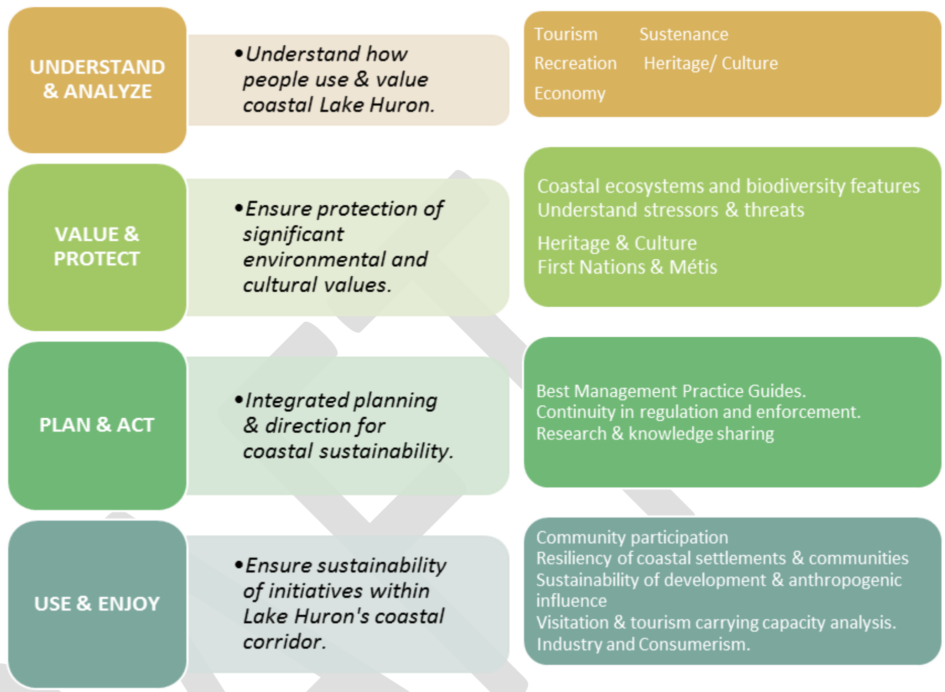


Chart 2 - CAP and CBPAR Methodologies

1.6.1 PUBLIC AND PARTNER ENGAGEMENT

The Community Based Participatory Action Research (CBPAR) method's core framework stems from involving community members and partners in all stages of the research and implementation of the project (Advancement Project, 2011). Engagement of community members and regional stakeholders is critical to the successful development and implementation of the Coastal Action Plan (CAP) during and after plan development. The process of engagement and collaboration is inclusive and collaborative, providing numerous opportunities for the public and stakeholders to participate in all phases of CAP development.

From 2016-2019, community involvement in plan development consisted of coastal community workshops, an online questionnaire, Municipal Forums, stakeholder workshops, newsletter articles, speaking at community events, and social media posts. Through these methods of engagement, approximately 850 people interacted with or contributed to the formation of the recommendations of this plan. To learn more about the results from these engagements, please refer to Chapter 2.

1.6.2 GEOGRAPHIC ASSESSMENT AND DATA ACQUISITION

The coastal corridor inland boundary was decided using biological and anthropogenic factors due to the diverse ecosystems and communities existing in this region. First, the physiographic regions regarded as the Huron Fringe and Huron Slope were analysed for their boundaries, [see the Great Lakes Conservation Blueprint for Terrestrial Biodiversity document by NHIC]. The Huron Fringe has a narrow, but appropriate inland stretch coinciding with the 2km coastal zone threshold in most areas, but in other areas only extends a few hundred metres inland. Therefore, between Grand Bend and Kincardine, the easterly boundary of the study area was increased to trace Highway 21. This highway is a major transportation corridor and is a definite separation feature along the coast. Another deviating aspect from the Huron Fringe and Huron Slope is that these areas northern extent ended short of the Bruce Peninsula. In order to incorporate the peninsula in our analysis to encapsulate the entire southeastern shores of Lake Huron, we had to derive a new method for determining inland reach north of Tiverton Ontario and south of Pinery Provincial Park. Quaternary watershed boundaries were used to delineate inland boundary from Sarnia to Pinery Provincial Park, and again from Tiverton to Tobermory. The quaternary watershed boundaries were extremely variable in their inland reaches, in some cases diving inland up to 10km, which was farther inland than our desired study area. Therefore, a consensual decision between steering committee members and project managers was made that the inland study boundary for this southern portion of the shoreline would be clipped to the northwestern side of Highway 21. This highway is the main transportation corridor along the coast and it provides a highly visual dividing line between coastal and inland environments.

The aquatic nearshore study area used bathymetric datasets acquired from NOAA to delineate the 6m depth. Most impact from adjoining land base, as well as sediment and nutrient transport occurs within the 6m depth from the nearshore.

Reliance on external information sources for most data acquired required data sharing agreements with partner agencies including NHIC, CA's, municipalities, MNRF, and NGOs like Ontario Nature and NCC. Environment Climate Change Canada was able to provide certain datasets to aid in ecosystem analysis. Other citizen science programs including E-Bird and The Ontario Amphibian Atlas were referenced for information. Sensitive NHIC species at risk dataset was acquired to determine areas of element occurrence for species at risk. GIS data varied in vintage, as well as detail and accuracy. Unfortunately, the best available data for this project fluctuates and therefore implies limitations and inconsistencies in the data. Other mapping limitations included ecosystems that are developed and maintained by dynamic processes (e.g. succession of meadows) are more likely to change over a shorter period than features that are more stable (e.g. mature woodlands) (Huron County, 2018).

CHAPTER 2: PUBLIC, PARTNER AND STAKEHOLDER ENGAGEMENT

Engagement of general public, grass-roots groups, local, and regional governance is critical to the successful development and implementation of the Coastal Action Plan (CAP). This plan unites organizations to address priority issues and expand public support for conservation and stewardship. The process has facilitated dialogue with the public and stakeholders on regional ecosystem goals and provided opportunities to learn about aspects of Lake Huron's coastal corridor. The process has been inclusive and collaborative, allowing public and stakeholders to provide options for contributing in all phases of CAP development.

2.1 Stakeholder Workshop

Working with the University of Waterloo's Heritage Resources Centre, a stakeholder workshop earned support for the project, determining what existing resources are available, drawing on the experiences of others to formulate a map of the coast highlighting threats, and valuable areas across the corridor. Twenty-two attendees attended the workshop on April 27, 2017 to contribute their expertise and provide opportunities across the shoreline.

2.2 Community Workshops

To involve the public and gather regionally-specific knowledge, twelve (12) Coastal Community Workshops (CCWs) over the 3-years of the Plan development (Table 4). These workshops were evening events hosted across the coastal corridor, and attracted residents and representatives from community groups, NGO's, and other clubs, to gain their regionally specific knowledge and incorporate their concerns and vision for Lake Huron into Plan development. These workshops presented material relevant to local coastal ecosystems and stressors to attendees and enabled communities to express their perceptions and concerns about the environmental health of their area as well as environmental threats and stewardship priorities that were important to them. In total, 408 attendees came to the CCWs and participated in the contribution of ideas for stewardship projects and action towards threats and habitat health in their community.

Table 4 - COASTAL COMMUNITY WORKSHOPS

Year	Location	Attendees	Total
2017	Bayfield	25	108
	Sarnia	30	
	Sauble Beach	16	
	Port Elgin	25	
	Point Clark	7	
	Grand Bend	5	
2018	Kincardine	44	120
	Goderich	59	
	Port Franks	17	
2019	Goderich	65	180
	Sarnia	35	
	Southampton	80	

2.3 Municipal Forum

To capture the attention of local and regional governance, four one-day conferences were held to educate, raise awareness, and get input from Municipal, County, Conservation Authority, First Nation, and Métis representatives. Stakeholder and partner engagement are critical to the formation of the CAP in order to identify regionally specific limitations, requirements, desires, and visions for the coastal corridor. The Lake Huron Municipal Forum was put on from 2016-2019. Dialogue during these events was focused on encouraging future sustainability of the Lake Huron coastal corridor and collaboration for these efforts. Attendees were able to enjoy 2-4 presentations discussing local conservation and restoration efforts, updates on shoreline conditions and lake health, and then break out into groups to discuss how their area and organizations tackles the issues of shoreline management. Over the four years of the meeting, ~180 individuals attended these events.

2.4 Community Questionnaire

An electronic questionnaire distributed during the planning process informed local community members about the project and ways to become involved, to provide feedback, and to gather broad input on community values. The online and paper questionnaire was distributed through Typeform (an online questionnaire software) for 11 months, from April 1 2017 to October 31, 2017. The questionnaire provided respondents the opportunity to comment on what their major concerns are for Lake Huron, describe what they care about most, and what vision they have for Lake Huron's future. There were 256 respondents who providing input for the formation of this plan, telling why they value Lake Huron, and how they envision the future of the southeastern shores. For more information on the results and feedback received from these workshops, please review the appendices of this plan.

2.5 Presentations at Community Events

Presentations related to the CAP were made throughout the lifespan of the Plan's creation (2016-2019). These presentations would occur typically through invitation to speak to individual groups, community events, cottage association annual general meetings, and special interest group meets. Approximately 630 individuals attended these community events and were able to become knowledgeable about the CAP, coastal ecosystems, and threats associated along the coastal corridor.

2.6 Social Media and Newsletters

Through the CAP process, engaging social media posts and newsletter articles were written to educate coastal citizens and raise awareness of threats and stressors. These posts provided thought-provoking and entertaining information about ecological processes, ecosystems, threats and stressors, events, opportunities to get involved in the planning, and promotion of communication products. As of July 2019, on Facebook alone, over 95 social media posts had been made, reaching +147,600 people, engaging +22,900 people in these posts. As an objective of this Plan, to increase awareness and educate individuals about the coastal corridor, this number is a helpful representation at the reach social media has and the ability to educate thousands of people every year with coastal information.

Interviews on radio and in newsprint were also done to promote the Plan, educate on different coastal issues, and raise awareness about sensitive coastal ecosystems. One reporter estimated the reach of a single media article to be between 2,000-8,000 people. Over the course of the CAP's development, 67 radio, newspaper, online news, and television interviews and articles were done, equating to a public reach of between 134,000 to 536,000 readers and listeners, learning about topics included in the CAP.

DEFINITION: *"Values influence our thinking and behaviour toward the environment by indicating which preferences are given priority. Values help us decide how to think about a choice and what to do" (Dietz et al., 2005, p.356).*

Individuals, businesses, and organizations value the Lake Huron coastal corridor differently. Someone who values aspects of their surroundings may emphasis a growth of understanding or respect of their area. The Values-Beliefs-Norms Theory suggests that our values influence decisions on environmental issues through our general beliefs and understanding, which alters our ability to quantify actual risk to the environment and actions reducing threats to ecosystems (Dietz et al., 2005). Scientific and psychological literature has clarified that broadly viewing people's environmental values assists in analysing human-nature relationships paralleling values of ecological services and ecosystem values (Schroeder, 2011, p.212). Values reflect our culture, society, and knowledge base, and can be influenced in the short or long-term through reflection or as we gain new understanding (Dietz et al., 2005). For example, individuals may have been prone to littering while driving, but upon learning hazards to wildlife posed by plastic litter specifically, their actions change and value of litter-free natural areas increases.

A binational poll conducted by the International Joint Commission's Water Quality Board in 2015 indicated 85% of residents in the Great Lakes basin feel it is important to protect the Great Lakes (ELPC, 2019). This binational poll was replicated in 2018 (IJC, 2018), affirming that public support for protecting the Great Lakes remains high (increased to 88%). The report specifies that "55% of residents are willing to pay more for consumer products as a result of regulations designed to restore and protect the Great Lakes… Residents in the Great Lakes were not keen to engage socially or politically in these issues (only ~30%), but the majority were willing to be more careful about what they dispose down the drain (83%) and with their water use (74%)" (ELPC, 2019).

Through the Coastal Action Plan (CAP), a questionnaire with 256 respondents were asked similar questions regarding their value of Lake Huron and the coastal corridor. The questionnaire revealed that 90% of respondents valued water quality and access to healthy drinking water, while 64% valued the presence of natural shorelines; 61% valued the preservation of natural areas; and surprisingly only 24% of respondents valued tourism (Chart 3). In regards to stressors, the IJC survey suggested 73% considered climate change a negative impact, whereas only 58% of respondents to the CAP questionnaire finding this a concern of high importance (ELPC, 2019; Chart 3).

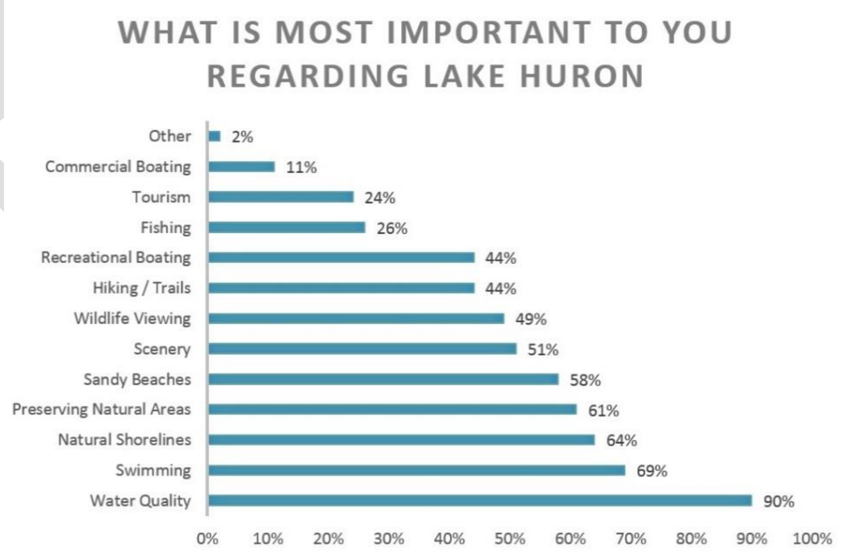


Chart 3 - Responses from 2017 CAP Questionnaire on Values

This example shows that values can vary in any topic regarding environmental issues. In the CAP, environmental values, economic values and social and historical values are under examination. Values within these categories ebb and flow into one another, but for the sake of this analysis have been discussed separately. Understanding values within these categories will allow targeted recommendations towards coastal stewardship efforts and identify gaps or areas needing more attention towards education and valuing coastal environments.

3.1 ENVIRONMENTAL VALUES

DEFINITION:

"A person's attachment to natural environment may involve a sense of respect and obligation that motivates the person to care for and protect a place for its own sake… It must be understood more broadly to include how environments serve the needs of people, and how people serve the needs of environments, places, and ecosystems" (Schroeder, 2011, p.215).

There are many types of environmental values, and ways people value their environment. Engineers and financial experts see value in the ecological services provided by their environments and in increased real estate values from living close to nature. Conservationists tend to recognise environmental value as the value of habitat to species relying on these habitats, and the interaction and aesthetic value of having nature around us. What researchers are beginning to realize and quantify is that people value natural environments even if the environment serves them no financial gain or services rendered (Schroeder, 2011). Schroeder (2011) describes five types of environmental values (Chart 4) including those related to material products, ecological processes, interaction between people and nature, social/psychological benefits, and how we ascribe meaning to a place:

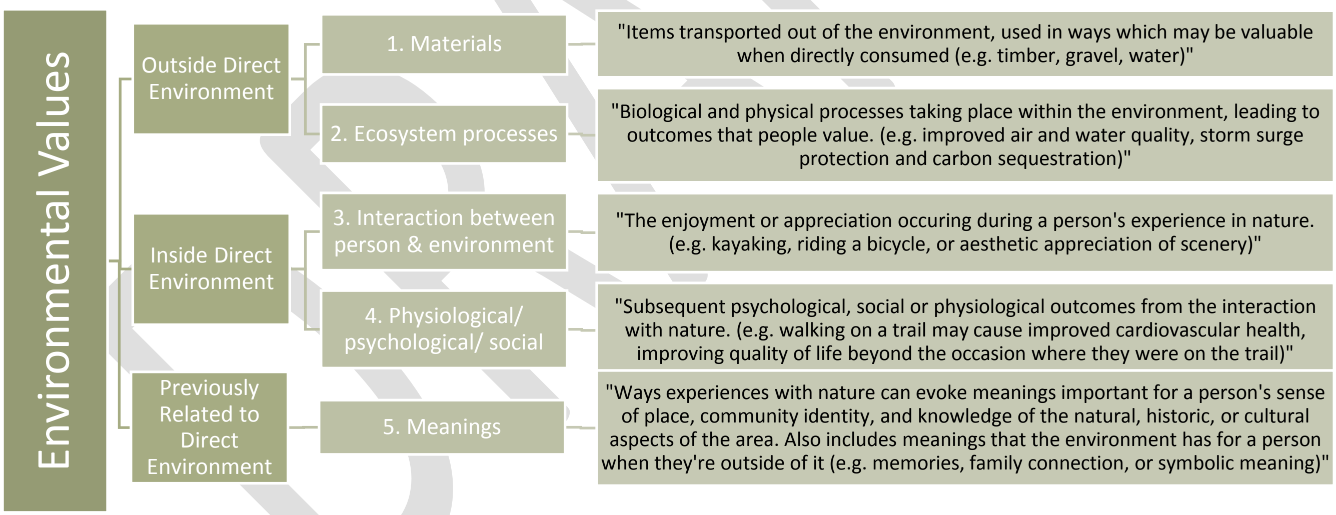


Chart 4 – Types of Environmental Values (Adapted from Schroeder, 2011).

Values represented by coastal First Nations are vast but some can be illustrated through the perspective of Wahkohtowin. First Nations Natural Law (*Wahkohtowin*) is a strong relationship and foundation identified by Ojibway, Anishinaabe, and Cree people across Canada. "*Our relationship with our mother the earth, the water, with all of the different plants, medicine, the herbs, the animals, the birds, all the four legged being[s]. Everything we encounter in our lives there is a relationship that we are always reminded of and are mindful about. We see ourselves belonging to the entire existence of our world; we are not separated from anything. Wahkohtowin talks* *about embodying that entire holistic idea of how we exist"* (LaBoucane-Benson et al., 2012, p.3). Through Wahkohtowin, we can more thoroughly comprehend the underlying environmental values of First Nations and Métis along Lake Huron. The Natural Law governs all people to love and respect the earth as not only their creator but as the mother that sustains us all. *"All things are related- we are all related, not only by blood- All things are alive. All things that were created are related – trees, grass and rocks. We are related to everything*" is the touchstone of the Natural Law, which has significantly influenced the management of the coastal environment throughout time by First Nations and Métis communities. Part of the oral tradition of passing down this law was for elders to teach youth how to live respecting the Earth, and one another. We asked members attending the Coastal Action Plan speaker's session at the Lake Huron Centre for Coastal Conservation's 10th biennial conference in May 2018 whether the concept of Wahkohtowin resonated with their personal values and their sense of place along Lake Huron. In a diverse audience consisting of members from the public and from across the shoreline, respondents felt that Wahkohtowin values aligned with their own values (Figure 5).

Figure 6 - Coastal Action Plan survey results when asked "Do you feel a connection to Wahkotowin through your way of life?" (2018).

From this survey, we can ascertain that it is not only First Nations cultures that these values and sense of place affect. Many of these values and intrinsic respect for Lake Huron could be increasing because of 'recent' resurgence in learning about local culture, historical value, and traditional ecological knowledge.

The environmental values of Métis and First Nations stem from their culture and teachings, like that of Wahkohtowin Natural Law and ethnoecology. The Midewiwin teachings observed by the Anishinaabe of Kettle and Stony Point believe in the Seven Grandfather teachings as the underlying values in the Anishinaabe culture and way of life; "*These teachings are: Wisdom, Love, Truth, Courage, Respect, Humility, and Honesty. The cultural practices of the Anishinaabe are based upon these beliefs and demonstrate a genuine respect for all walks of life, a love of family, community, and the natural environment, and a generosity that extends beyond the borders of their homeland." (KSPFN, 2009).* We understand through these teachings that underlying environmental values on the land and water represent the majority of Schroeder's (2011) divisions of environmental values. These values encourage a systemic understanding and respect for nature's fragility and resiliency. We asked members attending the Coastal Action Plan speaker's session at the Lake Huron Centre for Coastal Conservation's 10th biennial conference in May 2018 which of Schroeder's environmental value divisions they most closely aligned to. Figure 5 shows the responses obtained from a digital survey taken during the presentation. The pie-chart depicts the diversity of values, even within the small group of individuals attending the conference (Figure 7).

Conclusions drawn from this form of 'public input' on environmental values include ecosystem values connect with the public on many different levels, which create a challenge for cohesive, and collaborative stewardship efforts across the coastal corridor. In most County Official Plans there is interest explicitly stated regarding communities valuing the natural environment in a healthy state for water and air quality, plant diversity, wildlands and aesthetic values (Huron County, 2015a). No matter their reason for valuation, individuals value Lake

Huron's coastal environments, with communities seeming willing and interested in protecting or enhancing the coastal corridor to improve the habitats for ecological benefit, ecological services, and aesthetics.

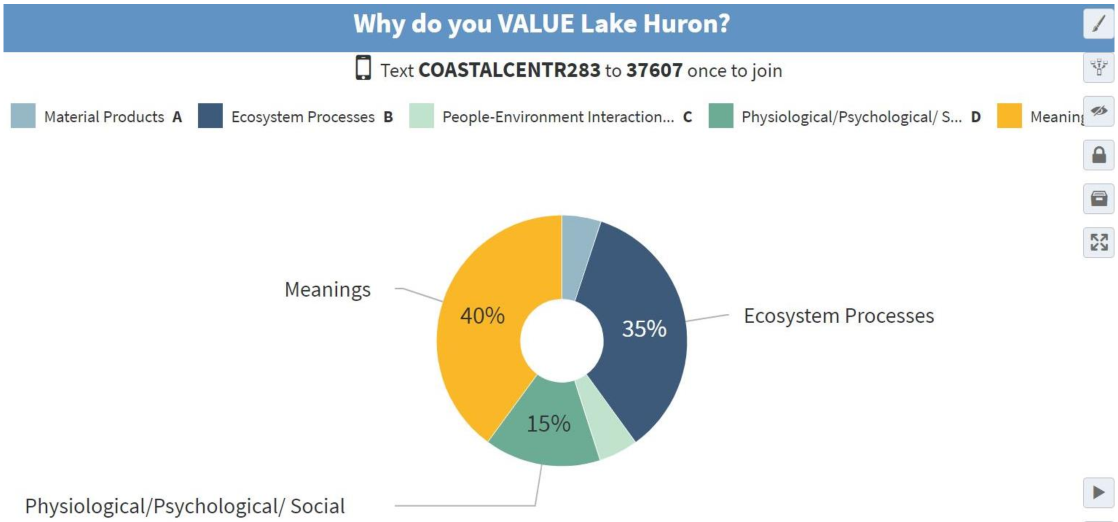


Figure 7 - Coastal Action Plan survey results when asked "Why do you value Lake Huron?" (2018).

3.2 ECONOMIC VALUES

The southeastern shore of Lake Huron is comprised of coastal communities, nationally significant agricultural lands, natural environment and resource areas. In Huron and Lambton Counties, agriculture dominates the landscape and is an important economic base (Huron County 2015, Lambton County, 2018). Interspersed throughout the coastal corridor are built up areas, natural areas, and transportation and communication infrastructure corridors. Natural resources within the coastal corridor hold economic value for the products they create, the tourism they draw, or the services they naturally provide. Those include productive soils (agricultural land), extractive resources (e.g. forest products, minerals, aggregates), and groundwater.

Economic values within the coastal corridor vary depending on the type of industry in the area. For example, in Bruce County, coastal communities rely on tourism, fishing, and agriculture for economic sustenance. Other industry such as Bruce Power Nuclear Generating Station, and many small provincial park areas provide many of the large-scale impacts in the coastal corridor of Bruce County. In Huron County, agriculture is most prominent, along with manufacturing, cottage community developments and major coastal communities serving as tourism hubs. Other industry such as the salt mine in Goderich, as well as the major shipping port provide the heavy-industry base in this area. In Lambton County, the coastal corridor is dominated by residential development, agriculture, resource extraction, and heavy-industrial uses such as major city centres and transportation corridors. These three counties rely on the coastal environment very differently for their economy with the northern portions relying more on the 'wilderness' and 'natural beauty' for its sustenance in the tourism industry, and recreation sectors.

3.2.1 ECOSYSTEM SERVICES

Ecosystem services are direct or indirect outcomes from natural processes. They can be provisional (e.g. food, fuel, fresh water), regulating (e.g. air quality, climate regulation, erosion control), cultural (e.g. recreation, aesthetics, spiritual), or supportive (e.g. oxygen production, soil formation) (LSC, 2019). These services can be defined as biological and physical processes taking place within the environment that lead to outcomes that people value including improved air and water quality, storm surge protection, or carbon sequestration. Ecological processes give economic benefits and act as natural infrastructure to municipalities that rely on water purification for drinking water, and flood attenuation of wetlands reducing the reliance and overuse of stormwater drainage.

Employing ecosystem services reduces costs for the equivalent services required by human-made infrastructure by the investment from municipal, provincial, federal, or private landowner. Placing value on the roles of ecosystem services is getting more notoriety and is now included in Canada's biodiversity goals and targets for 2020 (TD & NCC, 2017, p.5). Some ecological services provided by forests alone include carbon sequestration, disease regulation, water filtration and purification, flood control, nutrient recycling, and soil erosion prevention, to name a few (TD & NCC, 2017, p.10). Placing monetary value on ecosystem services naturally occurring in the coastal corridor assigns them higher value and, in some cases, may help persuade a natural ecosystem approach to shoreline development or alteration. For example, the Crane River property, a forested river valley on the Bruce Peninsula has been valued at providing $19,400 per hectare per year in ecosystem services (TD & NCC, 2017, p.29). Unfortunately, economists and environmental resource managers have found many challenges in valuing ecosystem services due to their wide-array of benefits and lack of comparable human-made alternatives. Some methods currently accepted for valuing ecosystem services include:

- **Willingness to Pay**: for a hypothetical or real product, services, or conditions (Voigt et al., 2013)
  - "Would you be willing to accept a tax increase of 5% to pay for manmade breakwaters to help prevent damage from storms and flooding? Yes/no". "How much would you be willing to pay to maintain the natural coastline in the study area that provides flooding attenuation?" (Annis et al., 2017).
- **Hedonic Pricing**: Prices reveal preferences among bidders (e.g. house proximity to a park) (Ontario, 2019). Valuation can be market based (materials or tourism) based on willingness to pay, rarity, popularity and price (regression analysis to determine economic value) (Annis et al., 2017).
- **Option and Bequest Value**: Willingness to pay or protect an area because they want the option of having it in the future for visiting, using, extracting, etc. Or, the value someone places on an ecosystem they can pass on to the next generation (Annis et al., 2017).
- **Avoided Cost:** determining the value of added damage that would occur if the ecosystem was not there. Or an accounting-based method estimating financial damages avoided by preserving an ecosystem and maintaining its services. (e.g. if flood-reducing wetlands were filled, how much damage would result to downstream housing). The ecosystem service must be worth at least what people pay to repair the damage caused by the force once regulated by the ecosystem. (Ontario, 2019; Annis et al., 2017).
- **Replacement Cost**: The cost to replace a natural service with 'human-made' alternatives (e.g. water treatment plant vs. wetland). Understanding how much the natural service gives vs. how much the human-made equivalent would give. The way to find out how much that ecosystem service is worth, would be how much people would be willing to pay for the equivalent human-made option (Annis et al., 2017).

Although the CAP has not quantified the number of ecosystem services existing in the coastal corridor, there is opportunity to calculate the economic value of these resources in order to better respect and manage the services provided by these ecosystems. "By learning the 'currencies' in which communities' value their coastal resources, we can apply resulting (or new) data to inform current and future conservation actions toward more ecologically, economically and socially resilient futures" (Annis et al., 2017). Partnership between municipalities and the academic community to quantify and denote monetary value on ecosystems within management boundaries could be an efficient way to collaborate and examine natural infrastructure across the coastal corridor.

3.2.2 ECONOMY OF TOURISM

Interactions between people and natural areas can glean economic value through the tourism industry and the businesses that work to supplement tourism. Many, if not all communities within the coastal corridor benefit from the tourism industry, and claim they are reliant on tourism to keep their economies flourishing (MTCS, 2018). Although tourism across the coastal corridor is increasing, the regional tourism organizations, RTO1, RTO4, and RTO7, combine different slogans to encourage visitors to their areas; "Ontario's Southwest: Shaped by Nature"; "Ontario's West Coast"; and "Bruce Grey Simcoe: Always in Season" respectively. Some estimates have been made that National Park visitation will increase by 5-14% in the 2020's and 7-31% in the 2050's, whereas Provincial Park visitation is expected to increase 11-27% in the 2020's and 15-56% in the 2050's (Scott, n.d.). The same reports are estimating that beach season and swimming seasons are expected to increase into the future (Table 5).

Table 5 - Beach, Watersports and Golf Seasons on Lake Huron (Scott, 2013)

Beach Use Season – Georgian Bay	Swimming Season – Georgian Bay	Golf Season – Orillia Area
Current: 152 Days	Current: 59 Days	Current: 192 days
2020's: 161 – 182 days	2020's: 76-99 days	2020's: 202 – 218 days
2050's: 166 – 216 days	2050's: 83-135 days	2050's: 202 – 229 days

Beach visits specifically are focused between April and September, with 94.4% of annual visits occurring during this time (Ontario, 2014). These estimations tell us that tourism along the coastal corridor, especially in currently protected areas is expected to increase in frequency, and throughout the year, thereby increasing the local economies and potentially providing more consistent visitation throughout the year. Increasing the shoulder seasons and peak season times will provide more consistent economic inputs for businesses in the community. Based on Huron County's recent Economic Impact Report 2017 – 2018, the average visitor to Huron County spends $417 per visit (average of 4 days), translating into adding more than $2.2 million annually to the local economy (OMTCS, 2018). Valuing the coast and preserving the ecological amenities the corridor provides will mutually benefit local economy, and proper land management will preserve the ecological areas.

3.3 SOCIAL AND CULTURAL VALUES

Ontario's West Coast has an array of freshwater natural ecosystems, people have been drawn to the shores of Lake Huron for generations to enjoy its miles of sandy beaches, blue waters, and many other ecosystems. The immeasurable sense of peace that we feel around water is what Wallace J. Nichols calls our "blue mind"—a chance to escape the hyper-connected, over-stimulated state of modern-day life, in favor of a rare moment of solitude. Research has long found that humans are pulled toward Mother Nature's blue for, in part, its restorative benefits. Take the Victorian era for example: Doctors prescribed "sea air" as a cure for all sorts of issues, from pulmonary complications to mental health conditions. More recent studies—including those out of a UK-based project called Blue Gym—have found that people who live near a coast are generally healthier and happier. Other studies find that when shown photographs of natural green spaces, people's stress levels drop, but more blue spaces in the photos, the more people prefer them. Real estate data even suggests a water view tacks a 116.1 percent premium on a property; and real-world figures suggest we're willing to pay 10 to 20 percent more for the same room with a sea view in a hotel. To place a precise numerical value on the importance of how coastal environments improve people's lives presents a challenge (Shortsleeve, 2017).

First Nations and Métis within the coastal corridor are active in the use and enjoyment of Lake Huron for recreation, sustenance, and livelihood. First Nations and Métis are active in their roles as educators passing traditional ecological knowledge throughout their communities and to younger generations. The sustainable use of Lake Huron and the coast is commonplace to these lasting cultures and there is much to be learned from their traditional land-use management techniques of finite resources.

Engagement with First Nations and Métis groups have told that the interest they hold for Lake Huron's shores and waters permeates through environmental values, cultural and historical significance, as well as current and future prosperity through resource use. Fishing and hunting are of obvious importance, but other traditional uses for the coast include medicinal plant harvesting, and items associated with spirituality including eagle feathers, sage, sweet grass, and edible wild plants (Lowitt et al., 2018). "*Indigenous spirituality is often closely connected to land-based activities, such as hunting, trapping, cultivating and harvesting practices. Some Métis people in Ontario mark the harvest with a festival that provides a special opportunity for the community to connect, take part in traditional Métis cultural activities and pass on traditional skills and oral traditions integral to Métis culture, identity, religion and spirituality*" (OHRC, 2018).

Social and cultural importance is one of Schroeder's (2011) divisions of environmental values, in which case the importance of hunting and fishing in Lake Huron's coastal corridor by First Nations and Métis is deeply-rooted in their cultural values. Saugeen Ojibway Nation (SON) alone has exclusive harvesting rights of 930 hectares on the Bruce Peninsula along with exclusive fishing reserves covering most of the waters around the Peninsula and their fishing islands (Lowitt et al., 2018). Some species harvested by First Nations groups have exceptional significance to their people's culture, including Whitefish. *"Currently, SON operates the largest Indigenous commercial fishery in the Canadian Great Lakes, with ~30 commercial fish harvesters in two communities, including seven tugs and four punts… Lake whitefish and lake trout comprise most of the harvest. Pickerel, ling (burbot), suckers, carp, salmon, rainbow trout, herring, and yellow perch are caught in lesser numbers. Whitefish is the only species for which a Total Allowable Catch (TAC) is set under the terms of the Commercial Fishery Agreement. Between 2013 and 2015, SON caught ~53–60% of its TAC, due mainly to the wholesale price volatility for local fish arising from supply gluts."* (Lowitt et al., 2018). Through this study of the fishing industry in the SON, respondents to the interviews specified that, "changes in culture are considered closely tied to changes in the environment" (Lowitt et al., 2018). This is mirrored in other communities that have changed from rural to urban over time, losing their identity and sense of place as expansion occurs.

There are many light stations peppering the shoreline, many of which commemorate the marine heritage of these communities and the Great Lakes. Light stations were installed in response to the epic number of shipwrecks occurring off the shores of the Peninsula (Parks Canada, 2018). Goderich, Point Clark, and Tobermory are three communities with lighthouses. The Point Clark lighthouse was built between 1855-1859 and is one of 6 Imperial light stations built on Lake Huron, a design exclusive to this area (Parks Canada, 2018). This lighthouse, once used for navigation, is now a museum operated by the Township of Huron-Kinloss, and is a draw for tourists and bolsters the summer economy for local business (Parks Canada, 2018). The installation of light stations at these ports was strategic, and encouraged harbours and shipping to generate more activity in these areas. Shipwrecks in these areas now have become a draw for tourism and recreational diving, significantly contributing to local economies.

3.4 SUMMARY: PROTECTING COASTAL VALUES

To revisit the questions of how Lake Huron's coast is valued, it has been found that environmental value, economic value, and socio-cultural value are the main contributors for why people continue to visit, live on, and enjoy the coastal corridor and nearshore environment of Lake Huron.

1. **"Why do people want to live on the coast?"**

People are drawn to the coast for many reasons, including historical and cultural connection; recreation and aesthetic appreciation including tourism like birding, beach-going, boating; economic drive and incentive of tourism or resource extraction industries; and environmental values including an appreciation of being submersed in a certain ecosystem or sense of place.

2. **"Why do people manage the coast in the ways they do?";**

The three most common reasons why people manage the coast the way they do are:

- Routine (this is how we've always done things!);
- Economic gain or subsistence (we have a limited budget or we need to manage it this way to make money or keep our financial situation viable);
- Unfamiliar with management techniques or best practices that can positively contribute to coastal management

Education and outreach, highlights values of individuals' and uses them as leverage to encourage change. This method in turn evokes adoption of recommendations.

3. **"What are impediments in making people take a conservation-minded approach to valuing the shoreline?"**

Major impediments to changing a mindset is the inability to make alterations to most people's values and outlooks 'short-term' (Dietz et al., 2005). Most changes from an environmental or values perspective take a few decades, if not one or two generations to become 'socially adopted as a norm'. In some cases, change does not occur before damage can be stopped (e.g. small vulnerable populations of endangered species may become extirpated before the societal change can take root). Another impediment is ensuring consistent and adequate education and awareness of community members, visitors, and local governance agencies. Newcomers to areas are often unaware of the cultural history or stressors and ecosystems of an area and are therefore less likely to place a high value on it. Education and awareness are key to improving the valuation of important resources to ensure that resource is protected for future generations. The last major impediment is greed. As eloquently stated in the term 'tragedy of the commons', if a shared resource is being taken advantage of by an individual user to benefit their own self-interest or economic status, that resource is being threatened by the greed of that one individual, often causing other users to equally abuse the resource to 'get their share'. Society in coastal areas must remember the teachings of the Cree and Ojibway First Nations, that our environment and the resources contained here are subject to the 'Natural Law' and are to be shared and respected by all- for all.

CHAPTER 4: COASTAL ECOSYSTEMS

Assessing the condition of coastal ecosystems on Lake Huron's southeastern shores, is important to determining their health, resiliency, and the sustainability of human influence on them. To determine their health, threats and stressors that affect them are overlaid and examined using indicators and thresholds to determine priority actions and opportunities to increase their health and resilience. Indicators are simple measures that quantitatively describe changes to the landscape over time. They detect change and trends such as the amount of forest area, or the number of non-point source (NPS) pollutants affecting a habitat. An indicator is a signal that informs landscape managers of how current environmental conditions compare to ideal conditions. Indicators are an accepted approach for assessing complex ecosystems. More specifically, Great Lakes indicators assess conditions and changes in ecosystems. Understanding existing and emerging issues and creating solutions; guiding programs and policies needed to prevent or address environmental problems and, setting priorities for research and program implementation all occur through analysis of indicators (ECCC & EPA, 2011). For the purpose of the Coastal Action Plan (CAP), ~40 indicators have been acknowledged through the Steering Committee and adapted from partner agencies and international systems to determine the health of Lake Huron's coastal corridor.

There are currently two initiatives underway, one by the Ministry of Natural Resources and Forestry (Province of Ontario), and one by Environment and Climate Change Canada (ECCC) that are taking 3-5 years to accurately map and monitor existing conditions and habitat presence along Great Lakes coastal ecosystems (within 2km of shoreline). These projects will be able to provide baseline data for future change analysis to species diversity, and ecological integrity of coastal vegetation communities. In these studies, habitats will be mapped to the Eco-Type level as per the Ecological Land Classification System (MNRF). The CAP recognises the work being completed by our partner agencies, applauds the investment in monitoring our coastal ecosystems, and will refer to these documents when completing action projects across the shoreline in the future.

4.1 BACKGROUND

The coastal corridor of Lake Huron has been an important area of community and livelihood for centuries. Human presence along the coast is dynamic in community identity, size and shape, and level of development. Métis and First Nations groups have lived along the shores of Lake Huron, and have Traditional Ecological Knowledge dating back almost 9,000 years in the Lake Huron Basin. Over that past century, Lake Huron's shoreline has seen negative changes to coastal ecosystems due to community development, hardening of shorelines for protection, channelizing streams and removing wetlands, decreasing nearshore water quality, and changing land-use from natural corridors to transportation routes, groomed corridors, and industrial sites. Positive changes along the shoreline have included the establishment of provincial and national parks in the 1960's and 1970's, as well as private conservation and preservation efforts from various groups. Although now viewed as areas of natural sanctuary, Provincial and National parks along the coastal corridor were established for recreation purposes- not specifically protection, which became a priority in later years as resource managers began to better understand sensitive ecosystems. Protecting and sustainably managing shorelines, restoration efforts, and reducing stormwater runoff in coastal communities began to take place around the 1980's and 1990's. Today, we are experiencing the cumulative effects of decisions made in past decades, and are collectively working towards positive change to establish healthy, resilient coastal ecosystems.

Documents such as the State of the Great Lakes Report and the Lake Huron Biodiversity Conservation Strategy provide deep-dives into indicators and thresholds for coastal ecosystems to determine lake health from a

Great Lakes watershed scale (ECCC & EPA, 2011). Chart 7 illustrates typical drivers of change affecting ecosystems eliciting responses to preserve and repair damages.

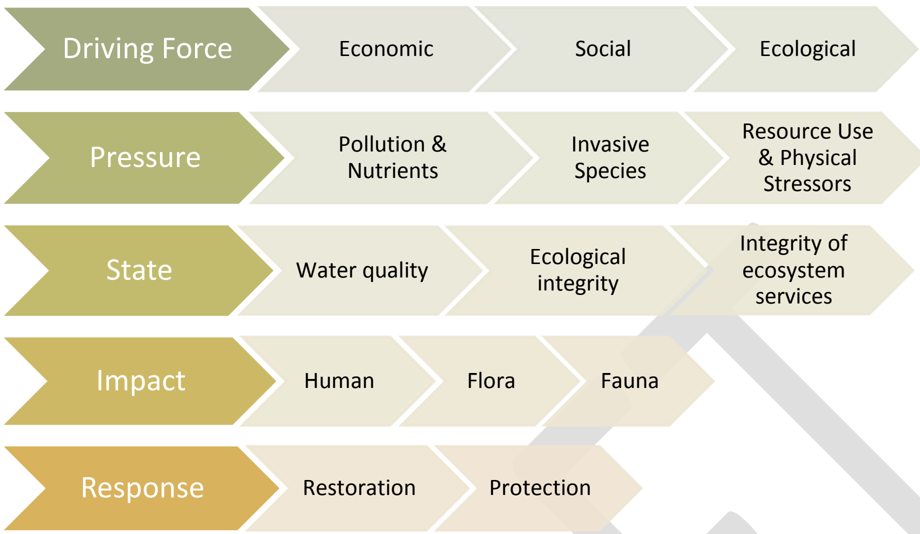


Chart 5 - SOLEC Reporting Categories

Efforts by many organizations to prioritise conservation action and partner with others to formulate responses to negative environmental pressures and to complete collaborative projects reducing negative trends in Lake Huron's coastal corridor have been made (Annis et al., 2017). Organizations have vocalized the need for conservation actions to meet measurable ecological thresholds to sustain recreation and ecological processes relied upon by coastal communities (Annis et al., 2017). To create measurable and attainable improvements in ecological integrity, a baseline assessment is needed to determine priority areas for conservation based on ecosystems, threats and stressors present.

Baseline assessments for the CAP were completed using data from partner sources with varying degrees of accuracy. Literature review of scientific reports, Geographic Information System (GIS) data, and assessment of other projects all contributed to the baseline data of the CAP. Some data from Federal and Provincial sources are broad-scale and less accurate at the level of analysis required. However, in some areas where local authorities are lacking similar data, this broad-scale data was relied upon as the only record of certain ecosystems. Therefore, recognition that data limitations and spatial accuracy of the best available data across partner agencies is variable. One coincidental outcome of this analysis was the process of reviewing all available data highlighted areas for future monitoring projects or data acquisition among partner agencies. For example, among the five CA's alone, there is varying amounts of GIS data available and are therefore not the most reliable to compare directly. However, data provided by most of the CA's at the scale of our analysis exceeded anything available through the Federal and Provincial government's digital data archives. Another coincidental outcome through this baseline assessment was the realization that open data sharing among partners is mutually beneficial to all entities sharing, and should be encouraged.

4.1.1 WHAT DOES A HEALTHY SHORELINE LOOK LIKE?

The definition of what a 'healthy' shoreline looks like is different to everyone, as discussed in the Chapter 3, but for our purposes can be defined using four factors; (1) presence and health of vegetation, (2) presence of roughage, (3) ability of the ecosystem to complete coastal processes, and (4) presence of wildlife. These factors must hold true at any analysis scale within the coastal corridor. Whether a single property, or an entire stretch of shoreline, these 4 factors determine the state and health of that ecosystem. The presence of these factors will indicate whether the coastal corridor is resilient to natural and anthropogenic (human) stressors. The coastal corridor's resiliency epitomises of the definition of "healthy" and the two terms can be used synonymously for the purposes in this chapter.

4.1.1 **Presence and health of vegetation:** Depending on the ecosystem, different forms of vegetation presence are appropriate. On sand beaches and dunes, a shoreline covered in Marram Grass, St. John's Wort, Milkweed, Common Juniper, and Oak Trees is best. On coastal forests, common vegetation includes White Cedar, Maple species, Red Osier Dogwood, and Bunchberry. Although very different species occur in these examples, relativity to determine 'health' through the diversity of species present, the density of vegetation, whether species are native, non-native, or invasive, and whether these species are being negatively impacted by natural or anthropogenic influences exists. One last consideration is using historical shoreline conditions as a touchstone for comparison when analysing current condition of vegetation in that habitat.

4.1.2 **Presence of roughage:** The term 'roughage' can apply to driftwood, wrack (washed-up dead vegetation), fallen trees and limbs, and leaf litter. The presence of this material contributes nutrient inputs on shorelines producing important breeding habitat and camouflaging opportunity for feeding birds, insects, and reptiles. Roughage provides habitat for small mammals (e.g. rabbits and mice) to seek shelter from predators (e.g. hawks and vultures) when approaching the shore for food or water. Roughage, whether washed up from the lake or fallen from nearby trees should always be left in place by cottage owners or beach managers. Around the Great Lakes, social stigma around roughage needs to describe that roughage is natural and important for coastal health; leading a systemic change in perceptions of 'clean' and 'healthy' shorelines.

4.1.3 **Ability to complete coastal processes:** Coastal habitats rely on natural processes to allow resilient function. For example, bluff and gully environments need to erode to supply sediment to sand beaches and dunes down the coast. If rates of bluff erosion are stopped or increased, it affects associated habitats. Most natural process inhibition in the coastal corridor is caused by human intervention. Built structures and hardened shorelines (e.g. sea walls, groynes) negatively impact littoral transportation processes that shape the coast. If the coastal corridor is afflicted with inappropriate structures and management techniques, ecological integrity will decrease and a domino effect will occur to wildlife diversity, resiliency to extreme weather events, and aesthetic value of these areas. Major coastal processes that occur include nearshore sediment transport engaging the erosion/accretion of erodible shoreline; lake level changes and seasonal precipitation events causing inundation and drying of the aquatic/terrestrial ecosystems like coastal wetlands; as well as potential changes to these processes through climate change (Haras et al., 2008, p.174).

4.1.4 **Presence of wildlife:** Wildlife presence within coastal ecosystems is an indicator of whether that habitat is providing all the amenities necessary for feeding, breeding, and nesting. The old expression, 'the canary in a coal mine' metaphorically describes a sensitive indicator species presence monitoring to determine status of ecosystem functionality. For most coastal environments, the presence of species at risk and whether the ecosystem is part of their 'critical habitat' range are valid measures to ensure ecosystem health to accommodate populations of diverse species. Presence of a diversity of species groups are important to ensure the food web is functioning properly. If one of these categories vastly outnumber the others, there may be a gap in the ecosystem's amenities. If monitoring shows a sudden decrease in a member of the food chain, managers can back-track and attribute the loss of that species to an influence induced anthropogenically or naturally.

Throughout the analysis completed in the CAP, we will be able to identify strategies of how determine if coastal environments are 'healthy' and whether current coastal management tactics cover these parameters.

4.2 DESCRIPTION OF COASTAL ECOSYSTEMS

The southeastern coastal corridor of Lake Huron supports a diversity of ecosystems and habitats along its 945.98 kilometres of shoreline. Aside from the rich cultural heritage and recreational uses for the coast, the ecosystems that exist along the southeastern shores include some of the rarest habitats in the world. Coastal ecosystem composition varies from north (Tobermory) to the south (Sarnia). This diversity creates complexity in the management and planning of ecosystems' regions.

For the purpose of the CAP, the term 'ecosystems' can be considered synonymous with the term 'habitats. Ecosystems are defined as natural areas consisting of homogeneous features including flora, fauna, and geology. Ten ecosystems were identified encompassing the biodiversity of Lake Huron: alvars and bedrock; sand beaches and dunes; cobble beaches; bluffs; gullies; islands; the nearshore zone; river mouths; wetlands; and woodlands. There is inherent value in all coastal ecosystems, whether fragile, rare, common, or popular. In the 2017 Online Questionnaire, respondents selected which coastal habitat types were important or significant to them. Chart 8 illustrates their responses. Most respondents felt connections to, or valued sand beaches and dunes, coastal wetlands and bluffs more than others ecosystem types. Although responses received were from individuals across the shoreline of Lake Huron, it was noted that ecosystems spanning more physical area and shoreline than others were found to have the most interest by members of the community. Respondents were able to select more than one ecosystem as being "important" with the question formatted as a yes-or-no option for each ecosystem versus a ranking system.

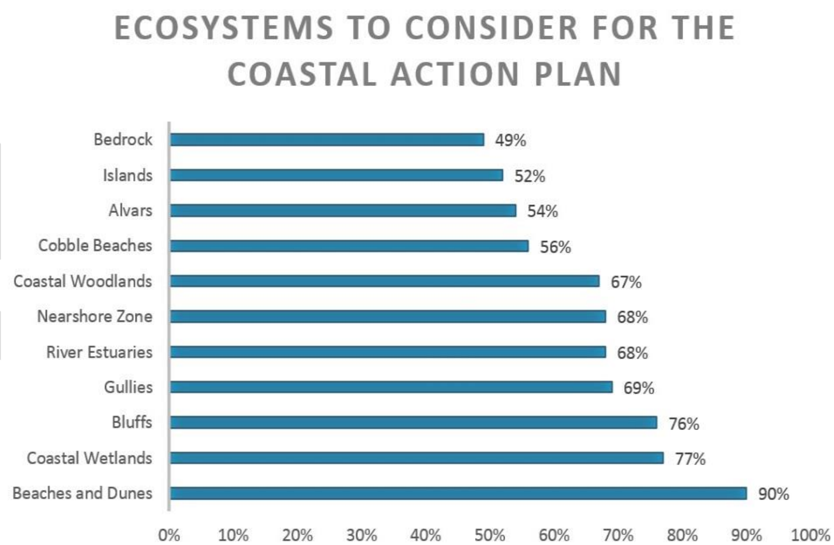


Chart 6 - Responses from the 2017 CAP Questionnaire on Ecosystems (256 Responses)

The CAP examines these ten ecosystems, what role they play on Lake Huron's coastal corridor and explain threats and stressors that affect these areas. Further analysis of ecosystems and stressors will be included in Chapter 5.

4.2.1 CURRENT MANAGEMENT STRATEGIES

Some local governance agencies, including CA's, municipalities, and counties, have regulatory documents and Official Plans to accommodate growth and development along Lake Huron's shores. Lambton County's Official Plan specifies their desire to provide opportunities for living along and enjoying Lake Huron for economic, tourism, historical and cultural purposes. Their plan claims that protection and preservation should be paramount in shoreline management considerations, where possible (Lambton County, 2019, 8-12). Lambton County has an immense development footprint along the coastal corridor including almost continuous shoreline hardening and residential development, and is plagued with multiple invasive species including the Emerald Ash Borer (*Agrilus planipennis*), European Common Reed (*Phragmites australis)*, and Spotted Knapweed (*Centaurea maculosa*). Although environmental considerations are being made, they inadvertently become second priority to other land-use including development, agriculture and industry. Huron County's recent Official Plan update has some similarities to that of Lambton County. They mention, "Lake Huron and its shoreline are important because of the recreational, residential, ecological and tourism services" (Huron County, 2015a, p.29), but it fails to mention the importance of the ecological services provided by these coastal ecosystems and the contributions they make towards water quality and erosion control. Huron County's Plan recognizes, "development can place considerable stress on the lakeshore environment. This stress requires that future development consider [the pitfalls of] existing development and demonstrate environmental sensitivity" (Huron County, 2015a, p.29). However, this plan falls back on Conservation Authority regulations to implement this opinion, thereby reducing ownership of enforcement and regulation. Unfortunately, very few types of modern development can meet Huron County's ambition to "minimize negative impacts and improve the natural condition of Lake Huron and its shoreline" (Huron County, 2015a, p.29). More effort is needed on the part of coastal municipalities and counties to solidify an unwavering commitment to the protection of ecosystems within the coastal corridor, including putting environmental protection and restoration higher on the priority list than development or land-use change for short-term economic gain.

Multiple agencies review and provide approval to ensure projects can proceed safely and do not negatively impact the aquatic environment, water quality, endangered species or adjacent properties. Rules, regulations and permitting processes intend to keep coastal communities safe and protect the environment by Conservation Authority regulation and Municipal bylaws. Recognising First Nation and Métis communities may have Indigenous or Treaty Rights potentially experiencing negative impacts by proposed shoreline alteration. These rights may vary depending on the community but often surround hunting and fishing. Regulatory agencies can consult local First Nation and Métis to determine how to address concerns.

4.3 SAND BEACHES AND DUNES

DEFINITION:
Coastal areas dominated by sand substrate dynamically altered through wave movements and wind action. These areas include sand beach/dune areas of Lake Huron's coast, along with the fore-beach occurring between bluffs and the water's edge. Size of sand beaches fluctuate as water levels oscillate (LHCCC, 2008).

ECOSYSTEM DESCRIPTION

Sand beach and dune habitats are one of the most popular areas for visitors and residents on Lake Huron's shoreline. These areas not only provide ample opportunity for tourism and enjoyment but are rare and fragile ecosystems. Sand beaches on Lake Huron have a reputation for being dynamic environments, growing and shrinking depending on lake levels. This fluctuation is part of what makes living on sand beaches and dunes potentially hazardous. The extreme rarity and ecological fragility of Great Lakes dune ecosystems have been caused to consider them of national significance (Municipality of Bluewater, 2013). A typical cross-section of a Lake Huron sand beach and dune ecosystem is illustrated in Figure 7.

Over the length of the shoreline (946 km), there have been 96 kilometres of Sand Beach and 145 kilometres of mixed sediment beaches delineated using the Ontario Shoreline Segmentation Data, as well as through orthophoto interpretation. Therefore, sand beaches make up 25% of the total shoreline *length*. Ontario SOLRIS land-use data allowed us to determine that beaches (mixed sediment, sand, and cobble combined) made up 738.5 hectares (0.8%) of the total project study *area* (85,838 hectares total). Mixed sediment beaches were included in the sand beach category instead of the cobble beach category, because in this analysis, sand was more prevalent in these mixed sediment beaches than cobbles. Therefore, mixed sediment beaches and sand beaches will be referred to as 'sand beaches' in this Plan.

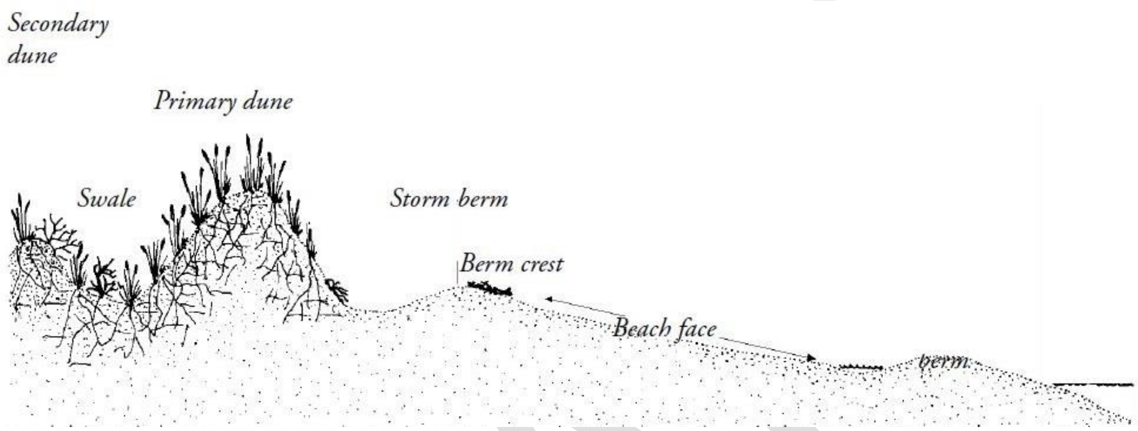


Figure 8 - Dune and beach profile (adapted from DFO, 1996a)

Sand beaches and dunes are dynamic ecosystems. Calm winds of summer bring sediment and sand onto beach areas, building dunes and eroding off-shore sandbars. Rough winter storms and ice formations carve out sediment from shores and beaches, reshaping sections of highly erodible shoreline (DFO, 1996a). Lake levels can expedite or slow this process. Fine sands and sediment easily blow far up onto beaches, forming dunes. Many dunes across the study area are active, meaning that they move back and forth parallel to the shoreline, growing and receding depending on lake levels, winds, and vegetation cover. Through aeolian movement, sand can cover roads and buildings adjacent to the shore if vegetation is sparse (DFO 1996a, p.8). This constant flux re-enforces the need to give sand beach and dune ecosystems space to expand and contract from year-to year. Although a popular place to build cottages and homes, we now know sand beach and dune environments are hazardous to develop and continued development is leading to habitat loss for endangered species. Healthy, mature dunes provide ecosystem services such as shore erosion protection from storm surges (DFO, 1996a, p.34). Healthy sand beach and dune environments provide critical nesting habitat for endangered species such as the Piping Plover (*Charadrius melodus*) which are extremely sensitive to human use and habitat augmentation (DFO, 1996a). Birds like the song sparrow (*Melospiza melodia*), vesper sparrow (*Pooecetes gramineus*), and the eastern bluebird (*Sialia sialis*) forage on insects of the foredune, as well as the eastern kingbird (*Tyrannus tyrannus*) and chipping sparrows (*Spizella passerina*) when scattered trees are present. Bank swallows (*Riparia riparia*) next in low, steep cliff faces of the dune, formed by erosion during winter storms, and both bank swallows and tree swallows (*Tachycineta bicolour*) are often seen feasting on the abundant flying insects of the dunes (LHCCC, 2008). Rare dune plants such as Pitchers Thistle (*Cirsium pitcheri*) and Green Milkweed (*Asclepias viridiflora*) rely on dynamic dune processes, and support rare insects adapted to harsh dune environments (Bakowsky & Henson 2014).

Scientific studies have been able to measure the supply of sand 'feeding' beaches on Lake Huron's southeastern shores. On Bayfield Beach, "the average annual supply of sand and gravel from updrift is estimated to be about 21,000 m^3… Sediment supplied from bluff, nearshore and gully erosion from the shoreline south of Bayfield is estimated to be a bit more than 40 000 m^3 and thus about 65 000 m^3 annually is deposited over the area south of Country Road #83" (Davidson-Arnott & Mulligan, 2016, p.40). Calculating and monitoring annual sediment deposition on Lake Huron's beaches can help support beach management discussions and determine the fragility of beach and dune environments based on a high or low deposition rate. Sand beaches and dunes with higher deposition rates are more resilient to human alteration but are not immune to poor beach management practices. Sand beaches don't always have dunes. Some sand beach environments are 'low energy' beaches; meaning that the amount of sand added to the beach every year through natural processes is not significant enough to encourage the growth of dunes. These beaches have low-slope environments, often with hydrophytic vegetation including grasses and sedges. Although rarer along Lake Huron and less 'healthy looking' than high-energy beaches, these beaches provide habitat for many aquatic species and are even less resilient to disturbance than high-energy counterparts. Low-energy beaches take a long time to recover from human manipulation because new sediment isn't deposited as quickly as in high-energy beaches. A notable example of a low-energy beach is Singing Sands (Dorcas Bay) on the Bruce Peninsula. Protection is the only management option for low-energy beaches, because restoration is often challenging, requiring additions of sediment manually, and the re-introduction of rare plants populations is often futile.

Sand beach and dune environments can be preserved and enhanced using very inexpensive, simple methods. Two accepted methods for repairing and restoring beach and dune ecosystems include installing sand fencing parallel to the shoreline, and planting dune vegetation such as Marram Grass (*Ammophila breviligulata*) (USACE, 2003). Avoiding compaction of soil by trampling is important to reduce mortality of dune vegetation and resiliency to erosion from storm surges. Two examples of beautiful, healthy dune and sand beach environments can be found in Pinery Provincial Park, and Station Beach in Kincardine.

THREATS AND STRESSORS

Within the southeastern coastal corridor, sand beaches and dunes are mostly privately owned, spread sporadically from north to south with inconsistent management styles and development regulations. Human impacts and disturbances to these habitats can be extremely detrimental and cause significant habitat fragmentation along the shoreline. Six threats that most heavily impact the health of sand beaches and dunes along Lake Huron (in no order of significance) have been identified;

4.3.1 Invasive species:

Invasive plant species on Lake Huron beaches are limited to species that thrive in disturbed areas, low nutrient soil types, and can withstand extreme heat. Spotted Knapweed (*Centaurea maculosa*), Common Soapwort (*Saponaria officinalis*), Common Reed (*Phragmites australis*), Sweet White Clover (*Melilotus albus*) and 'garden escapees' are the most prevalent invasive species known to occur on Lake Huron southeastern shore beaches. Invasive Species to beaches and dunes, "displace native dune vegetation because of their ability to grow aggressively, smother native dune species, and compete for available nutrients" (LHCCC, 2008). These species infiltrate dunes and swales, altering the composition of vegetation from dune to meadow to a point which may exclude native species (LHCCC, 2008).

Simple hand-pulling techniques to remove invasive species will preserve dune sediment from erosion, leaving native species such as Marram Grass in place. Figure 8 shows the removal of Sweet White Clover from a dune and swale, which only took a few hours to complete. Vigilant prevention, monitoring, and removal are continuous tactics required to combat invasive species on beach and dune environments. Landowners require education to identify invasive species, and methods of removal and treatment to adequately preserve their property's ecosystem. More information on invasive species can be found in Chapter 5 of this plan.

Figure 9 - Invasive species removal on a dune

4.3.2 Development and land-use change:

Coastal development, shoreline hardening, and land-use change are the most significant threats to beach and dune health on Lake Huron. In areas where beach and dune ecosystems are privately owned, and not being used for public beach areas, most of the sand beaches along the southeastern shores are covered mainly by residential development (Figure 9). Unfortunately, although there are some regulations and current management strategies in place to prevent destruction to sand beaches and dunes, when private landowners are uneducated on the importance of the presence and ecological services dunes provide, they often are removed or degraded to the point of very little ecosystem function. In many cases, homes and cottages were built as far forward as the fore-dune during the

Figure 10 - Cottages in Township of Huron Kinloss in 1986

settlement and development of the coastal fringe in the 1960's (Figure 9).

Our current understanding of coastal processes and the sensitivity of beach and dune ecosystems plays into regulation and bylaws that are in place for new development and alteration of properties along dynamic beach areas. Existing cottages on beach and dune ecosystems need to manage their impacts to shoreline resilience as many bylaws don't cover landscaping, and rules are often not enforced until damage has occurred. Inconsistencies in the shoreline management on beaches and dunes occurs across lakeshore communities, depending on knowledge of coastal processes and ecosystem services, as well as property turnover rates.

Figure 11 - Shoreline development along beach and dunes on Lake Huron

Shoreline hardening affects many ecosystems along Lake Huron's southeastern shores, but most notably affects sand beach and dune ecosystems because of their tendency to be highly dynamic. Hardening was thought to be a way for landowners to protect their investments from fluctuating lake levels. Shoreline hardening can encompass single structures such as groynes, jetties, sea walls, armour stone, gabion baskets, and poured concrete walls.

Figure 12 - Groynes along Lambton Shores

Regardless of size, these structures significantly affect the ability of sediment, nutrients and natural material to follow the littoral flow of the lake and supply these items to beaches further down the coast. *"In an effort to prevent erosion, humans attempt to harden the shoreline and make it more stable, often to protect property in the immediate area… Unfortunately, this protection is often short-lived and often comes at the expense of beach* *health. Hardened structures can cause erosion by preventing waves from accessing sandy reservoirs and by changing nearshore wave patterns" (UH, 2014).* Many structures installed between 1960-1980 are reaching the end of their lifespan and have become a hazard to human and animal health and safety (Figure 11 and 12). Hardened shorelines prevent sand beach features like dunes and swales from forming. Their removal would restore natural processes.

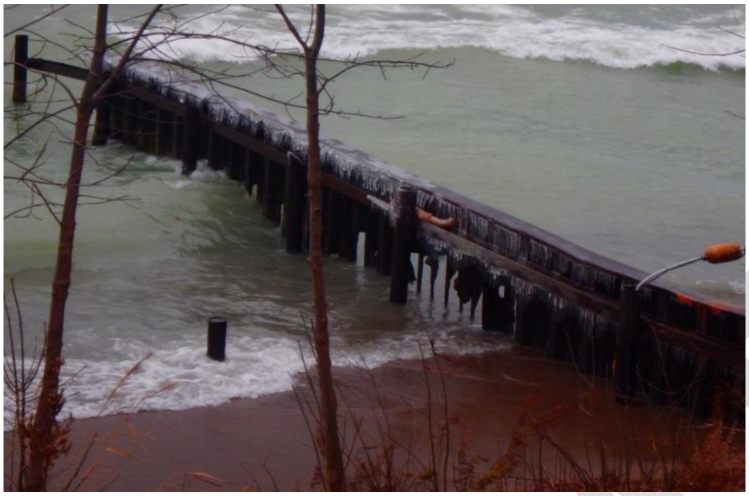


Figure 13 - Failed Groyne on Lake Huron Beach

Figure 14 - Gabion Baskets along Shoreline in Summer haven (1998)

4.3.3 Climate change:

Reduced ice cover in early and late winter have an impact on sandy beach systems as a result of increased frequency of intense storm events generating high waves and storm surges. Storm events and surges increase the probability of major dune erosion on sand beaches, particularly during periods of high lake levels. Under these conditions, there is increased potential for over-wash and barrier breach, particularly at vulnerable locations such as the proximal end of spits and groynes contributing to the undermining of these structures (ELPC, 2019). Climate change will affect recreation in beach and dune environments. Although climate change specialists claim that increased 'growing seasons' or beach seasons will occur, enticing people to use coastal areas, especially sand beaches more frequently throughout the year, the number of beach postings by health units due to compromised nearshore water quality will be a threat to the economies of coastal communities (Kemkes & Salmon-Tumas, 2019, p.78). Heavy precipitation events bringing more runoff from inland sources, and increased water temperatures are predicted to increase algae blooms on the Great Lakes, which is already being seen on Lake Erie and Lake Ontario (Kemkes & Salmon-Tumas, 2019, p.78; Sutherland, 2019). More information on how climate change will affect coastal ecosystems is provided in Chapter 5 of this report.

4.3.4 Point and non-point source pollution:

Water quality was identified as the most important concern in LHCCC's 2017 CAP Online Questionnaire and the issue permeates every ecosystem on Lake Huron's coast. Lake Huron's water quality has a diversity of stressors with inputs coming from inland landscapes, within the ecosystem itself, and from the atmosphere. Stormwater runoff entering the lake from small creeks, rivers and drains from dense agricultural sectors (Huron and Lambton Counties) is known through long-term studies done by CA's to have impacts on the nutrient loading and sedimentation of the nearshore waters and quality of water adjacent to beaches. Private shoreline properties can impact the quality of sand beaches as there can be inputs from household septic tanks; and shoreline hardening can result in poor water. Pollutants in the nearshore zone, whether human-made or natural, end up washing onto sand beaches and dunes, and unless regularly tidied, accumulate there and may even get buried in building sand dunes.

Algae, *E-coli*, and botulism are other major concerns for human and ecosystem health on Lake Huron's sand beaches. The aesthetics of algae presence along beaches has become such an issue that some municipalities have enacted bylaws and mechanical beach raking schedules throughout the year to remove the nuisance algae often reducing water quality. The Township of Huron-Kinloss has an Algae Clean-up Policy (Bylaw 2008-59) that states:

"Algae clean up shall be carried out within the Township of Huron-Kinloss on a limited basis in order to minimize the impact that such activity may have on the local ecology… The algae harvester may only be activated starting first week of May and terminate use Saturday of Thanksgiving weekend... Algae clean-ups are scheduled for two 7.5-hour days to complete a lakeshore clean-up either the first or second week of May. All subsequent clean-ups are scheduled once per week with rotating four- or five-hour schedule clean-ups until the third week of June. Beginning the last week of June, Algae clean-ups are scheduled bi-weekly either Mondays and Thursdays or Tuesdays and Fridays until Labour Day. After Labour Day, Algae clean-ups are scheduled every two weeks until Thanksgiving Weekend… If the wash-up is less than 15cm wide, 2.25cm deep and 250m long, no action will be taken… The harvester must be used within 4.9m of the waterline… Harvester operating procedure depth shall be no greater than 5cm to ensure minimal disruption or damage to the beach ecosystem… The dune safety zone set back shall be a minimum of 10 metres if possible" (Huron-Kinloss, 2014).

The detail to which this policy goes to specify why and how often algae control will occur, regardless of whether algae is present, is exclusive along the shoreline; Not every municipality has a policy and therefore most deal with algae on an ad-hoc basis.

Since 2013, Huron County's beach water quality has been deteriorating at Black's Point, Goderich Main, Goderich St. Christopher's, Goderich Rotary Cove and St. Joseph's Beach (Huron County Health Report, 2015; ECCC & USEPA, 2018, p.21; Figure 13). Regular monitoring of the water quality of beaches and key recreation nodes along the southeastern shores is undertaken by local Health Units that publish the results of the studies publicly to inform visitors of safe or unsafe swimming conditions. The Environment, Law and Policy Centre found that, "a single beach closure due to a pathogen like Escherichia coli (*E.coli*) reduces recreational value by around $2 per trip, or around 10%". The more beaches are 'posted' with a high bacteria count, the less trust visitors have in visiting and enjoying the area, and therefore tourists may choose a different location to visit – which in turn affects the area's long-term economic stability. Public health and safety and local economic impact of tourism are only two of many reasons why water quality concerns are extremely important to monitor in sand beach and dune ecosystems. Understanding how water quality affects social, economical, and ecological values of an area is extremely important to the quantification of its impact on the area.

Figure 15 - Huron County Health Unit Facebook post (2019)

Plastic pollution is an issue affecting all of Lake Huron's coastal environments. However, due to high visitation to these areas, plastic pollution is often increased in sand beach areas. Plastic pollution enters beach areas from littering on shore, blowing onto the beach from nearby communities, and washing up on the beach from the nearshore zone. "The presence of plastic on beaches changes the physical properties of the beach. This leads to the alteration of water movement and heat transfer, thus the disturbance of habitat. The smooth surfaces of small plastic fragments can decrease the friction between sand grains. This may contribute to increasing the permeability of the beach sand" (Froklage et al., 2013). Plastic pollution leads to entanglement of wildlife, consumption of plastic waste by animals, and potential human safety risks. More information on the threats of plastic pollution to coastal environments can be found in Chapter 5.

4.3.5 Incompatible recreation and maintenance:

Every sand beach on the southeastern shores of Lake Huron experiences recreation influxes during the summer months. In most cases, this tourism boost contributes to local economies. In recent studies "researchers estimate that Lake Erie beach trips were worth $15-$25 per trip. [Others] estimate that beach recreation in the lower peninsula of Michigan was worth $32-$39 per trip for day trips, and around $50 per day for multiple day trips," (ELPC, 2019). Therefore, balancing the demand for tourism to sand beach areas and preserving coastal ecosystems for their basic ecological functions is important to mediate impacts and stressors of over-use.

Over the decades, there have been many improvements to the way public beach areas are used. Clearly communicating the impacts parking on beaches had on beach ecology and dune presence has made the practice rare (Figure 14); however, there are still many more impacts from current recreation and maintenance methods yet to be rectified.

Figure 16 - Ipperwash Beach (London Free Press, 1968)

Other forms of recreation, including all terrain vehicle (ATV) usage on dunes can expedite a myriad of threats to beach environments. Vehicles passing over a dune can quickly damage dune plants, causing wind erosion, elevated risk for introduction of invasive species, reduction of storm protection capacity, and removal of habitat for fauna.

INDICATORS AND THRESHOLDS

Coastal buffer zones are a simple, effective way of reducing impacts to sand beaches and dunes (Stewart et al., 2003). Although different in geographic location, the Department of Fisheries and Oceans Canada has developed minimum buffer widths for development and natural buffers for beaches and dunes on Prince Edward Island. These buffer zones can be acknowledged, and compared when applying setback distances to sand beaches and dunes on Lake Huron's southeastern shores (Table 5).

Table 6 - Coastal buffer zones for beach and dune environments (Adapted from Stewart et al., 2003)		
Ecological Feature	**Minimum Buffer Width**	**Development Setback**
Natural Buffer Zone		
Beach	18.3m from top of bank adjacent to beach	
Primary or Secondary Sand Dune	18.3m from inland boundary of dune	
Setbacks for Buildings and Structures		
Beach		22.9m from the nearest exterior portion of a building or structure to the top of the bank.
Primary or Secondary Sand Dune		30m from the nearest exterior portion of a building or structure to the inland boundary of the dune.

Monitoring prevalence of threats is important and typically done using indicators, shoreline regulations and approvals. Scientific literature and coastal best management practices have helped determine indicators and thresholds for Lake Huron's sand beaches and dunes. Next steps include determining impacts of threats and health of the beach and dunes by identifying vulnerabilities using the indicators. One such method, the Dune Vulnerability Index (DVI) determines vulnerability using the dune's ability to return to its original dynamic state after system displacement (Williams et al., 2001). "The index classifies dunes in terms of response to various natural and human induced environmental changes that occur, and identifies the main source of vulnerability" (Williams et al., 2001). Thresholds derived as a list of indicators adapted from Williams et al., 2001, are listed in Table 5. Unfortunately, indicators in relevant literature don't pronounce gradients that would specify stable, minor, moderate, and severe conditions. Therefore, more work is needed to formulate gradients for quantitative analysis and monitoring.

Table 7 - Dune Vulnerability Index (DVI), Sand beach and dune ecosystem indicators adapted from Williams et al., 2001	
Dune Erosion	% foredunes cliffed by storm waves
	dune cliff as % of dune height
	recent over washes
	% active breaches in lakeward face
	% active blowouts
	sand blown inland from system
New Dunes (sand input)	% recent or embryo dunes along lakeward edge
	% breaches with new dunes
	% over washes with new dunes
	% blowouts with new dunes
Vegetation	% vegetation cover
	% damaged plants
Degradation	Path network density
	path incision
	on-dune driving degradation
	camping degradation
	housing degradation

	sand extraction/mechanical removal
	degradation by activities related to sporting installations (e.g. golf courses, volleyball courts
Dune Management and Conservation	Information boards
	Managed paths
	% area with restricted access
	Controlled camping / housing
	Controlled sand extraction
	Sand traps
	Planting on mobile area
	Sand nourishment (beach and/or dune)
	Protection works
Obstacles to sand transgression	% brushwood
	% forest
	% agricultural areas
	% urban dispersed areas
	% concentrated urban areas
	Camping and roads
Tourist Attraction	Level of tourist accommodation
	Road access and parking
	Leisure sites
	Level of development lakeside recreational activities

The DVI (Table 5) is the most comprehensive method of on-site beach health analysis and can be employed by shoreline managers, private landowners, and interest groups to begin measuring changes, either positive or negative, in this habitat. To generally and more broadly characterise biophysical vulnerability components of coastal dune systems, variables enunciating signs of degradation or regeneration of the system, as well as the type and necessity of managed response, have been described by the Lake Huron Centre for Coastal Conservation.

Table 8 - Dune Vulnerabilities Checklist (LHCCC, 2015)	
Site and dune morphology	Erosion caused by wind, waves or human influence and the evidence of sand blown inland from the system are indicators of the dune system's erosive condition. Dune erosion: % foredunes cliffed by storm waves, dune cliff as % of dune height, recent over washes, % active breaches in lakeward face, % active blowouts, sand blown inland from system. New dunes (sand input): % recent or embryo dunes along lakeward edge, % breaches with new dunes, % over washes with new dunes, % blowouts with new dunes.
Beach condition	The presence (or absence) of recent or embryonic dunes are indicators of a positive (or negative) dune sediment budget.
Pressure of use	Signs left by several types of use are indicators of anthropogenic dune degradation. Path network density, path incision, on-dune driving degradation, camping degradation, housing degradation, sand extraction/mechanical removal, degradation by activities related to sporting installations (e.g. golf courses, volleyball courts). Managed paths: % area with restricted access.

Vegetation resiliency	Dune vegetation cover and damage state are indicators of sand retention efficiency. Sand retention by vegetation cover: % damaged plants. Obstacles to sand transgression: % brushwood, % forest, % agricultural areas, % urban dispersed areas, % concentrated urban areas, camping, roads
Protection measures	Measures that could be implemented to manage coastal dune systems are indicators of dune management efficiency and conservation. Dune management and conservation Information boards. Controlled camping, controlled housing, controlled sand extraction, sand traps, planting on mobile areas, sand nourishment (beach and/or dune), protection works. Tourist attraction: Level of tourist accommodation, road access and parking, leisure sites, level of development of lakeside recreational activities.

This checklist is the broadest version of sand beach and dune health and resiliency monitoring, compared to the intricate details of the DVI methodology. LHCCC's checklist is accompanied by a list of indicators to include in monitoring efforts. Considering sensitivity (degree of transformation) and resilience capacity of a dune system as determinants of biophysical vulnerability, LHCCC has rated each variable and evaluated based on three vulnerability levels:

1. LOW sensitivity: resilience threshold not exceeded
2. VARIABLE sensitivity: at the resilience threshold
3. HIGH sensitivity: resilience threshold exceeded, considering the system's level of degradation and the desirable level of conservation (e.g. restricting anthropogenic utilisation and implement general or specific management measures).

Using the DVI and LHCCC's Dune Vulnerability Checklist to create a 'user friendly' standardized methodology to monitor dune and sand beach ecosystems within the coastal corridor in the southeastern shores would enable standardized management of this ecosystem. A standardized approach of monitoring would provide more opportunity to identify areas that need positive conservation, rehabilitation, or restoration measures.

Table 9 – Beach and dune ecosystem indicators identified for the southeastern shoreline of Lake Huron.

BEACH and DUNE INDICATORS IDENTIFIED	THREATS AND STRESSORS
% Hardened shoreline	– Development (e.g. groynes, sea walls, decks, armour-stone). – Beach and dune erosion (wind, wave, human alteration= sand loss).
Dune presence and vegetation	– Vegetation and/or dune removal apparent. – Dune degradation (e.g. pathway fragmentation),
# of invasive species	– Presence and abundance (e.g. *Phragmites australis*, Sweet white clover etc.)
Beach grooming, sand extraction, mechanical removal	– Sand loss – Removal of detritus – Soil compaction from heavy machinery – Recreational activity (e.g. tourism pressure, ATV)
Excess nutrient inputs	– Beach postings, algae presence

Sand beaches and dunes occur mainly AU's 1-4 and 6. Therefore, there it is mostly organizations in these regions that have specified mandates and management plans regarding sand beaches and dunes.

REGULATORY TOOLS:

Municipal Official Plans:

Lambton County (LC) includes in its 2017 Official Plan that primary use of sand beaches is for leisure and recreation, and use should be generally promoted and retained on publicly accessible lands. However, LC refers to the importance of proper beach management, without specifying management. In other cases, LC's beach and dune management is defined as beach grooming for the enjoyment of tourists or the careful protection of dune ecosystems for beach health benefits, flood prevention, and species habitat. LC's Official Plan states that shoreline management plans will be created by CA's to "safeguard the natural dune ecosystem, tourism potential, adjacent land-uses, and related public safety" (Lambton County, 2019, 8-13). Huron and Bruce Counties have similar, general terminology regarding sand beach and dune management. Clarification and specificity are required in Conservation Authority shoreline management plans, from which beach and dune best management practices can be derived. Refer to the Conservation Authority Regulations section for more information.

Municipal Bylaws:

The three counties and fourteen municipalities on the southeastern shores have various bylaws and regulations in effect to manage change and development on sand beaches and dunes, mainly in public beach areas and some on private property. In LC, the 2009 Beach Bylaw intends to preserve beach integrity by fining visitors who litter on beaches, use motor vehicles, remove sand, erect temporary structures, or deface or damage structures on the beach (MLS, 2009). Other municipalities along the shoreline, such as the Township of Huron-Kinloss have bylaws regulating activities on sand beaches and dunes including beach fires (Open Air Burning Bylaw), tree cutting bylaws, Beach Management Agreements, Algae Clean-up Policy Amendments, Motorized Vehicle Use on Beach, and others. The Municipality of Bluewater has a Usage of Beach, Marina and Water Area Bylaw (no. 89-2008) specifying that "Bayfield Main Beach and Bluewater Marina be maintained and controlled for the enjoyment and benefit of the citizens of and visitors to the Municipality of Bluewater" (Municipality of Bluewater, 2008). This single bylaw tackles prohibition of removal of vegetation, vehicles on beach, open fires, and animal clean up. Differences in presence and scope of bylaws exist depending on the Municipality or County, and it is currently landowner's responsibility to be aware of and adhere to these bylaws.

Hectares of Habitat per Assessment Unit		
AU	Sand Beach	Dune
1	58.30	0
2	182.18	340.68
3	103.34	0
4	78.11	0
5	12.36	9.89
6	99.48	0.68
7	140.44	0
8	1.09	0
9	0	0
10	1.32	0
11	0	0

CA Regulations and Management Plans:

The Province of Ontario, including the Ministry of Municipal Affairs and Housing define dynamic beach areas as areas with inherently unstable accumulations of shoreline sediments along the Great Lakes-St. Lawrence River and includes flooding hazard limits and dynamic beach allowance. CA's describe sand beach and dune environments as "dynamic beach areas", recognized as hazard areas. In some shoreline management plans, responsibly managing the shoreline means, "focusing first and foremost on adhering to legislated mandates to protect human life and property from the adverse effects of natural shoreline hazards" (Davidson-Arnott & Mulligan, 2016, p.8). This means, “no new hazards are created; existing hazards are not aggravated; and no adverse environmental impacts will result” (Davidson-Arnott & Mulligan, 2016, p.8). As per the *O.Reg.147/06: Ausable Bayfield Conservation Authority: Regulation Of Development, Interference With Wetlands And Alterations To Shorelines And Watercourses*, “no person shall undertake development or permit another person to undertake development… where a dynamic beach is associated with the waterfront lands, an allowance of 30-metres inland to accommodate dynamic beach movement” (Ontario, 2013). Although some CA’s regulate actions to and on dynamic beaches, not all beaches on the southeastern shores are considered ‘dynamic’. Therefore, there are gaps within the regulation and the awareness of landowners on privately owned shoreline areas. Clearly deciphering differences in beaches, or ‘blanket’ regulating all beach areas in regulatory management documents will provide more continuity in long-term management of this ecosystem despite changing staff and political interests.

STEWARDSHIP TOOLS:

Since 1998, LHCCC has created literature and guides to inform and educate landowners and partners on proper management and stewardship practices of sand beaches and dunes on the Lake Huron shoreline. Some fact sheets pertinent to this endeavour include “Damaging Wheels”; “True Grit”; “Learning about Beach and Dune Ecosystems”; “Beach and Dune Stabilization with Sand Fencing and Vegetation”; “Stewardship of Lake Huron’s Beaches and Dunes”.

Beach Stewardship Plans:

Typically prepared for municipalities and CAs, beach stewardship plans (BSP) provide science-based recommendations for addressing current and emerging issues related to Lake Huron’s coast. The goal of BSP’s is to enhance and restore coastal processes, biodiversity, water quality and build resiliency towards climate change. The hope is to adopt practices that minimize anthropogenic impacts on coastal ecosystems. For example, the Township of Huron-Kinloss has a Beach Management Agreement between the Township and the Ministry of Natural Resources and Forestry. Responsibilities under beach management agreements place responsibility on the Township to;

- Install interpretive signage: educating beach-goers on existing bylaws and sensitivities of beach environments
- Monitor beaches: enforce and maintain beaches against development and land-use changes
- Invasive species: control invasive species including Phragmites, Giant Hogweed and Wild Parsnip.
- Restoration: Dune restoration projects to improve health of beach areas (Huron-Kinloss, 2015).

Educational initiatives using interpretive signs (Figure 17), posters, radio ads and beach signs, to improve awareness of coastal processes associated with beach and dune environments, and encourage fewer negative impacts through stewardship and landowner accountability.

Figure 17 - Dune ecosystem signage from LHCCC

Other programs such as the Environmental Defence: Blue Flag Conservation Program is an incentive tool used to attract visitors to beach areas while implementing standardized techniques to improve water quality. (Grand Bend-certified, Bayfield-certified, Inverhuron applying, Sarnia-potentially revoked).

RECOMMENDATIONS

1. Standardized Beach and Dune Monitoring Protocol

Thorough analysis of different scales of beach management indicators, thresholds, and monitoring techniques suggest a standardized beach monitoring protocol should be developed to provide consistency of monitoring and management across the southeastern shores of Lake Huron. A system like the *Ecological Land Classification Guide for Southwestern Ontario* could be derived to better establish common thresholds and indicators for consistency in management and terminology. An example of established indicators and thresholds for monitoring across multiple jurisdictional boundaries is the Conservation Authority Watershed Report Cards published every 5-years with standardized descriptors and ratings for the health of ecosystems. No established, widely accepted methods are currently used to monitor and determine health of beach and dune ecosystems within the coastal corridor.

2. Continuity of Municipal Bylaws

A review of shoreline municipality bylaws relating to beach use and management shows a lack of standardization and scope of regulation. Variety in the scope and enforcement of prohibitions outlined in bylaws can cause confusion among shoreline residents who reside in different municipalities and aren't aware of the specificities within their municipality. Recommended actions include a review of bylaws among adjacent municipalities to incorporate sand beach and dune best management practices and consistent regulation of activities on private land and public access points alike.

3. Increased Public Education

Public education focusing on coastal ecosystem fragility will encourage actions towards improving resiliency and sustainability of land-use practices in the coastal corridor. Many agencies currently contribute to public education in this area through programs like Eco Mentors, public presentations, and speaker series events, and these efforts need to continue to ensure a coastline of informed, educated lakeshore residents and visitors who care about and will protect sand beach and dune ecosystems. Providing multi-pronged approaches to education, including social media posts, educational videos, partnerships with tourism organizations, CA's, and private communities to do in-person and digital presentations will keep coastal communities informed about best management practices, current conditions, and resiliency measures.

4.4 BLUFFS

DEFINITION:

A steep vertical exposure comprised of clay, sand, shale, bedrock, limestone, or any combination of these. These areas are prone to erosion due to their direct interaction with changing lake levels (LHCCC, 2013).

ECOSYSTEM DESCRIPTION

On Lake Huron, bluffs can be erodible, sandy cliffs, or non-erodible limestone dolomite, or bedrock cliffs. Most of the bluffs on the southeastern shores exist in the Southern stretch of shoreline between Grand Bend and Amberley Ontario. The bluffs along the southeastern shores mainly consist of St. Joseph till composed of 86% silt and clay, with the remaining 14% consisting of sand, gravel, and cobbles (Davidson-Arnott & Mulligan, 2016, p. 35). This sediment deposit, referred to as the Algonquin Bluff, "provides a distinct boundary between the Huron Slope and the Huron Fringe regions, due to a 10-30m near vertical drop. Streams, have cut deep gullies in the area reaching the outlet" (HLH, 2012). In the southern third of the coastal corridor, where most of the bluffs exist, have bluffs, up to 18-metres tall lying parallel to the shoreline, fronted by a narrow reach of beach at the toe of the slope (Davidson-Arnott & Mulligan, 2016, p.35). These erodible bluffs are one of the more volatile environments on the shoreline of Lake Huron. Along the southeastern shores, bluffs cover 368.87 hectares in the coastal corridor study area (85,837.83 hectares total). This equates to bluffs making up less than 1% of the total study area. Although small, these areas are extremely vulnerable and at risk to human destruction and natural alteration.

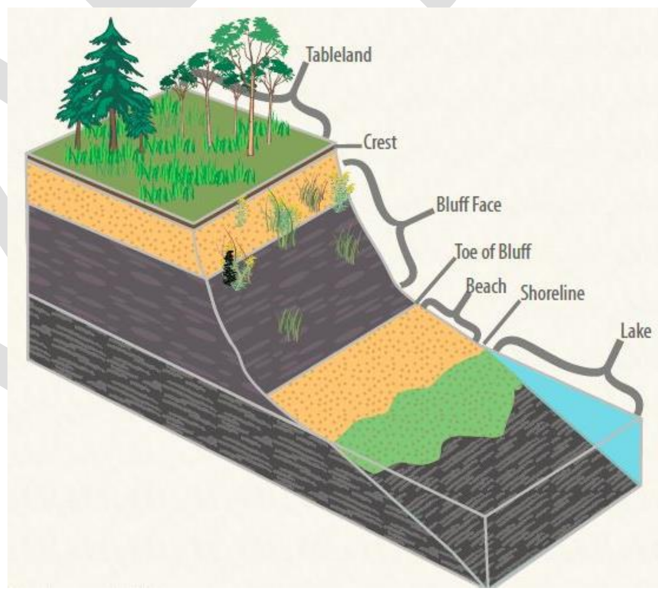


Figure 18 - Bluff ecosystem components (Cross, Campbell & Martz, 2007)

Coastal bluffs and cliffs offer spectacular waterfront views, and are highly visible from the water. The scenic beauty of this area attracts recreational boaters and cruise ships, contributing to local economies. Where properties are developed in these areas, land values are high because of the scenic views and waterfront location Hubbard et al., n.d., p.3). From a biodiversity and habitat perspective, bluffs and gullies are important to coastal habitats mostly for their ability to erode. Vertical cliffs comprised of erodible glacial till provide habitat for a menagerie of species, as well as supplying eroded sediment to adjacent beaches down-drift. The erosion of sediment from bluffs and gullies 'feed' beaches down-drift and provide sand and nutrients to beaches along the coast. Erosion of bluffs supply nearshore waters and beaches further south in deposition zones. In a recent estimation, ~72% of the sediment feeding beaches within the area comes from gully erosion (Baird, 2019).

Figure 19 - Sediment bluffs on Lake Huron

Without this input of sediment, many of the beaches on Lake Huron would be sediment starved if fresh sediment was not added every year from the eroding bluffs to the north. Ecosystem services provided by bluffs include habitat, carbon sequestration, and water-retention properties not provided by human-made structures.

Figure 20 - Development on Lake Huron bluff

Although erodible bluffs are volatile and ever-changing, natural stabilization methods including vegetated buffers, reduction of water-flow across the landscape, and proper development set backs are the easiest and most cost-efficient methods to preserving slope stability of gullies and bluffs (MVCA, 2013a). Natural stabilization methods are attractive for landowners with buildings within the highly erodible zone of shoreline, as delineated by CA's.

THREATS AND STRESSORS

Bluffs are highly unpredictable ecosystems, overlapping and bordering different habitat types. Direct threats to bluffs can be natural (e.g. invasive species, expedited erosion) but are more typically affected by anthropogenic influences. Development and site alteration, climate change, and erosion are the three most influential stressors and threats on bluff ecosystems within the southeastern shore coastal corridor.

4.4.1 Development and site alteration:

Three forms of development and site alterations include; (1) building structures including homes, septic systems and municipal infrastructure like roads; (2) removing vegetation, planting non-native, shallow rooting vegetation; (3) building shoreline hardening structures to protect the stability of the slope or the toe of the slope.

Most bluffs in the coastal corridor have been developed by seasonal and year-round communities, and infrastructure built from recently to 60+ years ago. Developing close to the top of the slope and even within higher risk bluff erosion zones can cause mass wasting events due to added weight close to the edge sitting on unstable sediment layers. Shear stress failures due to weight at top of slopes occurs on steeper bluffs than on bluffs with gradual slopes. Removal of vegetation on and around the bluff, including trees, shrubs, grasses and downfall to 'improve' views has increased potential for erosion and slumping. Although vegetation supports sediment retention on healthy bluff slopes in the 3-1 slope (run over rise), vegetation, no matter how healthy, is not likely to have any effect on preventing sheer stress failure. Reducing weight loading on the top of bluff slopes by restricting future development or reducing current loads by removing structures will help reduce potential for slope failure. As the U.S. Army Corps of Engineers state in their 2003 report, safe setback distances for bluffs and gullies need to consider:

- *"The expected recession distance of the slope edge of the life of the building;*
- *The height of the bank or bluff;*
- *Stability of the slope;*
- *The amount of room necessary to relocate the building if necessary" (p.16)*

Landowners with buildings close to the top of the bluff are in areas of high risk due to the volatile nature of bluff structure. In Huron County alone, there are ~1150 residences in the 15-metre at-risk area for damage to structures due to bluff failure (Allan, Callewaert & Olsen, 2018, p.37; Davidson-Arnott & Mulligan, 2016). When bluff heads are developed with structures like cottages, roads, and infrastructure, there is often a reduction of permeable surfaces into which precipitation, snow melt, and runoff can seep. Reduction in permeability causes water to run across the landscape, pouring over the bluff initiating surface erosion. Contrarily, if actions are taken to increase groundwater recharge or permeability where there naturally would not be any (e.g. septic tanks and weeping beds), this can cause bluff seeps, undermining the stability of the bluff, causing bluff failure. Groundwater management and limiting the weight at the top of the bluff may decrease the risk of shear stress failure" (Cross et al., 2007, p.19). More information on bluff and gully regulation limits can be found in the regulations of coastal CA's.

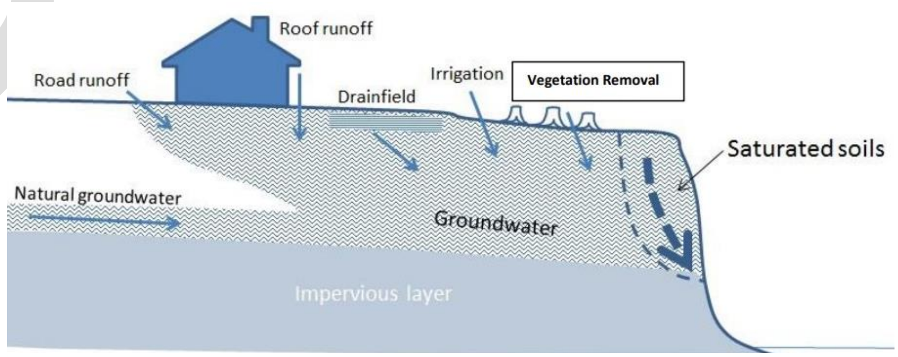


Figure 21 - Groundwater recharge along bluffs (Nichols & Brzozowski, 2014).

Increasing vegetation on slopes to up-take groundwater or water in seeps, as well as protect against surface erosion from precipitation and stabilizing the slope with deep roots all help keep the threat of ecosystem loss and slope failure at bay. It should be noted that a bluff barren of vegetation does not necessarily mean it is 'unhealthy'. It does mean that it faces more potential for erosion which could impact human safety. But, these types of bluffs are crucial for certain niche species. However, if a bluff is meant to be vegetated, but vegetation has been manually removed through cutting and mis-management, this will contribute to moderate or severe ecosystem health condition of that bluff. A few highly adapted, at risk animal species reside in eroding bluff faces, including bank swallows which burrow into the side of the cliff to make their nests (DFO, 1996a). Preserving vegetation on bluff environments for these types of species is extremely important for the preservation of critical nesting, feeding, and breeding habitat. Understanding that niche species, such as cliff swallows, use non-vegetated slopes is important from an ecological management and development perspective and need to be managed accordingly. Recognizing the presence of invasive species on bluffs is important in efficiently managing these areas. Removing invasive species and noxious weeds, as well as being conscious of the avenues of spread of these species when restoring bluff environments is extremely important in maintaining ecological integrity. Removing these species and immediately replacing them with native species reduced potential for surface erosion and maintains sediment stability with roots. Regular monitoring of invasive species in shoreline maintenance will alert their presence earlier reducing the spread and density of patches of these species.

Threats of high lake levels and bluff erosion ignite the human condition to 'harden' the shoreline to protect investments from change. Human-made structures such as sheet pile walls, gabion baskets, or concrete sills have most commonly been used in the past 60 years to 'protect' shorelines, and toes of bluffs from these threats, but are not ideal, as they are often extremely expensive and require consistent maintenance. Human-made structures tend to increase sedimentation, water runoff and are less visually appealing along the shoreline. These structures have a short lifespan, especially in high-energy areas, and should be avoided (USACE, 2003). The excavation required to implement 'effective' human-made structures cause more unnecessary compromise to slope stability than implementing natural protection measures.

4.4.2 Climate change:

Climate change impacts bluffs along the southeastern shores of Lake Huron in two major ways: (1) increased precipitation, storms, and weather events; (2) sporadic and intense lake level changes. An increase in the average number and intensity of storms in the winter months due to climate changes will have direct impacts on erosion of cohesive bluff shorelines and lead to increases in bluff recession rates on all Great Lakes. Because lake levels are generally lower in the winter months, there may be limited increases in short-term bluff toe erosion, but erosion of the nearshore profile (under water) will be enhanced. In turn, this leads to an increase in long-term recession rates (ELPC, 2019). "Underwater erosion of the lakebed controls the rate at which recession of adjacent cohesive shoreline slopes takes place, allowing waves to reach the toe of the bluff increasing rates of recession… Measurements have shown rates of vertical erosion in the range of one-half to six inches (1 to 15 centimetres) per year in glacial till. More typical erosion rates are one to two inches (three to five centimetres) per year" (USACE, 2003, p.10). If increases of storm intensity and frequency occur, partnered with changes in lake levels, toe erosion rates would increase, leading to more frequent, or more serious slumping events (Figure 20).

Lake level fluctuations are nothing new on Lake Huron. With highs occurring every 10-15 years (Figure 21), the coast, especially erodible shoreline ecosystems like bluffs, are restructured during these times. Beaches at the toe of the slope protect bluffs by absorbing wave energy, preventing erosion caused by wave action (Huron County, 2015, p.16). Bluffs and coastal areas with, “low recession rates are usually associated with beaches which offer some protection against erosion of the bluff toe and reduced rates of nearshore erosion” (Baird, 2019, p.15). When lake levels rise, this beach is often inundated with water, therefore exposing the toe of the bluff to wave energy. Throughout a review on relevant literature a consensus on changing lake level trends:

“There is now an understanding of the effects of seasonal and long-term lake level fluctuations on the dynamics of cohesive bluff shorelines. Based on this, a decrease in mean lake level will result in reduced bluff recession rates for a period of several decades and dune progradation of sandy shores. Conversely, an increase in the mean lake level will result in an increase in the rate of bluff recession for several decades and landward migration of the shoreline and foredune on sandy beaches.” (ELPC, 2019).

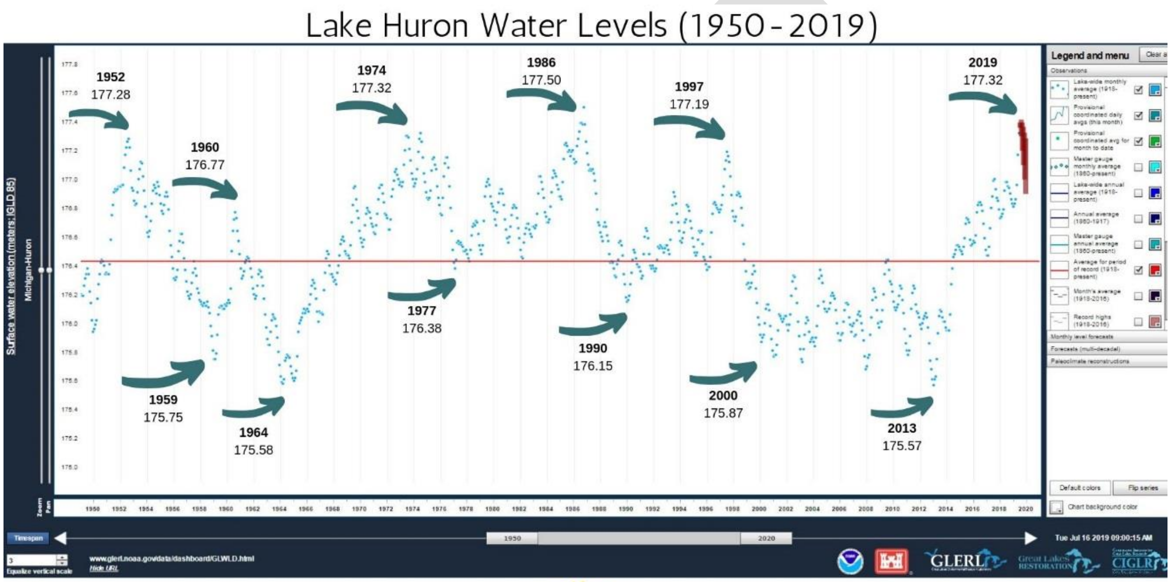


Figure 22 - Lake Levels on Lake Huron 1950-2019

Lake levels will continue to fluctuate into the future, regardless of climate change or anthropogenic influences. Therefore, understanding that toe erosion from wave energy is unavoidable, is necessary when forming bluff management best management practices and development restrictions.

4.4.3 Erosion:

The most rampant natural process affecting bluffs is erosion. Bluff erosion rate is influenced by geology, waves and weather but can be amplified through the influence of human activity and land-use change. The biggest challenge faced by lakeshore-residents is understanding that bluffs naturally erode and development needs to be tempered based on location, land-use type, and stabilization methods (MVCA, 2013a). Vegetated and non-vegetated bluffs exist on the shores of Lake Huron and differ in erosion rate and risk to landowners. It is for this reason that bluffs along Lake Huron are known for their unpredictability. The bluff’s slope face and the top of the bluff can erode in small quantities over many years, or quickly in one mass-wasting failure event (Allan, Callewaert & Olsen, 2018, p.23). Figure 22 illustrates the causes and effects of coastal erosion on the southeastern shores.

In this illustration, issues facing many of Lake Huron's bluffs, including bluff toe erosion, lakebed erosion, bluff slumping and surface water runoff are pictured. Naturally occurring bluff erosion is caused by seasonal flooding and snowmelt events, heavy rains eroding sediment, and a lack of vegetation protecting the slopes, sometimes expedited by erosion and reduction of root-hold. "The effects of rainfall are reduced by the presence of a continuous vegetation cover which shelters the soil from raindrop impact and helps to slow the flow of water down the slope" (Davidson-Arnott & Mulligan, 2016, p. 38). Different areas of the shoreline have different rates of recession. These rates are influenced by the type of sediment, littoral drift, and wave energy. Bluff erosion can range from zero to more than half a metre per year (MVCA, 2013a). Figures 23 shows the annual average bluff recession rates in the Ausable Bayfield Watershed. The highest recession rates are estimated at 0.98m/year whereas the lowest erosion rates are 0m/year (Davidson-Arnott & Mulligan, 2016, p.53-54). In the ABCA shoreline alone, they estimate that:

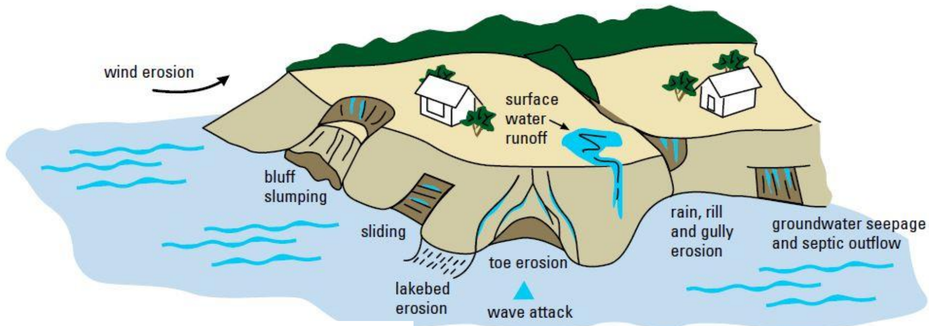


Figure 23 - Bluff erosion types (USACE, 2003)

- 13% of their shoreline is stable (0m/yr.)
- 67% of their shoreline is low average recession (0.1-0.3m/yr.);
- 13% of the shoreline is moderately receding (0.31-0.7m/year);
- 6.5% of the shoreline has high annual erosion (0.71-1.2m/year);
- 0% of the shoreline has very high erosion rates as per the MNRF rates of recession criteria (Baird, 2019, p.14).

Most of Lake Huron's bluffs have low annual erosion rates, but threats and stressors can cause failure events to cause 1.5m to 15.25m losses from the top-of-bluff (Allan, Callewaert & Olsen, 2018). CA's have done decades of study to determine low risk areas along the top of bluffs to protect public safety and coastal development investments. An example of bluff recession rate studies completed on Lake Huron is shown in Figure 23.

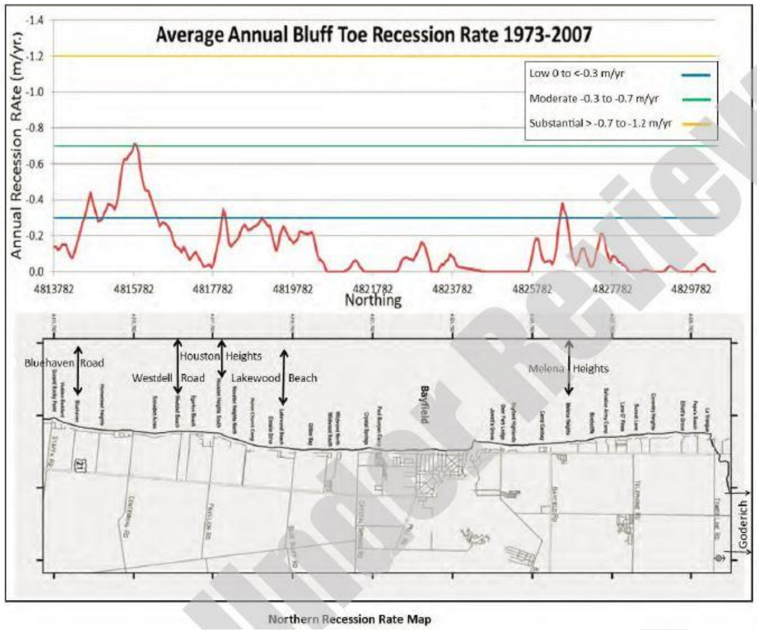


Figure 24 - Bluff recession rates (Baird, 2019)

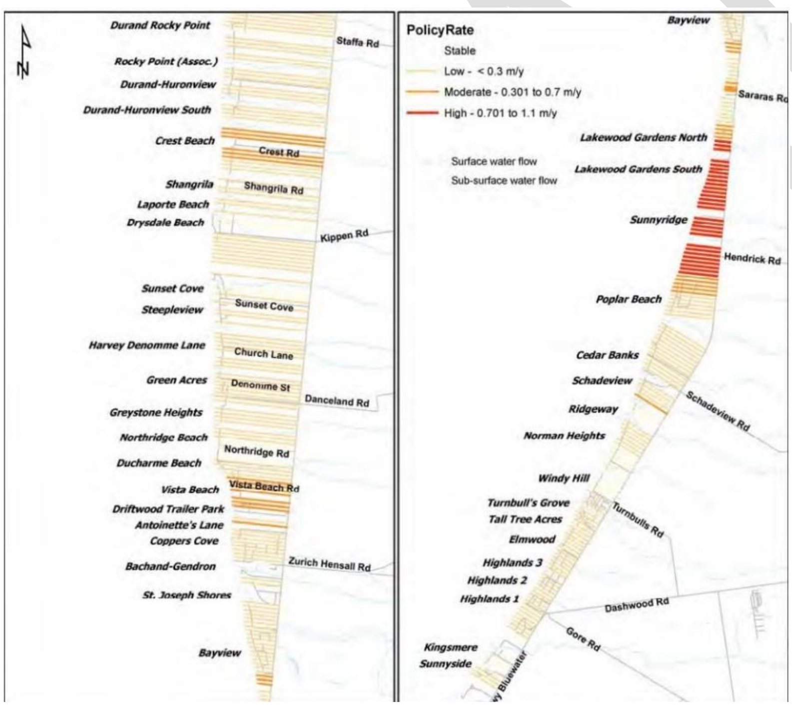


Figure 25 - Bluff recession rates (Baird, 2019)

Reiterating these maps and zones of recession to landowners from a semi-annual to bi-annual basis to account for landowner turnover, as well as updating for slumping events will assist in educating lakeshore owners of habitat types in which they choose to reside. Creating a culture of environmentally aware and educated citizens is imperative in protecting volatile ecosystems like bluffs, as well as protecting the ecological integrity of these areas and public safety of those living adjacent to bluffs.

INDICATORS AND THRESHOLDS

Indicators and thresholds for bluff stability and public safety setbacks have mostly been set by CA's that prioritize human safety and risk factors. An immense body of work and decades of research have contributed to the formation of development regulations and management of bluff ecosystems across the shoreline (SCRCA, ABCA, MVCA). The ecological health and state of bluffs on Lake Huron will need to be assessed over time and on a case-by-case basis to determine what is 'right' for that specific area.

Two avenues of bluff indicators focus on: (1) slope stability for human health and safety; (2) ecosystem integrity and health. As referenced previously, CA's have studied and regulated human interaction with slope stability on bluffs for human health and safety, reflected in planning regulations will be considered the proper monitoring techniques. Although suggested bluff hazard checklists exist, such as this one adapted from Bhurji, 2014 by LHCCC (Table 7), there are no established indicators and thresholds currently used along the southeastern shores to monitor ecological integrity and health of bluff environments.

Table 10 - Bluff hazard checklist (Adapted from Bhurji, 2014)

Indicator for Unstable Bluff	Presence (Y/N)	Notes
Prevalence of ground cracks		
Slumps or landslides		
Groundwater seepage and septic outflow		
Gullying		
Overland water flow		
Narrow beach (<20m)		
Bluff toe erosion		
Type of vegetation		
Indicator for a Stable Bluff	Presence (Y/N)	Notes
Gentle slope		
Well vegetated bluff		
Wide sediment ledge zone		
TOTAL		

Table 10 provides a checklist for bluff stability that could be used by lakeshore landowners and land managers alike, but lacks refinement and could be adapted with more specific management recommendations based on the outcome score. Table 11 provides an overview of bluff indicators identified by the CAP Steering Committee that best fit bluffs on the southeastern shores. These indicators were adapted from academic literature.

Table 11 - Bluff ecosystem indicators identified for the southeastern shoreline of Lake Huron.

BLUFF INDICATORS IDENTIFIED	THREATS AND STRESSORS
% of slope vegetated	– Vegetation loss on bluff faces. – Vegetation removal from humans. – Analysis of historical bluff vegetation levels where exposed sediment bluffs are typical.
# of invasive species	– Presence, distribution, population density, scope of work to remove. (e.g. *Phragmites australis*, Spotted Knapweed etc.)
% Hardened shoreline	– Development (e.g. groynes, sea walls, decks, armour-stone).
Undercutting of bluff	– Metres of barrier beach buffer zone at toe of slope.
Distance to development	– Encroachment into stable slope setback. – Recreational activities (e.g. ATV's)
Slumping frequency (erosion rate data)	– Expedition of erosion due to anthropogenic/ natural factors.

These indicators need more specificity into threshold quantification. More data collected across the shoreline using checklists such as the one outlined in Table 7 could establish a data set for baseline assessment, and resiliency recommendations as well as thresholds for ecosystem integrity.

CURRENT MANAGEMENT STRATEGIES

Many management strategies for bluffs derive from human health and safety precautions established by CA's. Regulations on coastal hazard lands were introduced by the Province of Ontario after the high-water levels of 1986 to protect human safety. CA's enforce regulations to appropriately manage development adjacent to volatile bluff ecosystems. However, risks posed and created by existing developed areas still exist.

Hectares of Habitat per Assessment Unit	
AU	Bluffs
1	29.91
2	172.20
3	166.75
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0

Coastal engineers define four management strategies for volatile environments like bluffs; "(1) adapt to natural coastal processes; (2) restore natural defences; (3) moderate effects of coastal processes; (4) armour the shore" (USACE, 2003, p.15). Adapting to natural coastal processes in this context is considered managed retreat, is a common term for reducing development encroachment on bluffs and gullies to reduce risks of future erosion, as well as physically moving structures at greatest risk farther back from hazard areas. Some CA's, including the ABCA Board of Directors, oppose the term and concept on managed retreat as not realistic within their jurisdictions to support shoreline landowners. Other shoreline management plans on Lake Huron and globally reference managed retreat as an option for protecting development and investments along the coast; although landowners on small coastal properties do not find this method popular. Restoring natural defences and moderating effects of coastal processes include tactics such as buffer zones, re-vegetating slopes, reducing surface water flow, and mediating groundwater seepage. Armouring the shore is, like on sand beaches and dunes, a last resort and not recommended by coastal engineers.

Few- if any management strategies regulate bluffs for preservation of bluffs as an essential environmental service feeding beaches, providing niche habitat for rare species, and acting as a core ecosystem influenced by development and human alteration. More management strategies should include the value of the ecological services bluffs provide into their regulation and management of bluff areas.

REGULATORY TOOLS:

Erodible bluffs within the coastal corridor strictly in Assessment Unit's 1-3, ranging from Sarnia to Amberley Ontario. Therefore, there are only two Counties and three CA's that manage these ecosystems through regulatory tools.

Municipal Official Plans and Bylaws:
In areas where bluff ecosystems exist, no relevant bylaws or regulation regarding development on bluff ecosystems was found within Huron County, Lambton County or Municipality online resources. In these plans, regulation of bluff ecosystems, and most shoreline ecosystems in general, including hardened structures and dynamic beaches are deferred to their respective CA's and Shoreline Management Plans they manage. This excerpt from the Lambton County Official Plan illustrates this point;

"8.5.3 Dynamic beaches, as evidenced by sand dunes and described in the shoreline management plans prepared by the Conservation Authorities, will be identified in local official plans and conserved to safeguard the natural dune ecosystem, tourism potential, adjacent land-uses, and related public safety. Development is not permitted within the limits of the dynamic beach hazard.

8.5.4 Local municipalities are encouraged to develop criteria in their respective local official plans that address the use, design, location, and repair of shoreline protection. These criteria will include factors related to the type, standards, and maintenance of protection, adjacent property impacts, environmental impacts, and consideration of access. Naturalization techniques as described in this Plan will be encouraged where feasible and appropriate."
(Lambton County, 2019).

Conservation Authority Regulations & Management Plans:
As part of their 2019 Shoreline Management Plan (SMP), Ausable Bayfield Conservation Authority, and Baird and Associates, developed shoreline development guidelines that complement planning regulations (Baird, 2019). In Appendix F, there are clear development guidelines for bluff areas regarding development, building, alterations, and methods for structure relocation (Baird, 2019). The SMP specifies the potential impacts stemming from installation of further property enhancements such as swimming pools, decks and septic systems adjacent to bluffs. Figure 25, gives examples of regulation surrounding shore protection:

Figure 26 - CA development guidelines for bluffs (Baird, 2019)

Development Guidelines – Shoreline Protection		
	Dynamic Beach Area	Bluff Areas
Shore Protection - new	Permitted to protect primary building. Must be landward of the location of the 100 year lake level plus 15m wave uprush allowance Protection works for non-essential structures and features, including but not limited to accessory structures (e.g., gazebos, sheds, bunkies, decks, stairs etc.), lawns and/or other landscaping features are not permitted. Application shall include mandatory review by qualified Coastal Engineer which shows that the proposed works will not aggravate natural hazards.	Permitted Must be landward of the greater of the following: 1.) the location of the 100 year lake level or 2.) a line connecting the toe of the bluff and /or existing shore protection of the two abutting properties on either side of the subject property or 3.) the toe of existing bluff Application shall include mandatory review by qualified Coastal Engineer which shows that the proposed works will not aggravate natural hazards.
Shore Protection - replacement or maintenance of existing	Permitted to protect primary building. Must be landward of the greater of the following: 1.) the location of the 100 year lake level plus 15m wave uprush allowance 2.) the existing shore protection being replaced Protection works for non-essential structures and features, including but not limited to accessory structures (e.g., gazebos, sheds, bunkies, decks, stairs etc.), lawns and/or other landscaping features are not permitted. All previous shore protection not used in the replacement (e.g. armour stone gabion stone etc.) must be removed from the site and disposed of. Review by qualified Coastal Engineer which shows that the proposed works will not aggravate natural hazards may be required.	Permitted Must be landward of the greater of the following: 1.) the existing shore protection being replaced 2.) the location of the 100 year lake level 3.) a line drawn between the toe of the bluff and /or existing shore protection of the two abutting properties on either side of the subject property 4.) the toe of the existing bluff All previous shore protection not used in the replacement (e.g. armour stone, gabion stone etc.) must be removed from the site and disposed of. Review by qualified Coastal Engineer which shows that the proposed works will not aggravate natural hazards may be required.
Groynes - new	Not permitted	Not permitted
Groynes -replacement or maintenance of existing	Permitted, but will be considered on a case by case basis.	Permitted, but will be considered on a case by case basis.

Regulatory tools such as this SMP, which provide clear decisive development guidelines for bluffs help landowners understand what they are safe doing on properties adjacent to Lake Huron bluffs. Continuity of plans, and descriptive guidelines are recommended for other CA jurisdictions across the southeastern coastal corridor of Lake Huron.

STEWARDSHIP TOOLS:

CA's such as the Ausable Bayfield Conservation Authority have put together fact sheets and recommended management practices to assist landowners in understanding management of bluff environments. Figure 26 illustrates this concept from ABCA's 2019 Shoreline Management Plan appendix products, this one titled, *Shoreline Slope Stability Risks and Hazards Fact Sheet* (Terraprobe, 2019).

Recommended Management Practices

DOs and DON'Ts along the Shoreline

Here are recommended management practices for properties located along the shoreline bluff:

Do:

- Any observation of severe slope instability should immediately be brought to the attention of the local municipality and conservation authority. A safety fence should be installed and maintained near the slope crest in the areas of slope failures, over-steepened and near vertical scarps to keep occupants/people away until the condition has been assessed by a qualified engineer.
- Property use should be conducted in a manner which does not result in surface erosion of the slope. In particular, site grading and drainage should prevent direct concentrated or channelized surface runoff from flowing directly over the slope. Water drainage from down-spouts, sumps, swimming pools, road drainage, and the like, should not be permitted to flow over the slope. Minor sheet flow may be acceptable. If water is collected at the slope crest, it should be safely discharged to the bottom of the slope by suitable piping.
- Consult with ABCA prior to removing vegetation on the slope.
- Maintain the lake bank in a natural state with native plants and vegetation.
- Maintain tiled or piped drainage systems in proper working condition to help prevent surface erosion and/or seeps on the lake bank.
- Monitor the condition of the bank regularly for signs of erosion and instability.
- Leave root systems intact in circumstances where tree removal is necessary.
- Undertake maintenance activities by hand where possible and avoid disruption of the lake bank with machinery or heavier equipment.
- All approvals and permits must be secured from ABCA prior to any site alteration.

Don't:

- In order to promote vegetation growth on the slope face, yard and other waste must not be discarded over the slope.
- The configuration of the slope should not be altered without prior consultation with a professional geotechnical engineer and approval from the local conservation authority.
- Do not remove trees unless removal is warranted and approved by authorities.
- On cohesive shores, the long-term stabilization of a bluff/slope with shoreline protection works, may not be practical due to erosion occurring underwater offshore. The ABCA, a professional geotechnical engineer, and a qualified professional coastal engineer should be consulted to determine the site-specific issues for the feasibility of any proposed coastal protection works.

Figure 27 - ABCA recommended management practices on bluffs

The Lake Huron Centre for Coastal Conservation (LHCCC) has created stewardship guides for coastal ecosystems along Lake Huron since 1998. They have developed Bluff Stewardship Guides, Bluff Native Plants Guides, coastal erosion fact sheets, and others. Although not a regulatory agency, these stewardship tools enable single landowners, to regional land managers alike to manage Lake Huron bluffs sustainably with resiliency at the forefront of the recommendations. These resources are available free of charge, digitally and in hardcopy to anyone who wants them. Disseminating this information and widely distributing the techniques and recommendations suggested in these resources will enable a coordinated effort in protecting the ecological integrity of bluffs within the southeastern coastal corridor. These stewardship tools could be updated every three years to keep them relevant and keep the material fresh for landowners who have lived along bluffs for years.

RECOMMENDATIONS

1. Consistency in Regulation, Policy, and Compliance

Continuity and consistency of shoreline management plans, as well as regulation and enforcement along the shoreline by CA's is important in landowner education and compliance. Using ABCA's 2019 Shoreline Management Plan and the related appendices as an example, further communication documents such as descriptive development guidelines are recommended for other CA jurisdictions across the southeastern coastal corridor of Lake Huron.

2. Standardized Bluff Management and Monitoring Guide

Using existing resources and stewardship tools created by LHCCC and partner agencies to create a public-friendly bluff monitoring checklist that landowners can use to monitor changes to their bluff. This checklist could be accompanied with an updated best management guide suggesting key ways landowners can protect their bluff and live symbiotically alongside this volatile shoreline habitat. A standardized BMP guide, like those created for dune management and restoration, would be beneficial to educating lakeshore landowners in the hazards, and opportunities for living along bluffs. A document like this will facilitate creating a coastal corridor of educated, aware, and environmentally resilient citizens prepared to deal with threats and stressors brought about by climate change, lake level fluctuations, and erosion.

4.5 GULLIES

DEFINITION:
An erosional feature cut into a bluff, typically "V- Shaped" when young, "U- Shaped" with age. These areas are formed through natural and anthropogenic influence and are typically caused by erosion of a water tributary feeding water, sediment, and debris perpendicularly into Lake Huron. (LHCCC, 2013; GBC, 2001, p.1).

ECOSYSTEM DESCRIPTION

Approximately 200 gullies have formed along the southeastern coastal corridor of Lake Huron, mainly between Grand Bend and Port Elgin Ontario. These gullies are diverse in their conception, some occurring naturally, and others that have formed through anthropogenic influences and land-use change to moderate stormwater. Anthropogenically influenced gully development began in the 1800's with deforestation of southwestern Ontario for agriculture. A lack of vegetation across the landscape to regulate surface water flow meant water was draining off the landscape more rapidly accelerating soil erosion of shoreline bluffs, cutting channels into the clay soil, forming gullies. Recently, agricultural field tiles, increased municipal drainage and urbanized development have contributed to the creation and growth of shoreline gullies. "Gullies develop in places along bluffs because of erosion by small streams flowing down the steep bluff slope. Over time, gullies extend inland producing unstable slopes on either side" (Davidson-Arnott & Mulligan, 2016, p.38). Once carved, gullies provide avenues for easy downslope movement of water from precipitation and snow melt. Flowing water erodes soil from the sides and floor of each gully, making it wider and deeper. Landslides, slumps, and related processes like those occurring on bluffs contribute to the removal of slope sediments and vegetation. The entry point of the gully advances upslope (inland), enlarging the gully system.

Erosion of gullies supply nearshore waters and beaches south of the gully's entrance to the lake in deposition zones. In a recent estimation, ~10% of the supply of sediment feeding beaches within the area comes from gully erosion (Baird, 2019, p.9).

Gullies provide ecosystems for flora and fauna. These habitats are in most cases well vegetated, and are often wildlife corridors for mega-fauna including white-tail deer and migratory birds. Within Assessment Units 2 and 3, there are more than 100 streams, many of which have formed gullies that discharge into Lake Huron (MVCA, 2013a). Entry (upland) and exit (lakeshore) points of these gullies experience the most erosion naturally due to water-inputs during spring freshet, as well as wave action carving them out at exit points during times of high lake levels (MVCA, 2013a). Most gullies appear relatively stable with little obvious erosion. However, drastic changes during precipitation events, snow melt, and increased flow rate events can cause significant erosion and even vegetation elimination on slopes (MVCA, 2013a). Exit points of gullies are influenced by lake water levels since high water inundates the mouth of the gully often pooling water in this area. Lower lake levels may provide wider beaches, sometimes cutting off water flowing from gullies into the lake, reducing water quality within gully bottoms.

Using Ontario SOLRIS land-use data, Conservation Authority top-of-slope and hazard layer data, as well as Google Earth 2018, we can orthorectify gullies within the coastal corridor. These GIS layers allowed us to determine that gullies made up 1,830 hectares of the total coastal corridor (85,838 hectares total). This equates to gullies making up 2% of the total study area.

THREATS AND STRESSORS

Gullies in the Lake Huron coastal corridor are sensitive ecosystems existing shoulder to shoulder with high levels of coastal development and inundated with upland stressors. Direct threats to gullies can be natural (e.g. invasive species, erosion) but are more typically anthropogenically influences. Three major threats most pertinent to gully ecosystems (in no order of significance); Climate change, Development and land-use change, and Point and NPS pollution.

4.5.1 Climate change:

Impacts from a changing climate include more variability in storm frequency. “Heavy rainfall that follow periods of dryness, anticipated to be more common in coming decades will decrease bluff stability. Bluffs could be destabilized by more frequent cycling between freezing and thawing temperatures that is expected to accompany warmer winters" (Kemkes & Salmon-Tumas, 2019, p.76). Recent research by the Maitland Valley Conservation Authority identified that intensity of precipitation events has increased throughout the watershed, particularly in fall, winter and spring. The research noted, "small streams and gullies which drain directly into Lake Huron may be particularly vulnerable, due to their actively eroding gullies, less competent geology and clay-rich soils. These areas tend to be extensively drained, further accentuating any potential erosion issues by increasing total runoff" (MVCA, 2013a). Slope failures following heavy precipitation events are a symptom of this changing climate regime.

4.5.2 Development and land-use change:

Disturbance to bluff and gully environments typically occurs in the form of land-use change in and upland from gullies, removal of vegetation, using these areas as 'dumping grounds' and inappropriate recreation use types like all-terrain vehicles. Turning buffer zones adjacent to bluffs and gullies into high impact land-use types like agriculture or development seriously affects the resiliency of these environments to adapt to increases in precipitation events, runoff, and extreme weather events like ice and wind storms. Damage due to increased water velocity caused by a lack of meandering streams up-stream of gullies contributing to bank erosion and a loss of vegetation on fragile gully slopes. High water velocity can hinder fish and aquatic species requiring slow pool-and-riffle streams that could be, "flushed out of watercourses during heavy precipitation events" (HLH, 2012). Maintaining vegetation and a significant buffer zone of at least 100 metres is essential in protecting the top of the slope as well as the quality of habitat to encourage wildlife movement, feeding and nesting potential (Huron County, 2015, p.18). Areas of vegetated habitat within the 100m buffer zones of gullies and valley lands are considered significant in most County planning documents (Huron County, 2015, p.18).

4.5.3. Point and non-point source pollution

Inappropriate uses of gullies as dumping grounds and for unsuitable recreation became apparent through feedback given through LHCCC's coastal community workshops in 2017. Members of the public attending these workshops noted the common use of the gullies adjacent to their communities being used for the purposes of yard waste disposal and garbage disposal and cited that negligence, lack of knowledge/education and lack of enforcement policing these offences as the main causes for their continued impact. In cases where individuals brought up these concerns, they vocalized concerned for the impacts these actions caused to gully and bluff environments but did not know what the appropriate channels were to go through to reverse or stop the damage. Education on why gullies should not be used as 'ad-hoc' landfills, and what caring landowners can do about reporting inappropriate dumping could be done by municipalities to rectify these concerns and advocate for gully health.

Stormwater runoff from agricultural fields can convey excess nutrients like nitrogen and phosphorus to Lake Huron. Water quality is affected significantly by soil erosion, increased levels of nitrogen and phosphorus, along with higher sediment loads, are the leading contributors to reduced water quality. Nitrogen and phosphorus move from fields to surface water when sediment is transported through runoff and soil erosion. As a result of the nitrogen and phosphorus enriched sediments, eutrophication—the growth of algae and other aquatic plants occurs, sometimes fouling local beaches. Channelization of streams, reducing buffer zones around up-stream creeks, and around gullies themselves, all contribute to an increase in nutrients entering the lake through gullies. Keeping gullies vegetated encourages some uptake of these nutrients before they enter the lake. More details on stressors and threats affecting bluffs and gullies is discussed in Chapter 5 of this Plan.

INDICATORS AND THRESHOLDS

Coastal buffer zones are a simple, effective way of reducing impacts to riparian corridors (Stewart et al., 2003). Although different in geographic location, the Department of Fisheries and Oceans Canada has developed minimum buffer widths for development and natural buffers forested riparian zones on Prince Edward Island. These buffer zones can be acknowledged, and compared when applying setback distances to gullies on Lake Huron's southeastern shores. Stewart et al. (2003) recommends a natural forested buffer zone of 20-30m from the edge of a watercourse and a 10m crop production buffer zone from the edge of a watercourse; as well as a 22.9m setback distance for buildings and structures.

Often bundled into the same regulatory framework as bluffs, gullies are typically managed under an environmental hazard category by CA's and municipalities. Gullies are exit canals of streams, can be considered 'valley land'. A myriad of indicators and thresholds describing the health and resiliency of a gully environment have been gathered through the official plans of municipalities and CA planning regulations. Indicators of the ecological integrity and human safety aspects of gullies include;

- Vegetation:
  - A vegetated buffer at least 100m wide from top-of-slope is recommended to encourage vegetation regeneration and wildlife movement… from a regulatory stand point, "All-natural heritage patches within 100m of a gulley or valley land are considered significant" (Huron County, 2015 p.18).
  - "Amount of forest cover within a 30 m of riparian zone adjacent to each side of an open watercourse. ECCC recommends 75% of stream length be naturally vegetated…"(Liipere, 2014);
  - Connectivity: "Excellent 90% to 100% (unimpaired connectivity); Good 70% to 90%; Fair 50% to 70%; Poor Less than 50% (impaired connectivity)" (IJC, 2014).
- Development:
  - Protecting gully slopes from load stress, 30m buffer zones are recommended around the top of a gully slope (Huron County, 2015).
  - "No development shall be permitted within 30 metres of the banks of a cold-water stream or 15 metres of a warm water stream. Landowners are encouraged to forest the area within 30 metres of any stream to maintain and improve fish habitat, ecological function of the stream and to increase natural connections" (County of Bruce, 2010).

CA's that have gullies within their watersheds include an analysis of gully health in the 5-year Watershed Report Card. This is described in more detail under the current management strategies section. Table 9 provides an overview of gully indicators identified by the CAP Steering Committee that best fit gullies on the southeastern shores of Lake Huron. These indicators were adapted from academic literature:

Table 12 - Gully ecosystem indicators identified for the southeastern shoreline of Lake Huron.

GULLY INDICATORS IDENTIFIED	THREATS AND STRESSORS
% Vegetated buffer zone (30m from top of slope)	– Removal of vegetation – Land-use change
Distance to development or cropland	– Encroachment into stable slope setback – Increased potential for runoff – Recreational activities (e.g. ATVs), – Dumping (e.g. garbage, yard waste, composting)

Habitat connectivity	– Species at Risk critical habitat – % canopy cover for cold water – Upstream river channelization, road crossings, culverts, dams	

CURRENT MANAGEMENT STRATEGIES

Gully environments are commonly known as 'hazard lands' to CA's and landowners. There are many regulations in place on bluffs and gullies to ensure human safety in the event of a 'failure', 'slump', or erosion event. Managing these areas from a CA perspective, gullies are often separated into two categories; 'significant valley lands' and regular gullies. 'Significant valley lands' are mapped and analysed on a case by case basis, in which development and alteration are rejected inside or adjacent (within 50 metres) to gullies (County of Bruce, 2010). Unfortunately, unapproved development and site alterations are not policed frequently on significant valley lands, let alone regular gullies. Therefore, land-use change can occur without the knowledge of the County or CA until after the damage is done. The Bruce County Official Plan specifies that, "*Landowners are encouraged to re-forest the area within 30 metres of any stream to maintain and improve fish habitat, ecological function of the stream and to increase natural connections*." (County of Bruce, 2010). However, many management strategies and official documents do not specify how people will be encouraged, whether there will be tax benefits, subsidies or incentives provided, or whether recognition of individuals who re-forest sensitive stream buffer zones will occur. Like the critique in the sand beaches and dunes section, more clarity or reference to other appropriate sub-plans needs to be made within County Official Plans to encourage funding applications to subsidize restoration projects; increase landowner awareness through educational programming and outreach; and habitat preservation through enforcement monitoring.

REGULATORY TOOLS:

CA Regulation and Shoreline Management Plans

Gullies have set back and development regulations through Conservation Authority jurisdictions. Regulations on gullies are determined more specifically depending on their slope stability;

1) Stable slopes – development limit 15-metres past stable top of bank;
2) Unstable slopes – from predicted long-term stable slope plus 15 metres past predicted stable top of bank (Ontario, 2013).

Therefore, depending on the state of the gully's slope stability, different set backs apply on a case-by-case basis. Educating landowners living beside or near gullies to which category applies to them is most important, and may organically change actions and land-use changes adjacent to gullies if all risk factors are known. Stewardship tools such as plans, fact sheets, and best management practice guides are all recommended.

Hectares of Habitat per Assessment Unit	
AU	Gullies
1	230.69
2	165.84
3	888.39
4	477.76
5	0
6	67.60
7	0
8	0
9	0
10	0
11	0

STEWARDSHIP TOOLS:

Bluff and Gully Stewardship Plans

Most Bluff and Gully stewardship guides and plans on the southeastern coastal corridor of Lake Huron were prepared for by the Lake Huron Centre for Coastal Conservation (LHCCC). The LHCCC's website and resource library hosts public-friendly information on gully stewardship. Although dated, the information and recommendations hole true. Some practical tips include:

1. Slow down water: too much water is artificially directed into the ravines. Stormwater runoff from tiled farm fields, roads, driveways and downspouts, and more impervious surface (concrete, asphalt) funnel water into the ravines in torrents when it rains, accelerating erosion. You may need to consult a professional to address serious drainage problems.
2. Don't throw yard waste into ravines, as it smothers the native plants and retains water (adding weight, de-stabilizing the slope). Use a composter located well away from slopes.
3. Create or maintain a buffer area of natural vegetation along the shoreline: A buffer of native plants prevents coastal erosion by stabilizing and holding the soil in place more effectively than lawns that have shallow root systems and are more prone to erosion.
4. Do not "clean up" your shoreline area by cutting back existing plants: Erosion can be magnified by indiscriminately removing shoreline vegetation by increasing the speed of stormwater. This increased runoff can quickly create gullies and washouts, undermine other landscaped areas and generally create more problems than you had when you started. If you do not want to lose your land, do not remove coastal plants.

Educational material including signs, interpretive events, and information panels installed in high-profile gully areas would increase awareness and understanding about the ecosystem services gullies provide, the threats they face, and what landowners can do to live alongside a gully safely.

RECOMMENDATIONS

1. Raising awareness of buffer zones for environmental integrity as well as public safety

Buffer zones adjacent to bluffs, as discussed in this section are imperative for the stability of the slope, as well as for wildlife corridors, habitat connectivity, and erosion prevention. More clarity on these buffers for landowners would assist them in being sustainable land stewards. Recommended buffers in the literature include:

- 3-6-meter buffer: Undisturbed land from the top of gully slope to reduce erosion (Cross et al., 2007);
- 10-meter buffer: of natural buffer between edge of watercourse to any crop production (Stewart et al., 2003);
- 30-meter buffer: Development buffer from the top of the gully slope to protect from load stress (Huron County, 2015);
- 100-meter buffer: Vegetated land to fortify sediment from erosion, provide a habitat corridor to support wildlife movement, and keep water in gully cool (Huron County, 2015).

A simple education and outreach document, partnered with a Best Management Practice guide with informative and easy-to-understand graphics would assist landowners in defining gully buffers as they pertain to their area.

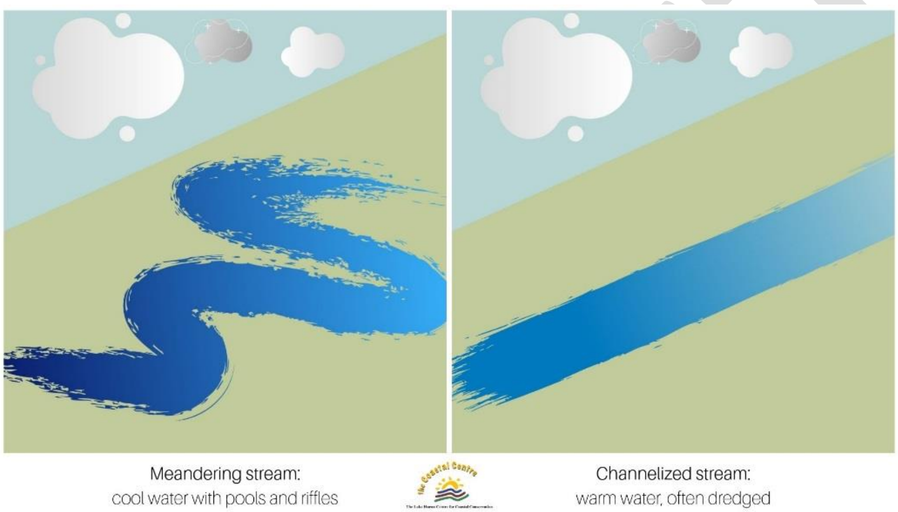
2. Community stewardship in keeping gullies free from pollution and dumping.

Community leaders are concerned about gullies being treated as dumping grounds. A program to support these leaders or a facet of an existing program, such as Coast Watchers by the Lake Huron Centre for Coastal Conservation, the Pine River Watershed Initiative, or Healthy Lake Huron may help recognize and encourage these individuals. Supporting, praising the efforts of, and encouraging public in cleaning up the gullies, much like their beaches, would help in awareness of the threats of pollution, as well as enlist them to becoming stewards and protectors of these areas from outside negative influence (e.g. the litterers).

3. Re-naturalizing creeks entering gullies

Supporting existing programs, and identifying gaps in programs that complete restoration efforts to restore and meander straightened creeks is important to slowing down the water entering gullies. Examples of these such projects can be seen through the work of Maitland Valley Conservation Authority, the Pine River Watershed Initiative Network, and private landowner efforts. Encouraging the continuation of these programs both through advertising and financial contributions will support water quality in the nearshore waters of Lake Huron. Figure 27 is an example of channelized vs natural meandering streams.

Figure 28 - Natural vs. channelized streams



4. Protect gully exits by fortifying a dune or beach area during times of low lake levels.

Implementing a buffer between the lake water mark and the gully exit will reduce bank erosion and ensure the toe of the slope is protected. More information on dune restoration and beach protection can be found in Section 4.1 of this document.

5. Reduce impermeable pavements and development in adjacent homes and settlements

Providing education to landowners adjacent to gullies in best management practices for their structures could be coupled into a best management practice guide and distributed widely across the shoreline. Suggesting supporting programs that overlap with these values, such as septic inspection programs, replacement grants, and alternative products will enable positive uptake to an initiative like this.

- Avoid surface water runoff to reduce erosion potential and increased stress on gully.
- Inspect septic outflows and weeping beds to ensure working order. Check with your local CA when making changes, repairs or upgrades. Avoid adding to groundwater where possible (green roof infrastructure, rain barrels, rain gardens).

4.6 COBBLE BEACHES

DEFINITION:
A coastal area dominated by substrates of various sized cobble, pebble, shingle, or boulder stones with less than 5% herbaceous cover, residing in littoral zones with direct interaction between wave and wind influences of Lake Huron (Liipere, 2014; MSU [1], n.d.).

ECOSYSTEM DESCRIPTION

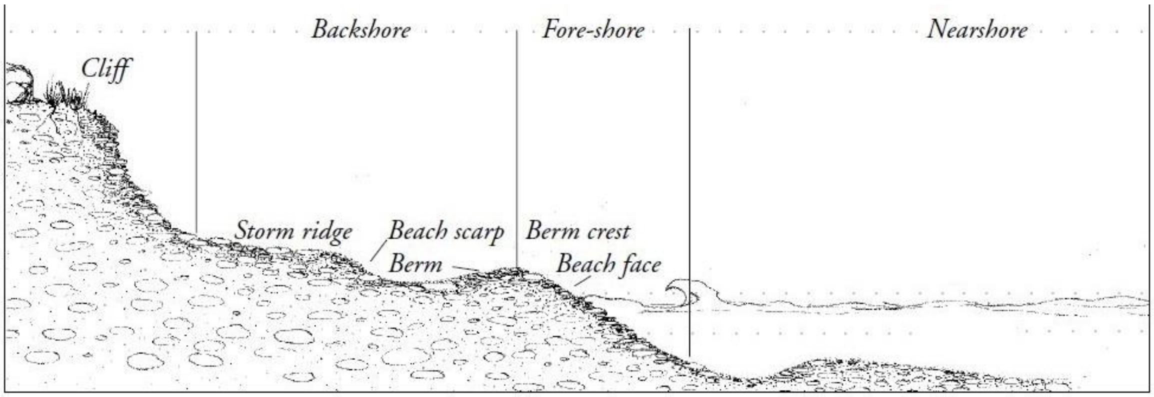
Cobble shoreline and beaches are appreciated for their visual appeal, their ecology, and coastal processes forming these areas. Cobble shorelines made of Silurian, Ordovician, and Devonian limestone rock are a rare geologic feature occurring in Georgian Bay, Lake Huron and Lake Michigan (MSU [1], n.d.). Cobble shorelines consist of stone sediment ranging from boulders (>256mm), cobbles (64 – 256mm), pebbles (4-64mm) and granules (2-4mm) that vary in size and diversity but are larger than sand particles (<1mm) (UH, 2014; Alden, 2017; DFO, 1996). Storm waves regularly disturb beaches, reconfiguring the stones and removing finer clay, silt, and sand particles from eroded glacial tills, resulting in a leftover cobble layer with finer till material underneath. During the winter, shoreline ice freezes to the lake bottom plucking cobbles loose during storms, further eroding and changing the lake bottom. "*Other rocky shores composed of bedrock and large boulders do not experience this movement of rock… Cobble beaches are usually reflective, meaning that they reflect the wave energy that strikes them and are dominated by plunging breakers*" (DFO, 1996, p.5). Frequent visitors to cobble beaches will recognize the distinctive sound cobbles make as the powerful wave action moves them around, creating a sound like pins colliding at a bowling alley. Some visitors disregard stone or cobble as the beach's 'material' as when most people think of beaches, they assume sand is the substrate.

The high energy nature of cobble shorelines, and permeability of the cobble limits soil development and therefore vegetation establishment (Kost et al., 2007). Cobble beaches are distinguished by having less than 5% herbaceous ground cover (MSU [1], n.d.). When vegetation can become established, limestone cobbles create a calcium rich environment favoured by graminoid species like goldenrods, rushes, dogwood, and poplars (Kost et al., 2007). Most of the fauna living on cobble beach shorelines are small invertebrates like crayfish, mayfly and stonefly species, and bird species like gulls, Common and Caspian Terns, and killdeer (Kost et al., 2007). Reptiles use cobble beaches for feeding, nesting, and basking with rare species including Blanding's Turtle, and Eastern Massassauga Rattlesnake (within their Bruce Peninsula range) (MSU [1], n.d.). "Insect larvae provides an important food source for nearshore fishes… migratory songbirds feed heavily on the adult insects that settle in coastal forests adjacent to cobble beaches" (Liipere, 2014). Cobble beaches provide seasonal spawning and migration areas for predator fish (e.g. Whitefish and Lake Trout). Cobble beaches often reside beside coastal fens, limestone bedrock shorelines, alvars, and forests in the northern-half of the southeastern coastal corridor (MSU [1], n.d.).

Throughout the southeastern shores (946 km), there have been 47 kilometres of cobble shoreline delineated using the Ontario Shoreline Segmentation Data, as well as through orthophoto interpretation. This equates to the southeastern shoreline consisting of ~5% cobble shoreline. An example of a terraced cobble beach exists at St. Christopher's Beach in Goderich.

Beach and shoreline profiles vary depending strongly on lake levels, movement from lake ice, and storm surges. Cobble beaches take this variable and exponentially represent these changes on a short-term scale. The 'stepped' profile of cobble shorelines is distinctive and typically forms different levels of beach-zone. "Beach slope increases as the sediment grain size increases, resulting in steep cobble beaches and flat sand beaches" (DFO, 1996, p.10). Higher slopes adjacent to the water may deter some swimmers and beach-goers, but these slopes allow these shorelines to be more resilient to strong storm surges (McLean & Kirk, 1969).

Figure 29 - Profile of a cobble beach (adapted from DFO, 1996)



Typically, cobble shorelines have a "wrack line" or a distinguishable line of driftwood, algae, dead grasses and other items washing up from the lake pushed up by storm surge waves (DFO, 1996, p.16). Wrack lines provide nutrients to the beach and habitat for species of insects, birds, and small rodents. Only highly adapted plants and animals can survive on cobble shorelines due to the ever-changing nature of the shore as well as the changing climactic conditions, making these areas sensitive to human and natural disturbance (DFO, 1996, p.16). Gulls, Terns, and Sandpipers are all commonly found on cobble shorelines for the nesting potential and local food supply. Other species like crayfish, water snakes, mice and minnows frequent cobble beach habitats for the benefits of habitat, feeding, and sunbathing (DFO, 1996).

THREATS AND STRESSORS

Disturbance to cobble shorelines most commonly occurs anthropogenically. Increased visitation and people physically removing vegetation, wrack line debris, and even the cobbles to 'clean-up the beach' disturbs the ecology and food web. Wash-ups of garbage and littering by visitors is another disturbance plaguing cobble beaches and most coastal shorelines on Lake Huron, and is equally as harmful to animals and plants residing on or using cobble beaches. Cobble shorelines are much more permeable than most other shoreline types, creating a dynamic water quality regime when combining inland-runoff and the impact of heavy precipitation events (DFO, 1996, p.10). Permeable beaches tend to have faster transmission times for pollutants and a longer residence time for garbage and waste. Six threats that most heavily impact the health of sand beaches and dunes along Lake Huron include: plastic pollution, vehicle use, invasive species, removing natural material and development and alteration.

4.6.1 Plastic pollution

Cobble shorelines are often used for recreation primarily in the summer months. Visitation, combined with dynamic, high energy shorelines create multiple input streams of pollution. Pollution takes the form of water bottles, plastic twine, fishing line, nets, microplastics, and larger items like tires. Not only does pollution pose a threat to human health and safety, but plastic waste is commonly consumed by fauna or entangle wildlife feeding and drinking in the area. Plastic pollution having longer residence time on cobble beaches is a concern because photochemical degradation of the plastic via solar radiation causes the plastic to break-down in to smaller fragments faster, making it more challenging to clean up the longer it is there (Froklage et al., 2013). Plastic is a known carrier of other chemicals latching onto the simple polymers. “Trace metal ions including chromium, zinc, cobalt, cadmium and lead” bind to plastic, and can bioaccumulate in areas like cobble beaches, where plastic litter can gather if not regularly cleaned up (Froklage et al., 2013). Many coastal bird species use cobble shorelines for feeding and nesting. The presence of plastic pollution increases the probability of entanglement and consumption of small plastic fragments. There are reports of birds using plastic fibers and fragments to line their nests, increasing the probability for toxic bioaccumulation in the bird eggs and increasing consumption risk (Froklage et al., 2013). More information on the threats of plastic pollution can be found in Chapter 5.

4.6.2 Vehicle use

Research has identified that vehicle traffic on cobble shorelines compacts sediment depth, loosens rocks at the surface of the beach, making it more susceptible to wind and wave activity. The effects of vehicle passage extend to a depth of ~20 cm. Vehicles can damage feeding and nesting grounds for shorebirds like killdeer. Due to fine sediment existing deeper within the cobbles, vegetation is typically sparse on cobble beaches. ATV’s and vehicle use on cobble beaches can crush any vegetation that is growing within cobbles, reducing floral diversity (Kost et al., 2007). Disturbing cobble beach areas through frequent ATV use can increase the potential for introduction of invasive species, as described in section 4.6.3.

4.6.3 Invasive species

Cobble shorelines are particularly susceptible to terrestrial and aquatic invasive species permeating the habitat. Because cobble beaches have so few nutrients to begin with, along with constantly changing through wave energy and ice scour, cobble beaches are threatened by the introduction of invasive species and the fragility of existing vegetation to be outcompeted by newcomers. Most commonly, Spotted Knapweed, *Phragmites australis*, Purple Loosestrife, Round Goby, and Rusty Crayfish (Kost et al., 2007). Invasive species are adept at out competing native vegetation for space and nutrients, and often form dense monocultures in the ecosystems they invade. Littoral flows through nearshore waters can carry seeds and spawn of invasives quite quickly onto cobble beaches and other shoreline habitats, causing visible impacts to the shoreline within one or two years.

4.6.4 Removal of natural material from the shore

Cobble shorelines are typically devoid of nutrients and organic material due to the high energy nature of the beach. The high energy environment is why many of these areas have wash-ups of logs and organic material, especially during spring storms. If this incoming material is removed by humans, it reduces nesting habitat for shorebirds, removes nutrient input potential, and can cause sediment erosion from around and under the cobbles, instead of rebuilding the underlying sediment. Natural material is often removed from cobble shorelines to ‘clean-up’ the beach for aesthetic purposes. With increases in washups of plastic pollution becoming intertwined with natural material, when shoreline visitors and owners try to clean up the plastic or other garbage, they will remove natural material as well. Or conversely, they will leave the natural material on the shoreline along with garbage intertwined, creating hazards for humans and fauna using the shore. Therefore, it can be challenging to convince landowners and land managers to leave natural material in place when it is riddled with tangled masses of pollution. More education is needed to inform those living on and using the shoreline of the benefits natural material provides and the importance of leaving as much of it in place as possible, while removing hazards caused by pollution.

4.6.5 Development and alteration

Like other shorelines on Lake Huron, cobble shorelines attract cottage development, seasonal visitation, and community infrastructure. Impediment of coastal processes through development and shoreline hardening is especially prevalent through cobble shoreline location naturally occurring in high energy beach areas. Groynes, jetties, and sea walls are the most common culprits of hardened disturbance to coastal processes of cobble shorelines, often refracting the wave energy instead of absorbing it like cobble shorelines naturally do, potentially causing more erosion in adjacent habitat types. Most cobble beach areas during high lake water levels are changing daily, discouraging semi-permanent structure creation. However, during times of low lake levels when the wave energy doesn't consume as much of the shoreline, lakeshore residents occasionally construct semi-permanent structures such as boat holds, decks, and tiki-bars. Eventually, when lake levels rise, these structures wash away in the nearshore waters potentially creating hazards down the coast when they wash up out of the lake. Building structures and reshaping the cobble profile in-land of wave action can expedite erosion of the shallow soil profile existent in cobble shorelines. Maintaining a healthy buffer between the high-water mark on cobble shorelines and any development protects the landowner from hazard and enables nutrients and sediment to filter off the landscape, through the cobbles, protecting nearshore water quality.

INDICATORS AND THRESHOLDS

Indicators and thresholds existing for the management and monitoring of limestone cobble shorelines were almost non-existent in literature reviewed for this plan. However, comparing the sensitivities of the ecosystem to the impending threats and stressors allows some illusion of what indicators and thresholds may be, in comparison to sand beach and dune environments.

COBBLE SHORELINE INDICATORS IDENTIFIED	THREATS AND STRESSORS
% Hardened shoreline	– Cobble erosion (wind, wave, human alteration) – Development (e.g. groynes, sea walls, decks, armuor-stone)
# of invasive species	– Presence, distribution, population density, scope of work to remove. (e.g. *Phragmites australis*, Spotted Knapweed, Rusty Crayfish, Round Goby, etc.)
Beach grooming, cobble removal	– Removal of wrack line or natural materials – Compaction from heavy machinery – Recreational activity (e.g. tourism pressure, ATV)
Excess nutrient inputs	– Beach postings, algae presence

CURRENT MANAGEMENT STRATEGIES

There were no specific management actions attributed to cobble shoreline areas specifically in literature reviewed for this Action Plan. There were, however, references to dynamic beach areas, which receive regulation and permitting through CA's. More about this was discussed in the Sand Beaches and Dunes section. Similar critiques to current management can be applied to cobble shoreline management including a cohesive management strategy across political boundaries to ensure consistent management across agencies.

STEWARDSHIP TOOLS:

Beach Stewardship Plans

Coastal stewardship plans, such as those created by the Lake Huron Centre for Coastal Conservation provide fact information about cobble shorelines, including healthy shore tips. However, more material specifically focusing on this habitat could be created to further educate private landowners and municipalities on their value.

Hectares of Habitat per Assessment Unit	
AU	Cobble Beach
1	3.54
2	2.22
3	0
4	4.97
5	2.35
6	14.99
7	0
8	0
9	0
10	0
11	0

RECOMMENDATIONS

1. More research and reports of threats to cobble shorelines

More monitoring could be conducted specifically to cobble shorelines to outline the distribution of threats such as development/ hardened shorelines, erosion, invasive species.

2. More educative material and guides for public and private use

Educating landowners and land managers a like on the sensitivities of cobble shorelines and the diversity of stressors that face them will help inform better management decisions in the future. Creating a coast of eco-conscious citizens that are aware and courteous to their shoreline ecosystems will holistically improve the resiliency of the southeastern shores to adverse impacts.

4.7 WETLANDS

DEFINITION:
"Lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; in either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants" (OMNR, 2013).

ECOSYSTEM DESCRIPTION

Great Lakes coastal wetlands are "transitional areas between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Simon et al., 2007). They occur where there is natural protection from powerful wave action and are strongly influenced by water level fluctuations. Coastal wetlands are directly influenced by the waters of Lake Huron, making their hydrology and vegetation structure different from that of their inland counterparts. Along Lake Huron, these wetlands take the form of coastal marshes, swamps, fens or bogs, (swamps and marshes being the most common). Coastal marshes are critical components of the Great Lakes nearshore ecosystem and provide habitat for many species of fish, amphibians, reptiles, birds, and macroinvertebrates.

Coastal wetlands are defined by the OMNR as any wetland that is on the Great Lakes or any wetland that is on a tributary to the Great Lakes and lies, either wholly or in part, downstream of a line located 2 km upstream of the 1:1000 year flood line (plus wave run-up) of the waterbody to which it is connected. Wetlands found within 2km of the shoreline are considered coastal wetlands and are significant (Huron County, 2018). The daily seiche, storm event, and interannual water level fluctuations have significant influence on the biological communities that develop (Simon et al., 2007). Coastal wetlands are distinguished based on geomorphology and climate (Simon et al., 2007). In the Great Lakes, coastal marshes generally occur in embayment's where shoreline geomorphology or bathymetric features (e.g. sand bars) reduce wave energy to a point in which rooted plants can persist (Albert et al., 2005). They have been classified as lacustrine (open-lake), barrier-protected (protected), and riverine (drowned river mouth-flooded estuary) (Simon et al., 2007). Lake-ward boundaries of coastal wetlands extend out to a depth of 2-metres, due to the nature of lacustrine and emergent wetlands being open to the lake's influence, and ever-changing lake levels (Simon et al., 2007).

Coastal wetlands function as flood storage, sediment traps, water quality filters, shoreline erosion buffers, habitat for plants, fish, and other wildlife, producers in the food web, and places of increased biodiversity (Maynard and Wilcox, 1996). Wetlands are critical in the cycling of global carbon because of their high productivity. Ecosystem services provided by coastal wetlands include storm protection, nutrient transformation, removal and storage, non-consumptive recreation, recreational fishing and hunting, and commercial fisheries (Simon et al., 2007).

The southeastern shoreline of Lake Huron (965.30 km, including islands) consists of 30% coastal wetlands (248.82 km). The southern coastal corridor from Sarnia to Inverhuron is comprised of a limited number of coastal wetlands. The most significant wetland in this area is a palustrine marsh near Kettle and Stoney Point Area First Nation Community. Most coastal wetlands are found in the northern part of the southeastern shoreline. The largest coastal wetland (measured by km of shoreline) is the Oliphant Fen, designated a provincially significant wetland. For a detailed assessment of individual wetlands along the SE shoreline please refer to the Assessment Unit Reports in Chapter 7. Another assessment method involves analysing land-use within the coastal corridor. The coastal corridor includes 11,306.37 hectares of wetland habitat.

Only six small swamp coastal wetlands occur between Sarnia and Point Clark along the southeastern shores (~340 ha), which reflect the high-energy shoreline environments. From Point Clark to the base of the Bruce Peninsula, the shoreline is mostly exposed with only five palustrine swamp and fen wetlands (~913 ha) found in sheltered bays. The western shore of the Bruce Peninsula has exposed irregular shorelines, with wide and shallow, boulder-strewn, limestone bedrock shelves, and many small islands, reefs, and sheltered bays. The irregular coast and islands provide many sheltered, low energy bay environments where wetlands develop. "Thirteen wetlands have been evaluated on the western side of the Bruce Peninsula, primarily wetland complexes with swamp, marsh and fen components, totalling ~1,765 ha" (Ball et al., 2003).

The ecology of Lake Huron's coastal wetlands is particularly unique. Fens, marshes, swamps, and bogs along Lake Huron provide habitat for provincially significant (PS), and nationally significant species including 40+ PS plants; 59 fish species, 5 of which are PS, some of which use the wetlands specifically for breeding and migration; 5 PS reptile species and 1 PS amphibian; as well as 1 PS lepidopteran species (ECCC, 2003, p.18-19). Table 10 identifies rare species present in coastal wetlands, to which they strongly rely for feeding, raising of young, long-term habitat, breeding, spawning and nesting areas, as well as migratory stop-over points (Cooper et al., 2012, p.148).

The Oliphant Fen

A fen is an alkaline wetland nourished by groundwater seepage, and is specialized to support a diverse and rich plant community. The Oliphant Fen wetland system extends 8 km from Chief's Point Indian Reserve northwards along the Lake Huron shoreline to just south of Red Bay (Tupman, 2004). Over this distance the fen varies in width from 20 to 500 metres. Therefore, the Oliphant Fen is the largest fen complex on the Great Lakes. The pH values typically range from 7.3 to 8.1. Its alkalinity comes from bicarbonate ions ($HCO3^-$) present in the groundwater that nourishes the wetlands. This bicarbonate is produced from dissolution of dolostone and limestone bedrock, which yields dissolved calcium and magnesium. The Oliphant Fen distinguishes itself from most fens because it does not contain peat (Tupman, 2004).

Table 13: Species reliant on wetlands in Lake Huron's Coastal Corridor (Adapted from ECCC, 2003, p.18-19).

Animalia	**Rare Species Identified**
Plant	*Blue hearts, Round-stemmed Purple False Foxglove, Twining Bartonia and Rigid Yellow Flax*
Fish	*Largemouth Bass, Rock Bass, Bluntnose Minnow, Pumpkinseed and Banded Killifish. Northern Pike, Walleye, Muskellunge and Smallmouth Bass. Pugnose Shiner, Lake Chubsucker, Grass Pickerel, Black Bullhead and Longear Sunfish.*
Amphibian	*Jefferson salamander*
Reptile	*Spotted Turtle, Eastern Spiny Softshell Turtle, Queen Snake, Eastern Fox Snake and Eastern Massasauga.*
Lepidopteran	*Mulberry Wing and Two-spotted Skipper*
Mammals	*Mink, Beaver, River Otter, Raccoon, Red Fox, Muskrat, White-tailed deer*

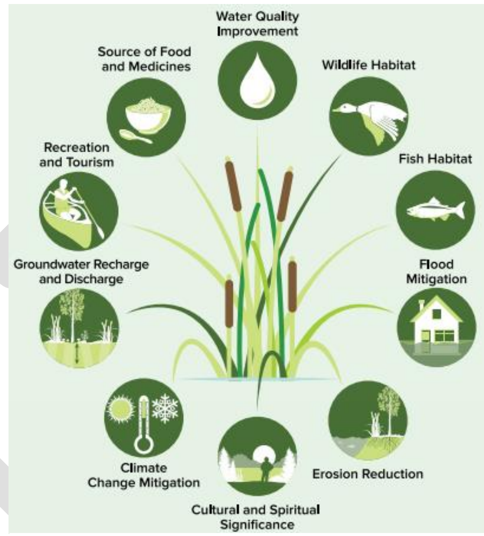


Figure 30: Ecosystem services provided by coastal wetlands. (Ministry of Natural Resources Wetland Conservation Strategy).

Open-shoreline wetland communities have diverse vegetation communities ranging from forest and shrubs to meadow marshes, emergent and floating vegetation closer to water. Variable water levels provide periodic flooding and drying necessary to maintain wetlands at productive and intermediate stages of development. During low water level periods, vegetation communities shift towards the receded water mark, while during high water level periods, vegetation communities retreat inland.

Stable water levels are not beneficial to coastal wetland ecosystems. During prolonged low water periods, perennial forest and shrub communities can take a foothold in locations formerly occupied by meadow marsh and emergent communities. Invasive species, such as *Phragmites australis* will take hold in a wetland ecosystem during such dry conditions. When water levels rise, these areas may no longer provide suitable habitat for fish and wildlife. In the same way, if property owners remove native vegetation during times of low water, native vegetation may no longer be in place to serve as protective cover for young fish and other wildlife when the water rises again. Additionally, development along the shoreline can restrict the natural migration of vegetation communities as water levels rise. As a result, vegetation communities pinched out of existence during high water levels do not have recolonization sources when water levels drop. Studies show that fish and invertebrates respond directly to the presence and absence of aquatic vegetation, which serves as their primary habitat (Simon et al., 2007). Therefore, the absence of vegetation communities has a direct correlation on fish and invertebrate populations.

Although wetlands are affected by fluctuating water levels, they mitigate impacts of water levels on coastal communities. Coastal wetlands serve as buffers, reducing shoreline and property damage during storms by absorbing wave energy (Allan, Callewaert & Olsen, 2018, p.25). Flood mitigation, and other ecosystem services provided by wetlands are often undervalued by communities and private landowners and rarely play a role in decisions to preserve wetland areas.

Natural and human-induced fluctuations impact a broad range of wetland characteristics, from water chemistry to plant community composition. Most often, vegetation is the first wetland component to be affected. Vegetation community alteration thereby changes the fish and wildlife community. Water level fluctuations impact wetland biology and many other components that make wetlands dynamic and productive systems. Currents, wave action, turbidity, acidity, temperature, and nutrient content are all affected by changing water levels. For example, low water levels can cause faster warming of wetland water and may result in unsuitable habitat for certain fish species. Conversely, high water levels may dilute nutrient and contaminant concentrations to decrease local toxicity to plants, fish and other wildlife. (ECCC, 2002, p.4).

THREATS AND STRESSORS

Coastal wetlands are subject to threats and stressors from adjacent ecosystems on land and nearshore waters. This dynamic results in coastal wetlands being vulnerable ecosystems that require frequent monitoring and protection to ensure ecological integrity. Like many coastal ecosystems, coastal wetlands on the southeastern shores are predominantly threatened by invasive species, land-use change, point and NPS pollution, and climate change. Depending on their location, these coastal wetlands experience a variation from all, to none, of these threats. Along with these overarching threats, cumulative long-term impacts exist. These impacts are difficult to assess, but can have significant influence on wetlands (e.g. road salting, fertilizer run off, leaking fuels, wildlife predation from domestic animals, recreation over-use (ECO, 2018). Due to their regulated status, whether provincially significant or not, most coastal wetland communities have had some monitoring and restoration efforts bestowed upon them previously. However, continuing these efforts is imperative to the sustained health and successful function of the ecosystem.

4.7.1 Land-use change

Land-use change due to development and agricultural expansion shapes the current landscape of southwestern Ontario. Many sources have estimated historical amounts of wetland across the landscape, but no comprehensive estimates of coastal wetland loss are available for the Canadian shore of Lake Huron. Regional losses of coastal wetland habitat are not known to have occurred because most of the shoreline is sparsely populated and remote. Most wetland loss is concentrated around small urban centres spread across the coastal corridor. Within the last 15-years, there has been incremental and site-specific loss of wetland area from agricultural encroachment and cottage development. One small example of the extirpation of coastal wetlands along Lake Huron is shown in the Pine River Watershed just south of Kincardine Ontario. “It has been estimated that ~160 years ago, over 50% of the Pine River watershed was covered with wetlands. Today the Pine River has less than 4% total wetland area” (HLH, 2012). Conservation policies and initiatives now exist throughout the Great

Lakes basin to limit further wetland losses, and restore lost area and functions. However, conservation remains an uphill battle as losses continue (ECCC, 2002, p.1).

Development adjacent to coastal wetlands can have long-term negative consequences to the ecological integrity and resiliency of the habitat. Land-use changes, within and adjacent to the wetland can take many forms; such as roads, structural developments, and agricultural expansion. Human induced disturbance can be associated with increases in nutrient and sediment loading from conversion of forests in the watershed into agricultural and urban land development (Simon, et al., 2007). "*Stressors appear to be site-specific and localized. In addition to outright wetland loss, urban encroachment, cottaging and marinas cause multiple stressors on remnant wetlands. On the western Bruce Peninsula and southern Georgian Bay, these stressors include shoreline modification, road crossings, dredging and channelization. Shoreline modification prevents the landward migration of remnant wetlands during high water periods. Road crossings alter wetland hydrology and, along with dredging, filling and channelization, fragment the remaining wetland habitat…"* (Allen, 1996; ECCC, 2003, p.19). Despite the ecological importance of Great Lakes coastal marshes, anthropogenically-caused fragmentation has commonly occurred in these habitats. Throughout the Great Lakes region, areas of coastal marsh have been drained for agriculture and urbanization while boat launches and navigational channels cut through many remaining marshes (Cooper et al., 2012, p.143). Although areas of wetland once developed can be 'restored', the ecosystem will never truly return to its original state, and natural coastal processes may never recover.

Negative repercussions of land-use change and development have the fastest impact on coastal wetlands that cannot be undone. Therefore, the pertinence of ensuring regulation and policy around development and land-use change in, and adjacent to ecosystems is paramount in the preservation of these sensitive ecosystems. Once, and if, restored properly, coastal wetlands may still provide some valuable ecosystem services to their local area.

4.7.2 Invasive species

Invasive species threaten many native ecosystems, and coastal wetlands are no exception. Species range shifts and invasive species are becoming a serious threat to the existing ecosystem compositions of coastal wetlands along the southeastern shore, possibly leading to reductions in biodiversity (Kemkes & Salmon-Tumas, 2019) Coastal wetlands in Lake Huron recognize a number of these species and the potential impact they will have if left unmonitored. *Phragmites australis*, Purple Loosestrife, Common Carp and Zebra Mussels are non-native, invasive species currently affecting coastal wetlands (Allen, 1996; ECCC, 2003, p.19).

Many invasive species thrive in hydrophytic soils, but none better that the invasive species *Phragmites australis. Phragmites australis,* known as European Common Reed, is a non-native invasive perennial grass that threatens coastal wetlands in the Great Lakes Basin. It can be identified by its brown to purple colored seed head, blue-green leaves and tall height sometimes reaching up to 15-feet tall.

Phragmites is a fast-growing species that uses seed production, above and below ground root structures, and the secretion of chemicals to suppress the growth of native vegetation. Growing up to 200-stems per square meter, this grass can quickly crowd out native vegetation causing disruptions to water flow and quality and creating poor habitat for wildlife. Coastal wetlands are home to numerous species at risk that are sensitive to changes in vegetation, habitat and food sources, and the introduction of Phragmites to these ecosystems presents issues for protecting species that are already declining. For example, fish that use coastal wetlands as important spawning areas, are unable to lay eggs in densely grown Phragmites stands. Several groups along the Lake Huron shoreline have formed out of the necessity to manage Phragmites in their communities, such as the Lambton Shores Phragmites Community Group. Recognizing the significant threat this plant poses, these groups lead initiatives to engage their communities in informative removal efforts. Without proper mitigation and management of Phragmites in coastal wetlands, irreversible declines in these rare ecosystems are imminent**.**

Purple loosestrife is easily identifiably by its vibrant purple flowers. This plant has a thick root mass that degrades wetland habitats, making it unsuitable for many native plant and animal species. Spotted knapweed belongs to the same family as sunflowers, *Asteraceae*, and has several small white to purple petals surrounding a "spotted" flower head. Knapweed is typically found in well-drained terrestrial areas, such as agricultural field. This plant is often found on the edges of wetlands and road-sides, potentially causing impacts to wildlife that moves between different habitat types. Round Goby are a small invasive fish found throughout the Great Lakes/St. Lawrence Basin. They are aggressive feeders, quickly consuming insects and other small organisms found in rivers and lakes. Round Goby outcompete many native sport fish for food and other resources. Round Goby are linked to outbreaks in *Botulism type-E*, a disease found in zebra mussels. Round Goby consume zebra mussels and potentially pass the disease on to fish-eating birds, leading to animal die-offs. Eurasian milfoil is an aquatic invasive plant that forms dense mats of vegetation in shallow waters. It is a fast-growing perennial plant that impacts aquatic ecosystems by reducing the amount of light received by native species, and by reducing the amount of available oxygen (O^2) in the water during the fall. Eurasian milfoil can impact recreational activities such as boating and swimming when dense mats of vegetation dominate water channels.

All these floral and faunal invaders negatively impact coastal wetlands ability to support native populations of species and complete ecological processes. With any invasive species, the best prevention is detection. Learning how to identify species that threaten wetland habitats is the first step in creating a viable management strategy. For more information on invasive species in Ontario, visit www.invadingspecies.com.

4.7.3 Climate change

Coastal wetlands on Lake Huron's southeastern shores are among the most vulnerable ecosystem types due to threats from climate change, including increased storm frequency and intensity, changing water levels, and higher water temperatures (ELPC, 2019). These stressors, affecting wetland hydrology, effectively impact wetland type, flooding them to become 'permanently' inundated, or drying them up entirely (Kemkes & Salmon-Tumas, 2019, p.72).

Increased evapotranspiration caused by a lack of lake ice and higher temperatures during the growing season will contribute to higher water temperatures and lower water levels; or higher water levels will inundate wetland areas eroding banks or increasing flooding inland, allowing wetlands to drain sediment and nutrients into the lake, reducing water quality of the nearshore (Kemkes & Salmon-Tumas, 2019, p.72). Decreasing water levels on the Great Lakes have been studied for their relation to a decrease in habitat suitability due to drying marshes for American Bittern (*Botaurus lentiginosus*), American Coot (*Fulica americana*), Black Tern (*Chlidonias niger*), Least Bittern (*Ixobrychus exilis*), Marsh Wren (*Cistothorus palustris*), Pied-billed Grebe (*Podilymbus podiceps*), Sora (*Porzana carolina*), Swamp Sparrow (*Melospiza georgiana*), and Virginia Rail (*Rallus limicola*) (ELPC, 2019). Decreasing lake levels effect amount of area available for fish spawning and feeding, which when reduced will decrease fish populations. Higher lake levels will allow wetlands to grow inland, in some cases connecting coastal wetlands with inland wetland pockets. If invasive species exist within one of these features, it could be transported easily through the higher water levels infecting a new wetland area causing damage to the ecological integrity and plant composition.

Increasing water temperatures will reduce the dissolved oxygen (O^2) content in the stagnant waters of some protected coastal wetlands, reducing water quality and ability for certain species of fish to successfully rear eggs and fry in these areas. Coastal wetlands at the mercy of lake levels and temperature can show more influential changes to the composition of flora and fauna caused by these factors than by changes to land-use in the adjacent terrestrial environments (Simon et al, 2007).

Increased storm frequency and/or intensity due to climate change will affect concentrations of point and NPS pollution; "such storms are associated with increased nutrient, sediment, and contaminant loading from tributaries and increased coastal erosion, directly impact habitat and biota in coastal areas" (ELPC, 2019). Landowners and communities residing near coastal wetlands will need to be more diligent than ever at maintaining their wellbeing and ability to complete ecosystem services to protect themselves from these amplified events.

4.7.4 Point and non-point source pollution

Pollution from in-land sources entering coastal wetlands from tributaries or sources coming through the nearshore waters compound and bioaccumulate in wetlands. It is for this reason that wetlands are so important for water quality purification. Coastal wetlands create sinks of nutrients and chemicals if too many pollutants are added. Increases in sedimentation and nutrients from inland runoff or land-use practices can feed into wetlands. Regardless of the pollution source, resulting eutrophic and turbid conditions generally lead to a higher biomass of benthic algae, which can reduce the species richness of submergent plants, in turn affecting species richness, species composition and size structure of high tropic levels such as zooplankton, benthic invertebrates and fish (Simon et al, 2007). As well, plastic pollution from nearshore waters, as discussed for previous ecosystems, cause entanglement of bird, fish, amphibian, and reptile species using coastal wetland areas. Plastic pollution is rampant on all Great Lakes. Clean-up measures and prevention tactics will need to be employed to ensure coastal wetlands remain pristine to support a host of rare and specialized species.

4.7.5 Size, proximity, and fragmentation

Small isolated wetlands provide habitat for many wetland dependent reptiles and amphibians whereas contiguous wetlands are important for area-sensitive species (Huron County, 2018). The value of a wetland is enhanced when they are close in proximity allowing wildlife movement to find favourable habitat, food and mates (Huron County, 2018). Wetlands situated within 100m of other wetlands are more likely to have movement of amphibians among them; and two or more patches are most likely to collectively support more species than they would if they are isolated from each other (ECCC, 2013). Provincial experts specify lands adjacent to significant coastal wetlands (within 120-metres) are important to protect from alteration and stressors as well (OMNR, 2005). Ecological functions of adjacent lands as defined by the Provincial Policy Statement, must be assed in relation to the functions of a wetland when considering its significance (OMNR, 2005). Wetland proximity can be especially important when a wetland is small, and meets the specialized needs of certain wildlife species (OMNR, 2013). According to the Southern Ontario Wetland Evaluation Manual (OMNR, 2013), any wetland located within 1000m of another wetland, regardless of hydrological connectivity, is functionally connected to that wetland from a biological and social context (Huron County, 2018). Reducing habitat fragmentation is therefore extremely important to support wetland-dwelling species. Although many coastal wetlands are fragmented from wetlands further inland, connections through creeks and streams provide corridors for movement of fish, reptiles, and amphibians, making these watercourses elemental in coastal wetland health.

INDICATORS AND THRESHOLDS

Coastal buffer zones are a simple, effective way of reducing impacts to coastal wetlands (Stewart et al., 2003). Although different in geographic location, the Department of Fisheries and Oceans Canada has developed minimum buffer widths for development and natural buffers for coastal wetlands on Prince Edward Island. These buffer zones can be acknowledged, and compared when applying setback distances on Lake Huron's southeastern shores. Stewart et al. (2003) recommends a natural buffer zone of 18.3m measured from the high water mark or edge of the wetland; a forested buffer zone of 20-30m from the edge of a wetland; a 10m crop production buffer zone from the edge of a wetland; as well as a 22.9m setback distance for buildings and structures.

The International Joint Commission (2014) identified indicator metrics to determine wetland health including: gains and losses of wetland area; land cover and land-use adjacent to wetlands; changes in land-use and land cover across the basin; and area dominated by invasive vegetation. Literature on indicators and thresholds for coastal wetlands suggest that watershed land-use to determine water quality, as well as adjacent land-use types, hydrological connection to other wetland habitats, and habitat suitability to support species are important to consider (Simon et al., 2007). On the Bruce Peninsula, studies have been done to relate road density to water quality of Great Lakes coastal wetlands. This study, "*found that coastal wetlands showed signs of degradation above a road density threshold of 14 m/ha, and recommended that this level be used to guide conservation efforts to protect Great Lakes coastal wetlands… The construction of roads and associated drainage ditches can alter surface water hydrology, particularly in coastal wetland and alvar communities where hydrological processes are critical for their viability*." (Liipere, 2014, p.84). From a landscape management perspective, Environment Climate Change Canada recommends a minimum wetland cover be 6% of every sub-watershed and 10% of every major watershed (Liipere, 2014). Table 11 provides a summary of indicators the CAP Steering Committee has identified for the assessment of coastal wetlands along the southeastern shores. For the purpose of this Plan, a select few indicators have been chosen to provide a baseline inventory and assessment of wetland health. For each of the respective indicators, the steering committee has identified associated threats and stressors.

Table 14 - Wetland ecosystem indicators identified for the southeastern shoreline of Lake Huron.

WETLAND INDICATORS IDENTIFIED	THREATS AND STRESSORS

Land-use change and Development	– % Historical cover +- % current cover – Adjacent land-use changes – Agricultural drainage, sediment and nutrient accumulation – Recreation activities (e.g. ATV's)
Habitat connectivity	– Upstream river channelization, road crossings, culverts, dams – Proximity to other coastal wetlands
# invasive species	– Presence and abundance (e.g. *Phragmites australis*, Purple Loosestrife, Eurasian Milfoil etc.) – Decrease in critical habitat for SAR
Habitat restoration	– Removal of invasive species – Re-introduction or proven resurgence of 'lost' species

CURRENT MANAGEMENT STRATEGIES

Hectares of Habitat per Assessment Unit	
AU	Wetlands
1	477.79
2	1,119.96
3	287.74
4	456.81
5	2,938.45
6	1,978.80
7	1,798.87
8	658.80
9	1,119.07
10	434.52
11	35.56

CA's in the coastal corridor have watershed report cards which have reported coastal wetlands to be in poor condition. They specify an increase of the number and quality of wetlands is needed to ensure healthy ecosystems upstream and in the nearshore zone. The *2018 SVCA Watershed Report Card,* rated coastal wetlands in Lake Fringe (Excellent), Penetangore River (Poor), and Pine River (Poor) Watersheds, and noted that, "more wetlands are needed in strategic locations, [and] commitment to conserving wetlands is needed across the SVCA jurisdiction" (SVCA, 2018). The *2018 ABCA Watershed Report Card* did not give ratings specific to the shoreline watersheds' wetland composition. GSCA's *2018 Watershed Report Card* did not analyse the Lake Huron shoreline (GSCA, 2018). *SCRCA's 2018 Watershed Report Card* rated the lakeshore watersheds, Sarnia (Very Poor), Cow and Perch Creeks (Very Poor), Plympton Shoreline Tributaries (Very Poor), and the Lambton Shores Tributaries (Poor) (SCRCA, 2018). SCRCA's Report Card stated "only 0.1% of the St. Clair Region watershed is covered by wetlands… more wetlands are needed in strategic locations across sub watersheds" (SCRCA, 2018). *MVCA's 2018 Watershed Report Card* graded Lake Huron adjacent watershed wetlands as; Eighteen Mile (Poor), North Shore (Poor), Mid Shore (Poor), South Shore (Poor) (MVCA, 2018). MVCA stated, "remaining wetlands need to be protected because of their important ecological functions" (MVCA, 2018). Overall, CA rating of coastal wetlands show poor health, or no data. This is a red flag that the state of coastal wetlands within the southeastern shores are at risk and need immediate action for protection and rehabilitation.

County Official Plans refer to the importance of protecting, rehabilitating, and connecting wetland communities. Lambton County's (LC) Official Plan made a goal to; "maintain, restore, and improve existing wetlands and to increase the overall wetland coverage in the County" (Lambton County, 2019, 8-8). However, no further detail as to how this goal will be accomplished was provided. LC's plan did specify that the creation of 'engineered' wetlands "will be encouraged where possible", and are managing wetlands under the 'no net loss' principal, which somewhat contradicts maintaining, restoring, and improving existing wetlands (Lambton County, 2019). Bruce County's (BC) Official Plan (2013) specifies that development proposals within 120-metres of a wetland need site-specific environmental impact statements if the development plan meets the policy requirements. BC's Official Plan only specifies protection for Provincially Significant Wetlands (PSW) using the Municipal Zoning Bylaw (County of Bruce, 2010). They specify how they are protecting wetlands but have no goals listed to restore, improve, or build new wetlands, like that of LC's Official Plan. Huron County's (HC) Official Plan states that there will be no development permitted in coastal wetlands (Huron County, 2015a). HC's Official Plan broadly states, "*The preservation of native plant and wildlife species is important to maintaining biodiversity and a healthy environment. The protection, expansion and enhancement of natural corridors, connections and linkages between natural features shall be maintained, promoted and improved*" (Huron County, 2015a) which could apply to wetlands. However, unevaluated wetlands can be close to PSW's, and zoned for development even though they provide benefits to PSW complexes. The Town/Municipality and CA's can attempt to address the presence of these unevaluated wetlands, but until these wetlands are officially evaluated and designated in the Official Plan, they will receive a lower level of protection (ECO, 2018). Official Plan designation may take years, Official Plan cycles are 10 years during which the wetland can be lost in legal loopholes or destroyed. In all Official Plans reviewed, it is clearly written that they will review development plans and utilize an environmental assessment, but do not specify the prevention of development outright for the preservation of ecosystems.

The Environmental Commissioner of Ontario recommends the province requires developers and planners to work with CA's in the early stages on planning decision that impacts wetlands. Some CAs choose to only regulate PSWs designated in official plans, while others regulate unevaluated and locally significant wetlands (ECO, 2018). CAs regulate wetlands through the new document, *Regulation of Development, Interference with Wetlands and Alteration to Shorelines and Watercourses*, providing consistent application to landowners.

The Provincial Policy Statement (PPS) provides overarching direction for Municipal land-use planning decisions in southern Ontario, and includes some baseline protection for natural features (ECO, 2018). However, the PPS protections for wetlands are limited. The Province of Ontario provides recommendations on how municipalities can determine what constitutes a reasonable distance for proposed adjacent activities. If these guidelines were strictly followed, they would still not necessarily be enough to prevent pollution, shoreline erosion, or disruptions to local hydrology. Specifically, the PSS states:

"The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features" (OMMAH, 2014).

The Ministry of Natural Resources and Forestry adopted the Wetland Conservation Strategy in 2017. This framework describes a series of actions the Ontario government will undertake. Those actions include improving Ontario's wetland inventory and mapping, developing polices and tools to prevent the further loss, and improving evaluation of Provincially Significant Wetlands. This agency administers an incentive program called, the Conservation Land Tax Incentive Program (CLTIP), a voluntary program that encourages wetland stewardship by offering 100% property tax exemption on eligible portion of a property to landowners who protect natural heritage features exists. More incentive programs specifically for Great Lakes coastal wetlands would ensure their protection and enhancement whether privately or publicly managed.

STEWARDSHIP TOOLS:

Some stewardship tools have been created in the past to encourage knowledge of wetland flora, fauna and ecosystem function. Lake Huron Centre for Coastal Conservation's *Lake Huron's Coastal Wetlands Ecosystems of Wonder* document primarily acts as a guide to encourage landowners with wetlands on their property to preserve and enhance them through best management practices. This document could be expanded to cover Great Lakes coastal wetlands specifically and distributed with up-to-date context of threats and stressors to encourage awareness and knowledge of coastal ecosystems by landowners.

RECOMMENDATIONS

1. Community stewardship of wetlands for invasive species removal

Community groups have been taking the charge against invasive species on the Lake Huron shoreline, and this type of advocacy should be supported in all coastal wetlands. Educating communities that live near coastal wetlands on their threats, arming them with the knowledge and skills to remove invasive species, partnering with them to find funding for larger projects, and recognising the work they do will support the prevention and early identification of invasive species in coastal wetlands. This method has proven successful in coastal wetlands that have experienced inundations of *Phragmites australis* Including the work done at Brucedale Conservation Area and Port Franks.

2. Creating and maintaining buffer zones

Although coastal wetlands mitigate flooding along the southwest shoreline, ensuring proper buffer zones between any human-made development and coastal wetlands is extremely important to protect the sensitive flora and fauna communities, the water quality within the wetland, the sediments trapping carbon and nutrients, and to protect human safety. Monitoring projects done by the academic community as to the effects of pollution in Lake Huron's coastal wetlands would be a valuable baseline and indicator study to determine actual levels of contamination from point and NPS pollutants.

3. Continuity of regulation

Coastal wetlands have standardized monitoring protocols and protection through provincial acts and legislation, if they are provincially significant. However, there is little to no protection put on locally significant or regular coastal wetlands. More strict, specific regulation is needed to prevent development outright, with loopholes in the language removed capitalized on by insistent developers. Coastal wetlands are often our first and last defense against flooding, improving water quality, and providing extremely important habitat for rare species. The ecological services they provide should be recognized as an essential service by regulation and treated with the utmost authority. Research from the academic community towards determining monetary value of these ecosystem services should be continued so land managers may better find value in protecting these sensitive ecosystems.

4.8 WOODLANDS

DEFINITION:
An area dominated by treed vegetation with the canopy cover exceeding 60%. Woodlands can consist of coniferous, deciduous or a mix of the two. Coastal Woodlands can appear on different sediment types and along different slopes.

ECOSYSTEM DESCRIPTION

Woodlands in the southeastern coastal corridor are remnants of what used to be large forests of pre-European settlement which covered ~90% of the landscape in southwestern Ontario. Today, coastal woodlands in the southern two thirds of the southeaster shoreline have mostly been reduced to small patches of forest, with contiguous forest swaths to the north. Most coastal woodlands lie in the northern third of the study area with small, isolated patches existing to the south. In some of the northern assessment units, tracts of second growth forests date from the early 1900's and in some areas, there are forest stands approaching older growth, undisturbed conditions (Liipere, 2014). The southeastern coastal corridor of Lake Huron is made up of 85,838 hectares of land; of this, 32,618 hectares are woodland (38%).

Coastal woodlands are diverse in their aesthetic; they can be contiguous, remote forest ecosystems, or thickly treed areas within urban development. Coastal woodland communities vary in vegetation composition from dense mixed-wood forests adapted to shallow, calcareous soils in the north; to highly diverse, Carolinian deciduous dominated forests adapted to sandy, well draining soils in the south (Figure 30). Coastal woodlands range in structure from naturalized, older growth stands to plantation plots. Plantations are woodlots which were traditionally planted with one species at a single point in time and intensively managed and usually harvested for lumber. Although somewhat unnatural, "Plantations can be important components to marginal ecosystems in that they are a means for the net removal of carbon dioxide from the atmosphere, produce oxygen, modify wind and temperature and remediate soil pollution. Plantations have the potential to quickly improve wildlife habitat, especially when used to increase woodland interior and woodland size, and may improve biodiversity by increasing the presence of species in adjacent woodlands and in the local landscape" (Huron County, 2018). This wide diversity in woodland vegetation communities and the species that inhabit these areas, assigning a stable definition of a woodland for management can be challenging. Woodlands have been defined in Official Plans and bylaws as being at least 1+ hectare in area with trees 6+-metres in height with a canopy cover of at least 35-40% containing;

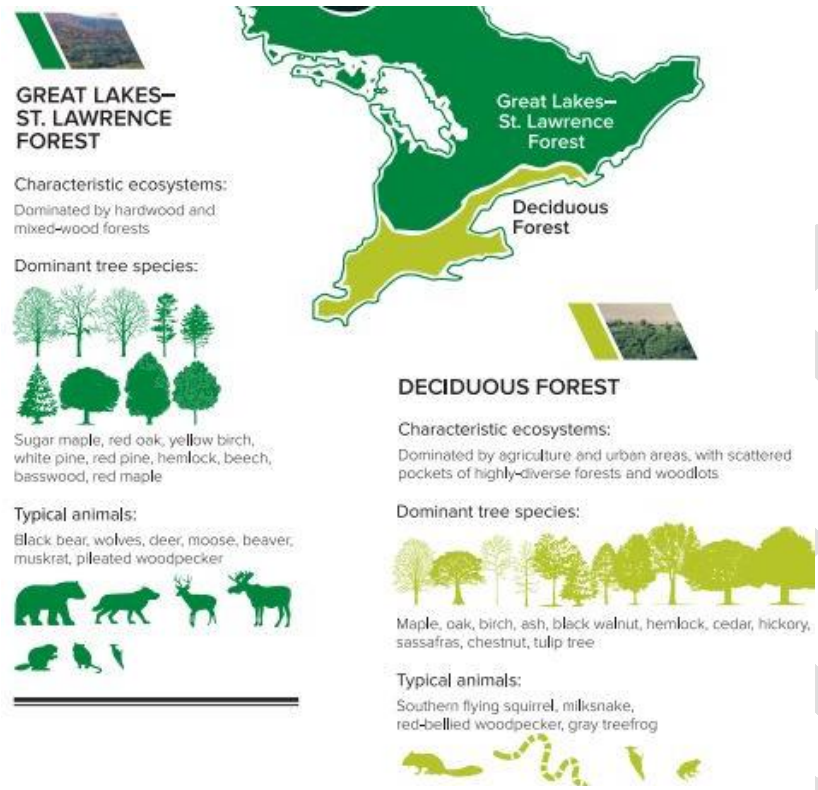


Figure 31 - Southern Ontario's forest regions (MNRF, 2016)

- 1000 trees per hectare, any size (405 trees/ acre);
- 750 trees over 5 cm DBH per hectare (304 trees/ acre);
- 500 trees over 12 cm DBH per hectare (202 trees/ acre);
- 250 trees over 20 cm DBH per hectare (101 trees/ acre);
- Does not include cultivated fruit or nut orchards or Christmas tree plantations (Lambton County, 2012; Huron County, 2013; ECCC, 2013).

Woodlots are smaller than woodlands, and are defined as treed areas at least 0.2 hectare (0.5 acre) and ≥one hectare (2.47 acre) with at least:

i. 200 trees, any size, per 0.2 hectare (0.5 acre);

ii. 150 trees, over 5 cm DBH, per 0.2 hectares;
iii. 100 trees, over 12 cm DBH, per 0.2 hectare;
iv. 50 trees, over 20 cm DBH, per 0.2 hectare (Huron County, 2013)

Woodlands and woodlots will be considered "woodlands" for the sake of this document. The coastal corridor was analysed using GIS orthophoto rectification and partner land-use layers including SOLRIS 2011 to derive the percent cover of woodlands per Assessment Unit.

Ecosystem Services

Most property owners know some direct benefits woodlands bordering the Lake Huron shoreline provide; shade during the summer providing needed relief from the hot sun; wind break from the intense winds off the lake during storms; the aesthetic value of the trees and the connection with nature. It has been proven that living near a forest has a positive effect on the stress-processing brain areas. Researchers found that city dwellers living close to a forest were more likely to have a healthy brain structure than those with no access to nature near their home... those city dwellers living close to a forest were more likely to show indications of a physiologically healthy amygdala structure und were therefore presumably better able to cope with stress (Kuhn et al., 2017). More fundamentally, woodlands provide many ecosystem services including filtering water, air purification, and carbon sequestration. They act as 'living filters' that intercept and store sediments from inland sources and absorb excess pollutants carried in runoff from adjacent lands. The more hindrance humans cause to the functionality of these processes, the more we can expect water quality along the lakeshore to deteriorate. Literature indicates that alteration to natural land cover of coastal woodlands has significant impact on the nearshore zone habitat and its inhabitants, along with water quality and quantity within the watershed (Liipere, 2014). Healthy woodlands are balanced ecosystems home to a variety animals, vegetation, soil, insects and microbes that each play a part in the health of coastal ecosystems.

Coastal woodlands on Lake Huron are notorious for hosting rare species of plants. Of the 60 species of Orchids that exist in Ontario, 43 are found in the Bruce Peninsula's various habitats, specifically forests (Parks Canada, 2017a). Along with the multitude of rare Orchids, the Peninsula's forest ecosystems sustain over 20 sub-species of ferns, accounting for the most diverse fern populations in the coastal fringe (Parks Canada, 2017a). The coastal corridor provides migratory bird stopover points and breeding bird sanctuary. Woodlands provide food, water and shelter for species during breeding seasons, or for resident species using tree cover to assist in their movements across the landscape. The effects of decreased forest cover and fragmented landscapes on birds, mammals, and vegetation is that certain species 'disappear' because they move to find other suitable habitat, with many remaining species become rare or failing to reproduce.

Large forest areas are imperative for megafauna species such as black bears residing on the Bruce Peninsula. Woodland areas previously relied upon by megafauna are now bisected by development, increasing animal/human interaction, often known to occur in cottage country. Although loss of woodlands has this effect on species needing core forest cover to sustain their lifecycles, species adapted to more open and successional habitats, as well as those that are more tolerant to human-induced disturbances in general can persist, and in some cases thrive (ECCC, 2013). Ensuring coastal woodland habitats are preserved, protected, and celebrated for the many ecosystem services they provide, as well as the globally rare species they host, is extremely important in preserving the ecological integrity of our lake and maintaining healthy populations of these species.

Coastal woodlands across the southeastern coastal corridor have many threats and stressors commonly affecting their ecological integrity. The main stressors and threats impacting coastal woodland environments include habitat fragmentation due to land-use change, climate change, limited protected area, invasive species, and harvesting practices (BPNP, 2019).

4.8.1 Land-use change

Land-use changes occur naturally and through human-induced methods. Bruce County, and the Bruce Peninsula now hold the largest area of continuous forest along the southeastern coastal corridor, but it was not always this way. In the 1800's, settlers were required to clear land and build one or two structures on their property in order to establish a claim to that land. Settlers cleared the land of trees to attempt agricultural practices before realizing the shallow soils over top of solid bedrock were not conducive for traditional tilling practices. Clearing land in southwestern Ontario followed suit, with much of the landscape being cleared within 50 years (HLH, 2012). The rapid clear-cutting left piles of dry branches and due to all the 'tinder', large-scale forest fires occurred during the late 1800's. These fires ended the lumber industry, mills closed and agriculture boomed in Lambton and Huron Counties (HLH, 2012). For most coniferous stands, fire is an essential part of the resurrection of the forest, clearing underbrush and allowing older stronger trees to thrive. Some pine species require the scalding temperatures of fire to open and release seeds from cones. Today, humans supress forest fire to protect establishments, communities, and cottage developments. Fire prevention measures have significantly reduced the potential for forest fires to occur, which may influence tree species such as Red Oak and Jack Pine (Liipere, 2014). Remaining coastal woodlands are threatened as more development and tree-clearing occurs. Reports indicate that negative effects of each residential building pocket within woodlands radiate outward, affecting up to 30 additional acres with increased disturbance, predation, and competition from edge-dwellers. This may not matter to generalist species like deer, raccoons, and blue jays, which may benefit from fragmentation, but it puts pressure on interior-dependent species like salamanders, goshawks, bats, and flying squirrels. The smaller the woodland remnant, the more influence of external factors and edge effects. "A wise person once likened it to ice cubes: the smaller ones melt faster." (Snyder, 2014). New subdivisions can impact woodlands through tree thinning, and introduction of more stressors such as pathways for invasive species, compaction of roots, and removal of canopy for views. As this happens, the ecological integrity of woodlands is lost which makes the woodland less resilient, more prone to disease and pests, and reduces the habitat's ability to complete ecological processes.

Forest interior is the area of a forest that is more than 100-metre from the forest edge and is critical for many area-sensitive species (Liipere, 2014). The 100-metre perimeter, considered "edge" habitat is prone to high predation, sun and wind damage, and intrusions by non-native species (Liipere, 2014). A lack of forest interior is a concern across the coast. In many areas only small, fragmented woodlots exist which do not provide forest interior, undisturbed areas for wildlife (MVCA, 2013). Forest interior is important to many reclusive bird species and megafauna species for breeding and nesting (ABCA, 2013).

In woodland environments, nest predation and brood parasitism rates increase near edges, while interior habitat is often less prone to disturbance and supports fewer predators. Land managers monitor forest interior habitat in lake-adjacent watersheds. For example, a meager 2% of the forests in the south gullies' region of the ABCA watershed is forest interior. In total, only 11.7% of the south gullies' region is forested, the rest of the area making way for development, agriculture, and infrastructure (ABCA, 2013). Ecologists recognize that distances between individual woodlands is an important factor in maintaining woodland integrity. Woodlands situated near each other or near other natural features have more potential for restoring connectivity.

4.8.2 Connectivity and fragmentation

Fragmentation of woodlands, and the lack of connectivity between forest fragments plagues most of the Lake Huron coastal corridor. The southern two thirds of the shoreline, apart from Pinery Provincial Park, is vastly devoid of woodland patches. The upper third of the shoreline is well forested despite shoreline development (Figure 31).

Figure 32 - Forest fragmentation comparison

When woodlands become isolated, the movement of plants and animals is inhibited. This restricts breeding and gene flow and results in long-term population decline. Woodlands host many species, including Black Bears (*Ursus americanus*) to the north. It is most important to protect woodland habitats to maintain habitat for large species that have dynamic ranges and distinct territory areas. Although not a rare species, Black Bears encompass this description, and recent, "research has shown that the American Black Bear population of the Northern Bruce Peninsula are genetically distinct and geographically isolated, meaning that the population is extremely vulnerable" (BPNP, 2019). Therefore, focus on threats impacting connectivity of forests is very important to the northern reaches of the coastal corridor.

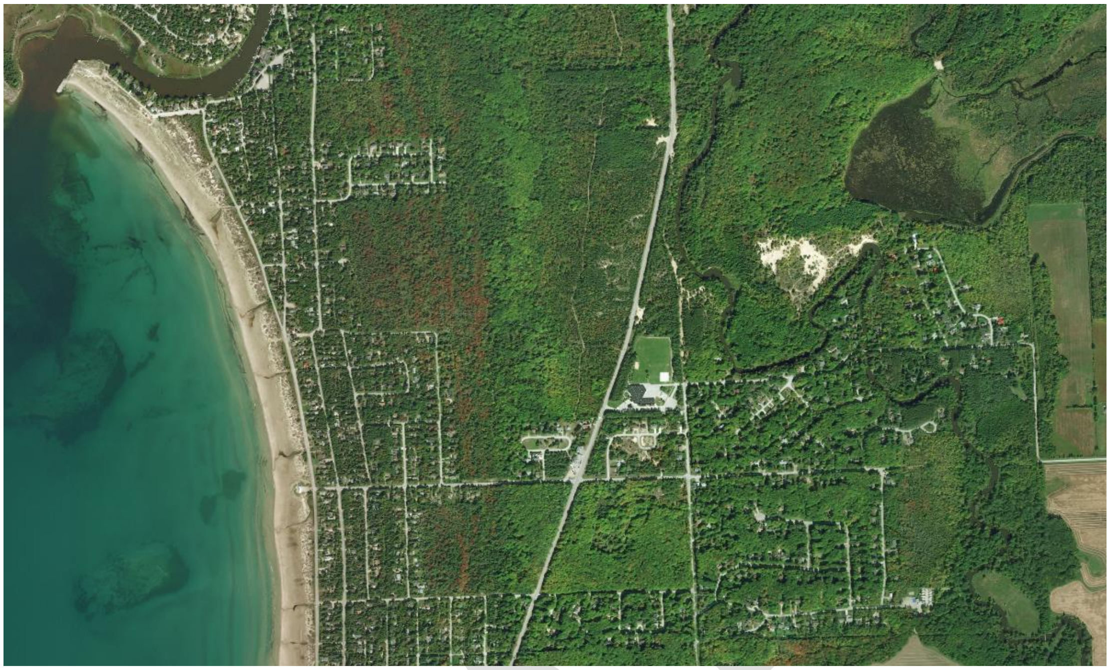


Figure 33 – Roads fragmenting woodland landscape

4.8.3 Invasive species

The introduction of invasive species into forest ecosystems occurs through a variety of ways. Through recreational impacts, transportation corridors, or through natural movement of species, forests are impacted significantly by invasive species. Introduced plant and animal species can alter natural functions in forests by removing the canopy, destroying the understory, or preventing natural regeneration. Forests and trees have difficulty defending themselves against invasive species because they may have no natural resistance or are unable to relocate, and as a result this can lead to high tree mortality (Forests Ontario, 2016, p.16). Invasive species are impacting every habitat type in the coastal corridor, and throughout Ontario. Woodlands have taken a few drastic 'hits' from significant invasive pests and diseases in the past few decades, contributing to the concern of landowners; invasive species were considered the highest stressor of concern in respondents to the 2017 questionnaire (LHCCC). The Asian Long Horned Beetle, Emerald Ash Borer, and Beach Bark Disease are the most commonly noted invasive species in coastal woodlands. Other invasive species such as Oak Wilt has not yet been identified in Ontario, but is extending north from the United States boarder.

Emerald Ash Borer (EAB) continues to be the primary issue influencing forest management in the Great Lakes basin. EAB is now present throughout the coastal corridor causing mortality in native Ash trees which contribute significantly to forest canopies within the southern two-thirds of the southeastern shores. Noticeable reduction of upper canopy in the Huron County region of coastal woodlands is apparent in 2019, with many of these woodlots being logged to remove dead stands, and consequently other timber-valuable trees. Retention of trees and upper canopy to provide habitat and food sources (nut trees such as Oak and Beech) for wildlife, as well as identification and protection of significant natural heritage features (stick nests, rare species), are important considerations which may influence restoration of some woodlands (ABCA, 2016, p.17).

Woodland restoration has different techniques depending on the forest type. For example, in Pinery Provincial Park, the Oak Savanna forest types remain protected, despite 99.93% of this global forest type being devastated or altered (Lambton County, 2014). Management efforts to preserve this forest type from influences include prescribed burns, and removal of non-native Pine tree species. Pinery Provincial Park now protects Oak Savanna along the coastal corridor which equates to 50% of the remaining global Oak Savanna ecosystems (Lambton County, 2014). Oak Wilt from the northern United States threatens this sensitive and rare forest type, and has been identified just south of Canadian boarders. Oak wilt has been identified as a devastating disease threatening Oak trees along the southeastern shores of Lake Huron, primarily dense in the southern assessment units including significantly dense patches in Port Franks, Pinery Provincial Park, and Grand Bend. "*Oak wilt is caused by the fungus Ceratocystis fagacearum which develops in the outer sapwood of the tree. The infected tree reacts by developing tyloses and gums which subsequently restrict the flow of water and nutrients in affected vascular tissues with the result that the tree wilts and subsequently dies*" (CFIA, 2018). Although Oak wilt has not yet made its way to Ontario, it is currently present in Michigan, USA, on the other side of Lake Huron. There is currently no cure for Oak Wilt, with infected trees typically dying within one to three years. Therefore, this invasive species threat is critical to monitor for forest health in regions that are heavily dominated by Oak trees. To mitigate and reduce introduction opportunities of Oak Wilt, it is recommended to reduce the transportation of Oak wood with bark still attached (primarily used as firewood) (CFIA, 2018). The CFIA recommends avoiding pruning Oak trees in spring, and wounds on Oak trees from wind or ice damage should be treated with a dressing as soon as possible to prevent the spread of infected mycelium (CFIA, 2018).

4.8.3 In-direct threats

Air pollution, climate change, and species movement will have in-direct threats on coastal forests, causing reassembly in most of the canopy and sub-canopy. "*Air pollution and acidification of soils increase the potential for nutrient deficiencies and imbalances, particularly in woodlands growing on shallow, poorly buffered soils, resulting in higher frequency and severity of woodland decline. A decline in forests due to air pollution exopodites the loss and fragmentation of woodland habitats, impacting species dependent on these ecosystems, particularly bird species*" (Henson et al., 2005, p.16). Air pollution indicators include number of smog advisory days, and reference microclimate temperatures present due to surrounding infrastructure.

Scientists have discovered that climate change is already influencing coastal forest ecosystems. Increased insect and disease outbreaks, including invasive species, will change the stratification of forest canopy and disrupt existing food-webs (Henson et al., 2005). Increased atmospheric carbon dioxide caused by climate change will likely create higher levels of herbaceous plant cover in the ground layer of forests while disfavouring woody plants such as trees and shrubs, potentially shifting forests from heavy canopy cover to more shrubland, grassland ecosystems (Henson et al., 2005). Species migration is another threat to small hardwood forest types of southwestern Ontario; *"Scientists predict that within the next century, plant species will begin to migrate northward due to shifting temperature regimes and lengths of growing seasons extending. For example, tolerant hardwood forests in central Ontario will advance to northeastern areas and the oak-hickory forests of the central United States may eventually advance into the Great Lakes - St. Lawrence forest region*" (Henson et al., 2005, p.16-17). New tree species spreading into current ecoregions will cause shifts in habitat types and a fluctuation of dominant species within coastal woodlands.

Scientists have measured migration of individual tree species moving northward and westward at 10-15 km per decade, with relatively strong shifts northward in northern hardwood forests around the Great Lakes (Henson et al., 2005). Climate change could affect the local habitat or the migratory patterns of many bird species frequenting the region, but integrated assessments need to be undertaken to determine how these would affect the avid population of people who engage in birding or other wildlife viewing activities (ELPC, 2019). Establishing baseline monitoring data, and carrying out concurrent monitoring to determine rate of species migration will be important in determining outcomes this will have to coastal woodland ecosystems.

INDICATORS AND THRESHOLDS

Indicators for woodland ecosystems include comparing current canopy cover with historical cover, quantifying restoration efforts, and monitoring presence and population density of invasive species. Table 11 shows how these indicators interact with known threats and stressors to coastal woodlands.

Table 15: Woodland Ecosystem Indicators identified for the southeastern shores of Lake Huron.	
WOODLAND INDICATORS IDENTIFIED	**THREATS AND STRESSORS**
Land-use change and Development	– % Historical cover +- % current cover – Adjacent land-use changes – Agricultural drainage, sediment and nutrient accumulation – Recreation activities (e.g. ATV's)
Habitat connectivity	– Average size – Corridor presence – Proximity to other woodlands – % forest interior
Habitat restoration	– Removal of invasive species – Re-introduction or proven resurgence of 'lost' species – Tree planting efforts
Invasive species	– Presence and abundance (e.g. Emerald Ash Borer, Beech Bark Disease, etc.) – Decrease in critical habitat for SAR

The *Natural Heritage Reference Manual* (NHRM), (OMNR, 2010) notes that woodland edge characteristics usually extend 100 m inward from the outermost trees. The NHRM and other supporting documentation recommend woodlands to be considered significant if the have at least 2-hectares of continuous interior habitat where woodlands cover is between 15% and 30% of the landscape and are located within 30-metres of another natural heritage feature. Tables 12 and 13 show us these recommendations. It is noted that a limitation to using these indicators includes the consideration that these were created for the watershed scale, not solely for coastal corridors. However, these indicators provide a basis to work from and to compare current landscape data to, to determine recommendations for restoration and improvement of coastal woodlands on the southeastern shores.

Table 16: Natural Heritage Reference Manual for Forest Cover on a watershed scale.		
NHRM, 2005 Criteria	**% of land cover**	**Significant Size**
Where woodlands cover	<5%	2 ha or larger
	5-15%	4 ha or larger
	15-30%	20 ha or larger
	30-60%	50 ha or larger
	> 60%	Minimum size not suggested, other factors should be considered

Table 14 describes parameters such as: percent cover, average size, and connectivity of these woodlands into one place. This table illustrates through colour coding what 'ranking' the Assessment Units receive when considerations of ecosystem health risks are considered.

Table 17: "How much Habitat is Enough" (ECCC, 2013). Guidelines to Forest Cover on a watershed scale.

HMHIE guidelines	% Cover	Average size	Large Forest	Connectivity
Stable, low-risk	>50		>5, 200ha forests	Corridors present connecting all woodlands
Moderate, Medium Risk	40-49		2-5, 200ha forests	Corridors present connecting most woodlands
Minimum, medium risk	30-39		1, 200ha forest	Some corridors present, 50-100m in width
Severe, high risk	<29		0, 200ha forest	No corridors present

Along with the importance of size, guidelines from Environment Canada (2013) suggest that connectivity width will vary depending on the area and attributes of the forest nodes that will be connected. Corridors designed to facilitate species movement should be a minimum of 50-100 metres in width. Corridors designed to accommodate breeding habitat for specialist species need to meet the habitat requirements of those target species and account for the effects of the intervening lands. Therefore, if habitat size cannot be increased, consideration for corridors linking existing patches could be considered. Natural areas close to protected areas are increasingly seen as important to the ecological integrity of the sites which are protect. Small woodlands that are nearby to big woodlands are more important in feature and function than those that are isolated. The *Huron Natural Heritage Plan Technical Document* identifies woodlands within 100m of another natural feature as significant.

CURRENT MANAGEMENT STRATEGIES

Woodlots are generally managed or supported through statements in Municipal Official Plans and Conservation Authority regulation. Regulatory tools through these avenues are only somewhat effective because of a lack of monitoring and enforcement of individuals disobeying regulation. Some individuals are making strides to increase forest cover through tree planting programs and government subsidies such as the Huron County Clean Water Project; However, these types of efforts will not directly show an increase in forest cover until trees become mature in 20-30 years.

REGULATORY TOOLS:

The Provincial Policy Statement, 2014 (PPS) sets out the general rules for land-use planning in southern Ontario. Municipalities then apply these rules in their respective Official Plans (ECO, 2018), which must be consistent with the PPS. The PPS prohibits development or site alteration in significant woodlands (identified and designated by municipalities), unless it has been demonstrated that there will be no negative impacts. The PPS definition of development is limited: subdivisions and commercial building are included, but roads, sewage or septic treatment and electricity transmission corridors are not. (ECO, 2018). The PPS does not protect woodlands from clearing for agriculture, it does suggest that woodlands designated as significant be protected from development unless no or minimal negative impacts on ecological functions are estimated (ECO, 2018). In other words, protection of woodlands depends on the designation of significant and supporting woodlands by Municipal governments in Official Plans (ECO, 2018). Some experts have criticized that the PPS, and Ontario's land-use planning regulations are weak and crippled with underestimating or not measuring cumulative impacts, therefore creating gaps in analysis when reviewing small forest clearance permits (SOK, 2010). Much like other ecosystems, there are loop holes in regulation that could permit development in sensitive ecosystems.

Some Counties require environmental impact studies to be completed for works undertaken near significant woodlots. The County of Bruce has required development in significant woodlots, for removal of more than 1-hectare of forest cover in a single proposal, or in townships with less than 30% forest cover to complete environmental impact studies before developments are completed (County of Bruce, 2010).

The Official Plan policies of the Townships of Ashfield-Colborne -Wawanosh and North Huron, and the municipalities of Bluewater, Central Huron, and Morris-Turnberry protect woodlands ≥4-hectares in size. All of these surpass recommended policies in the Natural Heritage Reference Manual. municipalities of Huron East and South Huron exceed NHRM guidelines by protecting all areas of natural environment and areas ≥2-hectares. The Township of Howick does not have a significance criterion, but states that woodlot significance will be determined in conjunction with the local Conservation Authority and County of Huron (Huron County, 2018).

	Development Restrictions	**Adjacent Lands**	**Significant Woodlands**	
Huron County	EIS required within or adjacent to natural heritage features. Development and site alteration shall not be permitted in significant woodlands, excluding islands; including significant wildlife habitat. (Huron County, 2018a). "The Huron County Forest Conservation Bylaw 38-2013 regulates all woodlots >0.2 hectares (0.5 acres) and woodlands >1 hectare (2.47 acres)." (Huron County, 2018a).	120m from natural heritage feature (Huron County, 2018a)	≥ 1 hectare	Forest cover will be increased in appropriate locations, where possible. Penalty: "on first conviction, to a fine of not more than $10,000.00 or $1,000.00 per tree injured or destroyed, whichever is greater; and (b) on any subsequent conviction, to a fine of not more than $25,000.00 or $2,500.00 per tree injured or destroyed, whichever is greater." (Huron County, 2013)
Bruce County	For municipalities with >30% forest cover, an Environmental Impact Study shall only be required for developments that propose four or more lots in one development, or that involve the removal of >1.0 ha of forest cover in a single proposal. (Bruce County, 2010, p.10).		Townships <30% forest cover, woodlands ≥ 40-hectares are considered significant. (Bruce County, 2010, p.10).	
Lambton County	EIS Required		≥2-hectares; has interior woodland habitat (100m from forest edge); is the largest woodland by landform or soil type; is the largest woodland patch in the valley land; ≥0.5-hectares in size and is located within 30 m of another natural heritage	Protect the remaining forest cover and encourage expansion and rehabilitation through management and stewardship initiatives with the Natural Heritage System, with specific focus on strengthening primary corridors and linkages (Lambton County, 2017, 8-9).

			feature; is in a highly vulnerable aquifer or significant groundwater recharge area; has woodland diversity (Eco district 7E-2); has an NHIC provincial ranking of S1, S2, S3 (Lambton County, 2017, 8-9, 8-10)	Woodlots are recognized as being a renewable resource that needs to be improved and maintained through proper forest management (Lambton County, 2017, 8-10). Fines for tree removal include maximum $100,000 or $10,000/tree, whichever is greater (Lambton County, 2012).

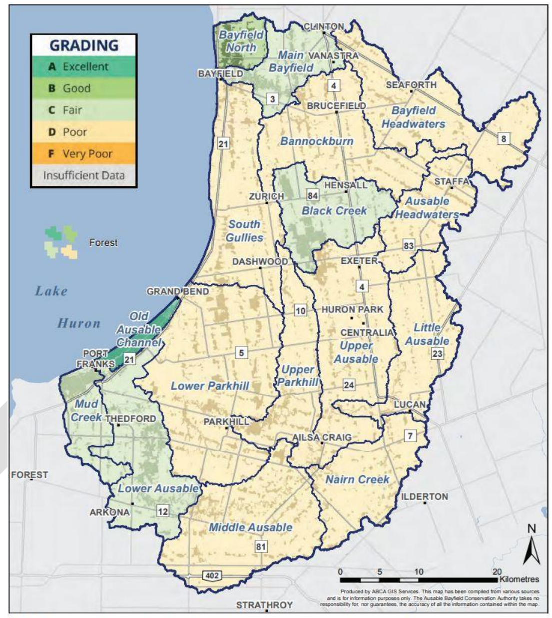
Municipal Zoning Bylaws

Provincial and Federal legislation assists in the protection and sustainable management of Ontario's forest resources. "The Crown Forest Sustainability Act (CFSA) regulates the harvest and renewal of Ontario's forests. The purpose of the act is to ensure the long-term health of Crown forests while meeting social, economic and environmental needs of present and future generations. Forest management in Ontario is subject to the Environmental Assessment Act. MNRF has approval under this act (Declaration Order MNR-75) to conduct forest management on Crown lands in central and northern Ontario." (MNRF, 2016, p. 5). Unfortunately, many of the forested areas along the Lake Huron shoreline are neither crown-property or large enough to be considered woodlands. On the county level, there are some protections in place, including tree cutting bylaws. Huron County's first 'Tree Bylaw' "passed in 1947 with the support of landowners and the farm community who were concerned about soil erosion and water issues that resulted from widespread clear cutting and overharvesting by previous generations" (Huron County, 2018). For the time, this Bylaw was quite modern, but this bylaw has some loopholes. This Bylaw only applies to woodlots larger than 0.5 acres (0.2 hectares), and "does not apply to owners harvesting trees on their own property for personal use (e.g. firewood) as long as the total number of trees per acre is not reduced below the threshold that defines a woodlot in the bylaw" (Huron County, 2018). Bruce County has similar bylaws, including the Forest Conservation Bylaw and Eastern White Cedar Cut Permits (Bruce County, 2004). Due to the lack of forested area in Lambton County, there have been no bylaws found in this region, not contributing to the regulation or preservation of remaining forested areas in this county. These loop-holes cannot stop landowners from removing important, healthy trees or small forested areas without approval, when added up across the shoreline could potentially lead to a significant decrease in healthy forest and canopy cover along the shoreline.

Establishment and enforcement of forest conservation bylaws is a crucial check on forest cover loss. However, there is no provincial requirement for municipalities to enact these bylaws. Since 2006, Ontario's Municipal Act has enabled municipalities to pass bylaws that protect trees on private and public property from removal or damage, but such bylaws are not mandatory, and they vary in restrictiveness and efficacy. Often, the fines for removing trees without a permit are not enough of a deterrent, are not enforced, and considered the cost of doing business. Municipalities may continue to struggle keeping up with inspections and issuing orders (ECO, 2018).

Conservation Authority Regulations

SVCA's *2018 Watershed Report Card* gave the Lake Fringe (Good), Penetangore River (Poor), and Pine River (Poor) watersheds gradings, as well as stating that the SVCA in total has ~27.5% forest cover (SVCA, 2018). The ABCA's *2018 Watershed Report Card* gave the Bayfield North (Good), South Gullies (Poor), Lower Parkhill (Poor), Old Ausable Channel (Old Ausable Channel), and Mud Creek (Fair) watersheds gradings, as well as stating the importance to ABCA; "to value and protect our existing forests, as there is high agricultural productivity and demand for much of the land meaning forest cover may remain limited" (ABCA, 2018).



Map 5: Grade distribution of forest conditions in the Ausable Bayfield watershed

Figure 34 - Forest condition in the ABCA Watershed (2018).

The 2018 *GSCA Watershed Report Card* does not analyse the Lake Huron shoreline, so there is a monitoring gap in this area (GSCA, 2018). The *2018 SCRCA Watershed Report Card* analysed forest conditions in the Lake Huron adjacent watersheds and rated them as; Sarnia (poor), Cow and Perch Creeks (Very Poor), Plympton Shoreline Tributaries (Poor), Lambton Shores Tributaries (Fair) (SCRCA, 2018). Their report card detailed, "A lack of forest interior is a concern throughout the watershed. In many areas only small, fragmented woodlots exist that do not provide undisturbed areas for wildlife" (SCRCA, 2018). The MVCA's *2018 Watershed Report Card* rated the shoreline adjacent watersheds in their jurisdiction and rated them as follows; Eighteen Mile (Poor), North Shore (Poor), Mid Shore (Poor), South Shore (Poor) (MVCA, 2018). MVCA's report card states that "Forest cover is low across all Maitland watersheds, especially in the southeast and along the Lake Huron shoreline… A lack of forest interior remains a concern throughout the area" (MVCA, 2018). Through CA watershed report cards, we can analyse improvements or degradation over time, and through indicators and thresholds they have set, can analyse forest health across the coastal corridor.

STEWARDSHIP TOOLS:

Education and outreach are important stewardship tools for grass-roots, local, and regional governance to use to improve awareness among lakeshore landowners and municipal land managers to reduce impacts to coastal woodlands. Healthy Lake Huron recognized forested lands along the southeastern shores mostly suffer from removal of understory and conversion to urbanized landscapes affecting the forests ability to filter sediment and nutrients (HLH, 2012). They suggest encouraging tree retention and naturalized landscapes to promote water filtration and slope stabilization in the coastal corridor (HLH, 2012). Encouraging landowners to maintain healthy forest areas using stewardship tools such as tree planting efforts and incentive programs are more effective than regulation and attempting to keep up with enforcement.

Tree planting efforts:

Communities in Bloom has been a long-standing NGO that holds tree sales in rural and urban communities within and more broadly around the Lake Huron coast. This program operates on a voluntary basis; landowners from across watersheds are encouraged to participate. Costs of trees through these programs are less than through nurseries, but typically more expensive than Conservation Authority (CA) programs. Some CAs have long-term tree planting programs that plant and facilitate sale of trees in their watersheds. Although specific numbers for the coastal corridor are unknown, historical numbers from our partners with respect to their tree planting programs have been obtained. Ausable Bayfield Conservation Authority have had overwhelming success in their tree planting program year after year, with numbers over the past 10 planting seasons exceeding 155,000 trees in their watershed. These types of tree planting efforts and sales encourage landowners to increase forest cover on private properties or replacing dead or dying trees caused by large-scale invasive species or disease.

Incentive programs:
The Managed Forest Tax Incentive Program (MFTIP), for private land through Ontario gives voluntary participants enrolled a 75% property tax break on eligible forested lands that they manage responsibility and according to site plans approved by the MNRF (ECO, 2018). Groups specific to certain communities, such as the Pine River Watershed Initiative Network have in the past provided trees for free and at a discounted rate to landowners within certain watersheds and areas along the coast to combat tree loss from invasive species, specifically the Emerald Ash Borer. The Potted Tree Ash Replacement Program targets landowners living along the Lake Huron shoreline in Huron-Kinloss township, participants receiving free replacement trees for their property (PRWIN, 2019). This program replaces dead Ash trees with Maple, Cedar, Spruce, Oak, Walnut, Beech and Birch trees (PRWIN, 2019). Fantastic programs like this are funded purely through grant money acquired by interest groups to provide services like this to landowners. The availability of programs like this to provide services such as free trees are enriching to stewardship and education about coastal ecosystems including woodlands. More incentive programs should be encouraged and supported by municipalities, the province, and grant programs.

Agency guides:
The LHCCC has prepared information on coastal woodland preservation and restoration on their website, lakehuron.ca, publicly accessible and free to download. Some of the information included in the recommendations includes:

- Reduce your impact by adopting stewardship measures that reduce impacts to woodlands.
- Preserve trees on property and keep your place natural as possible.
- Use native species when doing landscape planting and keep a vigilant eye out for damaging invader plants, like Garlic Mustard.
- Work with your neighbours and your cottage association in adopting conservation stewardship practices that will benefit the whole community.
- Encourage your municipality to adopt plans and bylaws that strongly protect remaining woodlands, and where development plans are already being considered, to adopt plans and bylaws that encourage future development to adopt conservationist or “new urbanist” designs that result in preservation of natural areas.

Although there are other agencies that are much more comprehensive with woodlot management guides, LHCCC information can get landowners started when it comes to woodlot preservation including some guides created in the past (e.g. the Biodiversity and Water Quality Guide, LHCCC, 2005).

RECOMMENDATIONS

1. Support programs and regulation are important

Protection of significant and supporting woodlands by Municipal governments in Official Plans is a regulatory tool that can be used to guarantee corridors, forest interior, and woodlands are protected. Ensuring support for Environmental Impact Statements as a standard for development within or adjacent to coastal woodlands is important. Wording in all Official Plans should be improved to support the protection of coastal woodlands at all costs, instead of “where possible”. More regulated, consistent support for establishment and protection of corridors to connect forest patches is recommended. Continuing Federal, Provincial, and Local financial support for tree planting programs and tree distribution programs is imperative to restoring areas of coastal woodland on private property. Fostering incentivized stewardship programs such as tree planting, woodlot restoration, and removal of invasive species will be crucial in getting landowners on board with these initiatives. Funding directed towards agencies and groups that complete outreach and programs of this nature at the grass-roots level will be most effective at this initiative.

2. Education and outreach

The Coastal Action Plan recognizes the position of coastal communities relying on agriculture, tourism, and development for their economies. Educating coastal citizens across the study area that coastal ecosystems provide the only buffer for cumulative impacts coming from inland sources is extremely important to improve water quality. Encouraging woodland cover and the ecological services they provide, including expansion of forests to sequester carbon, reduction of energy costs for landowners, water purification services, air temperature regulation, and soil retention to reduce impacts of climate change. Increasing education and awareness of residents and communities within the coastal corridor is important to improve decision making towards development opportunities and land-use change. Efforts for education and awareness can be simply, and inexpensively done through social media, presentations to community groups, educational videos, and best management practice guides. These types of efforts are continuous and must be completed annually to ensure uptake and consistent education.

4.9 RIVER MOUTHS

DEFINITION:
The location of connection between a large river enters Lake Huron is referred to as the River’s mouth. Large rivers provide sediment, vegetation refuse and fresh water from inland sources to feed the lake and shorelines further south.

ECOSYSTEM DESCRIPTION

Rivers are dynamic, continuously adjusting to natural and anthropogenic forces. Changes can be seen throughout the year and over longer periods of time as the river, surrounding landscape, and lake levels change. A river mouth exists at the end of the river- where the waters flow into another body of water- such as Lake Huron. River water is warmer and less dense than lake water (Donnelly, 2013); when the water flows into the lake it causes mixing of the two freshwater systems. This process contributes to lake “turnover” because the mixing of the waters with different water temperatures and densities (Donnelly, 2013). Frequent mixing of two freshwater sources can change the water chemistry, and energy of the area (Donnelly, 2013). As a river flows, it picks up sediment from the river bed, eroding banks, and debris on the water. The river mouth is where much of this gravel, sand, silt, and clay—called alluvium—is deposited (National Geographic, 2018). River mouths distinctively have high rates of sediment deposition where deltas may form, or moving farther out into the nearshore, forming a plume (Donnelly, 2013). Lake Depths, river mouth shape, and wind all determine the timing and extent to where the plume influences the nearshore area (Donnelly, 2013).

Gullies, by their nature, provide the bulk of sediment to the sediment supply feeding the nearshore sediment budget along the littoral zone of Lake Huron. Rivers and Creeks tend to be more mature in their development, longer in length which provides less overall sediment to the lake, per length of watercourse. Gullies are more recent geomorphological features that may still be responding to the last several decades of deforestation and wetland draining associated with the agricultural landscape. As described in Reinders (1989).

Figure 35 - Sedimentation in nearshore from river mouth

"Great Lakes river basins do not drain large continental areas nor do they originate in mountainous areas that supply large sediment volumes. They do provide suspended sediments to the Great Lakes. Due to isostatic rebound, the lower Great Lakes have a submerging coastal area which cause drowning of the stream and river mouths allowing accumulation in the floodplain, while Lake Huron has an emerging shoreline. Emergence causes continual downcutting of the base levels of streams and rivers (and gullies) allowing a continual sediment supply to the littoral drift" (page 13).

River mouths provide habitat for aquatic and terrestrial species that become reliant on this inter-connectedness for breeding, feeding, and nesting. Some Species at Risk including Queen Snake can only survive in river mouth's or adjacent habitats as they rely on a niche feeding source, in this case a single species of crayfish. River mouths are often known for recreational fishing hot-spots; "*Along with the alluvium, a river flushes many different species into the lake or sea. Larger fish, knowing this, wait at the mouth of the river for an easy meal. Thanks to the current of the river, the large fish have a "buffet" of smaller bait fish. This meeting of big and small fish means there is more for people to catch… In the Great Lakes area of North America, for instance, walleye take advantage of the holes*" (National Geographic, 2018). Ravines have a more consistent flow of surface water whereas gullies are more sporadic surface water flow and perhaps only after heavy rainfall and snowmelt.

Although areas of high turnover and change, river mouths on Lake Huron have historically attracted settlers, most communities still present today surrounding most of the large river mouths. Lake Huron river mouth ecosystems have long-supported the creation and sustain of communities because of their importance as marine harbours, sources of water, food and navigation, the provision of fish and wildlife, water quality protection, flood control, and other economic benefits (Donnelly, 2013). Examples of these

Figure 36 - Erosion from river velocity

communities within the Southeastern shores of Lake Huron include Sarnia, Grand Bend, Bayfield, Goderich, Kincardine, Southampton, and Sauble Falls.

River mouths along the coastal corridor range in size and shape, from large, flowing rivers to small river entry points and gully mouths. The coastline between Sarnia and Tobermory has many small to medium sized rivers that are important for fish production and diversity, providing spawning areas for fish and nesting areas for birds. There are a few rivers that meet the credentials for size and impact of a “river mouth”; including the rivers of, Sauble, Saugeen, Penetangore, Pine, Nine Mile, Maitland, Bayfield, North Ausable, South Ausable, Bright’s Grove, Cull Drain, and the St. Clair River. Development of river mouth’s and downstream channels has led to creation of harbours, dredging for boat traffic or shipping, hardening of shoreline, and natural habitat loss. The subsidiary impacts of harbours including dredging, shoreline hardening, and potential for chemical contamination create an abundance of threats towards these fragile ecosystems.

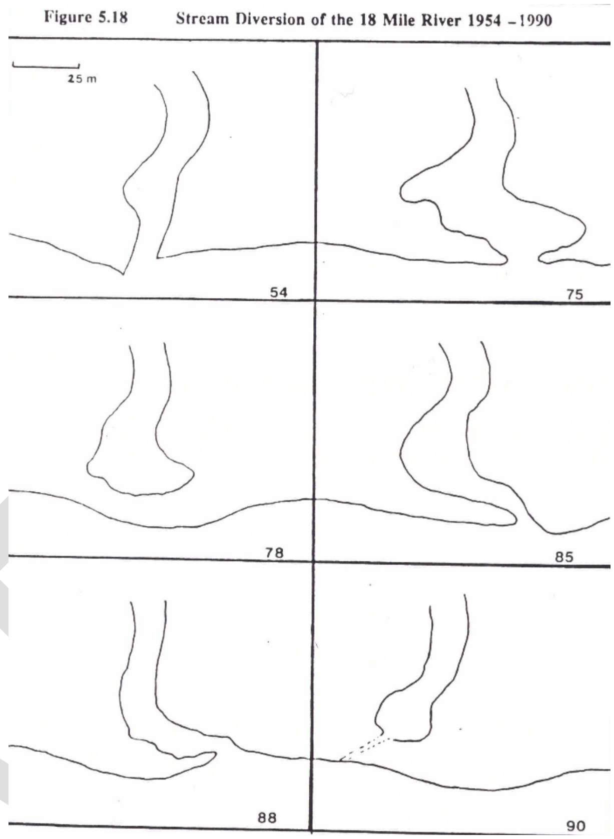


Figure 37 - Illustration of 18 Mile River mouth changes from 1954-1990

Some of the most dramatic reconfigurations of river mouth systems are linked to the creation of recreational boating marinas. Recreational boating marinas have the potential to modify environmental conditions through their influence on hydrodynamics, sediment resuspension, coastal processes and concentrations of contaminants (Rivero et al, 2013). These recreational areas are commonly found in sheltered areas of the waterways, if sheltered locations are not readily available, engineered structures such as break walls tend to be constructed for these purposes. The way marinas change natural systems requires thorough investigation for the successful conservation of local biodiversity.


Figure 38 - Aerial photo of the Bayfield river mouth in 2004.

Orthophoto analysis allowed for the identification of approximately 70 streams and creeks entering Lake Huron between Sarnia and Tobermory. The water near recreational boating marinas has demonstrated to contain higher concentrations of metals such as copper and lead. There are many activities that lead to leaching of chemicals including painting of vessels with antifouling paint, cleaning of pontoons can contribute to poor water quality. *"The size of a watershed can play a crucial role in determining the chemistry of tributary outflow. Larger watersheds can produce higher nutrient concentrations in receiving waters because they generate larger volumes of runoff with greater opportunity for physical and chemical alteration of water as it flows over and through the land toward the outlet"* (DeCatanzaro et al., 2009). Smaller rivers, streams and creeks cause stress to those living near by, as they fluctuate in flow and shape more than large rivers.

Figure 36 illustrates how a small river mouth can change over time. In the case of 18 Mile River, sand collects at the river mouth because there is insufficient wave energy to transport the san along the shoreline as a result of the protection provided by the nearshore shelf (Reinders, 1989). Natural streams vary considerably over short distance and time as discharges fluctuate by season and year. The most important features of a natural alluvial stream are pools, riffles, point bars, the flood plan and bank vegetation.

THREATS AND STRESSORS

River mouths and associated aquatic habitats (e.g. coastal wetlands) experience the highest rates of anthropogenic stress compared to other aquatic habitats. They are among the most populated areas and therefore experience threats from development, invasive species, sedimentation from soil erosion caused by development and mis-guided farming practices upstream, overfishing, drainage and filling of wetlands, eutrophication due to excessive nutrients from sewage and animals' wastes, pollution and damming for flood control or water diversion.

Figure 39 - Sedimentation from river entering nearshore waters

4.9.1 Land-use changes and hardening

Anthropogenic changes made to rivers include: river regulation water storage by reservoirs, diversion of water, bank stabilization, channelization, stream gravel extraction. Indirect stressors to river mouths involve activities such as land-use or land drainage alterations, increasing volume of runoff and sediment (Chandler, 1991). Moreover, vegetation removals, (e.g. woodlands), reforestation, changes in agricultural practices, building construction, urbanization, mining activity, agricultural drainage (e.g. field tile), and stormwater sewage systems will all cause long-term stressors on water in river mouths. Channelization is an engineering practice that involves straightening, deepening, or widening a stream channel. It can involve removal and control of trees and other vegetation, dredging, and will cause an increase in hydraulic resistance and flow velocity. Channelization attempts to improve drainage and minimize localized flooding by shortening the distance water travels expediting the movement of floodwaters downstream (Chandler, 1991). Connectivity losses due to low water levels are exacerbated by physical structures throughout the respective watershed, such as dams and culverts, which impede movement between critical habitats during migration periods and when conditions are less than optimal, e.g. elevated water temperatures, and low dissolved oxygen (ELPC, 2019). Loss in connectivity typically occurs in smaller watersheds. In the main river mouth areas along the southeastern shore, losses in connectivity would only occur in years with extreme low-level conditions in the far inland reaches of the watersheds.

4.9.2 Invasive species and climate change

Natural stressors on river mouths include similar threats posed to coastal wetlands, including invasive species and climate change. Invasive aquatic and terrestrial species can affect river mouths potentially more pronounced than adjacent ecosystems because of the higher concentrations of nutrients, higher water temperatures, lack of cover, and sedimentation. Invasive species such as Eurasian Water Milfoil, *Phragmites australis*, Water Soldier, and Water Hyacinth all pose serious threats to the movement of fish for spawning and feeding grounds, as well as for human recreation. Climate change will modify frequency and severity of storms on the Great Lakes. Therefore, more significant storm surges could impact river mouths causing more damage to their sensitive banks, as well as pulling sediment, nutrients, and vegetation from these areas, carrying them either further upstream or out into the nearshore waters of the lake. This would take any contaminants and stressors within river mouth areas and spread them widely across the shoreline, making the control of invasive species in these areas more imperative than ever.

INDICATORS AND THRESHOLDS

There is a research gap surrounding the ecological health indicators of major river mouths on Lake Huron. Although research about river deltas is common for oceanic rivers, very little scientific information could be found for Great Lakes river mouths. This plan has adapted indicators from the Biodiversity Conservation Strategy to pertain to monitoring health of the river mouths of the southeastern shores. Most indicators reference quality of water of the nearshore zone, and runoff from adjacent land.

Table 18 – River mouth ecosystem indicators identified for the southeastern shoreline of Lake Huron.

RIVER MOUTH INDICATORS IDENTIFIED	THREATS AND STRESSORS
Development	# of marinas and their capacity (e.g. # of boat slips) # of fuel spills per year Runoff mitigation features (rain gardens, bioswales, stormwater management) Garbage management
% hardened shoreline	– Sea walls, Groynes, Jetties, Break waters – Development (e.g. groynes, sea walls, decks, armour-stone)
# of invasive species	– Presence, distribution, population density, scope of work to remove. (e.g. *Phragmites australis*, Spotted Knapweed, Rusty Crayfish, Round Goby, etc.)
Habitat connectivity	– Species at Risk critical habitat – % canopy cover for cold water – Upstream river channelization, road crossings, culverts, dams – Proximity of naturalized habitats nearby
Excess nutrient inputs	– Water quality postings, algae presence – Dredging

CURRENT MANAGEMENT STRATEGIES

CA's in the coastal corridor have regulations to protect rivers and by association, river mouths from development or alteration. In the Ausable Bayfield River watersheds, the *Regulation of Development, Interference* *with Wetlands and Alteration to Shorelines and Watercourses*, provides consistent application to residents of all shoreline areas. In this regulation, "no person shall straighten, change, divert or interfere in any way with the existing channel of a river, creek, stream, or watercourses" (Ontario, 2013). However, in the same document, the regulation grants permission for the CA based on successful permit in writing, with or without conditions, to allow landowners to "straighten, change, divert or interfere with the existing channel of a river, creek, stream, or watercourse" (Ontario, 2013, section 6). As described here, there are a few obvious loopholes for persistent potential developers to alter river mouths, threatening the health or river mouth habitats.

STEWARDSHIP TOOLS:

Literature review for this plan has not found current, Great Lakes relevant, stewardship tools for the best management of river mouths. The gap in stewardship tools available to land managers and private landowners. This is an opportunity for partner organizations to create toolkits of best management practices for municipalities and landowners to use to best manage these areas to be resilient and sustainable to change.

RECOMMENDATIONS

1. Toolkits of best management practices

Toolkits of best management practices should be made and distributed to landowners and land managers across the coastal corridor to provide information about the threats and stressors affecting river mouths, appropriate management methods to be employed, information about river mouth habitats, and legislation and acts protecting river mouth areas. Creating a guide with cohesive information applicable to all river mouths along the coastal corridor would provide guidelines consistent management and accountability of land managers to conform to a set of standards to ensure the health of the coast and nearshore zones.

Number of Habitats per Assessment Unit	
AU	River mouths
1	8
2	9
3	3
4	2
5	5
6	2
7	0
8	2
9	0
10	0
11	0

2. Academic community contributing to research

Baseline research of river mouths on the southeastern shores of Lake Huron would be beneficial to establishing baseline data of water quality, shoreline condition, and species presence. This data could be used to more specifically inform management decisions on these rivers and tributaries feeding into the lake. Engaging the academic community in this research would be mutually beneficial as it would contribute to the education of future land managers as well as support monitoring programs experiencing funding cuts through CA's, municipalities, and NGOs.

4.10 ISLANDS

DEFINITION:

A sub-continental piece of land surrounded by a body of water.

ECOSYSTEM DESCRIPTION

The Great Lakes contain over 32,000 islands, the largest, most diverse collection of freshwater islands in the world (Northland College, 2019). Lake Huron is home to ~25,000 of these islands ranging in size from small, barely visible shoals, to the largest freshwater island in the world; Manitoulin Island (Henson et al., 2010). The exact number of islands and island groups, particularly small, low lying areas is dynamic and dependant on lake-levels. Islands along Lake Huron's southeastern shores consist of different ecosystem types ranging from bedrock and alvars to wetlands and woodlands. Due to their isolated nature, islands tend to vary drastically the northern reaches of the coast, to the south. Some are the exclusive home to rare species while others provide a necessary temporary rest-stop shelter for migratory wildlife. Many of these islands have provided safe refuge for generations of flora and fauna, fostering adaptations that cannot be found elsewhere. Food resources are available in surrounding nearshore waters and the isolation of islands from the mainland provides nesting birds refuge from predators.

Islands adjacent to the southeastern shores of Lake Huron make up ~122 km of the total 965 km of shoreline included in this plan; translating to 12.6% of the shoreline being made of islands. Islands in this analysis all occur within the northern section of the coastline, spanning Assessment Units 6-11. This plan has identified four sets of island clusters: (1) Oliphant Fishing Islands, (2) Stokes Bay Islands, (3) Chantry Island and (4) Saugeen and Cape Croker Fishing Islands. Islands have different physical and biological features depending on where they are located on the lake. Islands along the southeastern shores range from six-hectares to less than one hectare. Many of the islands in this region are less than one hectare in size. This section will expand on the island groups identified, for detailed analysis refer to Assessment Unit 6-11.

ISLAND COMPLEXES ON LAKE HURON

The Oliphant Fishing Islands (OFI) are a chain of islands ranging in size, Cranberry Island (~40 ha), while the smallest islands are no larger than the exposed top of a shoal. Most of Cranberry Island contains cottages which mainly require boat access. The OFI influences sediment transport, shoreline processes, and lake level patterns, acting as wind barriers and wave-breaks, diminishing wave action along Oliphant's shoreline. For this reason, Oliphant's mainland shoreline is dominated by coastal marsh habitats.

Chantry Island (19-ha), located about 1-km off the coast of the Southampton, in the southern portion of the OFI is the only protected island along the southeastern shores, existing as a bird sanctuary, and is recognized as an Important Bird Area (IBA). Chantry Island's Migratory Bird Sanctuary (MBS) boundary extends 183-metres offshore from the high-water mark of the island, which makes the MBS 63-hectares large (CWS, 2019). Environment and

Climate Change Canada (2019) has up-to-date land-use descriptions of Chantry island: The main beach ridge of the island runs the north-south length of the island on its east side. This ridge is ~3-metres high and is separated from the water by a 7-metre wide cobblestone beach. Smaller ridges have formed perpendicular to this main ridge, running westward. Vegetation on the long, main beach ridge is dense and includes Black Willow, Poplar sp., Basswood, Maple sp., Choke Cherry, Red Elderberry and Red-Osier Dogwood. Low ridges running east-west are sparsely treed to the west of the lighthouse, where the land is slightly lower than the beach ridge, there is a dense growth of White Ash along with some Red Oak and a nearby White Cedar/Tamarack complex. The western side of the island is flat with several rocky bays and ponds transitioning into Wet Meadow and which appear to be regularly flooded. The Wet Meadow, composed of sedges and grasses, slopes gently to the east where it merges with the treed area. The area directly around the lighthouse and two old, associated stone buildings are covered in dense growths of Lilacs.

Previous documents claim that Stokes Bay and Cape Croker Islands have little to no unique physical and biological diversity especially when compared to the other islands in Lake Huron (Henson et al., 2010, pg. 88). However, they remain an important part of the shoreline dynamic. According to Victorian Coastal Strategy (2014); small offshore islands play a critical role in supporting bird species by providing rookeries; and because they develop microclimates imperative to some species. Small pockets of woodlands grown on the exposed bedrock providing niche habitat and microclimates required by some species.

Only one company has 'rights' to conduct public tours of the lighthouse. The island sanctuary is primarily reserved for migratory birds; during breeding season the island is home to upwards of 50,000 birds including chicks. Other species that use this island include: Great Blue Heron, Great Egret, Blue Winged Teal, Double-crested Cormorant and more. Chantry Island is the only island on the southeastern shores with protected status.

FLORA AND FAUNA

Islands along the southeastern shores harbor flora and fauna species different from the mainland by virtue of their isolation and varying levels of disturbance. Lake levels, limited migration, and colonial nesting birds (e.g. Double Crested Cormorants) are some documented disturbances (Franks Taylor et al, 2010). More than one-dozen globally rare species have been documented on Lake Huron islands, including Piping Plover, Eastern Fox snake, Ram's-head Lady's Slipper, Hill's Thistle and Western Moonwort (Henson et al., 2010). Four globally rare species endemic to the Great Lakes have been identified– Lakeside Daisy, Pitcher's Thistle, Houghton's Goldenrod, Dwarf Lake Iris and Lake Huron Locust (Henson et al., 2010). Rare plant species documented observations include Sand Reed Grass- a Great Lakes endemic species, and American Beachgrass (a Great Lakes distinct species) (Henson et al, 2010). Predominant ecosystems types include bedrock outcrops, sand plain deciduous forests, and wetlands such as swamps and marshes. In addition, it's common to see cobble shores, mixed beaches and depositional sand beaches shorelines on island habitats. Many islands do not have natural populations of white-tailed deer resulting in abundance of plants that deer find edible such as Canada Yew, creating a vegetation structure that is uncommon on that mainland. There are no known listed species under the Species at Risk Act (SARA), that have been documented nesting on the southeastern islands of Lake Huron. However, species at risk have been observed on the islands. Lake Huron's islands have high biological diversity and complete important ecological services such as suitable habitat and occurrence of fish and stopover sites for birds.

THREATS AND STRESSORS

The island clusters along Lake Huron's southeastern shores are ecologically distinct from one another in their history and cultural significance. They share many of the same threats and stressors, far from shore or close to town, inhabited or naturalized. Islands within this Plan are small and isolated, and therefore have limited documented academic research on the threats facing them. Lake Huron's islands (excluding Georgian Bay), have little or no documented threats associated with them. Although no threats have been specifically documented, we can extrapolate threats to mainland shoreline types to the shorelines of these islands.

4.10.1 Development and protection

Populated islands on the southeastern shores are affected by building densities, of which 14 are considered to have high building densities. Access points for land vehicles can be found on several islands. Some islands are affected by residential and recreational development, and a couple islands are used as agricultural cropland e.g. Chantry Islands (Henson et al, 2010). Due to their isolation islands tend to be free of invasive species however, with more human interaction involving cottage development, tourism and recreation (e.g. ATVs), the risk of invasive species spreading from the mainland increases significantly. The only other group of islands that contain physical diversity are the islands of Dorcas Bay; remaining unprotected but with a much lower threat level than the others. Chantry Island is the only island within the study that has a protected status; considered to have one of the higher threat levels of all the islands on the southeastern shore. None of the islands apart from Chantry Island have development regulation for density or specific regulation about land-use on islands. This vulnerability causes potential for a significant reduction in ecological integrity of the islands in the southeastern shores.

4.10.2 In-direct threats

Other potential threats to island ecological integrity exist, however due to limited academic research, and lack of data availability at the time of analysis, this Plan will not be assessing them. Threats include wind power development, oil and gas exploration and extraction, and chemical spills. Hyper-abundant species on some islands, such as Double-crested Cormorant, or the White-Tailed deer may be perceived as a threat to biodiversity, but this metric is beyond the scope of this analysis (Henson et al., 2010). Climate change threatens islands, through the increase or decrease of lake levels altering the size, and flood area of islands, as well as abuse from more severe storms and reduced ice cover altering the landscape and vegetation on island communities.

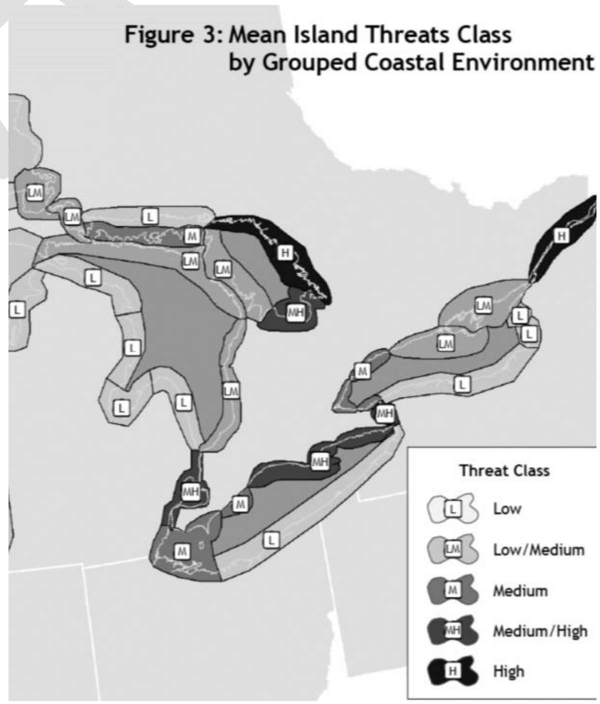


Figure 40 - Summary of island threats (adapted from the Nature Conservancy of Canada).

The Nature Conservancy of Canada (NCC) and the Ontario Ministry of Natural Resources and Forestry (MNRF) conducted a high-level study in 2010 for all the Great Lakes to assess the threat level for major coastlines and islands of Lake Huron. Figure 39 shows the southeastern shores. The entire southeastern shores coastline was classified as Low to Medium threat level; an indication of the size and density of these islands being smaller than other island communities throughout Lake Huron and the Great Lakes.

INDICATORS AND THRESHOLDS

Assessing changes to Lake Huron's islands individually, within their island clusters, and their ecological diversity is important to understand their state of health. Evaluating the amount and suitability of island habitat for species and communities allows researchers to infer success of current management strategies. These assessments focus future conservation efforts toward the most ecologically significant island habitats on Lake Huron that face threats that are not adequately protected (SOLEC, 2011).

Colonial nesting sites on Lake Huron island ecosystems provide necessary breeding habitat for sensitive species. Tracking the number of colonial water bird nests provides an indication of disturbance to the area and suitable habitat for feeding areas (Franks Taylor et al, 2010). These indicators pertain to number of Herring and Ring-billed Gulls; large populations indicate a lack of disturbance to nesting sites and maintenance of suitable habitat in feeding areas (Franks Taylor et al, 2010). Bird monitoring data and mapping have been adapted from partner organizations such as the Canadian Important Bird Areas (IBA), and Bird Studies Canada, supplemented with independent bird monitoring groups within the northern Islands of the Bruce Peninsula (refer to Chapter 6).

According Franks Taylor et al (2010), high populations of white-tailed deer can have significant impacts on vegetation composition and structure on islands. Since most of the southeastern islands are small, they can be susceptible to "over-browsing" because of limited food supplies for their populations. One limitation with this type of indicator is the requirement for frequent field monitoring surveys which involve resources such a personnel and funding. The Lake Huron Biodiversity Conservation Strategy [LHBCS] (2010) has a preliminary assessment concluding high over-browsing for some northern private islands where deer where introduced and fed during the winter season. Whereas, the southern (smaller) islands do not have the capacity to support deer populations.

Assessing building densities can be done using ortho-interpretation as there is no comprehensive data analysis for the southeastern coastline of Lake Huron. Shoreline classification is important as it may impact the land-lake processes affecting ecosystems such as the nearshore zone, wetlands, sand beaches and cobble shorelines. The CAP was able to identify the shoreline classification for through Provincial and Federal data mapping.

The presence and abundance of invasive species was identified as an indicator, considering their ability to intensively impact and alter ecosystems. Increasing human activity on Lake Huron islands intensifies the risk of spreading invasive flora and fauna. Common activities such as four-wheeling, transporting marine vessels to and from the mainland, driving on wetland areas during dry seasons and introducing species unintentionally are other major stressors taken into consideration.

The suite of threats on islands includes the presence of and proximity to pits and quarries, distance to mining claims, road densities (primary secondary and tertiary roads), building densities (number of buildings per island or island complex per square kilometre of island area) and the percent of island or island complex converted to cropland. Islands in Ontario are scored on direct threats that included high-use recreational beach area, recreational dive sites, lighthouses, anchorage sites, boat launches, access site for land vehicles, residential and recreational or cottage use areas, camp and recreation sites, tourism establishment areas, cottage residential areas, cottage residential sites, and building density as well as the presence of aquatic invasive species (Henson et al., 2010, p.12).

Limited research is available for the assessment of isolated smaller islands within the southeastern coastal corridor of Lake Huron. These islands consist of other ecosystems such as the nearshore zone, coastal wetlands and woodlands within their systems. This Plan has adapted indicators that are island specific from the LHBCS (2010). Table 16 provides a summary of the indicators identified by the CAP Steering Committee and associated threats and stressors.

Table 19 - Island ecosystem indicators identified for the southeastern shoreline of Lake Huron.	
ISLAND INDICATORS IDENTIFIED	**THREATS AND STRESSORS**
Abundant species	– Biodiversity decline due to hyper abundant species – Number and productivity of colonial nesting water birds (Herring & Ring-billed Gulls) – Predation on nesting, over-nesting of aggressive species (e.g. Double Crested Cormorants) – Over-browsing index (e.g. White-tailed deer)
Land-use change and development	– Development
Invasive species	– Presence and abundance (e.g. Phragmites australis, Purple Loosestrife etc.)
Building densities	– Development, recreational activities

CURRENT MANAGEMENT STRATEGIES

Less than 10% of Lake Huron's islands have conservation status or designation, and less than 25% of the highest biological diversity scoring islands are protected (Henson et al., 2010, p.24). Chantry Island contains key ecological systems for biological and physical diversity, and is designated a Migratory Bird Sanctuary as well as a Canadian nationally significant Important Bird Area (IBA) supporting species such as Great Egret and Black-Crowned Night-heron. There are a few buildings on this island, increasing its level of threat relative to other islands in this area. The southern cohort of islands along the southeast shores have increased opportunity for threats caused by residential use, recreational use and development, invasive species and lack of protection.

The Great Lakes Islands Alliance is a newly formed group associated with Northland College taking an interest in island preservation and restoration of island communities. However, this agency focuses on larger islands and island complexes, whereas most of the islands in the southeastern coastal corridor are much smaller and less significant than others throughout the Great Lakes. This Plan lends intends to lend further support to the LHBCS (2010) for islands of smaller-scale.

RECOMMENDATIONS

1. Protection and stewardship

Protecting and regulating stressors impacting island environments, significant or not, will ensure the ecological integrity and resiliency of these features to future stressors. Municipalities should, if not already, draft special Bylaw and policy surrounding the regulation of these areas. On the Northern Bruce Peninsula, no CA exists, therefore, it is up to NGO groups such as the Bruce Peninsula Biosphere Association and the municipality to conduct education and outreach to landowners and residents living and visiting island areas.

2. Partnerships with academic community

Improving and building relationships with groups like the Great Lakes Islands alliance from Northland College to monitor and create baseline inventories of islands will be important to monitor their changes over time. Recognising the work and recommendations made through documents such as the LHBCS (2010) provide a starting point for this analysis.

4.11 NEARSHORE

DEFINITION:

Submerged lands and water column of Lake Huron starting at 0-metres in depth (shoreline) and extending to 6-metres in depth not including areas upstream from river mouths and riverine coastal wetlands.

ECOSYSTEM DESCRIPTION

The nearshore zone of Lake Huron where the shoreline meets the water extending to a depth of 6-metres is dynamic and relies on the water levels of Lake Huron to define its boundaries- varying seasonally and annually. Environment Canada's nearshore framework defines the nearshore zone by area of impact where shoreline and watershed influences are observed. For the purpose of the Coastal Action Plan (CAP) assessment, assigning a nearshore depth of 6-metres based on data acquired will define the boundary of the nearshore zone. The nearshore zone differs from the northern Bruce Peninsula to the regions of Sarnia due to substrate type, water depth bathymetry, and adjacent shoreline ecosystems. The extent of the nearshore in Assessment Unit 11 where the 6m nearshore depth maximum occurs closer to the mainland, whereas Assessment Unit 1 has a shallower bathymetric retreat with the 6m depth reaching out farther offshore (Figure 40).

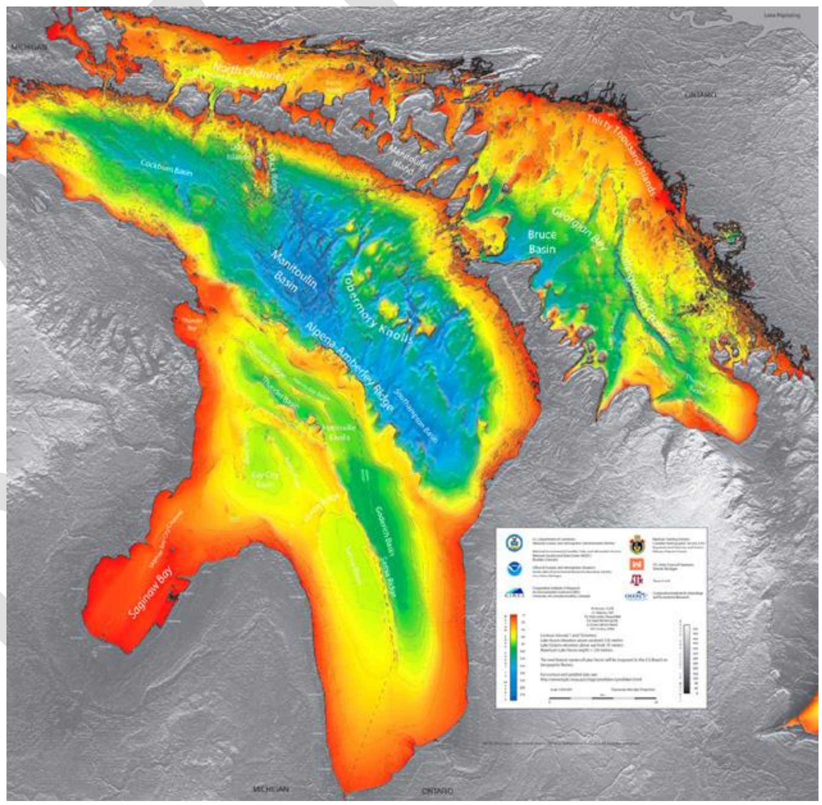


Figure 41 - Bathymetry of Lake Huron

Nearshore zones range in substrate from hard, dolomite shoals and blocks, to sandy, highly erodible substrates in the southern basin. To the north, glacially-scoured limestone bedrock lake bottom is clearly identified in aerial photography. On rocky coasts where recession rates are too small to measure adequately over a few decades, the presence of erosional features such as cervices and shore platforms raises the question of how much of the coastal morphology is inherited from previous interglacial period coastal processes (Davidson-Arnott, 2010).

The nearshore zone is directly influenced by ecosystems adjacent to the shoreline and cumulative impacts from further inland, as well as holistic influences. The most significant ecological process associated with the nearshore is wave action moving towards the shore from the open water offshore, shoaling and breaking as waves move across the lake bottom; inducing wave generated currents transporting sediment on shore, offshore and alongshore (Liipere, 2014). Wave energy and increases in precipitation significantly modify water quality of the nearshore zone. Sediment inputs from rivers, eroding bluffs, and the nearshore bed can be transported along-shore deposited in protected bays allows aquatic vegetation to establish (Liipere, 2014). Wave energy and lake level water fluctuations influence nearshore waters contributing to the dynamic character of this ecosystem (Liipere, 2014).

Most popularly used for recreation such as swimming, fishing, and boating, the socio-economic importance of the nearshore zone to coastal communities is strongly focused around tourism and use, instead of protection. Nearshore water quality has an important role in the health and safety of Lake Huron's coastal communities, with ~1.5 million individuals relying on Lake Huron drinking water, tourism and commercial fishing. Therefore, reducing threats, stressors, and impacts to the nearshore zone is of importance for natural and anthropogenic reasons.

BIOLOGICAL DIVERSITY

Prominent and dynamic interactions occur between the nearshore zone and shoreline ecosystems. Compared to the open water zone of Lake Huron, nearshore zones support a higher richness and diversity of fish and invertebrates (Franks Taylor et al., 2010). The structure and function of the nearshore zone influences several other ecosystem types such as coastal wetlands, woodlands, and river mouths. The CAP nearshore zone analysis includes a variety of substrate types, as well as submerged and emergent aquatic vegetation. This area supports benthic macroinvertebrates (e.g. burrowing Mayflies), fish (e.g. Walleye), spawning habitat (e.g. Walleye, Yellow Perch, Lake Herring), reptiles (e.g. Snapping, Map, Musk, Spiny softshell turtles), waterfowl and shorebirds, and native submerged aquatic vegetation. In shallow nearshore waters there is a high level of diversity of small fishes (>60 species), the majority of which are native to Lake Huron (ECCC & USEPA, 2018, p.38). Populations of benthic invertebrates, minnows, and small fish species using the nearshore and adjacent aquatic habitats for primary breeding zones significantly influence populations of fish residing in offshore waters of Lake Huron relying on these species for food. Biological productivity in the nearshore is often high attributed to associations with coastal wetlands and river mouths (Liipere, 2014).

There are many biological components occurring in the nearshore zone, including a complex food web. Starting with the primary producer's aquatic plant and algae converting solar energy into organic matter, taken up by secondary producers (benthic invertebrates), then getting eaten by small fish, and so-on. Benthic invertebrate communities are often used as indicators of aquatic ecosystem health, most species sensitive to pollution and sudden changes in their environment. Mayflies, Stoneflies and Caddisflies are pollution sensitive, whereas Chironomids are considered pollution-tolerant. Using presence/absence of these species prove essential when assessing nearshore water quality. Most CAs and National Park monitoring programs utilize benthic invertebrate indicators currently.

Gravel and cobble shoreline ecosystems adjacent to nearshore waters act as important spawning habitat for fish species such as Small Mouth Bass, Emerald Shiner, Lake Trout, Lake Whitefish, and others. Typically referred to as 'nursery habitat' cobble substrates can be generally defined as habitat used by young-of-the year fish, acting as adult feeding area (NRHM, 2005). Most nursery habitat can be generally defined as nearshore water depths of 2-metres or less, often associated with aquatic vegetation. Providing protection from predators, nursery habitat is popular for prey species. Predator fish such as Trout and Whitefish regulate prey fish populations and stabilize fish communities and aquatic ecosystems (Liipere, 2014).

THREATS AND STRESSORS

The nearshore zone experiences an amalgamation of stressors from adjacent shoreline ecosystems and land-uses. According to Allan et al (2012), the nearshore zone generally experiences 12-18 stressors- with a maximum of 31. This is concerning from a biodiversity perspective, because roughly 90% of Great Lakes fish and invertebrate species occupy in or rely upon nearshore habitats. Accord to Allan et al (2012), cumulative ecosystem stress is highest in nearshore habitat and is location dependant. The southeastern shores face more cumulative impacts due to higher population densities, intensified development and land-use, limited protection of natural features, along with effects of activities happening northward due to littoral drift along the coastline.

4.11.1 Nutrient and sediment loading

Other concerns for fish habitat in the nearshore adjacent lands such as increased nutrient inputs, sediment discharge, groundwater recharge areas, and increased impermeable surface area on adjacent landscapes (OMNR, 2005). Nutrient contributions from urbanized areas of watersheds and lakeshore development for residential, recreational and other uses can cause impacts to water quality (e.g. phosphorus and nitrogen). Higher levels of phosphorus increase the productivity of lakes producing vegetative matter, leading to exponential algae growth. Impacts are particularly detrimental to low-nutrient oligotrophic lakes, like Lake Huron. Decomposition of aquatic vegetation depletes oxygen (O^2) in the deep waters of the lake- called eutrophication, reducing fish habitat and sometimes leading to fish die-offs. Nutrient loading is of growing concern particularly on stream and nearshore water quality and influences aquatic habitat through NPS pollution from dense agriculture in lake-adjacent watersheds (ECCC & USEPA, 2018). Some aspects of fish habitat depend on groundwater recharge areas which can be indirectly affected by excess nutrient loading from land-based activities.

Augmented, developed landscapes with impermeable surface area affect surface and groundwater quality and quantity, stream stability, and stream flows entering Lake Huron creating inputs of warmer, sediment and nutrient enriched, sometimes contaminated waters (OMNR, 2005). Some agencies consider increased sediment loads entering the lake to be one of the most significant polluters on Lake Huron.

4.11.2 Threats to sustenance

The commercial fishing industry is directly impacted by climate related changes in water quality. Invasive species and oxygen level changes have caused a ~3.5% yield decline per year in the fishing industry across all the Great Lakes (Brenden et al., 2012; ELPC, 2019). Continued spread of *Phragmites australis* northward, is a threat as this plant can change the chemical composition of the nearshore water, reduce fish spawning and feeding grounds, and habitat for other reptiles and amphibians (See other sections within this chapter for further detail).

Many other concerns such as invasive species, climate change, hardening of shorelines, and development are covered in other sections within this chapter, within their respective ecosystem types. Because the nearshore abuts all terrestrial ecosystems, the stressors it faces are a culmination of those inland. Theoretically, if stressors are rectified inland, nearshore water quality and feedback to terrestrial ecosystems will improve.

INDICATORS AND THRESHOLDS

Indicators and thresholds for the nearshore zone were mainly adapted from the 2010 Biodiversity Conservation Strategy for Lake Huron [LHBCS]. Indicators were built upon using the Great Lakes Nearshore

Framework currently underway by Environment and Climate Change Canada. Literature indicates that alteration of natural land cover within coastal ecosystems (e.g. woodlands) may have significant impacts on the nearshore zone, coastal aquatic habitat and water quality (Franks Taylor et al, 2010). The Coastal Action Plan assessment for the nearshore is based on 3-4 indicators using best available data for the respective Assessment Units. For example, erosion and deposition rates are mostly available for the southern regions of Lake Huron where the coastline is actively eroding and being monitored; however, monitoring for erosion rates does not actively or regularly occur in the northern reaches of the coastal corridor where sediments are mainly non-erodible bedrock. Therefore, this indicator will not be applicable to Assessment Units where the nearshore zone is predominantly bedrock. Table 17 provides a summary of indicators identified by the Coastal Action Plan (CAP) Steering Committee and their associated threats and stressors.

Table 20 – Nearshore zone ecosystem indicators identified for the southeastern shoreline of Lake Huron.

NEARSHORE INDICATORS IDENTIFIED	THREATS AND STRESSORS
Land-use change and development	– Percent natural land cover within 2km of shore – Dredging activities – # hardened shorelines permeating nearshore waters (groynes, jetties, docks) – # Tourism locations (e.g. public beaches)
Erosion and deposition rates	– Recreational activities, climate change impacts (more intense storm surges)
Invasive species	– Presence and abundance (e.g. Spiny water flea, Phragmites australis)
Nutrient management	– Malfunctioning septic systems, nutrient runoff (e.g. poor farming practices) – Lake Huron Nearshore Framework monitors presence of chlorophyll using satellite imagery
Species composition (invasive, SAR)	– Invasive species, – Fishing prevalence – Native fish species richness – Spawning habitat quantity and quality

Shoreline hardening is an important indicator and has been used for numerous ecosystems. Shoreline hardening disrupts natural nearshore coastal processes that drive erosion and sediment transport, impacting species composition and richness, along with the extent of habitat available and habitat connectivity. This indicator is a measure of percentage of shoreline protected with hardened structures (e.g. armour stone, rip rap etc.) to help mitigate erosion. Consequences of shoreline hardening is felt locally, among neighbouring properties to that which has been hardened, along with the explicit loss of habitat, as well as disrupting the deposition and accumulation of sediment further along the littoral zone. Shoreline hardening disrupts natural nearshore coastal processes that prevent erosion and sediment transport, and therefore the extent of natural nearshore habitat and community structure of the nearshore zone. Changes to erosion and deposition rates are closely linked to hardened shorelines, where one creates the consequence of another. Literature suggests that alteration of natural land cover may have significant impact on the nearshore zone and coastal aquatic habitat. Land-use in the coastal corridor ranges in a variety of cover from north to south. For specific land-use cover assessments please refer to the assessment units. Wave energy and deposition rates are important indicators of nearshore profiles (Lawrence, 1991). They impact depths, drop offs, sand bars, and shoreline erosion. Lawrence compared low wave energy with gentle nearshore profiles to high energy monitoring stations with atypical concave cohesive shore profile and how much they can change. Deposition rates influence the nearshore profile, and quality of water. Reinders (1989) provides an examination of recession rates for Assessment Units 1-6, and can be found in the Beaches and Dunes section of the Coastal Action Plan.

Assessment of the concentration of priority toxic chemicals in offshore waters is undertaken by provincial and federal agencies monitoring nearshore waters (SOLEC, 2011). This metric is essential in monitoring pollution levels but is excluded from the CAP's scope of work.

Abundance and distribution of aquatic invasive species infers how much native community has been impacted. Gathering up to date GIS data is challenging as this changes every year. The CAP assessment units provide a summary of invasive species that have been observed within the nearshore zone. Nearshore invasives are mostly fauna such as the Sea Lamprey, Round Goby, and the Spiny water flea (amongst others). These organisms are impacting the Lake Huron food web. Assessing species diversity and abundance of aquatic oligochaete communities is important in order to determine the trophic status and relative health of benthic communities in Lake Huron (SOLEC, 2011). Monitoring the spawning and survival of key fish species in the nearshore zone provides estimates on population levels and habitat viability for spawning (Liipere, 2014). Key species identified to study for this metric include Small mouth Bass and Rock Bass (Liipere, 2014).

CURRENT MANAGEMENT STRATEGIES

Ontario has legislation, regulations, policies and programs in pace to protect nearshore water quality, including the Provincial Policy Statement, Great Lakes Protection Act, Environmental Protection Act, Ontario Water Resources Act, Safe Drinking Water Act, Clean Water Act, and the Nutrient Management Act. These acts help regulate what types of development and alteration is permitted in the nearshore zone. Other documents including shoreline management plans from CA's set regulatory requirements for development in nearshore waters and on nearshore adjacent ecosystems. County Official Plans touch on the importance of maintaining programs that, "support and encourage necessary measures and activities to reduce pollution and improve the quality of the water in Lake Huron" (Huron County, 2015a). Environment and Climate Change Canada is currently undertaking a project called the Great Lakes Nearshore Framework which intends to identify the ongoing and emerging threats and challenges faced by nearshore environments on the Great Lakes, as well as potential for activities to protect, restore, and support improving the nearshore environment. Upon completion of this framework, clear actions and best management practices will be described and employed by adjacent land managers on the southeastern shores of Lake Huron.

RECOMMENDATIONS

1. Regulatory consistency

The nearshore zone is an area of extreme importance for all individuals, governments, and agencies working along the lakeshore. This zone easily transports threats and stressors from one area to another, causing fast spread of pollutants, invasive species, sediment, and nutrients. Therefore, working together and having equivalent regulation and bylaws is needed to ensure high water quality for everyone along the southeastern shores. Having regulatory and enforcement consistency will make enforcement easier because all landowners and planning departments will be consistent in their standards.

2. Education and outreach

Although nearshore environments change in substrate and size, best management practices to protect water quality are relative. From an education and outreach perspective, providing education and signage in higher risk areas, such as wetlands, beaches, and bluffs, as well as limiting vehicle access and land-use changes of buffer zones will encourage a coast of eco-conscious citizens.

3. Supporting monitoring programs

Continuing diligent surface water quality monitoring, like that which is done by the Health Units at beaches, and stream water monitoring done by CA's, will enable tracking of changes to water quality across the landscape. More monitoring of the actual nearshore water quality done through CA's or LHCCC's Coast Watcher program will be beneficiary to the study of changes to nearshore water quality. Building partnerships to fill data gaps is important to monitor and protect this shared resource.

4. Incentive programs

Promoting, incentivising, and funding programs for best management practices including septic maintenance and replacements, beach and dune restoration, reforestation of shorelines, and shoreline pollution clean-ups and prevention will all directly support nearshore water quality improvement and protection.

4.12 ALVARS AND BEDROCK

DEFINITION:
"Alvar, a Swedish word, originally denoting the shallow-soiled grasslands on the limestone islands of Öland and Göteland in the Baltic Sea. The word is now applied to naturally open ecosystems found on shallow soils over relatively flat, glaciated limestone (or marble) bedrock, with less than 60% tree canopy cover" (Jalava, 2008).

ECOSYSTEM DESCRIPTION

Alvars in the southeastern coastal corridor of Lake Huron are internationally-recognized for their rarity, distinct ecological character, and exceptional variety of globally and provincially rare vegetation communities and species. Alvar ecosystems are distinctive features on Lake Huron adapted to extreme conditions such as shallow, impermeable sediment types, and weather conditions such as extreme temperature and precipitation schemes, fostering distinctive flora and fauna within the ecosystem. Low-lying alvars were scraped away by ice, wind and water and are now made up of grassland, savanna and sparely vegetated rock barren that develop on flat bedrock, with relatively shallow soils (Reschke et al, 1999). Alvar ecosystems vary by season; in spring, most alvars collect water in shallow pools and bedrock pockets, some areas remaining flooded for weeks (Goodban et al., 1999). By early summer, these pools evaporate, leaving shallow soils to dry and many of the flowering plants to turn brown (Goodban et al., 1999). Alvar ecosystems typically have very shallow soils, ranging from 0-20 cm. The underlying bedrock limits drainage after rainfall, which causes frequent and rapid flooding. Species endemic to alvars, including plants, molluscs and invertebrates are rare elsewhere in the Great Lakes basin. Alvar bedrock pavements, grasslands and savannas of are characterized by a blend of boreal, southern, and prairie species – relics of the cold post-glacial environment and the warmer, drier period which followed. Many species that occur in alvars are disjuncts, far from their normal range but able to survive in shallow soils and harsh conditions. These are often species that have a high degree of confinement to alvar sites.

Alvar ecosystems can look quite different from one another, but there are several key characteristics to identify them. According to Liipere (2014) alvars can be classified by the percentage of established vegetation: Open Alvars include alvar pavements and alvar grasslands (<25% tree cover and <25% shrub cover); Shrub Alvars (<25% tree cover and <25% shrub cover), and Treed Alvars (>25% tree cover) (Figure 41).

The Nature Conservancy of Canada classifies alvars into the categories below, and provides a more detailed description. Figure 41 provides a photographic comparison of the types of alvars found in the Lake Huron coastal corridor.

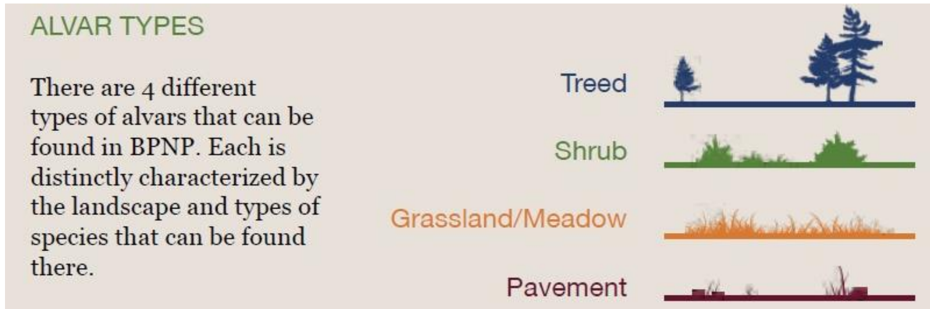


Figure 42 - Alvar types (BPNP, 2019)

Alvar pavement occurs where > 50% of the bedrock is exposed, and has less than 2cm of soil. Alvar shrublands have moderate to high cover of shrubs and a low percentage of tree cover with the trees appearing stunted. Alvar savannahs are the most uncommon alvar type, with 10-25% scattered tree cover that provides more range of habitat for wildlife, including birds and mammals, compared to other alvar types. Grassland alvars support grasses and sedges, with vegetation more meadow like and continuous, with a soil depth of 1-10cm. Lastly, wooded alvars have the highest tree cover in the community, are often adjacent to other alvar types and tend to be the oldest; therefore, have the highest succession rates. Alvar vegetation communities are highly influenced by periodic flooding and severe drought. According to Reschke et al (1999), most hydrological studies found a significant correlation between soil moisture conditions and vegetation types. Most flooding occurs during March, April, May, and into June, then again from late September to November (Reschke et al., 1999). Alvar grasslands are in the wettest, seasonally flooded areas (Reschke et al., 1999).

Within the southeastern coastal corridor of Lake Huron there are approximately 179 identified alvar sites. Interestingly, approximately 8 of the alvars within the coastal corridor occur on islands off the Bruce Peninsula (Liipere, 2014, p.34).

Figure 43: From left to right: alvar pavement, alvar shrubland, alvar savannah, alvar grassland, alvar woodland. Photos provided by Todd Norris and the Nature Conservancy of Canada (NCC).

Geology:

Most of Lake Huron's alvars occur on shallow, easily eroded limestone or more durable dolostone bedrock. This bedrock is part of a stratigraphic sequence from the Devonian, Silurian, and Ordovician periods that commonly underlay alvar sites (MSU [2], n.d.). Different bedrock produces specific surface weathering and erosion patterns, including cracks and crevices, in the local topography. For example, dissolution of limestone by mildly acidic water has created fascinating features, such as small circular holes (pitting), in sections of the Lake Huron shoreline (Parks Canada, 2017). Limestone and related rocks vary widely in their hardness and the rate at which they weather into soil. Bedrock is changed through ice seeping into cracks, expanding, contracting, cracking stone and breaking down bedrock into smaller and smaller pieces. Dripping water hollows out stone, not through force but through persistence (Reschke et al., 1999). This is very different compared to the sand beach and dune shorelines in the southern Assessment Units, where the ecosystems are highly influenced and shaped by changes in lake levels and wind action. These factors, in addition to local climatic conditions, may contribute to differences in vegetation communities found on alvars (Reschke et al., 1999). Geological forces and features influence types and distribution of plant communities (Fyon, 2009). Limestone and dolostone alvar ecosystems are very alkaline and low in nutrients. These harsh geological conditions combined with a limited growing season characterized by flooding and intense sunlight allow only highly adapted plants to thrive.

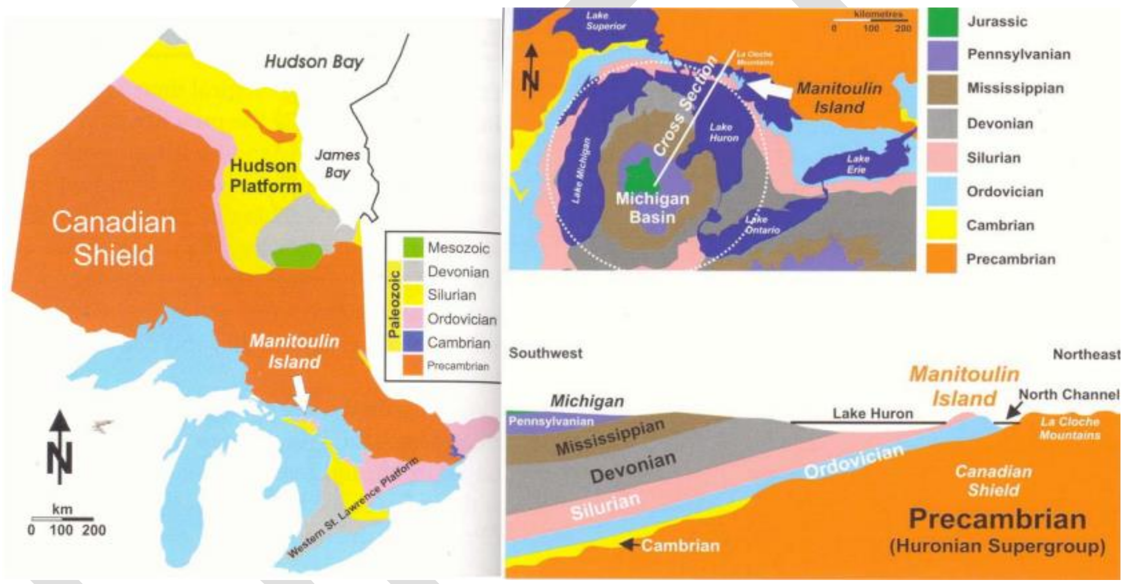


Figure 44: Geology of Ontario map. (Fyon, 2009).

BIOLOGICAL DIVERSITY

Alvars are recognized for their distinctive flora and fauna, supporting a variety of plants including uncommon wildflowers, mosses and lichens, grasses and sedges, and even some stunted trees (Jalava, 2008). Alvar communities command interest because of their rarity, distinctive character, and rare species. Many species are endemic to the Great Lakes region, and rare provincially, nationally or globally. According to Jalava (2008), there are at least 22 vascular plant species, 4 species of lichens, 5 mosses, 4 reptiles, 7 molluscs and numerous insects found on the alvars of the Bruce Peninsula that are globally or provincially rare and listed under the Species at Risk Act (SARA). For example, Lakeside Daisy and Dwarf Lake Iris are found only in the Great Lakes region and are globally rare (Henson et al., 2010). Ram's-head Lady slipper, Cooper's Milkvetch, Laurentian Fragile Fern and Houghton's Goldenrod are also globally rare (Henson et al., 2010). Gattinger's Purple False Foxglove is extremely rare in Ontario and is designated as endangered in Canada (Henson et al., 2010). Overall, 43 plant species regarded as rare in Ontario occur on alvars (Catling and Brownell, 1995). Almost all types of alvar communities are considered globally imperiled or threatened (Reschke et al., 1999). In addition to vascular plants, alvars support at least 62 algae species, 58 moss species, and 52 lichen species on the Bruce Peninsula according to Liipere (2014).

Some rare animals found in alvars include Eastern Massassauga Rattlesnake, Eastern Fox Snake, Mottled Duskywing and several endemic land snails (Henson et al., 2010, p.8). Alvars are particularly remarkable for their diversity of invertebrates. Rare butterflies in the Great Lakes region can be found on alvars; as well, some 26 species of land snails thought to be new to science have been found on alvars and are in the process of being inventoried and studied (Goodban et al, 1999). Though they are not restricted to this ecosystem, these species use alvars for parts of their life cycle. For example, the deep crevices and crack of alvars may be used by snakes, bats and rodents for foraging and nesting (Liipere, 2014). Alvars, although appearing barren, are extremely important to these species, therefore, the preservation of this habitat is essential to the survival of the species.

THREATS AND STRESSORS

Many alvars in the coastal corridor have protected status by governments and non-governmental organizations, however they still face several threats and stressors. Overgrazing from pastured animals has been identified as posing the biggest threat to alvars through removal of vegetation from the shallow soil overlay (Huron County, 2006). Threats to alvars include resource extraction activities, land-use change and development, recreation, predation and invasive species, and climate change.

4.12.1 Resource extraction

Quarrying, development and recreational activities continue to be of concern, particularly those close to urbanized areas. Limestone bedrock is attractive to quarry developers because it is readily accessible for quarrying as it is close to the surface and produces desirable building products (Henson et al., 2010). Seven (7) quarries exist across the Bruce Peninsula supplying stone for sale for building projects. Impacts of these specific quarries is unknown.

Logging of mature trees from alvar woodland communities can significantly alter the vegetation structure of a site. Some alvar areas have been used as skidways and log assembly areas, resulting in serious damage from ruts and debris accumulation. Establishment of conifer plantations and Christmas tree farms have historically devastated some alvar habitats.

4.12.2 Land-use change and development

Urban and rural development includes construction of houses, cottages, incompatible agriculture or industry on alvar habitat, and building or widening of roads (MSU [2], n.d.). Construction on alvars is an ongoing threat as these areas become more popular for seasonal residence. Shoreline alvars are especially at risk of development on the southeastern shore as this is a desirable location to build a seasonal or permanent dwelling because no significant land clearing is necessary (MSU [2], n.d.).

Intensive grazing by cattle can result in the loss of sensitive native species and the introduction of non-native species such as Common St. John's-wort and Common Mullein. Overgrazing or over browsing, that can occur by livestock and wildlife, including deer, can impact alvar species and composition (MSU [2], n.d.). Although this stressor does not occur widely across the coastal corridor and is focused mostly on inland alvars, it is worth mentioning because of the presence of cattle farming within the Ferndale flats.

Land-use changes adjacent to alvars pose a threat to alvar hydrology in two ways: (1) Spring freshet waters that flood the alvars are derived from a deeper groundwater source with an off-site recharge area, a change in the amount and timing of water recharge can alter the natural moisture regime (Reschke et al, 1999); (2) Off-site land-use changes may cause increases in surface water flow into an alvar site during normal times of drought (Reschke et al, 1999).

4.12.3 Recreation, predation and invasive species

Increases in seasonal and permanent shoreline residents parallels a threat of increased disturbance through recreation. Disturbance by motorized vehicles (e.g. ATVs, dirt bikes) and cyclists using alvars is incompatible recreational use causing trampling of vegetation, soil erosion and changes to drainage regimes (MSU [2], n.d.). The flat, open terrain and remoteness of some alvars attract trail bike, off-road truck, and ATV enthusiasts, whose vehicles cause ruts that disrupt shallow soils causing changes to critical water flow patterns. These changes create conditions and opportunities suitable for the invasion of exotic species.

Alvar vegetation is vulnerable to ornamental stone removal; bonsai and orchid collecting; and trampling by pedestrians. Removal of stunted old growth cedars and other trees by bonsai collectors is a growing threat to alvar environments. Predation of rare vegetation and harvesting of showy and rare flora such as orchids and iris species is becoming a serious management and enforcement problem. Introduction of invasive and non-native species is likely to increase with more 'traffic' to alvars. Species such as Eurasian grasses, including Timothy and Kentucky bluegrass, Phragmites, and Purple Loosestrife out-compete native species and change habitat composition. An array of non-native and invasive plants and animals have become established in Great Lakes alvar communities. Species most challenging and costly to remove include Common Buckthorn, Honeysuckle Shrubs, Dog-Strangling Vine and Mossy Stonecrop.

4.12.4 Climate change

According to the Environmental Law and Policy Centre (2019) bedrock shorelines on Lake Huron composed of limestone and dolostone will, for the most part, not be significantly affected by climate change over the next 100-years. Each alvar ecosystem type has its own balance of wetness and dryness, playing a crucial role in alvar hydrology and soil moisture regimes (Reschke et al, 1999). Threats to alvar hydrology can come from within their site boundaries as well as beyond. Climate change will alter precipitation frequency, intensity, and growing season determining which species thrives or can survive in alvar communities, thereby changing the basic vegetation composition in alvar communities.

Additional indirect threats to recovery of alvars and their component species include lack of public awareness of the ecological significance of alvars, and knowledge gaps relating to the biological needs of species at risk using alvars (Jalava, 2008).

INDICATORS AND THRESHOLDS

The ecosystem services provided by alvars, as well as their global rarity, increases the imperative to protect their presence everywhere, not specifically in the coastal corridor. Table 18 provides a summary of the indicator identified through literature research, along with the support and guidance of the CAP Steering Committee members.

Table 21 - Alvar ecosystem indicators identified for the southeastern shoreline of Lake Huron.	
WOODLAND INDICATORS IDENTIFIED	THREATS AND STRESSORS
Land-use change and development	– Aggregate mining – Development (e.g. building and road construction) – Recreational damage (e.g. ATVs) – Over-grazing
Invasive species	– Presence and abundance (e.g. Eurasian grasses, Timothy and Kentucky bluegrass) – % of Rare, Native Flora and Fauna
Protection	– Exist in a protected capacity (park, reserve, etc.). – Privately owned – Stewardship requirements

Mapping and inventorying the extent of alvars along the southeastern shores of Lake Huron provides a baseline for future research. The Alvar Recovery Team (2010) stresses the importance of maintaining total extent of alvar types across their range. Furthermore, this indicator will allow land managers to assess changes over time. Owing to their rarity, it is important to maintain or increase protection of alvars within the coastal corridor.

Liipere (2014) identifies indicators focused on the condition of alvars, encompassing a variety of attributes within alvar ecosystems including the level of historic and current disturbances such as abundance of non-native and invasive species, livestock grazing, logging, burning, trail and road development, quarrying, and buildings present. These indicators can only be assessed by doing a field assessment. Though this indicator will not be used within CAP assessment due to limitations of available data, it is important to address.

A field study by Jalava (2010) indicates the condition of the alvars of the Bruce Peninsula are in "good order". However, impacts from off-road vehicles, logging machinery, and non-native species were observed at some sites while others face potential impacts from encroaching residential development.

CURRENT MANAGEMENT STRATEGIES

The majority of alvars in the coastal corridor are on privately owned land, therefore are not receiving monitoring as frequently, if at all, by ecologists or land-use planners. Several landowners are participating in research projects to further study alvar ecology and management decisions; others allow access to naturalists and scientists to gather field data (Goodban, 1999). Working groups, recovery teams, and non-profit groups seem to be leading the charge on management strategies and protection of sensitive alvar environments within Lake Huron's basin. The International Alvar Conservation Initiative and Alvar Working Group is a collaborative effort to provide unified, consistent approaches to understanding and evaluating alvar ecosystems, and developing basin wide strategies to ensure their protection and stewardship. Major funding for the Initiative was provided by the Great Lakes Protection Fund, the C.S. Mott Foundation, The Nature Conservancy's Rodney Johnson Stewardship Endowment Fund, the U.S. Environmental Protection Agency Great Lakes National Program Office, and in-kind and financial contributions from State Natural Heritage Programs, the Ontario Natural Heritage Information Centre (NHIC), Couchiching Conservancy, and other government agencies and non-government organizations (NGOs). Similarly, the Manitoulin Island Alvar Ecosystem Recovery Team (MIAERT) has been developing an ecosystem-based recovery strategy for alvar environments. The MIAERT includes members from various disciplines and levels of government, as well as concerned landowners and the research community. Their ecosystem-based approach to developing a recovery strategy considers relationships and links between communities, species, and ecosystem processes and services to deliver strategies that will enhance the natural ecological features sustaining alvars (Jalava, 2008). Managing human impacts and activities on and adjacent to alvars is an integral consideration to the recovery strategy that MIAERT is forming.

RECOMMENDATIONS

1. Continuing habitat health assessments

Using baseline studies completed by Jalava (2008), and MSU [2], continuing bi-annual assessment of ecological integrity and presence of threats and stressors to alvar environments will ensure proactive management of invasive species, development, and incompatible recreation uses. Inventorying species using alvars will determine if species ranges are changing throughout time due to other stressors such as climate change.

2. Outreach, Education and Stewardship

Through public consultation on ecosystems for the Coastal Action Plan, alvars were often unknown or misunderstood. More education and outreach on the importance of alvars could be done to increase awareness of their importance and requirement for special treatment and preservation. The majority of alvars within Lake Huron's coastal corridor are privately owned and overlap cottage communities. Therefore, private stewardship and conservation strategies hinge on the knowledge and experience of each individual landowner. Increasing private stewardship is an essential means of conserving alvar habitats. Landowners can make important contributions to alvar conservation by restricting overgrazing preventing the use of ATVs, and by minimizing other disturbances such as invasive species removal.

1. Mediating tourism and land-use practices

Alvars can serve as an ecotourism attraction, bringing economic benefits to local communities. For example, wildflower displays on the Marblehead Peninsula alvars prior to quarry development attracted crowds of individuals. Currently, sites on the Bruce Peninsula are very popular with naturalists and photographers, and other alvar locations such as Manitoulin, Carden Plain, and Chaumont Barrens are experiencing increasing visitation (Reschke et al., 1999). Organizations such as the Bruce Peninsula Biosphere Association, government agencies such as The Municipality of Northern Bruce, Parks Canada and First Nation communities have potential to work directly with private shoreline property owners to develop a long-term conservation strategy that blends conservation with recreation. Strategic assistance by provincial, national and international groups would support these strategies with funding and expertise.

Number of Habitats per Assessment Unit		
AU	Alvars	Total Area (ha)
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	9	55.29
7	32	71.37
8	15	10.66
9	68	86.27
10	54	101.72
11	1	0.48

4.13 SUMMARY OF COASTAL ECOSYSTEMS

Coastal ecosystems existing on Lake Huron's shores are often unknown or misunderstood by residents and visitors to the coast. The underestimation of their importance and the ecosystem services they provide feed into the mismanagement of these resources. Education, outreach, and stewardship initiatives will bridge the gap, and foster a coast of eco-conscious caring citizens willing to protect, restore, and enhance these rare and sensitive ecosystems.

Analysis of coastal ecosystems across the coastal corridor of Lake Huron's southeastern shores has shown a continuity of the threats and stressors existing across all ecosystems. Lake Huron's water quality is a holistic representation of the choices made and land-uses in effect abutting nearshore waters. This concept and realization will be needed to inform current and future planning decisions.

Ecosystems exist across political and jurisdictional boundaries, properties, and countries. Partnering across disciplines and cooperation among land managers is imperative to complete restoration and protection programs in coastal habitats. Becoming resolute in enforcing existing regulation and re-designing existing bylaws to reflect future stressors and adapting to ensure resiliency in coastal communities is of utmost importance.

CHAPTER 5: COASTAL THREATS AND STRESSORS

A threat, or stressor, is an action, an item, an individual or group of people or things that causes strain or damage to an ecosystem, in this case, coastal habitats. Stressors, and threats are caused both by anthropogenic and natural causes across aquatic and terrestrial zones of the Lake Huron coastal corridor. In other Canadian Lake-wide Action Management Plans, threats to biodiversity included invasive species, climate change, dams and barriers, atmospheric deposition, coastal development, incompatible land-use, resource extraction, shoreline alterations, artificial drainage, high intensity visitation, and non-point source (NPS) pollution (ECCC & USEPA, 2018; Liipere, 2014). Coastal land managers need to consider the temporal (time), spatial (space), quantitative (amount of people), and qualitative (type of activity) aspects of management. A simple adjustment to one of these categories can rectify many different management complications (Williams & Micallef, 2009).

Determining where threats are greatest (e.g. where they overlay sensitive areas or species, or those which cause the most irreversible damage), enable land managers to plan restoration or mitigation efforts to protect natural features and ecosystem services. Other studies done in the region have utilized new methods for efficiently completing restoration investments through quantifying and mapping cumulative effects of stressors (Allan et al., 2012, p.372). Stressors and threats are dissected and recommendations provided for mitigating overall effects to coastal ecosystems.

The 2017 CAP Questionnaire asked 256 respondents which threats and stressors were of concern to them, and to lake health. Chart 9 Illustrates the responses. The respondents of this questionnaire ranged from general public, to lifetime shoreline residents, to land managers, to academia; Therefore, these results reflect a collective opinion of the threats of concern to Lake Huron's southeastern shores.

Threats of concern to respondents included invasive species, point and NPS pollution, new development, and shoreline hardening. Other studies on the Great Lakes have denoted stressors and threats to coastal ecosystems aligning with those identified through the CAP. For example, The Great Lakes Stress Index, developed through the Great Lakes Assessment and Mapping Project (2012) identified 34 stressors placing them into 7 categories: aquatic habitat alterations, climate change, coastal development, fisheries management, invasive species, NPS pollution and toxic chemical pollution were a few (ECCC & USEPA, 2018). This stress index uses % artificial shorelines, road density, building density, % natural land cover on coast, and natural land cover in the watershed as indicators and thresholds (ECCC & USEPA, 2018). Other literature providing indicators and thresholds include Bruce County's new tourism strategy defining impacts from tourism to coastal environments: unmanaged tourism growth, development of low-cost free attractions, increased negative impacts of visitation (traffic, litter, water quality), changing visitor characteristics and needs, and degradation of assets and reputation (Twenty31, 2017, p.25).

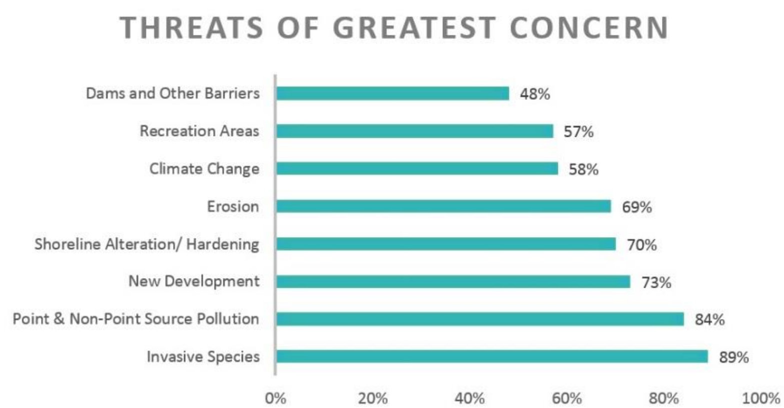


Chart 7 - Responses from 2017 CAP questionnaire on threats of concern

Combining indicators from across literature will provide a holistic representation of the threats and stressors affecting coastal ecosystems.

Federal environmental agencies from Canada and the United States have developed Lake-wide Action Management Plans (LAMPs) for all 5 Great Lakes. LAMP's create targets to assess, restore, protect and monitor ecosystem health, to improve the water quality of these shared lakes (ECCC & USEPA, 2018). Lake Huron's LAMP contains a rating criterion used in their methodology to assess the scope, severity, and irreversibility of threats and stressors affecting coastal ecosystems (ECCC & USEPA, 2018). Rating criterion methodologies are encouraged through the broad Coastal Action Planning process, as seen in work such as the LAMP's (ECCC & USEPA, 2018). LAMP's are consistent among all Great Lakes per the scope of the Canada-United States Collaboration for Great Lakes Water Quality; Therefore, the Lake Huron Coastal Action Plan will utilize the threat rating criteria developed by this group of experts to be consistent in methodology.

Rating criteria are separated into 3 groups; scope, severity, and irreversibility, with rating systems falling on a scale of very high, high, medium and low threat level. An adaptation of the threat rating criteria is as follows (ECCC & USEPA, 2018);

- **Scope:** The proportion of area reasonably expected to be affected by the threat within 10 years given continuation of current circumstances and trends:
  - **Very High:** Threat is pervasive, affecting the ecosystem across 71-100% of its occurrence.
  - **High:** Threat is widespread, affecting the ecosystem across 31-70% of its occurrence.
  - **Medium:** Threat is restricted, affecting the ecosystem across 11-30% of its occurrence.
  - **Low:** Threat is narrow, affecting the ecosystem across 1-10% of its occurrence.
- **Severity:** The level of damage and degree of destruction reasonably expected to occur within 10 years or three (human) generations given continuation of current circumstances and trends:
  - **Very High:** Threat is likely to destroy or eliminate the ecosystem by 71-100%.
  - **High:** Threat is likely to seriously degrade/reduce the ecosystem by 31-70%.
  - **Medium:** Threat is likely to moderately degrade/reduce the ecosystem by 11-30%.
  - **Low:** Threat is likely to slightly degrade/reduce the ecosystem by 1-10%
- **Irreversibility:** The degree to which the effects of a threat can be reversed and the habitat restored to pre-threat conditions:
  - **Very High:** Effects of threats cannot be reversed, and it is very unlikely the ecosystem can be restored, taking +100 years to achieve pre-threat conditions.
  - **High:** Effects of threats can technically be reversed and restored, but impractical due to time and money constraints, taking 21-100 years to achieve pre-threat conditions.
  - **Medium:** Effects of threats can be reversed and restored with a reasonable commitment of resources, taking 6-20 years to achieve pre-threat conditions.
  - **Low:** Effects of threats are easily reversible and restoration is easily done at relatively low cost within 0-5 years to achieve pre-threat conditions.

Threats and stressors to coastal ecosystems on the southeastern shores of Lake Huron are analysed against this threshold rating criteria to determine level of threat and importance for action.

5.1 HABITAT LOSS AND DEGRADATION

Habitat loss and degradation is one of the biggest threats facing ecosystems across southern Ontario through land-use changes and influences from threats and stressors. Through natural processes, Great Lakes shorelines retreat at various rates through coastal processes. However, land-use change and other anthropogenic (human) factors contribute to habitat loss and degradation (USACE, 2003). Years with high lake levels prompt added concern by landowners and land managers as terrestrial coastal environments are reduced. Natural fluctuations and reductions of habitat through coastal processes such as erosion and lake level fluctuation will continue to occur, and potentially increased due to human induced alterations. Habitat loss and degradation caused by anthropogenic influence will be analysed alongside natural stressors, and include land-use change and development, habitat fragmentation and invasive species.

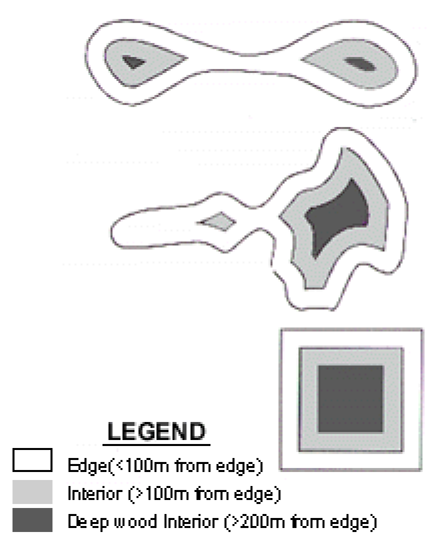
5.1.1 HABITAT FRAGMENTATION

Ecologists attribute habitat fragmentation as the most serious threat to biological diversity and the primary cause of extinctions in North America (USDA, 1999, 2-1). Habitat fragmentation occurs when cohesive ecosystem areas are broken up into smaller isolated patches of habitat through development and land-use change (USDA, 1999, 2-1). Fragmentation threatens coastal ecosystems by diminishing interior habitat and increasing edge habitat, isolating less-mobile species, increasing potential for invasive species, and lack of corridors for species movement. On Lake Huron's coastal corridor, there are various stressors influencing fragmentation including agricultural expansion, urban and industrial development, and transportation corridors. Fragmentation on the southern portion of the shoreline is mainly caused by expanding urban-style development, whereas the northern portion of shoreline is experiencing transportation corridor expansion, industrial development, and concentration increases in areas used by the tourism industry.

Interior and Edge Habitat:

The 'patch-work' nature of shoreline ecosystems contributes to increases in edge habitat, and reduction of interior habitat. As ecosystems become fragmented, habitat parcels are reduced and edge habitat permeates smaller patches entirely, leaving no interior habitat (Figure 44). Edge habitat is defined as the area within 100-metres from the edge of an ecosystem (Liipere, 2014; Huron County, 2018). Structure and function of edge habitat are inherently different from those in interior habitat, and as a result, these areas tend to support a different range of species (Liipere, 2014). Although edge habitat increases the number of generalist species, it is not suitable habitat for specialist species requiring interior habitats for breeding and nesting (Huron County, 2018). Organizations across the coastal corridor have made efforts to monitor interior habitat of woodlands and wetlands. For example, 2% of the forests in the south gullies' region of the ABCA watershed is forest interior. Although this metric is calculated, no threshold or minimum forest interior is defined. Although contiguous patches are preferable, smaller patches of natural woodland cover closely spaced can serve as stepping stones for species movement (Huron County, 2018). Lack of interior habitat is a concern across the southeastern shore in wetlands, woodlands, and alvars.

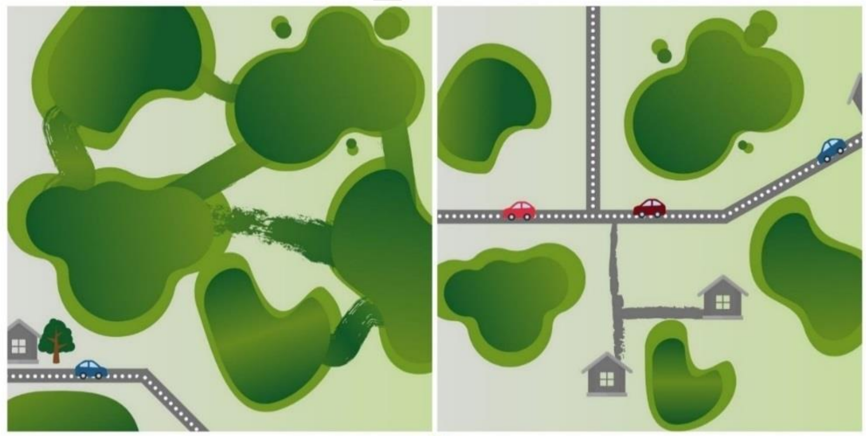
Figure 45 - Edge effects in ecosystems



Species Mobility & Habitat Corridors:

Fragmentation isolates species into smaller communities. For one species, this 'island effect' can begin to cause genetic diversity between patches, but reduce genetic diversity within each habitat fragment, making the population more susceptible to threats (USDA, 1999). Reduction in immigration of species from patch to patch is most common in small species with limited movement zones and vegetation species with lower rates of seed dispersal zones. As distances between patches increase, so does the ability of species to move between patches without connecting corridors. As rates of immigration among fragments decrease, "factors like inbreeding and catastrophic disturbances causing extirpation (e.g. Emerald Ash Borer) can cause the number of species within a patch to decline over a long period of time" (USDA, 1999, 2-4).

Megafauna species such as Black Bears and White-tailed Deer require contiguous patches of sheltered habitat to protect themselves from threats such as hunting and to provide adequate territory for mating. If habitats continue to be fragmented, amount of critical habitat required by mega fauna is reduced, negatively impacting population numbers. More gaps between habitat patches, especially those with road crossings, increase potential for vehicle/animal interactions, reducing human safety and impacting species populations. Therefore, maintaining and establishing corridors between habitat patches is necessary to preserve or improve wildlife populations, reduce potential for vehicular accidents between animal and human, and allow for the transport of genetic gene pools between habitat fragment.



Connected large forest patches: corridors, protected area for fauna

Fragmented small forest patches: no passages for wildlife more human impacts

Ecosystem corridors not only provide 'highways' for flora and fauna to move between ecosystem fragments, but also perform important ecological functions including habitat, filters and sinks for pollution, nutrients, and water, and climate-modifying services (USDA, 1999). Linkages are important for floral and faunal dispersal; most seeds (dispersed by wind), can travel up to 100m. In areas where connecting ecosystems do not exist, clusters of natural areas spanning a range of habitats located close together support a diversity of ecological processes. Plant community structure within corridors can be simple or complex. A complex vegetation structure consists of a range of species with a full canopy, sub canopy and ground layer, such as a gully with forest cover or a coastal wetland swamp. A simple vegetation structure would consist of a smaller diversity of species such as a thin windbreak. Corridors created after fragmentation may or may not be as successful at fulfilling ecosystem processes as corridors left through land-use changes around original ecosystem fragments. However, both provide services to species moving between fragments providing protection and habitat. Presence of habitat corridors has proven so integral that land managers use presence and state of corridors as an indicator of overall ecosystem health.

Potential for Invasive Species:

Increases in edge habitat, and permeation of interior habitat by roads and pathways increase the area invasive species can enter habitats. Unfortunately, invasive species thrive on disturbed land, fragmenting habitats that are much more susceptible to invasive species introduction (OISAP, 2019). As discussed in the next section of this Plan, invasive species out-compete native species putting them more at risk of extirpation and habitat change. Invasive species terrestrially move through the landscape quickly through runoff water movement, on tires of vehicles, through transportation of wood and equipment, trail use, and horticulture. Emerald Ash Borer, and Asian Long-horned Beetles were introduced to Ontario through firewood transportation and wooden shipping pallets (OISAP, 2019). Seeds of invasive plants cling to clothing, tires, boats, and pets, once dropped along a newly disturbed habitat thrive quickly often creating a dense mono-culture in the previously undisturbed area (OISAP, 2019).

5.1.2 INVASIVE SPECIES

Aquatic and terrestrial invasive species exist in the coastal corridor of Lake Huron. Invasive species are typically generalist, meaning they thrive in many different ecosystems. Luckily, many of these species are monitored and treatment with population control is occurring through multiple levels of government, communities, and individuals. Grassroots community groups have formed to eradicate certain invasive species that have taken over parts of the Lake Huron coast, including the Lambton Shores Phragmites Community Group out of Port Franks Ontario. Municipalities and CA's are also initiating invasive species treatment and removal programs including *Phragmites australis* to improve diminished visibility along roadsides by applying chemical controls during certain season to reduce the spread of the species. Digital tools for reporting invasive species have been created to monitor existing populations and identify new areas where they have been spotted (e.g. Ontario's Invading Species Awareness Program).

Along Lake Huron's coastal corridor, the most prevalent invasive species include *Phragmites australis*, Sweet White Clover, Spotted Knapweed, Emerald Ash Borer, Zebra and Quagga Mussels, and Round Goby. These invasive species affect all coastal habitats across the coastal corridor permeating forest patches, sand dunes, and coastal wetlands alike. Forests Ontario (2016) developed a management cycle illustrating the cycle of invasive species management (Figure 45).

Figure 46 - Invasive species management cycle (Forests Ontario, 2016)

Prevention and early detection are the most cost-effective, time-efficient ways to combat invaders. These steps typically require landowners and land managers to identify invasive species and remove them when the patch is still small and a dense seed bank has not yet formed. This requires training landowners to be able to accurately identify invasive species as they often look like native counterparts. Response and control efforts by municipalities, NGOs and CA's require funding provided by grants or specific project allocations. Where these services lack, grassroots local interest groups form to remove and control invasive species in their area. Management and adaptation occur when: the threat of a species is too far gone to manage the implications and adapt to damage the species causes (e.g. tree planting programs); or long-term management of the regrowth of an invasive species (e.g. Phragmites removal year-after-year). Typically, invasive species management and ‘touch-ups ‘are required for 5-10-years after the initial patch eradication. Constant vigilance is required during this time frame to ensure reintroduction does not occur. Adapting the altered ecosystem composition by replanting native species is essential to preventing regrowth.

Many tactics can be employed to control invasive species including: (1) Biological controls using other plants or animals that out compete or prey on the invasive species; (2) Chemical controls including pesticides insecticides and herbicides; and (3) Mechanical or physical removal such as hand-pulling or Truxor cutting machines (Forests Ontario, 2016). Unfortunately, all methods have drawbacks, making them very expensive, high risk, and time consuming to employ. Biological controls have long been known as high risk, potentially making the problem worse introducing another species, (e.g. Cane Toads introduction in Australia). Chemical controls are highly regulated in Ontario, especially if they are being applied in and around water sources (e.g. Glyphosate, commonly known as ‘Round-Up’ applications). Mechanical and physical removals are effective but extremely time consuming, expensive, labour intensive (e.g. Hand-pulling and spading or digging out the roots of invasive species). For these reasons, prevention and early detection are imperative to cost and energy savings in the long term.

Table 8 - Area of *Phragmites australis* per Assessment Unit, and associated cost of removal

AU	Mapped patches of *Phragmites australis* (km^2)	Cost of 3-year treatment (Annis et al., 2017)	Cost of 3-year treatment (recent Lake Huron projects).
1	2.47	$305,000	$1,220,000
2	0.56	$69,195	$276,780
3	0.01	$1,282	$5,128
4	0.13	$1,660	$6,640
5	1.92	$236,813	$947,252
6	0.55	$67,820	$271,280
7	4.20	$519,704	$2,078,816
8	0.02	$2,353	$9,412
9	1,757 m2	$217	$868
10	9,660 m2	$1,193	$4,772
11	no data	unknown	unknown

Terrestrial and aquatic invasive species that occur within the southeastern coastal corridor of Lake Huron are typically treated by mechanical and physical removal, and chemical control. Table 10 provides an estimate of removal costs of *Phragmites australis* based on the mapped patches of Phragmites through our partner agencies, along with The Nature Conservancy’s estimate of the cost of a three-year Phragmites treatment program being $500/acre (Annis et al., 2017). Three-year treatment of Phragmites is required to ensure any new growth is removed.

Based on recently completed restoration projects, more accurate removal costs are upwards of 4x the cost per acre than Annis et al., (2017) suggests (Table 10). Limitations to Phragmites removal estimates include a lack of current and accurate mapping of Phragmites across the shoreline. Becoming widespread throughout the province, this invasive species exists in coastal habitats and typically, rural and remote patches don’t receive as much monitoring or treatment as urban patches do.

5.1.3 SEVERITY OF THREATS

Habitat loss and degradation, including habitat fragmentation and invasive species, plagues every ecosystem within the coastal corridor on the southeastern shores. Using the LAMP threat rating criteria (ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10-years).

Threat	Rating
Interior and edge habitat	**Scope**: HIGH – threat of reducing interior habitat is widespread, affecting ecosystems across 31-70% of the coastal corridor.
	Severity: MEDIUM – the threat of increased edge habitat is likely to moderately degrade/reduce coastal ecosystems by 11-30%. Most of the damage to coastal habitats has already occurred, but will be increased in areas with larger contiguous natural areas.
	Irreversibility: MEDIUM – the threat of habitat edge effects and encroachment can be reversed and habitats restored to pre-threat conditions with a reasonable commitment of resources, taking 6-20 years to achieve pre-threat conditions (e.g. in woodlands, river corridors, and gully and bluff buffer zones, vegetation can be replanted to restore previously cleared areas, however, the hydrology and soil composition of the area may take a few decades to restore).
Species mobility and habitat corridors	**Scope**: HIGH – the threat of lack of habitat corridors affecting the mobility of species is widespread, affecting coastal ecosystems across 31-70% of the coastal corridor. Fewer corridors are being preserved as land-use change such as development and crop land infiltrate small remaining fragments of natural ecosystems.
	Severity: HIGH – the threat of corridor removals and lack of links between remaining ecosystems is likely to contribute to a serious degradation and reduction of ecosystem biodiversity by 31-70% in the next 10-years or three generations.
	Irreversibility: MEDIUM – the threat of loss of species mobility and presence of habitat corridors can be reversed and connections restored to near-pre-threat conditions with a reasonable commitment of resources, taking 6-20 years to achieve pre-threat conditions (e.g. re-vegetating stream corridors, gully zones, and woodland corridors, will provide enough canopy in 20-years to act as flora and fauna movement corridors. Other ecological services these corridors provide, such as water filtration, may take longer to fully recover).
Invasive species	**Scope**: VERY HIGH – the threat of invasive species is pervasive, affecting every coastal terrestrial and aquatic habitat across the coastal corridor. As a changing climate increases the range of where invasive species can survive and permeate, there is no coastal ecosystem type that will be unaffected without management.
	Severity: HIGH – depending on the type of invasive species, the level of damage and degree of destruction reasonably expected to occur within 10 years will moderately-to-seriously degrade and reduce ecosystem integrity by 31-70% (e.g. *Phragmites australis* would have destructive outcomes to a coastal wetland, whereas garlic mustard would have only moderate affects to the ecological integrity of a coastal woodland).
	Irreversibility: HIGH – depending on the type of invasive species, the degree to which the threat can be reversed and the habitat restored varies on the species. Effects of invasive species can technically be reversed and restored, but is impractical due to time and money constraints, taking 21-100 years to achieve pre-threat conditions (e.g. Round Goby or Zebra Mussel would be almost impossible to completely remove due to their ability to reproduce and their infection throughout the entire Lake Huron system. Whereas a species like Spotted Knapweed can be removed and controlled with continuous treatment and follow-up).

5.1.4 RECOMMENDATIONS**

5.2 COASTAL COMMUNITIES AND DEVELOPMENT

Many of Lake Huron's coastal areas are in ecological decline as a result of urban development pressures, poor beach management practices, invasive species, careless property management located in significant ecologically sensitive areas, and a generally poor understanding of lake level fluctuations and coastal processes. Add to that, a system of institutional 'silos' whereby agencies and organizations focus on jurisdictional boundaries and mandates, and the result is a situation in which management of the coast as an ecosystem is a difficult proposition. Communities along the coastal corridor have changed the land-use on the shoreline over decades, and as these communities grow, urban sprawl and intensification continue to reshape impacts to coastal environments. Shoreline land-use trends include rural sprawl of private shoreline development with bigger homes, less agriculture and less public access (SCER, 2004). These trends are likely to continue where nearshore habitats are already degraded. Baby boomer generations flock to coastal communities to live out their retirement years, contributing to trends of community growth along the shoreline. As these communities intensify and expand, resiliency and sustainability measures will be needed to preserve ecosystem services and reduce impact on shoreline environments. There is growing awareness of the impacts and expense of traditional shoreline hardening approaches shifting to restoring dunes and slowing erosion by managing water on the landscape. There appears to be more recognition of the services natural systems provide (SCER, 2004). Planning decisions made to support the growth and expansion of these communities such as beach grooming, road networks, marinas and recreational boating, hardened shorelines and tourism all influence health of adjacent coastal environments.

5.2.1 COASTAL COMMUNITIES

Like many coastal areas around the world, Canadians are drawn to Lake Huron's shores for vacation getaways, often in the form of permanent cottages and seasonal residences. Across the southeastern shores, the coast was 'developed' into cottage communities over time, starting in the late 1800's. "When cottage development first started taking place along Lake Huron, information wasn't readily available to help people locate their building safely". (LHCCC, 2018). Because there was no regulation, many of the small cottages and camps were built directly on the back-dunes and on bluffs, which as we know are extremely dynamic environments. "A number of cottages along the lakeshore were built in high-risk zones. Fortunately, information does exist now to allow people to locate their cottages a safe distance back from the shoreline, based on historical erosion rates and the potential for slope failure" (LHCCC, 2018). As these cottages have changed ownership through family members or newcomers, cottages and the surrounding developments have grown and density to create very dense cottage developments and closely-knit cottage association groups. In Bruce County, within the Municipality of the Northern Bruce Peninsula alone, a 2003 study estimated that 65% of the Lake Huron shoreline had been developed… suggesting that today, that number might have increased to 78% of the shoreline developed in one way or another (Liipere, 2014). Other estimates from the County of Bruce have suggested an 8.2% increase in permanent residents between 2001 and 2021, suggesting this healthy population growth will occur mainly in Kincardine and Saugeen Shores due to expansion in workforce at Bruce Power, expansion of tourism industries, and influx of retirees (County of Bruce, 2010). Some research has estimated that, "lakefront locations add 50% value to Great Lakes shore property compared with a similar house and lot inland" (USACE, 2003, p.34). Willingness to pay an increased price for shoreline property is shown through continual coastal community developments.

Not only are cottages and residential properties becoming more spread out across the shoreline, but the cottages on these properties are becoming stately and are being retrofitted or rebuilt into year-round homes (Figure 46). These properties are often popular to rent out in summer months changing the social dynamics of coastal communities. Advertisements for cottage rentals through Realtors and Real Estate companies touting; “The shores of Lake Huron and the Goderich, Bayfield and surrounding areas are an ideal place to own or rent a cottage. You will be impressed with what this lakefront community has to offer” (Talbot Realty, 2018). This influx of short-term rental properties (e.g. Airbnb) can negatively affect small cottage communities, heard through feedback received during the CAP’s coastal community workshops.

Figure 47 - Stately home built on the shoreline of Lake Huron

5.2.1.1 COTTAGE AND COMMUNITY DEVELOPMENTS

Although cottagers are an important and longstanding group of users along Lake Huron, there are a few significant stressors brought to the Lake Huron shoreline from this type of land-use and the developments associated. Some of the associated impacts from the changes of cottage communities to more developed, permanent residential area includes:

- Small cottages converted into million-dollar, year-round homes with enhanced septic systems, more impervious pavements, and expanded building footprints. (Davidson-Arnott & Mulligan, 2016, p. 14).
- Landowner turn-over brings uninformed people to the shoreline without knowledge of sustainable land-use practices or coastal processes (heard in CAP questionnaire and community workshop feedback).
- Changes to private beach access has caused some shoreline landowners to rebut against visitors on ‘their’ beaches, increasing a sense of entitlement or false ownership in some circumstances (heard in CAP questionnaire and community workshop feedback).
- Increased erosion and loss of ecological integrity caused by development sprawl (Liipere, 2014).

Educating landowners about best management practices to reduce impacts to the ecological integrity of shoreline ecosystems is key to mitigating impacts caused by shoreline communities. The Lake Huron Centre for Coastal Conservation (LHCCC) has been active in education and developing awareness of ‘how the coast works’ to existing and new landowners since 1998, and continues to work on creating a coast of informed citizens. Developing best management practice (BMP) guides to disperse information to residents has been requested through avenues of this Plan including the Online Questionnaire (2017), and through public feedback sessions at the 12 Coastal Community Workshops held between 2017-2019. Two such guides have already been completed to services two municipalities along the coastal corridor. The Town of Saugeen Shores, the Township of Huron-Kinloss and the LHCCC have developed BMP Guides to be given to shoreline residents in the respective jurisdictions to raise awareness of the threats caused by incompatible development, applicable regulations, coastal processes shaping their shores, and things they can do to improve the resiliency of their shoreline.

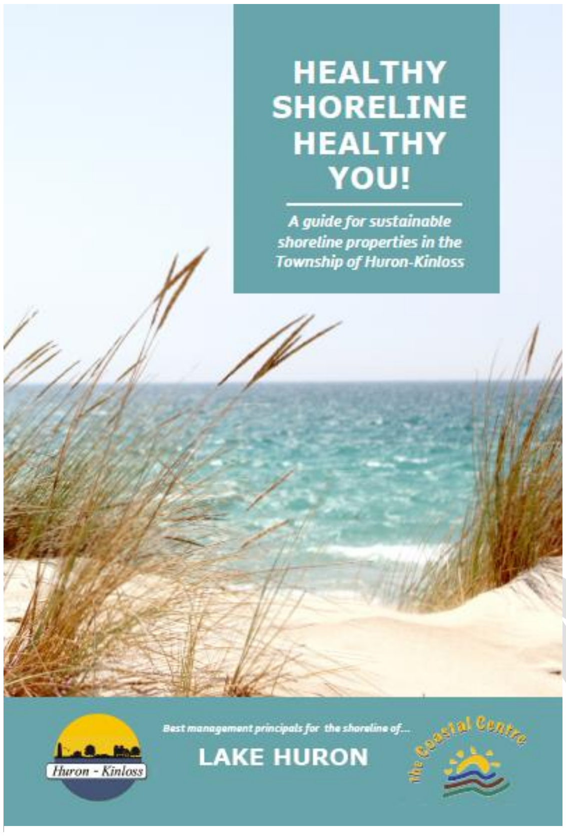


Figure 48 - BMP Guide for the Township of Huron Kinloss

Another initiative requested through the CAP questionnaire and community workshops was to create short videos available online to show different coastal habitats, threats that affect them, and things people can do to reduce these impacts. This request was fulfilled through the development of an 8-video series released in October 2019 which covered all coastal habitats existing on the southeastern shores. All videos are available free of charge on social media, YouTube and LHCCC's website, www.lakehuron.ca

LHCCC's Green Ribbon Champion Program has begun restoring shorelines within the Township of Huron-Kinloss by rebuilding dunes, planting windbreaks, relocating pathways, removing invasive species, and moving incompatible structures off the beach and out of hazard zones. Twenty-two landowners participated in the free, voluntary program in 2019, and become 'Green Ribbon Champions', making their properties examples for their neighbours on best management practices and help educate one another about ways they can work together as a community to be resilient and lower their impacts on their coastal environment. Programs such as Green Ribbon Champion are fully funded incentive programs, which raise awareness, build relationships with landowners, and restore coastal ecosystems. Continuing these types of programs is extremely challenging for non-profits to ensure funding is available year-after-year, threatened due to a lack of long-term, consistent funding.

New developments along the shoreline strive to be closer to the lake, sometimes clearing all vegetation between cottage and water's edge to get an unobscured view. Development and removal of dunes causes higher levels of aeolian sand transport further inland; "Sand that blows inland not only causes a loss of sand from the lakeshore system, it also means costly repairs and having to deal with sand drifts on roads, lawns, gardens and in storm drains" (Huron County, 2006). Research shows that development and structures too close to the shoreline have experienced more abuse from coastal processes, and in turn reduce property values. "*A safe distance between a coastal home and the edge of its coastal slope property is of greater economic value than proximity to the shore or size of the home. A coastal house imperiled by erosion gains economic value and a new lease on life when relocated, or when slope and shore protection is constructed. Many people who own coastal property face a risk of property damage or loss because their investment is near erratic powerful natural forces*" (USACE, 2003, p.39). As discussed in Chapter 4 of this Plan, development setbacks are necessary for protection against natural hazards and to buffer stressors coming from inland sources entering the lake (Lambton County, 2019, 8-18). In the northern reaches of the coastal corridor, incompatible or poorly placed residential development and the physical alteration of the ecosystem's vegetation structure, fragmentation, and disruption to hydrological processes is one of the most significant stressors to sensitive natural coastal ecosystems (Liipere, 2014, p.82). Therefore, regulation of development and consistent consideration for development setbacks for human safety and ecological integrity is necessary for a sustainable relationship between development and shoreline health. Planning for the future of the coast as a place where our environment communities coexist in a healthy balance is the social and environmental resiliency goal Lake Huron requires.

5.2.1.2 IMPERMEABLE PAVEMENTS

Urbanization and development reduce pervious substrates which absorb precipitation and runoff from storm events. When the percentage of impervious surfaces increase in a watershed, runoff is increased exponentially (Table 20). As discussed in the bluff ecosystem section, increases in permeable substrates is not always recommended in eroding environments. However, in most urbanized environments that have been established for decades, increases in permeability decreases reliance on stormwater systems, allows filtration of runoff and stormwater through substrates, recharging groundwater sources, and reduces sedimentation entering nearshore waters. If permeability cannot be improved, natural infrastructure features such as rainwater gardens should be incorporated into landscapes and neighbourhoods to encourage water retention during storms.

Table 22 - Effects Caused by Impervious Surfaces (USEPA, 2011)

Increase in impervious surfaces	Runoff increases (over forested catchments)	Degree of affected stream quality
1 - 10%	n/a	Sensitive
10 – 20%	Twofold	Impacted
35 – 50%	Threefold	Non-supporting
75 – 100%	+ Fivefold	n/a

Detailed stewardship guides have been created available to landowners and land managers within coastal communities. *Greening Your Grounds: A Homeowners Guide to Stormwater Landscaping Projects*, distributed by Ausable Bayfield Conservation Authority has information and examples of stormwater retention structures and techniques easily applied on many scales. Permeable pavements, rainwater catchment infrastructure and rain gardens are a few options covered in this guide. Guides like this raise about impacts of hardened surfaces, uncontrolled rainwater runoff, and development, describing projects that can be rolled out through partnerships with environmental organizations and municipalities. Best management practice guides are very popular among shoreline communities and are effective at communicating these strategies.

5.2.1.3 BEACH GROOMING

Beach grooming occurs on two scales: (1) small hand raking, spot cleaning of natural material wash-up, litter removal, and removing small areas of vegetation for pathways or sitting areas; and (2) large-scale beach grooming with tractor-towed surf rakes clearing litter, removing all vegetation in its path, and flattening beach and dune areas. Although both methods have negative impacts to natural ecosystem (other than plastic and litter removal), mechanical beach grooming is much more damaging to beach and dune habitats than hand raking. Coastal communities rely on tourism to sustain their economy. Beach grooming has inherently become a ‘crutch’ for cleaning public beaches of garbage to ensure a safe experience for visitors, without considering the implications for ecological integrity. Originally introduced as a cost-effective method for cleaning up spring vegetation wash-ups and heavy littering by visitors during peak season, surf rakes and mechanical groomers (Figure 48) are now over-used, in some cases used multiple times per week, which has expedited stressors to the beach through the disruption of fine top-sand and flattening of dunes.

Mechanical beach grooming machines can remove potential health and safety hazards and litter off the beach; However, the overarching effects these machines have on the health and resiliency of beach and dune environments make them a major stressor to beach and dune ecosystems along the coastal corridor (as discussed more in depth in the Sand Beach and Dune section of Chapter 4). "*Aside from the ecological effects of raking, there are compelling economic reasons for reconsidering the practice of beach raking. Losses of sand from the beach-dune system represent a loss to the protective capacity of the beach-dune system during high lake levels and storm events. While losses may not appear significant on a per annum basis, over the long-term it can amount to substantial quantities of permanent sand loss. The value of a beach-dune system simply as shore protection has been estimated at about $3000 per linear metre. Beyond this, dunes provide a buffer for water filtration, and reduces maintenance costs by preventing sand drifting*" (LHCCC, n.d [1]).

Figure 49 - A Barber Surf Rake beach groomer (HBarber.com)

From a human health perspective, beach grooming supports the removal of potentially harmful litter off the shoreline (e.g. broken glass, needles, etc.), but in doing so, "professional grooming significantly increased Escherichia coli (*E-coli*) content in beach sands relative to non-groomed or hand raked plots" (Kinzelman et al., 2010). Grooming beaches effectively removes the small 'fluffy' sand grains from the beach, lowering the beach profile to where heavier sand grains rest at the water table. This phenomenon is compared to a Zamboni on ice surfaces, causing the surface of the beach to become level, removing all material, both natural strandline and unnatural material, is why groomed beaches often become 'wet' over time (Figure 49).

Figure 50 - A Wet Beach caused by over-grooming, at Sauble Beach Ontario

Although some municipalities religiously rake and groom beaches, some areas have strict guidelines and bylaws regulating the practice (Huron-Kinloss), while other areas such as Pinery Provincial Park, have not embarked on a raking program (LHCCC, n.d. [1]). Some coastal beach areas in the lower United States (e.g. Palm Beach, Florida), "have re-evaluated their raking programs, based on their environmental impacts, and have radically scaled back their programs" (LHCCC, n.d. [1]). Recommended alteration in beach grooming practices include stopping surf-rake and algae-harvester operation all together and instead employing seasonal staff, such as students or part time workers to hand-groom beach areas. Other alternatives include implementing an `adopt-a-beach' program where volunteers commit to keeping beaches hand groomed to protect human safety and dune health (LHCCC, n.d. [1]). This method will support beach 'cleanliness' for human safety, but it will also encourage dune establishment, nesting area for coastal bird species, and natural infrastructure services for erosion control and wave uprush.

Recreation types and associated maintenance on public beach areas significantly affects beach and dune health. Specifically, beaches tend to be 'open' areas and therefore it is obvious when there is litter and inappropriate uses occur. During a multi-year program focused on beach use and litter on beaches, *Butt Free Beach* (LHCCC), interviewed beach-goers asking questions about their recreation frequency to Lake Huron beaches and their opinions on the cleanliness of the beach, influenced jointly by litter and maintenance practices to 'clean' the beach. Data collected through beach surveys done by the LHCCC in 2016 and 2017 supplement the analysis of the relationship between social carrying capacity and beach 'cleanliness' (Table 21).

Table 23 - Survey results of beach cleanliness compared to beach grooming frequency

Location:	Grooming Frequency:	% Respondents think the beach has a litter problem.
(Litter Problem results from Butt Free Beach Surveys¸ LHCCC 2016-2017. Grooming Frequency data gathered from pers. comm with municipalities.)		
Bayfield Main Beach	Hand grooming; log removal using a backhoe a few times per season.	16 of 32 (50%)
Goderich Main Beach	Grooming bi-weekly. $45,000 annual budget.	31 of 66 (47%)
Grand Bend Main Beach	Grooming Sat, Sun, Mon in summer. Own a groomer.	22 of 71 (31%)
Ipperwash Main Beach	No Data.	2 of 16 (12.5%)
Kincardine Station Beach	Groomed in spring and before long weekends. Own a groomer.	17 of 42 (40%)
Port Elgin Main Beach	4x/yr. Before long weekends, blitz in spring. Remove strand line. Hand grooming 1x/wk. with 5 staff.	25 of 44 (57%)
Sarnia (Canatara Park)	No Data.	23 of 59 (39%)
Sauble Beach Main Beach	Groom in early April- once before Piping Plovers nest.	9 of 24 (37.5%)
Southampton Main Beach	4x/yr. Before long weekends, blitz in spring. Remove strand line. Hand grooming 1x/wk. with 5 staff.	15 of 51 (29%)

Table 21 shows the frequency respondents visit Lake Huron's beaches, providing insight into their baseline for knowledge of how Lake Huron's beaches typically look. Chart 12 describes how the 403 respondents viewed the state of the beach's cleanliness. Respondents in this study ranked whether the beach had a litter problem through the responses (1) Yes, (2) Somewhat, (3) I don't know, (4) No. These results, directly compared to the data gathered in Table 21, show little correlation between beach grooming frequency and perception of beach cleanliness. The lack or relationship between maintenance and perception suggests that either beaches being groomed need more litter prevention education or are busier during peak season.

Chart 9 - Results from Butt Free Beach Survey (2016-2017) in Goderich, Ipperwash, Bayfield, Kincardine, Sarnia, Sauble Beach, Grand Bend

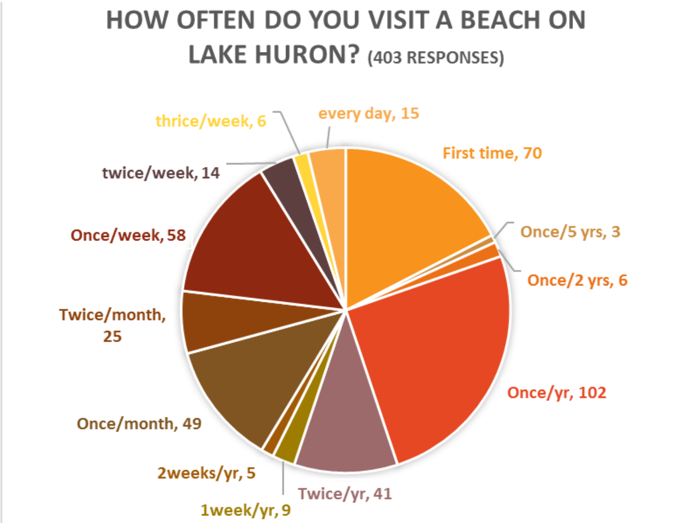
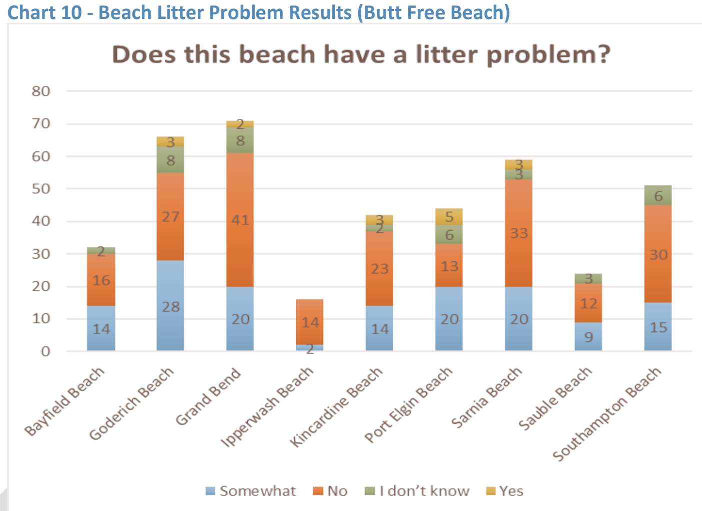


Chart 10 - Beach Litter Problem Results (Butt Free Beach)



Regardless of this beach survey, a consistent viewpoint of coastal scientists is that improper recreational use and poor maintenance techniques along Lake Huron's shore poses a significant risk to healthy ecosystems and will reduce resiliency in the long-term. An important tool to reduce the need for beach grooming is for beach managers to practice 'expectation management' by which they develop a more realistic expectation of visitors coming to the beach. In other words, being more sincere with photographs and information in all advertisement material, with photographs depicting a natural Lake Huron beach environment, will help tourists and visitors to the area understand why natural material is left on the beach (LHCCC, n.d. [1]). "The old notion of the 'pristine' beach, clear of nothing but sand, is one that fails to recognize the life that forms, or relies on, the beach ecosystem. Beaches are far from lifeless. Managing them as an ecosystem will restore some balance, where people's needs and the needs of the coastal environment occur in harmony" (LHCCC, n.d. [1]). Working alongside and partnering with municipal parks and recreation staff, as well as the Regional Tourism Organizations to standardize this messaging with municipalities is the best way to tackle this initiative.

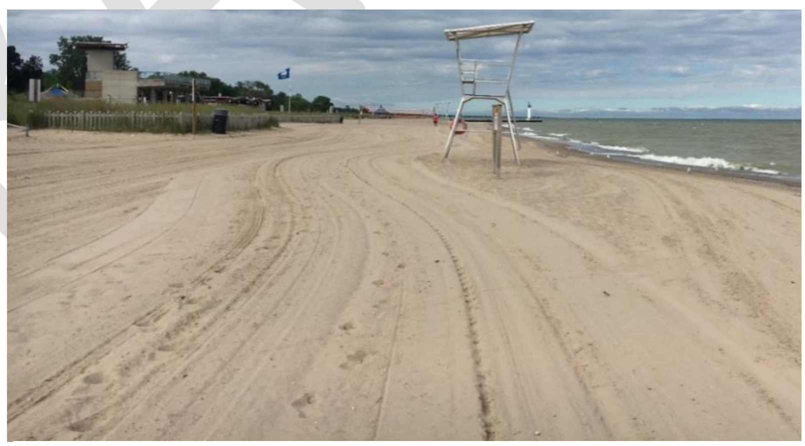


Figure 51 - Recent grooming at the Grand Bend Main Beach

5.2.1.4 ROAD NETWORKS

Ontario has a higher density of roads than any other region in Canada with no point of the landscape existing more than 1.5 km from a road, creating highly fragmented ecosystems, especially within forested regions (OBC, 2015; OREG, 2010). Roads can be precursors to future impacts, as they facilitate land development, housing, and industrialization and further expansion of the road network (Liipere, 2014). Although roads provide access to previously remote areas, this accessibility leads to higher level of threats and stressors to previous isolated areas.

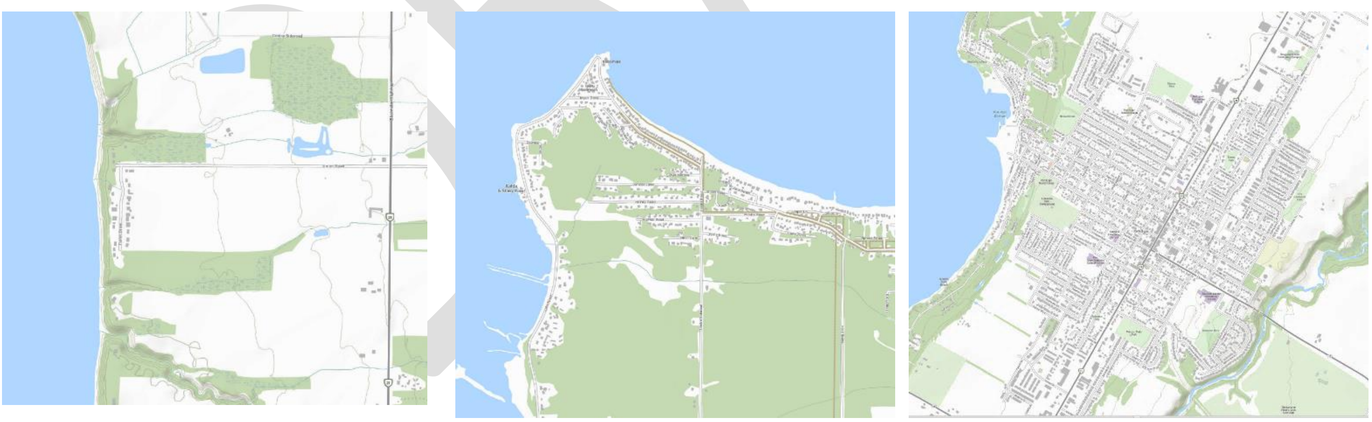
Roads fragment ecosystems, contribute nutrient inputs through road salting, provide pathways for invasive species through seed dispersal, and increase probability for pollution sources such as fuel leaks, garbage dumping, and unintentional litter. Extensive road networks have considerable ecological impacts on the landscape such as disrupting wildlife movements, modifying habitats, altering water drainage patterns, introducing non-native species, modifying microclimates and the chemical composition of the environment.

The difference between a narrow, gravel road will have different consequences than a paved multi-lane road, other than simply the footprint of the transportation corridor. Altered heat-regimes due to thermal absorption of asphalt pavement, increased noise on paved roads, and precipitation runoff regimes are all altered after development occurs. "*Road development in large forest areas can alter the habitat quality of many area-sensitive bird species or reduce habitat connectivity for wide-ranging species such as black bear and fishers… Poorly installed culvers at road-stream crossings can also have a significant impact on stream ecosystems and their associated species… causing barriers for spawning fish*" (Liipere, 2014, p.84). Above and beyond the original development of a road, sub-effects created through roads include:

- Pollution (vehicle debris and litter; engine emissions; road salt, engine fluids, oil and gas spill, dust from driving; light and noise; road vibrations);
- Predation risk (prey animals like rodents are exposed with no cover and easy for prey to catch);
- Runoff (sedimentation and debris into water courses; thermal alteration; promotes erosion);
- Roadside vegetation cutting/ removal (fragmentation);
- Pathway for invasive species introduction and spread (OREG, 2010, p.18).

Within the coastal corridor of the southeastern shores, there are three types of road networks apparent; (1) Heavy - intensified urban road networks, (2) Medium - rural community developments, (3) Light - single roadways feeding into cottage communities (Figure 46).

Figure 52 - Road Densities along Lake Huron Coastal Corridor



Light density road network | Medium density road network | Heavy density road network

In rural Huron and Lambton Counties, many of the road networks spanning the coastal corridor are light density, existing commonly as a 1km long gravel road travelling from HWY 21 to the lakeshore passing through agricultural fields leading to 20-30 cottages arranged in 2-rows parallel to the shoreline. Many of these roads are privately owned with access easements to allow cottage owner's permission to travel across, and are single access points whereby they are the only route in and out of the 'subdivision'. This is a safety concern for emergency vehicles if they are attempting to use these roads during a washout to the gravel lane due to extreme weather events. Most commonly, light density road networks are almost exclusively gravel. Medium density road networks are a little less vulnerable to storm events, as they typically have more than one entrance/exit and have many more residents and retail businesses within the community. However, in these areas, road networks typically progress very close to the water's edge and are therefore at risk of flooding during times of high lake levels. Roads in medium density networks are typically a mix of gravel, concrete, and asphalt. Heavy density road networks exist in urban coastal communities, including Sarnia, Goderich, Port Elgin, and Sauble Beach. Dense road networks have completely saturated the landscape and are therefore provide the most opportunity for stormwater and transmission of nutrients, pollutants, and chemicals. Roads in heavy density road networks are typically all asphalt or concrete pavement, with few exceptions of interlock brick and stone. Road development and density varies across the southeastern coastal corridor, with highest road density occurring in the southern two thirds of the coast. Road density on the Bruce Peninsula in general has been considered low compared to Southern Ontario, however, more roads are being established in this area than in other parts of the coastline which are previously developed, enhancing a future risk of stressors to these remote areas in Bruce County's coastal corridor (Liipere, 2014).

Although the density and location of roads are unlikely to change, understanding the level of threat in each coastal area is important for mitigating the sub-effects listed above and for land managers and planners to adequately install buffer zones to combat these effects. "The most commonly chosen threshold for impervious surfaces is 10% of the land cover within a watershed" (ECCC, 2013). Other thresholds suggested to specifically determine impacts of road density are:

- >14m per hectare of land (14m to 1km^2) wetlands will show signs of degradation (Liipere, 2014);
- 2 to 3 km of road per 1km^2 cause "increased peak flows in streams" (USEPA, 2011a);
- Within 1 to 2 km of a wetland, roads reduce species richness of wetland plants, amphibians/reptiles and birds (USEPA, 2011a).
- Low Density: <100m road/km^2; Fair Density: 100m – 690m/ km^2; Moderate Density: 700m-1999m/km^2; High Density: >2000m/km^2 (GBC, n.d, p.20);

Using these metrics, land managers can determine if the road density in the coastal corridor in their jurisdiction exceeds these levels, and by how much. If the road density is exceeded, it may indicate that natural infrastructure and stormwater management devices such as bioswales need to be installed to combat stressors caused by roads.

5.2.1.5 MARINAS AND RECREATIONAL BOATING

Many marinas have been in place for decades on Lake Huron and represent a vibrant and decorated history of nautical culture and enjoyment of the Lake. Marinas are important areas for many boaters enjoying the use of Lake Huron for recreation, but also represent important nodes for fishing industry, shipping, and transportation throughout the Great Lakes. *"In addition to their value in providing protected moorage for boats, coastal marinas provide many social and economic benefits including: access to coastal waters; focal points for community activities; focus for upland development; tax revenues for local communities; revenue for owners and the broader marine industry; [and] employment opportunities"* (USEPA, 1985). There are currently 18 'active' marinas along the southeastern shores, and are described in more detail in Table 22.

Table 24 - Marinas on Lake Huron's Southeastern Shores

LOCATION	NAME	NOTES
Sarnia	Lake Huron Yachts Marina	60-80 Seasonal Slips Slip season cost: $2,340.00 (30-foot boat)[2]
Cedar Point Line	n.d.	n.d.
Kettle Point	R & R Marina	63 slips (8 transient), with dock depth of 10-12 feet[3]
Port Franks	Port Franks Marina	70 seasonal slips, 2 transient slips[13] Slip season cost: $1,728 serviced "Dredging services and an open channel to the lake is provided by a private operator, contracted by the Municipality"[1]
Grand Bend	Grand Bend Marina	30 seasonal slips, 35 transient slips. [1] Slip season cost: $1,728 serviced. "Dredging services and an open channel to the lake is provided by a private operator, contracted by the Municipality"[1]
Bayfield	Bluewater Marina Harbour Lights Marina Bayfield	276 permanent slips, 14 transient slips. "maximum length of 50-feet, maximum draft of 7 feet. Extensive dredging as needed"
Goderich	Maitland Valley Marina	250 slips. Slip costs: $76 - $81/ ft "Accommodates boats up to 100' in length"
	Maitland Inlet Marina	100 slips
Point Clark	n.d.	n.d.
Kincardine	Kincardine Marina	154 Slips with 20 set aside for transient sailors.
Scott's Point	n.d.	n.d.
Port Elgin	Port Elgin Harbour Marina	274 Slips with 12 set aside for transient sailors "Vessel Limits Supported: Max Draft: 10ft, Max Length: 150ft"
Southampton	Southampton Town Dock & Southampton Yacht Club	For small boats only - bigger boats sent to Port Elgin. Southampton Yacht Club has docks for club members only.
Oliphant	Oliphant	50 docks with 2 boats per dock, with a dredged channel.
Little Red Bay	Little Red Bay Marina	~40 slips based on aerial imagery; $503.50/ season [4]
Tobermory	Big Tub Harbour	Approximately 18 slips based on aerial imagery
	Little Tub Harbour	50 transient slips "10ft depth at dock"

*** Information for this chart gathered from personal communication with members of the Canadian Power & Sail Squadron, Great Lakes Sailing.com, and from Yacht Club websites.*
[1] lambtonshores.com; [2] ***lakehuronyachts.com; [3] ontariossouthwest.com; [4] evergreenresortredbay.com***

Beyond the physical creation of these marinas along the coast for utility purposes, there is also a growing social aspect of these areas for clubs and socializing. There are ~9 yacht clubs on the southeastern shores corresponding with the existing marinas, and many of these have been in existence for almost a century. For example, the Sarnia Yacht Club was formed in 1930, now hosting a membership of around 125 (Sarnia Yacht Club, 2018); and the Kincardine Yacht Club formed in 1977, now hosting 152+ members (Kincardine Yacht Club, 2018). A passionate group of individuals, boaters and especially Yacht Club members are stewards of marinas, their slip fees go towards marina upkeep, and their members set the tone for the actions taken on by marina management. In some cases, these clubs manage marinas on behalf of the municipality, such is the case in Kincardine (Kincardine Yacht Club, 2018). Marina organizations and Yacht clubs on the Southeastern shores of Lake Huron include, but are not limited to:

- Ontario Power and Sail Squadrons (Goderich, Sarnia, Port Elgin, Kincardine)
- Lake Huron Yacht Club,
- Grand Bend Yacht Club/ Grand Bend Marina,
- Goderich Yacht Club/ Goderich Harbours (1; Maitland Valley Marina and Resort Park);
- Port Franks Marina/ Port Franks Harbour;
- Bayfield Yacht Club/ Bayfield Harbour (Harbour Lights Marina);
- Kincardine Yacht Club/ Kincardine Harbour;
- Port Elgin Harbour; Southampton Harbour;
- Big Tub Harbour/ Tobermory Harbour (Little Tub)/ Tobermory Yacht Club (open club, only a social group).

From a social perspective, harbours and marinas are small beating hearts of the Lake Huron coastline, containing small microcosms of potentially dedicated environmental stewards of the lake ecosystem. In some cases, a harbour defines the cultural identity of the community, providing cultural and historical significance. Boaters have an interest in keeping the lake healthy through their passion for the craft of sailing or water sport. However, marinas come with a host of potential stressors and threats to surrounding terrestrial and aquatic ecosystems. Marinas alter natural coastal processes of habitats that surround them, on the southeastern shores specifically these include river mouths, nearshore waters, and beaches. “Recreational boating marinas have the potential to modify local environmental conditions through their influence on hydrodynamics, sediment resuspension, and concentrations of contaminants” (Rivero et al., 2013). The most pervasive threats marinas cause to nearshore water quality and surrounding ecosystems include;

• Dredging and dredged material disposal	• Light pollution in dark sky areas,
• hardened shorelines and habitat modification	• Shoreline erosion, sedimentation and turbidity
• Wastewater, stormwater & parking lot runoff	• Disruption of wildlife
• Nutrient inputs, pollutant loading	• Boat operation and maintenance (e.g. oil spills, sewage discharges, boat painting and repair chemicals)
(USEPA, 1985; Morales, 2015; Rivero et al., 2013)	

Threats and stressors caused by recreational marinas are mirrored and sometimes compounded in industrial shipping marinas and ports like those in Sarnia and Goderich.

5.2.1.1 Dredging

Marinas use dredging to improve access to the open lake during low lake levels. *“Dredging can disturb the natural ecological balance through the direct removal of aquatic life… in the freshwater environment, bottom-dwelling organisms on which fish depend for food may be eliminated from the food chain. In addition, when spoils are deposited directly in a water system, they may smother the remaining organisms, and silt or sediments released from dredging activities can cover and destroy fish feeding and breeding habitats. Furthermore, contaminants accumulate over long periods of time in the sediments. Some toxic substances, which may reside in the sediment (e.g. Mercury) can re-enter the water system when the sediments are dredged. Such contaminants then endanger* *the health of water users, particularly the organisms that live in the body of water. Nutrients are also released by dredging. These can cause eutrophication of the system, resulting in oxygen depletion and possibly the death of fish and other aquatic organisms."* (O'Neill, 2012). Dredging occurs in many recreational marinas, and in small private communities (Figure 52 & 53). Historically, dredging in some marinas where sand is predominant (e.g. Port Franks) has included "propeller-wash" techniques whereby the vessel is made stationary with pilings secured into the river bottom and the ship propeller used to push sand away from the channel. This technique does not require additional permits to store dredged material above the water on land. Another special situation is the community of Oliphant where a dredged channel called "The Gut" or Smokehouse Channel, is maintained to provide boat access to island properties during high water levels. Alternatively, the area uses vehicles to access "island" properties during low water levels.

Figure 53 - Dredged Boat Channel

Figure 54 - Marina Dredging on Lake Huron

Management strategies to reduce stressors caused by marinas and recreational boating include, "water quality monitoring, gas management and spill mitigation, shoreline stabilization without hardened shorelines, stormwater runoff mitigations and vegetative buffers (e.g. rain gardens), fish waste management and boat waste management; upgrading sewage facilities, boat cleaning resources and areas; rip rap vs sheet pile or concrete, and dark sky approved lighting" (Morales, 2015). Reducing the need for dredging by encouraging boats with shallower drafts, or relocating boats with deeper drafts into specific, limited areas of the marina or other marinas, will reduce the need for dredging.

5.2.1.6 HARDENED SHORELINES

As more people are attracted to coastal areas, investments in cottages, homes, and infrastructure increases, as the risk of damage caused by climate change and high lake levels also increases. There is an inherent interest by landowners to protect their properties using hardened infrastructure. Hardened shorelines are common along all the Great Lakes, originally intended to help prevent wave action and lake level changes from damaging coastal properties. On the southeastern shores of Lake Huron, this is most prevalent on erodible shorelines within AU's 1-3 and in wetland dominant areas within AU's 7-9. For thousands of property owners living along the lake, the area remaining between their home or cottage and the water's edge, "is uncomfortably small and has been partly used up as erosion has carried away some of the land" (USACE, 2003, p.1). The common response to this issue is to harden the shoreline using metal and rock structures to protect their remaining property.

Many of Lake Huron's existing hardened shorelines on the southeastern shores were put in place in the mid 1970's and 1980's due to high lake levels and the desire to 'protect' coastal properties from damage. However, many of these structures were installed with no long-term maintenance strategy in mind and with poor engineering practices, often using infrastructure that was excessive or inappropriate for the application. At the time, and even into the early 1990's, the Ministry of Natural Resources did not have a policy for groyne development on the Great Lakes (Baird, 1994, p.31) but there were varying levels of regulation and policy from CA's and municipalities during this time. "E*cological impacts have generally not been considered in policy decisions regarding coastal armouring. However, as human populations continue to flock to the coast, sea level rises and coastal erosion accelerates; the need to understand the ecological consequences of armouring, in all its forms, on coastal ecosystems is increasingly urgent*" (Dugan et al., 2011, p.24). Although there is now modern regulation and approval needed for the installation of in-water and shore structures, existing structures are not being removed, and in some cases are being enhanced.

Not all shoreline hardening is considered equal. Shoreline structures vary with their negative and positive influence depending on their length, height, depth, shape, surface texture, permeability, and toe protection (USACE, 2003, p. 25). Types of hardened shoreline structures used on the southeastern shores of Lake Huron include:

Harbours: Generally, inlets adapted to dock boats, re-fuel at fuel stations, unload and load passengers or goods, and launch small watercraft from shore. These areas are typically dredged to ensure boat passage, hardened using sheet pile, and employ dock systems such as floating and permanent styles. The size of harbour typically depends on the size of the adjacent community. Other facets and supporting infrastructure of harbours include piers, channelization, and breakwater structures:

Figure 55 - Hardened Shoreline in a Harbour

Groynes: A groyne is a structure built out of metal sheeting or wood laying perpendicular to the shoreline, intended to trap sediment as it moves through nearshore waters, building beach material on the windward side of the structure (USACE, 2003). Groynes are installed to prevent beach erosion from coastal processes, high lake levels, and erosion, but their efficiency is dependent on littoral transport of sediment feeding beaches updrift from eroding ecosystems, such as bluffs (Baird, 1994). Types of groynes include metal (steel or aluminum), naturalized (sediment or stone), and riprap (concrete blocks, or gabion baskets filled with stone).

Figure 56 - Groyne in Lambton County

Walls: Walls are vertical human-made structures built parallel to shorelines typically made from corrugated metal, concrete, armour stone, and gabion baskets. Their intended use is to protect property from erosion due to high lake levels and storm surges (USACE, 2003). Vertical walls do not generally perform well against wave attack as they deflect wave energy downward, causing undermining and eventual failure of the wall. Types of walls on Lake Huron include concrete (poured or armour stone blocks), metal (steel or aluminum sheet pile or corrugated metal sheeting), rip-rap (large stones):

Figure 57 - Hardened Shoreline Structures on Lake Huron

The biggest issue with hardened shorelines is they replace natural shoreline erosion defences such as dunes with linear, stagnant blockades that are less resilient to extreme changes in lake level and storm surges. For these structures to be effective and non-destructive to other local properties, many individuals need to install them side-by-side which is costly, unsightly, and more destructive to the local habitat (USACE, 2003; Figure 56 & 57).

Figure 58 - Groynes in Lambton County

Groynes specifically gather sand on the updrift side of the structure, but end up depleting sand and sediment from the downdrift side, causing beach erosion, sometimes undermining the structures integrity (Figure 53). Changes to nearshore waters and longshore transport caused by groynes and jetties can create areas of stagnant water and hypoxia, altering benthic communities and reducing water quality (Dugan et al., 2011). Stagnant water will warm with sunlight, which creates low-oxygen environments, deterring fish, benthic invertebrates, and encouraging the growth of algae and harmful bacteria.

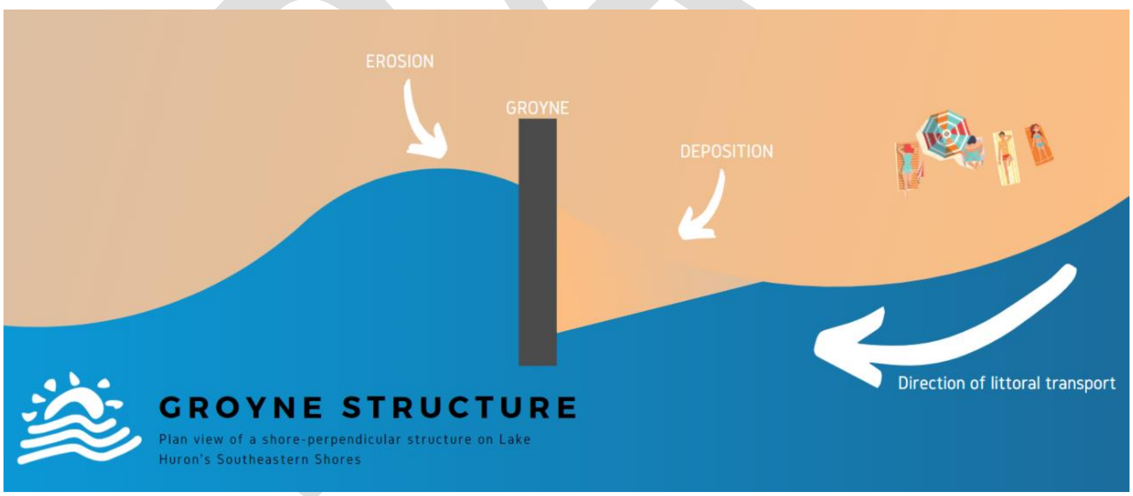


Figure 59 - Groyne deposition and erosion of sediment

Although they are prevalent along the southern coastline, “groynes will not provide adequate protection in areas subject to moderate to severe long-term recession” (Baird, 2019 [1]). Permits are required to build groynes, with any work within nearshore waters requiring permission from the Provincial Government (MNRF) and CA’s.

Sea walls have similar issues with continuity and undermining. Energy from waves does not disappear when it hits a solid object. Wave energy will hit the wall, be deflected downward and outward, eroding sediment within these areas. Upon continuous assault, the sediment will eventually erode to the point where the structure is undermined, allowing water to permeate behind the structure, causing it to wash into the lake (Figure 54). Many existing walls on Lake Huron have experienced this phenomenon, or have required hardening on either side of the wall to reinforce the structure using concrete angled abutments or rubble mounds to absorb wave energy.

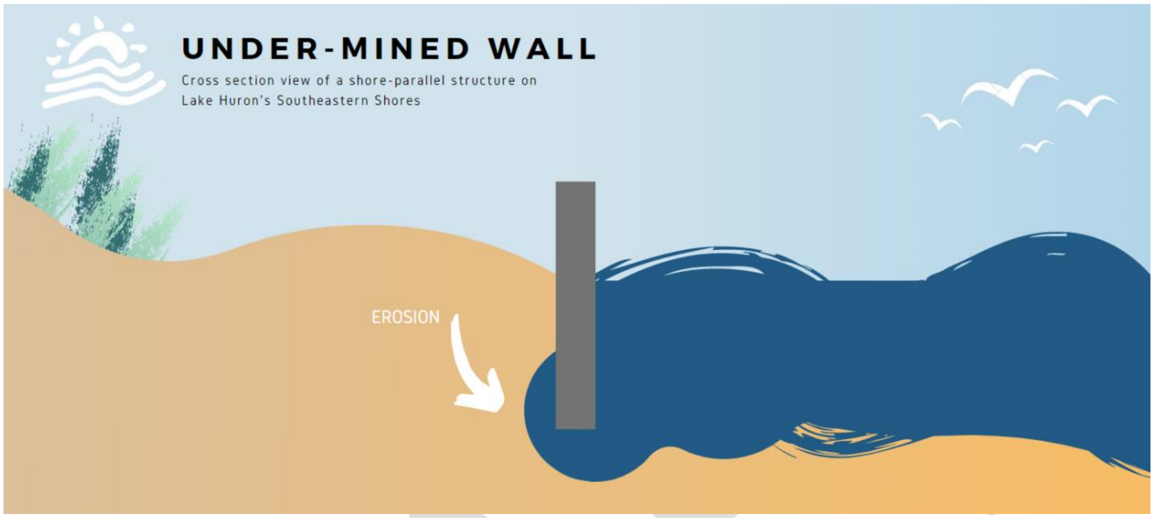


Figure 60 - Undermining of a Sea Wall on Lake Huron

Intended to preserve the beach environment, groynes, walls, and hardened structures cause beaches to erode by wave refraction. They also detract from the natural beauty of the ecosystem. "A *walk along the beach hindered by shore protection from a previous era—an overturned seawall, scattered remnants of a bulkhead or groin, pieces of concrete. Some of these failed structures and materials offer limited shore protection, [and] many are unsightly, a safety hazard and an obstruction to beach use*" (USACE, 2003, p.20; Figure 55). Groynes and walls are typically not properly maintained, as maintenance is very expensive and requires technical expertise such as engineers to assess methods for rehabilitation. "Armouring the shore should always be a measure of last resort. Armouring is not a one-time action but requires constant monitoring and occasional repair or replacement" (USACE, 2003, p.39).

The average lifespan of engineered hardened shoreline is 20 to 25 years on the Great Lakes, often neglecting maintenance costs that range from 2% to 5% of the initial building cost, per-year (USACE, 2003, p.36). Most of these structures were installed in the 1970's and 1980's, making the lifespan of most existing structures overdue for significant rehabilitation or complete replacement. This timeline along with the prevalence of a return of high lake levels, provides the opportunity to work with landowners to remove and rehabilitate the shorelines of their communities. Some CAs have a position statement and recommended applications of certain hardened shoreline techniques to attempt to work with landowners on their requests for this infrastructure. ABCA recommends that areas with severe long-term recession (0.3m/yr.) apply an engineered rubble mound or armour stone revetment (wall); where reflective sea walls made of steel sheet pile are not recommended due to wave reflection causing increased scour and risk for toe undermining (Baird, 2019 [1]). Consistency in recommendations in regards to whether shoreline hardening should or should not be permitted or endorsed is extremely important to sustainably manage the shoreline.

Figure 61 – Derelict groyne

Some studies have compiled lists of general costs of various shoreline hardening techniques, along with their benefits and impacts. Beavers et al., (2016) formatted one of these charts, which has been adapted and shown in Table 23.

Table 25 - Cost of Shoreline Hardening Techniques vs. Natural Techniques (Adapted from Beavers et al., 2016).

Shoreline Structure	General Cost (USD)	Benefits	Impacts
Sea walls	$6,526 - $9,843/m	Reduces upland erosion	Disrupts natural processes, causes erosion of lake bed, impacts habitat
Groynes and jetties	Groyne: $820 - $21,325/m Jetties: $52,493/m	Widen beach, limit sediment flow and wave energy in inlets	Disrupts natural processes (longshore transport); causes downdrift erosion
Sand fencing (removable)	$4 /m	Support natural vegetation growth and sand accumulation; reduces wind stress and storm spray	Can create debris or gather litter.
Living shorelines (natural)	Restoration Initial: $3,281 /m Annual Maintenance $328 /m (recent projects on Lake Huron suggest costs of $300 /m	Provides habitat, dissipates wave energy, slow inland water transfer	No upland flood prevention; vegetation presence can vary by lake level; offsite shoreline structures can affect the ability of shoreline to complete processes

As described in Table 23, built infrastructure have much more impacts than natural infrastructure, and are exponentially more expensive in initial and maintenance costs. During times of high lake levels, landowners are desperate to protect their property with any means possible, but it is during low levels that the installation of these structures occurs. Experts cross-jurisdictionally agree that shorelines should not be hardened by building revetments to protect beaches or shorelines from wave erosion (USACE, 2003; Baird, 2019 [1]; Davidson-Arnott & Mulligan 2016). Instead, abiding by recommended development setbacks, locating buildings outside harms way, and reinstating natural infrastructure like dunes and coastal vegetation will be more successful in the long term at creating a resilient property (Baird, 2019 [1]). Adaptation is a "*strategy of siting new buildings far enough from the edge of coastal slopes and high enough above the water that erosion won't claim them and flooding won't reach them" (USACE, 2003, p.16). Coastal engineers propose setback distances for future development or adjustments to existing communities, "should be estimated as if the shore protection structures were not present. Shore protection can fail – sometimes quickly and catastrophically. When this happens, the previously protected shoreline tends to recede rapidly toward the position of neighbouring unprotected shorelines, erasing the benefits gained from the former shore protection structure*" (USACE, 2003, p.16).

Communicating alternatives to landowners to improve shoreline health, allow resurgence of coastal processes, and reinstate human health and safety will be a multi-pronged approach to instilling a new mantra of natural coastal shorelines along the coastal corridor.

Two methods were used to determine whether the amount of shoreline structures and hardened shoreline per AU rank as 'excellent', 'good', 'fair', or 'poor'; (1) The Shoreline Alteration Index and, (2) number of structures per kilometer of shoreline. The first method is the Shoreline Alteration Index (SAI) commonly used by the International Joint Commission in their Great Lakes research (IJC, 2014). The SAI is, "a measure of human modified shoreline length that is physically and biologically unfavorable to the Great Lakes ecosystems" (IJC, 2014). SAI can be calculated using simple orthophoto rectification and quantitative analysis through Arc GIS, wherein the total linear length of the shoreline within the Assessment Unit is compared to the ratio of armoured and human modified shoreline versus natural shoreline (IJC, 2014).

For this method, SAI is calculated using a simple mathematic equation: SAI = 1 - (P ratio x B ratio). "(P ratio): human modified shoreline/ total shoreline... (B ratio): Biological shoreline indicator is the ratio of the lineal length of biologically incompatible structures (shore perpendicular structures, vertical sheet pile, concrete walls, and other "human-made" structures that cannot serve as biological habitat) relative to total lineal length of "human-made" shoreline." (IJC, 2014). The unit that is derived through this calculation determines how altered the shoreline is, and whether it is biologically compatible. "The greater the SAI value, the more unaltered the shoreline is" (IJC, 2014; Table 24 & 25).

Table 26 - Shoreline Alteration Index (IJC, 2014)

% Hardened Shoreline		**SAI INDICATOR**	**1 Structure / # km**
Poor	70% - 100%	>1	0 to >2 km
Fair	40% - 70%	0.75 - 1	2.1 - 4.0 km
Good	15% - 40%	0.5 - 0.75	4.1 - 6.0 km
Excellent	0% - 15%	0 - 0.5	>6 km

Table 27 - SAI Indicators, Adapted from IJC, 2014

INDICATOR	**Poor**	**Fair**	**Good**	**Excellent**
Physical	0.7 to 1	0.4 to 0.7	0.15 to 0.4	0.0 to 0.15
Biological	**bio ratio is lineal length of hardened shoreline structures relative to total length of shoreline			
SAI	0.0 to 0.3	0.3 to 0.6	0.6 to 0.85	0.85 to 1

The benefit of using the SAI is the comparability of this study to others across the Great Lakes, the calculation is scalable to any jurisdiction or shoreline length, meaning land managers from township to county can use it in land-use planning, and can be compared temporally to compare progress or shoreline naturalization. "The advantage of this approach is that as structures are removed and/or modified to provide habitat enhancements, the indicator will shift toward a more unaltered or natural state" (IJC, 2014). This approach was utilized given its adaptability to downscale to local situations.

The second method used to determine shoreline condition was the number of structures per kilometer of shoreline within each AU. This measurement was more challenging to find within relevant freshwater coastal ecosystem literature. Taking an average of the amount of structures per kilometer across the entire study area, and aligning this average with SAI ratings while considering the types of nearshore sediment movement across the nearshore waters, and determined a feasible rating system for the structures/km based on this calculation. As shown in Table 24 and Table 24. The colours denoted to the categories of 'poor', 'fair', 'good' and 'excellent' are projected into our overall assessment within Table 26. It is notable at first glance that the farther north the Assessment Unit is, the less hardened shoreline and less shoreline structures exist. This could have a direct correlation to:

- the division of erodible to non-erodible shoreline across the study area,
- the lake bathymetry dictating the impact lake level fluctuations have on shoreline properties,
- the density/ level of investment within these very different assessment units, and
- setback distances from the high-lake-level zone to the cottages and homes on these shoreline properties.

In-depth analysis on these assumptions will be broken down into each Assessment Unit summary.

To analyse the presence and concentration of hardened shorelines and shoreline structures on Lake Huron, a tally was taken using air photos and orthophoto rectification, as no up-to-date numbers existed in any relevant literature or Official Plan. Table 26 shows the prevalence of hardened shoreline and shoreline structures analysed by Assessment Unit. Further breakdown of the types of shoreline structures and types of hardened shorelines are analysed in the Assessment Unit summaries attached to this document.

Table 28 - Shoreline Structures and Hardened Shoreline on Lake Huron's Southeastern Shores

AU	Length of Shoreline (km)	Hardened Shoreline (km)	# of Shoreline Structures	% of shoreline Hardened	1 structure every ## km shoreline
1	81.20	13.29	379	16.37	0.22
2	120.85	15.04	205	12.45	0.59
3	63.94	9.77	53	15.29	1.21
4	39.76	2.30	10	5.79	3.98
5	53.31	10.94	16	20.51	3.33
6	82.91	15.30	59	18.45	1.41
7	191.43	4.55	155	2.38	1.24
8	84.61	0.00	52	0.00	1.63
9	126.36	0.00	13	0.00	9.72
10	75.79	0.00	0	0.00	0.00
11	45.14	1.21	0	2.68	0.00

The far-right column in this table describes the density of shoreline structures (e.g. AU1 has a shoreline structure every 0.22 km; AU 9 has a structure every 9.72 km). These calculated averages are compared to the SAI indicator ranking them 'poor', 'fair', 'good', or 'excellent'. Unfortunately, most of the southeastern shores rank poor, with an average structure every 1.7 km between AU's 1-8. The average of shoreline structures per length of shoreline for the entire southeastern shores is ranked as Fair at one structure every 2.12 kms.

5.2.2 TOURISM

Almost all coastal communities on Lake Huron's southeastern shore rely on tourism to sustain their economy. Maintaining the appeal for existing tourists and encouraging future tourism through positive visitor experience is extremely important for businesses that rely on seasonal visitors. However, some locations have exceeded many social and ecological carrying capacities at tourist hot-spots, leading to degradation of ecological integrity and negative visitor experiences. Global tourism has been estimated to double from 1-billion to 2-billion travellers by 2031 (Twenty31, 2017). In the coastal corridor specifically, "*In 2016, over 140,000 visitors came to the Grotto [in Bruce Peninsula National Park], while over 160,000 visitors were turned away due to capacity issues it is becoming increasingly evident that the current tourism model cannot accommodate this demand without compromising the ecological integrity of these areas, visitors' experiences, and local infrastructure throughout the region"* (Twenty31, 2018, p.15). Along with this exponential increase, changing visitor demographics and trends in recreational activities will continue to change visitor desires at current visitor nodes, requiring land managers in these areas to be adaptable to these changes in order to keep visitation high and sustain local economy. There is evidence that climate change is causing shoulder seasons (especially autumn) to be more attractive for tourists given changes in weather patterns (Donnelly, Pat, pers. comm.). Pinery Provincial Park is one that has adjusted programming and staffing to support autumn visitation numbers (Donnelly, P., pers. comm.).

Figure 62 - Tourists enjoying Flowerpot Island (Photo Courtesy of H.Cann).

Although many economies are sustained on tourism, the 2017 CAP online questionnaire found that only 24% of respondents said they felt tourism was important to them. In Huron County alone, (2016) there were over 2,000 people working in the accommodation, food services, arts and entertainment sectors alone, which claims to have "an under-developed tourism market relative to other rural areas in southern and central Ontario" (Huron County, 2016). The Sarnia Lambton Tourism Association claims that visitors to their information centre showed a 4% increase in 2017 compared to 2016 (Pers. Comm, 2018). Measuring levels of tourism is one facet of the analysis; Bruce Peninsula is one area doing specific research on what threats tourism causes to the sensitive ecosystems of their shoreline. As outlined in their regional tourism study (Twenty31, 2017, p.25), Priority threats and negative impacts associated with a continued growth of tourism with current trends and management strategies in place include;

- Strains on community infrastructure with low tax-base for improvement and maintenance in small communities; (restroom facilities, septic systems, waste management);
- Increases in vehicle traffic and parking (vehicle/animal conflict, increased emissions);
- Increase of litter and waste;
- Increased vegetation trampling and soil compaction along trails;
- Damage to cultural and natural resources;
- Increased low-cost or free attractions;
- Lack of staff to enforce bylaws and regulation (Twenty31, 2018).

Opportunities outlined in Twenty31's 2017 tourism study included dispersal strategies, enhancing marketing and messaging to attract quality tourists, extend shoulder seasons, educate tourism businesses, residents, visitors and municipality on sustainable tourism strategies, enhancing collaboration, and improving involvement with First Nations communities. Within this document, they outline example indicators that can be used to analyse improvement or continued degradation including widening of trails and roads for traffic, total kilograms of waste produced and processed at municipal waste facilities, number of reported road kill incidents, area expansion of barren, trampled areas; as well as surveys to locals regarding their support of tourism (Twenty31, 2018). Coastal land managers with tourism as an important component are encouraged to develop partnerships with their associated regional tourism office, to establish locally relevant indicators to monitor the effects of tourism on the ecological integrity of the coastal corridor.

5.2.1 OPPORTUNITIES:

Identified in HRH The Duke of Sussex's newest venture, Travalyst, a global initiative to reduce tourism impacts, has set the goal to reduce impacts on the environment and local communities;

"as tourism inevitable grows, it is critically important to accelerate the adoption of sustainable practices worldwide; and to balance this growth with the needs of the environment and the local population" (Travalyst, 2019).

Tourism studies have shown results that travellers and tourists want to reduce their impacts to the places they visit, with survey results identifying that 68% of people want money they spend on travel to be reinvested in the local community; and 71% of respondents desiring more sustainable travel choices to be provided through travel companies (Travalyst, 2019). With the desires of tourism companies and tourists alike in mind to reduce their impacts on the places they visit, land managers can better tune into indicators and thresholds they should monitor to ensure a reduction of impacts. Recommended monitoring avenues include;

1. Environmental impacts (physical and biological)
2. Experiential or Psychological impacts (visitor experience)
3. Economic impacts (on community)
4. Socio-cultural impacts on communities (changes to culture or local demographic)
5. Infrastructure impacts (quantity and lifespan). (Eagles et al., 2002).

Using a combination of qualitative and quantitative indicators to monitor these 5 monitoring avenues is recommended, and may overlap with monitoring results or initiatives undertaken in coastal environments. In some areas with sensitive ecosystems and high tourism visits, carrying capacity limitations may be required to preserve the ecosystem or infrastructure to handle the increase in tourism (LaCroix, 2015). Setting limits of acceptable change will aide in the monitoring of ecosystem impacts. Setting a limit of acceptable change can prompt pro-active management decisions to prevent the limit from being reached. Once the limit of acceptable change is approached or reached, reactive methods such as restoration should be employed (LaCroix, 2015). Through all these management initiatives, keeping communication between disciplines such as municipality-regional tourism office- and tour operators is key to ensuring all invested parties are aware of the strategic direction and willing to reduce impacts and make pro-active and reactive changes as required. This adaptive management style is key to preserving ecosystems and dealing with impacts and stressors as they arise (LaCroix, 2015).

In conclusion, the key to successful and sustainable tourism in the coastal environment is an understanding of the importance of tourism to the local economy, and the ability to adapt management approaches using infrastructure, spatial and temporal redistribution of tourists to mitigate negative impacts and offset stressors.

5.2.3 SEVERITY OF THREATS

Development and use of the shoreline for residential areas and tourism opportunities is a positive note for communities and economies along the coast. However, their unsustainable management practices cause a threat to coastal ecosystems and the ecological integrity and water quality of the coastal corridor. Using the LAMP threat rating criteria (ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10-years).

Threat	Rating
Cottage and community developments	**Scope:** VERY HIGH – The area of the coastal corridor reasonably expected to be affected by cottage developments, impermeable pavements, beach grooming, road networks, marinas and hardened shorelines within 10-years is pervasive, affecting 71-100% of the coastal corridor. As tourism grows, and seasonal and year-round communities expand, the threats of unsustainable development and land-use will continue to affect coastal ecosystems, unless stronger bylaws and enforcement, as well as awareness and grass-roots action occur.
	Severity: MEDIUM – the level of damage and degree of destruction reasonably expected to occur within 10 years is likely to moderately degrade coastal ecosystems by 11-30%. Most of the shoreline ecosystems have already been developed, and areas where more development is occurring are limited. The level of damage expected in the next 10 years includes alteration and enhancement of existing stressors.
	Irreversibility: HIGH – The degree to which the effects threats can be reversed and habitats restored is technically achievable, but impractical due to time and money constraints, taking 21-100 years to achieve. Many of the cottages and municipal infrastructure such as roads, shoreline structures, and marinas will not be removed in the next three generations, causing that irreversibility to be high, whereas beach grooming is something that has low irreversibility rates and can be changed annually.
Tourism	**Scope:** HIGH – The area of the coastal corridor expected to be affected by tourism within the near future is widespread, affecting 31-70% of the shoreline. Although tourism nodes are chronic across the southeastern shores, they are fairly contained, with some private beach and shoreline areas beginning to increase in use.

	Severity: LOW - The level of damage tourism will have will cause a slightly increased degradation of coastal ecosystems within the next 10 years. Although tourism numbers are expected to increase, the land-use of these areas will not change, even if use is increased. The way these areas are managed will determine the severity of the effect.
	Irreversibility: LOW – the effects of tourism can be reversed and habitats restored at relatively low cost within 0-5 years to achieve pre-threat conditions. In most areas of the shoreline, restoration of beaches to have dunes is low cost and highly effective, taking a short time to regain these natural structures. It is for these reasons that this method of restoration is highly effective at returning ecological integrity to visitor nodes.

5.3 POINT AND NON-POINT SOURCE POLLUTION

DEFINITIONS

Point source pollution: *Contaminants that enter a habitat at an identifiable point (e.g. pipe, channel, well, boat fuel spill…) (Morales, 2015)*

Non-point source pollution: *NPS pollution refers to contaminants that enter the environment as the result of everyday activities from numerous small sources. It is contrasted with the pollution from large readily identified sources, such as sewage plant outfalls and industrial smokestacks. (Stewart et al., 2003).*

Pollution of any kind is bad for aspects of the environment, whether it come from litter, contaminants in the air, water, or habitats that exist in coastal environments. "NPS pollution degrades water quality and habitats, and generally interferes with ecosystem processes. Long-term cumulative effects, as well short-term immediate effects on the environment, need to be considered in planning decisions in the coastal zone" (Stewart et al., 2003). It is a shared responsibility among grass-roots, local, and regional governance to manage and regulate point and NPS sources of pollution entering our coastal environments and inevitably affecting human health[i].

Many locally-significant pollution sources affect the coastal zone of Lake Huron every day as evidenced by beach postings and garbage and algae washing ashore. The Government of Canada created the *Canadian Environmental Protection Act* in 1999 to set a prescient for the prevention and management of pollution sources and threats in Canada. This act states that the Canadian Federal Government commits to, "*implementing pollution prevention as a national goal and as the priority approach to environmental protection; [and] acknowledges the need to virtually eliminate the most persistent and bio-accumulative toxic substances and the need to control and manage pollutants and wastes if their release into the environment cannot be prevented… the Government of Canada will continue to demonstrate national leadership in establishing environmental standards, ecosystem objectives and environmental quality guidelines and codes of practice*" (Government of Canada, 1999, p.1). The Environmental Protection Act states that toxic substances and pollutants are of national concern and rely on science and traditional aboriginal knowledge to make decisions to protect environmental and human health (Government of Canada, 1999, p.2). The Federal Government has committed through this Act that they will, "take preventative and remedial measures to protect, enhance and restore the environment" (Government of Canada, 1999, p.2). Although there is a strong commitment from levels of government to prevent pollution, unfortunately, there are many forms of natural and anthropogenic sourced pollution affecting the coastal corridor of Lake Huron. Beach postings, plastic pollution, agricultural inputs, light and thermal pollution, industry and shipping, power generation, and resource extraction are pollutants analysed as their impacts are the most widespread across the southeastern shores.

5.3.1 BEACH POSTINGS

***E.coli* CONCENTRATION INFLUENCES**	
Environmental Influences	Point Sources of *E.coli*
Rainfall	Storm drains
Air and water temperatures	Septic systems
Shape of the coastline	Rivers
Wind speed/ Wave height	Groundwater seeps
Relative Humidity	Bird and pet waste
Turbidity	Swimmers
Ultra Violet Light Exposure (bathymetric depths)	Agricultural runoff

A beach posting is a warning provided by Regional Health Units identifying that water samples of beach areas indicate with elevated levels of bacteria higher than agreed upon thresholds, indicating the potential for developing minor infections and stomach effects if water is consumed. The Huron County Health Unit alone, “samples 14 public lake shore beaches [twice per week] during June, July and August. At least 5 water samples are collected at each beach and are sent to a laboratory for bacterial analysis. This determines the number of *E.coli* colonies present in the sample. *E.coli* in the water indicates the potential presence of disease-causing organisms such as bacteria and viruses” (HHU, 2019). Lambton Public Health samples 7 public beaches every week day between June and August; Public Health Grey Bruce samples 12 beaches (8 on the southeastern shores) monthly (LPH, 2019; PHGB, 2019). Looking at the long-term data set for beach posting on Lake Huron’s southeastern shores show some trends in the number of postings per assessment unit (Table 27). This is not a perfect comparison because the three health units’ sample at different intervals, skewing the data set. However, it indicates of the number of beach postings that occur across the coastal corridor.

Table 29 - Beach Postings on the Southeastern Shores

Assessment Unit	2012	2013	2014	2015	2016	TOTAL	AVG / YR
1	2	2	0	3	4	11	2.2
2	105	81	216	64	78	544	108.8
3	54	64	52	44	31	245	49
4	0	0	2	0	0	2	0.4
5	0	0	0	0	0	0	0
6	1	0	2	2	0	5	1
7	0	0	0	0	0	0	0
8	0	0	1	0	0	1	0.2
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0

Beach postings and increases in *E.coli* concentrations occur from nutrients and pollutants. Health Units provide information to the public about what they can do to advocate for their own safety if beach postings have ended for the year in the off-season. There is consensus among all three Health Units around which stressors affect nearshore water quality and nutrient levels. Higher levels of nutrients and *E.coli* occur because of fecal matter concentrations encouraging the growth of bacteria. “The current *E.coli* test is only an indicator that there was fecal contamination from either animal, human, or both, and that there could have been other harmful bacteria, parasites and viruses present in the water when the samples were collected.” (HHU, 2019). Typical sources are from agricultural storage or manure field spreading, leaky septic systems, improperly constructed or maintained weeping beds, or municipal sewage overflow events. Effective buffer zones of vegetation around creeks and shorelines, wetlands, and meandering creeks slow down water coming off the landscape, thereby allowing filtration of these nutrients through plants and sediment, reducing levels entering nearshore waters. Higher velocity of water coming off the landscape through precipitation events expedites the sedimentation and nutrient inputs entering the nearshore as well, whether from agricultural areas or from shoreline areas covered in animal feces (e.g. ducks, gulls, dogs). Ensuring shoreline areas are less appealing to flocks of birds by limiting mowed turf grass, as well as ensuring visitors are picking up after their pets, are integral to beach and shoreline management. Encouraging and insisting on buffered watercourses, protection of coastal wetlands, and presence of cover crops in shoulder seasons will improve water retention on inland sources and increase the filtration of these nutrients.

Wind and wave activity, as well as lake levels and bathymetric profile of the shoreline can also have impacts on the frequency and concentrations of nutrients affecting beaches. "Increased wave activity can stir up settled contaminants and cause water quality conditions to have increased levels of *E.coli*" (LPH, 2019). Wave activity in areas with shallower nearshore topography see higher disturbance, especially in areas with fine sediment making up the lake bottom. This is the case for the southern two-thirds of the southeastern shores, where there are erodible shorelines. Higher concentrations of nutrients and bacteria may also be present in shallower nearshore areas because the thermal radiation from the sun and UV rays can permeate the nearshore waters to the lakebed, encouraging the growth of bacteria and virus. However, this factor also exists in non-erodible shorelines where waters are clear from lack of sedimentation, allowing sunlight to permeate deeper into the water column. It is this factor that also encourages the growth of algae.

Figure 63 - Geese on Rotary Cove Beach in Goderich (2005)

Algae blooms are nothing new on the Great Lakes, but their frequency and spread is increasing across Lakes Huron, Erie, and Ontario (ELPC, 2019). Climate change has been denoted as the major culprit, increasing water and atmospheric temperatures, increasing storm frequency and strength, and extending growing seasons (ELPC, 2019). Climate change is very likely to have significant negative effects on source water quality that will put stress on drinking water infrastructure. Higher mean temperatures and more heavy precipitation events are favorable for this algal growth (ELPC, 2019). Urban wastewater and stormwater systems also deliver significant nutrient loads to surface and groundwater (ELPC, 2019). Causes for the increase in algae growth has been attributed to, "increased nutrient loading caused by agricultural fertilizers, urban wastewater, and soil erosion" (ELPC, 2019). Ecologists suggest that, "*unless nutrient and sediment loads are offset by improved land management practices… nutrient loading to Great Lakes coastal zones is generally expected to increase…mostly due to a greater frequency of significant precipitation events that increase runoff from agricultural landscapes in the surrounding watersheds*" (ELPC, 2019). Algae naturally forms in lake ecosystems and most algae species do not cause a threat to human health, only limiting the aesthetic appeal of shorelines. However, when decomposing in the fall, algae, along with other plant material consume oxygen creating an anoxic environment, reducing habitat for fish and other benthic invertebrates if prolific amounts of algae are decomposing in shallow water. At water temperatures above 20ºC, the growth rates of freshwater eukaryotic phytoplankton stabilize or decrease, while growth rates of many bloom-forming cyanobacteria increase (e.g. *Microcystis*, *Anabaena*, and *Cylindrospermopsis*) (ELPC, 2019). Toxic blue-green algae threaten human health due to the cyanobacteria it produces, and can cause

Figure 64 - Algae wash-up on Bruce Beach (2007)

beach closures in recreation areas for long periods of time. Monitoring levels of nutrients and controlling their entry into nearshore water environments will positively contribute to the reduction of beach closures and effects on tourism due to algae. As discussed in Chapter 4, some municipalities have machines to clean up algae events like the one seen in Figure 58, but are often over used.

Citizen science has begun filling the gap of monitoring water quality and algae bloom appearances. For example, LHCCC's Coast Watchers program has a network of volunteer data collectors which monitor atmospheric and water temperature parameters, as well as qualitative states such as algae blooms, plastic washup events and storm events. Rotary Club members in Grand Bend and members of cottage associations have also in the past done water quality testing to take accountability for monitoring the nearshore water quality for human health and enjoyment (e.g. swimming).

RECOMMENDATIONS:

Water sampling frequently assists land managers in making more informed decisions on whether a beach's *E-coli* levels are changing quickly, or over the longer term, and larger data sets help inform land managers over time where changes or increases are occurring. Sampling a beach monthly does not provide an adequate reading for the beach's overall condition for the month, as the sample may be a 'fluke' or outlier in an otherwise normal, or abnormal condition. Frequent monitoring of at least once per week is recommended for long-term monitoring, and for public health. However, resources such as time, budget, and available staff are all limitations for Health Units to complete these samples. Another limitation is the time between when the sample was taken, and when results are returned to the community. Nutrients and bacteria causing a beach posting may have dissipated by the time the official posting is done.

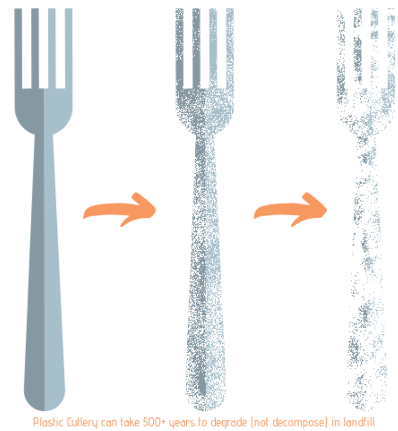
Health Units across the shoreline recommend if visitors have not checked the beach postings, or if visitors are at the beaches outside of the June-August monitoring window, to self-evaluate whether it is safe to swim using three metrics:

1. "Is the water turbid (can't see my feet while standing waist deep in water)?
2. Has there been heavy rainfall in the last 24-48 hours?" (HHU, 2019).
3. "Are there other problems evident on the beach such as dead waterfowl or fish, algae/scum, or dangerous debris" (PHGB, 2019)

Although not a perfect science, beach postings monitor nearshore water quality for the health of coastal ecosystems and human safety. Encouraging public awareness and education about factors influencing water quality will improve understanding as to why beaches may be posted, and what they and their communities can do to improve water quality.

5.3.2 PLASTIC POLLUTION

Figure 65 - Plastic cutlery fragmenting into microplastics



The emerging issue of Great Lakes plastic pollution threatens the holistic health of the Great Lakes ranging from water quality, to human and wildlife hazard, to bioaccumulation risks. Plastic debris has the capacity to adversely affect aquatic environments as it is a form of pollution but can be mitigated through public awareness, municipal regulation, and diligent maintenance. In 2018, awareness and even bans on the use of plastic straws catalyzed a global increase in plastic pollution awareness, specifically the harm of single-use plastic items on wildlife and water quality in the world's oceans. Although the Great Pacific Garbage Patch is well known for its elevated concentration of plastic pollution, current research Through Dr. Chelsea Rochman and the University of Toronto shows that Lake Superior, Lake Huron and Lake Erie's plastic concentrations far exceed data in the many oceanic patches (Campbell, 2018; Froklage et al., 2013). Scientific estimates quantify that certain parts of the Great Lakes contain more than 500,000 pieces of plastic per square kilometre, comparably equating to 2,500 pieces of plastic in the area of a standard football field (Campbell, 2019; LHCCC, 2019). Plastic pollution has many forms and comes in many sizes. Big items such as vehicle tires, laundry jugs, and household items to smaller items like tooth brushes, food packaging, pens, and straws, to micro and mesoplastics all plague the southeastern shores of Lake Huron. "*Microplastics are plastic particles less than 5 mm in size originating from a variety of sources. Primary microplastics include products deliberately manufactured such as microbeads and nurdles, while secondary microplastics come from the breakdown of larger items such as food and beverage containers, bags, and textiles*" (Oceanwise, 2019; Figure 64).

In recent studies of fish in the Great Lakes, almost all fish sampled contained forms of microplastics 5 millimetres and smaller, which backs up estimates that approximately 22-million pounds of plastic enter the Great Lakes every year (Campbell, 2018). Plastic pollution is an issue because plastic does not biodegrade the way other items made of natural materials do, and appear to simply break apart into smaller and smaller pieces (Figure 64). Plastic pollution enters the Great Lakes and enters coastal ecosystems through;

1) Stormwater and agricultural runoff and through rivers and streams;
2) Wastewater treatment plants lacking fine-enough filtration of effluent;
3) Litter directly blown into the lake;
4) Marine debris (e.g. fishing gear, nets) (Campbell, 2018).

There are many types of plastic, some of which are made of plasticizers and chemical additives that are potentially harmful if they leach into environments. Research has also shown that plastic particles can act as vehicles for other pollutants and chemicals in aquatic environments meaning they attach to the surface of plastic and could transfer to wildlife that consume them (Belton, 2018). If an animal consumes enough plastic pollution containing harmful chemicals, concentrations of toxins can build up in the animal (bioaccumulation) causing death through poisoning (Belton, 2018). Plastic is also a physical hazard for wildlife; animals can become in entangled in large debris, and consume small debris, causing obstructions and infections in the body. This has been observed in birds, reptiles, and even mammals. Plastic pollution is rapidly increasing, as society continues to move towards a convenience and throw-away lifestyle.

It is important to note that there is only one originating source to target when trying to combat plastic pollution, being humans. Considerations such as secure garbage containers, ensuring there are enough garbage receptacles to accommodate the number of people, and employing enough maintenance staff to empty the garbage containers can reduce the release of garbage. Encouraging visitors to reduce litter by providing signage to 'pack in and pack out' and providing recycling options will reduce waste. Working with local businesses to change food takeout containers and sales bags from plastic to reusable or compostable items will reduce effects on shorelines. Other forms of point source pollution, such as microfiber pollution through laundering synthetic fabrics will be harder to tackle, as controlling this takes more education to consumers, working with clothing companies to increase natural fibers in clothes, and incentivising and installing micro-fiber filters on washing machines will captures these pollutants before they enter the waterways (TheOceanCleanup, 2019).

Figure 66 - Types of Microplastics in the Environment (Orange, 2019)

Beach and shoreline clean-ups remove plastic waste and are inexpensive but time consuming to do and requires constant vigilance. Plastic pollution ends up on shorelines through wind blowing litter from inland sources, being washed up out of the lake during storm events, and travelling down rivers and ending up on the banks and nearshore environments. Unfortunately, plastic pollution is often very hard to remove once in smaller forms such as microplastics (LHCCC, 2019). Therefore, the best way to reduce this form of pollution is to reduce the amount of single-use plastic items we use in our daily lives, as well as increasing waste management and recycling schemes. The most effective way to reduce NPS plastic pollution is through systemic change which would include reducing plastic use in the whole Great Lakes watershed and moving towards a more sustainable circular economy.

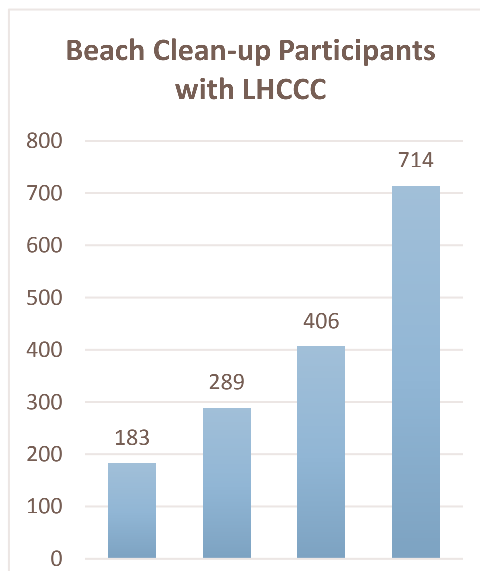


Chart 11 - Beach Clean-up Participants with LHCCC between 2015-2018

Coastal clean-up efforts are one way to attempt to manage this pollution source. Between 2015 and 2019, LHCCC has partnered with many different agencies across the Lake Huron shoreline to arrange beach clean-ups across the southeastern shores. As shown in Chart 13, there has been a significant increase in the number of beach clean-up volunteers participating in LHCCC led beach clean-ups eager to keep our shorelines clean. These numbers only reflect the clean-ups put on in partnership with LHCCC and do not include the valuable work done by other groups, including *Keep the Bruce Clean and Green Tobermory*, which also conduct beach clean-ups regularly. More broadly, The Great Canadian Shoreline Cleanup has been coordinating and collecting data from shoreline clean-ups across Canada since 1994, and in 2019 alone recorded data from 1,887 coastal clean-ups, removing 95,837 kg of litter across 3,322km of shoreline (ShorelineCleanup.ca). The breadth of their partnerships across the country and ability to track types and densities of plastic pollution is unparalleled in Canada. Although extremely important, beach clean-ups address the result and not the cause of the plastic pollution on beaches. Clean-ups inland, along rivers, creeks, and roadsides are equally as important, to prevent plastic waste from travelling by water and wind from land to lake.

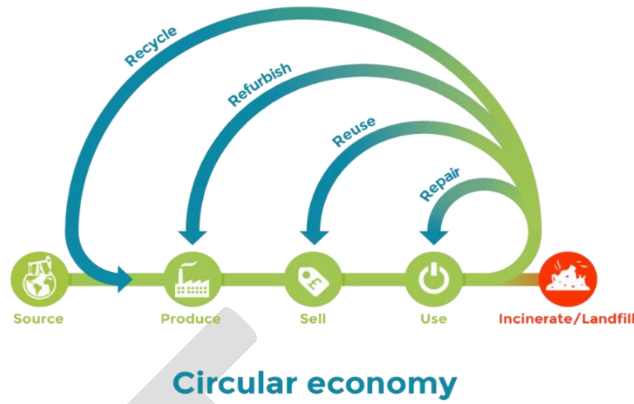


Figure 67 - Circular economy (Circular Tayside, 2017).

OPPORTUNITIES:

Plastic free solutions are gaining in popularity. Several communities along the southeastern shoreline have already established single-use plastic bans in their community and within local business to reduce unnecessary plastic waste and distribution and use of this source of pollution. Most notably, two grass-roots community groups along Lake Huron, Blue Bayfield and Green Goderich, have received national attention for their initiatives to "*reduce the use of disposable plastics and prevent plastic and pollutants from entering our Great Lake and waterways*" (BlueBayfield.ca). Blue Bayfield has installed five water bottle refilling stations throughout the village, facilitates annual beach clean-ups, works with the local food establishments and the business community to offer sustainable packaging, and works with local food vendors to source local and seasonal alternatives. Along with these initiatives, Blue Bayfield has been designated a plastic-free community since 2018, and has gained a social media following where they educate and raise awareness about plastic pollution in Lake Huron, and recommend alternatives for people to participate to become a 'Blue' community. In 2019 alone, 32 communities across Ontario have contacted Blue Bayfield to ask for assistance on how to tackle plastic pollution (Durst, 2019).

Similarly, Green Goderich, a newly formed grassroots environmental action group, has the mission to eliminate plastic pollution and improve community environmental resources through education, action and advocacy (Greengoderich.com). Along with the

Figure 68 - Goderich water bottle refill station (2019)

Environmental Action Committee in Goderich, these groups have installed two water refill stations in the town to reduce single use beverage containers. Providing refill infrastructure such as water stations and openly promoting these investments will reduce single-use waste and encourage people to bring a container, while also providing exposure to the municipality for their green initiative. The mayor of Goderich stated in an interview regarding the water bottle refill stations; “It’s about community pride, leadership, moving our community forward and creating a culture of environmental awareness and action, it is our future” (Smith, 2019). Encouraging municipalities to make positive environmental changes on plastic-conscious living through grass-roots organizations and committees will enable stewardship, awareness, and action towards these initiatives.

Reducing plastic pollution at the source has received a lot of attention in the past few years. Items like the Cora Ball, which has been designed to catch plastic fibers in washing machines, are extremely effective at reducing their introduction into waterways; “*technologies added to washing machines (Cora Ball and the Lint Luv-R) [are between 26% -90%] effective in reducing microfiber emissions to the environment. While further investigations are needed to understand the relative contributions of microfibers from other textile products and their pathways to the environment, we know that textiles laundered in washing machines are one source of microfibers and that effective mitigation tools currently exist*” (McIlwraith et al., 2019). Other forms of plastic pollution such as single use plastics which have gained notoriety such as plastic shopping bags, Ziplock bags, and water bottles, are seeing reusable versions entering the marketplace, including the Stasher Bag, ChicoBag produce bags, and Colibri reusable snack bags. Some consideration as to the price of these alternatives points out that their adoption might favour those with more financial means, with one Cora Ball costing $37.00 USD, and bag alternatives such as the Stasher Bag costing $12.00 CAD to $30.00 CAD. As many products in society, the highest cost of these products occurs at the beginning of their introduction, with costs typically declining the longer they are on the market, and as competition drives prices down.

In 2019, the Provincial Conservative Government announced the launch of a Producer Responsibility Plan (PRP), where, “producers (the companies that design, create and market products and packaging) will be responsible for managing and paying for the full life-cycle of their products to make recycling easier and more accessible across the province” (Ontario, 2019). The PRP reduces strain on municipal waste diversion programs and reduces unnecessary packaging waste, but this plan will not start until 2023 (announced in 2019). A 4-year timeline to work with producers, local business, and retailers to adopt more sustainable options or alternatives does not hasten the process of reducing plastic waste production in Ontario. During this 4-year timeframe, education through outreach and raising awareness of the systemic problem of point and NPS plastic pollution is extremely important in reducing the impact this item has on coastal environments. Through the CAP Coastal Community Workshops held between 2016-2019, participants highlighted that grassroots organizations and committees can get initiatives funded and completed often before their governments are able because there is more flexibility in time frame, budgets, and private grants that can be applied for. Much like other environmental challenges, the way plastic pollution will be reduced is through partnerships, collaboration, and participation by all individuals within coastal, and inland communities. Ensuring continuous education, awareness and reduction campaigns are in effect through all these agencies will ensure a safe, active, and healthy coastal corridor.

5.3.3 LIGHT POLLUTION

Light pollution is a relatively new phenomenon and threat to our natural world, with the invention of stronger, brighter, and cooler toned lights. Light pollution is considered a point-source polluter, since its source can be identified and diagnosed; as well as including chronic or acute illumination and glare (Longcore & Rich, 2004). Research has indicated that light pollution affects all animal life, inhibiting the natural cycle of day-and-night which strongly dictates physical cycles such as breeding, feeding, and migration of animals (Irwin, 2018). This form of `passive' pollution has been noted in recent scientific literature as, "*one of the most pervasive forms of environmental alteration. It affects otherwise pristine sites because it is easily observed during the night, hundreds of kilometres from its source in landscapes that seem untouched by humans during the day, damaging the nighttime landscapes even in protected areas, such as national parks*" (Falchi et al., 2016, p.1). Most of the communities on the southeastern shores are small and population, creating less light pollution than larger urban cities further inland. Figure 68 illustrates the presence and intensity of light pollution in Southwestern Ontario, and the coastal corridor of Lake Huron.

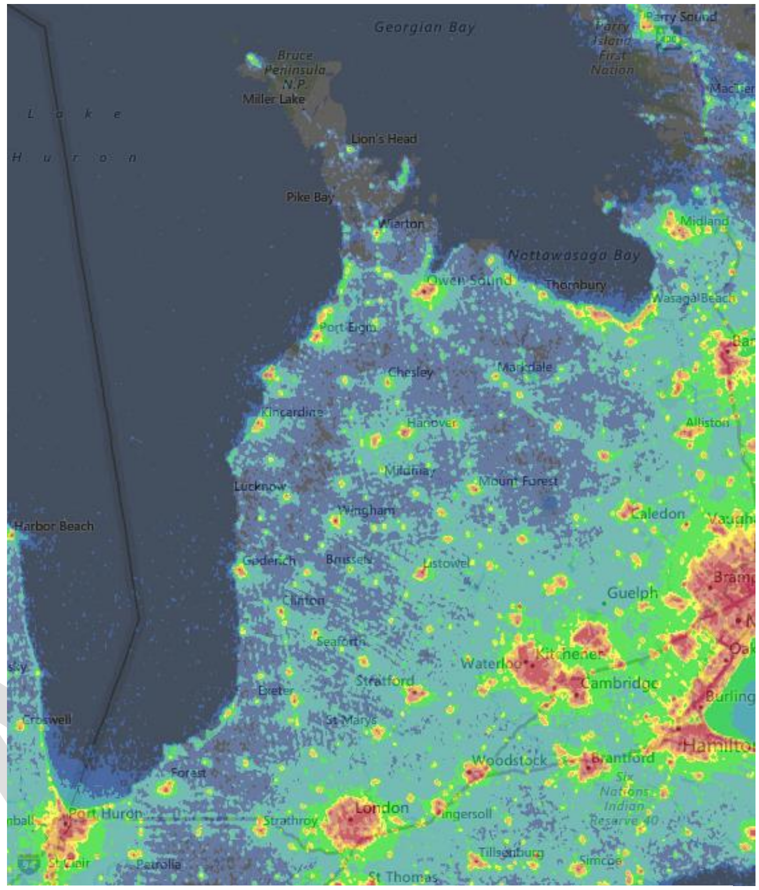


Figure 69 - Light pollution map (www.lightpollutionmap.info)

Increased presence of artificial light during the night can disorient or attract certain animals, especially migratory species, affecting their ability to navigate their routes to summer or winter destinations (Longcore & Rich, 2004; Irwin, 2018). Artificial lighting is extremely detrimental to the coastal corridor which is a migratory fly-way funneling species up the Bruce Peninsula and across to Manitoulin Island to Northern Ontario. It is also documented that night lighting attracts and kills insect species, reducing food sources for other species that primarily feed "on-the-wing" (while flying) including bats and dragonflies. Artificial night lighting is also known to have effects on small fish, who use nearshore waters and rivers often adjacent to communities and harbours for feeding, breeding, or migration. Artificial lights attract small fish because of increased insect presence and perceived safety from predator fish. However, attracting small baitfish species through artificial lights of piers and harbours will effectively attract predator fish, "thus, the influence of artificial night lighting on predator and prey behaviour makes it difficult to estimate how impacted food webs may be altered" (Bolton et al., 2017). Therefore, a seemingly unobtrusive development such as lighting along the coastal corridor can have far-reaching impacts are not yet fully understood.

Research is showing that artificial night lighting creates long-term impacts to wildlife populations, which inherently creates stress on ecosystems that already suffer from physical and chemical toxins (Irwin, 2018). Along the coastal corridor, harbours and industrial port facilities are notorious for being brightly lit, "often lit 24 hours per day for safety reasons" (Perkin et al., 2014). Researchers have noted that it is extremely challenging to measure light pollution accurately in natural environments, and how this light will affect the spectrum of wildlife

(Irwin, 2018). “*Estimates suggest that more than one-tenth of the planet`s land area experiences artificial light at night – and that rises to 23% if sky glow is included. The extent of artificially lit outdoor areas spread by 2% ever year from 2012 to 2016. An unexpected driver of the trend is the widespread installation of light emitting diodes (LEDs) which are growing in popularity because they are more energy efficient than other bulbs. They tend to emit a broad-spectrum white light that includes most of the frequencies important to the natural world*” (Irwin, 2018). LED bulbs in transport corridors or industrial applications are moving towards a ‘bright white’ light tone, instead of the traditional ‘warm white’ light. The traditional ‘warm white’ light is produced by a sodium bulb; “high-pressure sodium lights, will attract moths because of the presence of ultraviolet wavelengths, while low-pressure sodium lights of the same intensity but not producing ultraviolet light will not” (Longcore & Rich, 2004). LED bulbs, if adopted in the appropriate colour tone, can also have added benefits for municipalities and businesses in saving costs. For example, the Bayfield street lights alone cost $34,655.92 annually to run (Municipality of Bluewater, 2019), and upon conversion to LED, will show a significant cost reduction to these lights alone. The Town of Goderich upgraded to LED streetlights in 2016, translating to a saving of 864,968 kWh / year (Town of Goderich, 2019).

Light pollution seems to be one of the easiest forms of NPS pollution to reverse – you simply must turn off the light. The most effective method of reducing this problem is to work with communities in the coastal corridor to reduce non-essential night lighting, or to switch to dark-sky-friendly options. For homeowners within the coastal fringe, three easy methods to reduce light pollution include (1) downward-pointing lights that don’t allow shine above the horizontal access of the light; (2) reducing the colour tone of the bulb to under 3000K warmth; and (3) using motion-sensor lights (Warkentin, 2018; Berkers, 2018). Municipalities, counties, towns, and businesses can switch their industrial lighting using similar techniques, which may also reduce the operating costs of lighting public areas. Using red-toned lights which are considered benign to wildlife, in high sensitivity areas such as wildlife zones will also reduce the impact on the breeding, feeding, and migrating patterns of flora and fauna (Irwin, 2018). The International Dark Sky Association has a lighting fixture seal of approval program which certifies different outdoor lighting apparatus with a seal of approval because of their ability to minimize the amount of blue-white light entering the sky (IDA, 2019).

Figure 70 - Dark sky certified LED lights (IDA, 2019)

The amount of light in a pristine environment is limited to 1% of the natural background's darkness, as per the recommendations of the Dark Sky Atlas (Falchi et al., 2016). Controlling light pollution can be done on an individual and business, grass-roots level. Increasing education and awareness on the topic will encourage less unnecessary light emissions around the residential, urban, and industrial areas of the Southeastern shores. There is some pressure being put on local building codes to adapt their lighting requirements to conform to dark-sky friendly options. However, no changes have been made to the current Ontario Building Code to reflect these recommendations (IDA, 2019). Other agencies have created in-depth guides to aid in proper application of lighting.

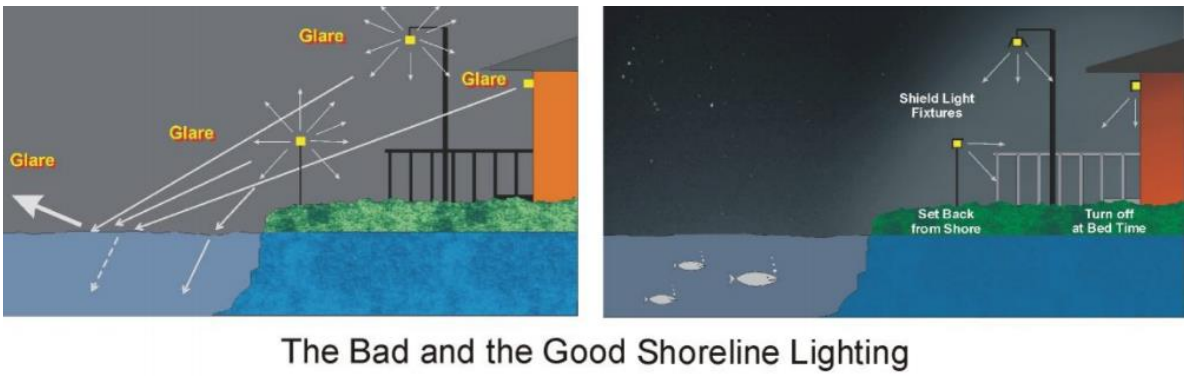


Figure 71 - Shoreline lighting comparison (RASC, 2018)

The Royal Astronomical Society of Canada (RASC) produced a free guideline for outdoor lighting which is widely used by Parks Canada, Darks Sky Preserves, Nocturnal Preserves and Urban Star Parks (RASC, 2018). This guide can be used by individuals, business owners, and municipalities alike to choose the right lighting at the right time and for the right application, to reduce sky glow and maintain dark skies. The best way to move forward with initiatives to reduce light pollution in the coastal corridor is to create awareness of the issue, present alternatives that will reduce the threat when updates and infrastructure projects are underway, and encourage the adoption of alternative products to those within and adjacent to the coastal corridor.

RECOMMENDATIONS:

The Municipality of Bluewater is making changes to reduce light pollution and consumption of electricity as per the requirements of the Ontario Regulation 507/18. Their new *Energy Conservation and Demand Management Plan 2019* outlines an energy reduction target of 2.5% between 2019 and 2023 (Municipality of Bluewater, 2019). Their previous projects have included street light replacements, retrofitting motion sensor lighting in community centres; while future projects include lighting retrofits of the Bayfield Pier, municipality wide street light replacements, and switching to LED lighting (Municipality of Bluewater, 2019).

Other groups have been making changes necessary to preserve their dark skies by reducing lighting pollution. "*Through the efforts of the Bruce Peninsula Environment Group, the Municipality of the Northern Bruce Peninsula declared itself a 'Dark Sky Community' in August 2004 and both National Parks were awarded the 'Dark Sky Preserve' designation in March 2009. In 2010 the Biosphere Association formed the community-based Dark Sky Committee to conserve our dark sky by promoting the adoption of dark sky friendly lighting practices… A dark sky culture was created among community residents as proved by an independent third-party survey that shows 90% of residents support preserving dark skies*" (BPBA, 2019). Increasing awareness of their initiatives, and steps to take for other community groups and cottage associations to reduce their impact relies on communication and education events, such as the coastal community workshops the Lake Huron Centre for Coastal Conservation put on every year across the southeastern shores.

1. Stay under 3000K – A warmth rating of less than 3000 Kelvin in LED lights will help reduce skyglow and have less impact on the circadian rhythms of human and animals using the coastal corridor (IDA, 2019a).
2. Use 'shielded' dark sky compliant light fixtures – "*To minimize the harmful effects of light pollution, lighting should:*
    a. *Only be on when needed;*
    b. *Only light the area that needs it;*
    c. *Be no brighter than necessary;*
    d. *Minimize blue light emissions;*
    e. *Be fully shielded (pointing downward, lower 180* or less*)" (IDA, 2019b)
3. Lighting bylaw for municipalities – The International Dark Sky Association and the Illuminating Engineering Society created an example of a Lighting Ordinance to make it easier for municipalities to adopt lighting plans by simply basing a lighting bylaw on this one which considered best management practices for dark sky certified lighting (IDA & IES, 2011).

5.3.4 THERMAL POLLUTION

Thermal pollution is the change to water quality due to any process or input that alters the natural temperature of a water source or micro-habitat. Thermal pollution can cause impacts to species that rely on certain temperatures for breeding or the viability of their eggs, like certain migratory fish species. "*Temperature increases as little as 1 to 2°C can alter communities because they are lethal to some species and can affect growth and reproduction of others. Raising water temperatures just 2 to 3°C above the optimal for some aquatic insects can reduce the number of eggs produced by females because more energy is used to support higher metabolic rates and less is available for egg production*" (Dodds & Whiles, 2010). This type of pollution is also known to reduce the oxygen content in water creating 'dead zones' where plants are less able to grow and some fish species that thrive in colder waters are not present when originally they would be. There are different methods that thermal pollution can occur; (1) warming on the land surface and water running off into creeks that outlet into Lake Huron, and; (2) direct entry to Lake Huron from industry outputs.

'Natural' Entry: 'Natural' entry of thermal pollution can happen in urban and rural environments. Most thermal pollution occurs through solar or passive heating of water due to open-access to sun, shallow uncovered streams, or direct pipelines through storm sewers. For example, streams in natural and rural environments traditionally have significant treed cover preventing the water in these shallow streams from warming too much from the sun. However, as deforestation occurs through removal of riparian vegetation for agriculture, residential development, or transportation corridors, solar penetration and increase in water temperature occurs (Dodds & Whiles, 2010). Along with vegetation removal and deforestation practices such as creek dredging, more stream surface area is exposed to sunlight, tangibly warming the water that enters Lake Huron. Similarly, in urban areas, water that runs across impermeable pavements warms due to thermal holdings in asphalt, concrete, and other hardened infrastructure, typically then running into a storm sewer entering the lake directly. This form of thermal pollution is expedited by impermeable pavements in urban areas, shorter distances from storm sewer to lake, and the lack of 'settling' or 'holdback' areas like coastal wetlands or naturalized stormwater ponds in existence in coastal communities. "*Along with industrial sources, urban and suburban runoff can contribute to thermal pollution, particularly during short, intense thunderstorms in watersheds with high amounts of impervious surfaces such as* *asphalt. Depending on local groundwater inputs, discharge, and other factors that influence thermal regimes, even small municipal discharges can alter stream temperatures for considerable distances downstream*" (Dodds & Whiles, 2010). Typically, water that can permeate back into the groundwater level is able to cool with geothermal regulation before it is brought back to the surface. An increase in our draw on shallow groundwater reserves can be another cause leading to thermal pollution.

Direct Entry: Direct entry of thermal pollution is most commonly associated with pipes or channels directly entering Lake Huron through industry and power generation. With the variety of industry on Lake Huron, there are many potential contributors, but many of these stakeholders are aware of this issue and monitor their potential influence on thermal inputs to Lake Huron. In some areas, "*Power plants and industrial factories are the major point source contributors to thermal pollution… [and] mitigating the thermal effects of power plant effluent obviously has a significant financial cost*" (Dodds & Whiles, 2010). However, on Lake Huron, we see these effects rarely, as many of the stakeholders self-regulate their outputs diligently. Although not currently a stressor on Lake Huron's southeastern shores, it should be noted that, *"Factories frequently discharge effluent at a higher temperature than the [lake] water, thereby adding thermal pollution to chemical effects. Such pollution is generally insignificant, and it is only with the advent of power stations, and particularly nuclear power stations, that serious study of the effects has been undertaken"* (Brown & McLachlan, 2002, p.16). The Bruce Power Nuclear Generating Station, has been monitoring its thermal effects widely across the shoreline through the deployment of temperature loggers (Bruce Power, 2018). Through their most recent projects, they have concluded that thermal pollution would most significantly affect whitefish, but that the levels outputted by the Bruce Power NGS is so low that the thermal effluent causes little to no risk to aquatic life residing in and around the generating station (Bruce Power, 2018). Other forms of direct entry containing thermal pollution include treated water exiting wastewater treatment plants and water from storm sewers (Dodds & Whiles, 2010).

RECOMMENDATIONS:

Monitoring thermal pollution is a valuable first step in determining peak locations, major areas under threat, and species this could impact. Without long term data sets and monitoring consistently across the shoreline, baseline data cannot be gathered, and spikes in thermal pollution cannot be identified. Long term data sets of this nature are typically cost-intensive, time-intensive, and challenging to collect. There are some overarching principals and best management practices that can be adopted to ensure thermal pollution is reduced across the shoreline within a variety of communities and across different land-use types:

1) Keep streams covered (reduce solar warming);
2) Protect existing or provide new settling / cooling areas to reduce direct-entry into the lake (vegetated stormwater ponds, rain gardens, coastal wetlands);
3) Increase permeable pavements in urban areas (reduce asphalt and concrete);
4) Reduce runoff by implementing vegetated buffers, cover crops, and using lot-scale infrastructure like rain barrels;
5) Hold industry accountable (encourage enhanced monitoring programs alive and partner across the shoreline with others)

5.3.5 INDUSTRY AND SHIPPING

Within the coastal corridor, only two harbours rely on shipping for their economy; Sarnia and Goderich. The shipping industries on Lake Huron between Ontario and Michigan, "contribute over 90,000 jobs and $13.4 billion

(CAD) to both economies" (ECCC & USEPA, 2018). The Port of Goderich alone receives approximately 250 shipping vessels annually, receiving and sending commodities including grain, salt, and calcium chloride (Huron County, 2016). The Port of Goderich is the only seaway-depth port on the southeastern shores and is reliant on lake levels and dredging to maintain access for shipping vessels (called 'Lakers', or 'Salties') who dock and collect goods here. "Dredging is the excavation and relocation of sediment from an area to improve navigational access, for land reclamation and to allow for the development of coastal infrastructure" (Fraser et al., 2017). Because of fluctuating lake water levels, dredging has become necessary to maintain port access to ensure commodities are exchanged to stabilize the local economy. However, dredging and managing dredged material are noted as one of the biggest issues surrounding coastal management. "*The conflict between the economic importance of river mouths and their ecological significance as rich and complex environments makes it urgent to identify the impacts caused by human activity on the dynamics of river mouth ecosystems, in order to develop efficient methods to minimize them*" (Junior et al., 2012). Dredging causes concern for nearshore water quality because the act of removing lake-bed sediment increases turbidity, sedimentation, and light availability to nearshore vegetation (Fraser et al., 2017). Dredging will also disturb feeding profiles for fish residing in the nearshore by disturbing benthic communities, changing sediment on the lakebed, and may release contaminants and excess nutrients contained in the sediments being removed (Fraser et al., 2017). Unfortunately, to maintain shipping ports, dredging will be continually required to maintain proper depth to accommodate the draft of shipping vessels due to the littoral movement of sediment in the nearshore waters of Lake Huron. However, reducing the frequency of dredging, and dredging during less-impactful times of year for fish spawning may reduce the impacts to local food webs.

One other concern around industry and shipping is the potential for oil and chemical spills either through accident or runoff across impermeable harbour pavements. These types of spills have serious implications for the nearshore water quality and can be transported along the coast quickly due to littoral drift. Therefore, one 'small' incident can end up impacting the drinking water and recreational water quality of thousands of people downstream. Most harbours on the southeastern shores have fuel stations and therefore have emergency spill management protocols. However, small spills still occur on occasion, similarly to that at car-refueling stations. For this reason, it is of the utmost importance to reduce the potential for these types of events to occur, and to have a reporting protocol in effect to notify coastal communities 'downstream' when this type of issue arises.

5.3.6 SEVERITY OF THREATS

Point and NPS pollution in Lake Huron`s coastal corridor have far reaching effects for the health of the ecosystems, fauna, and humans residing in the area. Other coastal guides have created a list of approaches for mitigating point and NPS pollutants and can be used by individuals and organizations alike (Appendix D). Using the LAMP threat rating criteria (ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10-years).

Threat	Rating
Nutrient inputs (beach postings)	**Scope:** HIGH – Although beach postings are only applicable and monitored by Health Units on public beach areas, the underlying threat of nutrient and E-*coli* loading in the nearshore waters is pervasive along the entire coast. The threat is anticipated to be widespread in the next 10-years as lake water warms, nutrients continue to enter the lake, and climate change alters precipitation cycles.
	Severity: HIGH – The level of damage algae blooms and high *E-coli* levels can do to shoreline ecosystems and the nearshore waters is likely to serious degrade

	ecosystems by influencing fish spawning grounds, reducing the ability of beach-goers to use the beach and nearshore, and impacting drinking water sources.
	Irreversibility: MEDIUM – The effects of nutrient inputs and beach postings can be reversed and restored with a reasonable commitment of resources through adaptive management of land-use in and adjacent to the coastal corridor. By implementing recommendations to reduce fertilizer and pesticide inputs to farmland, as well as requiring septic inspections and stormwater treatment, nutrient loading can be controlled and reduced.
Plastic pollution	**Scope:** VERY HIGH – The proportion of the shoreline currently, and expected to be affected by plastic pollution in the next three years remains very high, being that the threat is pervasive, affecting 71-100% of the shoreline. Plastic washing up out of the lake, being added directly to the shoreline through visitors, and entering the shoreline ecosystems through inland sources cause a triple-threat to coastal ecosystems.
	Severity: MEDIUM – Plastic pollution is likely to moderately degrade coastal ecosystems within 10 years. Causing issues of water quality pollution, bioaccumulation of plastic and toxins in wildlife and humans, and causing entanglement hazards, plastic will permeate and affect shoreline ecosystems until we stop using plastic and clean up plastic currently in the ecosystems.
	Irreversibility: VERY HIGH – in many cases, the degree to which plastic pollution can be reversed and habitat restored is near-impossible with current technology, budgets, and techniques. It may take over 100 years to fully remove the threat from the coastal corridor. Large plastic items like tires, bags, and household items are easy to clean up and remove, whereas small microfibers and microbeads already in our water sources are next to impossible to clean up at the scale of the entire lake system. Chronic efforts to clean up the threat are required, to keep up with the addition of plastic into our environment every year.
Light pollution	**Scope:** VERY HIGH – the proportion of area currently, and expected to be affected by light pollution is 71-100% of the shoreline. As more developments occur, and developed areas expand, the amount of artificial light created will only increase unless work to reduce the impact of these lights is seriously undertaken by all individuals, communities, businesses, and municipalities.
	Severity: MEDIUM – unfortunately, the actual implications of light pollution are hard to fully quantify. However, best estimates determine that light pollution will moderately degrade the circadian rhythm of animals and humans using the coastal corridor.
	Irreversibility: MEDIUM – The effects of light pollution can be diminished, if not reversed with a reasonable commitment of resources, taking 6-20 years to complete, by installing dark-sky friendly lighting options as infrastructure upgrades come due. For landowners, requiring dark sky certified lighting fixtures in all homes in southwestern Ontario will reduce skyglow and diminish the threat.
Thermal pollution	**Scope:** MEDIUM – Thermal pollution caused through inputs of warm stormwater and industry outputs can reasonably expected to affect 11-30% of the coastal corridor within the next 10-years. Through trends of reducing vegetation cover over watercourses and urban areas, as well as no existing regulation of thermal

	pollution entering the lake, this threat will be prevalent and affect water quality in the nearshore waters.
	Severity: MEDIUM – the level of damage reasonably expected to occur through thermal pollution to nearshore waters and coastal habitats due to thermal pollution are systemic and are anticipated to moderately degrade the ecosystem. Higher water temperatures enable bacteria to thrive, dissolved oxygen levels to decrease causing lack of viable spawning area for fish, and will increase vegetation growth such as algae blooms. It is for this domino effect of stressors that thermal pollution causes that a medium ranking has been appointed.
	Irreversibility: MEDIUM – The effects of thermal pollution can be reversed and restored with a reasonable commitment of resources to re-vegetate and cover river systems, reduce the heat-island effect and impermeable pavements in urban areas, and slow down water leaving the landscape by rebuilding rain gardens, bioswales, and coastal wetlands to allow time for the temperature to reduce before entering the lake. This may take 6-20 years to achieve pre-threat conditions.
Industry and shipping	**Scope:** LOW – industry and shipping are not anticipated to affect more area than it currently occupies given the continuation of current circumstances and trends, meaning that the threat is narrow, affecting only 1-10% of the coastal corridor.
	Severity: LOW – the level of damage expected to occur above and beyond the current destruction that has occurred is not likely to degrade or reduce the health of coastal ecosystems by much more. However, the longevity of the chronic impacts will continue to have overarching consequences on the shoreline and nearshore waters.
	Irreversibility: HIGH – the degree to which the effects of industry and shipping can be reversed and habitats restored depends on the size of the operation, but on average, an estimation that the threats can technically be reversed and restored between 21-100 years, but are impractical due to time and money and socio-economic constraints. Unfortunately, many of the current infrastructure will remain and not be reclaimed.

5.4 AGRICULTURE

Falling adjacent to some of the most productive farmland in Canada, Lake Huron's coastal corridor is influenced by agriculture. Within the coastal corridor along Lake Huron's southeastern shores, 22,101 hectares or 26% is categorized as agricultural, primarily land used for commercial crops. "Huron County is recognized as the most agriculturally productive county in Ontario, boasting more census farms (3,260) and more acres of farmland (711,525) than any other county in Ontario" (Huron County, 2018a). Adjacent to the southeastern shores, the three counties, Lambton, Huron, and Bruce, have "800,000 hectares (1.98 million acres) of farmland are under production on 6,500 farms throughout [these] counties" (ECCC & USEPA, 2018, p.18).

When settlement of the Great Lakes basin occurred, swaths of the mixed-wood plains were converted to agriculture because of their rich, deep soils (ECCC & USEPA, 2018). Crop and livestock agriculture in Southwestern Ontario have changed immensely within the last 100-years; seeing movement from small 50-150-acre family farms, to farming operations working 400-2000 acres of land easily per year. From 1996 to 2011, the number of farms in Huron County alone decreased from 3,150 to 2,467 farms, with many of these amalgamating into one another (PCUW, 2013). To give an example of the most common and popular farmed 'products' in adjacent watersheds include beef (543 farms), corn (110 farms), soybean (296 farms), swine (310 farms), and dairy (192 farms) (PCUW, 2013). Farming and food production are extremely important, if not the most significant base of the economy in Lambton and Huron Counties, and are important to maintain. The protection of agricultural land and livelihoods of farmers is very clearly promoted in both County Official Plans. Because of the variety of stressors created by this land-use type, many end up affecting the surrounding landscape. Threats caused by intensified agriculture in the coastal corridor include:

- Stormwater management (e.g. tile drainage and creek straightening);
- Nutrient runoff;
- Soil health, erosion and carbon sequestration;
- Plastic pollution and waste management;
- Loss of biodiversity (e.g. crop rotations, larger monocultures);
- Land-use changes;
- Inputs to sensitive ecosystems (e.g. wetlands) (Empson-LaPorte, pers. comm).

5.4.1 LAND-USE CHANGES

Statistics Canada reported that the, "Canadian agricultural sector continues to restructure as many farms expand in scale of operation, consolidate, draw on technological innovations to enhance productivity and augment their sales" (Statistics Canada, 2011). This consolidation often manifests as larger field sizes in agricultural land-uses, when equipment sizes increase with the number of acres to be cropped. As field sizes increase, water moves across the landscape with fewer and fewer impediments, such as fencerows and windbreaks. A declining rural population also means a decrease in the number of farmsteads, which served historically to act as barriers to water movement. With water moving faster across the landscape, it can pick up sediment, vegetation, litter, nutrients and pollutants much easier, carrying them into adjacent watercourses, eventually ending up in Lake Huron.

A major challenge for soil health is that more than one third of farmland is rented rather than owned by the farmers working the land. The landowners may be relatives, neighbours, city dwellers, investors, land developers, or even public agencies. They may have limited knowledge and appreciation for soil health practices and the relation to long term productivity. For short-term rentals, there is less incentive for farmer investment in stewardship than on land owned by the farmer. Stewardship leases are one tool to help address this. The feasibility and effectiveness of other tools that have been suggested, such as increased education and incentives, need further examination (OMAFRA, 2019).

5.4.2 STORMWATER MANAGEMENT AND IMPLICATIONS FOR SENSITIVE ECOSYSTEMS

Under the Drainage Act, 1990, a 'drainage works' includes a drain constructed by any means, including the improving of a natural watercourse, and works necessary to regulate the water table or water level within or on in any lands to regulate the level of the waters of a drain, reservoir, lake or pond, and includes a dam, embankment, wall, protective works or any combination of these (Drainage Act, RSO 1990). Historically the Drainage Act was frequently used to drain marginal farmland, swampy areas, and wetlands to increase the productivity of agricultural land. Today, it is being used to balance the need for drainage in agricultural and rural areas while maintaining existing wetlands and restoring degraded wetlands. Water management structures such as dams, dykes, or weirs can be incorporated into drainage projects to raise the water level in areas that have historically been wetlands. These structures also provide flood attenuation and improvements to water quality by impounding water (OMAFRA, 2019, p.215). There are several local and provincial funding programs that encourage the construction of these projects.

5.4.3 NUTRIENT RUNOFF

Applied across the landscape, manure, synthetic fertilizers, and pesticides containing nutrients such as phosphorus and nitrates can be transported easily through significant precipitation events into ground and surface water, stimulating aquatic vegetation growth and eutrophication in water bodies (Liipere, 2014; ECCC & USEPA, 2018). Organic and synthetic fertilizers, and bacterial pollutants are NPS pollutants typically impacting water sources such as ground water, nearby creeks and rivers, and eventually the nearshore environments. Over the past 50-60 years, the Great Lakes have experienced more algae blooms, beach postings, and drinking water advisories, and Lake Huron is no exception. Many studies have been completed on this myriad of NPS pollutants, and one notable study has concluded that*, "long-term, low-level exposures are of concern because of subtle effects that toxic contaminants may have on reproduction, the immune system and development in young. Amphibians, for example, are key indicators of ecosystem health. Commonly used chemicals such as pesticides, herbicides and fertilizers have been found to be highly detrimental to frog populations. The reduced abundance and diversity of frog species are a warning signal about the impacts of pollution*" (Henson et al., 2005, p.16).

Many farmers are aware of the importance of timing, and rate of application of these products to reduce impacts on water bodies, and attempt to reduce the impacts by reducing tillage, controlling erosion, planting cover crops, and working with certified crop advisors.

5.4.4 LOSS OF BIODIVERSITY

Farms planting new crops every year benefit from having a diversified crop rotation (planting different crops in the same field in successive growing seasons). This helps control pests, more effectively manage nutrients, and improve soil properties and yield, increasing long-term profitability. However, increases in farm sizes and a fluctuating global market in crop prices have narrowed the typical commercial crops to corn and soybeans. Some crops that might be used to diversify a crop rotation may not have a high value in the marketplace, or markets for these crops are not accessible to Ontario producers. Rather than crop rotation, growers of perennial crop species (e.g. fruit trees and plants), use other practices to diversify plant species cover (OMAFRA, 2019).

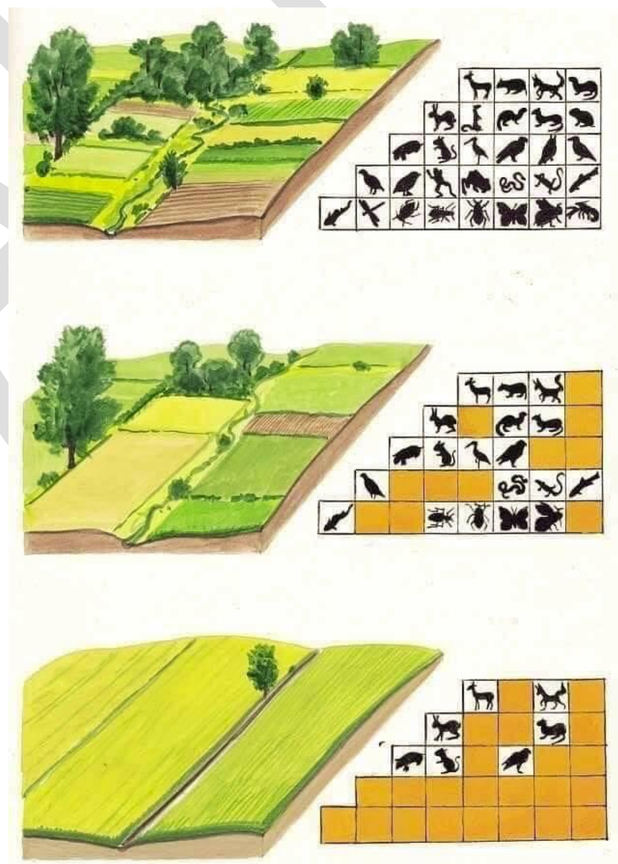


Figure 72 - Image by Ecological Consciousness

As family farms have grown, windbreaks removed, and workable acres with no impediments expanding there are less barriers for water to be slowed down, absorbed, and filtered when running across farmland after the growing season is done. Many of the farms within and adjacent to the coastal corridor have installed subsurface drainage tiles to even increase flow rates off farmland and into creeks. "*When land is too wet to grow crops, farmers can use underground artificial tile drainage to remove the excess water. Tiles were traditionally made from fired clay; however today plastic tubing is often used. Tile drainage removes excess water from the crop root zone in the soil. While tile drainage can improve crop productivity and help to prevent flooding it may [influence] local water hydrology. In Ontario, 43% of land classified as cropland has been tile drained. Tile drainage in Ontario is shallow, within only 3 feet (1 meter) of the surface"* (Forests Ontario, 2017, p.27; OFA, 2019b)). Water moving faster across the landscape picks-up sediment, vegetation, litter, nutrients and pollutants easily, carrying it into adjacent watercourses ending up in Lake Huron.

5.4.5 SEDIMENTATION, EROSION, AND CARBON SEQUESTRATION

Overall, Agriculture and Agri-food Canada's Agri-environmental indicators suggest that soil health and conservation are not improving in Ontario. Key indicators of interest are soil organic carbon, soil erosion risk, and soil cover. The latest estimates are that:

- 82% of Ontario's agricultural soils are estimated to be losing more CO2 to the atmosphere rather than increasing soil organic carbon
- 68% of Ontario's farmland is estimated to be in an unsustainable erosion risk category.
- 53% of Ontario's cropland is estimated to have low or very low soil cover, covered less than 275 days or 75% of the year" (OMAFRA, 2019).

Along with these indicators, notable trends in farming practices that have occurred through recent decades have had adverse effects on soil health including:

- "*A shift to more annual crops (three main annual crops increased from 28% to 61% of crop and pasture lands 1976-2016) and less diverse rotations.*
- *More tillage (in 2016 the reported acreage of conventional tillage increased for the first time since 1991.*
- *Fewer fencerows and windbreaks.*
- *Fewer ruminant livestock farms resulting in a reduction in the total area of hay and pasture (52% decrease 1976-2016) and availability of manure.*
- *Consolidation of smaller fields.*
- *Use of bigger heavier equipment*" (OMAFRA, 2019).

Fewer fence rows and windbreaks, as well as consolidation of smaller fields into swaths of field allow farmers to more efficiently harvest land by using bigger, heavier equipment (Ontario, 2018, p.10). However, because of the expansion of workable acreage, an increase in aeolian erosion and water flow across landscapes causes negative effects to the landscape through soil health degradation and sedimentation of waterbodies. A reduction in yields caused by threats to soil health causes farmers and producers to add products to the land to increase yields to previous levels, feeding into the cycle of land degradation. Increasing tillage, lower diversity of crop rotations, shifts away from perennial forages, and bare soil in winter all contribute to the many challenges associated with maintaining water quality and ecological integrity of landscape habitat for species (Ontario, 2018). There are 8 challenges to soil health in agricultural lands identified by the Ontario Federation of Agriculture. These challenges span nutrient concentrations, salinity, contamination, and erosion. The 8 challenges include:

- Low fertility (naturally acidic soils or low nutrient soils)
- High fertility (fertilizers have been added beyond recommended levels)
- Salinity (salty soils caused by irrigation or fossil fuel extraction)
- Contaminated soils (used as brownfields, industrial sites, spill sites)
- Wind erosion (movement of soil and organic material by wind)
- Water erosion (movement of soil by water, loss of topsoil)
- Tillage erosion (relocation of soil downslope from tillage and gravity)
- Flooding or drought (poor drainage or lack of organic matter reduce soil yields) (OFA, 2019b).

Maintaining soil health is also important to retaining this industry within coastal communities to support the economies of the coastal corridor and improve water quality in the nearshore environment.

5.4.6 PLASTIC POLLUTION AND WASTE MANAGEMENT

Farms use many forms of equipment to work the land and rear animals. However, many of the items used on farms often dismissed or forgotten about may pose potential consumption or entanglement issues include bale wrap, twine, netting, ear tags, and other small plastic fragments used for livestock farming. Bales of hay are wrapped in thin plastic sheeting to preserve the product, sealing out oxygen (O^2) and moisture, allowing the forage to ferment to make baled silage. Bales are wrapped to preserve them and allow them to last longer through the year until a new crop is harvested the following year. However, sometimes if not appropriately removed, bale wrap can escape the farm through wind and water transportation, clogging up creeks, making its way into the lake. Bale wrap is usually UV protected, to prevent it from breaking down when on the bales, and tear and puncture resistant which makes it even more dangerous if it enters the environment. Bale netting and twine are also used and is meant to keep bales in shape while getting transported off fields and into storage facilities. However, this netting is also UV protected, and sometimes coated in an anti-decomposition chemical which impedes the material from biodegrading. Similarly, to bale wrap, twine and netting cause a massive entanglement hazard to all forms of mammalian, reptilian, and avian wildlife, if blown off farm and into natural corridors and coastal environments. There has been some interest by the private sector to create bale wrap recycling programs for farmers across Ontario (Switchenergycorp.com, out of Clinton Ontario), but programs like this are at an added cost to farmers, and do not mitigate the impacts of unintentional loss of plastic products on farms. Switching to an alternative product that would decompose would be in better interest of adjacent coastal ecosystems.

5.4.7 SEVERITY OF THREATS

Agricultural practices have many affects on the coastal corridor and inputs to the nearshore waters of Lake Huron. Using the LAMP threat rating criteria ((ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10-years).

Threat	Rating
Agriculture	**Scope:** HIGH – the proportion of area expected to be affected by agriculture within 10 years given continuation of current circumstances and trends seems widespread, affecting 31-70% of the coastal corridor. As agricultural producers continue to expand, so do demands on the landscape for workable acreage, pastureland, and livestock barns. Without proper mitigation of threats, or containment of land-use change,

	agriculture is anticipated to remain or increase in and adjacent to the coastal corridor.
	Severity: MEDIUM – the level of damage reasonably expected to occur within 10-years is likely to moderately degrade coastal ecosystems by 11-30%. With no action, and continuation of current circumstances and trends, we will see continual nutrient inputs, topsoil erosion, sedimentation and straightening of watercourses, and removal of woodlots, windbreaks, and wetland areas. However, if more best management practices are adopted, this trend may be reversed with threats becoming reduced.
	Irreversibility: MEDIUM – Effects of threats caused by agriculture can be reversed and the habitat restored (somewhat) taking 6-20 years to achieve. This plan by no means intends to imply that all agricultural land in the coastal corridor should be restored into natural land-use systems. Therefore, implementing natural structures to curb the impacts of agriculture is what this section intends to incite. Establishing windbreaks, re-naturalizing watercourses, using stormwater management structures, and cover crops will all play into the reversibility of the threats of agriculture.

5.4.8 RECOMMENDATIONS:

There are many farmers and producers already concerned about their impacts on the land and water. Many of these individuals, along with local and regional governance bodies are encouraged to make sustainable changes and take advantage of the growing research and opportunities available to try out on their farms to ease the scope of work and increase or maintain yields. Overarching opportunities in the agricultural sector to reduce impacts and improve resiliency and sustainability include;

- Adoption of best management practices (e.g. cover crops, crop rotations, species diversity, erosion control);
- Provincial soil health strategy;
- Incentive programs;
- Education and outreach;
- Research and cross-disciplinary cooperation.

ADOPTION OF BEST MANAGEMENT PRACTICES

A best management practice is a method or technique that has been studied and proven to be the most effective and practical way to complete a task, in this case, maintaining agricultural yield while maintaining or improving the surrounding ecological condition. "When responsibly farmed, agricultural lands use drainage systems that mimic natural conditions while still allowing for seedbed preparation and planting. The use of buffer strips, cover crops, grassed waterways, and two-stage ditches help to minimize soil erosion and flooding" (ECCC & USEPA, 2018). Some farmers in and adjacent to the coastal corridor are employing these best management practices in their operations, however, much more work is needed to ensure these measures are commonly being implemented to reduce impacts of point and NPS pollution on Lake Huron's southeastern shores.

COVER CROPS

Cover crops are off-season crops planted on agricultural land during shoulder seasons after the cash crop is harvested primarily to cover the bare soil and add nutrients back into the soil. Cover crops are usually planted to reduce soil erosion by providing cover reducing the impact of precipitation on bare soil and slowing the flow of water draining off the landscape (OMAFRA, 2019). Depending on the crop, some cover crops are also used for livestock feed (OMAFRA, 2019). Cover crops have received a lot of publicity in the past few years along Lake Huron. Over-wintering cropland with a cover crop like sunflowers, buckwheat, or radishes will retain phosphorus in the ground, which is often leached out into creeks and enters Lake Huron (Anderson, 2018).

Cover crops are typically at an added cost to farmers, but are becoming more popular. “The Census of Agriculture found that the percentage of farmers using cover crops doubled (12% to 25%) between 2011 and 2016” (OMAFRA, 2019). This increase in adoption of cover crops as a best management practice on farmland has been incentivized by local CA’s. Maitland Valley Conservation Authority and Ausable Bayfield Authority provide grants to farmers that use different species of cover crops, providing a maximum grant of $1,000 per landowner (ABCA, 2018). In total, Huron County farmers planted more than 10,000 acres of cover crops between 2016-2017 (ABCA, 2018). Educating landowners as to the benefits of cover crops, incentivising their use through funding programs will help protect water quality by reducing sedimentation and erosion annually.

SOIL HEALTH STRATEGY

Keeping healthy soil on farmland in and adjacent to the coastal corridor is extremely important for the productivity of that land, and for the health of coastal ecosystems which can be affected by sedimentation and excess nutrients attached to soil particles. Soil health deteriorates when erosion, nutrient depletion, and organic matter removal occurs (Ontario, 2018). Agricultural producers ensuring their soil is healthy will;

- Improve crop yields through retained nutrients and organic matter;
- Increase absorption rates and storage for precipitation, reducing runoff;
- “Can reduce greenhouse gas emissions and increase soil carbon”;
- Be resilient to more extreme temperature fluctuations, weather events, and drought periods;
- Increase biodiversity and beneficial organisms and insects living around the cropland (Ontario, 2018).

Reducing the potential for soil to leave farmland, and enter surrounding coastal ecosystems include methods such as soft infrastructure (e.g. berms, sediment control basins [WASCoB’s], and built wetlands), and residue management and cover (e.g. no till farming, cover crops) (OFA, 2019b). Ensuring farmers are working with certified crop advisors and soil testing laboratories will benefit other coastal habitats by keeping soil, and nutrients, on agricultural land ensuring productive cropping and a reduction in sedimentation and input nutrients into adjacent environments.

FIELD DIVISIONS AND RIPARIAN BUFFERS

Field divisions by way of treed wind breaks, drainage ditches, roads, and ecosystem corridors provide necessary benefits to water and air quality, as well as heat island effects and wildlife movements. Single-row windbreaks, multiple row windbreaks, and field shelterbelts are all easy way to divide cropland in order to limit aeolian erosion and slow water down flowing across the landscape (OFA et al., 2019a). “Prevailing winds across cropland with minimal tree cover will move soil off fields and onto roads, ditches and fencerows. Soil organic matter and crop inputs often move offsite with the soil particles. Soils subjected to wind erosion are at risk of experiencing other soil health challenges including loss of tilth, structural degradation and soil desiccation” (OFA et al., 2019a).

Buffer strips and grassed waterways are a way to 'retire' sections of land prone to flooding and erosion and provide areas to slow down water coming off the landscape. Along with retaining and creating adequate buffer zones around creeks, fencing pastured animals out of waterways and dividing pastureland into multiple pastures is a way to reduce impacts to water quality, reduce land compaction, erosion, and vegetation destruction. Case study 7 outlines how creating buffers and dividing fields promote water quality flowing into Lake Huron.

CASE STUDY 7: PINE RIVER WATERSHED CATTLE FENCING

Livestock on pasture land and feedlots contribute to point and NPS pollution sources entering Lake Huron. Pasture areas where livestock roam freely often have streams to cross to access other areas of pasture. When allowed to roam across water crossings such as creeks, ditches, and water courses, grazing animals contribute to riparian vegetation damage both in the stream and on the stream banks (Huynh, 2015). Livestock in watercourse negatively impact water courses entering Lake Huron through, "*soil compaction, vegetation removal through grazing and trampling… impacting native perennial cover, increasing the number of exotic plants present, decreasing litter cover, increasing erosion, changing concentrations of nutrients present in the soil, and decrease the rate of water infiltration through the soil*" (Huynh, 2015). Livestock exclusion fencing has been heavily researched in the academic community and widely accepted by agricultural producers within the past few decades in Ontario. Beef production is the largest form of agriculture in Huron County, these farms range from feed lots to ranches (PCUW, 2013). When livestock enter watercourses, they disrupt stream bed sediments, reduce water quality through defecating in or near streams, and trample riparian vegetation that stabilizes stream banks and filters surface runoff, enhancing erosion (PRWIN, 2017).

Establishing fences running parallel to watercourses to prevent animals from entering them is a relatively inexpensive way to improve water quality in these watercourses that enter Lake Huron. Re-establishing a healthy riparian zone once the fencing is in place reduces the severity of erosion and sedimentation entering the watercourse, improving water quality (PRWIN, 2017). "*Livestock defecation in and near streams is also a problem when animals have unrestricted access to a stream, and can introduce manure-born bacteria, along with excess nutrients to the watercourse. This is problem for the immediate and downstream environment, while also negatively impacting the health of the livestock themselves when they drink from the contaminated area. It has been demonstrated that livestock health and productivity is improved when their access to a watercourse is restricted, and higher quality sources of drinking water are provided elsewhere*" (PRWIN, 2017). In and adjacent to the coastal corridor, the Pine River Watershed Initiative Network (PRWIN) has been working hard to bring awareness to issues of livestock using streams and rivers, and through programs, have installed over 11-kilometres of exclusion fencing on creeks entering Lake Huron's southeastern shores (PRWIN, 2017). Along with the exclusion of livestock from streams, the hilly landscape of Bruce County requires livestock crossings to access other areas of pasture. Therefore, the PRWIN developed 7 livestock crossings with producers to protect riverbanks, water quality, and prevent sedimentation (PRWIN, 2017).

EDUCATION AND OUTREACH

As with other facets of conservation planning, education and outreach, as well as knowledge sharing significantly increase the individual and grass-roots changes needed across the coastal corridor. Cooperatively working towards educating regional, local, and grass-roots levels on most current research, and lessons through demonstration plots are being communicated to landowners and governance alike. "Knowledge about building and maintaining healthy soils need to get into the hands of the people who can best use it: farmers, agricultural landowners, industry partners and advisors. Knowledge is a two-way street – ongoing communication is essential between researchers, policy developers, farmers, agricultural landowners and other interested partners" (Ontario, 2018, p.6). Most individuals want to do their best towards land stewardship while maintaining or improving their returns on investment; therefore, communicating that these two principals can work simultaneously is important to increase uptake of incentive programs and sustainable land-use practices. In order to encourage the education and awareness of producers and all landowners along the shoreline as to the regulations and bylaws in place, three strategies are recommended by experts in the field working with landowners, in this order;

(1) Education and creating awareness
(2) Incentivize alternatives
(3) Enforce regulation and bylaws

Opportunities for farmers and producers to become more aware of environmentally friendly farming methods and opportunities is highlighted in the Canada-Ontario Environmental Farm Plan program. This voluntary program allows farm families to increase their environmental awareness in 23 different areas on their farm to determine areas of strength, areas of environmental concern, and set action plans to improve their environmental impacts (OSCIA, 2019). Through participation in this program, incentives exist to cost-share improvements identified in the action plan (OSCIA, 2019). Farmers and producers completing environmental farm plans promote sustainability in the production of agricultural products as well as land stewardship.

INCENTIVE PROGRAMS

For agricultural producers relying on prosperous yields and reduced costs to ensure a profitable return on investment for their yearly crops, it can be financially straining or impossible to implement best management practices on their farms without some sort of financial help or incentive. This "pressure on farmers to balance short-term economic gain with long-term benefits of investing in soil health and conservation" (Ontario, 2018, p.9) make incentive programs that much more important to the success of BMP opportunities. As discussed earlier in this section, incentive programs for cover crops are successfully making these a more viable option for farmers. However, there are many other opportunities by way of incentive programs that exist, and should be continually supported in order to encourage the uptake of best management practices for agricultural businesses. Funding programs can change based on environmental priorities and availability of funding sources.

Providing resources for the added education of alternatives, incentive programs for cover crops and buffer zones along streams, and enforcement of regulations for manure application and setbacks from watercourses all reduce impacts of agriculture on Lake Huron's water quality. Ensuring messaging is getting to inland agricultural producers about bioaccumulation of nutrients entering Lake Huron from the presence of farming in Bruce, Lambton and Huron Counties is important to encourage partnership and collaboration of initiatives within and adjacent to the coastal corridor.

5.5 CLIMATE CHANGE

Human induced climate change has emerged as one of the most important global environmental issues; with July 2019 being the hottest month in recorded history on Earth (The Associated Press, 2019). This plan outlines the physical impacts of changing climates across the coastal corridor, effects are much broader in scope. Ecosystem resiliency, renewable resources, food security, health and well being, energy, economic prosperity, cultural integrity and other facets of the social-ecological systems are all impacted (Atkinson et al, 2016).

Climate is defined by the long-term trend of specific characteristics of the seasons and related weather patterns, over years and decades. Climate shapes and influences the soil, the forests and our societies. Weather, on the other hand, are the short-term characteristics usually over several days or a week, when describing temperature, precipitation and wind. Changes to the climate are anticipated to have major changes to our weather, making it warmer, wetter and wilder. This altered state of climate has already created more frequent and more severe storms and southern Ontario has already experienced the impact. In the Great Lakes basin (GLB), we often experience “lake effect” weather, which means that air masses and weather systems either build or diminish in intensity when crossing these massive bodies of water due to differential heating and cooling of the land and water. Climate scientists from Canada and the USA are already seeing seven key changes to the GLB, and more specifically Lake Huron’s bordering land masses (SWG, 2013) including:

- an increase in air temperatures by 3 to 4.5˚C by the end of the 21st century;
- slight increase in annual precipitation, with seasonal shifts in amounts;
- an increase in annual average water temperatures of 5 to 7˚ C throughout the 21st century;
- continued decrease in the extent and duration of ice cover through the 21st century;
- increased wind speeds;
- decreased water levels and;
- an earlier onset of spring and summer and an increased growing season.

Evidence suggests that some of these changes are already underway, including increases in open-water summer temperatures and changes in lake stratification, and reductions in winter ice cover (Austin and Colman 2008). The best-known indicator for tracking climate change is global mean surface temperature, estimated as the average temperature for the world from measurements of sea surface temperatures and of near-surface air temperatures above the land (Zhang et al., 2019).

Temperature and precipitation are fundamental climate characteristics that directly affect human and natural systems. They are routinely measured as part of the meteorological observing system that provides current and historical data in Canada. These datasets show that temperature in Canada has increased at roughly double the global mean rate, with the mean annual temperature having risen 1.7°C (potential range 1.1°C –2.3°C) between 1948–2016. Reports from the Government of Canada are now showing the physical distribution of temperature changes due to climate change and global warming. As illustrated in Figure 72, the GLB will be hit the hardest in terms of increases and duration of temperature and seasonal shifts.

Historical climactic warming has led to changes in rain and snow, river’s and lakes, ice, coastal zones, and these changes are challenging our sense of what a “normal” climate is. The challenge for users of climate information is to determine how best to incorporate the information into the methods and tools used for assessment and planning within our communities. Natural Resources Canada is undertaking a series of reports to assess impacts and adaptation response across regions and sectors. Figure 72 shows past and future projected changes in the seasonal distribution of streamflow in many snow-fed rivers basins across Canada. The research shows increasing winter flows, with earlier and reduced snowmelt peak flows, and reduced stream flow in the warmer months.

With impacts caused by climate change, there may be more (or less) frequent lake level changes, more frequent and extreme storm events, changes to water temperatures, altered seasonal precipitation patterns, and reductions in water quality. Recent research and analysis completed by the Environmental Law and Policy Centre (ELPC, 2019) suggests that the speed of water level change reaching the extreme high and low levels may increase with the overall range of level change (2 metres) staying mostly constant. This phenomenon has recently occurred with the low levels of Lake Huron in 2013 and the high levels of 2019 (6 years apart). If these impacts ensue, shorelines will become more vulnerable to erosion due to higher wave energy; number of species may decrease due to lack of habitat or altered growing conditions; increased concentrations of toxic pollutants through human and natural sources could cause higher human health risks; and the way we use and enjoy our lake could change from a recreation and sustenance perspective (SWG, 2013; LSBP, 2012). Although designed for all of Canada's coastlines, this summary of the impacts a changing climate can have on coastal ecosystems and communities has been compiled, and is listed in Table 28. Land managers and planners can use this information to inform policy and land-use decisions, including implementing adaptation policies and regulation in order to become resilient to these changes and foster a healthy and safe community.

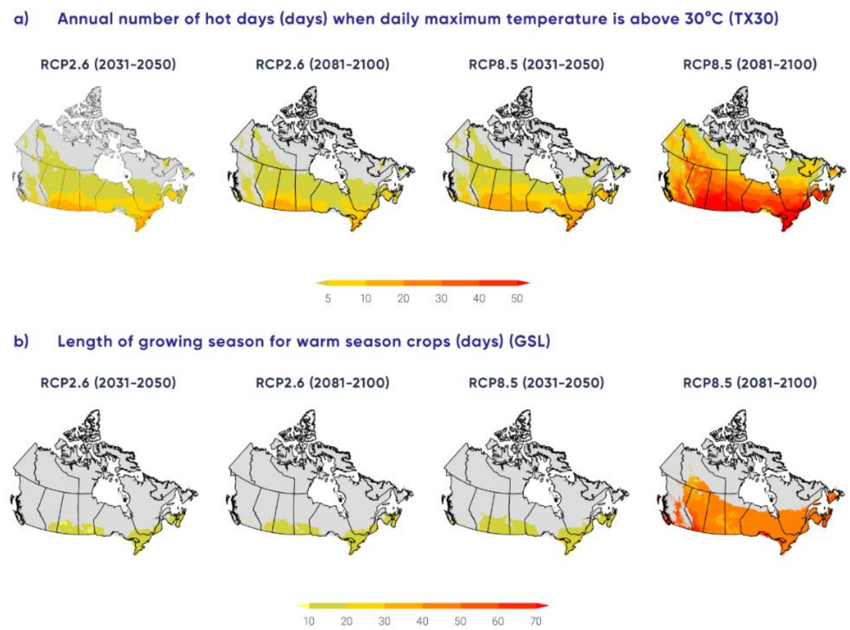


Figure 73 - Multi-model median projected changes (Zhang et al., 2019)

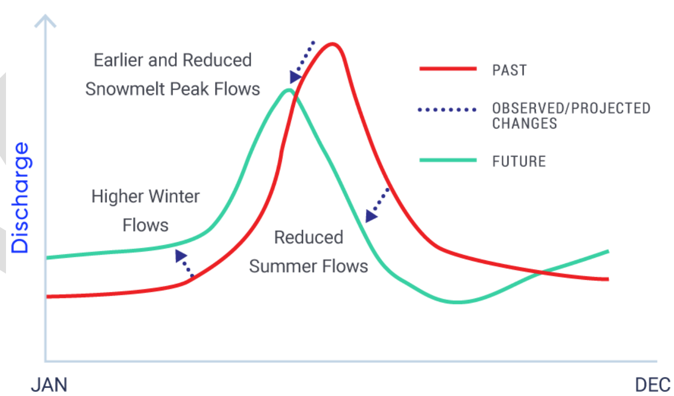


Figure 74 - Projected changes in seasonal distribution of streamflow (Zhang et al., 2019).

Table 30 - Summary of the impacts a changing climate can have on the coast (Adapted from VCC, 2014).

Measures	Impacts
Lake Level Changes	− More frequent and extensive inundation of low-lying areas Cliff, Beach, and foreshore erosion; − Altered coastal wetland habitats, loss of, damage to, and reduce functionality of infrastructure, (e.g. seawalls, jetties, roads, walking tracks, beach access, dune fencing, navigation aids, and drainage systems); − Loss of and damage to private property, and changes to land-use;

	− Loss of coastal habitat for biodiversity, e.g. roosting and nesting sites for shorebirds, intertidal areas, and coastal wetlands; − Loss of significant heritage sites; − Loss of coastal Crown land for tourism and recreation.
More frequent and extreme storm events	− Intense and destructive flooding of land and buildings on the coast and in areas where drainage systems lose their functionality − Loss of and damage to private and public property and infrastructure − Beach, foreshore and cliff erosion; − Pollution from sewer overflows; − Inundation of low-lying coastal environments.
Changing water temperatures	− Species distribution shifts; − Spread of invasive species and diseases; − Increased water surface temperatures and altered currents; − Changes in flowering, breeding and migration (e.g. phytoplankton blooms).
Altered patterns of wet and dry periods	− Changed nutrient and sediment flows; − Changed river mouths, extremes of high flows and altered flood lines from riverine and lake environments; − Reduced water clarity; − Increased frequency and intensity of fires on land, with impacts beyond the coast − Increased visitation to the coast in hot, dry periods
Water Quality	− Impacts on early life stages of species, particularly plankton; − Loss of plankton base for food webs; − Damage to infrastructure.

Vulnerability assessments of coastal environments can allow land managers to understand relative impacts caused by climate change, thereby informing priorities for response. "*The degree to which a resource, asset or process is susceptible to adverse effects of climate change, including climate variability and extremes, is called its vulnerability. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed; its sensitivity; and its adaptive capacity*" (Beavers et al., 2016, p.1). Using the measures of impacts from climate change as discussed in Table 24, land managers can begin to formulate vulnerability assessments of their respective communities to discern best course of action to sustain these altered states of normality. Access to shoreline communities during extreme storm events should be a high priority as many communities in the study area are serviced by a single road. Past research by CA's have identified areas in high risk zones which will need special attention in these vulnerability assessments.

5.5.1 LAKE LEVEL FLUCTUATIONS

Water levels on Lake Huron have been monitored for more than 100 years by Canadian and USA Federal agencies. Tobermory and Goderich are the only Canadian sites on Lake Huron with water level gauges providing readings. Lake water levels show a degree of variability due to natural climate variations, as well as to direct human management (e.g. dredging, diversions). Lake level fluctuations have significant influence on shoreline erosion, flooding of property, navigation, recreation, aquatic ecosystems, and human health. Seasonally, water levels typically progress from a summer maximum to a minimum in the winter/spring (Bonsal et al., 2019). Lake Huron exhibits a year-to-year and multi-year fluctuations of approximately 2 metres (Bonsal et al, 2019). Changes in basin climate conditions, such as increased precipitation and cooler temperatures, along with increased ice cover the winter previous, can lead to gradual increases in water levels, contributing to the long-term flux in water levels (Lawrence, 1995).

Under a changing climate scenario, predictions of annual precipitation amounts show a general increase, with a shift to wetter winter and spring conditions, and more variable summers that are likely to become hotter and drier by the end of the century (ELPC, 2019). However, predictions of Lake Huron water levels are much more difficult to determine. Predictions have also determined that reduction in lake ice cover and warmer atmospheric temperatures will continue to increase evaporation, leading to water level drops on the Great Lakes (ELPC, 2019) However, with increased precipitation in spring, runoff will become more rampant, potentially causing more erosion from the landscape, and will effectively change the net basin supply of water entering the Great Lakes, potentially leading to increased lake levels (ELPC, 2019). Rising lake levels and higher wave energy cause lakebed erosion creating deeper water close to the shoreline, leading to waves pounding shoreline ecosystems (USACE, 2003). Falling lake levels can have the opposite effect, however offshore lake bottom erosion will continue (USACE, 2003). Another prediction states that water levels on the Great Lakes are expected to decrease, because lack of ice cover will increase evaporation (Beavers et al., 2016). Many factors play into predications of lake levels, and are therefore many predictions on what lake levels will do with effects caused by climate change.

Economic impacts due to changing water levels by climate change are complemented by significant impacts to recreation, shipping, hydroelectric generation, water use, and waterfront property values. According the Environmental Law & Policy Centre (2019) as much as a 1-meter decrease in Lake Michigan-Huron water levels results in a 3.6% to 12.2% increase in shipping costs (1.9% to 7.4% increase for a 0.7m drop). Slips provided in local harbours may also be hindered and their availability reduced due to lower lake water levels. The International Joint Commission estimated that the income lost through slip loss, damages, and adaptations (e.g. new docks), will have these cost implications:

	Min. cost implication	***Max. cost implication***
1-foot drop	$823,490	$1,450,985
2-foot drop	$2,811,110	$3,244,719
3-foot drop	$6,865,423	$11,610,577

From a harbour recreation and shipping perspective, lower water levels would be very detrimental on the ‘bottom line’. However, lower water levels may increase beach and shoreline tourism thereby increasing revenues in this area.

More sporadic lake level changes due to climate change will impact ecological integrity of coastal ecosystems, including invasive species introductions, reduction of sensitive habitat, and altered hydrologic regimes. Lower water levels would be favourable to the invasive Common Reed, while higher water temperatures may favour aquatic invasive species such as Sea Lamprey (LSBP, 2012). Rising water temperatures are also expected to expand the ranges of and give new advantages to some invasive species such as the zebra mussel, and will encourage the growth of waterborne bacteria that cause illness and human health risks. The most significant observed changes in freshwater availability are in altered temporal distributions of snow-melt and increases in seasonal streamflow. For example, mid-winter snowmelt will occur more frequently, altering the timing of spring peak flow to happen earlier, preceding an overall reduction in summer flow. There are many other indicators including annual streamflow magnitude, surface and shallow groundwater levels, soil moisture content and droughts, that will be altered with climactic changes (Bush, E., and Lemmen, D.S., 2019). The levels of freshwater lakes and wetlands are governed by a simple equation:

Inputs-Outputs= Changes in storage (e.g., water level, or net basin supplies [NBS])

Inputs include river inflow (runoff), direct precipitation onto the water body, snowmelt, and groundwater inflow. Outputs include river outflow, evaporation, and exchange with groundwater. The contribution from these variables fluctuate with the size of the water body. Lake Huron's drainage basin is 134,100 km^2 (USEPA, 2019), with a drainage area this size, the multitude of land-use stressors and events upstream affect lake health, in addition to local and regional climate. Smaller lakes and wetlands are more responsive to local climatic conditions and have higher and lower peaks and dips. Lakes and rivers in Canada are becoming increasingly vulnerable to climate-related stressors and human management decisions such as flow regulation and land-use change (Bonsal et al, 2019). Table 25 describes how climate change will affect Lake Huron's water level fluctuations, as determined by the International Joint Commission (2014).

Table 31 - Seasonal and long-term fluctuations in Great Lakes water levels (IJC, 2014)

1. Long-term water level variability	Temporal water level variability can serve as indices of significant changes in regional meteorology and climate and a reflection of anthropogenic influence (including regulation of outflows from Lake Superior and Ontario), and an important indicator of potential impacts on coastal ecosystems, hydropower capacity, and socioeconomic factors.
2. Timing of seasonal water level maximum and minimum	Water levels typically decline through the fall months (primarily through increased evaporation rates and reduced runoff), reaching a typical seasonal low in early winter. Persistent shifts in the timing of seasonal maximum or minimum may reflect shifts in the regional water budget (including changes in the timing and magnitude of precipitation, tributary flows, and evaporation) and provide insight into potential impacts on aquatic plants, fish spawning habitats, and sensitive aspects of the coastal ecosystem.
3. Magnitude of seasonal rise and decline	This measure is based on assessing trends over time in the magnitude of spring rise, and the magnitude of fall decline. A persistent increase in the magnitude of spring rise might reflect increasing "flashiness" in tributary inflows, while periods of decreased declines in the fall may reflect cooler water temperatures and diminished evaporation rates.
4. Lake-to-lake water level difference	Differences between the water levels of each Great Lake may follow a relatively consistent and predictable pattern; anomalies in these differences may suggest an imbalance in the regional water budget, physical changes in the channels that connect the lakes, or the apparent and physical impacts of glacial isostatic adjustment on recorded water levels

Luckily, long-term datasets and monitoring occurs for lake levels, allowing land managers and environmental planners to track changes and determine and predict severe conditions. However, climate change will make these predictions a little more unreliable, however, changes will be able to be monitored and actions put in place to better protect human safety and ecosystem services required for protection.

5.5.2 LAKE TEMPERATURE AND STRATFICATION

Climate change will alter the surface and body temperatures, as well as the stratification of temperature zones in Lake Huron's nearshore waters. According to the Environmental Law and Policy Centre (2019) climate change will also alter the times the lake 'flips', a process called turnover, where the warmer upper layer above the thermocline, mixes with the lower, cooler waters below. This is important as it has the potential to have negative impacts to spawning and hibernation patterns of the biodiversity of Lake Huron, as well as the elemental composition of the lake. Turnover brings nutrients up from the sediment at the bottom of the lake, and oxygen (O^2) down from the surface, crucially influencing viability of habitat for fish, amphibians, reptiles, and benthic invertebrates (ELPC, 2019). Fresh water has a maximum density at 4°C (39°F) meaning that water at temperatures above or below this value can form a stable layer above cooler water, or below warmer water. Historically, Lake

Huron experiences seasonal turnover twice during each year, in the fall and spring. As the surface water cools from its maximum temperature of the year (usually during September), it begins to mix with warmer and less dense water at greater depths. Continued cooling makes this mixing reach even deeper into the water column until it reaches the 4°C threshold, after which further cooling produces less dense water that can form a layer of ice at the surface. When spring comes and atmospheric temperatures begin melting ice, this cool ice-melt mixes downwards until complete mixing occurs when it approaches 4 °C (ELPC, 2019).

Temperature changes in the lake-atmosphere system are expected to shift the timing of lake turnover, as well as the timing of ice formation and melting. Lake surface temperatures simulated by Xiao et al (2018) show that points in Lakes Superior, Michigan, and Erie now reach the 4°C mixing threshold earlier in the spring and later in the fall (other lakes were not analyzed). This also leads to suppressed mixing once the temperature threshold is passed in the spring (ELPC, 2019). Increases in lake temperature due to climate change will also increase the growing season for algae, *E-coli*, and other water borne bacteria. This could lead to extended beach seasons, but many more beach postings due to the presence of these bacteria and algae. Increases in algae, and the decomposition of more vegetated matter in the lake will cause Lake Huron to experience a reduction in dissolved Oxygen which as discussed previously, will reduce viable habitat and fish egg hatching rates. Lake temperature, much like lake levels and ice cover, is tracked by many organizations, and therefore can be monitored and compared to long-term data sets. Monitoring of location where more warming is occurring can also help prompt management action, restoration efforts of coastal ecosystems, and rehabilitation efforts of at-risk species, as well as eradication of invasive species.

5.5.3 ICE COVER TRENDS

An important and reliable indicator of climate change is analysing lake ice cover. Lake ice cover on the Great Lakes and Lake Huron has been tracked by the National Oceanic and Atmospheric Association (NOAA) since 1973, providing land managers and environmental planners with a long-term data set to infer changes and predictions from. Climate change will alter the amount of ice cover Lake Huron has each year, which as discussed, will increase evaporation over winter months, potentially leading to higher spring precipitation or lower lake water levels. Other sources say conditions such as heavy rains or snowmelt in locations upstream or elsewhere in the watershed also affect the length of time a lake is frozen. Conversely, shorter periods of ice cover suggest a warming climate. ESA and SOLEC (2011), have provided thresholds and indicators of monthly ice cover amounts, scoring annual ice cover levels based on its comparison to an average rating. If ice cover is;

4-weeks shorter than average:	Very Poor
3-weeks shorter than average:	Fairly Poor
2-weeks shorter than average:	Average
1-week shorter than average:	Very Good

This method of analysing ice cover is not as specific as analysing a graph, and although an ice cover rating is below average, does not necessarily mean it is cause for concern. Ice cover, like lake levels, have natural variations. However, when outliers become farther from average, this will trigger concern and reactive management decisions. If trends are noted year-after-year of increased or decreased levels, this is also an indicator of changing climate. NOAA’s data showing historical ice cover annual maximum levels on Lake Huron is shown in Chart 9 (NOAA, 2019). This data was charted and a trend line applied to show the overall trend of ice cover has decreased slightly from ~72% to ~58% average annual maximum ice cover. This data was acquired from the National Oceanic and Atmospheric Association, which has been tracking ice cover from 1973 to present day, and has been tracking Great Lakes water levels since 1918. Therefore, this data represents the most reliable depiction of ice cover for Lake Huron.

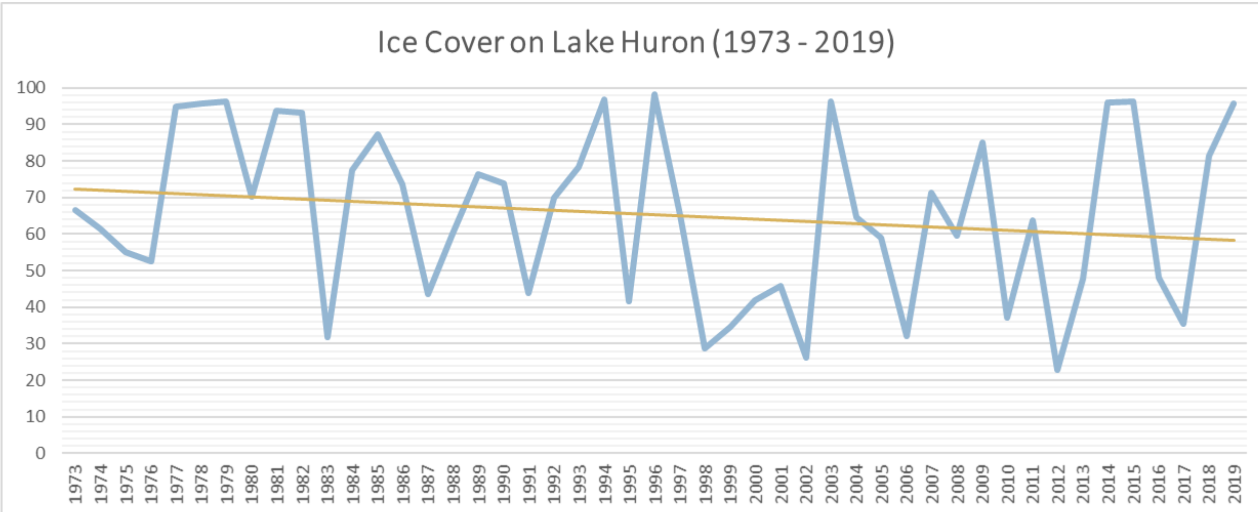


Chart 12 - Historical Ice Cover Maximums on Lake Huron (NOAA, 2019)

Other Non-Government Organizations such as the Ontario Biodiversity Council use Great Lakes ice cover as one of five specifically chosen indicators for climate change (OBC, 2015). According to Derksen et al (2019), the duration of seasonal lake ice cover has declined across Canada over the past five decades due to later ice formation in fall and earlier spring break-up. The same report indicates spring lake ice breakup will be 10 to 25 days earlier by mid-century, and fall freeze-up 5 to 15 days later, depending on the emissions scenario and lake-specific characteristics such as depth.

Lake ice cover is well monitored through both Canadian and American agencies, and therefore provides an indication of climate change and warming patterns. Funding towards these monitoring programs is imperative to continue the record of the monitoring data, as well as funding research into more remote and vulnerable areas of Lake Huron, specifically nearshore monitoring.

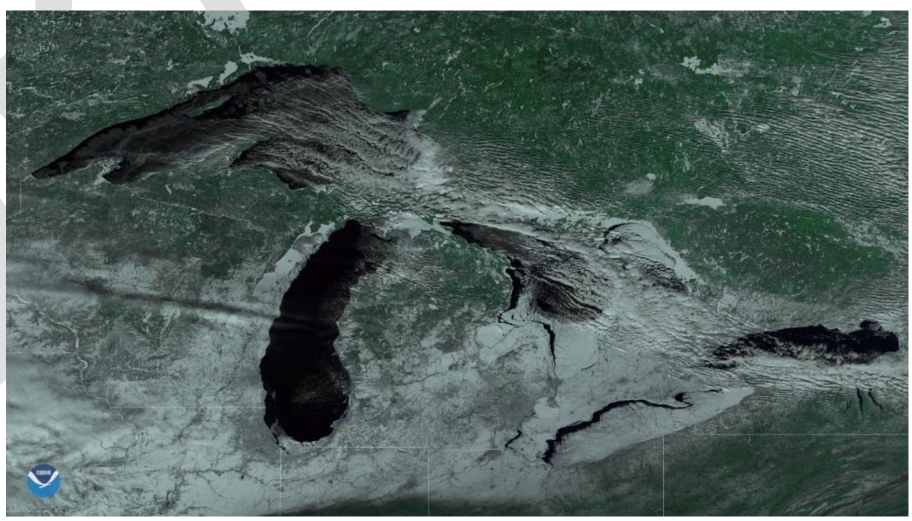


Figure 75 - Ice cover on Great Lakes (NOAA)

5.5.4 CLIMATE CHANGE EFFECTS ON LAKE HYDROLOGY

Climate change will affect the way water enters Lake Huron. Changes to weather patterns are estimated to cause less snow build-up on the landscape, causing a gentler spring freshet, but increasing precipitation and rain, causing higher mean streamflow amounts and precipitation directly falling on the lake (Cherkauer & Sinha, 2010). In the watersheds of the main rivers entering Lake Huron on the southeastern shores (Maitland, Ausable, Bayfield, Saugeen, Sauble Rivers), annual peak flows will occur earlier in the season, potentially causing more frequent low water advisories further into the growing season (ELPC, 2019). Smaller watersheds and tributaries, such as the gully tributaries in Huron County will have increased frequency and magnitude of storms towards the late-spring as snowmelt drives annual peak flow events (ELPC, 2019). Increased flood risks due to intense precipitation followed by long periods of low-water advisories are also projected to increase in the future (Cherkauer and Sinha, 2010; ELPC, 2019). Coupled with summer precipitation that is increasingly variable and likely lower, summer river flows will be lower than historical observations by the end of the century (ELPC, 2019). The increased intensity of summer storm events is likely to contribute to an increase in the flashiness, or day-to-day variability, of river discharge (Cherkauer and Sinha, 2010). The need for natural stormwater management systems such as rain gardens, wetlands, and rain barrels will be needed to reduce the flow rates crossing the landscape, as well as utilizing this water throughout low-water periods. Installing this infrastructure will enable established systems to tolerate impacts of more intense storms in the future. Increasing education of landowners and municipalities and providing incentive programs to encourage installation will aid in the adoption and understanding the necessity of natural infrastructure to protect communities from climate change creating more resilient coastal communities.

Higher summer and fall air temperatures can increase evaporation during the growing season. Water storage in the landscape, as soil moisture, aquifer recharge, and the refilling of wetlands and small lakes will change as evaporation continues to intensify during the growing season and as the landscape changes due to development and tiling of farm fields (ELPC, 2019). The Environment, Law, and Policy Centre estimate soil moisture storage will decrease by about 8% in September and October by the end of the century under the high greenhouse gas emissions scenario. For the same scenario, the Environmental Law and Policy Centre (2019) projects soil moisture storage to increase by around 10% in February and March by the end of the century. These changes to soil moisture will drastically affect the way crops and agriculture is harvested, planted, grown, and irrigated. Industries reliant on growing seasons, water flow, and water catchment will experience the need for innovations to continue current practices across the southeastern shores. Improving natural infrastructure to reduce the temperature of landscapes and waterways by providing shade will be important to reduce evaporation. Increasing vegetated buffers, increasing tree canopy cover around residential and built environments, and increasing vegetation cover along streams and gullies will improve soil moisture regimes, and enable water to stay in the soil longer, improving ability for plants and crops to grow without the use of irrigation. Increasing support of tree planting programs, buffer creation with landowners, and education about the importance of water retention areas such as wetlands will enable a reduction of evaporation.

5.5.5 LAND-USE CHANGE

Land-use and land cover influences climate by changing local temperatures, precipitation, vegetation, and the patterns of thunderstorms. Land-use is projected to remain an important contributor to local changes in climate and often occurs concurrently with hydrologic change. Urban areas have a disproportionate influence on climate, hydrology, and water quality. (ELPC, 2019). In recent studies, increases in urbanization were concentrated in coastal areas of the Great Lakes, thereby expediting effects towards local climactic changes (ELPC, 2019).

Land-use planning on Lake Huron's southeastern shores as a climate change adaptation strategy will be crucial to adapt to changing patterns. Habitat protection, expanded buffer zones and vegetation strips along hazard zones, landscape corridors, and reversing negative impacts from urbanizations will be necessary, not optional, to protect our coastal communities and habitats (SCER, 2004). Land-use planning measures such as urban intensification instead of sprawl will be another mitigation measure to reduce ecological footprint and preserve ecological functions and services (SCER, 2004). Land-use planning is the responsibility of local jurisdictions that have no direct influence on upstream or adjacent uses and management; therefore, collaboration is necessary to ensure effective protection and mitigation of threats. In addition to public infrastructure, private coastline property owners would also be affected by changes in climate. Changes in frequency and intensity of storms and major precipitation events, and changes in the frequency and severity of free-thaw cycles, may bring soil condition that will alter slope stability in ways that were not experience by property owners during their years of ownership (USACE, 2003).

Land-use changes will have successive effects on water quality and the ability for current built infrastructure to keep up with demand for stormwater management, and water treatment. Higher rates of harmful algae bloom activity associated with climate change are likely to increase future water treatment costs. Higher treatment demands resulting from climate-exacerbated runoff and sedimentation translating directly into a higher carbon footprint (ELPC, 2019). Higher temperatures and longer dry periods discussed previously have the potential to reduce soil moisture to levels that can be harmful to buried pipe infrastructure through subsidence. Coastal roads are vulnerable to erosion from increased precipitation and wave energy, as well as damage from extreme heat (ELPC, 2019). In addition, high costs associated with updating these road systems or replacing them more frequently to repair damage result from the need to change the composition of asphalt in roads in order to handle higher temperatures and different freeze-thaw patterns. More frequent replacement costs will put municipalities in a more difficult position to budget accordingly, downloading these costs to the taxpayer. Warmer winter temperatures and less ice on roadways may potentially have positive effects including extending the life of road surfaces and reducing the need to use salt or ice-melting chemicals which wash into water systems (ELPC, 2019).

Energy infrastructure is built for long-term operation, and current energy infrastructure was built based on historical water levels and temperature regimes. Changes in climate that decrease water availability or effectiveness for cooling are therefore likely to decrease regional energy production (ELPC, 2019). Increased temperatures reduce heat-transfer efficiency for cooling, which can limit power production to the level necessary to avoid overheating (ELPC, 2019). Power plants along tributary waterways and the Great Lakes themselves are vulnerable to these effects (ELPC, 2019). This is important for the southeastern shores of Lake Huron due to Bruce Power, the nuclear power plant facility located on the shores of Assessment Unit 4 and 5.

There are recreational opportunities in the Great Lakes region, such as birding which engages 30-35% of the population, that are likely to be affected by climate change, although the effects are not known (ELPC, 2019). Recreational winter activities could experience the largest impacts of climate change and are directly related to the winter tourism for Bruce, Huron and Lambton Counties. For instance, decreases in the depth and duration of winter snow cover will result in fewer opportunities for winter recreation, including skiing, snowmobiling, and snowshoeing. According to ELPC (2019) of the 122 resort-style businesses in the Great Lakes states currently identified as supporting winter recreation, only 80 are in areas that receive enough snow to regularly support such activities By the end of the century (under the highest emission scenario) all existing ski resorts in the region will become non-viable due to lack of snow and the conditions required to make snow.

Recommendations for land-use change decisions to protect coastal environments and communities, and to combat climate change should focus on preventative measures, instead of waiting to react. Adapting to a changing climate should include, such measures as increasing permeable pavements and natural water retention structures such as wetlands, community rain gardens, and rainwater catchment systems, which will reduce added stress on existing municipal infrastructure systems. This will extend the life of these systems while saving tax dollars and still accommodating storms with heavier flows. Encouraging appropriate and wider than necessary setbacks for new development will further reduce impacts close to hazard areas like bluffs, beaches, and gullies. Ensuring wide vegetated buffers along the shoreline and joining watercourses will filter sediments and nutrients entering Lake Huron's nearshore waters. A collaborative effort between land managers and landowners is needed to complete projects of all scales.

5.5.6 BIODIVERSITY AND INVASIVE SPECIES

Climate impacts biodiversity in many ways. It sets the physiological limits of species range distribution, controls the co-evolutionary processes that cause species to become mutually dependent, and influences the spread and interactions among species that control community membership. The ultimate impact of climate change on biodiversity on Lake Huron's coastal corridors will depend on how the various component of climate change (warming, increased CO^2 concentrations, changes in water acidity and oxygen levels, altered frequency and intensity of storms etc.) collectively impact biodiversity (ELPC, 2019). There are four factors that regulate biodiversity, those are: (1) invasive rates by new, non-native species, (2) replacement of widespread or abundant species by those that are presently uncommon or rare, (3) emergence or proliferation of new pests and disease that might impacts established species populations, and (4) extinction rates of the existing established species assemblage. While extinctions caused directly by climate change are likely to be rare, the potential of extinctions caused indirectly through climate change's impact on invasive species, species replacement, or the proliferation of new pests and disease are possible. However, the importance of these indirect effects is currently controversial, and has a high degree of uncertainty. The Environmental Law and Policy Centre (2019) find that while it has historically been assumed that invasive species are a leading cause of native species extinction, recent evidence suggests that invasive species rarely cause extinctions and, in fact, non-native introductions often cause biodiversity to increase as invasion rates outpace extinction rates. Therefore, the cumulative impact of climate change on extinctions (direct and indirect effects) is presently unknown (ELPC, 2019).

It is projected that coastal wetlands could shrink, negatively impacting fish and wildlife populations. Lower water levels would be favourable to the spread of invasive Common Reed (*Phragmites australis*), while higher water temperatures may favour aquatic invasive species such as Sea Lamprey (LSBP, 2012). Deciduous forests may shift northward due to warmer air temperatures and changes in precipitation. Forest pests may also spread widely due to higher air temperatures (LSBP, 2012). Boreal species that are dependent on cooler temperatures and microclimates may experience a reduction in suitable habitat due to increased air temperature and lower lake water levels (LSBP, 2012). Assisted migration may be needed to maintain certain species populations, and extra efforts may be required to monitor and control invasive species as they spread across the shoreline.

According to the ELPC (2019) fish species in the Lake Huron region will be directly affected by climate change phenomena including temperature increases, increases in storm intensity and frequency, and shifting seasonal patterns. Many Great Lakes fish species such as Lake Trout and Lake Whitefish are influenced by water temperature (e.g. contributions to distinct cold, cool, and warm-water assemblages throughout the region). As previously stated, shifting seasonal patterns of precipitation and ice formation can similarly affect species whose behavior is cued to those events. Besides these direct changes, effects of climate change phenomena on fish habitats will further impact species. Changing precipitation patterns and storms will impact drainage patterns, connectivity, water levels, and the extent and quality of littoral habitat.

Increases in water temperature, along with earlier warming in spring, can increase the depth and duration of stratification. This, in turn, will promote depletion of upper oxygenated layers of water, resulting in more widespread and profound periods of bottom anoxia (ELPC, 2019). The cumulative impact of these changing environmental drivers will have multiple effects on Lake Huron fish species by changing their geographic ranges, overall system productivity, species-specific productivity, spatial arrangement within a system due to changing habitat suitability and changes in physiological state and performance (ELPC, 2019).

Species that will be affected include Lake Trout (*Salvelinus namaycush*), Northern Pike (*Esox lucius*), Walleye (*Sander vitreus*), Lake Whitefish (*Coregonus clupeaformis*) and Yellow Perch (*Perca flavescens*). ELPC (2019) predict that range expansion of Smallmouth Bass (*Micropterus dolomieu*) will be extremely detrimental to the populations of forage fish. Under the best-case GHG emission scenario, 10-40% of Ontario lakes are expected to be impacted by major shifts in community composition (ELPC, 2019). While climate change could affect participation and expenditures in fishing, it may have more important effects on the value of ecosystem services related to recreational fishing in the Great Lakes. Estimates suggest that, at present recreational fishing in the Great Lakes Region provides ecosystem services values ranging from $3-million to over $1-billion per year (ELPC, 2019).

5.5.7 SEVERITY OF THREATS

Climate change and the effects it will cause to Lake Huron and the coastal corridor are a big unknown, as scientists still work on developing projections for the effects changes in annual temperature will cause. Using the LAMP threat rating criteria ((ECCC & USEPA, 2018), these threats are rated for their severity trend into the near future (10-years).

Threat	Rating
Climate Change	**Scope:** VERY HIGH – 100% of the coastal corridor is anticipated to be affected by the threats caused by climate change.
	Severity: MEDIUM – depending on the sensitivity of the coastal ecosystems, the level of damage and destruction reasonably expected to occur within 10 years due to climate change is variable, but is predicted to moderately degrade ecosystems by 11-30% if no rehabilitation methods are employed.
	Irreversibility: HIGH – Effects of climate change could technically be reversed and restored on a continual basis but may be impractical due to time and money constraints, taking 21-100 years to achieve. In some cases, it may be unlikely the ecosystems can be restored to pre-threat conditions depending on how society decides to combat the causes of climate change.

5.5.8 ADAPTATION

Adaptation is the ability of ecosystems and communities (both human and non-human) to change in order to be resilient to the impacts of climate change. Adaptation is necessary given the current and predicted conditions that a changing climate does and will encompass. These adaptation measures are necessary to our current systems, efforts and community infrastructure to be responsive to changing climate, associated weather patters and the effects to the coastal corridor. Adapting our current 'norms' to prepare and increase resilience to unpredictable challenges that will arise will reduce the vulnerability of sensitive coastal ecosystems and communities to changes. Figure 75, adapted from Beavers et al., 2016 illustrates how vulnerability is related to exposure and impact.

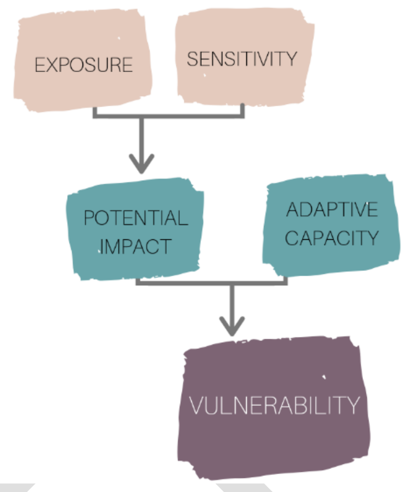


Figure 76 - Vulnerability framework (Adapted from Beavers et al., 2016)

Adaptation can occur at all scales, by individual landowners, cottage communities, municipalities, regions, and provinces alike. However, grass-roots changes will lead the way to making appropriate adaptations depending on the community they are in and the challenges they face. Policy and regulation typically follow. Applying integrated and adaptive management techniques is an ongoing process, but will use the successes and failures of completed projects, as well as incorporate new projects, to best improve the resiliency of our coast. Adaptation is best done as a consorted effort between all shoreline groups, making cooperation and communication more important than ever to tackle challenges that influence one another. The time to think of climate change as being an issue in the future is over. Reports from the United Nations International Panel on Climate Change (IPCC), and climate activists such as the Swedish student, Greta Thunberg (Figure 76), the time to begin adaptation and resiliency measures is now.

"*Adaptation involves making adjustments in land management decisions, activities and ways of thinking. Adaptation can include behavioural changes, operational modifications, technological interventions, planning changes and revised investment practices, regulations and legislation. While adaptation in the natural environment occurs spontaneously, adaptation in human systems often benefits from careful planning that is guided by scientific research and detailed understanding of the systems involved*" (NRCAN, 2017).

It is most effective and successful to prepare for issues before they arise, then to rely on a reactive management style. Regarding lake water levels specifically, it is easier to adjust and rebuild dunes and natural defences during low water levels, to prepare for high water levels in years to come- there is not much protection you can provide when the waters return to high levels (USACE, 2003). "When high water levels occur with more intense and frequent precipitation events and periods of damaging storm waves, adaptation will be more challenging (USACE, 2003). Therefore, climate change adaptation recommendations promoted by Environment Climate Change Canada, and the Ministry of Environment, as well as the countless other environmental groups focusing on climate change, should be implemented within our coastal communities to ensure resiliency of our communities. "Communities should favor actions that yield benefits regardless of what the climate is in the future.

In this way, communities may build their resilience to climatic uncertainty" (Kemkes & Salmon-Tumas, 2019, p.78). The Coastal Action Plan recognises that we all have a role to play in understanding the impacts of a changing climate, normalizing the conversation about climate change, increasing our resilience to climate risks, and acting to manage risks. This includes all levels of government, business, communities and individuals.

Figure 77 - Greta Thunberg, Swedish climate activist. (Globalnews.ca)

Policy responses to climate change could also have strong influences on adaptation in regards to land-use change. It has been suggested that the implementation of natural climate change mitigation solutions, including expansion of forests to sequester carbon, are economically feasible at costs comparable to energy sector mitigation options (ELPC, 2019). According to recent studies, there are significant opportunities to establish forests throughout the Great Lakes watershed, with policy efforts aimed at mitigating climate change which could strongly influence land-use and land cover throughout the region. In general, these changes would involve expansion of forests at the expense of agriculture and grazing land, however compromise can be done on a local level (ELPC, 2019). Green infrastructure such as parks, green street corridors, rain gardens, and natural areas, are increasingly examined as cost-effective strategies for cities to increase water storage in soil and groundwater, decreasing stormwater runoff (ELPC, 2019).

Efforts to adapt with irrigation, acceptance of new varieties, and alternative management approaches can help mitigate yield losses experienced by growers. Climate change will provide the incentive for farmers to adapt by switching to new crops all together, among other approaches (ELPC, 2019). For some areas, this may include double-cropping where more than one crop is grown in a field per year, increasing use of cover crops, and changes to new mixtures of crops better suited for the future climate (recognizing differences in soil productivity across the Great Lakes region). There is evidence that some cash crops (e.g. corn and soybean), will shift northward (ELPC, 2019). Agriculture will need to seek innovation to keep up with a changing climate as one of the biggest industries within and adjacent to the coastal corridor.

5.5.8.1 OPPORTUNITIES

Many Municipal and County Governments along the southeastern shores of Lake Huron are taking on projects related to Climate Change research, and mitigation and adaptation planning. For example, in 2010, Huron County released the framework document, *Take Action for Sustainable Huron,* which identified the importance of natural environment features within the County. However, at that point in time there was no focus on climate change impacts. More recently in 2019, the County of Huron is beginning a formal 5-year review process for that document to ensure that the community vision and values, direction, policies and actions in the Plan meet the needs of the community into the future, including new policies to reflect changes. During the review of the Huron County Official Plan, one of the new theme areas, and goals identified by the community was climate change. Individuals identified priorities included a Climate Change Action Plan, along with specific best management practices for the agricultural sector. There was major community support for current County-wide projects and initiatives including the Water Protection Steering Committee and Sustainability Planning. These projects will include impact assessments from climate change threats.

There have been 11 Assessment Units created for the analysis of the land-use and shoreline types of the southeastern shores of Lake Huron. Assessment Unit boundaries were formed using littoral cell nodes determined in the Flood Damage Reduction Program (FDRP) mapping completed in the 1980's. These boundaries were cross referenced with work being completed with Environment and Climate Change Canada on a Nearshore Framework for the Great Lakes, and Lake Huron in particular. Assessment Units 'disregard' political jurisdictions of municipalities, federal and provincial districts, and Conservation Authority boundaries; and intend to analyze the coastal corridor using this ecologically-derived boundary. Using this method places the call for action on multiple stakeholders in each Assessment Unit, and will encourage communication, and collaborative action fulfilling the recommendations made in the CAP.

Each assessment unit determines that area's defining features, main threats and stressors, along with how they measure up to known indicators and thresholds. By allowing this type of analysis, a call to action is implied to improve the ecological integrity of the coastal ecosystems existing in that region.

ASSESSMENT UNIT 1: SARNIA AND LAMBTON COUNTY

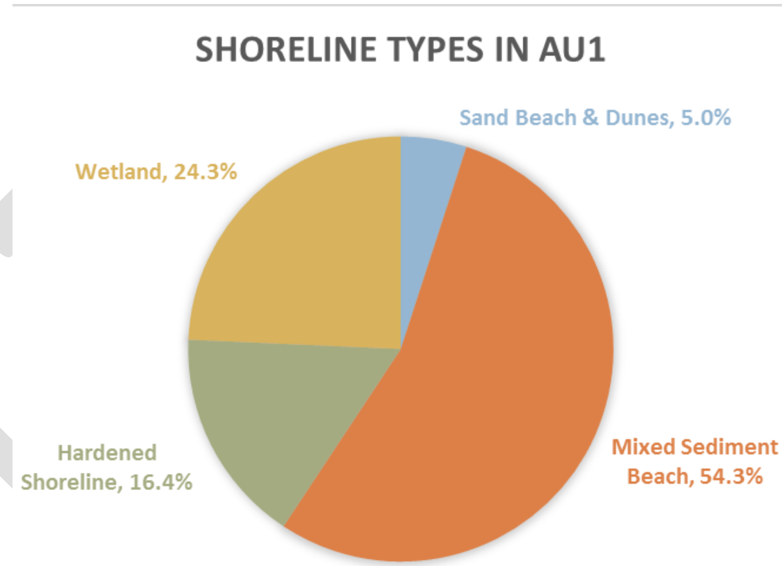
The Sarnia and Lambton County Assessment Unit 1 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 1 (AU1) has 81.2 km of shoreline, with the coastal corridor covering 8,582.3 hectares of diverse habitat.

DEFINING FEATURES

- Flat topography and Bathymetry
- Intensive development of lakeshore
- City of Sarnia, urban infrastructure and stormwater
- High density of shoreline structures
- Sandy, erodible sediment
- High agricultural productivity
- Kettle Point First Nations Reserve No.44
- Carolinian Forest Zone
- Rivers (Cull Drain)

SHORELINE COMPOSITION IN ASSESSMENT UNIT 1

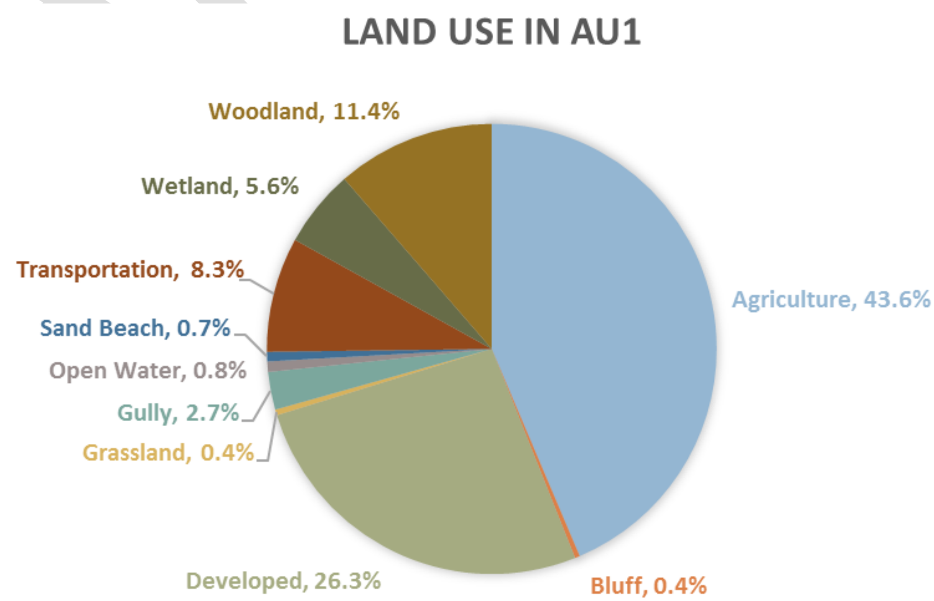
Total km	*Sand beach & Dunes*	*Mixed Sediment Beach*	*Hardened Shoreline*	*Island*	*Wetland*
81.20	4.14	44.07	13.29	0.34	19.70
% coverage:	5%	54.3%	16.4%	0.4%	24.3%



MAP 1: Shoreline Types in AU 1

LAND-USE COMPOSITION IN ASSESSMENT UNIT 1

Total Hectares	8,582.31	(% of AU)
Agriculture	3,742.17	43.6%
Bluff	29.91	0.35%
Cobble Beach	3.54	0.04%
Developed	2,254.94	26.27%
Grassland	36.43	0.42%
Gully	232.68	2.71%
Nearshore	8,683.57	n/a
Open Water	64.35	0.75%
Sand Beach	58.30	0.68%
Transportation	707.76	8.25%
Wetland	477.79	5.57%
Woodland	976.43	11.38%



MAP 2: Land-Use Types in AU 1

ECOSYSTEM HEALTH ANALYSIS

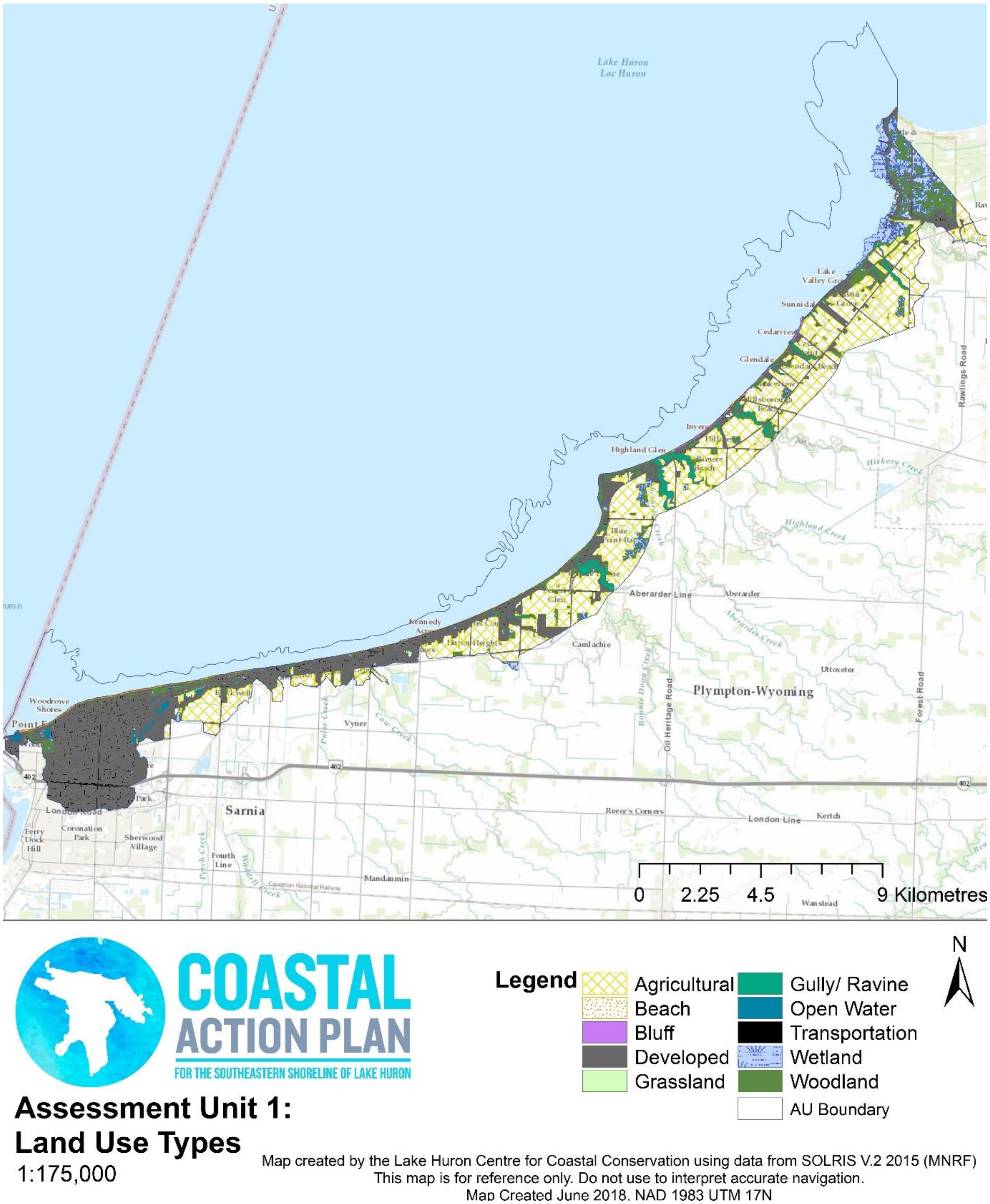
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Natural land cover within 2 km of shoreline (%)	<20%	**20-40%**	40-70%	>70%
	Naturally vegetated bluff buffers (%)	0-20%	**20-50%**	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	**0**	1	2-5	>5
*** Current developed area in AU 1 is 34.52%, with 44% as agriculture, leaving approximately 21.88% natural land cover.* *** 46% of Gullies has 75+% natural vegetated buffer.* *** Woodland cover is 11.38% in AU 1's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 379 hardened structures in water or parallel hardening structures. 13.3km of shoreline is hardened (16%).* *** 1 structure every 210-metres.*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	**No grooming**
*** Municipality of Plympton Wyoming doesn't actively groom beaches; Municipality of Sarnia has no data.*					
Presence of Wildlife	Invasive Species	At least 18 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
*** 2.5km2 of Phragmites australis has been identified, approximating $305,000 CAD for 3-year eradication treatment.*					
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	**20-40**	<20
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Area of transportation corridor (%, ha)	8.25%, 2,962.70 ha			
*** Coastal corridor is 34.52% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Density of shoreline hardening structures	Restoration of shoreline through structure/hazard removal.
Lack of forest cover	Tree planting and reinstating windbreaks.
Presence of invasive species	Increase invasive species awareness program and treatment programs.
	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.

MAP 1 - Shoreline Types in AU 1

MAP 2 – Land-Use Types in AU 1



ASSESSMENT UNIT 2: KETTLE POINT TO GODERICH

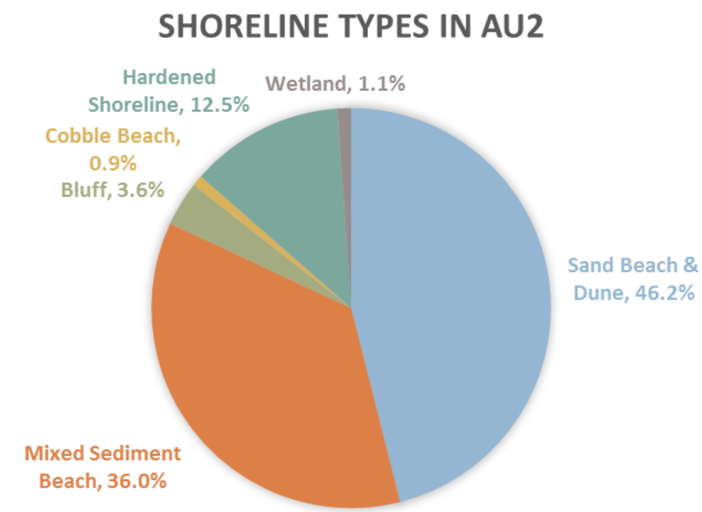
The Kettle Point to Goderich Assessment Unit 2 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 2 (AU2) has 120.85 km of shoreline, with the coastal corridor covering 8,939.55 hectares of diverse habitat.

DEFINING FEATURES

Building and development within floodplains (Port Franks)	High intensity seasonal visitation to beach communities
1 Provincial Park (Pinery)	Highly developed communities within hazard zones
Carolinian Forest	Highly erodible bluffs
Major Rivers (Ausable, Bayfield)	High agricultural productivity
St. Joseph's till sediment, clay and sand	Deep gullies

SHORELINE COMPOSITION IN ASSESSMENT UNIT 2

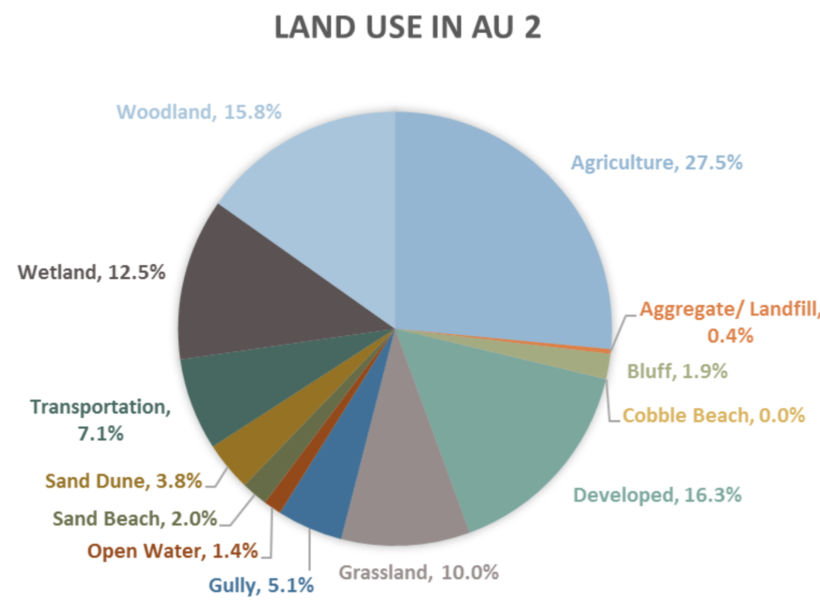
Total km	*Sand beach & Dunes*	*Mixed Sediment Beach*	*Bluffs*	*Cobble Beach*	*Hardened Shoreline*	*Wetland*	*River mouths*
120.1	55.5	43.2	4.3	1.1	15.0	1.3	9
% coverage:	46.2%	36%	3.6%	0.9%	12.5%	1.1%	0



MAP 1 & 2: Shoreline Types in AU 2

LAND-USE COMPOSITION IN ASSESSMENT UNIT 2

Total Hectares	8,939.55	(% of AU)
Agriculture	2,435.88	27.25%
Aggregate / Landfill	31.98	0.36%
Bluff	172.20	1.93%
Cobble Beach	2.22	0.02%
Developed	1,456.17	16.29%
Grassland	889.66	9.95%
Gully	454.80	5.09%
Nearshore	6,106.60	n/a
Open Water	124.52	1.39%
Sand Beach	182.18	2.04%
Sand Dune	340.68	3.81%
Transportation	636.66	7.12%
Wetland	1,119.96	12.53%
Woodland	1,409.64	15.77%



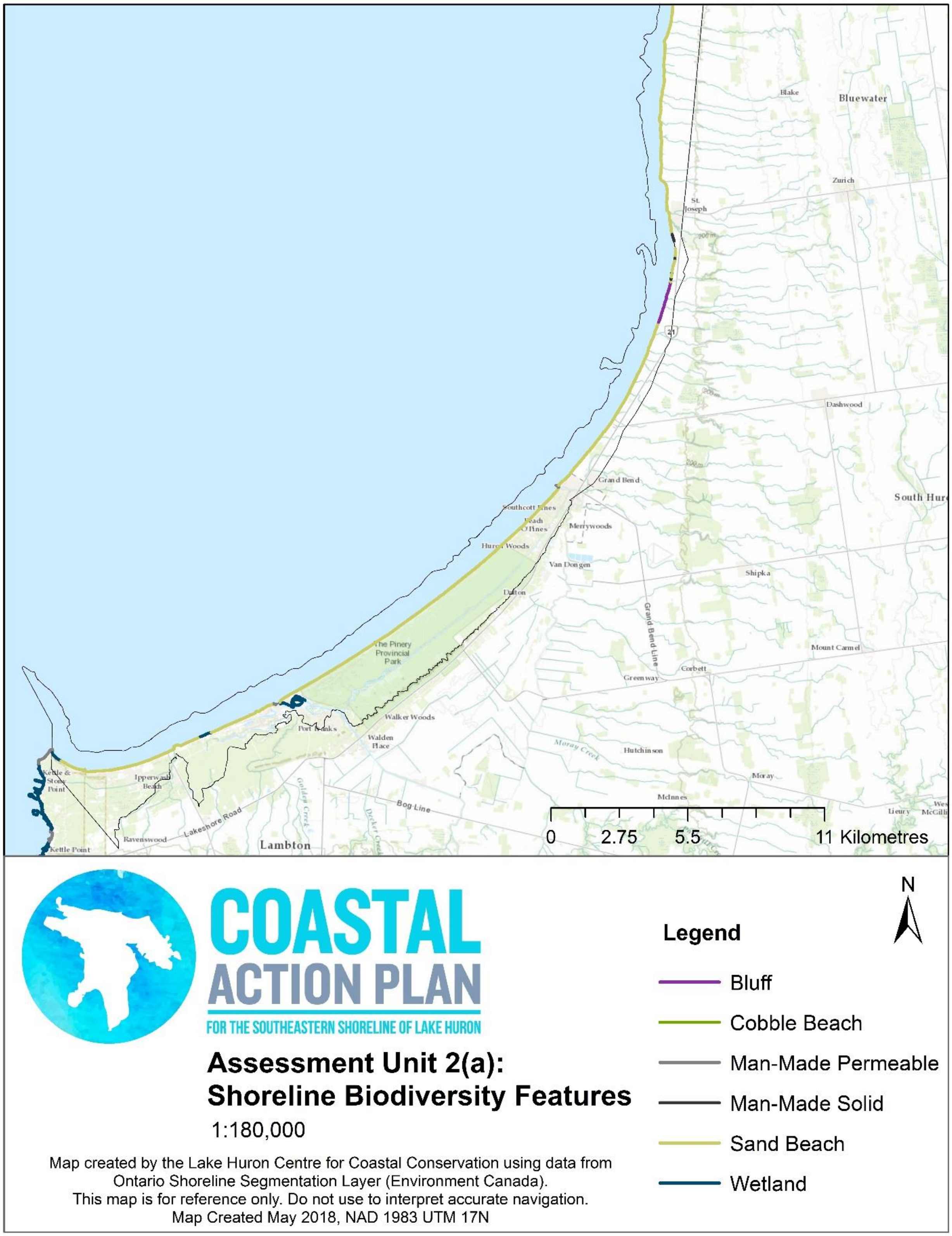
MAP 3,4 & 5: Land-Use Types in AU 2

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40	**40-70**	>70
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	**0**	1	2-5	>5
*** Current developed area in AU 2 is 23.41%, with 27.3% agriculture, leaving approximately 52.53% natural land cover.* *** 46% of Gullies has 75+% natural vegetated buffer.* *** Woodland cover is 15.8% in AU 2's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 205 hardened structures in water or parallel hardening structures. 13.3km of shoreline is hardened (16%).* *** 1 structure every 590-metres.*					
Presence of Roughage	Sand beach grooming: Mun. Lambton Shores	**Groom 2+x times / week**	Groom 1x / week	Groom 1x / month	No grooming
	Sand beach grooming: Mun. South Huron	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	**Hand grooming**
	Sand beach grooming: Mun. Bluewater	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	**Hand grooming**
	Sand beach grooming: Town of Goderich	Groom 2+x times / week	**Groom 1x / week**	Groom 1x / month	No grooming
	Sand beach grooming: Mun. Central Huron	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	**Hand grooming**
*** Municipality of Lambton Shores own their own grooming machine* *** Town of Goderich groom Bi-weekly, $45,000 annual budget* *** Municipality of Bluewater and Central Huron use small machinery if need be a few times per year*					
Presence of Wildlife	Invasive Species	At least 18 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	**20-40**	<20
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Area of transportation corridor (%, ha)	7.12%, 2,092.83 ha			
*** Coastal corridor is 23.4% developed, including transportation.*					

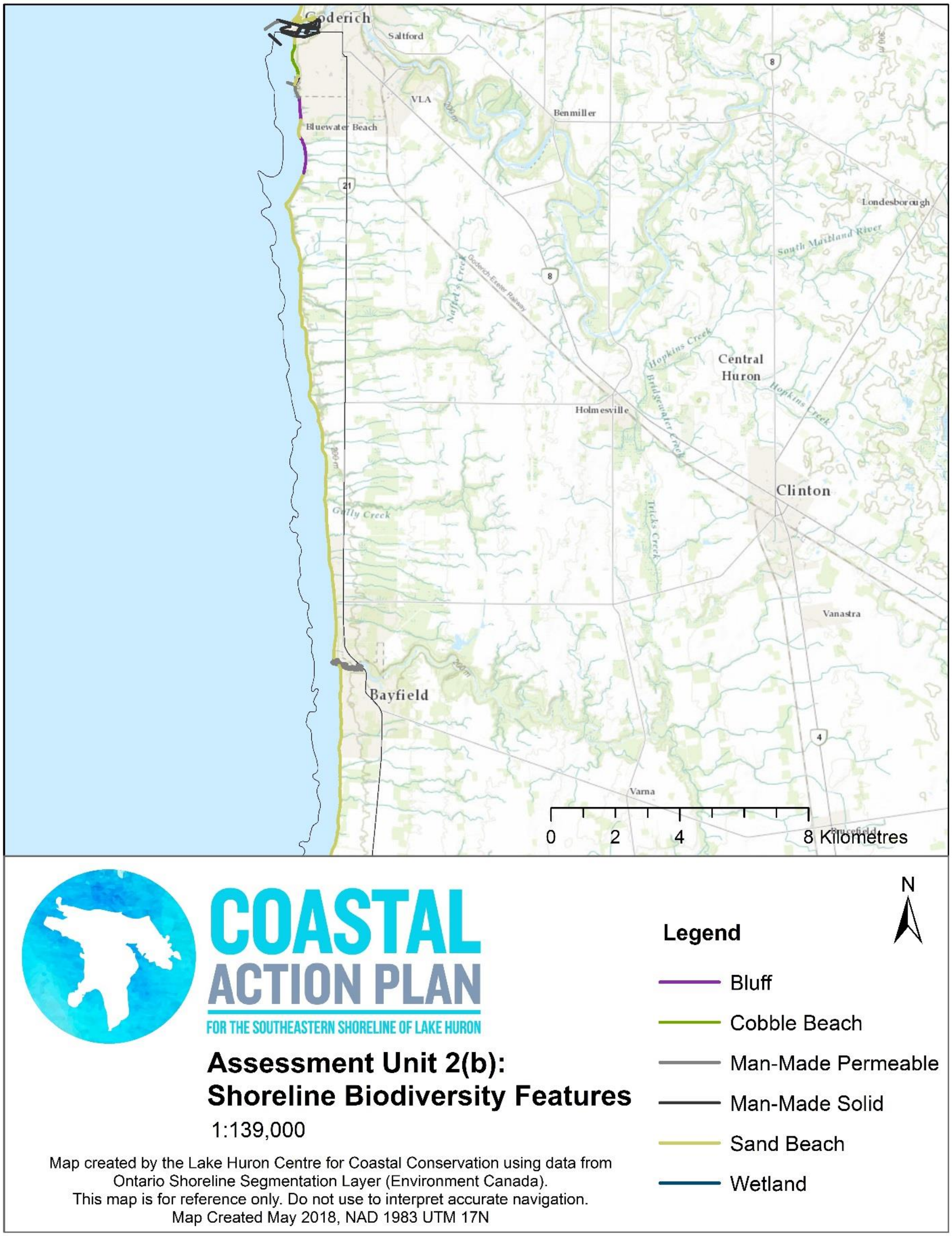
KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Lack of buffer zones between development and shoreline	Restoration of shoreline through structure/hazard removal.
Lack of forest cover	Tree planting and reinstating windbreaks.
Presence of invasive species	Increase invasive species awareness program and treatment programs.
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.
Habitat loss	Incentivize and enforce stream, gully, and bluff vegetation cover and development buffer zones

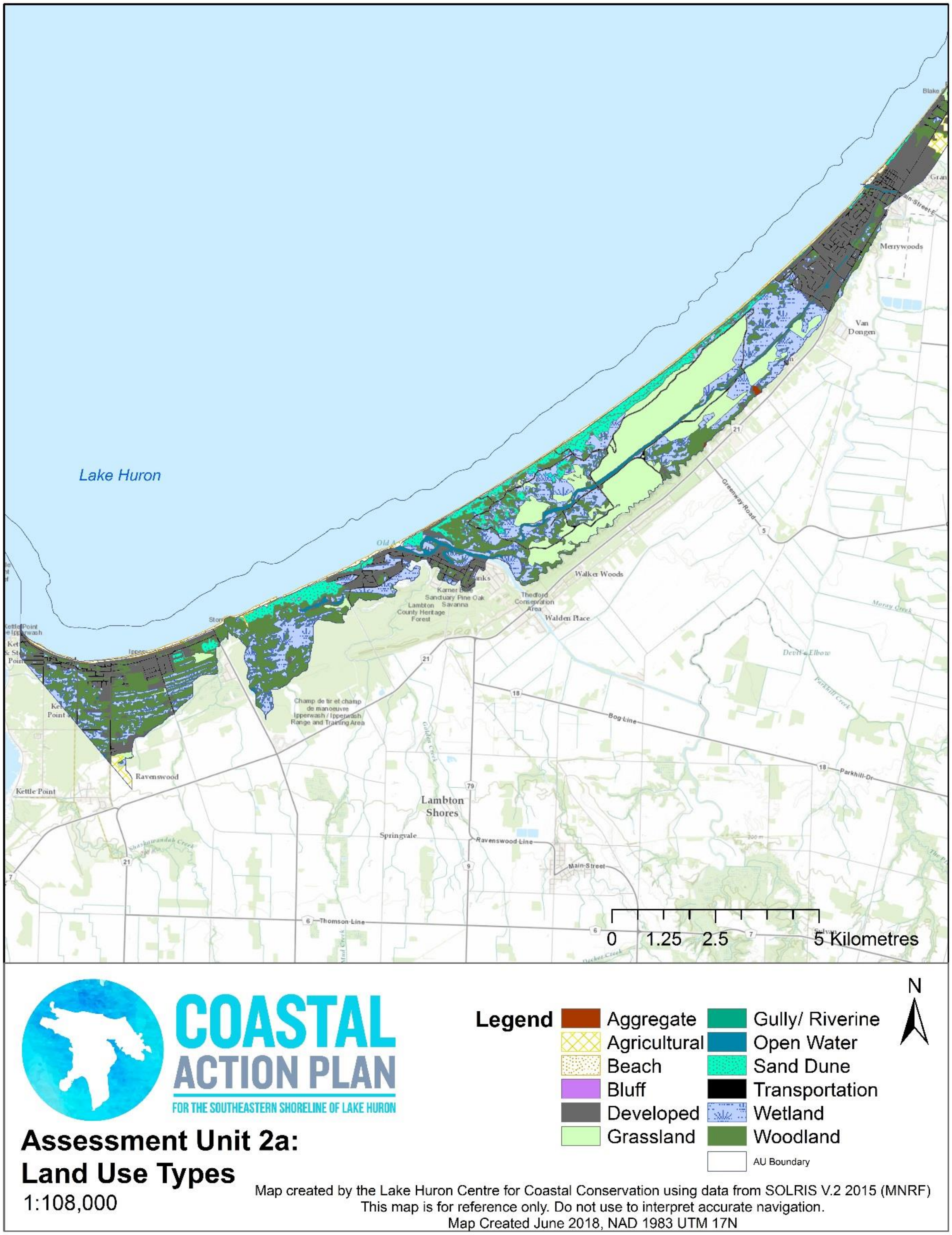
MAP 2 - Shoreline Types in AU 2



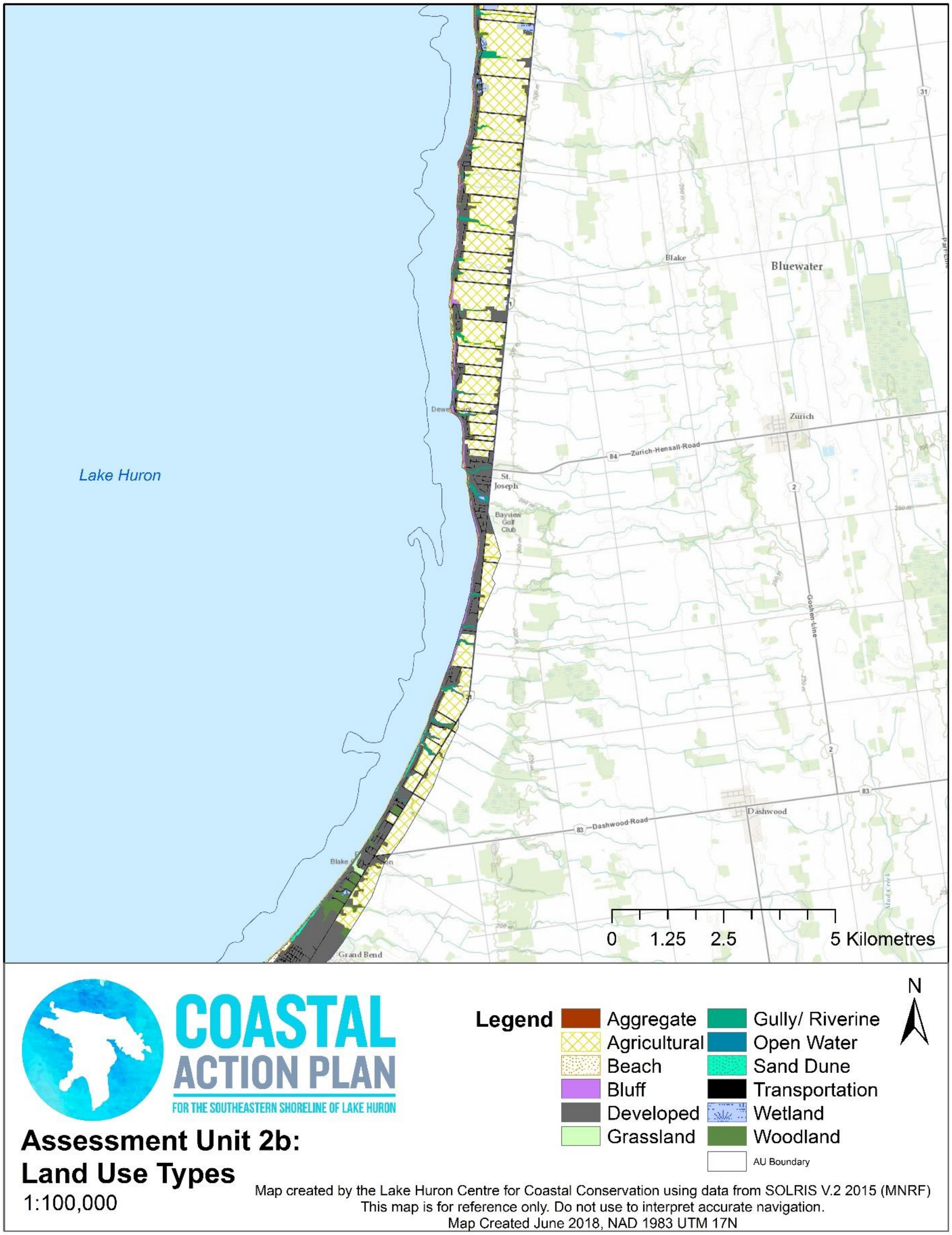
MAP 2 - Shoreline Types in AU 2



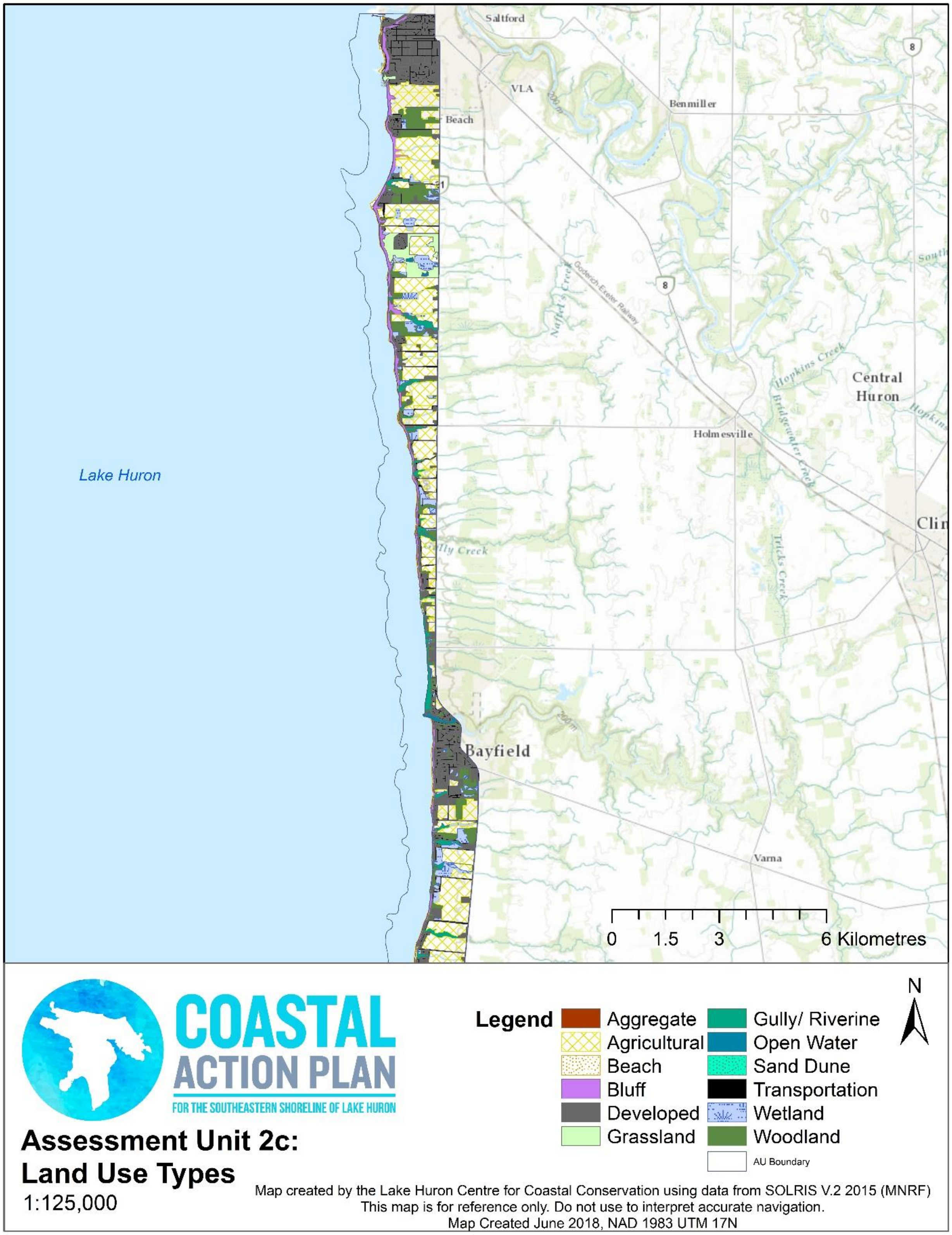
MAP 3 – Land-Use Types in AU 2



MAP 4- Land-Use Types in AU 2



MAP 5- Land-Use Types in AU 2



ASSESSMENT UNIT 3: GODERICH TO POINT CLARK

The Goderich to Point Clark Assessment Unit 3 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 3 (AU3) has 63.94 km of shoreline, covering 7,297.41 hectares of diverse habitat.

DEFINING FEATURES

High intensity seasonal visitation to beach communities and cottages

Highly developed communities within hazard zones

Deep gullies

Highly erodible bluffs

High agricultural productivity

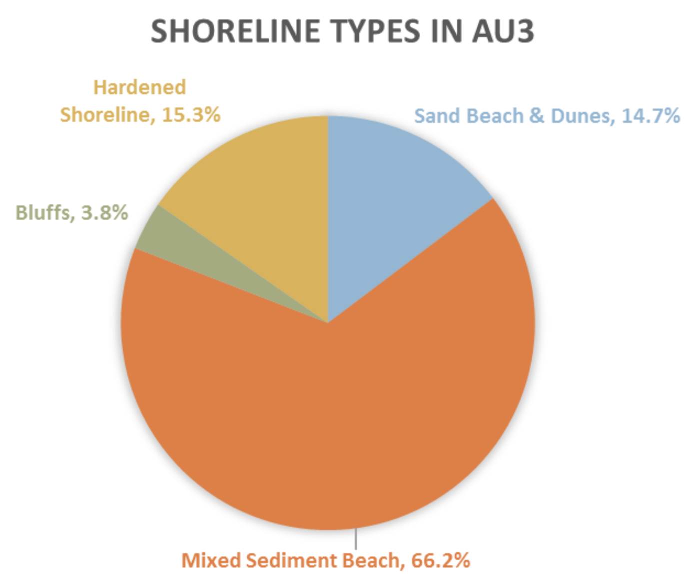
St. Joseph's till sediment, clay and sand

1 Provincial Park (Point Farms)

Rivers (Maitland, Nine Mile)

SHORELINE COMPOSITION IN ASSESSMENT UNIT 3

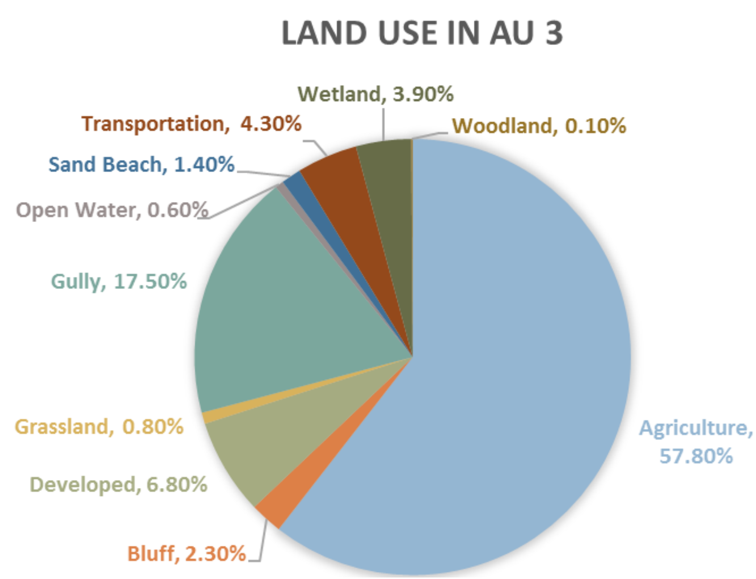
Total km	Sand beach & Dunes	Mixed Sediment Beach	Bluffs	Hardened Shoreline	River mouths
63.94	9.42	42.34	2.41	9.77	3
% coverage:	14.7%	66.2%	3.8%	15.3%	n/a



MAP 1: Shoreline Types in AU 3

LAND-USE COMPOSITION IN ASSESSMENT UNIT 3

Total Hectares	7,297.41	(% of AU)
Agriculture	4,220.19	57.8%
Bluff	166.75	2.3%
Developed	498.97	6.8%
Grassland	60.31	0.8%
Gully	1,279.24	17.5%
Nearshore	5,122.99	n/a
Open Water	39.81	0.6%
Sand Beach	103.34	1.4%
Transportation	315.82	4.3%
Wetland	287.74	3.9%
Woodland	706.30	9.7%



MAP 2&3: Land-Use Types in AU 3a & 3b

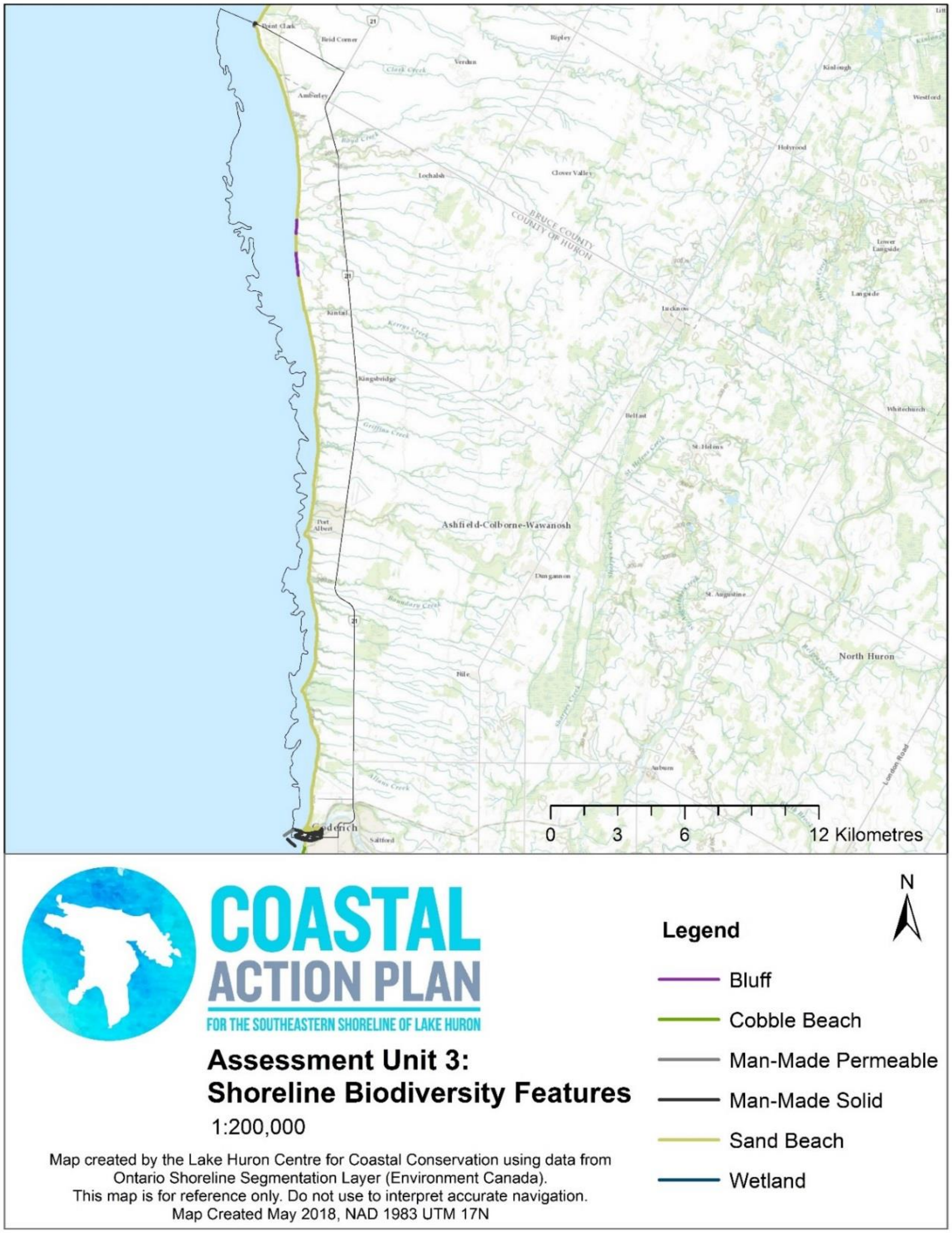
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	**20-40**	40-70	>70
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	**0**	1	2-5	>5kj
*** Current developed area in AU 3 is 11.2%, with 57.8% agriculture, leaving 31% natural land cover.* *** Amount of naturally vegetated bluff buffers is unknown. 47 gullies exist* *** Woodland cover is 9.7% in AU 3's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 53 hardened structures in water or parallel hardening structures. 63.94km of shoreline is hardened (16%).* *** 1 structure every 1,210-metres*					
Presence of Roughage	Sand beach grooming: None Applicable	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	No grooming
*** No data available regarding beaches receive grooming in AU 3.*					
Presence of Wildlife	Invasive Species	At least 18 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	**20-40**	<20
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	7.12%, 2,092.83 ha			
*** Coastal corridor is 23.4% developed, including transportation.*					

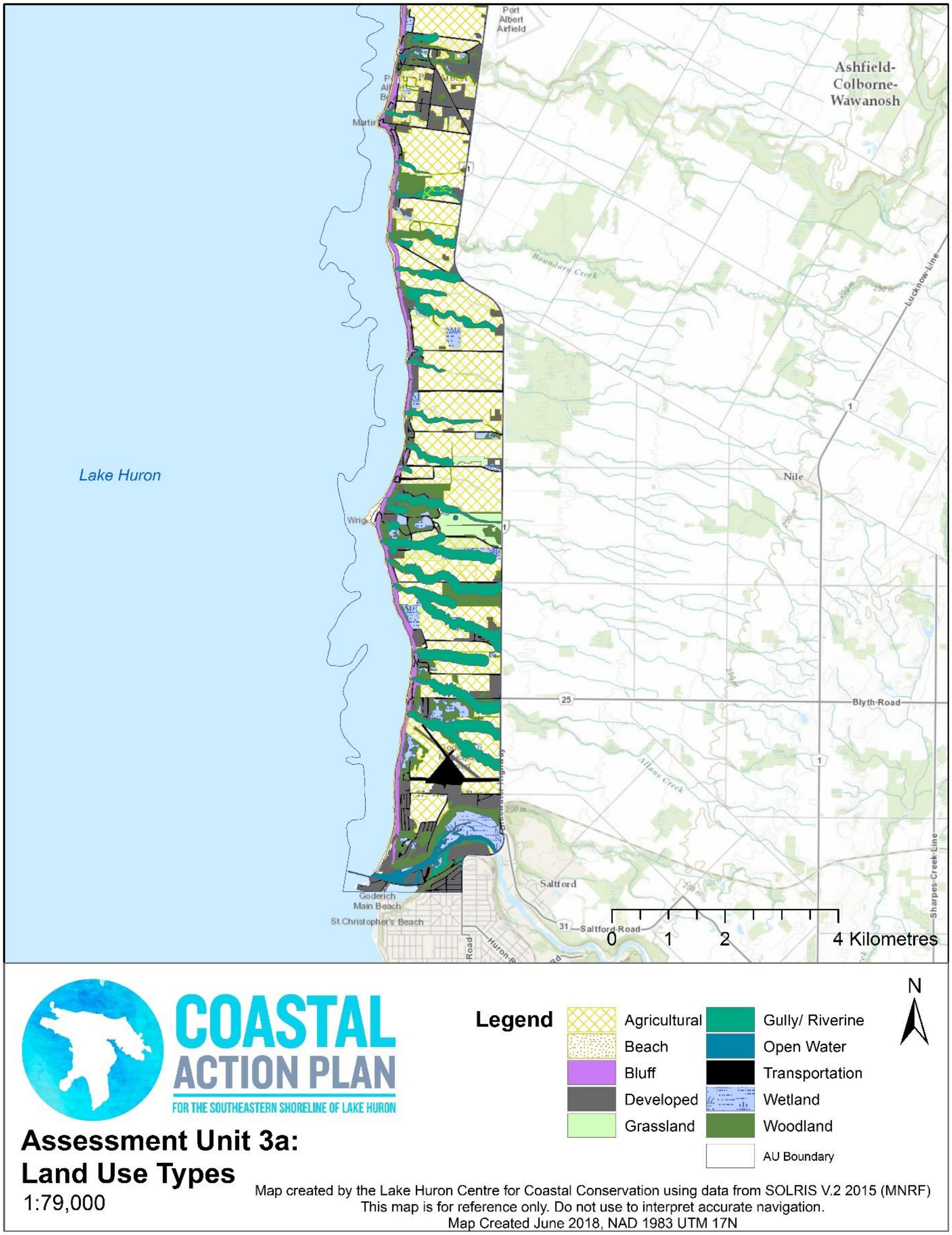
KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Density of shoreline hardening structures	Restoration of shoreline through structure/hazard removal.
Lack of forest cover	Tree planting and reinstating windbreaks.
Presence of invasive species	Increase invasive species awareness program and treatment programs.
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.

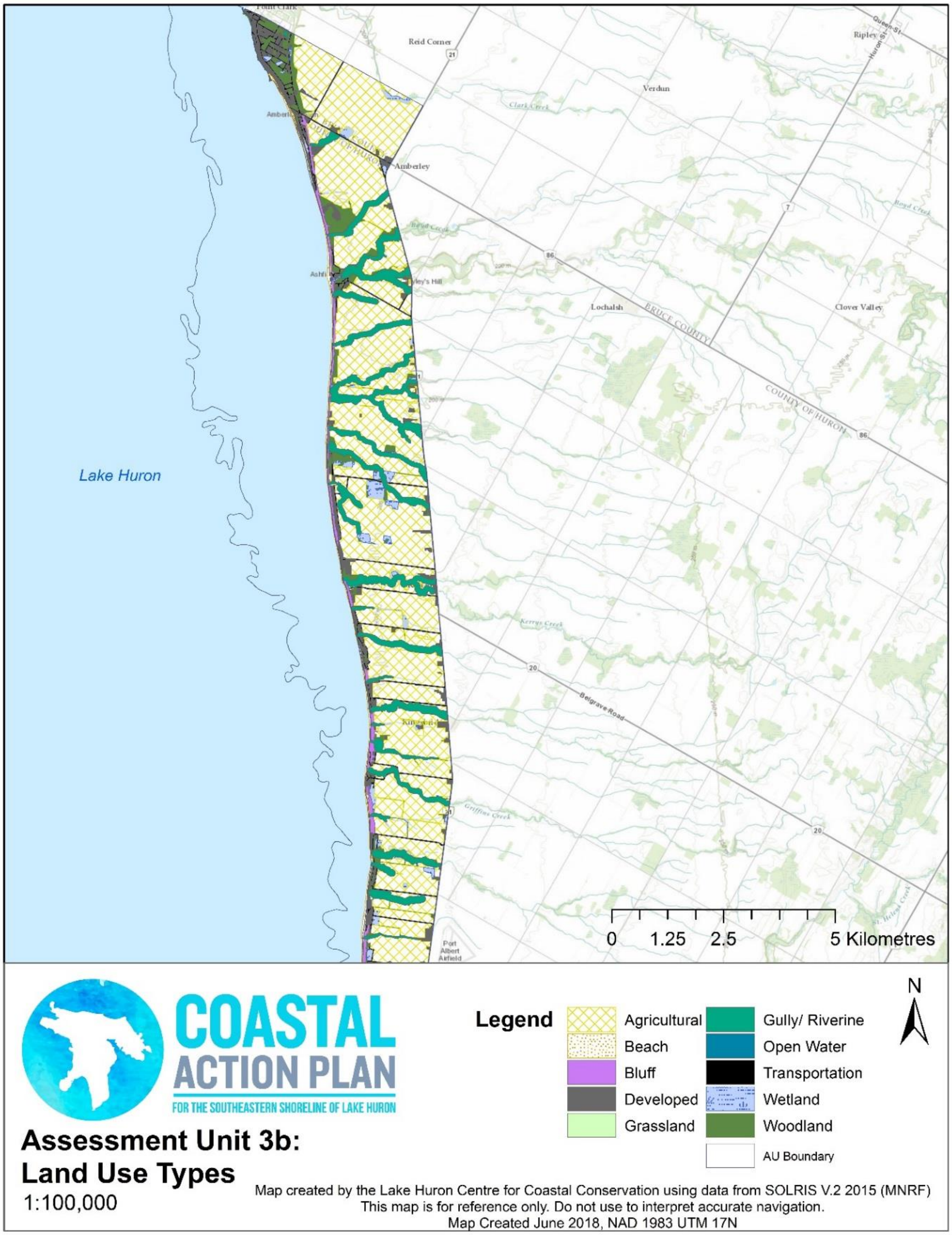
MAP 3 - Shoreline Types in AU 3



MAP 4 – Land-Use Types in AU 3a



MAP 3 – Land-Use Types in AU 3b



ASSESSMENT UNIT 4: POINT CLARK TO INVERHURON

The Point Clark to Inverhuron Assessment Unit 4 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 4 (AU4) has 39.76km of shoreline, covering 8,681.95 hectares of diverse habitat.

DEFINING FEATURES

Many cottages directly on mature dunes, cottage communities along almost whole coast

Flat topography, sandy, many mature dunes, woodlots

Stoney Island Conservation Area and Inverhuron Provincial Park

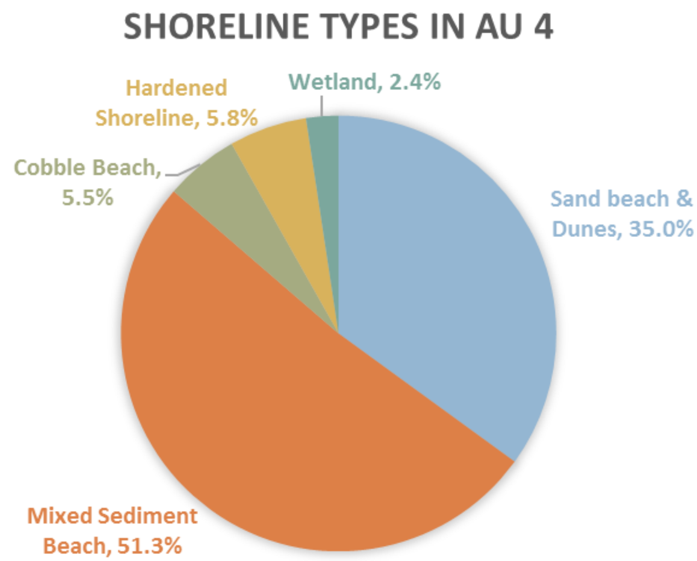
Rivers - Pine and Pentagore

Developed community of Kincardine

Great Lakes St. Lawrence Hardwood woodlands

SHORELINE COMPOSITION IN ASSESSMENT UNIT 4

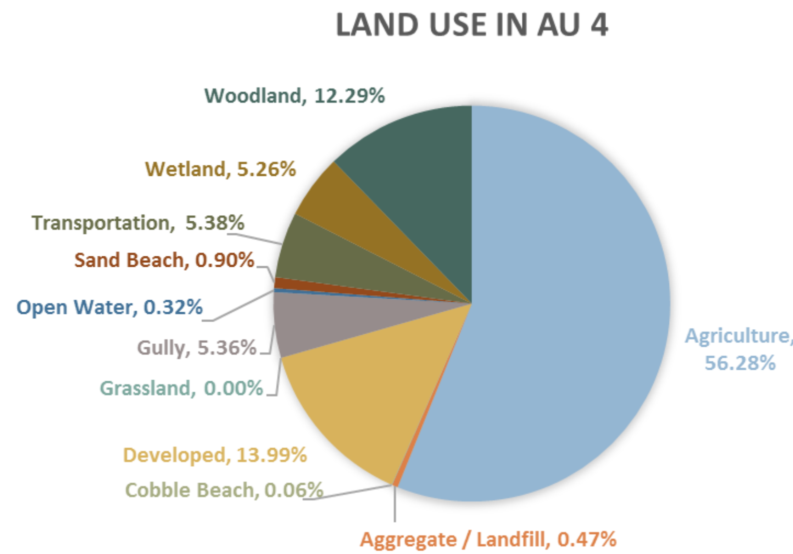
Total km	*Sand beach & Dunes*	*Mixed Sediment Beach*	*Cobble Beach*	*Hardened Shoreline*	*Wetland*	*River Mouth*
39.76	13.92	20.39	2.2	2.3	0.96	2
% coverage:	35%	51.3%	5.5%	5.78%	2.4%	n/a



MAP 1: Shoreline Types in AU 4

LAND-USE COMPOSITION IN ASSESSMENT UNIT 4

Total Hectares	8,681.95	(% of AU)
Agriculture	4,885.95	56.28%
Aggregate / Landfill	40.41	0.47%
Cobble Beach	4.97	0.06%
Developed	1,214.40	13.99%
Grassland	0.09	0.001%
Gully	466.04	5.36%
Nearshore	2,749.79	n/a
Open Water	28.04	0.32%
Sand Beach	78.11	0.90%
Transportation	467.47	5.38%
Wetland	456.81	5.26%
Woodland	1,066.94	12.29%



MAP 2: Land-Use Types in AU 4

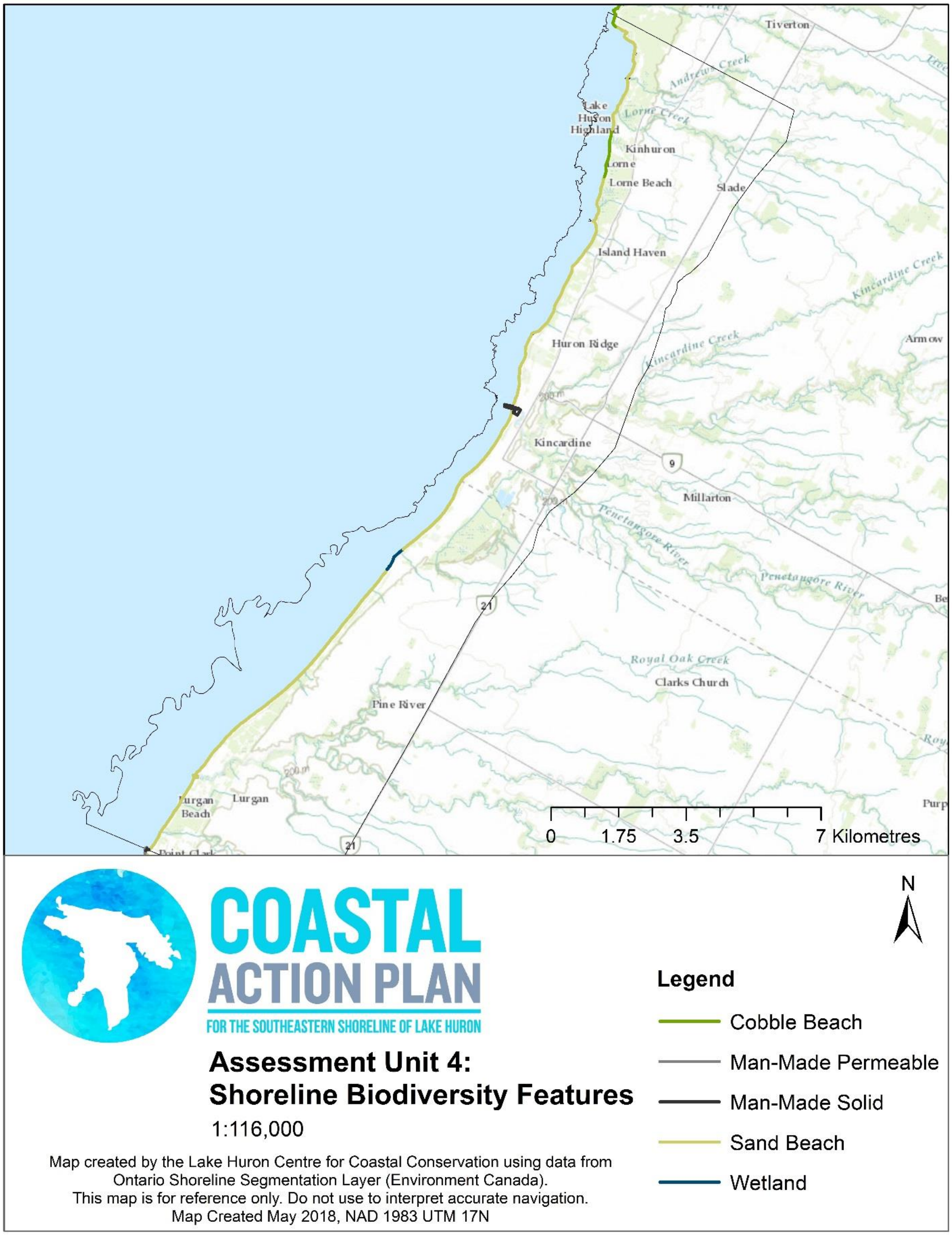
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20%	**20-40%**	40-70%	>70%
	Naturally vegetated bluff buffers (%)	<20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	**0**	1	2-5	>5kj
*** Current developed area in AU 1 is 19.4%, with 56.28% as agriculture, leaving 24.4% natural land cover.* *** Amount of naturally vegetated bluff buffers is unknown. 22 gullies exist.* *** Woodland cover is 12.29% in AU4's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	**2.1 – 4**	4.1 – 6	>6
*** approx. 10 hardened structures in water or parallel hardening structures. 13.3km of shoreline is hardened (16%).* *** 1 structure every 3,980-metres.*					
Presence of Roughage	Sand beach grooming	**Groom 2+x times / week**	**Groom 1x / week**	Groom 1x / month	No Grooming
*** Municipality of Huron Kinloss grooms beaches 2x/week from June-August with a $25,000 annual budget.* *** Municipality of Kincardine groom once per month approximately, at the beginning of the season and before long weekends.*					
Presence of Wildlife	Invasive Species	At least 8 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	5.38%, 467.47 ha			
*** Coastal corridor is 19.37% developed, including transportation.*					

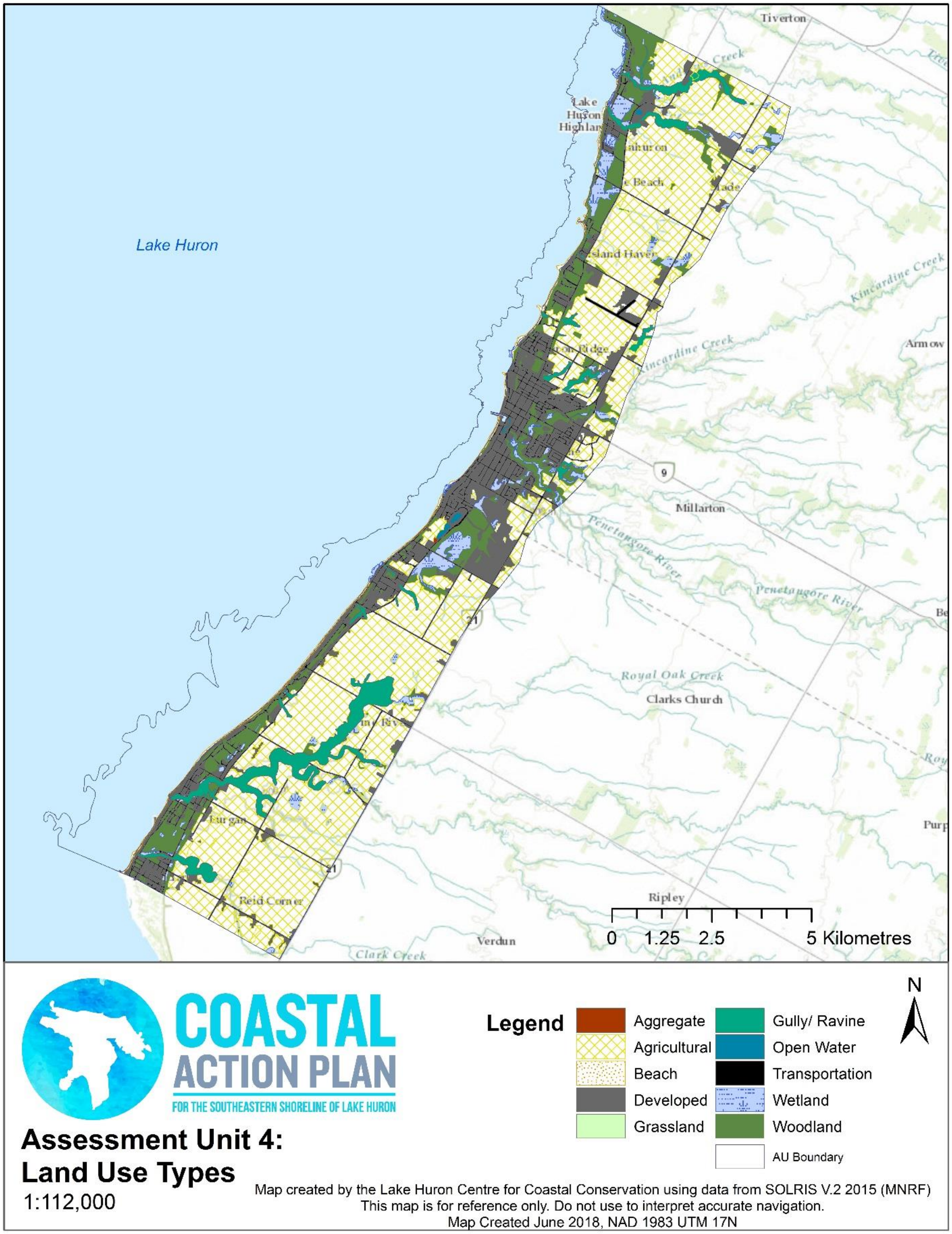
KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Presence of Invasive species	Restoration of shoreline through structure/hazard removal.
Lack of naturalized ecosystems along shoreline	Need beach and dune restoration
Invasive species	Increase invasive species awareness program and treatment programs.
Development and Land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.

MAP 5 - Shoreline Types in AU 4



MAP 6 – Land-Use Types in AU 4



ASSESSMENT UNIT 5: INVERHURON TO MACGREGOR POINT

The Inverhuron to MacGregor Point Assessment Unit 5 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 5 (AU5) has 53.31 km of shoreline, the coastal corridor covering 10,865.82 hectares of diverse habitat.

DEFINING FEATURES

Provincially Significant Wetland - Baie Du Dore

MacGregor Point Provincial Park, Brucedale Conservation Area

Bruce Power Nuclear Generating Station

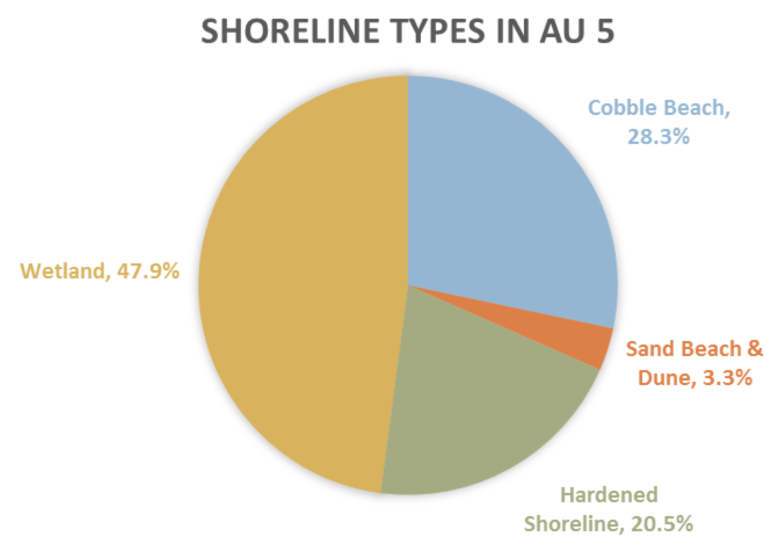
Dominated by coastal wetlands and forests

Very little coastal development, mainly seasonal usage

SHORELINE COMPOSITION IN ASSESSMENT UNIT 5

Total km	*Sand beach & Dunes*	*Cobble Beach*	*Hardened Shoreline*	*Wetland*	*River Mouth*
53.31	1.77	15.07	10.94	25.53	5
% coverage:	3.3%	28.3%	20.52%	47.9%	n/a

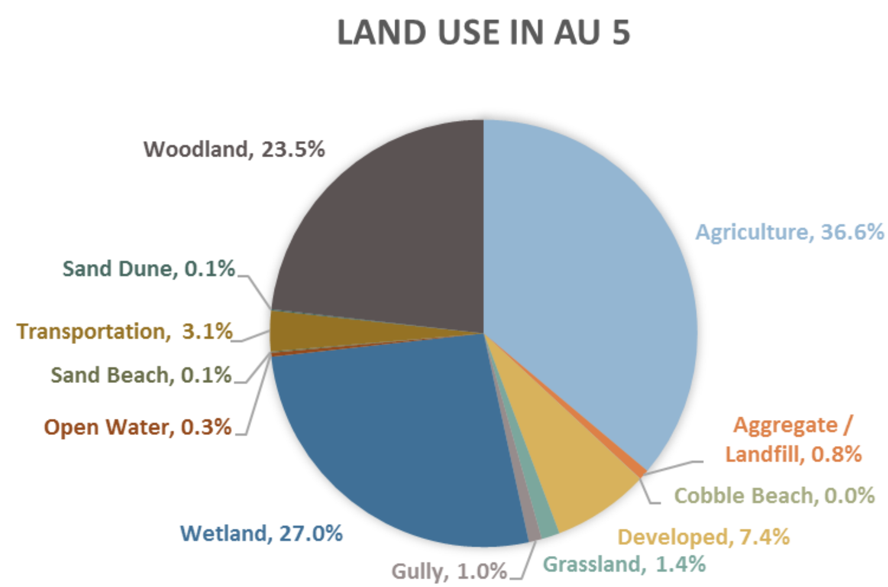
MAP 1: Shoreline Types in AU 5



LAND-USE COMPOSITION IN ASSESSMENT UNIT 5

Total Hectares	8,681.95	(% of AU)
Agriculture	3,972.26	36.6%
Aggregate / Landfill	89.10	0.8%
Cobble Beach	2.35	0.02%
Developed	799.48	7.4%
Grassland	154.59	1.4%
Gully	113.27	1.0%
Nearshore	2,000.84	n/a
Open Water	30.77	0.3%
Sand Beach	12.36	0.1%
Sand Dune	9.89	0.1%
Transportation	338.41	3.1%
Wetland	2,938.45	27.0%
Woodland	2,556.43	23.5%

MAP 2: Land-Use Types in AU 5



ECOSYSTEM HEALTH ANALYSIS

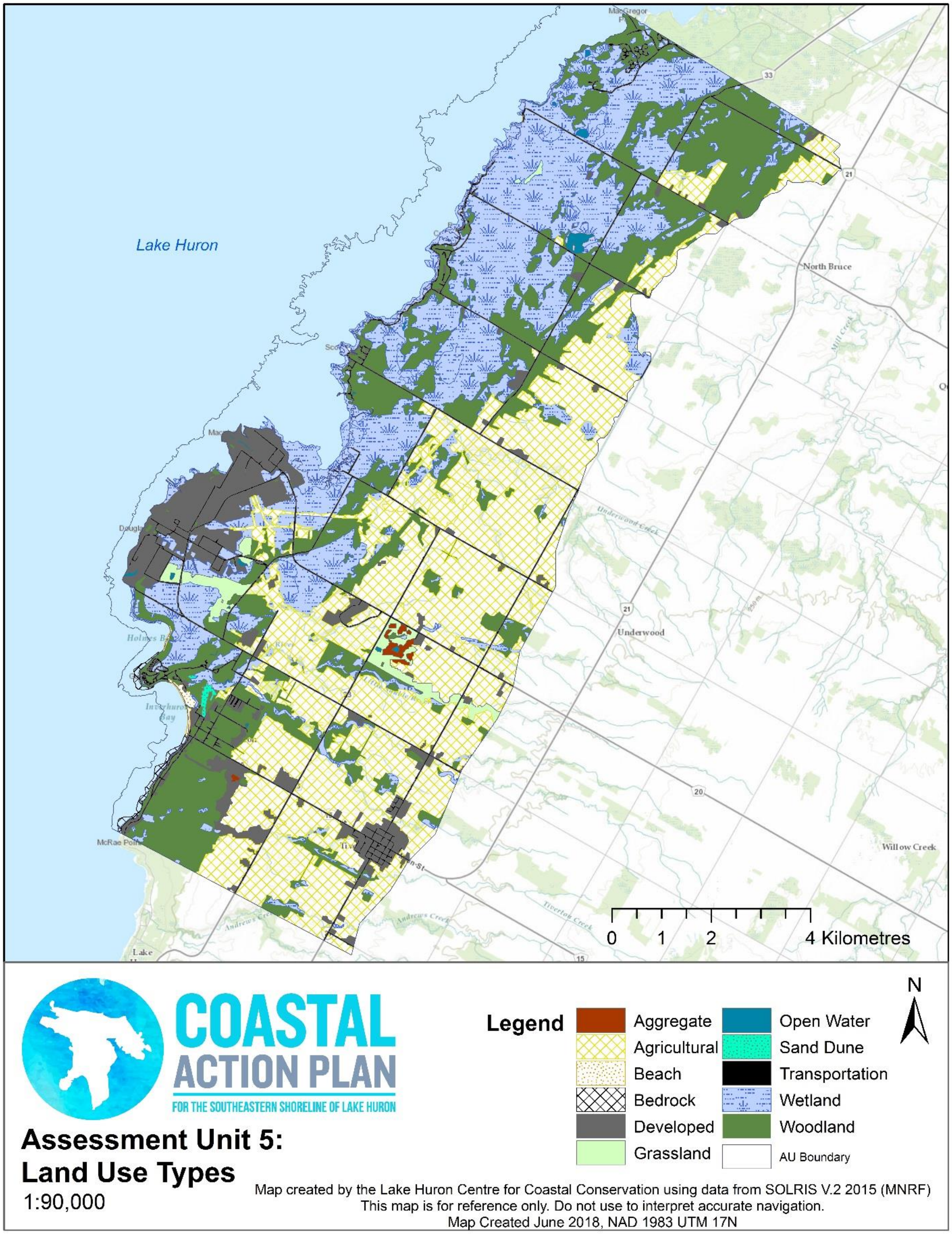
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	**40-70%**	>70%
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	**<29%**	30-39%	40-49%	>50%
	Number of large forest patches (+200ha)	0	**1**	2-5	>5
*** Current developed area in AU 5 is 10.47%, with 36.56% agriculture, leaving 52.97% natural land cover.* *** Amount of naturally vegetated bluff buffers is unknown. 3 gullies exist.* *** Woodland cover is 23.53% in AU 5's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	0 to <2	**2.1 – 4**	4.1 – 6	>6
*** approx. 10 hardened structures in water or parallel hardening structures. 10.94km of shoreline is hardened (20.52%).* *** 1 structure every 3,330-metres.*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	**Groom 1x / month**	No Grooming
*** Municipality of Saugeen Shores grooms by hand once/week (5 ppl), with Barbar surf rake usage 4x/yr. before long weekends, a blitz in the spring, and removal of detritus.*					
Presence of Wildlife	Invasive Species	At least 2 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	3.11%, 338.41 ha			
*** Coastal corridor is 10.47% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Density of shoreline hardening structures	Restoration of shoreline through structure/hazard removal.
Lack of forest cover	Tree planting and reinstating windbreaks.
Presence of invasive species	Increase invasive species awareness program and treatment programs.
Development and Land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.

MAP 7 - Shoreline Types in AU 5

MAP 8 – Land-Use Types in AU 5



ASSESSMENT UNIT 6: MACGREGOR POINT TO OLIPHANT

The MacGregor Point to Oliphant Assessment Unit 6 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 6 (AU6) has 82.91km of shoreline, the coastal corridor covering 11,931.26 hectares of diverse habitat.

DEFINING FEATURES

Chief's Point First Nations Reserve No.28, Saugeen First Nation Reserve No.29

Sauble Falls Provincial Park

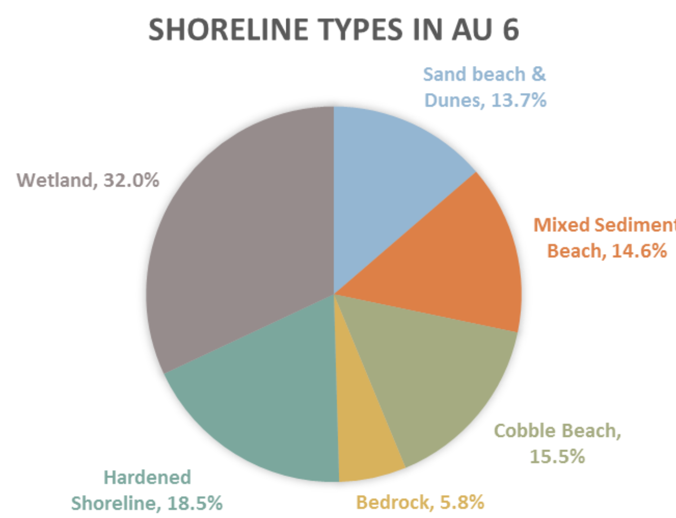
Chantry Island Bird Sanctuary

Agricultural productivity

Communities of Port Elgin, Southampton, Sauble Beach

SHORELINE COMPOSITION IN ASSESSMENT UNIT 6

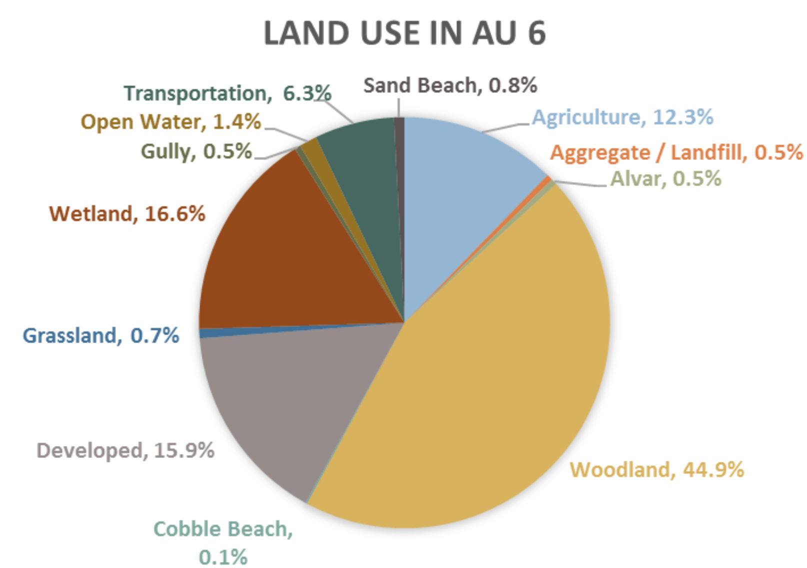
Total km	Sand beach & Dunes	Mixed Sediment Beach	Cobble Beach	Bedrock	Hardened Shoreline	Wetland	River Mouth
82.91	11.37	12.11	12.85	4.79	15.30	26.51	2
% coverage:	13.7%	14.6%	15.5%	5.8%	18.5%	32%	n/a



MAP 1: Shoreline Types in AU 6

LAND-USE COMPOSITION IN ASSESSMENT UNIT 6

Total Hectares	11,931.26	(% of AU)
Agriculture	1,470.09	12.32%
Aggregate / Landfill	58.51	0.49%
Alvar	56.60	0.47%
Cobble Beach	14.99	0.13%
Developed	1,892.30	15.86%
Grassland	88.14	0.74%
Gully	58.67	0.49%
Nearshore	3,738.79	n/a
Open Water	165.25	1.39%
Sand Beach	99.48	0.83%
Sand Dune	0.68	0.005%
Transportation	751.30	6.30%
Wetland	1,978.80	16.59%
Woodland	5,355.12	44.88%



MAP 2: Land-Use Types in AU 6

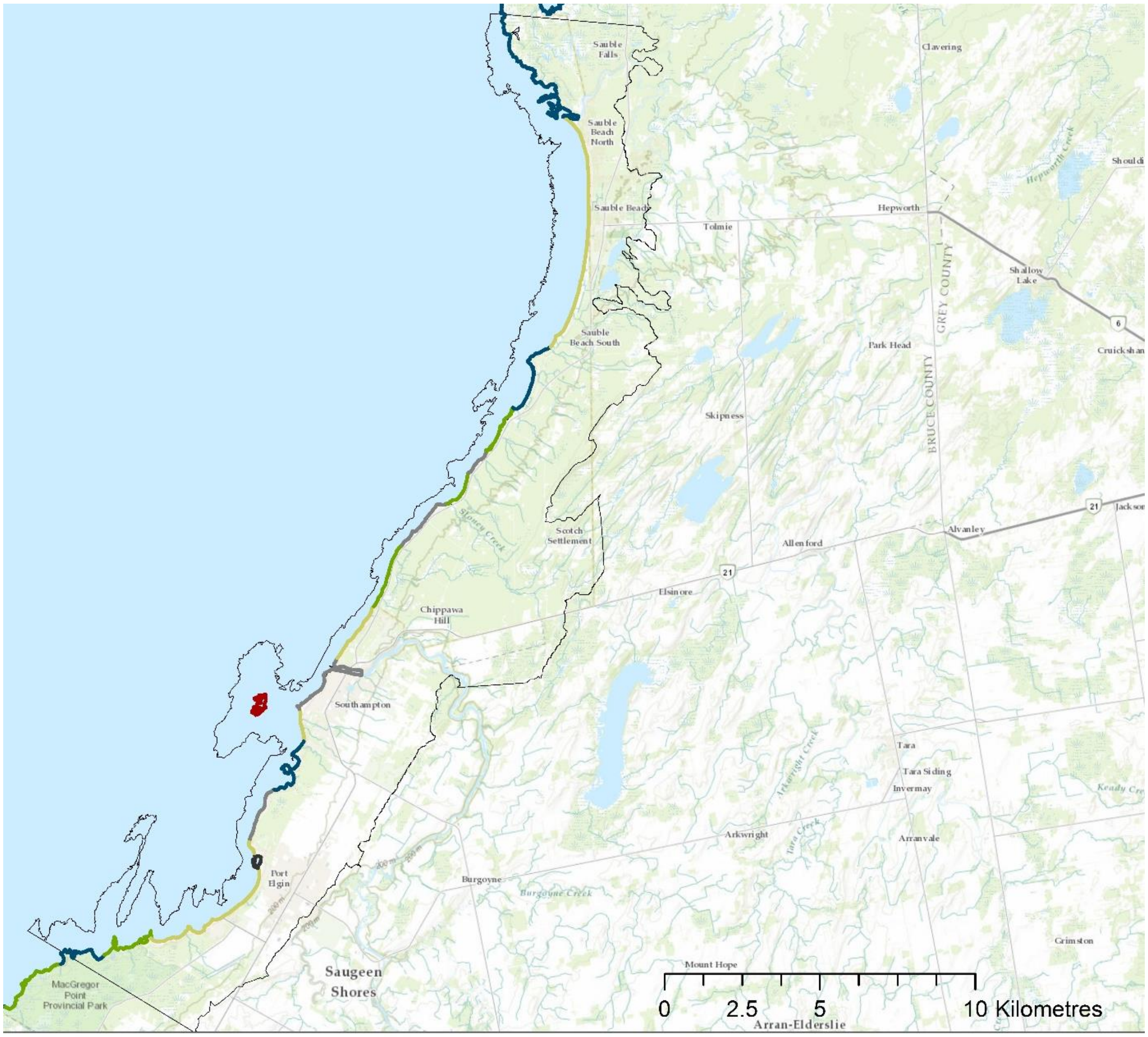
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	**40-70%**	>70%
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	**40-49%**	>50%
	Number of large forest patches (+200ha)	0	**1**	2-5	>5
*** Current developed area in AU 6 is 22.16%, with 12.32% agriculture, leaving 65.52% natural land cover.* *** Amount of naturally vegetated bluff buffers is unknown. Gullies exist.* *** Woodland cover is 44.88% in AU 6's coastal corridor. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 59 hardened structures in water or parallel hardening structures. 15.30 km of shoreline is hardened (18.5%)* *** 1 structure every 1,410-metres.*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	**Groom 1x / month**	No Grooming
*** Town of South Bruce Peninsula groom in early April before the Piping Plovers nest.*					
Presence of Wildlife	Invasive Species	At least 8 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	**20-40**	<20
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	6.30%, 751.30 ha			
*** Coastal corridor is 34.48% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.
Encroachment on wetlands	Ensure protection of wetlands and buffer zones around wetlands.
Light pollution	Adapt infrastructure in urbanized and shoreline communities to be dark sky compliant.
Beach grooming	Re-build dunes and natural shoreline 'structures' such as wrack lines, mature dunes, and shoreline buffers.

MAP 9 - Shoreline Types in AU 6



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 6:
Shoreline Biodiversity Features
1:175,000

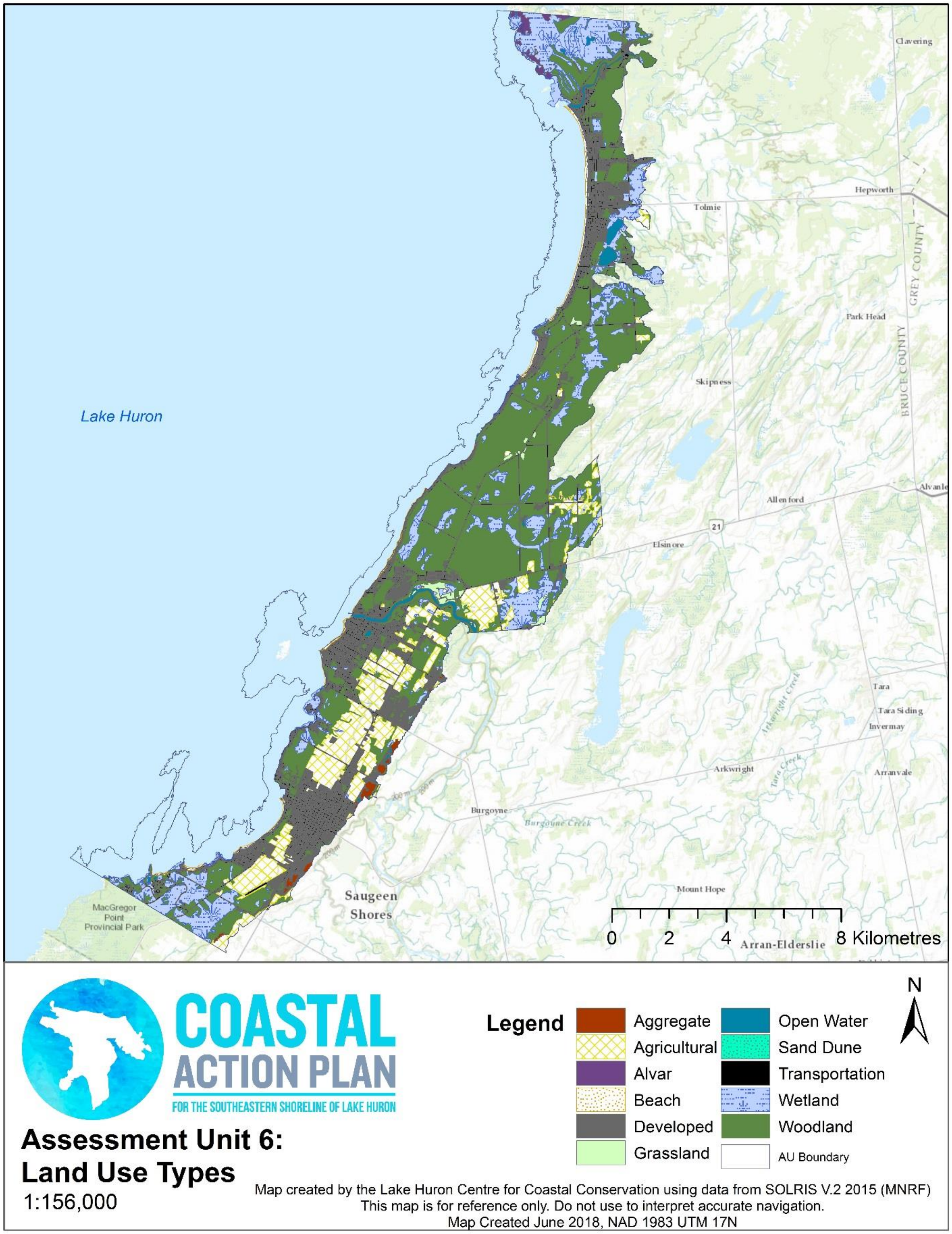
Map created by the Lake Huron Centre for Coastal Conservation using data from Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

N

Legend

- Bedrock / Alvar
- Cobble Beach
- Man-Made Permeable
- Man-Made Solid
- Sand Beach
- Wetland

MAP 10 – Land-Use Types in AU 6



ASSESSMENT UNIT 7: OLIPHANT TO PIKE BAY

The Oliphant to Pike Bay Assessment Unit 7 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 7 (AU7) has 191.43km of shoreline, the coastal corridor covering 8,339.08 hectares of diverse habitat. This AU has the longest shoreline out of all 11 AUs.

DEFINING FEATURES

Coastal wetlands - rare fens

Fishing islands complex

Alvars

Development on islands, with transportation to islands varying from boat to terrestrial vehicles

Great Lakes, St. Lawrence Forest Region dominates landscape

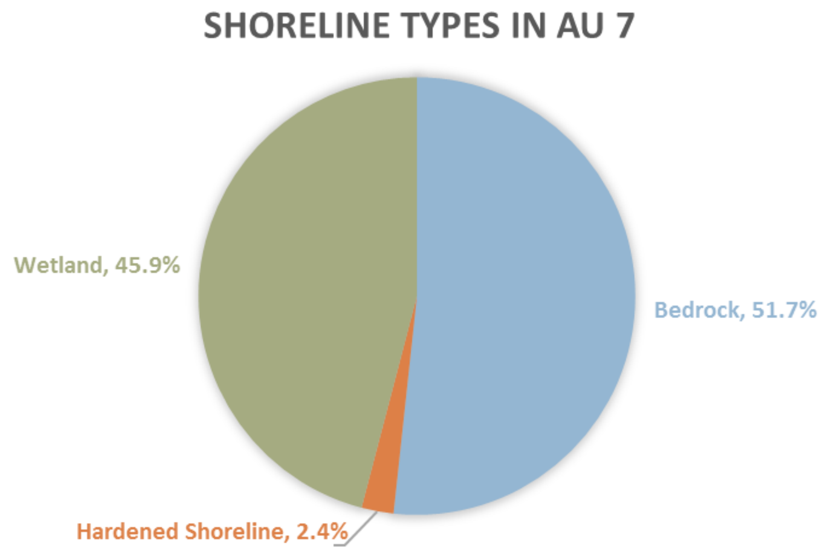
Petrel Point Nature Reserve

Provincially Significant Wetland - Red Bay

SHORELINE COMPOSITION IN ASSESSMENT UNIT 7

Total km	*Bedrock*	*Hardened Shoreline*	*Island*	*Wetland*
191.43	98.97	4.55	87	87.91
% coverage:	51.7%	2.37%	45.45%	45.9%

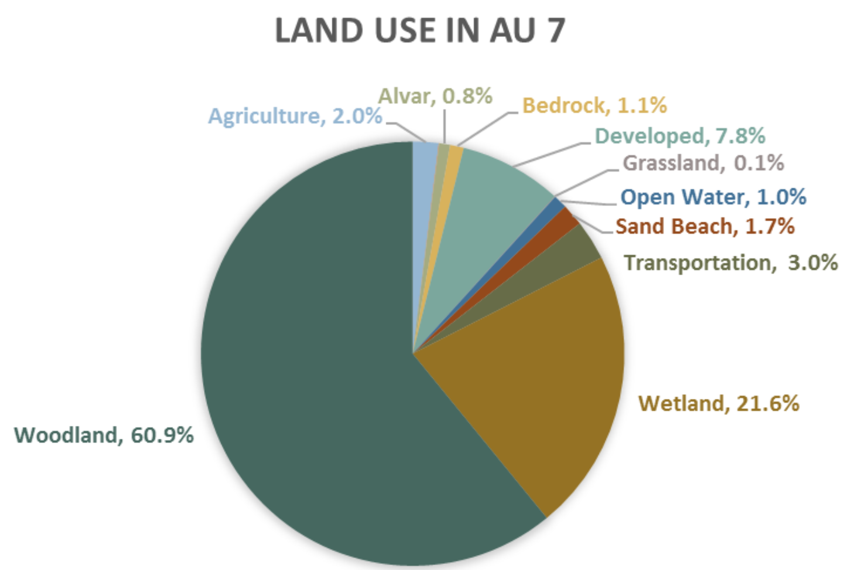
MAP 1: Shoreline Types in AU 7



LAND-USE COMPOSITION IN ASSESSMENT UNIT 7

Total Hectares	8,339.08	(% of AU)
Agriculture	163.27	1.96%
Aggregate / Landfill	3.69	0.04%
Alvar	69.19	0.83%
Bedrock	87.50	1.05%
Developed	652.09	7.82%
Grassland	4.21	0.05%
Nearshore	7,907.65	n/a
Open Water	86.72	1.04%
Sand Beach	140.44	1.68%
Transportation	253.84	3.04%
Wetland	1,798.87	21.57%
Woodland	5,079.24	60.91%

MAP 2: Land-Use Types in AU 7



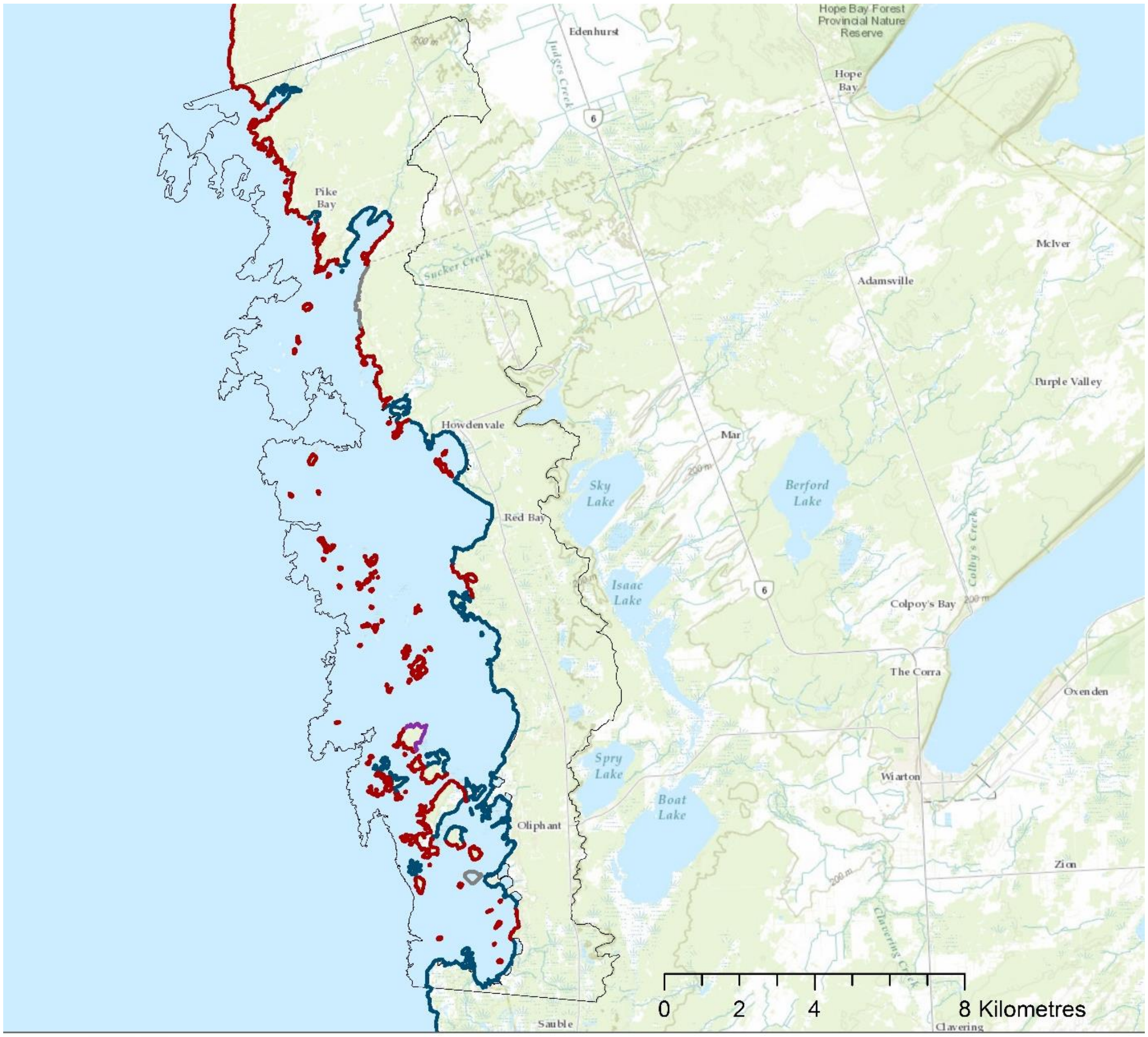
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+200ha)	0	1	**2-5**	>5
*** Current developed area in AU 7 is 10.86%, with 1.96% agriculture, leaving 87.18% natural land cover.* *** Amount of naturally vegetated bluff buffers is unknown. Gullies exist.* *** Woodland cover is 60.91% in AU 7's coastal corridor with 2, 200+ ha. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 155 hardened structures in water or parallel hardening structures. 4.55 km of shoreline is hardened (2.4%).* *** 1 structure every 1,240-metres.*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	**Groom 1x / month**	No Grooming
*** Town of South Bruce Peninsula groom in early April before the Piping Plovers nest.*					
Presence of Wildlife	Invasive Species	At least 8 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	3.04%, 253.84 ha			
*** Coastal corridor is 10.86% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms. Reduce impacts from development on islands, including more solutions to transportation to cottages on islands during times of low lake levels.
Encroachment on wetlands	Ensure protection of wetlands and buffer zones around wetlands.
Presence of invasive species	Increase invasive species awareness program and treatment programs.

MAP 11 - Shoreline Types in AU 7



FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

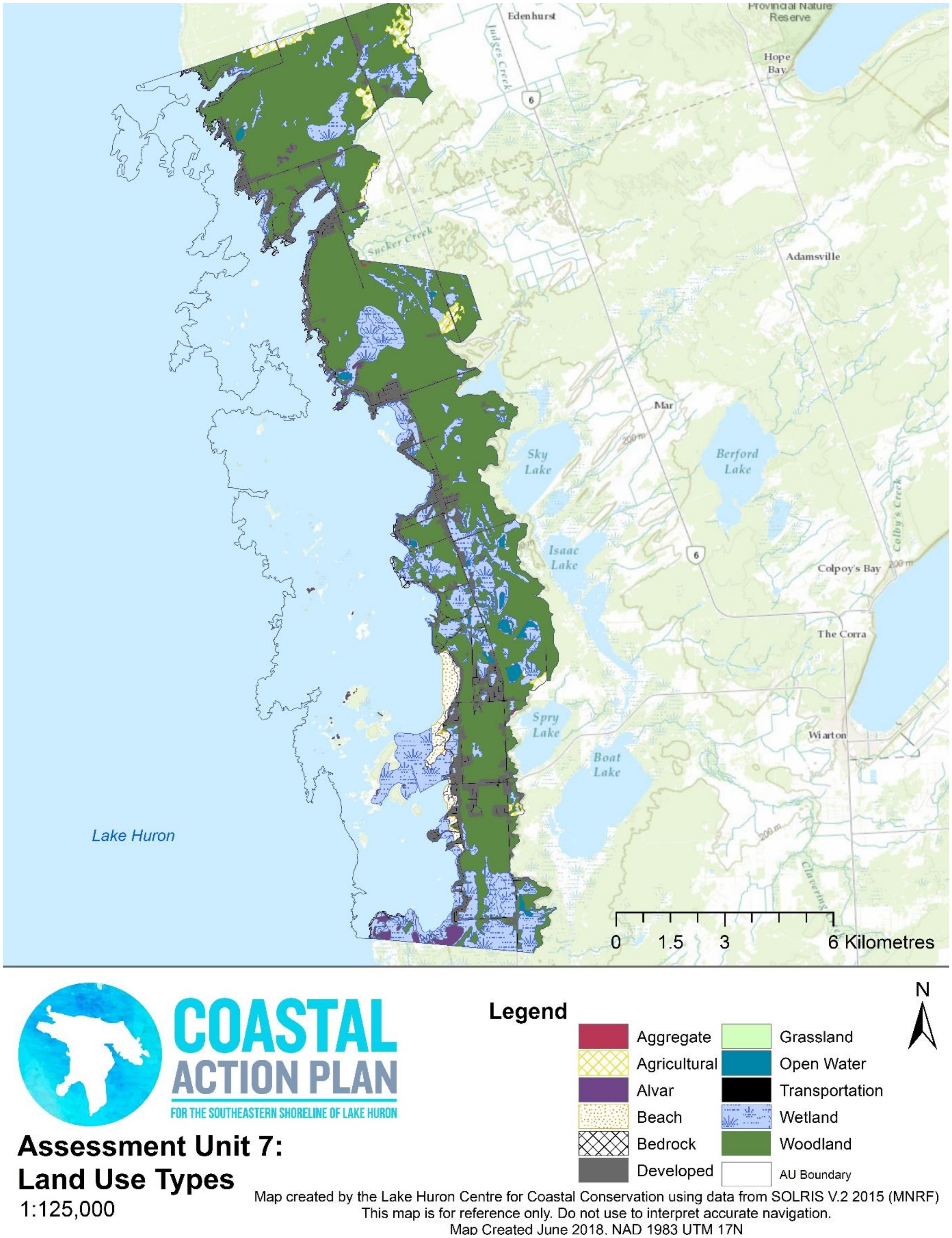
Assessment Unit 7:
Shoreline Biodiversity Features
1:145,000

N

Legend
- Bluff
- Bedrock / Alvar
- Man-Made Permeable
- Man-Made Solid
- Wetland

Map created by the Lake Huron Centre for Coastal Conservation using data from
Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

MAP 12 – Land-Use Types in AU 7



ASSESSMENT UNIT 8: STOKES BAY

The Stokes Bay Assessment Unit 8 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 8 (AU8) has 84.61km of shoreline, the coastal corridor covering 5,567.19 hectares of diverse habitat.

DEFINING FEATURES

Shoreline heavily developed with seasonal cottages and in-water structures

Landscape dominated by coastal wetlands (swamps) and coastal woodlands

Island complexes, with heavy development and some roads onto islands

Rivers (Old woman river)

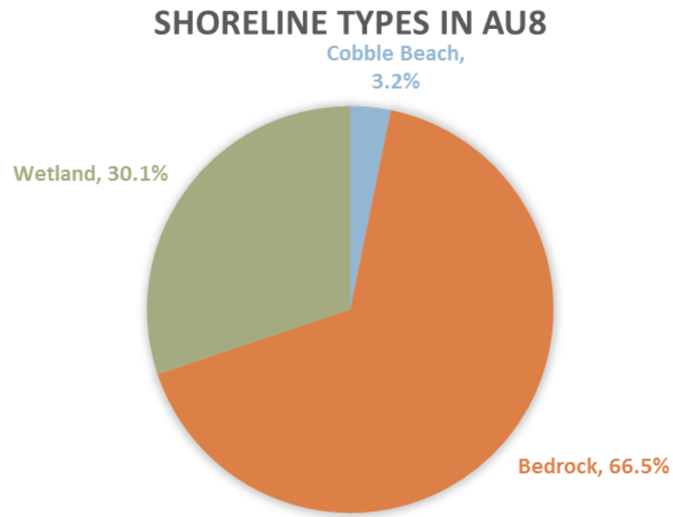
Steep Bathymetry

Provincially Significant Wetlands – Stokes Bay, Howdenvale Bay

SHORELINE COMPOSITION IN ASSESSMENT UNIT 8

Total km	*Cobble Beach*	*Bedrock*	*Island*	*Wetland*	*River Mouth*
84.6	2.7	56.3	24.7	25.5	2
% coverage:	3.2%	66.5%	29.2%	30.1%	n/a

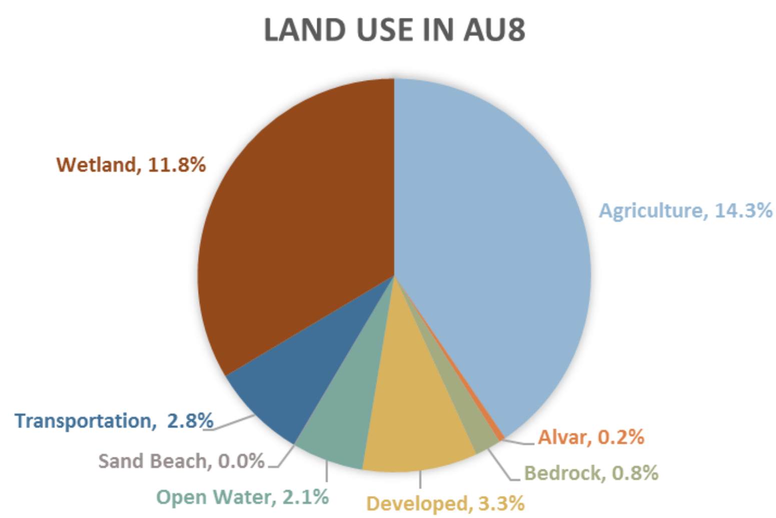
MAP 1: Shoreline Types in AU 8



LAND-USE COMPOSITION IN ASSESSMENT UNIT 8

Total Hectares	5,567.19	(% of AU)
Agriculture	794.48	14.27%
Alvar	10.66	0.19%
Bedrock	42.31	0.76%
Developed	185.64	3.33%
Nearshore	3,660.81	n/a
Open Water	115.36	2.07%
Sand Beach	1.09	0.02%
Transportation	155.22	2.79%
Wetland	658.80	11.83%
Woodland	3,603.64	64.73%

MAP 2: Land-Use Types in AU 8



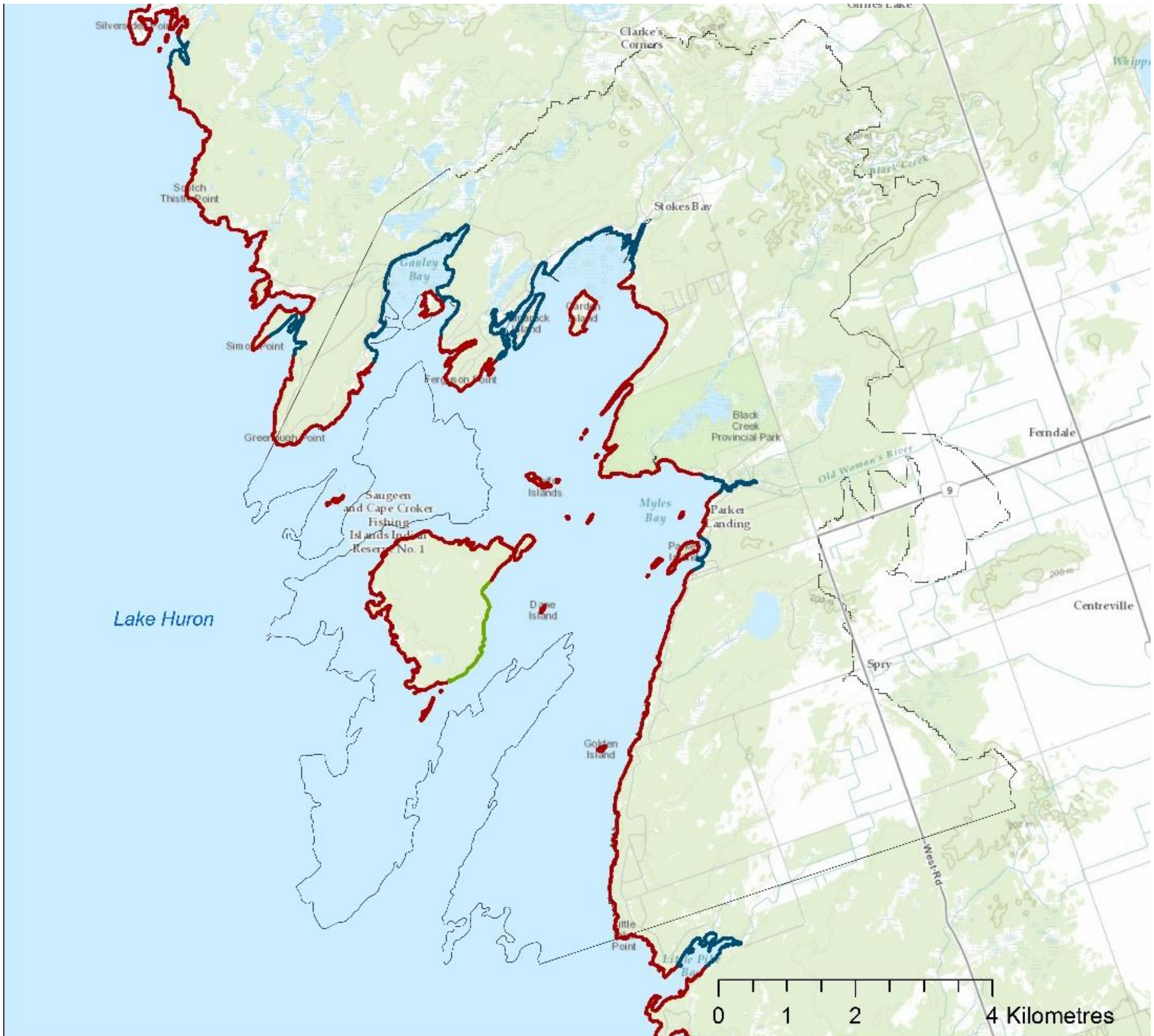
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+200ha)	0	1	**2-5**	>5
*** Current developed area in AU 8 is 6.12%, with 14.27% agriculture, leaving 79.61% natural land cover.* *** Woodland cover is 64.73% in AU 8's coastal corridor with 5, 200+ ha. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	**0 to <2**	2.1 – 4	4.1 – 6	>6
*** approx. 52 hardened structures in water or parallel hardening structures. 0 km of shoreline is hardened (0%).* *** 1 structure every 1,630-metres.*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	**Groom 1x / week**	Groom 1x / month	No Grooming
*** Municipality of Northern Bruce Peninsula tractor groom bi-weekly, hand groom a few times a week.*					
Presence of Wildlife	Invasive Species	At least 5 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	3.04%, 155.22 ha			
*** Coastal corridor is 6.12% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Density of shoreline hardening structures	Restoration of shoreline through structure/hazard removal.
Presence of invasive species	Increase invasive species awareness program and treatment programs.
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.
Light pollution	Adapt infrastructure in urbanized and shoreline communities to be dark sky compliant.
Point and NPS pollution	Regulate or provide incentives to ensure septic systems have the proper inspection and replacement schedule to limit nutrient inputs.

MAP 13 - Shoreline Types in AU 8



COASTAL ACTION PLAN

FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 8: Shoreline Biodiversity Features

1:80,000

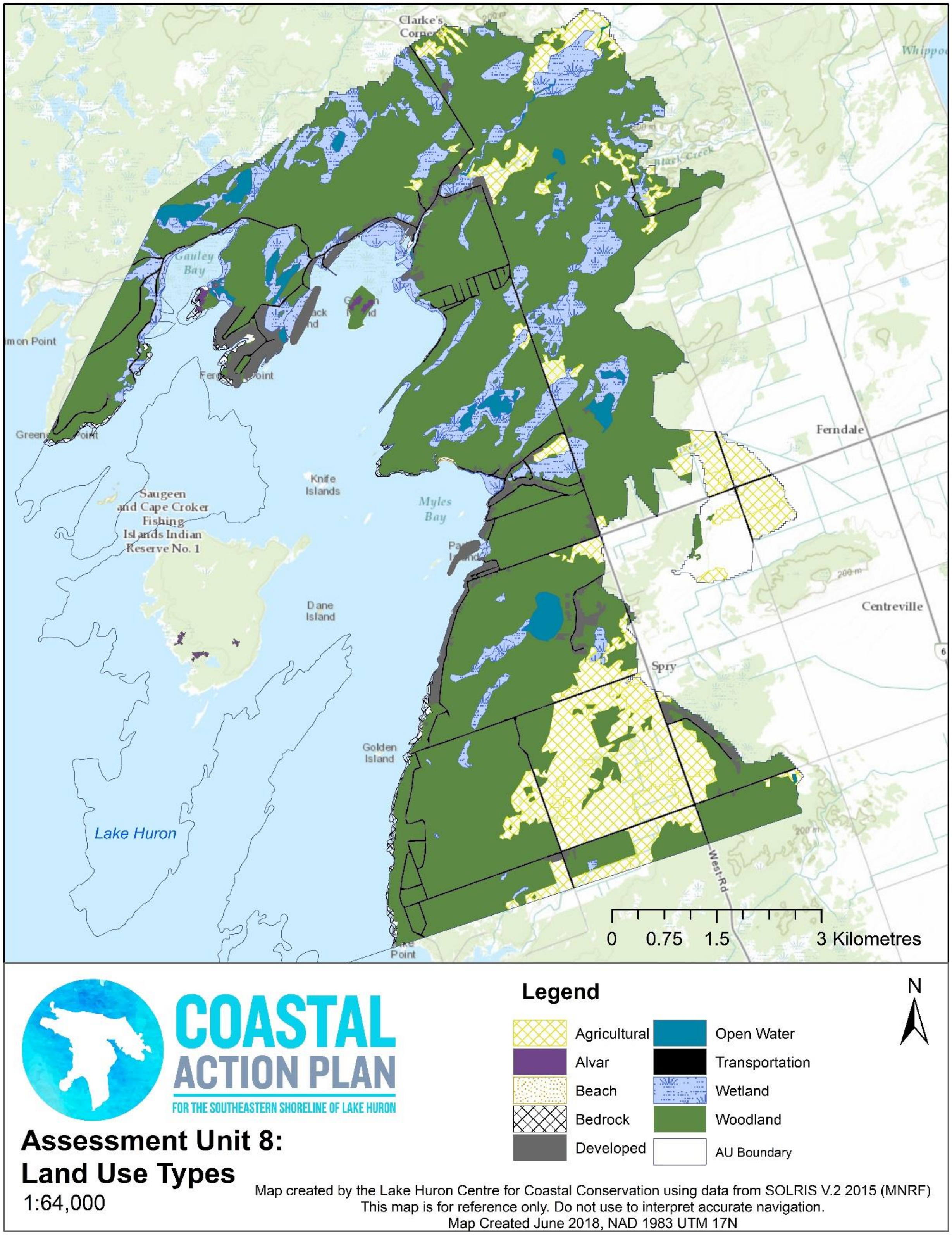
Legend

- Bedrock / Alvar
- Man-Made Permeable
- Man-Made Solid
- Wetland
- Cobble Beach

N

Map created by the Lake Huron Centre for Coastal Conservation using data from Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

MAP 14 – Land-Use Types in AU 8



ASSESSMENT UNIT 9: STOKES BAY TO DORCAS BAY

The Stokes Bay to Dorcas Bay Assessment Unit 9 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 9 (AU9) has 126.36 km of shoreline, the coastal corridor covering 10,108.32 hectares of diverse habitat.

DEFINING FEATURES

Highly occupied shoreline by seasonal residents.

Bruce Peninsula National Park - Singing Sands (Dorcas Bay),

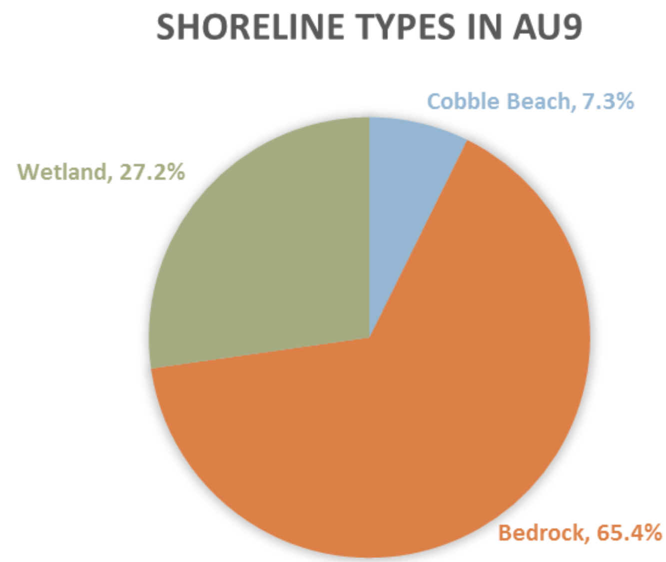
Provincially Significant Wetland - Johnsons Harbour and Scugog Lake

Steep Bathymetry

Landscape dominated by coastal wetlands (swamps) and coastal woodlands

SHORELINE COMPOSITION IN ASSESSMENT UNIT 9

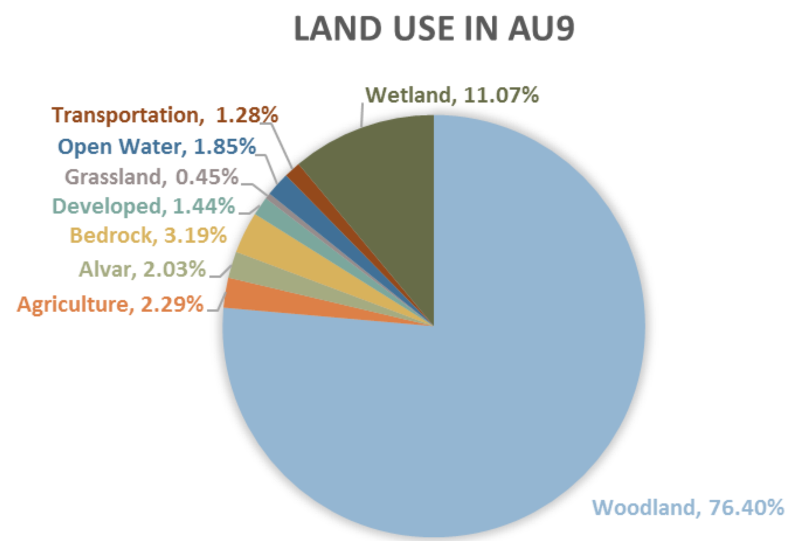
Total km	*Cobble Beach*	*Bedrock*	*Island*	*Wetland*	*River Mouth*
126.36	9.25	82.70	5.24	34.42	2
% coverage:	7.3%	65.4%	4.1%	27.23%	n/a



MAP 1: Shoreline Types in AU 9

LAND-USE COMPOSITION IN ASSESSMENT UNIT 9

Total Hectares	10,108.32	(% of AU)
Agriculture	231.37	2.29%
Alvar	205.30	2.03%
Bedrock	322.16	3.19%
Developed	145.37	1.44%
Grassland	45.69	0.45%
Nearshore	2,606.24	n/a
Open Water	186.90	1.85%
Transportation	129.46	1.28%
Wetland	1,119.07	11.07%
Woodland	7,723.00	76.40%



MAP 2: Land-Use Types in AU 9

ECOSYSTEM HEALTH ANALYSIS

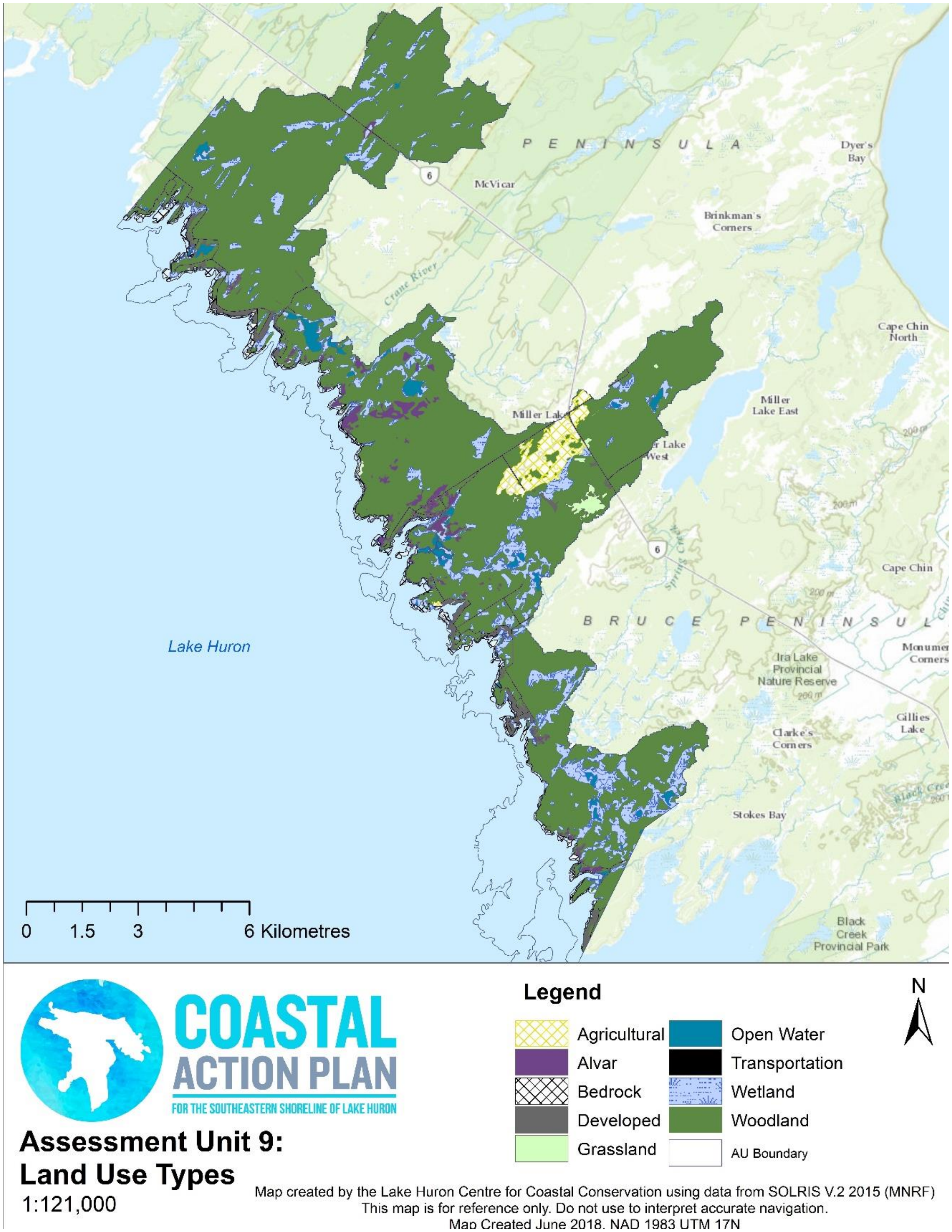
Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+200ha)	0	1	**2-5**	>5
** Current developed area in AU 9 is 2.7%, with 2.3% agriculture, leaving 95% natural land cover. ** Woodland cover is 76.4% in AU 9's coastal corridor with 8, 200+ ha patches. (HMHIE Guidelines)					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	0 to <2	2.1 – 4	4.1 – 6	**>6**
** approx. 13 hardened structures in water or parallel hardening structures. 0 km of shoreline is hardened (0%). ** 1 structure every 9,720-metres.					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	No Grooming
** No data available for beach grooming in AU 9.					
Presence of Wildlife	Invasive Species	At least 7 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	1.28%, 129.46 ha			
** Coastal corridor is 2.72% developed, including transportation.					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Development and land-use change	Protect alvar areas with appropriate development restriction buffers and protection efforts.
Light pollution	Adapt infrastructure in shoreline communities to be dark sky compliant.
Point and NPS pollution	Regulate or provide incentives to ensure septic systems have the proper inspection and replacement schedule to limit nutrient inputs.

MAP 15 - Shoreline Types in AU 9

MAP 16 – Land-Use Types in AU 9



ASSESSMENT UNIT 10: DORCAS BAY TO CAPE HURD

The Dorcas Bay to Cape Hurd Assessment Unit 10 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 10 (AU10) has 75.79 km of shoreline, the coastal corridor covering 4,416.38 hectares of diverse habitat.

DEFINING FEATURES

Steep Bathymetry

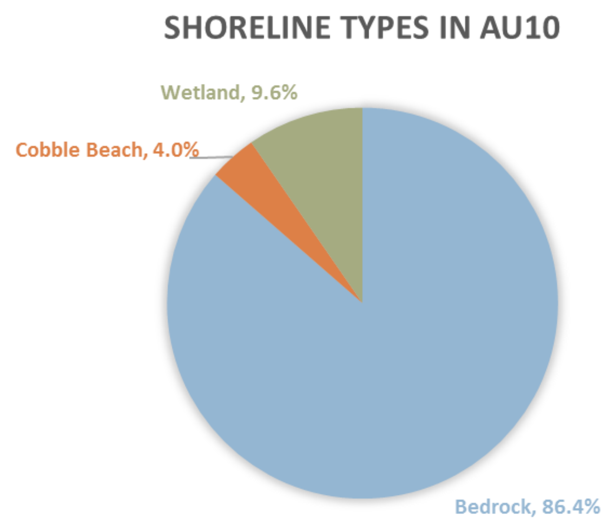
Bedrock shoreline

Heavy development by cottage communities

Coastal woodlands dominate landscape

SHORELINE COMPOSITION IN ASSESSMENT UNIT 10

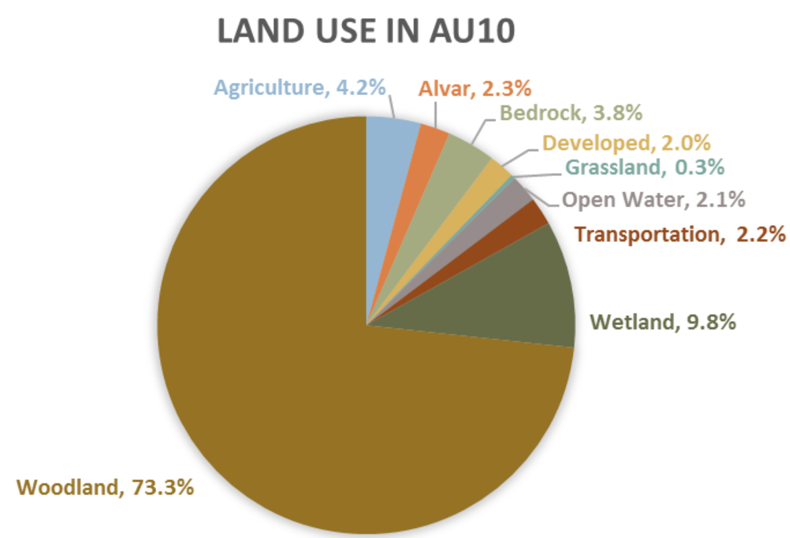
Total km	Cobble Beach	Bedrock	Island	Wetland
75.8	3.0	65.5	1.3	7.3
% coverage:	3.95%	86.4%	1.7%	9.63%



MAP 1: Shoreline Types in AU 10

LAND-USE COMPOSITION IN ASSESSMENT UNIT 10

Total Hectares	4,417.38	(% of AU)
Agriculture	185.94	4.21%
Alvar	101.71	2.3%
Bedrock	165.61	3.75%
Developed	87.44	1.98%
Grassland	14.44	0.33%
Nearshore	1,351.14	n/a
Open Water	93.19	2.11%
Sand Beach	1.32	0.03%
Transportation	95.81	2.17%
Wetland	434.52	9.84%
Woodland	3,237.13	73.28%



MAP 2: Land-Use Types in AU 10

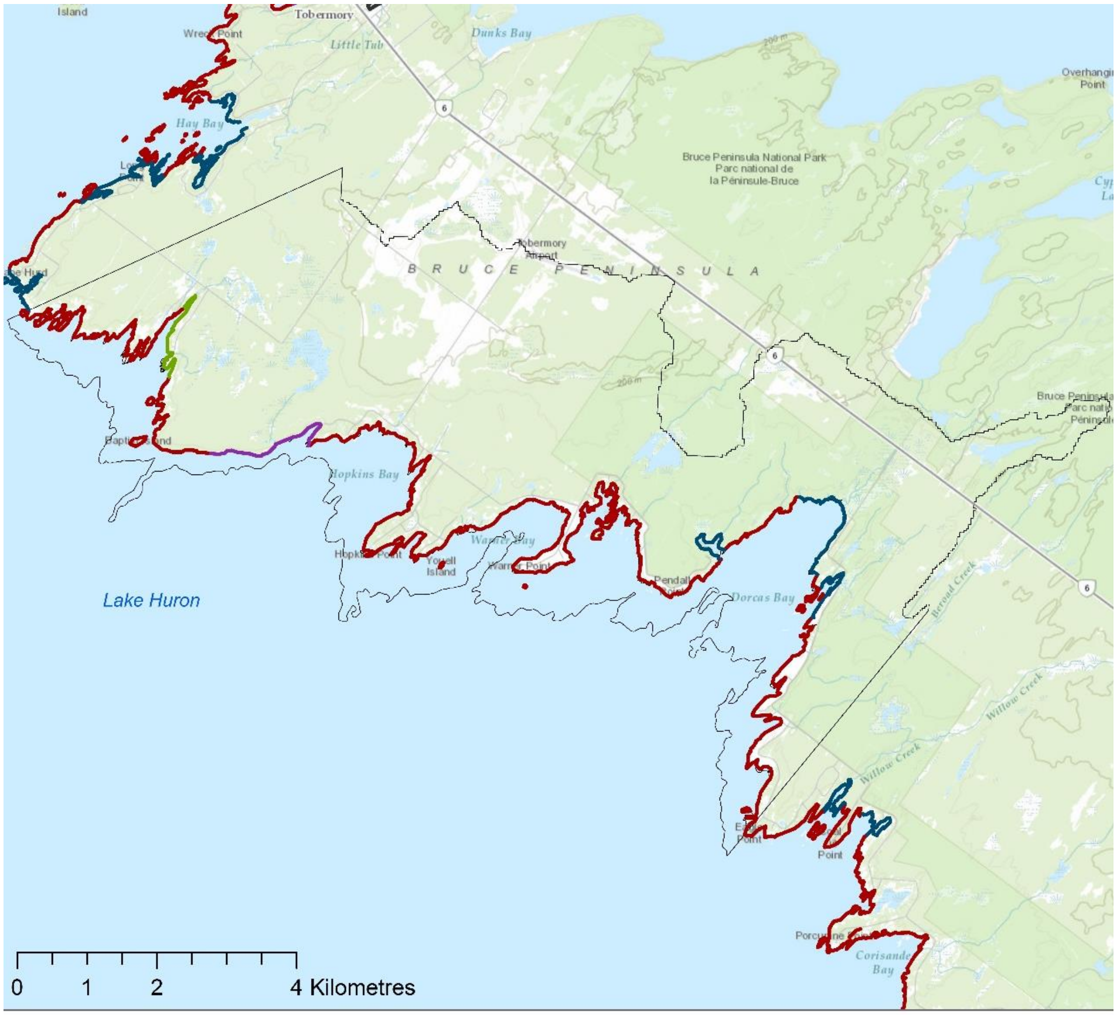
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+200ha)	0	1	**2-5**	>5
*** Current developed area in AU 10 is 2.7%, with 2.3% agriculture, leaving 95% natural land cover.* *** Woodland cover is 76.4% in AU 10's coastal corridor with 8, 200+ ha patches. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	0 to <2	2.1 – 4	4.1 – 6	>6
*** approx. no detected hardened structures in water or parallel hardening structures. 0 km of shoreline is hardened (0%)*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	No Grooming
*** No data available for beach grooming in AU 10.*					
Presence of Wildlife	Invasive Species	At least 7 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	1.28%, *129.46 ha*			
*** Coastal corridor is 2.72% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Point and NPS pollution	Regulate or provide incentives to ensure septic systems have the proper inspection and replacement schedule to limit nutrient inputs.
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms. Protect alvar areas with appropriate development restriction buffers and protection efforts
Light pollution	Adapt infrastructure in urbanized and shoreline communities to be dark sky compliant.

MAP 17 - Shoreline Types in AU 10



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

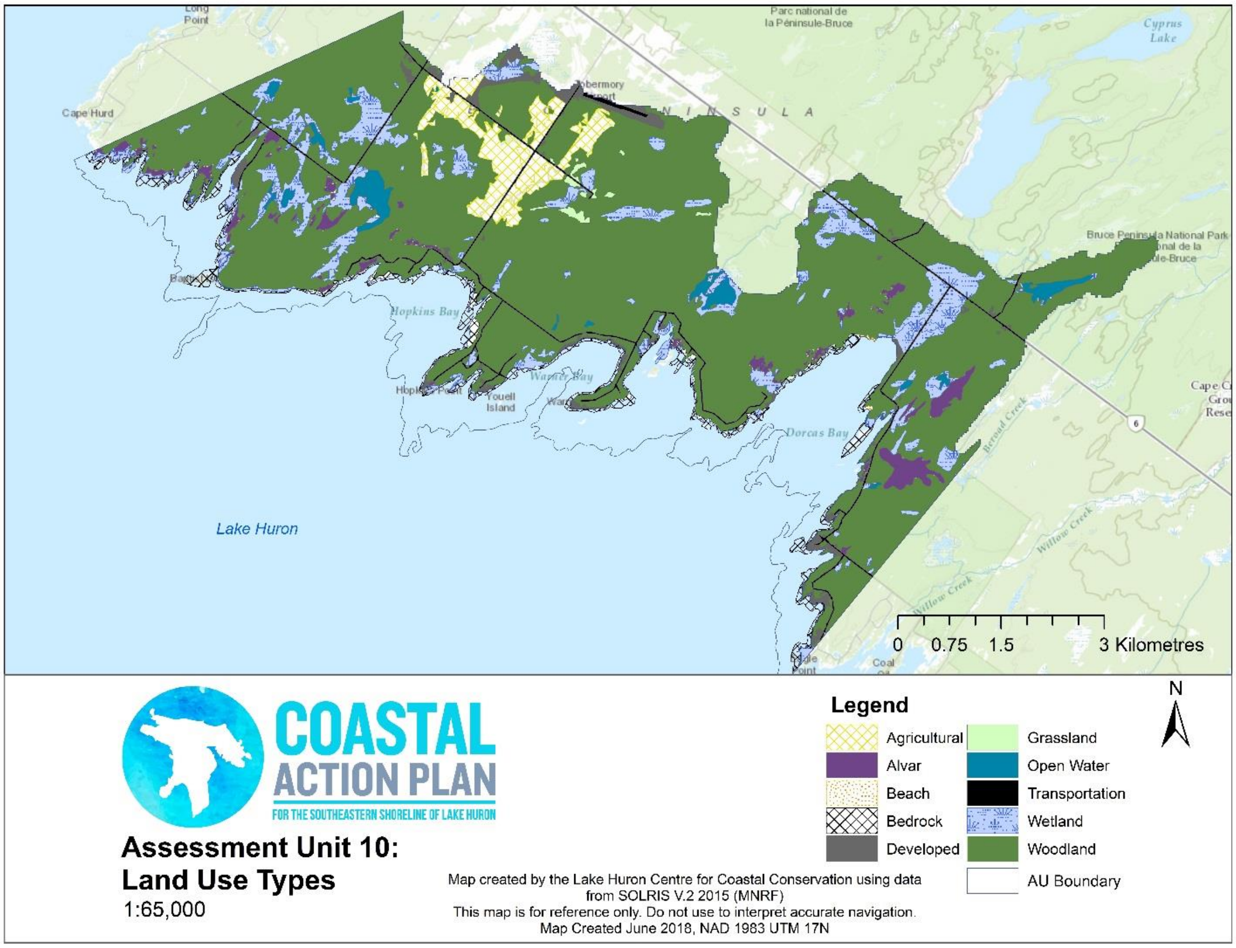
Assessment Unit 10:
Shoreline Biodiversity Features
1:76,000

Map created by the Lake Huron Centre for Coastal Conservation using data from Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

N

Legend
- Bedrock / Alvar
- Man-Made Permeable
- Man-Made Solid
- Wetland
- Cobble Beach
- Bluff

MAP 18 – Land-Use Types in AU 10



ASSESSMENT UNIT 11: CAPE HURD TO TOBERMORY

The Cape Hurd to Tobermory Assessment Unit 11 is one of eleven littoral cells spanning from Sarnia to Tobermory on the southeastern shores of Lake Huron. Assessment Unit 11 (AU11) has 45.14 km of shoreline, the coastal corridor covering 4,416.38 hectares of diverse habitat.

DEFINING FEATURES

Steep Bathymetry

Bedrock shoreline

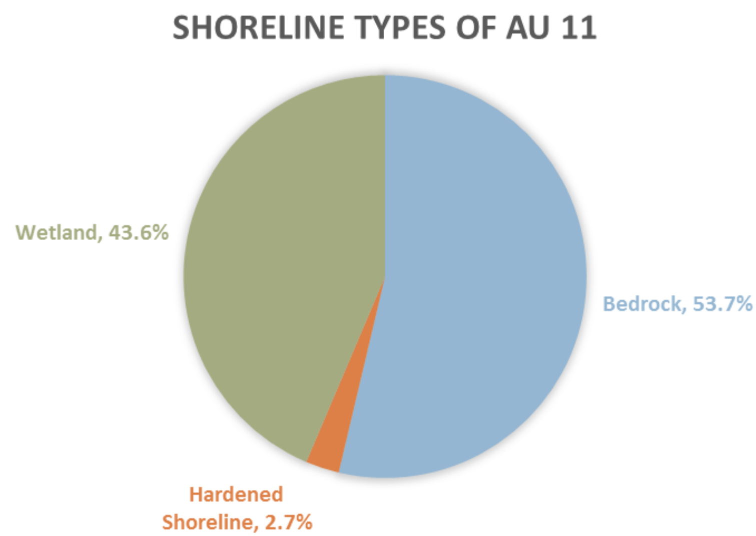
Heavy development by cottage communities

Coastal woodlands dominate landscape

SHORELINE COMPOSITION IN ASSESSMENT UNIT 11

Total km	*Bedrock*	*Hardened Shoreline*	*Island*	*Wetland*
45.14	24.25	1.21	3.41	19.68
% coverage:	53.7%	2.7%	7.6%	43.6%

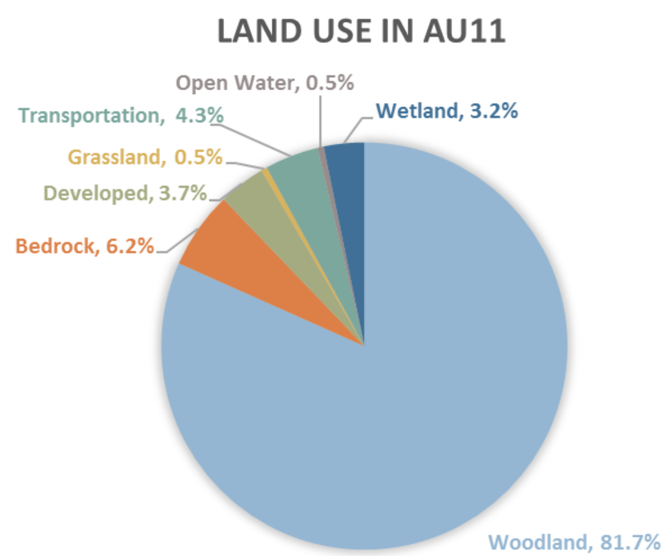
MAP 1: Shoreline Types in AU 11



LAND-USE COMPOSITION IN ASSESSMENT UNIT 11

Total Hectares	1,107.56	(% of AU)
Agriculture	0.01	0.0
Alvar	0.09	0.01%
Bedrock	68.11	6.15%
Developed	41.37	3.74%
Grassland	5.21	0.47%
Nearshore	358.23	n/a
Open Water	5.59	0.50%
Transportation	47.28	4.27%
Wetland	35.56	3.21%
Woodland	904.31	81.65%

MAP 2: Land-Use Types in AU 11



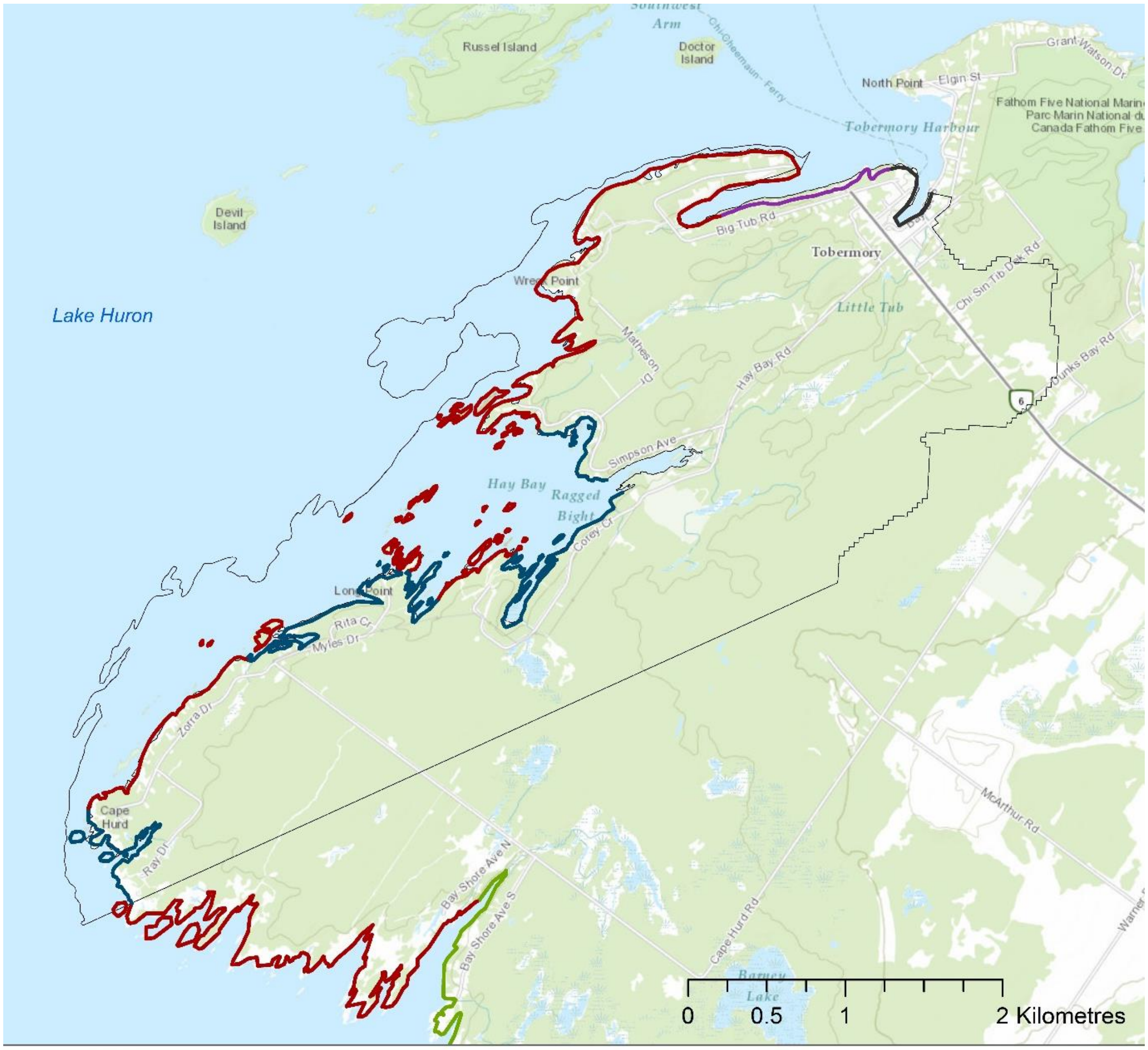
ECOSYSTEM HEALTH ANALYSIS

Key Attribute	Indicator	Poor	Fair	Good	Very Good
Presence and health of vegetation	Percent natural land cover within 2 km of shoreline	<20	20-40%	40-70%	**>70%**
	Naturally vegetated bluff buffers (%)	0-20%	20-50%	50-75%	>75%
	Woodland Cover land-use (%)	<29%	30-39%	40-49%	**>50%**
	Number of large forest patches (+200ha)	0	1	**2-5**	>5
*** Current developed area in AU 11 is 2.7%, with 2.3% agriculture, leaving 95% natural land cover.* *** Woodland cover is 76.4% in AU 11's coastal corridor with 8, 200+ ha patches. (HMHIE Guidelines)*					
Ability to complete coastal processes	Number of shoreline hardening structures per km. (1 structure / #km)	0 to <2	2.1 – 4	4.1 – 6	>6
*** approx. no detected hardened structures in water or parallel hardening structures. 1.21 km of shoreline is hardened (2.7%)*					
Presence of Roughage	Sand beach grooming	Groom 2+x times / week	Groom 1x / week	Groom 1x / month	No Grooming
*** No data available for beach grooming in AU 11.*					
Presence of Wildlife	Invasive Species	At least 7 aquatic and terrestrial invasive species exist in the Coastal Corridor.			
Developed Area	Amount of corridor developed (%, ha)	>70	40-70	20-40	**<20**
	Amount of impervious cover (% of developed area)	>26%	11-25%	1-10%	0%
	Presence of transportation corridor (%, ha)	1.28%, *129.46 ha*			
*** Coastal corridor is 2.72% developed, including transportation.*					

KEY STRESSORS AND OPPORTUNITIES

Stressors	Opportunities
Point and NPS pollution	Regulate or provide incentives to ensure septic systems have the proper inspection and replacement schedule to limit nutrient inputs.
Development and land-use change	Increase Low Impact Development features in urbanized areas to reduce waterflow and increase water retention during storms.
Light pollution	Adapt infrastructure in urbanized and shoreline communities to be dark sky compliant.

MAP 19 - Shoreline Types in AU 11



COASTAL ACTION PLAN
FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 11:
Shoreline Biodiversity Features

1:35,000

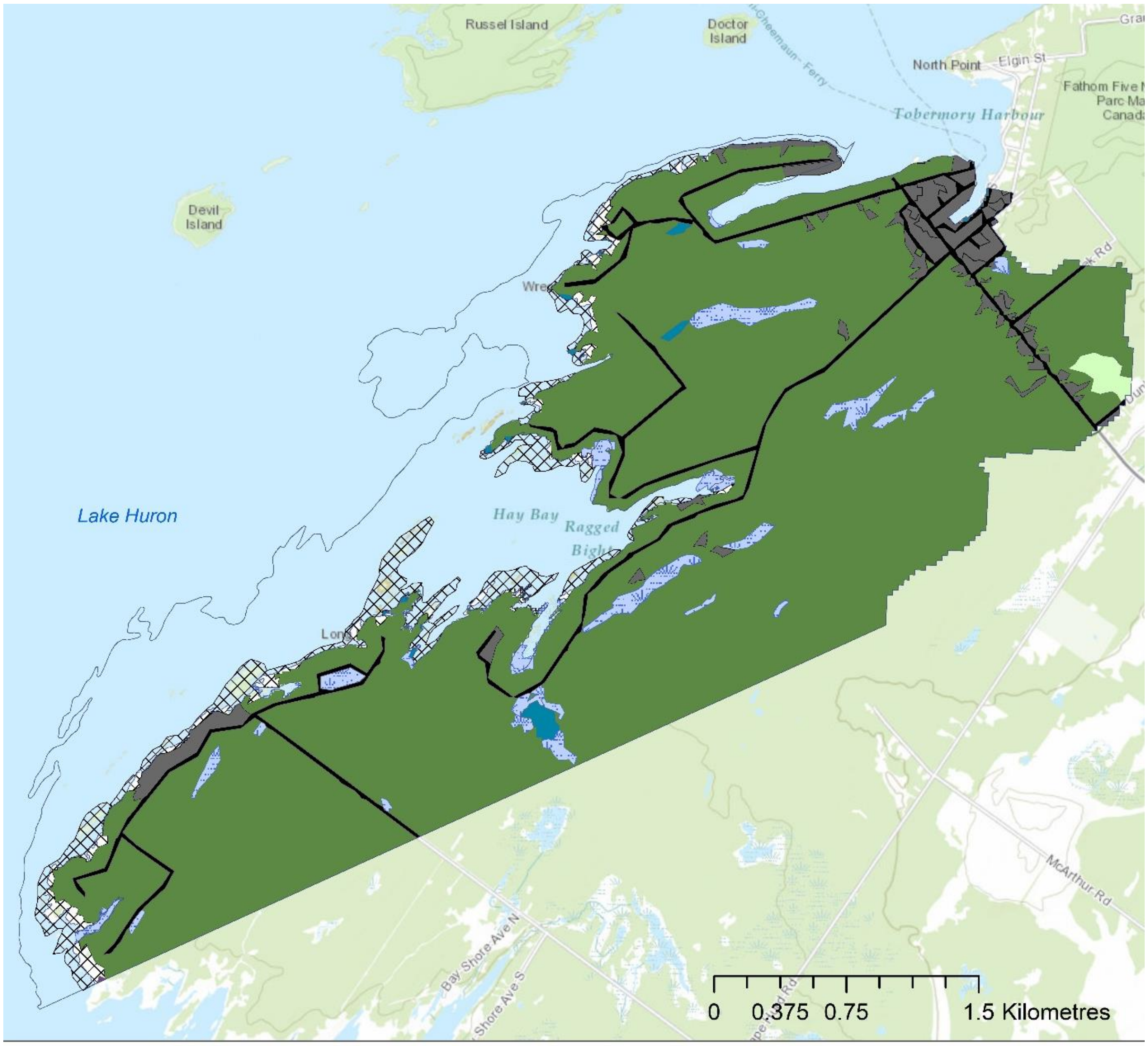
Map created by the Lake Huron Centre for Coastal Conservation using data from Ontario Shoreline Segmentation Layer (Environment Canada).
This map is for reference only. Do not use to interpret accurate navigation.
Map Created May 2018, NAD 1983 UTM 17N

N

Legend

- Bedrock / Alvar
- Man-Made Permeable
- Man-Made Solid
- Wetland
- Cobble Beach
- Bluff

MAP 20 – Land-Use Types in AU 11



COASTAL ACTION PLAN FOR THE SOUTHEASTERN SHORELINE OF LAKE HURON

Assessment Unit 11: Land Use Types

1:31,000

Map created by the Lake Huron Centre for Coastal Conservation using data from SOLRIS V.2 2015 (MNRF)
This map is for reference only. Do not use to interpret accurate navigation.
Map Created June 2018, NAD 1983 UTM 17N

Legend

N

- Agriculture
- Alvar
- Bedrock
- Developed
- Grassland
- Open Water
- Transportation
- Wetland
- Woodland
- AU Boundary

CHAPTER 7: HOLISTIC APPROACHES TO COASTAL MANAGEMENT

The southeastern shoreline of Lake Huron crosses a continuously changing landscape with very diverse land-use practices. Along Lambton County's coastal corridor, agriculture and urban development dominate; Huron County's coast hosts patches of urbanized communities, cottage developments and agriculture interspersed between gullies and woodlots; Bruce County's coastal corridor hosts small seasonal communities, a few rural towns, industry, rare coastal wetlands, and tourism hot-spots. These three distinct regions across the coastal corridor pose a challenge when managing the southeastern shores cohesively. Cooperation among individuals, grass-roots organizations, local governance, and regional governance will enable a shared approach to acting on opportunities and tackling stressors and threats as a united front. Working together to support the intricate socio-economic framework of Lake Huron's southeastern shores, while preserving and enhancing the ecological integrity of the fragile coastal ecosystem is key to creating a sustainable, resilient coast. Holistically approaching coastal management encompassing social, economic, and environmental aspects will ensure thriving communities, resilient to threats, while remaining malleable enough to foster thriving futures for healthy coastal communities.

All levels of land management (Figure 77), working together to maximize resources, taking advantage of opportunities, and continuing to work towards long-term goals, will allow the coastal corridor to become healthy, sustainable, and resilient places for the environment and communities to live symbiotically.

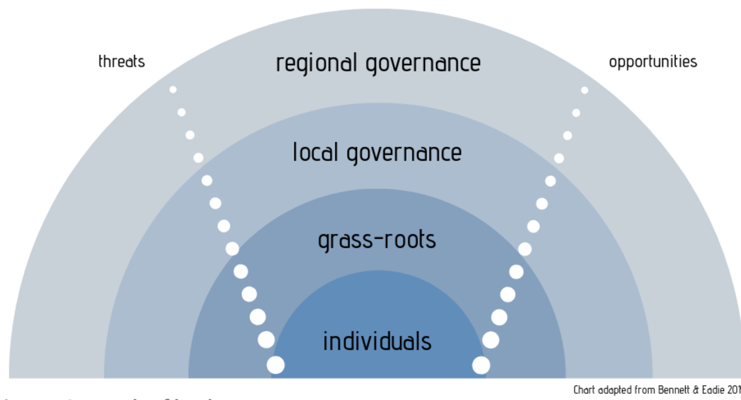


Figure 78 - Levels of land management

7.1 ECOSYSTEM-BASED AND ADAPTIVE MANAGEMENT

Definition: *"The goal of ecosystem-based management (EBM) is to improve human well-being (the health and happiness of people and communities). Human well-being encompasses physical health, economic prospects, our mental state and spiritual connection, pride to express cultures, traditions and customs, and to develop communities, raise families, and prosper"* (Coastal First Nations, 2017b).

Heraclitus, a Greek philosopher said, "change is the only constant in life", and this principal holds true for natural fluctuations in coastal habitats, in socio-economic states of our communities, and in the threats that impact these systems. A management style that changes and improves through time is the best method for learning and adapting using the experiences and changes seen. Ecosystem-based management puts human well being, and relationships with the ecosystems we live in at the forefront of management. Whereas, adaptive management monitors the effects of changes made, learns from the results, and changes course based on the results of the monitoring. In a society which is entrenched in short-term plans, governance, and ideals based on which political party is in power, or what funding is available to complete projects, adaptive management seems like the only viable option to manage our impacts on the environment. "The challenge is not one of how to prevent any human-induced change, but rather one of deciding how much change will be allowed to occur, where, and the actions needed to control it" (Stankey et al, 1985).

For land managers alike, the most important concerns for improving environmental health and coastal community vitality is not to segregate them into two silos, but rather to amalgamate them into a holistic system.

Disregarding political boundaries and jurisdictions when conservation, restoration, and development projects are needed, by working in partnership with all stakeholders is the only way to fully complete these types of programs across the coastal corridor. These partnerships and interaction are only starting to become commonplace in the current system. Consistency in education, incentives, management, regulation, and enforcement styles across jurisdictions will create consistency and a united front in tackling systemic issues and will mutually benefit the coastal corridor. Consistency will also improve awareness by residents and communities in the threats and stressors to their local ecosystems, and the bylaws, regulations, and requirements of them to preserve and improve ecological integrity of coastal ecosystems. Method of analysis for holistic coastal management approaches employs four scales of land manager (Figure 72);

(1) Individuals (e.g. landowners, visitors, tourists, seasonal residents)
(2) Grass-roots organizations (e.g. community groups, environmental charities, small NGO's, businesses)
(3) Local governance (e.g. CA's, municipalities, First Nations, Métis)
(4) Regional governance (e.g. Ministry of Natural Resources, Ministry of Environment Conservation and Parks, Government of Ontario, Parks Canada, Ontario Parks, etc.).

Although there are many ways to recommend ecosystem-based actions and adaptive management, the CAP dissects responsibilities on three scales (grass-roots, local, regional) to examine opportunities for conservation and protection, habitat restoration, community development and land-use planning, education and accountability and partnerships.

7.2 CONSERVATION AND PROTECTION

Definition: *"Conservation is the careful preservation and protection of something, especially planned management of a natural resource to prevent exploitation, destruction, or neglect" (Merriam-Webster Dictionary).*

GRASS-ROOTS

Apart from land acquisition, conservation and protection involves stewardship from all levels of stakeholder. Most of the coastal corridor is privately owned, meaning that landowner stewardship and grass-roots level conservation and protection efforts are of extreme importance. If landowners and land managers within the coastal fringe were able to conserve and protect coastal ecosystems, many of these habitats would be safe from damage and destruction.

A main aspect ecosystem conservation and management is monitoring their state and comparing changes to the history of data. As discussed in Chapter 4, creating standardized Best Management Practice Guides, with resources such as dune vulnerability checklists, will enable landowners and grass-roots groups to frequently monitor the state of their ecosystems and identify when stressors are causing ecological damage. Frequent monitoring will enable early identification of stressors, such as invasive species, and reduce costs associated with habitat restoration. Programs engaging citizen science volunteers to monitor their section of shoreline or coastal corridor for ecosystem indicators will have resounding effects on conservation and protection in a political climate which cuts funding for many grass-roots and local organizations to monitor these changes through structured programs (e.g. Coast Watchers through LHCCC). Through Coast Watchers citizen science program, volunteers are trained to identify species at risk, invasive species, and anthropogenic (human) use and stressors on their shoreline. The long-term data set created by this program enables participants to become more educated and aware of impacts to coastal ecosystems, they take ownership of 'their' section of shoreline, and become a community steward taking initiatives to protect coastal health, such as initiate impromptu shoreline clean-ups and advocate against neighbours causing irreversible damage to their shoreline properties.

LOCAL GOVERNANCE

A multitude of land managers across the coastal corridor form a 'quilt' of jurisdictions, overlapping and working together towards ecological sustainability and resilience. A major component of municipalities and CA's are their regulations and bylaws. As discussed in Chapters 4 and 5, there needs to be more consistency and continuity of regulation and bylaws by these agencies. Upon reviewing municipal bylaws for all shoreline municipalities, the following table shows those which are slightly related or have mention to any sort of beach or shoreline ecosystem protection. However, it should be noted that only a few provide any specifics for protection of coastal ecosystems above and beyond permitted actions on recreational beach areas.

Table 32 - Municipal Bylaws applicable for shoreline ecosystem protection

Municipality	Bylaw
City of Sarnia	92-1991 – construction of shoreline erosion protection bylaw 65-2001 – authorize construction of armourstone shoreline protection on Lake Huron 34-1992 – tree bylaw 206-1999 – parks bylaw
Town of Plympton Wyoming	33-2009 – cleaning and clearing of waste bylaw
Lambton Shores	11-2019 – parks and facilities bylaw 27-2004 – site alteration (grade) bylaw
Municipality of South Huron	None applicable
Municipality of Bluewater	89-2008 – management, control, and usage of Bayfield main beach, Bluewater marina, and water areas bylaw
Municipality of Central Huron	25-2006 – tree bylaw 23-2013 – tree bylaw
Town of Goderich	82-1993 – tree bylaw 76-1989 – municipal parks bylaw
Ashfield-Colborne-Wawanosh	45-2016 – shoreline tree preservation bylaw
Township of Huron-Kinloss	85-2011 – tree preservation bylaw 62-2008 - motorized vehicles on the beach bylaw
Municipality of Kincardine	16-2016 – off road vehicle bylaw
Town of Saugeen Shores	75-2006 – general provisions zoning Bylaw 70-2015 – ATV bylaw
The South Bruce Peninsula	102-2017 – Sauble Beach bylaw 98-2015 – off road vehicles bylaw
Northern Bruce Peninsula	None applicable

Clear, consistent bylaws for shoreline preservation and coastal ecosystem protection are needed across the shoreline municipalities. Bylaws such as a "shoreline preservation bylaw" could encompass appropriate beach usage, dune protection, shoreline tree protection, gully protection, and many others. A Green Bylaws Toolkit has been prepared by the Environmental Law Clinic et al, which can be used as a launching point for municipalities to reference to enhance their coastal ecosystem protection strategies (ELC, 2007). In this toolkit, examples of ecologically based bylaws and permit areas include:

- Rainwater management: Runoff control requirements, sedimentation treatment;
- Landscaping and screening: Dune protection, protection from wind and wave action;
- Tree protection bylaw;
- Watercourse protection bylaw;
- Alien invasive species and pesticide control bylaws;
- Urban growth boundaries;
- Environmental impact assessment development permit (ELC, 2007)

Coordinating protection, enhancement, and rehabilitation efforts of coastal ecosystems overlapping multiple jurisdictional boundaries is imperative to maintaining the ecological integrity of coastal habitats. Education and awareness are the most important first steps in creating a coast of ecologically sensitive citizens. Ensuring local governance plays a role in sharing their work, and educating all local communities and industries about the threats affecting coastal health will improve choices made by individuals and businesses when potentially causing threats without knowledge of the consequences. Improving the enforcement of development setbacks, buildings and developments, manure application and other agricultural practices within buffer zones of water courses will aid in the conservation and protection of soil, water, and air quality within the coastal corridor. Improving the consistency in the enforcement of these offences, and implementing harsher consequences for infractions would also aid in the respect placed on the regulations and bylaws. Halting incompatible management techniques done by local governance themselves including mechanical beach grooming, will improve conservation of shoreline resources.

REGIONAL GOVERNANCE

The southeastern shores of Lake Huron have a diversity of ecosystems and habitat types, many of which are currently protected through institutions such as Provincial or National Parks, Environmental NGO ownership, or Nature Reserves. Maintaining the protection of these areas will ensure the stability of the ecological integrity and health of the contained ecosystems. However, these 'patches' of protected areas are threatened by stressors outside their boarders. Therefore, increasing conservation and protection efforts around existing designated areas will be crucial for the overall health of rare coastal ecosystems. Increasing protected area, whereby environmental agencies purchase privately owned land and protect and restore it is challenging along the southeastern shores, where property values are high and demand for real estate follows suit. However, these types of land acquisitions do occur periodically, and are therefore supported and recommended by this plan to continue through agencies such as Parks Canada, Nature Conservancy of Canada, CA's, and Ontario Nature. Areas that could be of most importance for protection include areas highly susceptible to threats and stressors now or in the future, as well as areas that are adjacent to existing 'at-risk' resources or ecosystems. Maintaining the ecological integrity of existing protected areas through monitoring and adaptive management will enable existing protected areas to be sustainable into the future. Regional governance can also play a crucial role in maintaining and enhancing the environmental policies, acts, and provincial/federal regulations integral for enforcement on the local level (e.g. Endangered Species Act, Environmental Assessment Act, Provincial Policy Statement). Ensuring the political party du jour cannot retract or rewrite significant environmental laws to suit their campaigns or partnerships with resource extraction or development companies is of utmost importance. These plans, acts, and policies should be enhanced to further protect our Great Lakes waters, our rare coastal ecosystems, and support low impact development initiatives while discontinuing unsustainable development practices.

7.3 HABITAT RESTORATION

Definition: *"Restoration of a natural shoreline is bringing back natural coastal defences against the processes that cause erosion. Restoration is nourishing and retaining beaches, revegetating beaches and slopes, reconstructing dunes and beach ridges, creating or restoring wetlands, and removing failed and failing shore protection structures" (USACE, 2003, p.18)*.

Conservation and restoration often overlap in scope and importance with land management practices. The Nature Conservancy provides a scale of ecosystem management status, from preservation and restoration, to structures with nature and structures alone (Figure 70). Through this diagram, restoration is considered the next best option to preservation, and can restore coastal processes to reinstate the ecological integrity of these habitats.

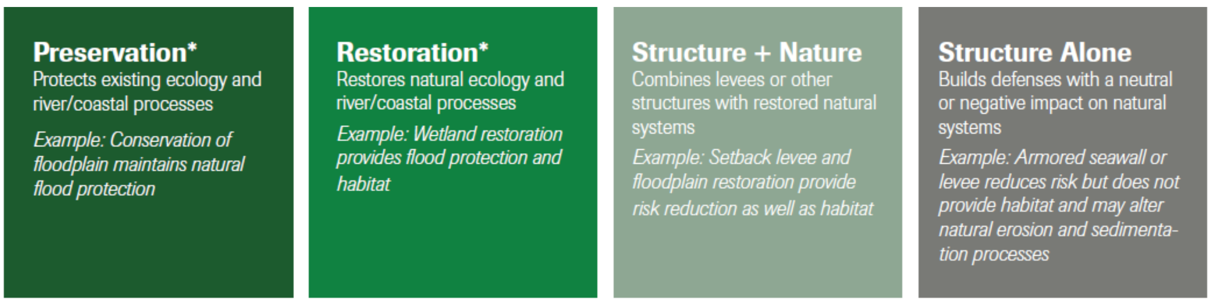


Figure 79 - Natural Infrastructure Methods (Downing, 2013, p.3)

Restoring coastal ecosystems is a key action to be completed, however without repairing the relative impacts of stressors affecting the restoration site, true restoration will be hard to achieve as threats will constantly be inundating the restored area (Allan et al., 2012, p. 374). Therefore, holistic action and management is required to ensure effectiveness of investment in restoration projects. For example, if you remove *Phragmites australis* from a bay, but a creek enters the bay with *Phragmites* at it's headwaters, there will always be a threat of reintroduction. Co-operation to effectively use time, resources, and effort through partnerships and various stakeholder groups will allow for diligence and efficiency in tackling restoration projects.

As discussed in previous chapters in this plan, structural protection approaches are extremely detrimental to coastal ecosystems on the southeastern shores. Therefore, non-structural and gray-green approaches outlined by University of Michigan (2018) could be applied in the place of existing derelict hardened shoreline structures through restoration projects. Natural infrastructure and gray-green infrastructure are structures that serve ecological functions and produce engineered outcomes for shoreline protection. Utilizing the ecosystem services of certain natural features is also an aspect of this category of shore protection. "*There is increasing evidence, in many circumstances, that natural ecosystems may offer solutions of comparable engineering efficiency with considerable economic savings and with the maintenance of collateral ecosystem services and functions*." (Dugan et al., 2011, p.36). Elements such as healthy dunes, vegetated buffers, natural revetments, and rain gardens are a few of the many methods of natural infrastructure that can-and are- being employed to protect coastal infrastructure on the southeastern shores. "*Approaches using plants, rather than hard construction materials, can also serve to reinforce the soil, improve water drainage, prevent erosion and dewater wet soils. There are limits to these approaches as well; where there is ongoing toe erosion, these measures can only enhance stability in the short-term, and over the medium to long-term they have no effect on changing the recession rate*" (Allan, Callewaert & Olsen, 2018, p.7). In cases where natural infrastructure and grey-green infrastructure are used, these areas can absorb the power of storms, adapt to changing lake levels, and fluctuate with natural processes in a way that hardened structures cannot do. This resiliency is going to be key with increased pressures from climate change including more weather pattern variability and stronger storm surges.

Grass-roots, local governance, and regional governance all participate in restoration at their various scales, and the responsibility for restoration falls to everyone equally. Habitat restoration on Lake Huron's southeastern coastal corridor has many facets. Restoration could include:

(1) Land-use change (e.g. field to forest),
(2) Re-instating habitats which have been destroyed previously (e.g. rebuilding dunes on sand beach);
(3) Removing human-made threats (e.g. structures, plastic pollution, and other NPS pollution inputs); or
(4) enhancing existing habitats (e.g. planting, reintroduction, or removal of invasive species to improve function and ecological integrity).

GRASS-ROOTS

Grass-roots habitat restoration initiatives include removing point and NPS pollution, development setbacks, and enhancing existing habitats. Beach clean-ups have become a common annual event across Lake Huron's coast. Volunteerism in these events is on the rise (Chapter 4 & 5), and thanks to partnerships, cooperation, and excellent community passion towards healthy shorelines, removal pollution has been possible. Encouraging the continuation of these events through outreach, awareness, and societal change will vastly improve coastal habitats, restoring them to a more natural state.

Invasive species removals have been a widely successful initiative by grass-roots partnerships to restore coastal habitats, most notably coastal wetlands. Groups like the Lambton Shores Phragmites Community Group which restored a stretch of shoreline near Port Franks through the removal of *Phragmites australis*, would not have been possible without the passion and dedication of community volunteers, and the successful recipient of grants and donations to get the work completed. Without grass-roots community involvement, this massive restoration project would not have been possible. Numerous examples of similar efforts are apparent across the southeastern shores, including the removal of *Phragmites* at Brucedale Conservation Area through partnerships between SVCA, LHCCC, and the Brucedale Community Group (Figure 71).

Grass-roots organizations kick starting reforestation programs and providing incentive programs to encourage habitat restoration of coastal forests devastated through improper management and the Emerald Ash Borer have led to an increase in restoration across the shoreline. Groups like the Pine River Watershed Initiative Network, who launched a reforestation campaign to lakeshore landowners within the Pine River Watershed were able to give free trees out to landowners to increase forested habitat. Other groups like Communities in Bloom allow landowners to purchase trees for their properties and through this community organization they raise money to keep their community beautiful.

Other shoreline restoration programs available at cost or free by incentive program such as the Green Ribbon Champion Program which completes beach site visits on coastal properties and creates restoration plans for the property owner, as well as completing some of the restoration work, improve and restore the ecological integrity of shorelines enabling coastal processes and ecosystem services to be reinstated. Encouragement of restoration programs through municipal and corporate support allows grass-roots projects to succeed.

Figure 80 - Brucedale Conservation Area, Before and After Phragmites removal

LOCAL GOVERNANCE

In order to determine priority for shoreline and coastal restoration treatments, local governance must determine thresholds of desired future ecosystem condition, structure, and function (HLH, 2012). Determining what these thresholds are is imperative to measuring success or room for improvement of restoring coastal habitats. To adapt to changes along the coastal corridor, land managers and landowners will need to think-outside-the-box, and come up with creative solutions to increase resiliency to intensivied climactic conditions and increased visitation and population, while maintaining sustainability with investments, time, and energy spent working on and managing aspects of the coast. An example of the process of identifying how much restoration is required within a local governance jurisdiction is provided in Case Study 1.

CASE STUDY 1- FOREST COVER RESTORATION IN WATERSHEDS:

Improving forest cover can be done in rural or urban areas, to receive multiple restoration outputs for air quality, temperature regulation, and water quality and retention. Environment Canada recommends the guidelines in Table 13 for forest cover. That a stable, low risk forest cover be over 50% of the watershed, a moderate risk being +40%, minimum risk being +30%, and high risk being under 29%. Table 26 shows that Assessment Units 1-6 require action by local governance agencies to improve the forest cover within the coastal corridor.

Table 33 - Assessment of % forest cover by AU, with attributed risk level

AU	% Forest Cover	Risk Level
1	11.3	Severe, high risk
2	15.8	Severe, high risk
3	9.7	Severe, high risk
4	12.3	Severe, high risk
5	23.5	Severe, high risk
6	44.9	Moderate, medium risk
7	60.9	Low risk
8	64.7	Low risk
9	76.4	Low risk
10	73.3	Low risk
11	81.6	Low risk

A threshold analysis such as this gives communities in the coastal corridor a baseline to meet and exceed when planning urban and rural forestry projects, and the amount up program uptake they need to successfully improve this metric. However, attaining these thresholds can be long-term programs, with high cost and time commitments. For example, Ausable Bayfield Conservation Authority did an analysis of how much reforestation would be required to increase total cover by 1%; this estimate determined that approximately 6,000 acres of land and ~4,200,000 tree seedings would be needed (ABCA, 2018). Based on current reforestation programs which plan between 50 and 100 acres of trees per year, it would take 60 years to complete a reforestation program of 1% (ABCA, 2018). Two obvious ways to hasten this progress would be to increase the area planted per year, to decrease time to completion.

Similar restoration projects, such as *Phragmites australis* removal are long-term programs required on roadsides, river channels, and the shoreline itself. Local governance is attempting to control invasive species through new budgetary line items that fund the control and removal of noxious weeds. Other examples of restoration projects which could be undertaken on a local governance level include length of rivers requiring cattle fencing, amount of habitat fragmentation, historical wetland cover compared to present day cover, dune and bluff health and presence of vegetation on these features.

REGIONAL GOVERNANCE

Regional governance contributes to restoration programs in Ontario and on the southeastern shores by funding large-scale initiatives available to local governance and grass-roots groups through successful application, or funding smaller projects done by these groups and agencies directly. For example, The Government of Ontario has the Great Lakes Guardian Community Fund (GLGCF) which "helps grassroots community groups, non-profit organizations and First Nations and Métis communities restore the [Great Lakes] through local projects" (Ontario, 2012). Regional governance funding smaller local projects enables engagement of passionate and knowledgeable local entities such as community groups and non-profits to complete restoration projects in a way that makes sense for the area. The GLGCF specifically has provided $1.5 million in 2012 alone to fund restoration programs across the province with grants of up to $25,000, with one project specifically undertaking beach and dune restoration in Grand Bend Ontario, within the southeastern coastal corridor (Ontario, 2012). Other government grants available through application include the Ontario Trillium Foundation's Grow Grant, "Encouraging people to support a healthy and sustainable environment [through] more ecosystems protected and restored, [and] people reducing their impact on the environment" (OTF, 2019). These types of grants are extremely important for small local grass-roots organizations which need help funding restoration projects. Unfortunately, they cannot fund all the projects that apply to the program, but through the number of applicants they receive, realization by the Provincial Government should be made to increase the programs to enable support for all sustainability and resiliency initiatives across the coastal corridor and province.

Aside from funding pools, regional governance bodies play a role in restoration projects across the coastal corridor through land management and restoration expertise. Parks Canada, a federal agency, manages two National Parks overlapping the coastal corridor on the southeastern shores. A recent example of a restoration project undertaken by Parks Canada is the work completed in Dorcas Bay at the Singing Sands dunes and coastal fen in Case Study 2.

CASE STUDY 2: PARKING LOT RESTORATION AT SINGING SANDS

Singing Sands, in Dorcas Bay on the southeastern shores of the Bruce Peninsula hosts an environment consisting of a relic sand beach and a coastal fen wetland. For decades, this location has been owned and operated by Parks Canada through Bruce Peninsula National Park. Unfortunately, previous planning was not as adept at determining threats caused by parking lots and visitation to such sensitive coastal habitats, and a parking lot was constructed running parallel to the beach, seperating the beach from the fen almost entirely. Positioning the parking lot this way reduced water flow between the two coastal habitat types, and put compounding stressors on both environments during the extremely busy peak summer season. Through this increased visitation geared towards enjoying the beach area for recreation, litter, erosion, vegetation trampling, and 'nutrient' inputs were caused. In 2017, restoration efforts to move the parking lot off the relic dune and restore the coastal fen environment by installing a better boardwalk was initiated. Figure 72 shows pictures before and after rehabilitation of a coastal relic beach, dune and coastal fen ecosystem that was transformed from a parking lot to a swale, boardwalk complex.

Extremely different in scope and infrastructure to what was previously there, the restoration work completed restored the relic dune and swale, reconnecting the beach and fen, while also providing opportunity for movement and recreation through the landscape using a boardwalk and viewing tower, reduced continuous impacts that would be done to the area through increased visitation. Creative thinking by moving the parking lot offsite to a location across the road also allowed for increased visitation without further impacting the sensitive ecosystems of Singing Sands. Utilizing the already disturbed environment of the front half of the parking lot for washrooms, and a small picnic area reduced the footprint of the new development, and provided an expanded range of visitor amenities available at this site.

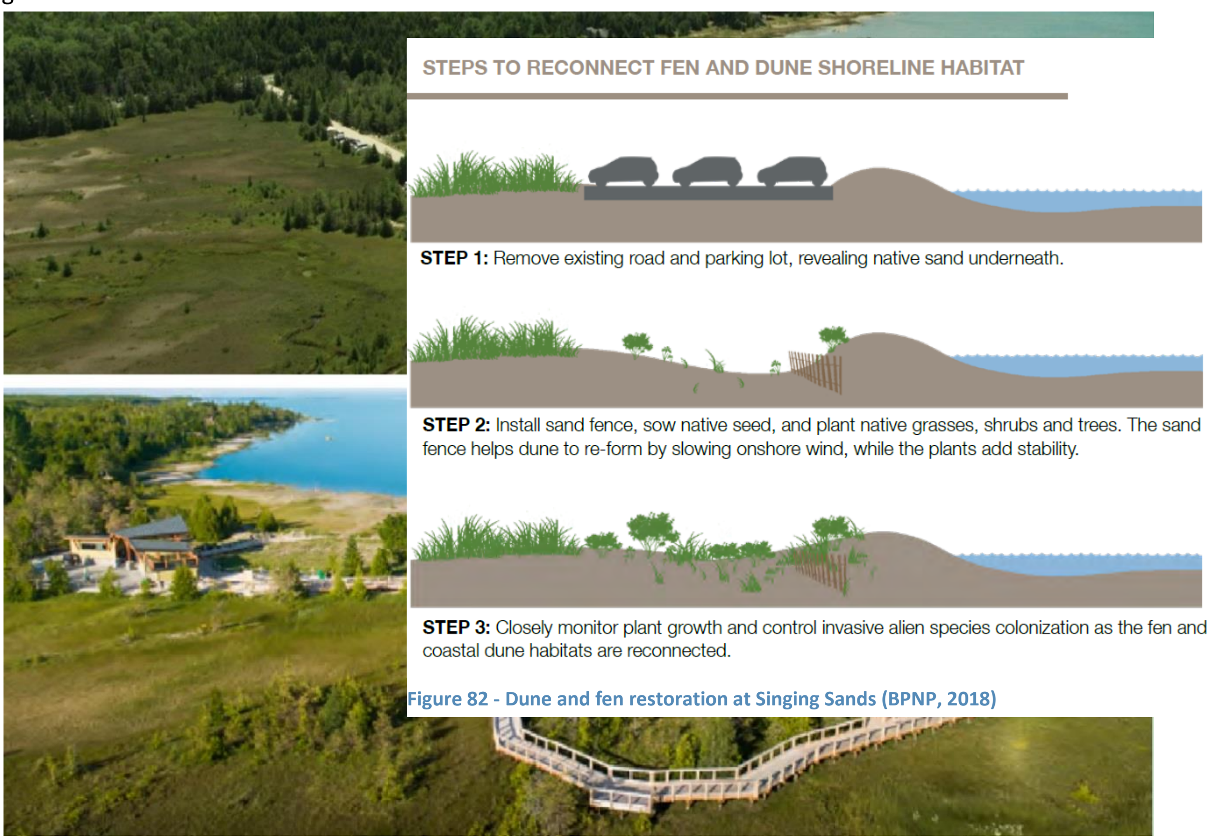


Figure 82 - Dune and fen restoration at Singing Sands (BPNP, 2018)

Figure 81 - Before and after restoration at Singing Sands, Bruce Peninsula National Park

This case study provides a shining example of balancing a restoration project aimed at improving ecological integrity and protecting sensitive ecosystems, while also providing the infrastructure required to accommodate increased visitation and economic prosperity of the area. Projects of this nature are also fantastic demonstration sites for local governance and grass-roots organizations to emulate in their own communities. National Park staff used the same principals to restore this property that a landowner would use on a smaller scale; remove existing infrastructure, install sand fencing, remove invasive and plant native vegetation, monitor plant growth and continue to control invasive species (Figure 81).

This case study shows that the best management practices for habitat restoration, in this example coastal wetlands, can transcend grass-roots, local governance, and regional governance scopes. Similar recommendations and work can be completed by all levels of land management, from the private landowner, to the federal government.

7.4 COMMUNITY DEVELOPMENT AND LAND-USE PLANNING

Visitation and immigration to the southeastern coastal corridor is predicted to increase, causing concern for the ecological integrity of coastal ecosystems due to land-use change and exceeded carrying capacities. To control these threats, initiatives to intensify development instead of urban sprawl; utilizing low impact development practices, and masterfully planning infrastructure upgrades to incorporate natural infrastructure or eco-friendly options will be imperative to improving coastal community resiliency and health.

'Greening' coastal communities through conservation, restoration, and redesign will have positive effects towards the ecological integrity of coastal habitats, and on the economy of these communities. Recent scientific reports focused on the relationship between living close to nature and impacts on mental, physical, and social health have uncovered that living in closer proximity to nature or in greener urban areas have shown associations with improved mental health of residents, as well as less perceived stress and better diurnal cortisol responses (Kuhn et al., 2017). Specifically, the coastal corridor contains 'green' space, but also contains 'blue' space. According to another scientific study,

"*women who lived in areas with greenery had a 12% lower death rate compared to those who lived in areas with little greenery. When looking at specific causes of death, the study found that women near nature had a 41 percent lower death rate for kidney disease, a 34 percent lower death rate for respiratory disease and a 13 percent lower death rate for cancer. Women also reported a 30 percent improvement with their mental health… Living near blue spaces (e.g. water) is also known to reduce stress and improve well-being…may be because blue spaces tend to be all natural, while green spaces often include human-made areas like playgrounds*" (Dube, 2017).

Through the extensive academic literature related to the importance of living near nature for mental and physical health, an increase in natural surroundings in coastal communities can be attributed to improve the health and wellbeing of its residents and visitors. Coastal communities could advertise the health benefits of living close to nature potentially increasing population and by association tax-base, allowing municipalities and local governance bodies to implement more green infrastructure projects. Increasing natural landscapes into urbanized areas will also improve the tourism market in the coastal corridor. Nature-based tourism experience opportunities including fishing, cultural engagement, kayaking, wildlife viewing, and forest bathing would enhance the diversity of existing tourism opportunities in coastal communities, shifting focuses from only beach day-use and camping, to a more diverse set of opportunities that can occur during shoulder seasons (Coastal First Nations, 2017a). Increasing tourism opportunities into nature-based approaches would increase the local job market associated with tourism, and enable a steadier economy throughout the year. Partnerships between the Regional Tourism Organizations, municipalities, and local business owners and operators would bring this recommendation to fruition. Once again, cooperation, collaboration, and partnerships are the key to community development and bridging the gap between land-use and ecological integrity.

There are many ways community development and land-use stressors can be reduced at the grass-roots level. Community improvements including increasing urban tree cover exist and are present within coastal watersheds. The Ontario Urban Forest Council is one group uniting small grass-roots organizations to, "take action to support strong urban forest policy and programming" through funds provided by provincial governments including the 50 Million Tree Program (OUFC, 2019). They have found that, "Ontario has a growing number of grass-roots organizations working hard within their own communities to plant, steward and protect their urban trees" (OUFC, 2019).

Low impact design (LID), also known as water sensitive urban design, and sustainable urban drainage systems, are natural infrastructure techniques used to reduce water quality and improve water quality entering our environments. Typical LID infrastructure includes rain gardens, swales, constructed wetlands, pervious pavements, and rainwater catchment cisterns. Using LID principals, homeowners, community groups, and businesses can create more resilient and sustainable landscapes in both rural and urban areas. Implementing these practices has been proven to, "fill gaps in your municipality's existing stormwater program and build resiliency to climate change, reduce costs associated with flooding, contribute to more livable communities, and enhance the property values of your residents, and demonstrate that your municipality is proactive about future infrastructure needs and environmental issues" (CVC, 2015).

Figure 83 - Low Impact Development example of a Rain Garden in London Ontario (City of London, 2019)

Some simple methods grass-roots organizations and individuals within communities can apply best management practices to community development and land-use include;

- Reducing impermeable pavements by replacing with permeable options (e.g. interlocking stone vs. asphalt);
- Capturing rain water and allowing it to slowly release after storm events; (e.g. rain barrels, rain gardens, constructed wetlands);
- Re-naturalizing landscaping (e.g. replace non-native garden species with native, drought tolerant, pollinator encouraging species; increasing tree canopy cover on property);

Throughout Section 7.4. case studies providing example of LID practices being employed in the coastal corridor of Lake Huron are discussed, echoing the simple LID methods listed here. These projects and programs can set examples for other opportunities and areas across the coast that can use similar practices to provide increased resiliency and sustainability measures.

CASE STUDY 3: CAPTURING WATER

Community groups within shoreline watersheds are taking action to make rainwater catchment devices more accessible to landowners. Bayfield River Valley Trails Association has been providing the service of selling rain barrels to landowners in Bayfield at a cost of $55.00 CAD to conserve water, capturing water runoff, and save money (ABCA, 2019).

Figure 84 - Rain Barrel (CVC, 2015)

Rain gardens are another simple, cost effective method for capturing water from precipitation or runoff that can be easily installed by individuals or grass-roots organizations. "*Rain gardens are shallow, sunken gardens. They protect local water quality when they collect, absorb and filter water running off land during storms. When it rains or when snow melts, water runs off roofs, patios, and driveways. Rain gardens can prevent this water, along with contaminants the runoff picks up, from draining directly into a local storm sewer or nearby watercourses… The Bayfield and area community prepared a community watershed plan. Landowners and residents and community groups are implementing that plan with support from funding partners including the Fred A. and Barbara M. Erb Family Foundation*" (ABCA, 2018a).

Rain gardens on the coastal corridor have cost $1,000 to $3,000 CAD in recent projects completed, but through grants up to $500 CAD provided by local governance through projects such as the Huron County Clean Water Project, and the Municipality of Bluewater's Blue Flag initiative (ABCA, 2018a). This example of incentives initiating partnerships between grass-roots individuals and organizations and local governance perfectly illustrates the potential for positive action towards resilient coastal communities.

Working cooperatively, sharing resources and time to complete these projects help make efforts more efficient, tailored to the community, and provide a dissemination of information about the threats and stressors that could impact the work completed as well as monitoring opportunities for restoration follow-up.

Figure 85 - Rain Garden in Bayfield Ontario (ABCA 2018)

LOCAL GOVERNANCE

Many settlements along Lake Huron's shores have been established for 150-years, and some issues around maintenance and expansion of these communities is not new. Traditional hardened development and intensified land-use are still affecting these communities. However, opportunities and alternative management practices are becoming more common. One ranking of hardening and modification impacting ecological integrity done by Stankey et al., (1984) grouping development into 5 categories of modification severity:

Pristine:	Unmodified natural environment not measurable affected by development
Primitive:	Minimally affected by development
Semi-Primitive:	Moderately affected by development
Developed:	Many locations substantially affected by development

Severely Developed: All locations significantly compromised by development

Ranking communities big-and-small across the shoreline into the five categories will allow awareness of how much work needs to be done to re-naturalize the ecosystems adjacent to the coastal community. Once an understanding of the baseline condition of the community or area is achieved, specific projects can be tailored for each community or area of concern. For example, adjusting existing programs and services to be more resilient and sustainable would improve ecological integrity without increasing costs (e.g. municipal landscaping could plant native, drought tolerant, pollinator supportive species, or allow community vegetable gardens in certain plots, instead of showy-annual species requiring regular irrigation and maintenance).

Planning for the lifespan of infrastructure could incorporate simple and cost-effective switches from traditional techniques to ecologically sustainable options such as dark sky lighting for streetlights, permeable pavements on walkways and city centers, rain gardens in boulevards or condensing urban and community road networks, making more pedestrian and cyclist friendly areas. Using the principals of low impact development to achieve community resiliency to heavier storms and shifting seasonal climates will benefit the community by cutting down on future repair costs to existing infrastructure. Low impact development incorporates principals found in nature to manage stormwater as close to its source as possible, mimicking natural ecosystems and slowing the flow of water across the landscape (Allan, Callewaert & Olsen, 2018 There is a strong recognition in urban areas that as the number of impervious surfaces increases, so do the needs for water-removal infrastructure.

Municipalities, First Nations, Métis and CA's manage a diverse set of landscapes, with diverse stressors and threats, but are common among one another across the coastal corridor of Lake Huron. Coastal communities attempting to rehabilitate areas containing infrastructure (both rural and urban), there are three approaches; gray-green infrastructure, non-structural, and structural approaches (Allan, Callewaert & Olsen, 2018, p.6; Figure 85). Depending on the influence human-made structures have had on the shoreline in the past, the prescription for how to move forward with aesthetics, cost, and conservation are most important. Figure 85 outlines approaches to shoreline stabilization and infrastructure preservation tactics tailored to Great Lakes ecosystems.

STRUCTURAL	NON-STRUCTURAL	GRAY-GREEN
Revetment	Vegetation maintenance and enhancement	Breakwater with living shoreline
Groin	Sand dune construction	Living breakwater or artificial reef
Sea wall	Wetland restoration	Living revetment/ sea wall
Breakwater	Beach nourishment	
	Managed retreat	

Figure 86 – Examples of shoreline stabilization and protection approaches (Allan, Callewaert & Olsen, 2018)

Under perfect conditions, restoration of shorelines would progress from structural hardened approaches to non-structural approaches, only relying on gray-green infrastructure in occasional applications. Although individuals and grass-roots level initiatives can be successful, shoreline restoration is most profound when done holistically and with continuity, which includes publicly owned shoreline areas. As shown in Figure 86, existing coastal infrastructure such as roads and parking lots adjacent to the shoreline, may no longer be appropriate, with the enhanced knowledge we have about coastal processes, and threats of more extreme storms and precipitation events.

Figure 86 shows that existing road location was hindering coastal processes; once relocated and a beach reestablished, coastal processes are able to resume, creating habitat, while also providing similar opportunity for visitation and enjoyment. When planning for and designing new infrastructure, marrying the needs of the environment *and* recreation *and* business will be a necessity, and may result in a more desirable end product for everyone. A similar example of beach-parking infrastructure dynamics is unpacked in Case Study 2.

As 'concrete jungles', urban areas often suffer from increased runoff and evapotranspiration rates due to an inability of precipitation to permeate the ground, replenishing groundwater reserves and aquifers. In some cases, the difference of the amounts of runoff in natural areas and urban areas can be considerable, as evidenced in stormwater outflow quantities. Low Impact Development (LID) is a term and methodology being popularized in urban areas to reduce costs and impacts associated with classic hard infrastructure by employing natural processes to manage stormwater. "LID practices incorporate 'green infrastructure' such as infiltration basins, green roofs, bioretention swales, engineered wetlands, and rain gardens to support the functions of traditional 'grey infrastructure' such as storm sewer pipes and outfalls." (City of London, 2018). Many of the LID methods are inexpensive to add to new communities and easy to retrofit into existing development and can range from large to small-scale projects (CVC, 2010). For example, a community or sub-division can implement a network of rain gardens to filter water and encourage shallow infiltration, or a single household can use rain barrels on downspouts to reduce a significant portion of their runoff water from entering storm sewers. In new developments, vegetated filter strips or eco-retention areas like wetlands can be preserved when planning a

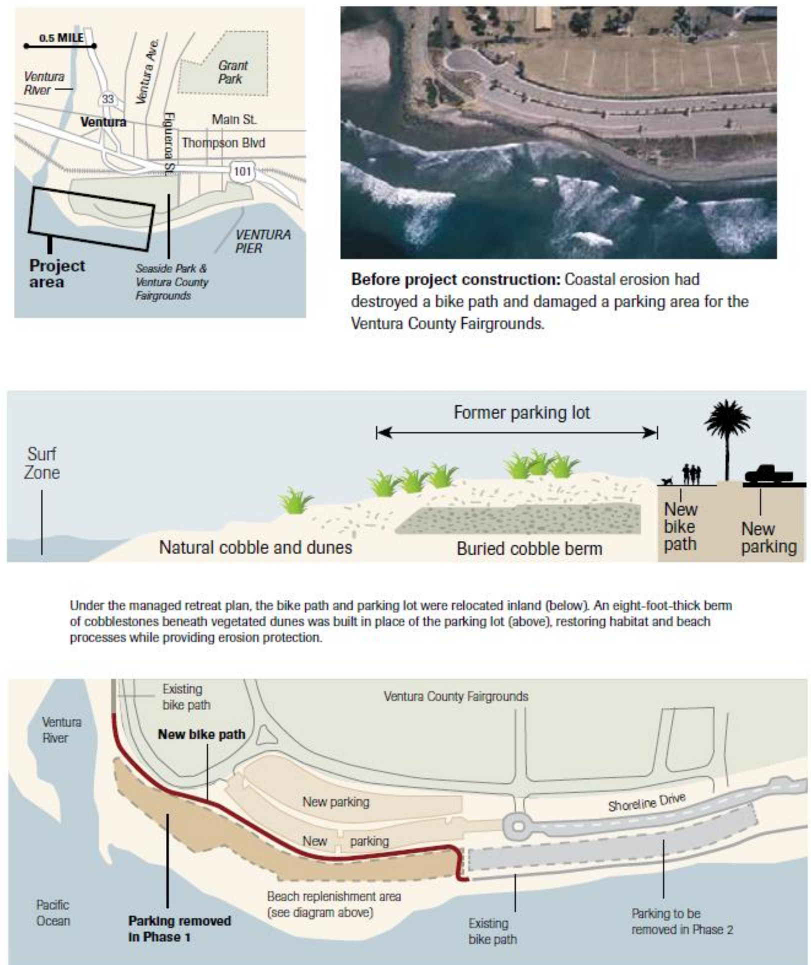


Figure 87 - Example of managed retreat in Surfers Point, Ventura California. Similar to North Shore Road in Port Elgin (Downing, 2013, p.17)

development, as well as using permeable pavements on roads and walkways to reduce water-influx on bordering natural ecosystems.

Figure 88 - Water movement in natural and urban areas (CVC, 2010).

Staff working at local governance agencies can easily access LID training courses through Credit Valley Conservation, both remotely and in-person training. Opportunities include becoming certified in *Sediment and Erosion Control,* or the *National Green Infrastructure Certification Program* (CVC, 2019). Requiring planning staff to be trained, or take training courses related to LID will enable these design measures to be more easily incorporated into the landscape of coastal communities, reducing impacts to water quality and improving community resilience.

Focusing on built environments that are the most degraded, including industrial lands, as well as areas of highest risk (e.g. development affecting sensitive coastal ecosystems like dunes) will enable local governance to prioritize projects. Local governance in other nearby communities has already provided incentives to businesses looking to reduce their ecological footprint and improve the ecological integrity of their lands.

CASE STUDY 4: BUFFERS AND IMPERMEABLE PAVEMENTS

Many public shoreline access points on the southeastern coastal corridor are owned or managed by local governance agencies. These locations are often hardened with impermeable pavements, hardened shoreline structures, or infrastructure to provide amenities to high summer visitation. Although best intentions were made to efficiently invest in infrastructure that would withstand many seasons of use, often inappropriate or misguided techniques have been employed, where alternative infrastructure could be used in its place. In this example, comparisons of good and bad community development Best Management Practices (BMP’s) can be viewed on one site. There is rarely consistency across the shoreline, or within individual recreation areas. This example (Figure 88) illustrates the application of vegetated mature dune and buffer strip near point 1, where sand is halted in the vegetation keeping it off the parking lot. Rain water falling on the parking lot area is also filtered by the vegetation as it makes its way to the nearshore waters. The vegetation is trapping any point and NPS pollution that could be travelling with the runoff water or snow melt, including nutrients, chemicals, or plastic pollution and garbage. Whereas, 60-metres away at Point 2, there is no vegetation to catch or filter pollutants, sand is blowing up on the parking lot, due to aeolian transportation, and the beach has been flattened, with no mature dune blocking wave uprush or sediment erosion off the beach.

Figure 89 - Buffers and impermeable pavements in Sarnia

This site is challenging because of the asphalt parking lot meant to accommodate heavy visitation with parking for almost 700 vehicles covering an expanse of the coastal corridor. The buffer area between the parking lot and beach area is covered by trees and shrubs, creating a mature dune area approximately 40-metres wide. Some heavily used areas, like that of Point 1 in Figure 88, are common within shoreline recreation areas, where the dune has been flattened by trampling, vegetation removed, and slope of beach reduced.

There are two improvements that could be made for this area to reduce stressors; (1) retrofit parking area to permeable pavement upon the end of its lifespan; (2) apply bioretention swales adjacent to parking lot and in boulevards to allow for infiltration of runoff to enter groundwater and reduce flow towards municipal stormwater drains or the mature dunes. “Parking lots produce the most significant pollutant loads and runoff volumes per unit area on public lands sites. Targeting runoff from these areas for bioretention practices produces a significant benefit to the local water balance and improves water quality” (CVC, 2015a, p.20). Replacing the asphalt surface with permeable pavements such as interlocking pavers which allow water to seep through cracks (e.g. Figure 89) will reduce runoff, improve nearshore water quality, and have a higher cultural aesthetic feel than intensified expansive concrete.

Figure 90 - Permeable interlocking concrete pavement (building.ca)

Permeable pavements and pavers are in use all over Ontario and can have snow plowed off them, making them perfect for extended seasonal visitation in winter. These pavement types are already being used at the Singing Sands visitor parking lot, and other forms of permeable surfaces, such as gravel, are being used in smaller visitor nodes. Installing bioretention swales with native, perennial, drought tolerant vegetation will increase pollinator habitat, reduce landscaping costs and grass cutting efforts, and will provide aesthetic value to the area. In this example, the parking lot is separated into two areas with a grassed strip separating them (Figure 90). This grassed area could be retrofitted into a swale to catch runoff water, provide pollinator habitat, and increase shaded areas around the parking lot to reduce the heat island effect.

Positive aspects going for this day use area include a lack of excess light pollution (no street lights), and the wide mature dune vegetated buffer, whereas other stressors to this area include the metal groynes, and uncertain invasive species treatment methods. Another positive aspect of this location is the partnerships formed to improve dune habitat. Natures Way, the Sarnia Air Cadets, and other partners have events to restore the dunes at Canatara Park by planting dune grass, harvested from local provincial parks and to do beach clean-ups to remove litter and hazards (Kula, 2019). Partnerships and initiatives between grass-roots groups and local governance provide a 'many hands make light work' approach to shoreline stewardship, with organizers of these types of events saying that dune grass planting and beach clean-ups are at "no cost to the city, and it really makes a difference to the health of our water quality, and it provides incredible habitat for so many species" (Kim Gledhill; Kula, 2019). Partnerships with local field naturalist groups, horticulturalists, students, and special interest groups could be made to build and maintenance rain gardens, bioretention swales, or further dune improvements, mutually benefitting all groups and visitors to the area.

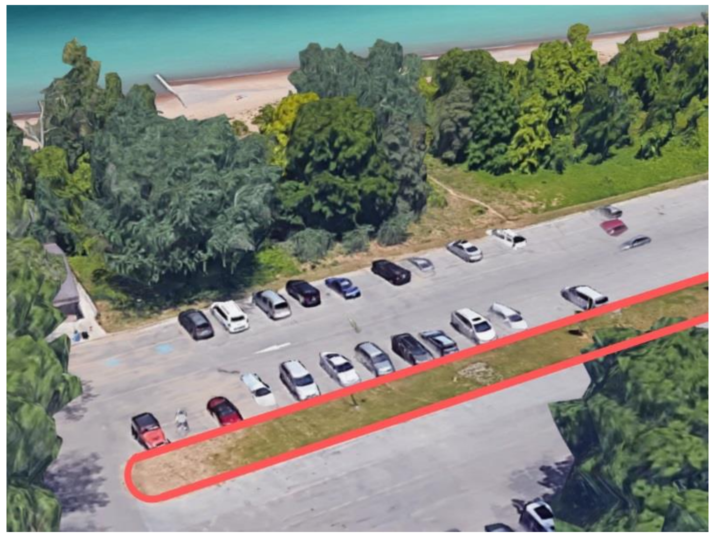


Figure 91 - Area available for bioretention swale opportunity at Canatara Beach and Park (Google Maps)

REGIONAL GOVERNANCE

Regional inputs to improvements of community development and land-use planning may take the longest to implement, but would be extremely beneficial in creating standards for development and planning that demand resiliency and sustainability measures be adopted for coastal and inland communities. Methods of contributions by regional governance include:

- Amendments to building codes requiring LID practices applied to developments and infrastructure projects.
- Encourage demonstration areas of resilient and healthy coastal communities through funded projects and multi-level partnerships in high-use areas to restore or protect areas.

Adapting current regulation, bylaws, and building codes is a medium to long-term approach to improve community resiliency and encouragement of coastal communities and landowners to uptake sustainability initiatives. In the current regional governance climate, regulation through acts, bylaws and regulation are most common, but are rarely understood by local landowners. Planning approaches using regulation, "*attempt to lessen* *undesirable impacts of development. While effective, regulation misses the positive opportunities associated with citizen interest and action. A community-based approach to addressing ecosystem issues is needed to bring about positive change. The notion of 'Think Globally, Act Locally' provides motivation*" (Huron County, 2015a, p.23). Therefore, amending these documents and regulations are important to push unwilling people to change, but should not be used in isolation of promoting and funding coastal grass-roots groups and local governance to completing resiliency projects that fit best for their community.

In other parts of the world, installation of LID technology is commonplace and widely accepted for its cost saving and environmentally conscious services. For example, in Victoria Australia, where fresh water is a limited resource, rainwater catchment is commonplace at the regional scale, with the City of Melbourne building and managing several systems to capture and treat stormwater to reduce urban flooding, improve water quality of nearby waterways, reduce costs of fresh water, and enhance liveability of coastal citizens living in Melbourne (City of Melbourne, 2019). Applying LID practices on regional level infrastructure will take time as infrastructure lifespans end and replacement becomes necessary, contributing to a long-term coastal resiliency plan. However, upgrading this infrastructure will set the tone for other 'green' infrastructure projects that are attainable in the short term, including urban forestry canopy cover increases, invasive species control, repurposing existing gardens into rainwater catchment or bioretention areas.

7.5 EDUCATION, ACCOUNTABILITY AND PARTNERSHIPS

Increased public awareness and education about coastal processes, sensitivity of coastal habitats, and initiatives to reduce stressors are needed across all three levels of 'governance'. A demand for educational resources, online, in person, and easily accessible in different formats was requested by the public and partners during the LHCCC 2017 online questionnaire and through the 2017-2019 Coastal Community Workshops. The main concern of people responding to the survey, or attending these events was that they are 'preaching to the converted', and environmental groups need to increase awareness through other avenues to convey to those not typically drawn to environmental events workshops or information. Four methods of education and outreach were requested and recommended by attendees and respondents;

- short informational videos,
- social media posts,
- workshops and,
- presentations to community groups.

These methods were identified as the most practical and diverse set of communication and education tools. These four methods of increasing awareness and educating the coastal community are all fantastic, but short lived, meaning they must be repeated annually to ensure the information is getting to all individuals, through different channels, and providing the most up-to-date scientific data. Although projects like restoration initiatives or campaigns can disseminate this type of information, there are rarely funds that grass-roots organizations can apply for that are strictly education and outreach driven. Partnerships and combining multiple outcomes of certain projects can allow for this type of work during a project.

Other forms of organic education and outreach through societal norms are possible as the awareness of impacts increases. For example, 2018 was the year of the plastic straw, where social media and news coverage was inundated in the issue of plastic pollution in the worlds oceans and the effects this has on wildlife and water quality. Through the recognition and sharing of these issues, society all over the world recognized that alternatives were needed to replace the ‘status quo’, which also brought about plastic bylaws including some businesses and cities pledging to go single-use plastic free in the next decade.

Accountability of grass-roots, local governance, and regional governance to answer to stressors put on coastal environments is still an emerging concept with issues around engagement and policy to ensure uptake. “Accountability refers to the obligation that authoritative actors have to provide justification for their actions, and the right of those affected to evaluate and sanction those actions” (Kramarz & Park, 2017). Accountability works best when taken on from a holistic community approach, with many willing partners influencing other less willing partners to positively change to increase environmental integrity. “Accountability can enable due processes and tangible outputs that address specific problems” (Kramarz & Park, 2017). Holding organizations accountable to stressors they create and insisting on change may enable education, awareness and partnership creation to mitigate impacts.

Figure 92 - Plastic straw reduction tips

GRASS-ROOTS

Encouraging communication and partnerships among grass-roots organizations, clubs, businesses, and NGO’s will effectively encourage education, awareness, and success/failure associated with preservation and restoration initiatives. Creating space and opportunity for this type of knowledge sharing seems most effectively done currently through grass-roots run events, social media, and expansion of current partnerships. Reminding one another that we are all aiming at similar targets, and sharing the successes and ways they were able to overcome challenges will allow similar positive projects to be efficient with time and money, as well as encourage other communities and groups to complete similar initiatives. Blue Bayfield has become a blue community, reducing single use plastic, and inspiring two more communities along the southeastern shores to follow suit. They have had inquiries from over 30 communities across southwestern Ontario about how to become a blue community.

Engaging existing community groups such as Business Improvement Associations (BIA’s) to expand their mandates to hold businesses in communities accountable to conform to certain sustainability standards to reduce impacts, including what products they sell or produce, alternative eco-friendly alterations to businesses could be extremely effective in reducing stressors added to coastal ecosystems.

“The B.I.A. usually involves improvements to the physical environment and appearance of the business area, and economic redevelopment programs such as area-wide promotions and advertising campaigns… B.I.A. improvements and activities also help to create a more vibrant local community and a more prosperous local economic environment. A more vibrant community attracts more visitors and retains more local customers of all

types of services – including dining, entertaining and professional services. In addition, a more vibrant community creates a more inviting atmosphere that clients and customers will enjoy visiting" (Goderich BIA, 2019).

Environmental organizations addressing stressors affecting environmental integrity of coastal ecosystems adjacent to communities could approach BIA's or cottage association presidents to encourage accountability and partnerships to cohesively reduce impacts produced by the community. For example, some local businesses are eagerly reducing their impacts of point and NPS pollution, but others are completely oblivious of their impacts. Increasing education and awareness of effects coastal communities have on coastal ecosystems, and increasing accountability measures through keeping up with community eco-champions will set the tone for the rest of the coastal communities.

CASE STUDY 5: LOCAL BUSINESS TAKING ACTION THROUGH ACCOUNTABILITY

Educating local business through partnerships about how point and NPS pollutants affecting coastal environments has had ripple effects in communities. Cait's Café, a coffee shop in Goderich Ontario realized the impact their coffee cups, cold drink containers, take out bags, and straws had on the waste stream and potential for littering on the shoreline of Goderich. They reduced their impacts by ensuring drink containers were recyclable, as Goderich doesn't have a municipal composting program; take out containers were decomposable or recyclable; and straws were paper. Cait's Café installed a water bottle refill station in their café; provide a discount to patrons bringing reusable drink containers, and ensure local produce is used in their food and drink to support local producers. Figure 92 shows Caitlin, owner of Cait's Café unpacking their first shipment of paper straws in April 2018.

Figure 93 - Caitlin Vail of Cait's Cafe unpacking paper straws

Patrons are supporting the switch; "*customers are happy to see we have paper straws. The paper straw does cost about 14x more than plastic, so while they are included in the purchase of any of our iced drinks, we do charge $0.10 if they want a straw with our canned beverages. At first, people were a bit surprised by the price, but once they saw they were paper straws, they understood. A lot of people refuse to buy a straw, so that's nice to see as well. I think if people were given a choice every ▯me, a lot of people would opt to go straw-less. Often, we are given a lot of encouragement and support in our decision to switch from plastic to paper*" (LHCCC, 2018a).

Cait's Café is taking accountability for the positive and negative impacts their business has on the environment and on the health and wellness of their community. Through awareness of these impacts, they were able to make informed, sustainable changes that did not impact the business's bottom line, and in effect became a positive draw for consumers wanting a greener option.

LOCAL GOVERNANCE

Local municipalities, CA's, First Nations, and Métis will all succeed through enhanced partnerships. In a time with ever-changing governments, and ever-changing budgets, having partnerships between local governance groups will encourage resource sharing. Saugeen Valley Conservation Authority (SVCA) relys on the Lake Huron Centre for Coastal Conservation (LHCCC) to provide coastal and shoreline specific expertise to their planning department, regulations department, and landowners within that watershed. By partnering with the LHCCC, SVCA can use their existing extensive knowledge base, while being able to focus on their own knowledge base of riparian and watershed-scale initiatives. Working together towards restoration projects, such as the Brucedale Conservation Area Phragmites removal, enables a sharing of fiscal and temporal resources, and a collaboration of expertise among these two groups and other experts from across the discipline. Participation of local industry is important to partnerships with local governance agencies as well, to increase knowledge sharing. Typically, corporate industry has corporate responsibility initiatives that can benefit and enhance partnership activities like restoration projects, rehabilitation efforts, and monitoring initiatives. Grasping onto these opportunities for collaboration more frequently will enable long-term formation of relationships and better communication across the coastal corridor. Collaboration and consistency among agencies in their regulations and bylaws will improve consistency of preservation and improvement of shoreline ecosystems.

A Stewardship Guide for the Lake Huron Coastline prepared in 2006 by a partnership of organizations produced a guide, "intended for non-farm residents, cottagers and property owners along the Canadian shore of Lake Huron from Tobermory to Sarnia" (Huron County, 2006). This guide was developed as a tool to allow landowners and individuals to evaluate properties and management opportunities through completion of worksheets and frameworks, allowing the user to learn how they may improve their local water quality through land stewardship (Huron County, 2006). Similar guides have been produced for specific communities across the southeastern shores and provide education to those living in the coastal corridor. Partnering local governance groups and grass-roots organizations can produce guides specific to each community to relay best management practices for interactions between community and coastal ecosystems.

Programs like Green Ribbon Champion (LHCCC), and Green Shores (BC Stewardship Centre) provide education and outreach, resources and technical information to enable landowners, land managers, and local governments guiding principles to preserve or restore their shorelines to enhance the ecological integrity of shoreline ecosystems, reduce pollutants entering ecosystems, and reduce cumulative impacts to nearshore waters (SCBC, 2019). The programs have various funding sources, but can provide the education and incentive for landowners to complete work on their property to reduce stressors and enhance environments. Partnerships and collaboration are necessary to support programs like this, often requiring permits, funding, and support from multiple levels of governance.

MANAGING EXPECTATIONS

Understanding why people value the shoreline, and why they want to visit or live along Lake Huron's shores is only one part of managing the expectations of those who use this coastal corridor. The ability for land managers and planners to mitigate the expectations of those living and visiting this fragile piece of nature is becoming more and more important in the equation of getting support for best management practices. If visitors or landowners expect to have a certain service provided, like beach grooming, they will be disappointed or their experience will be altered due to reality not meeting their expectation. Something as simple as using a photo of a home on a clear bluff, or a perfectly groomed beach on tourism or real estate advertisements is an easy way that someone could have their expectation set. They then want their cottage to look like 'the home with a view' in the ad, or when they go to the beach if it isn't perfectly groomed then they could perceive this area as having poor maintenance or 'dirty'. Working with partner agencies across different disciplines and industries in this area to taper messaging to realistic conditions will enable higher customer satisfaction when visiting, and more understanding of how Lake Huron's coast is naturally formed when living on the coast.

Some organizations in Michigan have excellent examples of how to tailor the expectation of visitors and residents in promotional material. In one guide, the organization states clearly that expectations may not be met if those unaware of the natural location's ecological state is different to that of which they expected;

"*If having a sandy beach is very important to you, you may be disappointed with a lake that has a natural muck bottom. A natural shoreline may appeal to those seeking a quiet retreat, scenic beauty, or good fishing spots. If you enjoy power boating or water skiing, you may be looking for a deeper, larger lake that can accommodate the right equipment. It may also be important that you and your neighbours share a common vision (lake culture) of desired lake experience. If everyone on the lake is there for similar purposes, there may be fewer conflicts over how the lake is being used. Many potential waterfront property buyers have a mental picture of the ideal lake setting and experience they would like. But property owners' attempts to change the natural features of their lake (shorelines, lakebed) can harm many of the features (good water quality, fishing) and values (privacy, natural setting) that drew them to the water in the first place. With more than 15,000 lakes in the state, there are many types and sizes all with their own unique character and natural assets. Waterfront property is a big investment. Make sure you find the lake property that best matches your expectations and desired lake experience*" (Wisconsin Lakes, 2016)

Clearly stating what to expect, how to make choices that best suit the needs of the visitor or landowner, and providing alternatives to match that person's interests with an existing location will better mitigate negative effects from incompatible development, land-use change, and actions. Regional tourism organizations or real estate companies could become fluent in the natural amenities each community and shoreline area have, as well as level of threats by natural or human-made causes, and provide this information to potential buyers before they purchase property. Alternatively, keeping education and awareness flowing to existing landowners and communities is important to notify them of changes both positive and negative to the ecological integrity of their area of the shoreline. For example, Wisconsin Lakes provides outreach material to enable understanding of how landowners can protect their shoreline and why this should matter to them;

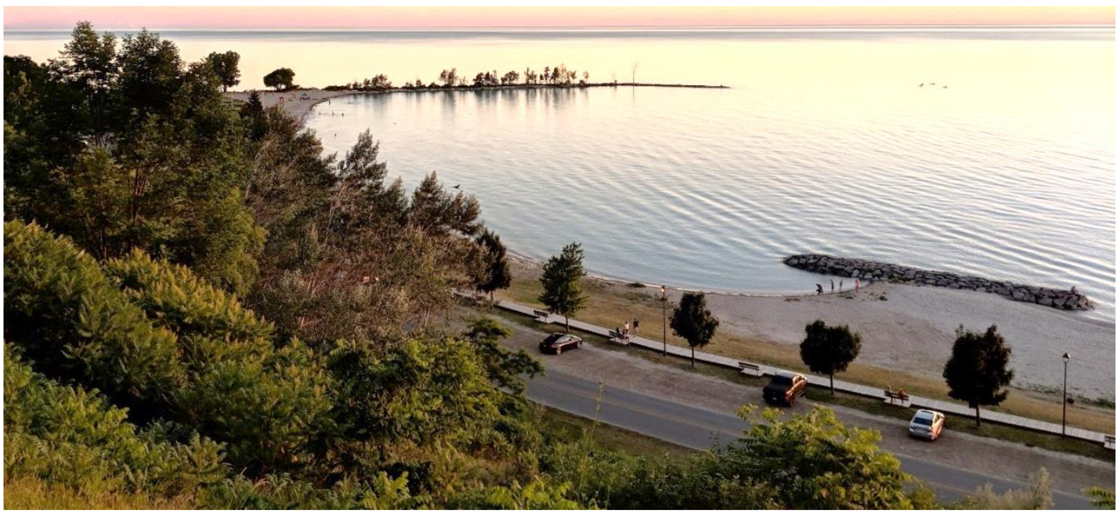
"*As a shoreline property owner, you can help protect water quality, open space and natural beauty for yourself, your neighbours, and future generations. A growing number of studies show that people prefer clean water and will pay more to live on lakes with better water quality. What you and your neighbours do to sustain or improve water quality will improve resale potential. On the other hand, if water quality is degraded, lower property values could result. Activities such replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for aquatic invasive species to establish themselves in a lake, muffle noise from watercraft, and preserve privacy and natural scenic beauty."* (Wisconsin Lakes, 2016).

Local governance and agencies must be accountable to the limitations of carrying capacity and ecological integrity they rely on for tourism, real estate, business and recreation. Through mitigating the expectations of residents and visitors, understanding and action towards improving ecological integrity will be less of a surprise to residents and more of an initiative to be proud of. In Case Study 6, the Town of Goderich shows that up-front costs are not the only factor that should influence development, using the shoreline boardwalk as a platform to discuss the importance of coastal health, dynamic beach areas, and accountability for ecological integrity.

CASE STUDY 6: GODERICH BOARDWALK IS ACCOUNTABLE

The Town of Goderich hosts a beautiful sand beach and dune, and cobble beach shoreline, which is used year-round for recreation and enjoyment. Along the 1.5 km of shoreline, there runs a wooden boardwalk heavily used and accessible to beach users, runners, and families alike. Installed in the mid-1980's, this boardwalk is up for replacement, with several options being proposed by the awarded consulting firm. The new 3-meter wide boardwalk could be made from pressure treated timber, concrete, or a combination of the two (Jackson, 2019). From an up-front cost perspective, timber would cost approximately $160.00 CAD per square meter, whereas concrete would cost $90.00 CAD, both with an anticipated lifespan of 15-20 years (Jackson, 2019). Mayor John Grace hopes to keep the natural aesthetic and benefits of the wooden boardwalk to reducing runoff and thermal pollution stating the increased cost of using timber would be worthwhile when considering maintaining the notable cultural identity of the existing wooden boardwalk and reducing ecological impact (Jackson, 2019).

Figure 94 - Rotary Cove in Goderich, showing the wooden boardwalk running parallel to the shoreline



Other council members were keen to change the boardwalk to a combination of concrete and wood, or completely concrete, however, concrete boardwalks are less environmentally friendly than wooden slat boardwalks. Runoff, thermal pollution, and loss of infiltration opportunity from precipitation all make concrete the less favourable choice from an ecological perspective. Although the cost of timber is almost double, Mayor John Grace is holding the Town of Goderich environmentally accountable for the choices they make as infrastructure is replaced. In an interview, John Grace says, "There are some things that are going to cost more, and this is one of them. I think it is precious to keep our waterfront as pristine and natural as possible. We are not Toronto, we are not St. Catherine's, we are Goderich, on the shores of Lake Huron" (Jackson, 2019). Another point of replacing the existing boardwalk with timber is maintaining the character of the existing structure, as it has become a notable feature of the three beaches across Goderich's shoreline, and replacing it with a similar product would maintain the cultural identity of this area. The Town of Goderich, and Mayor John Grace is showing that it is possible to be accountable for tough decisions, while educating and raising awareness of environmental integrity in the process.

REGIONAL GOVERNANCE

Regional governance often plays a role in initiatives that happen through grass-roots and local governance through fiscal support and general policy and regulation. However, through this somewhat 'hands-off' approach to many community projects, respondents from the 2017 questionnaire and attendees to coastal workshops stated there is an 'ivory tower effect' where staff at the MNRF, MECP, and ECCC are not as available or approachable for inquiries and assistant as staff in local governance or grass-roots groups. Although regional governance funnels funding to local groups through grants, funds, and allocations, they rely on the trust built between landowners and local agencies that have expertise and knowledge of local areas and issues. Work done by regional governance is extremely important to analysing the health assessments of coastal ecosystems, with inventory projects concurrently being produced at the same time as this plan is being written. Without baseline inventories of coastal habitats across the shoreline, land management would not be possible to find adequate improvements necessary to improve the ecological integrity of coastal habitats.

As stated through the Great Lakes Guardian Community Fund, a major goal is to, "partner with conservation groups, watershed organizations, environmental organizations, the public and others on projects to protect the Great Lakes, such as projects to reduce pollution, manage fisheries, conserve and restore wetlands, and recover species at risk" (Ontario, 2012). Continuing partnerships with local and grass-roots organizations to provide funding opportunities for restoration, protection, and education initiatives will enable these groups to continue the important work they do to create awareness and action towards resiliency and sustainability in their communities. Without partnerships between grass-roots, regional and local governance, and the fiscal contributions they have made, plans like this could not be possible, therefore, they are integral to continue and expand.

Providing standards of resiliency and sustainability through policy and regulation for environmental accountability is important to setting basic standards for environmental protection and land management. These acts and policies are essential when defending ecosystem destruction cases in a court of law, however, are hard to enforce if 'grey area' exists in the writing. Ensuring consistency among regional acts and plans to cover the entire southeastern shores, as well as what will and will not be defended and enforced, will enable higher levels of compliance across shoreline landowners and land managers.

CHAPTER 8: SUMMARY OF RECOMMENDATIONS

The Coastal Action Plan would not be complete without a set of actions and recommendations made through the review of coastal habitats and stressors and threats that affect them. There have been many recommendations made throughout the extent of this document; this section attempts to summarize them.

Strategies

Area of Concern	Action Item	Target if applicable	Needs
1.0 Sustainable and climate resilient development			
1.1 Permeable pavements	– Should be applied where appropriate as per CVC's guidelines as infrastructure upgrades are needed, these practices should be considered before traditional methods.		– Education of staff for awareness of products, and maintenance procedures.
1.2 Dark sky lighting	– All municipal lighting should be switched to dark sky certified as infrastructure replacement projects arise. – 3000K or less – All outdoor lighting should be shielded	– All municipalities and counties along the southeastern shores should adopt a Lighting bylaw based on IDA & IED, 2011 Model Lighting Ordinance or other valid bylaws. – 100% dark sky compliant fixtures in municipal and residential settings by 2029.	– Education of staff and individuals for the importance of these features. Bylaw requiring these fixtures to be used.
1.3 Stormwater sinks	– As infrastructure upgrades are completed, bioswales, rain gardens, and pollinator habitat should be incorporated into the design using LID best management practices.	– All new infrastructure upgrades incorporate LID design to reduce stormwater runoff.	– Education of staff for awareness of products and maintenance procedures. – Regional incentive programs for municipalities, community associations and landowners to build and maintenance stormwater sinks.
1.4 Eco harbours and river mouths	– Using actions from AOC's, 1.1, 1.2, 1.3, LID practices should be used for the operation of harbours. – Dredging activities should be ceased immediately, with use of floating docks and re-naturalized shorelines where applicable.	– Bylaws restricting or eliminating dredging activities.	–
1.5 Hardened shorelines	– Reduce amount of shoreline hardening structures and km of hardened shorelines.	– <10% of shoreline hardened, maximum. – <1 structure every 6km maximum.	– Landowner education and awareness of stressors caused by hardened shorelines. – Collaboration and community willingness to remove all structures. – Municipality support to remove structures by implementing a bylaw requiring the restoration of shoreline when structure reaches end of life.

1.6 Transportation corridors	– Reduce salt use on roads, enable vegetative cover over roadways, during infrastructure upgrades, install eco-passages, reduce road density where possible, remove invasive species from roadsides.	– Road density thresholds exceeding 14m/ha cause negative impacts to water quality of wetlands and inland waters. – Map and monitor abundance/population of roadside noxious weeds and invasive species.	–
1.7 Beach Grooming	– Stop mechanical beach grooming, switch to hand grooming. Work with blue flag beach program to incorporate these standards	– Stop all mechanical beach grooming- switch to hand grooming. – Groomer may be used once per year at the beginning of the season after ice melt to remove storm debris including plastic.	– Reallocation of beach grooming budget to go from beach groomer algae harvester, to employing summer staff to walk beaches every day cleaning up by hand, ensuring adequate garbage and recycling receptacles are available, and ensuring these are emptied frequently.
1.8 Societal Consumerism	– support community groups in becoming 'blue communities' to reduce single-use plastic waste, encourage refill stations in public areas, and local business who reduce waste.	– All major communities in the coastal corridor become blue communities.	–
2.0 Restoration of coastal ecosystems			
2.1 Beaches and dunes	– Increase dunes on beaches across the coastal corridor	– 8-10m wide dunes existent on all sand beaches not considered relic at low water level (<176.43m, IGLD85). – Stop vehicles from driving on beaches using barriers, education and enforcement.	– Education for private landowners and businesses along shorelines to build and maintain dunes. – Incentive programs for individuals requiring resources to complete dune restorations. – Enforcement for infractions of dune destruction.
2.2 Bluffs and gullies	– Increase education of bluff erosion	– 100m wide vegetated buffer at top of slope of Gully and Bluff. – 30m wide development restriction buffer zone to protect from load stress.	–
2.3 Wetlands	– Remove invasive species from coastal wetlands, increase protection status of locally significant coastal wetlands to meet the provincially significant designation. Increase enforcement of infractions of development in and around wetlands	– 6% of sub-watersheds and 10% of major watershed should be wetland cover – No loss of current wetland cover – Protection of all locally significant wetlands through bylaws and CA regulation.	–
2.4 Woodlands	– Connectivity increases, forest cover increases to minimum standards	– 30% of each Assessment Unit woodland canopy cover.	– Increase awareness of importance of interior habitat to landowners to preserve existing large coastal habitats.
2.5 Re-naturalize corridors, and buffer zones	– Reinstate the adequate buffer zones around creeks and rivers as per regulation and policy. Enforcement of infraction to be increased to ensure compliance.	– 30m vegetated buffer on either side of warm and cold-water watercourses. – 75% of stream length must be naturally vegetated and have canopy cover.	– Increased resources put towards incentives for buffers, and enforcement of these thresholds.
3.0 Monitoring, Education, and Outreach			

3.1 Best management practice guides	– Create or update Best Management Practice guides for shoreline stewardship.	– Each municipality or township will have their own BMP guide tailored to their specific shoreline. Two guides are already in existence (Township of Huron-Kinloss, Municipality of Kincardine), and other municipalities can follow suit.	– Funding and resources required, and partnerships necessary to complete BMP Guides.
3.2 Monitoring toolkits	– Create or update standardized monitoring toolkits for each habitat type.	– Create or update monitoring tool kits for each ecosystem type, partnering between grass-roots.	– Monitoring toolkits available for free, resources required to create these toolkits. Partnerships and combination of resources to enable this action.
3.3 Academic community contributing to research	– Academia to partner with land managers to collect data on biodiversity features, indicators and thresholds.	– Enable academia to create targets for resiliency and sustainability.	–
4.0 Partnerships and Collaboration			
4.1 Support annual communication events	– Continue to host the Annual Municipal Forum for Lake Huron's Shoreline; the 'Is the Coast Clear' Lake Huron Conference, the 'State of Lake Huron Conference', and others.	– Continually increase attendance at these events. – Include local and regional governance, grass-roots groups, First Nations and Métis, and individuals.	
4.2 Partnerships to complete work	– Support knowledge and data sharing between groups to enable grass-roots change, supported by local and regional governance. (e.g. Healthy Lake Huron, Blue Bayfield, Green Goderich).	–	– Need communication strategies, and partnership opportunities through projects.
5.0 Governance, Regulation and Incentives			
5.1 Incentive programs	– Regional and local governance giving/ receiving incentive programs to local NGO and landowners to complete restoration projects on private land	–	–
5.2 Regulation, bylaw, and policy consistency	– Consistency in bylaws for shoreline management, including: shoreline protection bylaw (Appendix C), shoreline tree preservation bylaw	– Consistent bylaws implemented by 2022	
5.3 Education and Awareness			–

CHAPTER 9: CONCLUSIONS

Through the development of the Coastal Action Plan, public support from coastal communities along the Sarnia to Tobermory coastline has been palpable. Many individuals, agencies, and groups want to make positive changes, but don't know where to start. The CAP's intention is to encourage partnerships, and positive action through awareness of best management practices, and targeted goals to aim towards.

Intentions to review the actions proposed through this document in 3-5 years to see how land managers and individuals have taken the recommendations and translated them into positive land management practices are set. Evaluation of changes made by grass-roots, local, and regional entities and how they align with the thresholds and actions recommended will allow for an adaptive management loop to re-evaluate and improve the goals and targets originally set out by this plan. The key aspects governing whether this plan is successful at eliciting change is pronounced in the "Action" completed through the recommendations. Taking a baseline assessment of coastal ecosystems, stressors that affect them, and opportunities that exist for improvement provoke action to improve the state of our coastal corridor health. Through the completion of projects guided by recommendations, a feedback loop of monitoring, evaluation, and reporting is required through the principals of adaptive management. As Peter Drucker, a writer of Management practices states, "what gets measured gets managed". Measuring changes both positive and negative through monitoring will enable land managers in grass-roots, local, and regional governance to plot their impacts and successes towards resiliency and sustainability. "*The results of monitoring will help evaluate program effectiveness and improve future programs. If monitoring shows that conditions remain better than standards, then current actions can be maintained until monitoring shows that standards will likely be exceeded. If monitoring shows that previously acceptable conditions have deteriorated and now exceed standards, then new actions are called for*" (Stankey et al., 1985, p.19). The theories of accountability, communication, and cooperation are at the forefront of inspiring positive environmental action across the coastal corridor. Once partnerships are formed, holding one another accountable for negative changes, or a lack of positive changes will encourage consistency in management. Supporting one another using communication and cooperation to complete large, expensive, or widespread projects to address issues will reduce the burden of tackling them alone, sharing the responsibility of success and failure.

CA's already have a system of monitoring, evaluation, and reporting through their watershed report cards, which have successfully been tracking the health of indicators in their watersheds for almost a decade. However, a system like this does not currently exist for the shoreline, most likely due to a lack of consistent monitoring protocols or thresholds, as discussed in Chapters 4 and 5. By engaging with grass-roots, local, and regional governance about the recommendations of this CAP, working together to devise a strategy of implementation, monitoring, communication, and adaptation, fulfillment of the recommendations will happen. A strategy to monitor and recognize change include;

1) Revisiting this CAP in 3-years (2022) to determine what strategies were implemented, where work still needs to be done and where hurdles occur. Reporting the progress of recommendation implementation will hold partners accountable and allow celebration of the successes together.
2) Continuing to hold the Annual Coastal Municipal Forum to share successes, communicate struggles, and discuss opportunities for collaboration among local and regional governance.
3) Ensuring constant awareness campaigns to increase the education and outreach of information covering topics of sensitive coastal ecosystems, best management practices, and stressors. These communications should be multi-pronged with academic published papers, educative videos, social media, community workshops, webinars, and presentations and presence at community events.

Adaptive management suggests setting milestones and adapting to new goals as others are met. Ensuring projects are completed, celebrated, and built upon will produce healthy, resilient coastal ecosystems and communities. Carrying on outreach and engagement activities such as the coastal community workshops, questionnaires, and municipal forum to unite and share information are extremely important in eliciting change. The Lake Huron Centre for Coastal Conservation intends to continue these opportunities to support these recommendations in the Plan. The 2016-2019 Coastal Action Plan for the Southeastern Shores of Lake Huron was developed thanks to motivated and passionate individuals who care about the coastal corridor of the Lake Huron. This project would not be possible with the generous funding of: Ontario Trillium Foundation, Environment and Climate Change Canada, Ministry of Environment, Conservation and Parks.

RESOURCES

Aamjiwnaang First Nation [AFN]. (2018). *Welcome to Aamjiwnaang*. Retrieved from, http://www.aamjiwnaang.ca/

Advancement Project. (2011, Dec). *A Short Guide to Community Based Participatory Action Research*. Retrieved from, https://hc-v6-static.s3.amazonaws.com/media/resources/tmp/cbpar.pdf

Albert, D., Wilcox, D.A., Ingram, J.W., Thompson, T.A. (2005, Dec). *Hydrogeomorphic Classification for Great Lakes Coastal Wetlands.* Journal of Great Lakes Research. 31:129-146. DOI: 10.1016/S0380-1330(05)70294-X

Alden, A. (2017, June 5). *All about sediment grain size.* Geology. Thoughtco Science. Retrieved from, https://www.thoughtco.com/all-about-sediment-grain-size-1441194.

Allan, D. J., McIntyre, P.B., Smith, S.D.P., Halpern, B.S., Boyer, G.L., Buchsbaum, A., Burton, G.A.Jr., Cambell, L.M., Chadderton, W.L., Ciborowski, J.J.H., Doran, P.J., Eder, T., Infante, D.M., Johnson, L.B., Joseph, C.A., Marino, A.L., Prusevich, A., Read, J.G., Rose, J.B., Rutherford, E.S., Sowa, S.P., Steinman, A.D. (2012). *Joint analysis of stressors and ecosystem services to enhance restoration effectiveness*. Proceedings of the National Academy of Sciences of the United States of America. Vol 110. No.1, P.372-377.

Allan, M., Callewaert, J., Olsen, K. (2018). *Great Lakes Water Levels Integrated Assessment Report*. Graham Sustainability Institute. University of Michigan. 80pp.

Allen, G. (1996). Personal Communication.

Annis, G.M., Pearsall, D.R., Kahl, K.J., Washburn, E.L., May, C.A., Franks, T.R. (2017). *Designing coastal conservation to deliver ecosystem and human well-being benefits*. PLoS ONE 12(2): e0172458. Retrieved from, https://doi.org/10.1371/journal.pone.0172458

Ausable Bayfield Conservation Authority [ABCA]. (2019). *Protect Water, buy a Rain Barrel.* News. Retrieved from, https://www.abca.ca/post/?ID=929

Ausable Bayfield Conservation Authority [ABCA]. (2018). *Huron County Clean Water Project.* Forestry and Stewardship. Retrieved from, http://www.abca.on.ca/page.php?page=huron-county-clean-water-project

Ausable Bayfield Conservation Authority [ABCA]. (2018a, Feb). *Rain gardens are helping to protect Lake Huron.* Healthy Lake Huron. Retrieved from, https://www.healthylakehuron.ca/post/?ID=194

Atkinson, D.E., Forbes, D.L. and James, T.S. (2016). *Dynamic coasts in a changing climate; in Canada's Marine Coasts in a Changing Climate,* (ed.) D.S. Lemmen, F.J. Warren, T.S. James and C.S.L. Mercer Clarke; Government of Canada, Ottawa, ON, P.27-68.

Austin, J., Colman, S. (2008). *A century of temperature variability in Lake Superior*. Limnology and Oceanography 53:2724-2730.

Baird. (2019 [1]). *Appendix B: Considerations for Shoreline Protection Structures.* Shoreline Management Plan 2019. Ausable Bayfield Conservation Authority. Baird and Associates.

Baird and Associates [Baird]. (2019, Feb). *Shoreline Management Plan 2019*. Ausable Bayfield Conservation Authority. Prepared by Baird and Associates.

Bakowsky, W.D., Henson, B.L. (2014). *Rare Communities of Ontario: Freshwater Coastal Dunes.* Natural Heritage Information Centre. Ontario Ministry of Natural Resources. 10pp + appendices. Retrieved from, https://www.researchgate.net/profile/Wasyl_Bakowsky/publication/282365025_Rare_Communities_of_Ontario_Freshwater_Coastal_Dunes/links/560ea69208aec422d11213d4.pdf

Ball, H., Jalava, J., King, T., Maynard, L., Potter, B., Pulfer, T. (2003). *The Ontario Great Lakes Coastal Wetland Atlas: A Summary of Information (1983-1997).* Retrieved from, https://longpointbiosphere.com/download/Environment/Ontario.Great_.Lakes_.Coastal.Wetland.Atlas-2003.pdf

Baird, 1994

Beavers, R.L., A.L. Babson, and C.A. Schupp [eds.]. (2016). *Coastal Adaptation Strategies Handbook.* NPS 999/134090. National Park Service. Washington, DC

Belton, K. (2018, Jun). *Removing Microplastics from Our Environment.* Canada's National Observer. Retrieved from, https://www.nationalobserver.com/2018/06/29/opinion/removing-microplastics-our-environment

Berkers, T. (2018). *Light Pollution & Smart Solutions.* Presentation in Port Franks Ontario for the Lake Huron Coastal Speaker Series.

Bhurji, J. (2014). *Lake Huron Bluff Coastal Geo-Hazard Checklist.* Prepared by the Lake Huron Centre for Coastal Conservation. 10pp. + Appendices.

Bolton, D., Mayer-Pinto, M., Clark, G., Dafforn, K., Brassil, W., Becker, A., & Johnston, E. (2017). *Coastal urban lighting has ecological consequences for multiple trophic levels under the sea*. Science of The Total Environment,576, P.1-9.

Bonsal, B.R., Peters, D.L., Seglenieks, F., Rivera, A., and Berg, A. (2019). *Changes in freshwater availability across Canada.* Chapter 6 in Canada's Changing Climate Report, (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario, p. 261–342.

Brenden, T.O., Brown, R.W., Ebener, M.P., Reid, K., Mewcomb, T.J. (2012). Great Lakes Commercial Fisheries: Historical Overview and Prognoses for the future. University of Michigan. Retrieved from. https://www.canr.msu.edu/qfc/publications/pdf-publications/2011-publications/GLFPM_Commerical_Fishing_Chapter_Submitted_Revision_031110.pdf

Brown, A.C., McLachlan, A. (2002). *Sandy shore ecosystems and threats facing them: some predictions for the year 2025.* University of Cape Town, South Africa. Zoology Department. P.16

Bruce Peninsula Biosphere Association [BPBA]. (2019). *Dark Skies.* Conservation, Sustainable Development, Capacity Building. Retrieved from, https://www.bpba.ca/projects/dark-sky

Bruce Peninsula National Park [BPNP]. (2018). *Resource Conservation Annual Report 2018.* Bruce Peninsula National Park and Fathom Five National Marine Park. 28pp.

Bruce Peninsula National Park. [BPNP]. (2019). *Resource Conservation Annual Report 2018.* Bruce Peninsula National Park and Fathom Five National Marine Park. Parks Canada.

Bruce Power. (2018). *Bruce Power's License Renewal Briefing.* Published work. CS170222 R000

Bush, E., Lemmen, D.S. (2019): *Canada's Changing Climate Report; Government of Canada*, Ottawa, ON. Editors. P.444

Canadian Food Inspection Agency (CFIA). (2018). Ceratocystis fagacearum (Oak Wilt) – Fact Sheet. Plant Pests/ Invasive Species. Government of Canada. Retrieved from, http://www.inspection.gc.ca/plants/plant-pests-invasive-species/diseases/oak-wilt/fact-sheet/eng/1325629194844/1325632464641

Campbell, Don. (2018). *Plastic not just a problem in our oceans, also affecting the Great Lakes: U of T Research.* University of Toronto News. Retrieved from, https://www.utoronto.ca/news/plastic-not-just-problem-our-oceans-also-affecting-great-lakes-u-t-research

Canadian Wildlife Service [CWS]. (2019). Important Bird Areas site summary. Retrieved from, https://www.ibacanada.com/site.jsp?siteID=ON154&ang=EN&siteID=ON154&ang=EN

Carolinian Canada Coalition. (2018). Conservation Action Planning. Retrieved from, https://caroliniancanada.ca/conservation-action-planning

Chandler, J, P. (1991) *River Channelization: Impacts and Alternatives.* Research Review. University of Guelph.

Cherkauer, K.A., Sinha, T. (2010). *Impacts of future climate change on soil frost in the midwestern United States.* Journal of Geophysical Research. Vol. 115, D08105. doi:10.1029/2009JD012188, 2010

Chippewas of Kettle and Stony Point First Nation [KSPFN]. (2009). *Arts Language and Culture.* Retrieved from, http://www.kspcommunityculture.ca/culture.html

City of London. (2019). *Low Impact Development (LID).* City of London Stormwater Management. Retrieved from, https://www.london.ca/residents/Sewers-Flooding/stormwater/Pages/Best-Management-Practices-(BMP's).aspx

City of Melbourne. (2019). *The Value of Stormwater.* Retrieved from, http://urbanwater.melbourne.vic.gov.au/melbournes-water-story/the-value-of-stormwater/

Circular Tayside. (2017). *What is the Circular Economy?* From a linear to a circular economy. Retrieved from, https://circulartayside.co.uk/what-is-the-circular-economy/

Coastal First Nations. (2017a). *Local Economic Development Fact Sheet.* Coastal First Nations. EBM Fact Sheet 6. Retrieved from, http://coastalfirstnations.ca/our-land/land-stewardship/

Coastal First Nations. (2017b). *Keeping the Land and People Fact Sheet.* Coastal First Nations. EBM Fact Sheet 5. Retrieved from, http://coastalfirstnations.ca/our-land/land-stewardship/

Cooper, M.J., Gyekis, K.F., Uzarski, D.G. (2012). *Edge effects on abiotic conditions, zooplankton, macroinvertebrates, and larval fishes in Great Lakes fringing marshes.* Journal of Great Lakes Research. 38. 2012. 142-151. DOI:10.1016/j.jglr.2011.12.011

The Corporation of the Township of Huron-Kinloss [Huron-Kinloss]. (2015). *Beach Management Agreement: By-law 2015-79.* October 19, 2015.

The Corporation of the Township of Huron-Kinloss [Huron-Kinloss]. (2014). *Algae Clean Up Policy Amendment: By-Law 2014-59.* July 21, 2014.

County of Bruce. (2010). *County of Bruce Official Plan.* Bruce County. Retrieved from, https://brucecounty.on.ca/sites/default/files/County%20Plan_Consolidated_September%202017_2.pdf

Credit Valley Conservation [CVC]. (2019). *Low Impact Development Training.* Credit Valley Conservation Authority. Retrieved from, https://cvc.ca/low-impact-development/lid-training/

Credit Valley Conservation [CVC]. (2015). *Low Impact Development Residential Retrofits: Engaging Residents to Adopt Low Impact Development on their Properties.* Residential Lands. Credit Valley Conservation. 60 pp. Retrieved from, https://cvc.ca/wp-content/uploads/2015/01/Grey-to-Green-Residential-Guide1.pdf

Credit Valley Conservation [CVC]. (2015a). Low Impact Development Public Lands Retrofits: Optimizing Parks, Public Buildings, Schools and Places of Worship through Low Impact Development. Public Lands. Credit Valley Conservation. 128 pp. Retrieved from, https://cvc.ca/wp-content/uploads/2014/03/Grey-to-Green-Public-Lands-Retrofits-Complete_3.pdf

Credit Valley Conservation [CVC]. (2010). *Low Impact Development Stormwater Management Planning and Design Guide*. Credit Valley Conservation Authority & Toronto Region Conservation Authority. Retrieved from, https://sustainabletechnologies.ca/app/uploads/2013/01/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf

Cross, M., Campbell, M., Martz, M. (2007). *Vegetative Best Management Practices: A Manual for Pennsylvania/Lake Erie Bluff Land Owners.* Pennsylvania Coastal Zone Management Program. CZM Project Number 2005-PS.04. http://seagrant.psu.edu/publications/erosion.htm

Davidson-Arnott, R., Mulligan, R. (2016). *Shoreline Management Plan 2016 Consultant Recommendation Report.* Ausable Bayfield Conservation Authority. August 2016.

DeCatanzaro, R., Cvetkovic, M., Chow-Fraser, P. (2009). *The Relative Importance of Road Density and Physical Watershed Features in Determining Coastal Marsh Water Quality in Georgian Bay.* Environmental Management (2009) 44:456–467. DOI 10.1007/s00267-009-9338-0

Department of Fisheries and Oceans [DFO]. (1996a). *Module 6: Sandy Beaches and Dunes.* By the Sea. A guide to the coastal zone of Atlantic Canada. ISBN 0-660-16410-8

Derksen, C., Burgess, D., Duguay, C., Howell, S., Mudryk, L., Smith, S., Thackeray, C. and Kirchmeier-Young, M. (2018). *Changes in snow, ice, and permafrost across Canada; Chapter 5 in Canada's Changing Climate Report.* (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario. P.194–260.

Dietz, T., Fitzgerald, A., Shwom, R. (2005). *Environmental Values.* Annual Review Environment and Resources. 30(1):355-72. DOI:10.1146/annurev.energy.30.050504.144444. Retrieved from, https://www.researchgate.net/publication/228624754_Environmental_Values

Dodds, W.K., Whiles, M.R. (2010). *Responses to Stress, Toxic Chemicals, and Other Pollutants in Aquatic Ecosystems.* Freshwater Ecology (Second Edition). Retrieved from, https://www.sciencedirect.com/science/article/pii/B9780123747242000167 or, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/thermal-pollution

Donnelly, P. (2013). *Southern Georgian Bay Shoreline Stewardship Guide.* The Lake Huron Centre for Coastal Conservation. 52pp.

Downing, J. (2013) *Reducing Climate Risks with Natural Infrastructure).* The Nature Conservancy. Prepared with support of the California Landscape Conservation Cooperative, the California Coastal Conservancy, and Pacific Gas and Electric.

Dube, D. (2017, Apr 19). *Living near nature may be the secret to a longer life and better mental health.* Global News. Retrieved from, https://globalnews.ca/news/3389031/living-near-nature-may-be-the-secret-to-a-longer-life-and-better-mental-health/

Dugan, JE., Airoldi, L., Chapman, MG., Walker, SJ., Schlacher, T. (2011). *Estuarine and Coastal Structures: Environmental Effects, A Focus on Shore and Nearshore Structures.* Treatise on Estuarine and Coastal Science. Vol.8,17-41, DOI: 10.1016/B978-0-12-374711-2.00802-0, Elsevier Inc.

Durst, B. (2019, June 14). *Tackling Plastic.* Goderich Signal Star. Retrieved from, https://www.goderichsignalstar.com/news/local-news/tackling-plastic?fbclid=IwAR1xdX7WiC8ZQQ6At5oH0B9bzhOahnVShWb0GglKr_4BFWmjK2ArtpMZwvE

Eagles, P.F.J., McCool, S.F., Haynes, C.D.A. (2002). *Sustainable Tourism in Protected Areas: Guidelines for Planning and Management*. IUCN Gland, Switzerland and Cambridge, UK. xv + 183pp.

Environment and Climate Change Canada & U.S. Environmental Protection Agency [ECCC & USEPA]. (2018). *Lake Huron. Lake-wide Action and Management Plan*, 2017-2021. Cat. No. En164-56/2018E-PDF; ISBN 978-0-660-25841-6

Environment and Climate Change Canada & U.S. Environmental Protection Agency [ECCC & USEPA]. (2011). *State of the Great Lakes, 2011 Highlights.* ISSN 1924-0279. Cat. No. En161-3/2011E. Retrieved from, https://archive.epa.gov/solec/web/pdf/solec2011highlights_e.pdf

Environment Climate Change Canada [ECCC]. (2016). *The Great Lakes Nearshore Framework.* Retrieved from, https://binational.net/wp-content/uploads/2016/09/Nearshore-Framework-EN.pdf

Environment Climate Change Canada [ECCC]. (2013). *How Much Habitat is Enough?* Third Edition. Toronto, Ontario. ISBN. 978-1-100-21921-9. Retrieved from, https://www.epa.gov/climate-indicators/climate-change-indicators-lake-ice

Environment Climate Change Canada [ECCC]. (2003). *The Ontario Great Lakes Coastal Wetland Atlas: A Summary of Information (1983-1997).* ISBN Number: 0-662-33822-7. P.123.

Environment Climate Change Canada [ECCC]. (2002). *Great Lakes Coastal Wetlands – Science and Conservation.* Great Lakes Fact Sheet. Catalogue No. En 40-222/11-2002E; ISBN 0-662-31654-1

Environmental Commissioner of Ontario [ECO]. (2018). *Back to Basics- Southern Ontario's Wetlands and Forests.* 2018 Environmental Protection Report. Toronto: The Queens Printer for Ontario.

Environmental Law Clinic, University of Victoria faculty of Law, and Deborah Curran & Company [ELC]. (2007, Nov). *Green bylaws Toolkit for Conserving Sensitive Ecosystems and Green Infrastructure.* Retrieved from, http://www.elc.uvic.ca/press/documents/greenbylaws_web1207.pdf

Environmental Law & Policy Centre [ELPC]. (2019). *An Assessment of the Impacts of Climate Change on the Great Lakes.* 74 pp. Retrieved from, http://elpc.org/wp-content/uploads/2019/03/Great-Lakes-Climate-Change-Report.pdf

Falchi, F., Cinzano, P., Duriscoe, D., Myba, C.C.M., Elvidge, C.D., Baugh, K., Portnov, B.A., Rybnikova, N.A., Furgoni, R. (2016, Jun). *The new world atlas of artificial night sky brightness.* Science Advantage. E1600377. P.1-25

Forests Ontario. (2016). *Invasive Species: A Challenge to the Environment, Economy and Society.* Retrieved from, https://www.forestsontario.ca/wp-content/uploads/2016/01/FinalStudyGuide-1.pdf

Franks Taylor, Rachael, Amy Derosier, Keely Dinse, Patrick Doran, Dave Ewert, Kim Hall, Matt Herbert, Mary Khoury, Dan Kraus, Audrey Lapenna, Greg Mayne, Doug Pearsall, Jen Read, and Brandon Schroeder. (2010). *The Sweetwater Sea: An International Biodiversity Conservation Strategy for Lake Huron – Technical Report.* A joint publication of The Nature Conservancy, Environment Canada, Ontario Ministry of Natural Resources Michigan Department of Natural Resources and Environment, Michigan Natural Features Inventory Michigan Sea Grant, and The Nature Conservancy of Canada. 264 pp. with Appendices.

Fraser, M.W., Short, J., Kendrick, G., McLean, D., Keesing, J., Byrne, M., et al. (2017, July). *Effects of dredging on critical ecological processes for marine invertebrates, seagrasses and macroalgae, and the potential for management with environmental windows using Western Australia as a case study.* Ecological Indicators. Vol 78, P.229-242.

Froklage, R., Lant, C., Misbah, A., O'Leary, E., Payton, E. (2013). *Assessing and Mitigating Plastic Pollution in Lake Huron.* Prepared for The Lake Huron Centre for Coastal Conservation by Hydra Horizons Consulting.

Fyon, A. (2009). *Life on the Rocks: Manitoulin Geology and Flowering Plants*. Ontario Geological Survey. Retrieved from, http://ontariowildflower.com/manitoulin_nature_club_june0509_andy_fyon_final.pdf

Goderich BIA. (2019). *Downtown Goderich BIA.* Goderich BIA. Retrieved from, http://www.goderichbia.ca/detailed-information-of-a-bia

Goodban, A., Reid, R., Riely, J., Potter, H., and Reschke. (1999). *Great Lakes Alvars.* The Nature Conservancy (TNC) and the Federation of Ontario Naturalists (FON).

Government of British Columbia [GBC]. (n.d.). Road Density by Watershed. Forests, Lands, Natural Resources. Retrieved from, www.for.gov.bc.ca/hfd/pubs/docs/mr/mr112/page20.pdf.

Government of British Columbia [GBC]. (2001). *Gully assessment procedure guidebook.* 4th Edition., Version 4.1. For. Prac. Br., Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. ISBN 0-7726-4653-8

Government of Canada. (1999). *Environmental Protection Act.* Retrieved from, https://laws-lois.justice.gc.ca/eng/acts/C-15.31/

Government of Ontario [Ontario]. (2019, Aug). *Produce responsibility for Ontario's waste diversion programs.* Government of Ontario. Retrieved from, https://www.ontario.ca/page/producer-responsibility-ontarios-waste-diversion-programs

Government of Ontario [Ontario]. (2018). *New Horizons: Ontario's Agricultural Soil Health and Conservation Strategy.* Ontario Ministry of Agriculture, Farming, and Rural Affairs. Retrieved from, http://www.omafra.gov.on.ca/english/landuse/soilhealth.htm

Government of Ontario [Ontario]. (2014). *Ontario Beach Tourism.* Ministry of Tourism, Culture and Sport. Presentation. 34 slides. Retrieved from, https://rto7.ca/Documents/Public/Reports-Ministry-of-Tourism-Culture-and-Sport/Ontario-Beach-Tourism-2014

Government of Ontario [Ontario]. (2013). *Ausable Bayfield Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses.* Conservation Authorities Act 1990. Ontario Regulation 147/06.

Government of Ontario [Ontario]. (2012). *Great Lakes Guardian Community Fund.* Ontario's Great Lakes Strategy. Retrieved from, https://www.ontario.ca/page/ontarios-great-lakes-strategy#section-6

Grey Sauble Conservation Authority [GSCA]. (2018). *Grey Sauble Watershed Report Card 2018.* Retrieved from, http://www1.greysauble.on.ca/wp-content/uploads/2018/03/GSCA_WRC_2018_CO_format_website.pdf

Haras, W.S., Bukata, R.P., Tsui, K.K. (2008). *Methods for Recording Great Lakes Shoreline Change.* Canada Centre for Inland Waters. P.174–184

Healthy Lake Huron [HLH]. (2012). *Pine River Watershed Integrated Watershed Management Plan.* Healthy Lake Huron, Pine River Watershed Initiative Network, Saugeen Valley Conservation Authority, OMAFRA. Retrieved from, http://www.healthylakehuron.ca/docs/2012-07-PRPLAN.pdf

Henson, B.L., D.T. Kraus, M.J. McMurtry and D.N. Ewert. (2010). *Islands of Life: A Biodiversity and Conservation Atlas of the Great Lakes Islands.* Nature Conservancy of Canada. 154pp.

Historic Saugeen Métis [HSM]. (2018). *Historic Saugeen Métis.* Retrieved from, http://saugeenmetis.com/about/

Hubbard, B., Kirkby, J., Ward, P. (n.d.). *Saving Sensitive Ecosystems: Coastal Bluff Ecosystems.* East Vancouver Island and Gulf Islands. Environment Canada; Ministry of Environment, Lands and Parks, British Columbia; Habitat Conservation Trust Fund. Retrieved from, http://www.env.gov.bc.ca/sei/van_gulf/doc/bluffs.pdf

Huron County. (2018). *Forestry Services.* Retrieved from, https://www.huroncounty.ca/plandev/forestry-services/

Huron County. (2018a). *Huron Natural Heritage Plan DRAFT.* Huron County. January 3, 2019. 29 pp. Retrieved from, https://www.huroncounty.ca/wp-content/uploads/2018/04/Huron-Natural-Heritage-Plan-April-2018.pdf

Huron County. (2016). *Huron County Economic Development Plan 2016-2020.* County of Huron Economic Development Department. Retrieved from, https://www.huroncounty.ca/economic-development/new-strat-plan/

Huron County. (2015). *Huron Natural Heritage Plan Technical Document.* Draft. Huron County Planning Department. 115 pp.

Huron County. (2015a). *Huron County Official Plan.* County of Huron Planning and Development Department. Retrieved from, https://www.huroncounty.ca/wp-content/uploads/2013/08/Huron_Official-Plan_2015.pdf

Huron County. (2013). *Forest Conservation By-Law.* BY-LAW: NO. 38-2013 – HURON COUNTY

Huron County. (2006). *A Stewardship Guide for the Lake Huron Coastline*. Huron Stewardship Council. 162 pp. Retrieved from, http://theguide.huronstewardship.ca/wp-content/uploads/sites/10/2014/01/coastal_manual.pdf

Huron Health Unit [HHU]. (2019). *Beach Water Quality*. Retrieved from, https://www.huronhealthunit.ca/health-topics/beach-water-quality/

Huynh, Patricia. (2015). *A bioassessment of the impact of livestock restriction on benthic macroinvertebrate communities in the Grand River watershed in Ontario, Canada.* Masters Thesis presented to the University of Waterloo. Retrieved from, https://uwspace.uwaterloo.ca/bitstream/handle/10012/9722/Huynh_Patricia.pdf?sequence=3&isAllowed=y

International Dark Sky Association [IDA] (2019). *Light Pollution*. Retrieved from, www.darksky.org

International Dark Sky Association [IDA]. (2019a). *LED: Why 3000K or Less*. Retrieved from, https://www.darksky.org/our-work/lighting/lighting-for-citizens/3k/

International Dark Sky Association [IDA]. (2019b). *Outdoor Lighting Basics*. Retrieved from, https://www.darksky.org/our-work/lighting/lighting-for-citizens/lighting-basics/

International Dark Sky Association [IDA], Illuminating Engineer Society [IES] (2011). *Model Lighting Ordinance*. Retrieved from, https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_MLO_FINAL_JUNE2011.PDF

International Joint Commission [IJC]. (2014, June). *Great Lakes Ecosystem Indicator Project Report.* A Report of the IJC Priority Assessment of Progress towards Restoring the Great Lakes. International Joint Commission.

Irwin, A. (2018, Jan). *The dark side of light: how artificial lighting is harming the natural world.* NATURE. 553, 268-270. DOI: 10.1038/d41586-018-00665-7

Jackson, P. (2019). Goderich to price new beach front boardwalk. Bayshore Broadcasting. Retrieved from, http://www.country1049.ca/news_item.php?NewsID=111982

Jalava, J.V. (2008). Alvars of the Bruce Peninsula: A Consolidated Summary of Ecological Surveys. Prepared for Parks Canada, Bruce Peninsula National Park, Tobermory, Ontario. iv + p.350 + appendices.

Junior, D. R., Santos, S. R., Travassos, M., Vianna, M. (2012). Impact on a fish assemblage of the maintenance dredging of a navigation channel in a tropical coastal ecosystem. Brazilian Journal of Oceanography,60(1), p.25-32.

Kemkes, R., Salmon-Tumas, M. (2019). *Climate Change Adaptation Guide*. Center for Rural Communities. Northland College.

Kettle & Stony Point First Nation [KSPC]. (2018). *Kettle & Stony Point First Nation.* Retrieved from, https://kettlepoint.org/

Kincardine Yacht Club (2018). *Kincardine Yacht Club.* Retrieved from, http://www.kyc.ca/?page_id=355).

Kinzelman, J.L., Pond, K.R., Longmaid, K.D., Bagley, R.C. (2010). *The effect of two mechanical beach grooming strategies on Escherichia coli density in beach sand at a southwestern Lake Michigan Beach.* Aquatic Ecosystem Health & Management. Volume 7. P.425-432

Kost, M.A., Albert, D.A., Cohen, J.G., Slaughter, B.S., Schillo, R.K., Weber, C.R., Chapman, K.A. (2007). *Natural Communities of Michigan: Classification and Description.* Michigan Natural Features Inventory, Report No. 2007-21, Lansing, MI.

Kramarz, T., Park, S. (2017, Jan). *Introduction: The Politics of Environmental Accountability.* Review of Policy Research. Vol 34, Issue 1. P.4-9.

Kuhn, S., Duzel, S., Eibich, P., Krekel, C., Wustemann, H., Kolbe, J., Martensson, J., Goebel, J., Gallinat, J., Wagner, G.G., Lindenberger, U. (2017, Sep). *In search of features that constitute an 'enriched environment' in humans: Associations between geographical properties and brain structure.* Science Rep. 7(1):11920. Doi: 10.1038/s41598-017-12046-7

Kula, T. (2019, April 27). *Dune Grass Planting Part of Parks Cleanup Day*. The Sarnia Observer. Retrieved from, https://www.theobserver.ca/news/local-news/dune-grass-planting-part-of-parks-cleanup-day

LaBoucane-Benson, P., Gibson, G., Benson, A., Miller, G. (2012). *Are We Seeking Pimatisiwin or Creating Pomewin? Implications for Water Policy*. The International Indigenous Policy Journal, 3(3). Retrieved from: http://ir.lib.uwo.ca/iipj/vol3/iss3/10 DOI: 10.18584/iipj.2012.3.3.10

LaCroix, H. (2015). *Opportunities for Redistribution and Area Planning in Parks: A Case Study at Bruce Peninsula National Park.* Master of Environmental Studies Thesis. University of Waterloo. 83pp.

Land Stewardship Centre [LSC]. (2019). *Ecosystem Services.* Retrieved July 15, 2019 from; http://www.landstewardship.org/ecosystem-services-biodiversity/

Lake Huron Centre for Coastal Conservation [LHCCC]. (2019). *Plastic Free Lake Huron.* Plastic Action Plan, A Quick Guide to Plastic Pollution in the Great Lakes. Fact Sheet. Lake Huron Centre for Coastal Conservation.

Lake Huron Centre for Coastal Conservation [LHCCC]. (2018). *Sustainability Spotlight: An Interview with Cait's Café.* July 2018 E-Newsletter. Lake Huron Centre for Coastal Conservation.

Lake Huron Centre for Coastal Conservation [LHCCC]. (2015). *Dune Vulnerabilities Checklist*. The Lake Huron Centre for Coastal Conservation.

Lake Huron Centre for Coastal Conservation [LHCCC]. (2013). *Lake Huron Bluff Stewardship Guide.* The Lake Huron Centre for Coastal Conservation.

Lake Huron Centre for Coastal Conservation [LHCCC]. (2008). *Stewardship of Lake Huron's Beaches & Dunes.* The Lake Huron Centre for Coastal Conservation.

Lake Huron Centre for Coastal Conservation [LHCCC]. (n.d. [1]). *The Trouble with Beach Grooming.* Fact Sheet. Lake Huron Centre for Coastal Conservation.

Lake Superior Binational Program [LSBP]. (2012). *Lake Superior Lakewide Management Plan Annual Report 2012. Retrieved from,* https://binational.net//wp-content/uploads/2013/01/ls-lamp-2012-en.pdf

Lake Superior Lake-wide Action and Management Plan Superior Work Group. [SWG] (2013). *Lake Superior Biodiversity Conservation Assessment.* P.130. (Updated March 2015).

Lambton County. (2019). *County of Lambton Official Plan.* County of Lambton. 136 pp.

Lambton County. (2014). *Urban Forestry – Municipal*. Lambton Shores. Retrieved from, http://www.lambtonshores.ca/en/things-to-do/resources/Part_5_2014_-_Urban_Forestry.pdf

Lambton Public Health [LPH]. (2019). *Beach Water Quality Surveillance.* Retrieved from, https://lambtonpublichealth.ca/health-info/beach-water-quality-surveillance/

Laporte, J. (2010, Sept). *Winter Application of Manure and Other Agricultural Source Materials.* Nutrient Management Act, 2002. Factsheet. Order No. 10-073. AGDEX 720/538

Lawrence, P.L. (1995). *Great Lakes Shoreline Management in Ontario.* The Great Lakes Geographer. Vol. 2. University of Waterloo. Department of Geography, No. 2. P.1-20

Lawrence, L.P. (1991). *Wave Energy and Sediment Transport patterns on southeastern Lake Huron and Implications for Shoreline Management.* University of Guelph, Faculty of Graduate Studies.

Liipere, S. (2014). *Community Conservation and Stewardship Plan for the Bruce Peninsula.* Bruce Peninsula Biosphere Association, Lion's Head, Ontario.

Longcore, T., Rich, C. (2004, May). *Ecological Light Pollution.* Frontiers in Ecology and the Environment. Vol 2. Iss. 4. Pp.191-198. https://doi.org/10.1890/1540-9295(2004)002[0191:ELP]2.0.CO;2

Lowitt, K., Johnston-Weiser, D., Lauzon, R., Hickey, G.M. (2018, Feb). *On food security and access to fish in the Saugeen Ojibway Nation, Lake Huron, Canada.* Journal of Great Lakes Research. Vol 44. Iss.1., P.174-183

Maitland Valley Conservation Authority [MVCA]. (2018). *Maitland Valley Watershed Report Card 2018.* Maitland Valley Conservation Authority. Retrieved from, http://www.mvca.on.ca/wp-content/uploads/2018/03/Watershed-Reportcard-2018.pdf

Maitland Valley Conservation Authority [MVCA]. (2013a). *Watershed Report Card, 2013.* Shoreline Sub-Basin. Maitland Valley Conservation Authority.

Maynard, L., Wilcox, D. (1996). *Background Report on the Great Lakes Wetlands.* Prepared for the State of the Great Lakes 1997 report issued jointly by the U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois, and Environment Canada, Toronto, Ontario.

McIlwraith, H.K., Lin, J., Erdle, L.M., Mallos, N., Diamond, M.L., Rochman, C.M. (2019, Feb). *Capturing microfibers – marketed technologies reduce microfiber emissions from washing machines*. Marine Pollution Bulletin., Vol 139. Pp. 40-45. https://doi.org/10.1016/j.marpolbul.2018.12.012

McLean, R.F., R.M Kirk. (1969). *Relationships between grain size, size-sorting, and foreshore slope on mixed sand – shingle beaches.* New Zealand Journal of Geology and Geophysics. 12:1, 138-155. DOI: 10.1080/00288306.1969.10420231

Michigan State University [MSU [1]]. (n.d.) *Limestone Cobble Shorelines.* Species and Natural Community Abstracts. Michigan Natural Features Inventory. Retrieved from, https://mnfi.anr.msu.edu/publications/abstracts

Michigan State University [MSU [2]]. (n.d.) *Alvars*. Species and Natural Community Abstracts. Michigan Natural Features Inventory. Retrieved from, https://mnfi.anr.msu.edu/publications/abstracts

Morales, C.I.M. (2015, Nov). *The Environmental Impacts of Marinas and Recreational Boating: Management Measures and How to Reduce Them.* Presentation. 27 Slides. Retrieved from, https://www.slideshare.net/lorettar/the-environmental-impacts-of-marinas-and-recreational-boating-management-measures-and-how-to-reduce-them

Municipality of Bluewater. (2019). *Energy Conservation and Demand Management Plan 2019-2023.* Schedule "A" to By-law 57-2019. Retrieved from, https://www.municipalityofbluewater.ca/Public/Page/Files/372_Energy%20Conservation%20and%20Demand%20Management%20Plan%20-%202019.pdf

Municipality of Bluewater. (2013). *By-Law No.16 – 20.* The Corporation of the Municipality of Bluewater. Retrieved from, https://bluewater.civicweb.net/filepro/document/3554/By-law%2016-2013%20-%20Authorize%20Blue%20Flag%20Program%20Application%20Submission.pdf

Municipality of Lambton Shores [MLS]. (2009). *Beach By-Law.* By-Law number 38 of 2009. The Corporation of the Municipality of Lambton Shores. Retrieved from, http://www.lambtonshores.ca/en/our-government/resources/beachbylawconsolidated.pdf

Municipality of Bluewater. (2008). *Usage of Beach, Marina and Water Areas: By-law 89-2008.* Municipality of Bluewater. December, 15, 2008.

National Geographic, (2018). *Mouth.* Encyclopedic Entry. Education. Retrieved from, https://www.nationalgeographic.org/encyclopedia/mouth/

National Oceanic and Atmospheric Association [NOAA]. (2019). *Historical Ice Cover Data.* Lake Huron. Retrieved from, https://www.glerl.noaa.gov/data/ice/#historical

National Oceanic and Atmospheric Administration [NOAA]. (2017). *Healthy Coastal Ecosystems.* Sea Grant. Retrieved from, http://seagrant.noaa.gov/WhatWeDo/CurrentFocusAreas/HealthyCoastalEcosystems.aspx\

Natural Resources Canada [NRCAN]. (2017). *Canada's Climate Change Adaptation Platform.* Annual Report for April 2016 to March 2017. Retrieved from, https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/adaptation/AP-AnnualReport-2016-17_accessPDF_EN.pdf

Nichols, K., Brzozowski, A. (2014, Aug). *A Landowner's Guide to Protecting Shoreline Ecosystems.* Islands Trust. Retrieved from, http://www.islandstrust.bc.ca/media/282417/Landowners-Guide-September-draft-revised.pdf

Northland College. (2019). *Healthy Sustainable Island Communities*. Great Lakes Islands Alliance. Retrieved from, https://www.northland.edu/sustainability/crc/great-lakes-islands/

Oceanwise. (2019). *Plastics Lab.* Coastal Ocean Research Institute. Retrieved from, https://research.ocean.org/program/plastics-lab

O'Neill, D. (2012, Aug). *Social, economic, and environmental concerns related to a marina development in Nova Scotia.* Petitions Catalogue. Retrieved from, http://www.oag-bvg.gc.ca/internet/English/pet_341_e_37603.html

Ontario Biodiversity Council [OBC]. (2015). *State of Ontario's Biodiversity.* Ontario Biodiversity Council, Peterborough, Ontario. Biodiversity Report. Retrieved from www.sobr.ca

Ontario Federation of Agriculture [OFA]. (2019). *Field Wind Breaks.* Best Management Practices. AF-167. Retrieved from, http://www.omafra.gov.on.ca/english/environment/bmp/AF167.pdf

Ontario Federation of Agriculture [OFA]. (2019). *Soil Health in Ontario.* Best Management Practices. AF-151. Retrieved from, http://www.omafra.gov.on.ca/english/environment/bmp/AF151.pdf

Ontario Federation of Agriculture [OFA]. (2018, April). *OFA reiterates responsible land-use policies to government.* Newsroom Commentaries. Retrieved from, https://ofa.on.ca/newsroom/ofa-reiterates-responsible-land-use-policies-to-government/

Ontario Human Rights Commission [OHRC]. (2018). *Indigenous spiritual practices.* Retrieved from, http://www.ohrc.on.ca/ko/node/16411

Ontario Invading Species Awareness Program [OISAP]. (2019). *Pathways.* Ontario Invading Species Awareness Program. Retrieved from http://www.invadingspecies.com/movement-of-wood/

Ontario Ministry of Agriculture, Food, and Rural Affairs [OMAFRA]. (2019). *New Horizons. Ontario's Agricultural Soil Health and Conservation Strategy.* Government of Ontario. 67 pp.

Ontario Ministry of Municipal Affairs and Housing [OMMAH]. (2014). *Provincial Policy Statement.* Retrieved from http://www.mah.gov.on.ca/Page10679.aspx

Ontario Ministry of Natural Resources [OMNR]. (2013). *Ontario Wetland Evaluation System Southern Manual.* 3rd Edition, Version 3.2. Ontario Ministry of Natural Resources. ISBN 978-1-4606-0201-0 PDF

Ontario Ministry of Natural Resources [OMNR]. (2005). *Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement.* 2nd Edition. Ontario Ministry of Natural Resources. ISBN 978-1-4435-1791-1

Ontario Ministry of Tourism, Culture and Sport [OMTCS]. (2018). *The Economic Impact of Visitor Survey 3028 in Huron County* (3540). Huron County. 5 pp.

Ontario Road Ecology Group & Toronto Zoo [OREG]. (2010). *A Guide to Road Ecology in Ontario.* Prepared for the Environment Canada Habitat Stewardship Program for Species at Risk. ISBN: 978-1-89541-50-6

Ontario Soil and Crop Improvement Association [OSCIA]. (2019). *Canada-Ontario Environmental Farm Plan.* Workshops and Webinars. Retrieved from, https://www.ontariosoilcrop.org/oscia-programs/workshops-webinars/environmental-farm-plan/

Ontario Trillium Foundation [OTF]. (2019). *Investment Strategy – what we fund.* Ontario Trillium Foundation. Retrieved from, https://otf.ca/sites/default/files/investment_strategy2.pdf

Ontario Urban Forest Council [OUFC]. (2019). *Provincial and Community Action.* Retrieved from, https://www.oufc.org/tree-education/community-action/

Orange, R. (2019, Jan 25). *How to clean Microplastics from the Oceans.* Alfa Laval. Retrieved from, https://www.alfalaval.com/media/stories/municipal-wastewater-treatment/membranes-a-solution-to-microplastics-in-our-oceans/

Parks Canada. (2018). *Point Clark Lighthouse National Historic Site.* Retrieved from, https://www.pc.gc.ca/en/lhn-nhs/on/clark/natcul-discover

Parks Canada. (2017). *Bruce Peninsula National Park – Geology.* Parks Canada. Retrieved from, http://www.pc.gc.ca/en/pn-np/on/bruce/decouvrir-discover/natcul1

Perth County United Way [PCUW]. (2013). *Huron County Agriculture.* Fact Sheet – Issue 1. 2013 Fact Sheet, Huron County, Ontario, Canada. Retrieved from https://perthhuron.unitedway.ca/wp-content/uploads/2014/01/Huron-County-2013-Agriculture-fact-sheet.pdf

Public Health Grey Bruce [PHGB]. (2019). *Recreational Water.* Retrieved from, https://www.publichealthgreybruce.on.ca/Your-Environment/Safe-Water/Recreational-Water

Pine River Watershed Initiative Network [PRWIN] (2017). *Livestock Exclusion Fencing.* Pine River Watershed Initiative Network Projects and Programs. Retrieved from, http://www.pineriverwatershed.ca/livestock-exclusion-fencin.cfm

Reinders, F.J. and Associates Canada Limited. (1989). Lake Huron Shoreline Processes Study for Ausable-Bayfield Conservation Authority, Maitland Valley Conservation Authority, St. Clair Region Conservation Authority, and Saugeen Valley Conservation Authority.

ReForest London. (2019). *Industrial Land Planting.* Retrieved from, http://reforestlondon.ca/industrial-land-planting-limited-time-offer

Reschke, C., Reid, R., Jones, J., Feeney, T., Potter, H. (1999, March). *Conserving Great Lakes Alvars.* Final Technical Report of the International Alvar Conservation Initiative. The Nature Conservancy.

Rivero, N.K., Dafforn, K.A., Coleman, M.A., Johnston, E.L. (2013). *Environmental and ecological changes associated with a marina.* Biofouling, 2013. Vol. 29, No. 7, P.803-815. http://dx.doi.org/10.1080/08927014.2013.805751

Royal Astronomical Society of Canada [RASC]. (2018). *Guidelines for Outdoor Lighting for RASC Dark-Sky Protection Programs.* Retrieved from, http://rasc.ca/sites/default/files/RASC-GOL_2018_1.pdf

Saugeen Ojibway Nation [SON]. (2018). *Saugeen Ojibway Nation.* Retrieved from, www.saugeenojibwaynation.ca

Saugeen Valley Conservation Authority [SVCA]. (2018). *Saugeen Conservation Watershed Report Card 2018.* Saugeen Valley Conservation Authority. Retrieved from, http://saugeenconservation.com/downloads/WatershedReportCard2018-SVCA.pdf

Sarnia Yacht Club. (2018). *Sarnia* Yacht *Club History.* Retrieved from http://www.sarniayachtclub.ca/content/sarnia-yacht-club-history)

Schroeder, H.W. (2011). *Environmental Values and Their Relationship to Ecological Services.* The Environmental Design Research Association. Proceedings of the 42nd Annual Conference of the Environmental Design Research Association. Chicago, Illinois. Retrieved from, https://www.nrs.fs.fed.us/pubs/jrnl/2011/nrs_2011_schroeder_001.pdf

Scott, D. (2013). *Climate Change, Water Levels and Ontario Tourism: Risks and Opportunities*. Presentation. Canada Research Chairs in Global Change and Tourism. University of Waterloo Environment. 33 slides. Retrieved from, https://rto7.ca/Documents/Public/Declining-Water-Levels/Declining-Water-Levels-Daniel-Scott-Research.aspx

Shortsleeve, C. (2017, Aug). *Why Being Near Water Really Does Make Us Happier?* Conde Nast Traveler Magazine. Retrieved from, https://www.cntraveler.com/story/why-being-near-water-really-does-make-us-happier

Simon, T.P. and Stewart, P.M. (2007). *Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat, and Indicators*. Authorhouse, Bloomington, IN. 1st Edition. ISBN:9781425928483

Smith, K. (2019, July). *More Water Filling Stations in Goderich*. Goderich Signal Star. Retrieved from, https://www.goderichsignalstar.com/news/local-news/more-water-filling-stations-in-goderich

Snell and Cecil Environment Research [SCER], (2004). *Land-use Planning as a Climate Change Adaptation Strategy for Great Lakes Coastal Wetlands.*

Snyder, M. (2014, Oct). *What is Forest Fragmentation, and Why is it a Problem?* Northern Woodlands. Retrieved from, https://northernwoodlands.org/articles/article/forest-fragmentation

SOLEC. (2011). *Great Lakes Indicator Review: Findings and Future Direction.* Retrieved from: http://lnsbr.nipissingu.ca/wpcontent/uploads/sites/10/2013/12/SOLEC_2011_GreatLakesIndicatorReviewFindingsandFutureDirection.pdf

Sources of Knowledge [SOK]. (2010). *Forests*. Sources of Knowledge Blog. Retrieved from, https://sourcesofknowledge.blog/

Stewardship Centre for British Columbia [SCBC]. (2019). *Green Shores.* Retrieved from, https://stewardshipcentrebc.ca/Green_shores/about/

Stewart, P.L., Rutherford, R.J., Levy, H.A., Jackson, J.M. (2003). *A Guide to Land Use Planning in Coastal Areas of the Maritime Provinces.* 177p. Retrieved from, http://www.dfo-mpo.gc.ca/Library/316491.pdf

Stankey, G.H., McCool, S.F., Stokes, G.L. (1984). *Limits of Acceptable Change: A New Framework for Managing the Bob Marshall Wilderness Complex.* Western Wildlands. 10 (3): 33-37.

St. Clair Region Conservation Authority [SCRCA]. (2018). *St. Clair Region Watershed Report Card 2018.* St. Clair Region Conservation Authority. Retrieved from, https://www.scrca.on.ca/wp-content/uploads/2018/03/SCRCA-WRC-2018.pdf

St. Clair Region Conservation Authority [SCRCA]. (2017). *Lambton Shores Tributaries Management Plan*. Retrieved from, http://www.healthylakehuron.ca/docs/Lambton_Shores_Management_Plan_Draft-May_2017.pdf

Sutherland, S. (2019). *Lake Erie's Toxic Algal Bloom Spreads, Prompting Warnings.* The Weather Network. Tuesday August 6th, 2019. Retrieved from, https://www.theweathernetwork.com/ca/news/article/ootw-algae-forecast-predict-large-summer-harmful-algal-bloom-for-lake-erie

Talbot Realty. (2018). *Cottage Lake Huron*. Talbot Realty Incorporated. Retrieved from, http://talbotrealty.com/lake-huron-cottages/

Terraprobe. (2019). *Shoreline Slope Stability Risks and Hazards Fact Sheet.* Appendix E: Ausable Bayfield Shoreline Management Plan 2019.

TD Economics & Nature Conservancy of Canada [TD & NCC]. (2017, Mar). *Putting a Value on the Ecosystem Services Provided by Forests in Canada: Case Studies on Natural Capital and Conservation.* 37 pp.

The Associated Press. (2019, Aug). *July was worlds hottest month on record, WMO says.* Technology & Science. Canadian Broadcasting Corporation (CBC). Retrieved from, https://www.cbc.ca/news/technology/july-hottest-month-1.5233368

The Ocean Cleanup. (2019). *How Can I Help Prevent Plastic Pollution?* Frequently Asked Questions. Retrieved from, https://theoceancleanup.com/faq/

Town of Goderich. (2019). *Energy Conservation and Demand Management Plan.* Town of Goderich. Retrieved from, https://www.goderich.ca/en/town-hall-and-services/resources/Documents/Town-of-Goderich-Energy-CDM-Plan-2019-005.pdf

Township of Stone Mills. (2015). *Shoreline Preservation Bylaw.* Retrieved from, https://stonemills.civicweb.net/document/5216/Shoreline%20Protection%20First%20Draft.pdf?handle=4AB9C1C23BD043208DF28C3256470C6C

Travalyst. (2019). *Travalyst: Travel as a catalyst for good.* Retrieved from, https://travalyst.org/

Tupman, K. (2004). *Impacts at the coast: Climate change influences on Lake Huron's water levels at Oliphant (Ontario).* Wilfred Laurier University. Theses and Dissertations (Comprehensive). 485. http://scholars.wlu.ca/etd/458

Twenty31. (2018). *Northern Bruce Peninsula Sustainable Tourism Management Plan: Recommendations for Consideration.* Final Report. 125pp. Retrieved from https://rto7.ca/RTO7/media/RTO7-Public-Documents/NBP-Sustainable-Tourism-Management-Plan-June-22.pdf

Twenty31. (2017, Dec). *Northern Bruce Peninsula Sustainable Tourism Management Plan*. Phase 2 Report – Updated. P.42

United Nations Environment Programme [UNEP]. (2019). *Coastal Zone Management.* Retrieved from, https://www.unenvironment.org/explore-topics/oceans-seas/what-we-do/working-regional-seas/coastal-zone-management

United States Army Corps of Engineers [USACE]. (2003). *Living on the Coast. Protecting Investments in Shore Property on the Great Lakes.* U.S. Army Corps of Engineers. Retrieved from, http://www.seagrant.umn.edu/downloads/ch002.pdf

United States Department of Agriculture [USDA]. (1999). *Chapter 2: Habitat Fragmentation.* Conservation Corridor Planning and the Landscape Level: Managing for Wildlife Habitat. Natural Resources Conservation Service. https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015259.pdf

United States Department of Agriculture [USDA]. (1985). *The Limits of Acceptable Change (LAC) System for wilderness planning.* General Technical Report INT-176. 43pp.

United States Environmental Protection Agency. [USEPA]. (2019). *Physical Features of the Great Lakes.* Retrieved from, https://www.epa.gov/greatlakes/physical-features-great-lakes

United States Environmental Protection Agency. [USEPA]. (2011). *Watershed Percent Impervious Cover*. Recovery Potential Metrics Summary Form. USEPA Office of Water Recovery Potential Screening Website. Retrieved from, https://www.epa.gov/sites/production/files/2015-11/documents/rp2wshedimperv1109.pdf

United States Environmental Protection Agency [USEPA]. (2011a). *Watershed Road Density.* Recovery Potential Metrics Summary Form. United States Environmental Protection Agency. Retrieved from, https://www.epa.gov/sites/production/files/2015-11/documents/rp2wshedroaddens1109.pdf

United States Environmental Protection Agency [USEPA]. (1985). *Coastal Marinas, An Environmental Approach.* 904K86100. Retrieved from the National Service Centre for Environmental Publications.

University of Hawai'i [UH]. (2014). *Coastal Interactions: Beaches and Sand.* Exploring our Fluid Earth. The Curriculum Research & Development Group, College of Education. Retrieved from, https://manoa.hawaii.edu/exploringourfluidearth/physical/coastal-interactions/beaches-and-sand

University of Kansas (2017b). *Section 3. Creating Objectives.* Community Tool Box. Retrieved from, http://ctb.ku.edu/en/table-of-contents/structure/strategic-planning/create-objectives/main

Victorian Coastal Council [VCC]. (2014). *Victorian Coastal Strategy 2014.* The State of Victoria Department of Environment and Primary Industries Melbourne. ISBN 978-1-74326-967-1

Voigt, B., Troy, A., Johnson, G. (2013). *Ecosystem service values.* Environment and Energy. Retrieved from, https://www.ontario.ca/page/ecosystem-service-values

Warkentin, M. (2018). *Dark Skies on the Bruce Peninsula.* Presentation in Kincardine Ontario for the Lake Huron Coastal Speaker Series.

Western Coastal Board [WCB]. (1999). *Warrnambool Coastal Action Plan.* 32 pp. Retrieved from, http://www.wcb.vic.gov.au/warrnamboolcap/Coastal%20Action%20Plan%20-%20Warrnambool.pdf

Williams, T., Micallef, A. (2009). *Beach Management: Principles and Practice*. Earthscan. ISBN: 978-1-84407-435-8

Williams, A.T., Alveirinho-Dias, J., Novo, F.G., Garcia-Mora, M.R., Curr, R., Pereira, A. (2001). *Integrated Coastal Dune Management: Checklists*. Continental Shelf Research. 21. 1937-1960. DOI: 10.1016/S0278-4343(01)00036-X

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019). *Changes in Temperature and Precipitation Across Canada*; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193.

Ellis, 2014

Ontario, 2012

APPENDICIES

APPENDIX A: REGIONAL, LOCAL AND GRASS-ROOTS STAKEHOLDERS

There are many entities working on and studying the Lake Huron coastal corridor. This is a summation of those involved. Others may be present that are not listed below:

Regional:

MNRF: Aylmer District, Guelph District, Midhurst District

MECP: Ministry of the Environment, Conservation and Parks

ECCC: Environment Climate Change Canada

OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs

Local:

Conservation Authorities: St. Clair Region Conservation Authority, Ausable Bayfield Conservation Authority, Maitland Valley Conservation Authority, Saugeen Valley Conservation Authority, Grey Sauble Conservation Authority.

First Nations and Métis: Aamjiwnaang First Nations, The Chippewas of Kettle & Stony Point First Nation, Saugeen Ojibway Nation, Historic Saugeen Métis

Municipality: Sarnia, Lambton Shores, Plympton-Wyoming, Lambton Shores, Central Huron, Goderich, Ashfield-Colbourne-Wawanosh, Huron-Kinloss, Kincardine, Saugeen Shores, South Bruce Peninsula, Northern Bruce Peninsula

County: Lambton County, Huron County, Bruce County

Parks: Ontario Parks (Provincial), Parks Canada (National)

Grass-Roots:

Clubs: Blue Bayfield, Green Goderich, Huron Fringe Field Naturalist Club, Maitland Trail Association,

Charities & Non-Profit Groups: Lake Huron Centre for Coastal Conservation, Pine River Watershed Initiative Network, Bruce Peninsula Biosphere Association

APPENDIX B: GLOSSARY OF TERMS

Feature	Definition	Sources
Beach	*"A beach is an accumulation of loose sediments at the edge of a body of water. The sediments are shaped and formed in response to wave action… The three common beach types include those composed of sand, those with a shingle or cobble ridge that forms the landward boundary with a broad apron of sand, and those composed only of cobbles."*	DFO, 1996 (p.6)
Sand Beach	*An area of the coast dominated by a substrate of sand that is dynamically altered through wave movements and wind action. These areas can include the sand beach/sand dune areas of Lake Huron's coast, along with the fore-beach occurring between a bluff and the water's edge. The area of a sand beach is ever-changing as water levels fluctuate.*	(LHCCC, 2008)
Sand Dune	*A dynamic beach area consisting of a mount, hill, or ridge of fine sand created by the littoral movement of sand deposition running parallel to the lakeshore. Sand dunes lie behind the active beach area affected by wave action.*	(LHCCC, 2008)
Cobble Beach	*An area of the coast dominated by a substrate of various sized cobble, pebble, shingle, or boulder stones residing in the littoral zone of the coast which has direct interaction with wave and wind influences of Lake Huron.*	(Liipere, S., 2014)
NPS Pollution	*Non-Point Source Pollution*	
Shore Bluff	*A steep vertical exposure comprised of clay, sand, shale, bedrock, limestone, or any combination of these. These areas are prone to erosion due to their direct interaction with changing lake levels.*	(LHCCC, 2013)
Gully	*An erosional feature cut into a bluff, typically "V- Shaped" when young, "U- Shaped" with age. These areas are formed through natural and anthropogenic influence, and are typically caused by erosion of a water tributary feeding perpendicularly into Lake Huron.* *"Gully systems are steep headwater channels that discharge water, sediment, and woody debris onto lower valley slops or into valley-bottom streams". (GBC, 2001)*	(LHCCC, 2013); (GBC, 2001, p.1)
Healthy Beach	*A beach that has obvious ecological function retained, this being adequate sand transportation in the littoral zone; significant 'top sand' (no 'wet beach'); presence of at least one mature dune system stratified with dune grass and/ one or more restoration measure in place (sand fencing, boardwalk, staircase over dune).*	(LHCCC, 2008)
Unhealthy Beach	*A beach that is obviously compromised due to anthropogenic factors including copious beach raking (removal of top-sand), dune destruction via foot traffic or vehicle influence, invasive species present, over-visitation by humans, obvious chronic algae or nutrient enrichment problems (including beach closures and algae blooms), and pollution via litter and 'wash-up' that establishes itself in the sediment.*	(LHCCC, 2008)
Assessment Unit	*A fraction of the overall study area derived using the littoral zone methodology developed by Environment and Climate Change Canada. This area represents the extend of sediment transportation on a micro scale alone the shoreline from Sarnia to Tobermory. These units will represent each area of analysis.*	

Major Watercourse	*A linear feature equal to or greater than 20m wide. Appears black, blue, grey or different shades of brown on IRS imagery.*	(Huron County, 2010, pp. 43)
Minor Watercourse	*A linear feature less than 20m wide. Appears black, blue, grey or different shades of brown on IRS imagery.*	(Huron County, 2010, pp. 43)
Dynamic beach	*Areas of inherently unstable accumulations of shoreline sediments along the Great Lakes- St. Lawrence River System and large inland lakes. The dynamic beach hazard limit includes the flooding hazard limit plus a dynamic beach allowance. "Dynamic Beach: In the absence of detailed technical information, a dynamic beach is the sum of the 100-year flood level, 15-metres (m) wave uprush limit and an additional 30 m allowance for the dynamic nature of beach movements."*	OMMAH (2017); Davidson-Arnott & Mulligan (2016).
Coastal Woodland	*An area dominated by treed vegetation with the canopy cover exceeding 60%. Woodlands can consist of coniferous, deciduous or a mix of the two. Coastal Woodlands can appear on different sediment types and along different slopes.*	
Coastal Wetland	*"Lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; in either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants"*	OMNR (2013).
Limits of Acceptable Change	*"The variation that is considered acceptable in a particular component or process of the ecological character of [a habitat], without indicating change in ecological character that may lead to a reduction or loss of [habitat health]" (*	Australian Government (n.d.)
Erosion	*"Erosion is the movement of weathered rocks and minerals from one location to another" (UoH 2014)*	UoH, 2014
Sea Wall	*"A rigid wall structure made of cement or other building materials placed parallel to a shoreline"*	UoH, 2014
Rip Rap	*"Loose collections of large rock or cement blocks placed along a shoreline"*	UoH, 2014
Groin (or Groyne)	*"A rigid structure often built perpendicular to the shoreline that interrupts water flow and movement of sediment"*	UoH, 2014
Breakwater	*"Offshore structures made of large boulders or cement blocks used to protect anchorages or harbor entrances from wave energy"*	UoH, 2014
Jetty	*"A rigid structure built in pairs perpendicular to the shoreline to stabilize inlet channels"*	UoH, 2014
Islands	*"Any land mass (natural or anthropogenic) within the Great Lakes or connecting channels that is surrounded by an aquatic ecosystem. Therefore, a particular island can be periodically connected to the mainland or part of a reef depending on water levels. Rock, shoals, shallow reefs and breakwaters can all be considered islands"*	Henson et al., 2010.
Alvar	*""Alvars are natural communities of humid and sub-humid climates, centered around areas of glaciated horizontal limestone/dolomite (dolostone) bedrock pavement with a discontinuous thin soil mantle. These communities are characterized by distinctive flora and fauna with less than 60% tree cover, that is maintained by associated geologic, hydrologic, and other landscape processes.*	Reschke et al., 1999

	Alvar communities occur in an ecological matrix with similar bedrock and hydrologically influenced communities.""	
Light Pollution	*Light pollution is the alteration of night natural lighting levels caused by anthropogenic sources of light*	Falchi et al., 2016

APPENDIX C: EXAMPLE OF A SHORELINE PROTECTION BYLAW

A proposed first draft of a Shoreline Protection Bylaw by the Township of Stone Mills, Ontario.

"WHEREAS Section 7.6 of the Official Plan of the Township of Stone Mills provides that:

'Shoreline areas will be protected from insensitive development that may have the effect of removing natural vegetation, disturbing the existing soil mantle and impairing water quality in the adjacent water body. Development should be creatively designed to enhance and protect the sensitive nature of shoreline resources, avoiding the crowding of buildings, the removal of vegetation and the pollution of ground and surface waters. A natural vegetative buffer strip of 30 m [98.4 ft.] should be maintained adjacent to the water's edge to filter pollutants from runoff. Within this buffer area, clear cutting of trees is not permitted. However, landowners will be encouraged to maintain shoreline vegetation in a healthy state through pruning, thinning, removal of diseased trees and replanting. Access to the waterfront for residential properties should be designed as a natural pathway with minimal disturbance to the natural features"; and WHEREAS the Council of the Township of Stone Mills deems it appropriate to enact a bylaw to provide for the protection of the shoreline areas by regulating the removal of trees, other vegetation and site alteration that will or could result in the deterioration of the quality of the water in the lakes and rivers within the Township…

Objectives 1. The objectives of this Bylaw are to:

- *1.1. Provide regulatory conformity with the approved polices of the Official Plan for the Township of Stone Mills in respect to the protection of the shoreline areas within the Township;*
- *1.2. Minimize the destruction of trees;*
- *1.3. Sustain a healthy natural environment by maintaining and improving the ecosystem services provided by trees;*
- *1.4. Protect significant and sensitive natural areas;*
- *1.5. Contribute to human health and quality of life through the maintenance of tree cover;*
- *1.6. Maintain water quality;*
- *1.7. Reduce airborne pollution;*
- *1.8. Maintain and enhance natural habitat;*
- *1.9. Prevent soil erosion and water runoff;*
- *1.10. Protect, promote and enhance the aesthetic values of land;*
- *1.11. Protect fish habitat as defined in the Fisheries Act, Revised Statute of Canada 1985; and*
- *1.12. Minimize the stress on watercourses…*

Shoreline Rejuvenation
11. Owners are encouraged to rejuvenate the shoreline areas through the re-establishment of the natural vegetation to the greatest extent possible.
12. When owners are rejuvenating the shoreline area, the Township will assist the owner to identify those species of natural plants and trees Shoreline Protection Bylaw Page 7 together with the development of a plan that will best achieve the objectives of this bylaw.

13. The Township shall consult with such professionals and make such information available that will further the objectives of this bylaw" (Township of Stone Mills, 2015).

APPENDIX D: POINT AND NON-POINT SOURCE MITIGATION APPROACHES

Recommendations in this guide have been taken from a coastal guide created for the Maritime region of Atlantic Canada, and can be applied to the Great Lakes Coastal Region (Stewart et al., 2003).

Information for Public Education Approaches for Typical Non-point Sources in Coastal Areas (New Hampshire Department of Environmental Services)

Septic Systems

- Inspect yearly and pump out if the sludge and surface scum are one-third of the depth of tank.
- Do not flush bulky items, toxic materials, food waste or grease.
- Repair leaking fixtures to reduce the amount of water your system handles.
- Use environmentally friendly cleaning products.

Road Construction

- Minimize or avoid constructing roads near sensitive areas (wetlands, lakes, streams, mudflats and coastal marshes).
- Avoid building roads up and down steep slopes; instead follow the contours of the land.
- Stabilize a site with seeding, mulching, silt fence, hay bales, etc. as soon as possible during and after construction.
- Schedule activities during times of little rainfall.
- Minimize the amount of bare soil exposed.
- Construct and install stable outlets for all ditches and stormwater sewer systems before building the ditches and pipe outlets.
- Direct runoff away from construction areas and stormwater channels until proper stabilization has been achieved.
- Protect existing stormwater inlets and culverts from sediment by using sediment traps, silt fences, hay bales or perforated risers.
- Minimize the length of road per unit area and the number of watercourse crossings, especially in sensitive areas.
- Avoid wet seasons prone to severe erosion or spawning periods for fish.

Road Salting and Snow Dumping

- Storage sites should be located away from surface water and covered to prevent runoff.
- Salt applicators should be made aware of sensitive areas (e.g., public water supplies).
- Disposed snow should be stored near flowing surface waters, but at least 25 feet (8 m) from the high water mark of surface waters or the coast.
- A silt fence should be placed between snow storage area and high water mark.
- The snow storage areas should be 75 feet (25 m) or more from any private water supply wells, 200 feet (60m) from community water supply wells, and 400 feet (120m) from municipal wells.

Site Excavation and Development

- Retain natural vegetation where possible.
- Minimize the duration of bare soil exposure.
- Prevent erosion by mulching or providing other cover where possible.
- If possible divert clean runoff around disturbed areas.
- Minimize slope lengths and provide immediate erosion control measures (matting).
- Monitor the effectiveness of mitigation and adjust, maintain and repair periodically and after every storm.

Gravel Excavation

- Allow space for mild pit slopes (no greater than 2 to 1), diversions and adjacent owner protection.
- Assess the impact on nearby drinking water wells.
- Store petroleum products outside the pit area and provide an above-ground containment area if petroleum storage is essential in the pit.
- Have a spill prevention plan that all employees are aware of and trained in. Report and clean-up spills immediately.
- Maintain and wash equipment outside of the pit.
- Control dust.
- Use retention basins to trap fine material.
- Have natural buffer strips between the pit and surface water.

Agriculture

- Apply pesticides only when needed and store and handle pesticides properly.
- Do no apply pesticides on windy days or before a heavy rainfall.
- Plant crops along contour lines.
- Rotate crops.
- Maintain filter strips between fields and surface waters.
- Control runoff via stabilized diversions.
- Restrict livestock from streambanks or sensitive areas.
- Avoid spreading manure or fertilizer on frozen or snow covered ground.

Urban Runoff

- Vegetation should be used extensively to filter runoff.
- Divert runoff around sites where pollutants could be picked up.
- Keep parking areas, outdoor storage areas and streets clean of debris; maintain catch basins and other flow control devices.

Chemical and Petroleum Storage

- Keep an up-to date material inventory.
- Have periodic inspections for leaks or other problems.
- Have a spill prevention and response plan.
- Store containers in areas that will contain leaks.

Timber Harvesting

- Erosion control guidelines are available for woods and road construction.
- Divert water from exposed soils through road ditching, culverts, and drainage management techniques for distances of 50 feet (15m) or more.
- Include filter strips (wider on steep slopes) between exposed soils and waterbodies (slopes of 0-10 degrees).

Docks, Moorings and Marinas

- Use phosphate-free detergents and treat wash water before it is discharged into a waterbody.
- Periodic out-of-water engine maintenance for boats.
- Use propylene glycol instead of ethylene glycol antifreeze.
- Painting, scraping, sandblasting, etc. should be done out of the water and containment devices should be used.
- Install containment booms at fueling stations and install catch basins around boat launches to prevent pollutants from entering the water.